PORT OF LOS ANGELES
INVENTORY OF AIR EMISSIONS - 2013

THE PORT
OF LOS ANGELES

Technical Report
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Prepared by:
STARCREST CONSULTING GROUP, LLC

INVENTORY OF AIR EMISSIONS FOR CALENDAR YEAR 2013

Prepared for:

THE PORT
OF LOS ANGELES

July 2014

Prepared by:

STARCREST CONSULTING GROUP, LLC
ENVIRONMENTAL MANAGEMENT
AIR QUALITY • CLIMATE • SUSTAINABILITY

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Please note that there may be minor inconsistencies, due to rounding, associated with emission estimates, percent contribution, and other calculated numbers between the various sections, tables, and figures of this report. All estimates are calculated using more digits than presented in the various sections.

ACRONYMS AND ABBREVIATIONS

Act	Activity
AIS	Automated Identification System
AMP	alternative maritime power
APM	A.P. Moeller-Maersk
AQMP	Air Quality Management Plan
ATB	articulated tug and barge
BNSF	Burlington Northern Santa Fe Railroad
BSFC	brake specific fuel consumption
BW	breakwater
CAAP	Clean Air Action Plan
CARB	California Air Resources Board
CF	control factor
CH_4	methane
CHE	cargo handling equipment
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CTP	Clean Truck Program
D	distance
DB	dynamic braking
DF	deterioration factor
DMV	Department of Motor Vehicles
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
DPM	diesel particulate matter
DR	deterioration rate
DWT	deadweight tonnage
E	emissions
ECA	emission control area
EEAI	Energy and Environmental Analysis, Inc.
EEDI	Energy Efficiency Design Index
EF	emission factor
EI	emissions inventory
EMFAC	CARB's EMission FACtor model
EPA	U.S. Environmental Protection Agency
ESI	Environmental Ship Index
FCF	fuel correction factor

g/bhp-hr	grams per brake horsepower-hour
g/kW-hr	grams per kilowatt-hour
g/mi	grams per mile
GHG	greenhouse gas
GVWR	gross vehicle weight rating
GWP	global warming potential
HC	hydrocarbons - total
HDV	heavy-duty vehicle
HFC	hydrofluorcarbon
HFO	heavy fuel oil
hp	horsepower
hrs	hours
IAPH	International Association of Ports and Harbors
ICTF	Intermodal Container Transfer Facility
IFO	intermediate fuel oil
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ITB	integrated tug and barge
kW	kilowatt
kW-hr	kilowatt-hours
LF	load factor
LLA	low load adjustment
Lloyd’s	IHS Lloyd’s Register of Ships
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LSI	large spark ignited (engine)
MarEx	Marine Exchange of Southern California
MARPOL	International Convention for the Prevention of Pollution from Ships
MCR	maximum continuous rating
MDO	marine diesel oil
MGO	marine gas oil
MMGT	million gross tons
MOU	Memorandum of Understanding
mph	miles per hour
MY	model year
N	north
nm	nautical miles
NO_x	oxides of nitrogen

N_2O	nitrous oxide
NYK	Nippon Yusen Kaisha
NRE	National Railway Equipment Co.
OBD	onboard diagnostics
OCR	optical character recognition
OGV	ocean-going vessel
PCST	Pacific Cruise Ship Terminals
PDTR	Ports Drayage Truck Registry
PHL	Pacific Harbor Line
PFC	perfluorocarbon
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
POLB	Port of Long Beach
ppm	parts per million
PZ	precautionary zone
Reefer	refrigerated vessel
RFID	radio frequency identification
RO	residual oil
RoRo	roll-on roll-off vessel
rpm	revolutions per minute
RSD	Regulatory Support Document
RTG	rubber tired gantry crane
S	sulfur
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SFC	specific fuel consumption
SF_6	sulfur hexafluoride
SoCAB	South Coast Air Basin
SO_x	oxides of sulfur
SPBP	San Pedro Bay Ports
TEU	twenty-foot equivalent unit
tonnes	metric tonnes
tpy	tons per year
TWG	Technical Working Group
U.S.	United States
ULCC	ultra large crude carrier
ULSD	ultra low sulfur diesel

UNFCCC	United Nations Framework Connection on Climate Change
UP	Union Pacific Railroad
USCG	U.S Coast Guard
VBP	vessel boarding program
VLCC	very large crude carrier
VDEC	verified diesel emission control system
VMT	vehicle miles of travel
VOC	volatile organic compound
VSR	vessel speed reduction
VSRIP	Vessel Speed Reduction Incentive Program
W	west
ZH	zero hour
ZMR	zero mile rate

EXECUTIVE SUMMARY

The Port of Los Angeles (the Port or POLA) 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 approximately 32% of all U.S. containerized trade flows[1]. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will increase over the next two decades[2]. San Pedro Bay region is also home to over 10 million inhabitants. The ability of the San Pedro Bay Ports to accommodate the projected growth in trade will depend upon the ability of the two ports and their tenants to address adverse environmental impacts and, in particular, air quality impacts that result from such trade.

In November 2006, the San Pedro Bay Ports adopted the joint San Pedro Bay Ports Clean Air Action Plan (CAAP) which was designed to minimize health risks by reducing emissions associated with port-related operations, while allowing port development to continue. On November 22, 2010, the Harbor Commissioners of the two ports unanimously approved an update to the CAAP that identifies longer-term emissions and health risk reduction goals that build upon the commitments made in the original CAAP[3]. In order to track CAAP progress, the Port has committed to develop annual inventories of port-related emission sources starting with the 2005 Inventory of Air Emissions, which also serves as the CAAP baseline.

This study, the 2013 Inventory of Air Emissions, includes port-related emissions estimates based on 2013 activity levels and a comparison with 2005 through 2012 emissions estimates to track the Port's CAAP emissions reduction progress. As in previous inventories, the following five source categories are included:

- Ocean-going vessels (OGV)
- Harbor craft
- Cargo handling equipment (CHE)
- Locomotives
- Heavy-duty vehicles (HDV)

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[1] American Association of Port Authorities (AAPA), *NAFTA Region Container 2012 Traffic,* May 2013
[2] The Tioga Group, Inc., *San Pedro Bay Container Forecast Update*, July 2009
[3] POLA and POLB, *www.cleanairactionplan.org/*

Exhaust emissions of the following pollutants that can cause regional and local air quality impacts have been estimated:

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

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

- Carbon dioxide equivalent (CO_2e)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

For presentation purposes in the report, only CO_2e values are provided as they include all three GHGs in an equivalent measure to CO_2.

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 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 includes emissions from the aforementioned port-related sources operating within the harbor district—rail locomotives and on-road trucks transporting cargo to and/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 comprised of an over-water area 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.1 shows the geographical extent of this inventory, and other overlapping regulatory boundaries. Of special note, the CARB Marine Fuel Switch Boundary was changed in late December 2011 and in effect for all of 2013. Figure ES.1 also shows the CARB new boundary.

Figure ES.1: Emissions Inventory Geographical Extent

Summary of 2013 Activity

Table ES.1 presents the number of vessel calls and the container cargo throughput for calendar years 2005 through 2013. Comparing 2013 to the previous year, the number of twenty-foot equivalent units (TEUs) decreased by 3% and the number of container ship arrivals increased by 7%. The 9% decrease in TEUs/call is due to more containership calls and less TEUs in 2013 as compared to previous year. Compared to that in 2005, the 2013 TEUs increased by 5% while containership calls decreased by 1%, resulting in a TEUs/containership-call efficiency improvement of 6%.

Table ES.1: Container Throughput and Vessel Arrival Call Comparison

Year	**All Arrivals**	**Containership Arrivals**	**TEUs**	**Average TEUs/Call**
2013	2,033	1,463	7,867,863	5,378
2012	1,968	1,370	8,077,714	5,896
2011	2,072	1,376	7,940,511	5,771
2010	2,035	1,355	7,831,902	5,780
2009	2,010	1,355	6,748,995	4,981
2008	2,241	1,459	7,849,985	5,380
2007	2,528	1,577	8,355,038	5,298
2006	2,707	1,632	8,469,853	5,190
2005	2,516	1,479	7,484,625	5,061
Previous Year (2013-2012)	**3%**	**7%**	**-3%**	**-9%**
CAAP Progress (2013-2005)	**-19%**	**-1%**	**5%**	**6%**

There were several changes occurred in 2013 that resulted in lower overall port-wide emissions as compared to previous years. Major highlights by source category include:

- For ocean-going vessels, there was increased vessel speed reduction (VSR) compliance and increased use of shore power at-berth. CARB's new boundary for marine fuel regulation was in effect for the entire calendar year in 2013.
- For heavy-duty vehicles, implementation of the Port's Clean Truck Program (CTP) resulted in significant turn-over of older trucks to newer and cleaner trucks. In 2012, the CTP requirement banned all pre-2007 engines. For 2013, there were fewer turnovers than in 2012.
- For harbor craft, implementation of CARB's Commercial Harbor Craft Regulation along with funding incentives resulted in continued replacement of existing older vessels and engines with cleaner, lower-emitting units.

- For the cargo handling equipment, implementation of CAAP measures and CARB's Cargo Handling Equipment Regulation, along with funding incentives, resulted in continued replacement of existing older equipment with cleaner units, retrofits, and repowers which lead to lower emissions.
- For locomotives, the fleet-wide emission rates continued to decrease somewhat relative to cargo throughput due to gradual introduction of cleaner line haul locomotives into the fleets, in part resulting from compliance with the CARB Memorandum of Understanding. The switching fleet now consists almost completely of ultra-low emission locomotives; so changes in emissions from switching operations correlated with throughput level.

Summary of 2013 Emission Estimates

This section provides a high-level summary of the Port of Los Angeles 2013 Inventory of Air Emissions results. Table ES.2 summarizes the 2013 total port-related mobile source emissions of air pollutants in the SoCAB by category. The total port-related mobile source carbon dioxide equivalent (CO_2e) emissions in the SoCAB are in metric tons (tonnes) per year (2,200 lbs/tonne) instead of the short tons per year (2,000 lbs/ton) used for criteria pollutants. Note the CO_2e values are derived by multiplying the GHG emissions estimates for CO_2, N_2O, and CH_4 by their respective global warming potential (GWP)[4] values and then adding them together.

Table ES.2: 2013 Port-related Emissions by Category

Category	**PM_{10}** tpy	**$PM_{2.5}$** tpy	**DPM** tpy	**NO_x** tpy	**SO_x** tpy	**CO** tpy	**HC** tpy	**CO_2e** tonnes
Ocean-going vessels	105	97	90	3,515	535	423	215	195,804
Harbor craft	26	24	26	705	1	372	64	48,067
Cargo handling equipment	15	14	13	678	1	693	73	138,632
Locomotives	29	27	29	828	1	190	46	66,969
Heavy-duty vehicles	18	16	16	1,241	4	378	64	353,594
Total	**193**	**178**	**174**	**6,967**	**542**	**2,056**	**462**	**803,066**

DB ID457

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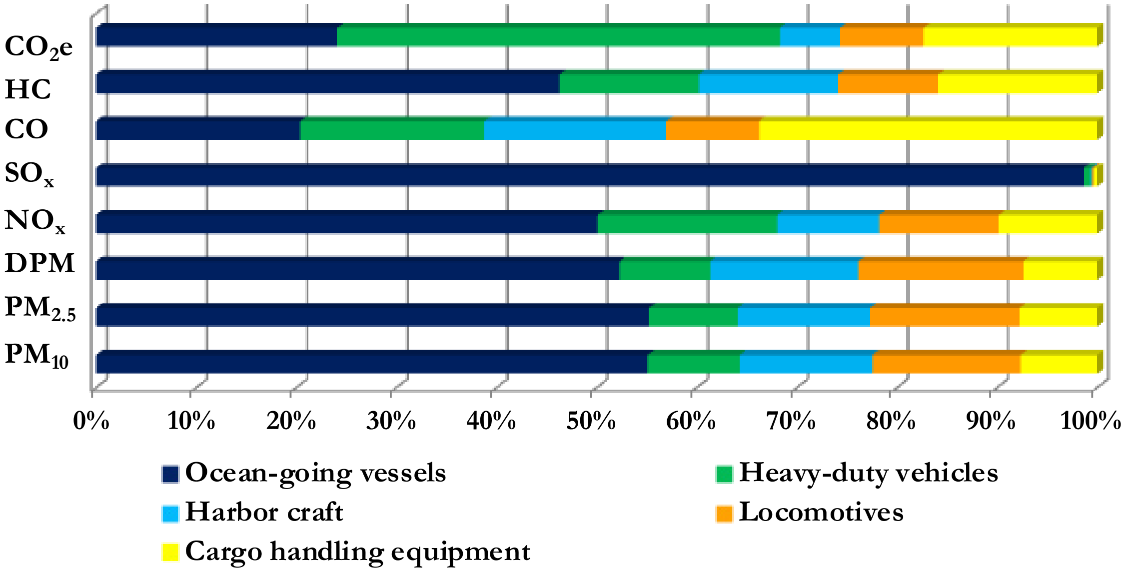
[4] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*, April 2013

Figure ES.2 shows the distribution of the 2013 total port-related emissions of each pollutant from each source category. OGV (52%), locomotives (16%), and harbor craft (15%) contributed the highest percentage of DPM emissions among the port-related sources. Approximately 99% of the SO_x emissions were emitted from ocean-going vessels. OGV (50%) and HDV (18%) accounted for the majority of NO_x emissions. CHE (34%), ocean-going vessels (20%), harbor craft (18%) and HDV (18%) accounted for the majority of CO emissions. OGV (46%) and CHE (16%) accounted for the majority of hydrocarbon emissions.

Figure ES.2: 2013 Port-related Emissions by Category



In order to put the port-related emissions into context, the following figures and tables compare the Port's contributions to the total emissions in the SoCAB by major emission source category. The 2013 SoCAB emissions are based on 2012 AQMP Appendix III.[5] The other mobile source category includes aircraft, trains, ships, commercial boats, recreational boats, offroad recreational vehicles, and offroad equipment. The on-road source category includes light duty vehicles, medium duty trucks, heavy duty trucks, motorcycles, and buses. Due to rounding, the percentages may not add up to 100% in the pie charts shown below. It should be noted that SoCAB PM_{10} and $PM_{2.5}$ emissions for on-road vehicles include brake and tire wear emissions whereas the Port's HDV emissions do not include brake and tire wear.

Figure ES.3: 2013 PM_{10} Emissions in the South Coast Air Basin

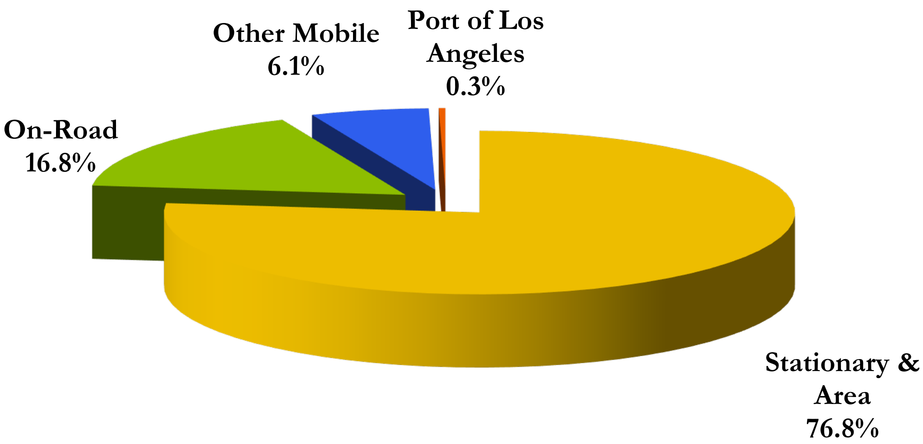
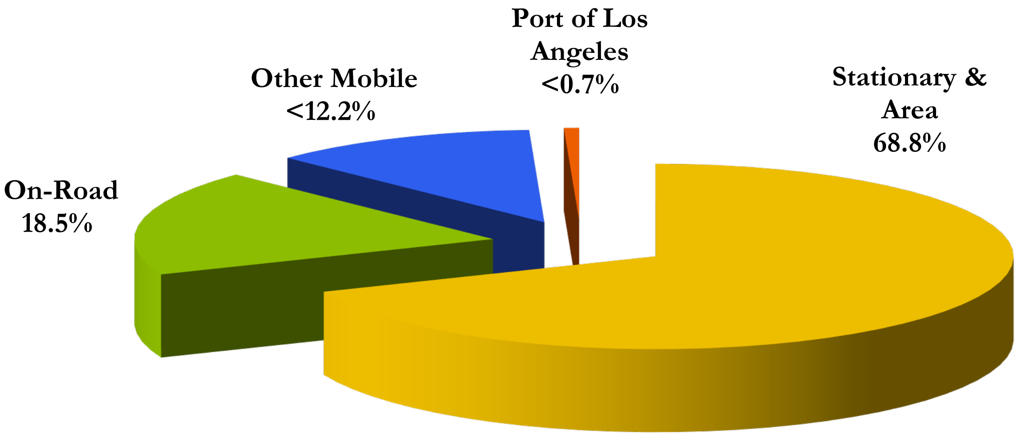


Figure ES.4: 2013 $PM_{2.5}$ Emissions in the South Coast Air Basin



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[5] SCAQMD, *Final 2012 AQMP Appendix III, Base & Future Year Emissions Inventories*, February 2013

Figure ES.5: 2013 DPM Emissions in the South Coast Air Basin

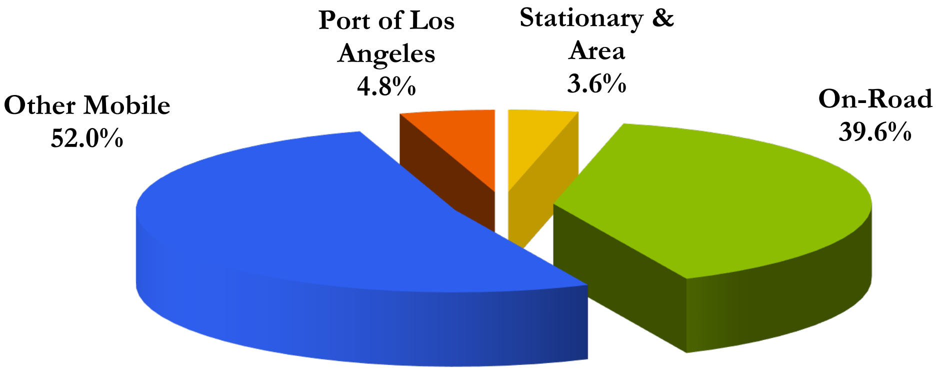


Figure ES.6: 2013 NO_x Emissions in the South Coast Air Basin

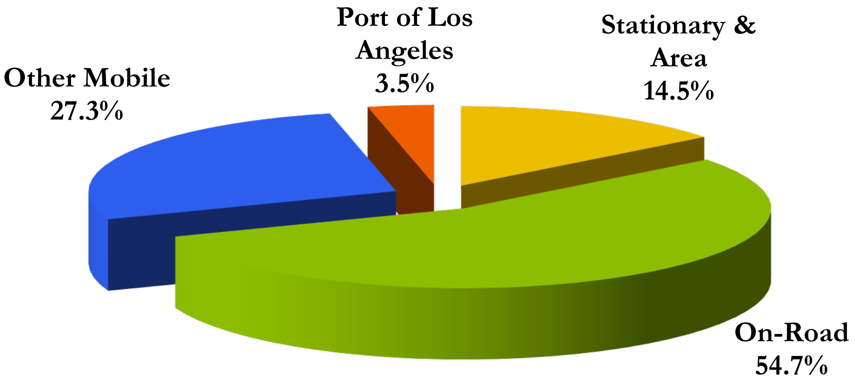


Figure ES.7: 2013 SO_x Emissions in the South Coast Air Basin

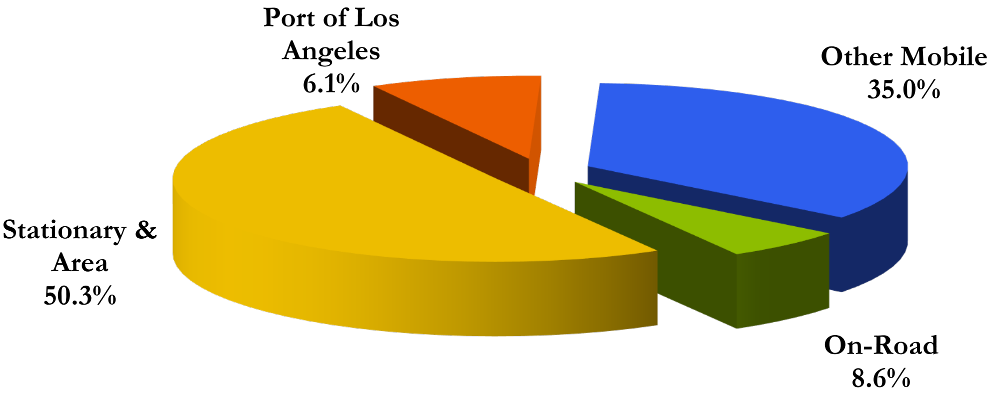


Figure ES.8 presents the decline of the port-related mobile source emissions in percentage of the total SoCAB emissions from 2005 to 2013. As indicated, the Port's overall contribution to the SoCAB emissions has decreased significantly since 2005, primarily because of the implementation of various emission reduction programs by the Ports, agencies, and efficiency improvements from the maritime industry.

Figure ES.8: Port's Emission Contribution in the South Coast Air Basin

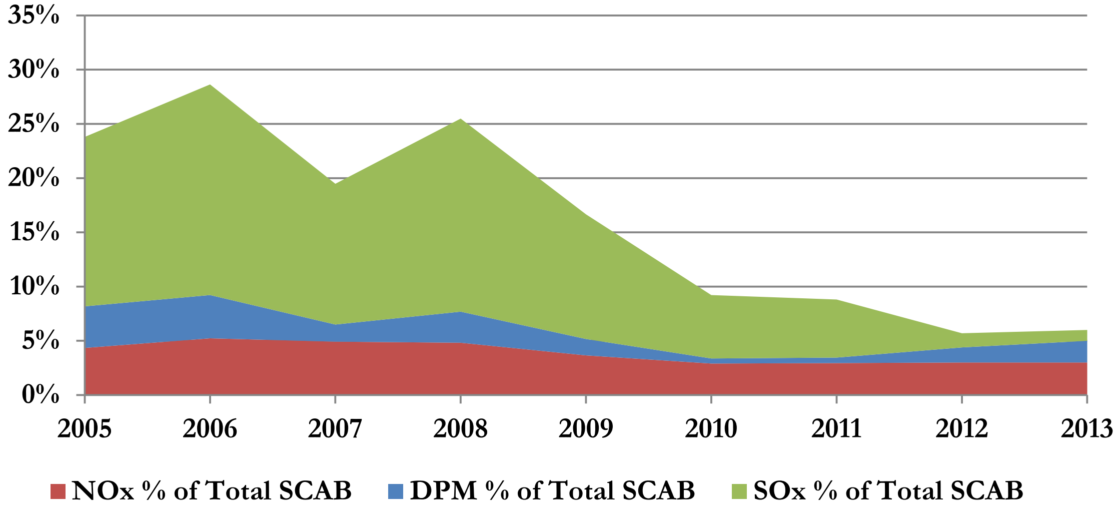


Table ES.3 presents the total net change in emissions from all source categories in 2013 as compared to previous years. In 2013 as compared to previous year, there was a 3% decrease in cargo throughput, while emissions of DPM decreased by 7%, NO_x decreased by 7%, and SO_x decreased by 8%. CO and hydrocarbons increased by 1%. Between 2005 and 2013 there was a 5% increase in cargo throughput, yet emissions of DPM decreased by 80%, NO_x decreased by 57%, SO_x decreased by 90%, CO decreased by 44%, and HC decreased by 40%. GHG emissions decreased 6% in 2013 as compared to previous year and decreased by 23% since 2005. The GHG reduction was mainly due to better cargo movement efficiency, the Port's investment in CAAP, and regulatory measures that have GHG emission reduction co-benefits.

Table ES.3: Port-wide Emissions Comparison

EI Year	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
2013	193	178	174	6,967	542	2,056	462	803,066
2012	207	193	187	7,473	592	2,027	459	851,560
2011	295	263	266	8,062	1,269	2,033	480	838,077
2010	310	276	282	8,231	1,299	1,988	472	843,824
2009	494	428	451	10,884	2,386	2,615	557	888,075
2008	764	656	696	15,016	3,718	3,452	716	1,021,509
2007	727	637	633	16,366	3,340	3,649	774	1,088,238
2006	1,044	893	945	18,483	5,611	4,175	863	1,223,555
2005	972	829	886	16,278	5,186	3,657	766	1,043,983
Previous Year (2012-2013)	**-7%**	**-8%**	**-7%**	**-7%**	**-8%**	**1%**	**1%**	**-6%**
CAAP Progress (2005-2013)	**-80%**	**-79%**	**-80%**	**-57%**	**-90%**	**-44%**	**-40%**	**-23%**

Figures ES.9 through ES.11 show the emission trends from 2005 to 2013 in DPM, NO_x and SO_x emissions from the ocean-going vessels, harbor craft, cargo handling equipment, locomotives, and heavy-duty vehicles emission source categories. As indicated, emissions from all categories have generally decreased over the years, primarily due to the implementation of the Port's emissions reduction programs and the emissions reduction regulations. There are some spikes in emissions due to throughput level changes and changes in regulations and control measures.

As shown in Figure ES.9, OGVs contribute the majority of DPM emissions. DPM emissions from all categories have decreased between 2005 and 2013. OGV and HDV emissions have significantly decreased in recent years primarily due to the Port's VSR, CARB's fuel regulation and the Port's Clean Truck Program (CTP).

Figure ES.9: DPM Emissions Comparison by Category, tpy

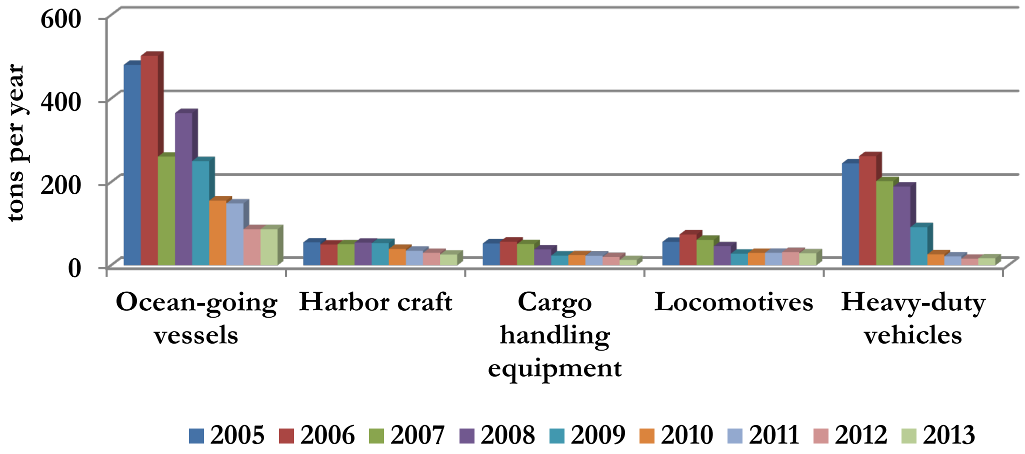


Figure ES.10 illustrates that emissions of NO_x from HDVs were lowered significantly due to the Clean Truck Program. Currently, OGVs dominate the port-related NO_x emissions. Overall NO_x emissions show a downward trend over the last several years.

Figure ES.10: NO_x Emissions Comparison by Category, tpy

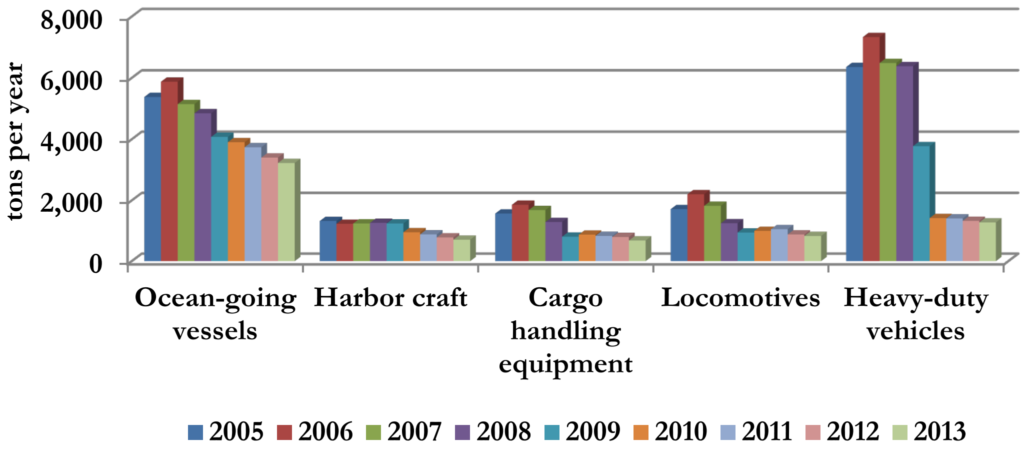
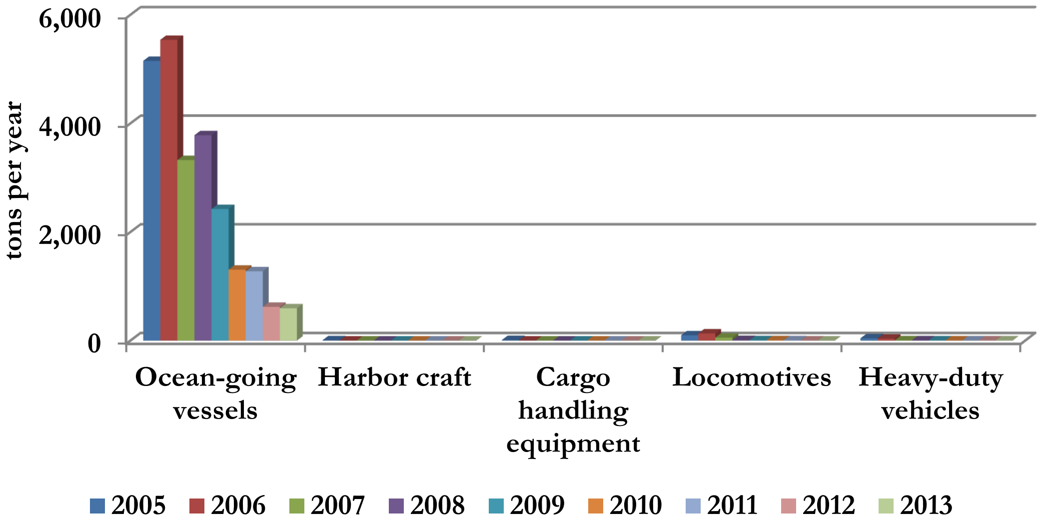


Figure ES.11 shows that OGVs are by far the largest SO_x emissions contributors at the Port. This is because SO_x emissions are produced from the sulfur in the marine fuel burned by ship engines, and OGV engines typically burn fuels with relatively high sulfur content while the other source categories use fuels that are much lower in sulfur. In mid-2009, the CARB fuel regulation went into effect which resulted in significant reduction in OGV SO_x emissions, starting in 2009 and continuing through 2013. The other source categories have switched to using ultra low sulfur diesel (ULSD) with a sulfur content of 15 parts per million (ppm).

Figure ES.11: SO_x Emissions Comparison by Category, tpy



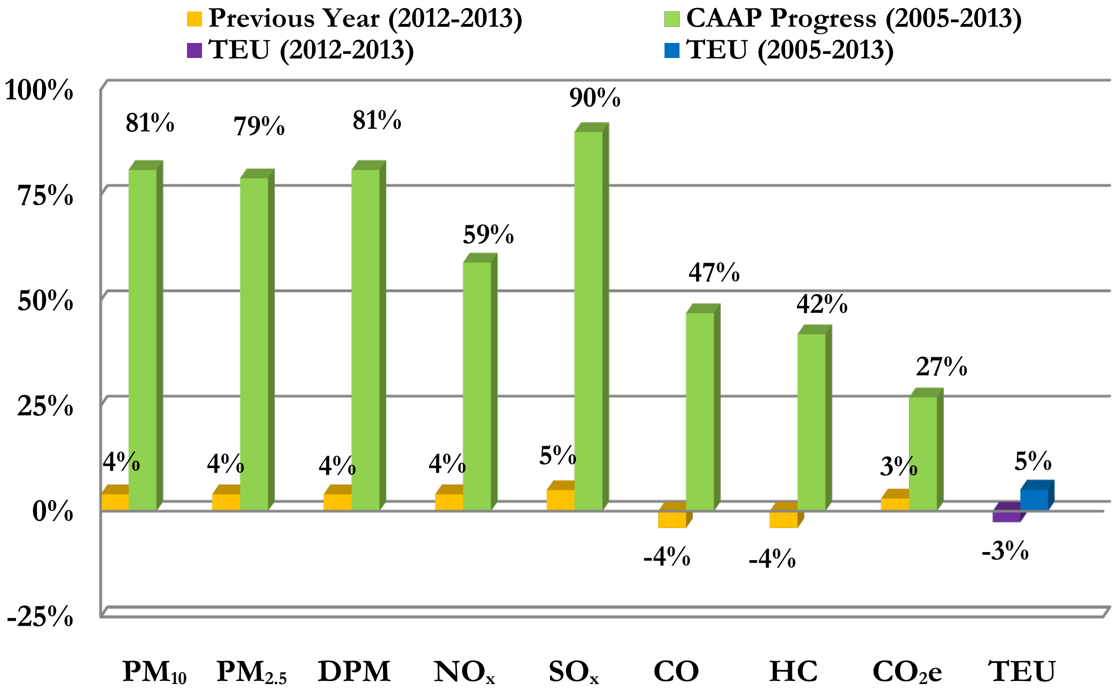
To compare emission reduction separately from the effects of throughput differences, the Port also calculates emissions on a ton per 10,000 TEU basis; which the Port refers to as "emissions efficiency". Emissions efficiency is calculated by dividing the TEU throughput by 10,000, and dividing the result into the number of tons of emissions. Table ES.4 summarizes the annualized emissions efficiencies for all five source categories. The overall port emission efficiency in 2013 improved for all pollutants as compared to 2005 baselines. A positive percentage means an increase in emission efficiency in Table ES.4 and Figure ES.12.

Table ES.4: Emissions Efficiency Metric Comparison, tons/10,000 TEUs

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2013	0.25	0.23	0.22	8.85	0.69	2.61	0.59	1,020
2012	0.26	0.24	0.23	9.25	0.73	2.51	0.57	1,054
2011	0.37	0.33	0.34	10.15	1.60	2.56	0.60	1,056
2010	0.40	0.35	0.36	10.51	1.66	2.54	0.60	1,078
2009	0.73	0.63	0.67	16.13	3.54	3.87	0.83	1,316
2008	0.97	0.84	0.89	19.13	4.74	4.40	0.91	1,301
2007	0.87	0.76	0.76	19.58	4.00	4.36	0.93	1,302
2006	1.23	1.05	1.12	21.82	6.62	4.93	1.02	1,445
2005	1.30	1.11	1.18	21.75	6.93	4.89	1.02	1,395
Previous Year (2012-2013)	**4%**	**4%**	**4%**	**4%**	**5%**	**-4%**	**-4%**	**3%**
CAAP Progress (2005-2013)	**81%**	**79%**	**81%**	**59%**	**90%**	**47%**	**42%**	**27%**

Figure ES.12 compares emissions efficiency changes in 2013, and between 2005 and 2013. The purple bar represents TEU throughput change from the previous year (a 3% decrease) and the blue bar represents the TEU throughput change since 2005 (a 5% increase). The emissions efficiencies improved for all pollutants.

Figure ES.12: Emissions Efficiency Metric Change



CAAP Standards and Progress

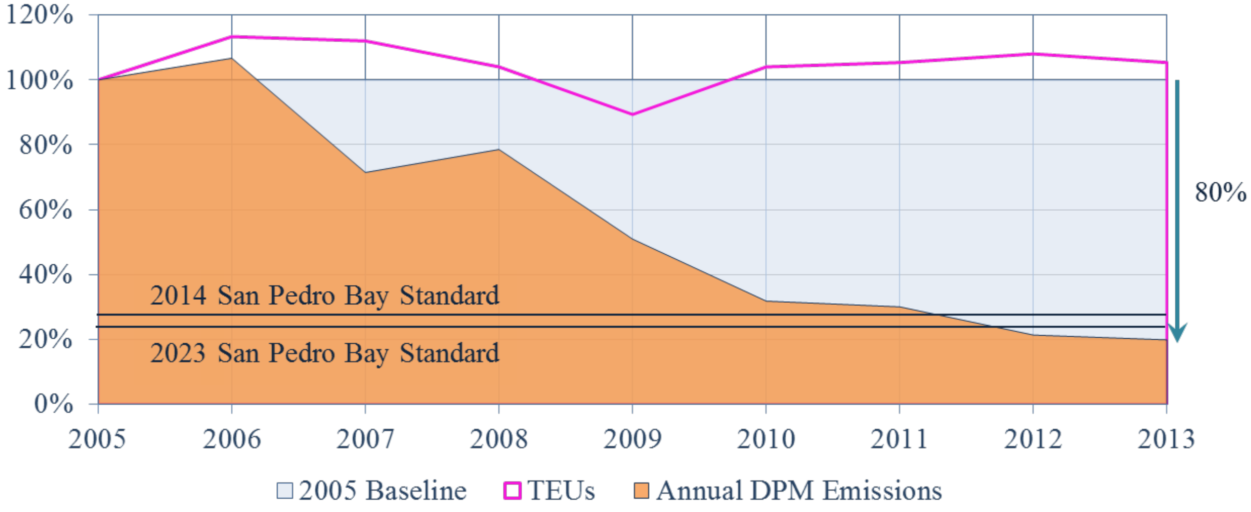
One of the main purposes of the annual inventories is to provide a progress update on achieving the CAAP San Pedro Bay Standards. These standards consist of the following reduction goals, using the 2005 published inventories as baseline.

- 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 93% for SO_x
- Health Risk Reduction Standard: 85% reduction by 2020

The emission reduction standards are represented as a percentage reduction of emissions from 2005 levels, and are tied to the regional SoCAB attainment dates for the federal $PM_{2.5}$ and ozone ambient air quality standards in the 2007 AQMP. This EI is used as a tool to track progress in meeting the emission reduction standards. Figures ES.13 through ES.15 present the 2005 baseline emissions and the year to year percent change in emissions with respect to the 2005 baseline emissions. The 2014 and 2023 standards are also provided as a snapshot of progress to-date towards meeting those standards. The pink line in the figures represents percentage TEUs throughput as compared to 2005 TEU throughput. This addition to the CAAP progress figures provides context to the relative correlation between cargo throughput and emissions.

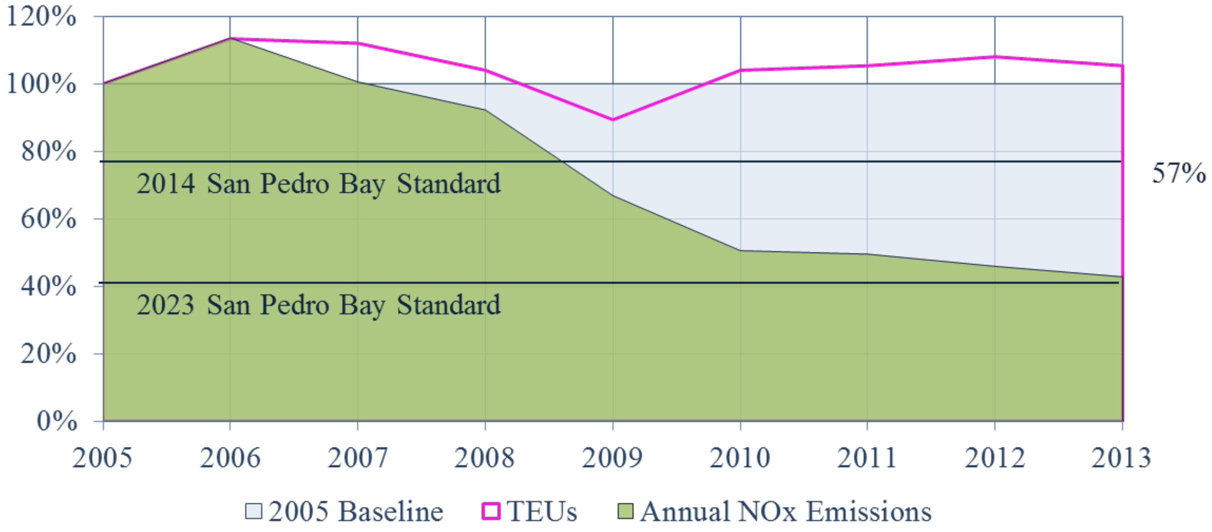
DPM emissions reductions are presented as a surrogate for $PM_{2.5}$ reductions in Figure ES.13 since DPM is directly correlated to $PM_{2.5}$ (DPM consists of PM emissions from diesel-powered sources) and DPM is also tracked as a health risk reduction surrogate as described below. As presented in Figure ES.13, the Port has met the 2014 and 2023 DPM emission reduction standards with an 80% emission reduction in 2013. Starting in 2006 and again in 2009, correlation of DPM emissions with cargo throughput has been disassociated due to the implementation of CAAP measures, CARB regulations, and system wide efficiencies that have been introduced by Port's logistics chain partners that operate inside the inventory's geographical domain. It is anticipated, in 2014, that this disassociation will again widen with the implementation of 0.1% sulfur fuel for OGVs from the CARB fuel rule and the increase number of ships using shore-power under the CARB shore power rule, as well as continued efficiency improvements from the operators.

Figure ES.13: DPM Reductions to Date



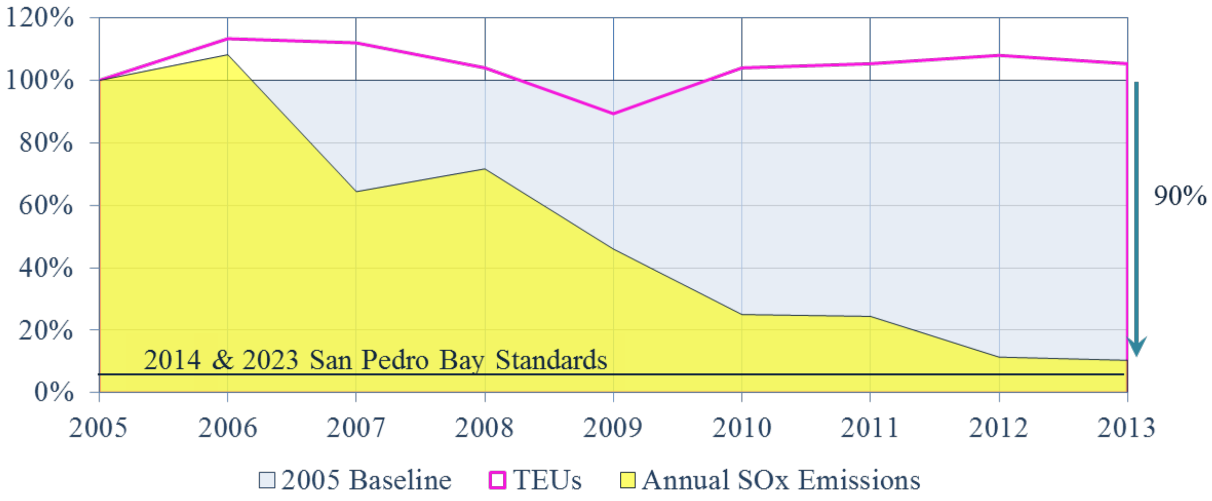
NO_x emissions reductions, presented in Figure ES.14, are targeted by the standards because NO_x is a precursor to ambient ozone formation and it also contributes to the formation of $PM_{2.5}$. As demonstrated in Figure ES.14, the Port exceeded the 2014 NO_x mass emission reduction standard in 2013 and has nearly met the 2023 standard emission reduction standard with a 57% reduction. Starting in 2007 and again in 2009, correlation of NO_x emissions with cargo throughput has been disassociated; the NO_x emission reduced significantly as adjusted to the cargo throughput. This separation was due to the implementation of CAAP measures, CARB regulations and system wide efficiencies gained by the Port's logistics chain partners that operate in the inventory's geographical domain. It is anticipated in 2014; this disassociation will again widen with the increase number of ships using shore-power under the CARB shore power rule, as well as continued efficiency improvements from the operators.

Figure ES.14: NO_x Reductions to Date



SO_x emissions reductions, presented in Figure ES.15, are targeted by the standards because of the contribution of SO_x to $PM_{2.5}$ emissions. By 2013, the Port is close to meeting the SO_x mass emission reduction standards with a 90% reduction. Starting in 2006 and again in 2009, correlation of SO_x emissions with cargo throughput has been disassociated drastically due to the implementation of CAAP measures, CARB regulations, and system wide efficiencies gain among the OGV operators. It is anticipated in 2014 that the SO_x reduction will accelerate with the implementation of 0.1% sulfur fuel for OGVs from the CARB fuel rule and the increase number of ships being shore-powered under the CARB shore power rule, as well as continued efficiency improvements from the operators.

Figure ES.15: SO_x Reductions to Date

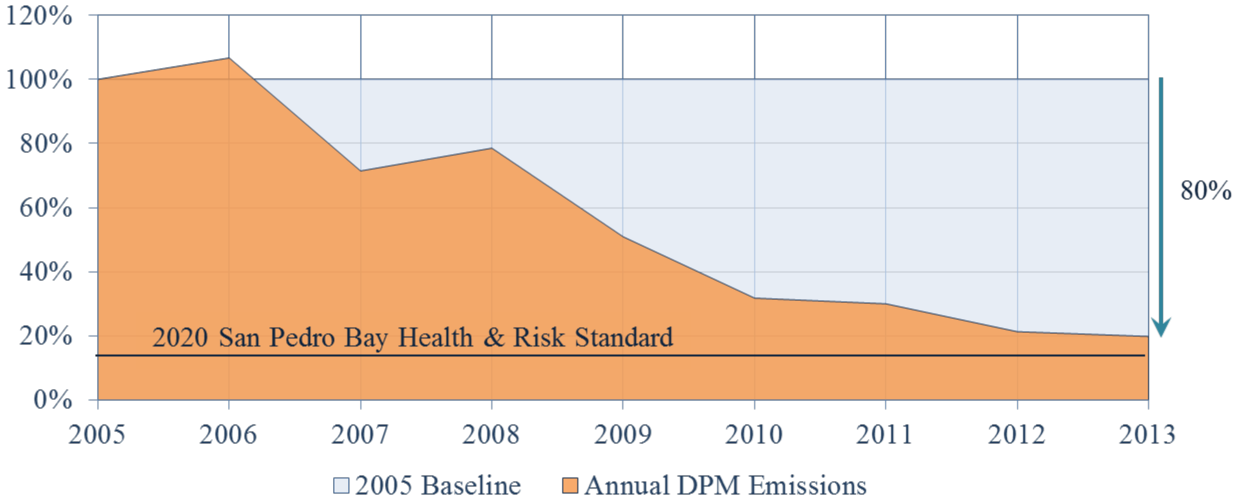


Health Risk Reduction Progress

As described in the 2010 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. The Health Risk Reduction Standard was established 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 suitable surrogate for health risk reductions. It should be noted that the use of DPM emissions as a surrogate for health risk reductions is to track relative progress. A more detailed health risk assessment will be prepared by the Port outside the scope of this EI in the future.

Progress to-date on health risk reduction is determined by comparing the change in DPM mass emissions to the 2005 baseline. Figure ES.16 presents the progress of achieving the standard to date. By 2013, with an 80% reduction, the Port is nearly 95% of the way towards meeting the 2020 Health Risk Reduction Standard (85%).

Figure ES.16: Health Risk Reduction Benefits to Date



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 approximately 32% of all U.S. containerized trade flows[6]. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will increase over the next two decades[7]. The economic benefits of the two ports are felt throughout the nation.

San Pedro Bay region including the Los Angeles-Long Beach metropolitan areas is home to over 10 million inhabitants. The ability of the San Pedro Bay Ports to accommodate the projected growth in trade will depend upon the ability of the two ports and their tenants to continue to address adverse environmental impacts and, in particular, air quality impacts that result from such trade. In November 2006, the San Pedro Bay Ports adopted their landmark Clean Air Action Plan (CAAP), designed to reduce health risks by reducing emissions associated with port-related operations while allowing port growth to continue. In November 2010, the Harbor Commissioners of two Ports unanimously approved an update to the CAAP that establishes longer-term goals building upon the commitments made in the original CAAP[8].

In order to track CAAP progress, the Port has committed to develop annual inventories of port-related sources starting with the 2005 Inventory of Air Emissions (which served as the CAAP baseline). The detailed annual activity-based inventory, with associated emissions estimates, is a critical and integral component to the success of the CAAP. Activity-based inventories, based on detailed data collected from activities that occurred in a specific time period, provide the most comprehensive 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 and its tenants and partners have undertaken.

The Port released its first activity-based emissions inventory in 2004, documenting activity levels in the baseline year of 2001. The 2001 baseline emissions inventory evaluated emissions for all Port terminals from five source categories: ocean-going vessels, harbor craft, off-road cargo handling equipment, railroad locomotives, and on-road heavy-duty vehicles and evaluated operations at all Port terminals. The 2001 inventory provided the technical basis for the CAAP. In 2007, the Port released the 2005 Inventory of Air Emissions which was the first update to the baseline inventory and also the first of the annual inventories to follow. The Port has subsequently released an annual emissions inventory for each calendar year since the 2005 EI. These inventory reports are available on the Port's website[9].

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[6] American Association of Port Authorities (AAPA), *NAFTA Region Container 2012 Traffic,* May 2013
[7] The Tioga Group, Inc., *San Pedro Bay Container Forecast Update*, Inc., July 2009
[8] POLA and POLB, *www.cleanairactionplan.org*
[9] POLA, *www.portoflosangeles.org/environment/studies_reports.asp*

1.1 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. The purpose of the 2013 Inventory of Air Emissions (2013 EI) is to develop emission estimates based on activities that occurred in calendar year 2013.

1.1.1 Pollutants

Exhaust emissions of the following pollutants have been estimated:

- Particulate matter (PM) (10-micron, 2.5-micron)
- Diesel particulate matter (DPM)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Carbon dioxide equivalent (CO_2e)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)

Particulate matter

Particulate matter refers to tiny, discrete solid or aerosol particles in the air. Dust, dirt, soot, and smoke are considered PM. 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, and cars (on-road sources), and diesel-powered marine vessels, construction equipment, and trains (off-road sources). DPM has been shown to contribute up to 84% of the carcinogenic health risk[10] related to the portion of outdoor pollutants classified as "toxics."

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[10] AQMD, *www.aqmd.gov/prdas/matesIII/Final/Document/b-MATESIIIChapter1and2Final92008.pdf*, pages 2-10

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 hydrocarbons and oxides of nitrogen in the presence of sunlight. The primary manmade sources of NO_x are motor vehicles, electric utilities, and other sources that burn fuels.

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

Hydrocarbons

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

Carbon monoxide

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

Greenhouse gases

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

CO_2, CH_4, and N_2O are emitted naturally or through human activities such as combustion of fossil fuels and deforestation. SF_6, HFCs and PFCs are synthetically produced for industrial purposes. This Emissions Inventory Report includes estimates of CO_2, CH_4 and N_2O from combustion of fuel in cargo handling equipment, harbor craft, on-road heavy-duty trucks, locomotives, and vessel operations associated with port operations.

Each GHG differs in its ability to absorb heat in the atmosphere. Estimates of greenhouse gas emissions are often normalized in a single greenhouse gas value known as carbon dioxide equivalents (CO_2e), which weights each gas by its global warming potential (GWP) value relative to CO_2. To calculate CO_2e, the GHG emission estimates are multiplied by its GWP and then summed. The GWP values are as follows:[11]

- CO_2 – 1
- CH_4 – 21
- N_2O – 310

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

1.1.2 Emission Sources

The scope of this inventory includes the following five source categories:

- Ocean-going vessels (OGV)
- Harbor craft
- Cargo handling equipment (CHE)
- Locomotives
- Heavy-duty vehicles (HDV)

Examples of the five source categories 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 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 those are included in stationary source permitting programs administered by the South Coast Air Quality Management District (SCAQMD).

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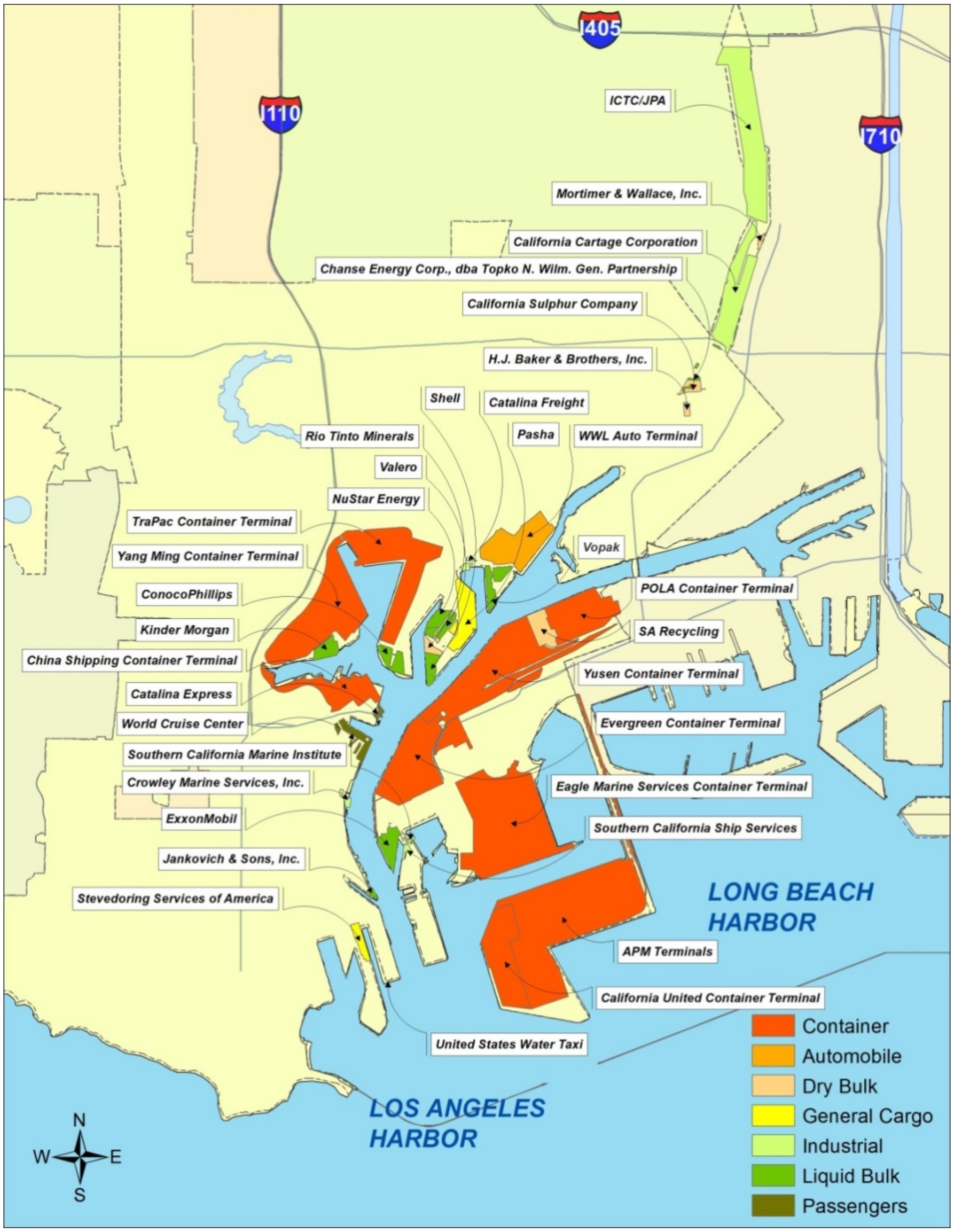
[11] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*, April 2013

1.1.3 Geographical Delineation

The Port of Los Angeles is a landlord port, most of the marine transportation and cargo moving activities are conducted by the Port tenants. This 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 1.1 shows the land area of active Port terminals in 2013. The geographical scope for cargo handling equipment is the terminals and facilities on which they operate.

Figure 1.1: 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, travel and idling within the terminals, and 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 South Coast Air Basin (SoCAB) boundaries. Emissions are estimated up to first point-of-rest within the SoCAB or up to the basin boundary.

Figure 1.2 shows the SoCAB boundary for locomotives and HDV in relation to the location of the Port. Since both the Port and POLB 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.

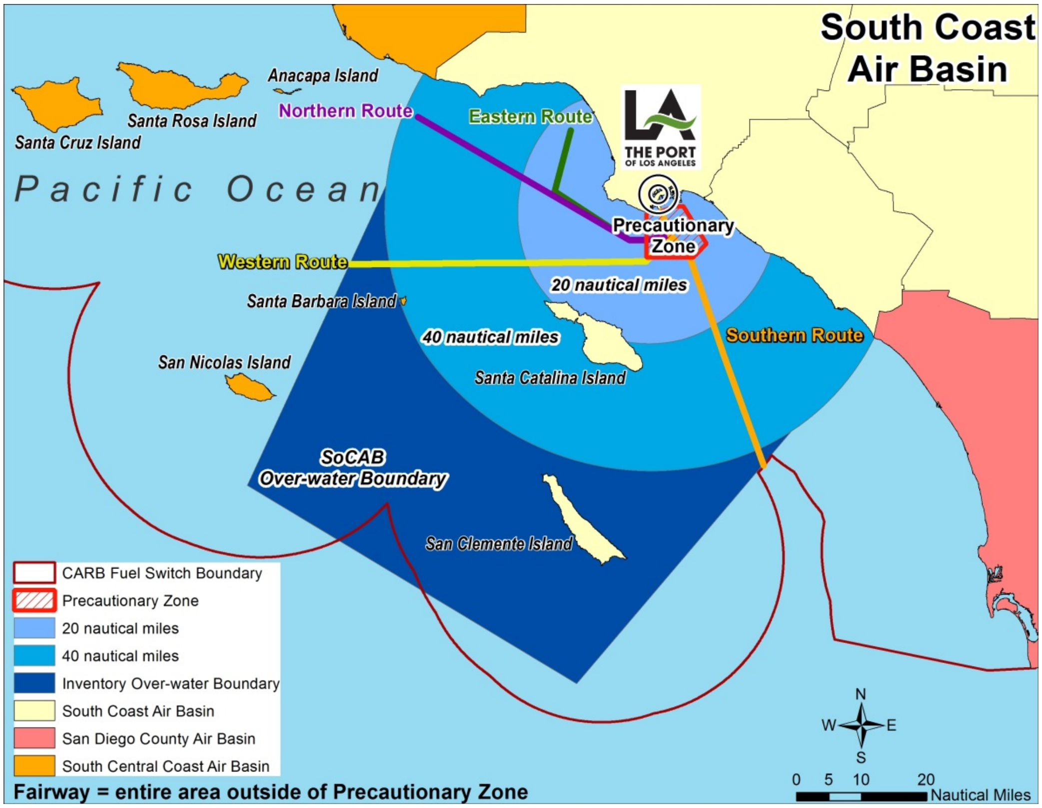
Figure 1.2: South Coast Air Basin Boundary

For marine vessels (OGVs and commercial harbor craft) the geographical extent of the emissions inventory is based on the same boundary that was used in previous marine vessel inventories developed for the SCAQMD and in the 2001 EI and subsequent inventories. The northern and southern boundaries are 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:

- Northwest corner: latitude 34°-02'-42.4" North (N) by longitude 118°-56'-41.2" West (W)
- Southwest corner: latitude 33°-00'-00.0" N by longitude 119°-30'-00.0" W
- Southeast corner: latitude 32°-30'-00.0" N by longitude 118°-30'-00.0" W
- Northeast corner: latitude 33°-23'-12.7" N longitude 117°-35'-46.4" W

Figure 1.3 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. The precautionary zone (PZ) is further discussed in Section 3.2. The dark red line in the figure depicts the new boundary for area subject to the CARB Marine Fuel Regulation.

Figure 1.3: OGV Inventory Geographical Extent



1.2 Methodology Comparison

In order to make a meaningful comparison between annual emission inventories, the same methodology must be used to estimate emissions each year. If methodological changes have been implemented for a given source category in 2013 compared with a previous year, then that year's emissions were recalculated using the new 2013 methodology on that base year's activity data to achieve a valid basis for comparison.

1.3 Report Organization

This report presents the 2013 emissions and the associated 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 presents findings and results
- Section 9 compares 2013 emissions to previous years' emissions
- Section 10 presents a discussion of emissions improvements

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

This section discusses the regulatory initiatives and Port measures related to port activity. Almost all port-related emissions come from five diesel-fueled source categories: OGVs, HDVs, CHE, harbor craft, and locomotives. The responsibility for the emissions control of the majority of these sources falls under the jurisdiction of local (South Coast Air Quality Management District [SCAQMD]), state (CARB), or federal (U.S. Environmental Protection Agency [EPA]) agencies. The Ports of Los Angeles and Long Beach adopted the landmark CAAP in November 2006 to curb port-related air pollution from trucks, ships, locomotives, and other equipment. In November 2010, the Harbor Commissioners of the two ports unanimously approved an update to the CAAP (2010 CAAP Update). The 2010 CAAP Update is part of the original pledge to ensure that the CAAP is a "living document" which will be updated as needed. The 2010 CAAP Update sets additional aggressive goals for reducing air pollution and health risks from port operations. A model for seaports around the world, the CAAP, and the 2010 CAAP Update, are the boldest air quality initiatives undertaken by any seaport. They consist of wide-reaching measures to significantly reduce air emissions and health risks while allowing for the development of much-needed port efficiency projects, infrastructure and growth.

San Pedro Bay Standards Included in the 2010 CAAP Update
The San Pedro Bay Standards are perhaps the most significant addition to the original CAAP, and a statement of the ports' commitments to significantly reduce the air quality impacts from port operations. Achievement of the standards listed below will require diligent implementation of all of the known CAAP measures, additional aggressive actions to find further emissions and health risk reductions, and identification of new strategies that will emerge over time.

Health Risk Reduction Standard

To complement the CARB's Air Pollution Reduction Programs including Diesel Risk Reduction Plan, the Ports of Los Angeles and Long Beach have developed the following standard for reducing overall port-related health risk impacts, relative to 2005 emissions level:

- By 2020, reduce the population-weighted cancer risk of ports-related DPM emissions by 85% in highly-impacted communities located proximate to port sources and throughout the residential areas in the port region.

Emission Reduction Standard

Consistent with the Ports' commitment to meet their fair-share of mass emission reductions of air pollutants, the Ports of Los Angeles and Long Beach have developed the following standards for reducing air pollutant emissions from port-related activities, relative to 2005 emission levels:

- By 2014, reduce emissions of NO_x by 22%, of SO_x by 93%, and of DPM by 72% to support attainment of the national fine particulate matter ($PM_{2.5}$) standards.
- By 2023, reduce emissions of NO_x by 59%, of SO_x by 93%, and of DPM by 77% to support attainment of the national and federal 8-hour ozone standards and national fine particulate matter ($PM_{2.5}$) standards.

The following section presents a list of regulatory programs and CAAP measures by each major source category that help reduce emissions from the Port.

2.1 Ocean-Going Vessels

IMO Emission 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 in or after 2000. The Tier 1 NO_x standards vary from 17.0 grams per kilowatt-hour (g/kW-hr) (for <130 revolutions per minute [rpm]) to 9.8 g/kW-hr (for ≥ 2000 rpm), depending upon the rated 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 from 2000 because the standards became retroactive to that year, once Annex VI was ratified.

In April 2008, the Marine Environment Protection Committee (MEPC) of the IMO approved a recommendation for new MARPOL Annex VI NO_x limits for marine diesel engines. In October 2008, the IMO adopted these amendments to international requirements under MARPOL Annex VI, which introduced new Tier 2 and Tier 3 engine emission rate limits for NO_x for marine diesel engines installed on newly built ships[12]. Tier 3 standards are required for vessels built on or after January 1, 2016 and that operate in an Emissions Control Area (ECA); this will be the case for all vessels calling the port.

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[12] IMO, *www.epa.gov/otaq/regs/nonroad/marine/ci/mepc58-23-annexes13-14.pdf*, Annexes 13 and 14 to the report of the Marine Environment Protection Committee on its fifty-eighth session (MEPC 58/23), pages 19 and 21

At the 65th session (May 2013), MEPC agreed to consider a draft amendment to postpone the date for the implementation of Tier 3 NO_x standards applicable within ECAs from 2016 to 2021. The United States, along with Canada, Denmark, Germany, and Japan, provided information in a paper that challenges the reasoning behind that decision and recommending that the Committee reconsider its decision and retain the original implementation date of January 2016. The Tier 3 NO_x Standards applicable to marine diesel engines that are installed on ships constructed on or after January 1, 2016 and which operate in the North American Emission Control Area or the U.S. Caribbean Sea Emission Control Area that are designated for the control of NO_x emissions were adopted during the 66th session of MEPC in March 2014, and are expected to be operative in September 2015.

The Tier III requirements do not apply to a marine diesel engine installed on a ship constructed prior to 1 January 2021 of less than 500 gross tonnage, of 24 m or over in length, designed and used solely, for recreational purposes.

The MEPC also approved draft amendments to MARPOL Annex VI regarding adoption of Annex VI NO_x regulations for engines solely fuelled by gaseous fuels. The committee is expected to adopt this amendment during the 67th session of MEPC.

The current NO_x engine standards, in grams per kilowatt hour (g/kW-hr), are summarized in Table 2.1 as follows:

Table 2.1: NO_x Limits for Marine Engines, g/kW-hr

Tier	Keel Laid Date	Engine Speed (n) in rpm		
		n<130	130 ≤ n < 2000	n ≥ 2000
Tier 1	2000–2010	17	$45 \times n^{-0.20}$	9.8
Tier 2	2011–2015	14.4	$44 \times n^{-0.23}$	7.7
Tier 3 (ECA only)	2016+	3.4	$9 \times n^{-0.20}$	2.0

Existing ships built between 1990 and 2000 with marine diesel engines > 5,000 kW and a per cylinder displacement ≥ 90 liters are subject to retrofit requirements of the Tier 1 NO_x standards provided that an approved method for that engine has been certified and notification has been submitted to IMO . Finally, major conversions, as defined by IMO, of marine diesel engines on all existing ships built prior to January 1, 2000, would be subject to the Tier 1 NO_x standards.

IMO Low Sulfur Fuel Requirements for Marine Engines
In April 2008, the MEPC of the IMO also approved a recommendation for new MARPOL Annex VI and placed global sulfur limits for fuel and ECAs. In October 2008, the IMO adopted these amendments to international requirements under MARPOL Annex VI, which placed a global limit on marine fuel sulfur content of 3.5% by 2012, which will be further reduced to 0.5% sulfur by 2020, or 2025 at the latest, pending a technical review in 2018. In ECAs, sulfur content was limited to 1.0% beginning in August 2012, and will be further reduced to 0.1% sulfur in 2015. On March 26, 2010, the IMO officially designated waters within 200 miles of North American coasts as an ECA. From the effective date in August 2012 until 2015, fuel used by all vessels operating in this area cannot exceed sulfur content of 1.0%, which will be further reduced to 0.1% beginning in 2015.

IMO Energy Efficiency Design Index (EEDI) for International Shipping
On July 15, 2011, the IMO amended the MARPOL to include energy efficiency standards for new ships through the designation of an Energy Efficiency Design Index (EEDI)[13]. The EEDI standards are expressed as percent emissions reductions from reference lines established for each ship class. Reductions in fuel consumption will subsequently result in reductions of CO_2 emissions and other pollutants emitted into the air. Currently, the EEDI standards are applicable to container ships, general cargo ships, refrigerated cargo carriers, gas tankers, oil and chemical tankers, dry bulk carriers, and combination dry/liquid bulk carriers. At the 66th session of MEPC held March 31 to April 4, 2014, the committee adopted an amendment to extend the EEDI implementation to RoRo cargo, passenger ships, LNG carriers, and cruise passenger ships. The amendment is expected to be operative in September 2015.

By requiring minimum efficiency levels for ships, reductions in fuel consumption will subsequently result in reductions of CO_2 emissions and other pollutants emitted into the air. The EEDI standards were included in the new chapter 4 of MARPOL Annex VI are phased in over several years as follows:

- 2013: meet or exceed applicable reference line
- 2015: 10% reduction from the applicable reference line
- 2020: 20% reduction from the applicable reference line
- 2025: 30% reduction from the applicable reference line

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[13] EPA, *www.epa.gov/otaq/regs/nonroad/marine/ci/420f11025.pdf*

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,[14] the EPA finalized a three-part program designed to dramatically reduce emissions from marine diesel engines with displacement less than 30 liters per cylinder. EPA listed the following categories for compression ignition diesel marine engines based on engine displacement per cylinder:

- Category 1: less than 5 liters
- Category 2: equal to 5, less than 30 liters
- Category 3: equal to or greater than 30 liters

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 began in 2009. Tier 4 standards apply to engines above 600 kW (800 horsepower [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.

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

EPA is pursuing two parallel, related actions for establishing emission standards for Category 3 marine diesel engines: (1) EPA is a member of the U.S. delegation that participated in negotiations at the IMO with regard to amendments to Annex VI that were adopted in October 2008 including additional NO_x limits for new engines, additional sulfur content limits for marine fuel, methods to reduce PM emissions, NO_x and PM limits for existing engines, and volatile organic compounds limits for tankers, and (2) In January 2003, EPA adopted Tier 1 standards for Category 3 marine engines, which went into effect in 2004, establishing NO_x standards based upon internationally negotiated emissions rates and readily available emissions-control technology. In December 2009, EPA finalized emission standards for Category 3 marine diesel engines installed on U.S. flagged vessels as well as marine fuel sulfur limits that are equivalent to the amendments adopted in MARPOL Annex VI. The final regulation establishes stricter standards for NO_x.

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[14] EPA, *www.epa.gov/otaq/regs/marine.htm#regs*

The final near-term Tier 2 NO_x standards for newly built engines apply beginning in 2011 and require more efficient use of current engine technologies, including engine timing, engine cooling, and advanced computer controls. The Tier 2 standards will result in a 15 to 25% NO_x reduction below the current Tier 1 levels. The final long-term Tier 3 standards for newly built engines will apply beginning in 2016 in ECAs, and will require the use of high efficiency emission control technologies such as selective catalytic reduction to achieve NO_x reductions 80% below the current levels. These standards are part of EPA's coordinated strategy for addressing emissions from ocean-going vessels; this strategy also includes implementation of recent amendments to MARPOL Annex VI and designation of U.S. coasts as an ECA.

Over recent years, several cruise lines have applied for flexibility under the IMO requirements to support the development of exhaust gas cleaning technology. In August 2013, Carnival Corporation received an approval from United States Coast Guard and EPA for a trial program under which 32 Carnival ships will be exempt from ECA low sulfur fuel requirement in support of development of exhaust gas cleaning technology that has potential to meet or exceed 2015 fuel sulfur standard ECA requirements, as well as provide additional benefits in the reduction of particulate matter and black carbon, at a lower cost than using lower sulfur fuel. The exhaust cleaning systems will be installed between 2014 and 2016 during ship's dry-dock schedule[15].

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, to be implemented in two phases, required the use of marine gas oil (MGO) with sulfur content less than 1.5% by weight or marine diesel oil (MDO) with a sulfur content equal to or less than 0.5% by weight. For auxiliary engines, main engines, and boilers, the Phase I requirements started July 1, 2009.

Originally, Phase II required the use of MGO or MDO with sulfur content equal to or less than 0.1 % in all engines and boilers by January 1, 2012. In October 2011, the Office of Administrative Law (OAL) approved CARB's proposed amendment[16] to the low sulfur fuel requirement as follows:

- Starting in August 2012, sulfur requirement of MGO is reduced from 1.5% to 1.0% and there is no change in sulfur requirement of MDO.
- The Phase II requirement has been delayed from January 2012 to January 2014 to more closely coincide with ECA Phase 2 and meet SCAQMD's 2007 Air Quality Management Plan (AQMP) goals.

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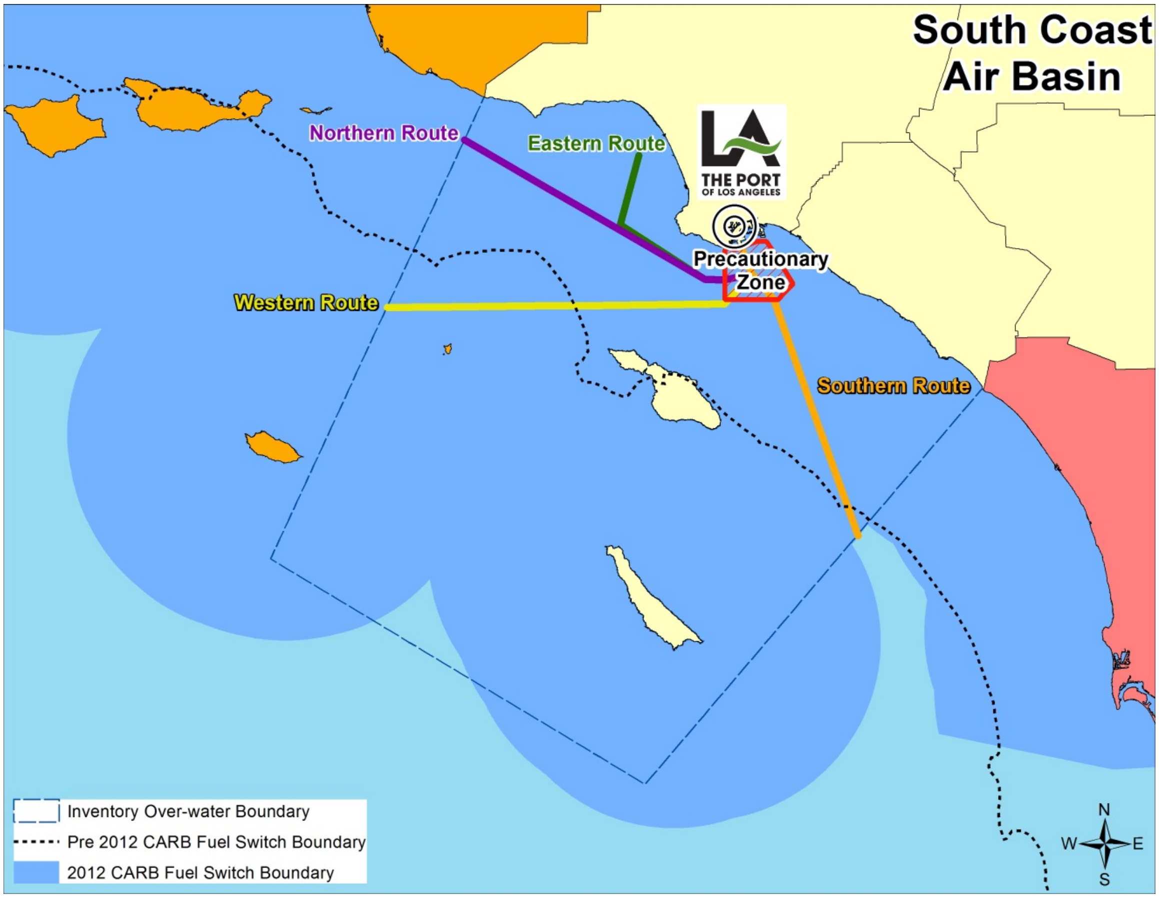
[15] EPA, *www.epa.gov/otaq/documents/oceanvessels/carnival-letter-epa-uscg-response-8-8-13.pdf*

[16] CARB, *www.arb.ca.gov/regact/2011/ogv11/ogv11.htm*

- The regulatory boundary was expanded in Southern California to be consistent with the Contiguous Zone. In December 2011, CARB started enforcement of the expanded regulatory boundary. This new boundary includes the region 24-nm from the California shoreline, including 24-nm from the shoreline of the Channel Islands. There is also a small region near the north end of the Santa Barbara Channel that was excluded from the regulatory boundary to encourage vessels to use the established shipping lanes in the Channel.

Figure 2.1 below shows the previous and the current (shown as proposed in the figure) traffic route covered by the regulation[17].

Figure 2.1: CARB Marine Fuel Regulation Boundary



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[17] CARB, *www.arb.ca.gov/ports/marinevess/documents/marinenote2011_2.pdf*

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 OGVs while at-berth for container, cruise, and refrigerated cargo vessels. The regulation requires that auxiliary diesel engines on OGVs be shut down for specified percentages of fleets' visits and also for the fleet's at-berth auxiliary engine power generation be reduced by the same percentages. While the use of shore power is expected to be the primary means of compliance, as an alternative, vessel operators may employ any combination of clean emissions control technologies to achieve equivalent reductions. Specifically, by 2014, vessel operators that choose shore power as their compliance mechanism are required to shut down their auxiliary engines at-berth for 50% of the fleet's vessel visits and also reduce their onboard auxiliary engine power generation by 50%. The specified percentages will increase to 70% in 2017, and 80% in 2020, respectively. 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.

In December 2013, CARB issued a regulatory advisory[19] that provides relief to those vessel fleets that have shown good faith effort in complying with various requirements of at-berth regulation, but need flexibility from January 1 to June 30, 2014 with five scenarios:

1) The vessel fleet visiting the port is equipped to receive shore power but the terminal's berth is not shore power ready,
2) During calendar year 2014, a vessel makes its first commissioning visit to a terminal (one commissioning visit per terminal), and during the visit, the auxiliary engines operate longer than three hours.
3) During the first and second calendar quarters of 2014, a vessel uses shore power but fails to meet the three/five-hour time limit for connecting to or disconnecting from shore power.
4) During the first and second calendar quarters of 2014, a vessel is unable to use shore power due to delays in receiving shore power equipment and making retrofits to the vessel to utilize the equipment.
5) During the first and second calendar quarters of 2014, vessels are using an alternative technology (while that technology is undergoing in-use emission testing) to help comply with the At-Berth Regulation.

In order to qualify for temporary relief as described above, vessel fleet operators will have to submit certain documentation so that CARB can ensure good faith effort.

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[18] CARB, *www.arb.ca.gov/regact/2007/shorepwr07/shorepwr07.htm*

[19] CARB, *www.arb.ca.gov/ports/shorepower/forms/regulatoryadvisory/regulatoryadvisory12232013.pdf*

CARB Vessel Speed Reduction Program

In order to meet the mandates of AB 32, the California Global Warming Solution Act, under CARB's Scoping Plan, implementation of VSR was identified as one of the early action plan measures. CARB plans to evaluate the emissions benefit associated with this measure and the best approach to implement it through regulatory or volunteer/incentive-based approach. Since 2009, CARB staff has not engaged in any activity related to this measure.

CARB's Regulation Related to Ocean-going Ship Onboard Incineration

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

CAAP Measure- San Pedro Bay Ports (SPBP)-OGV1; Vessel Speed Reduction (VSR) Program

In May 2001, a Memorandum of Understanding (MOU) between the Port, the POLB, EPA Region 9, CARB, SCAQMD, the Pacific Merchant Shipping Association, and the Marine Exchange of Southern California (MarEx) was signed. This MOU called for OGVs to voluntarily reduce speed to 12 knots at a distance of 20 nm from Point Fermin. Reduction in speed demands less power from the main engine, which in turn reduces NO_x emissions and fuel usage. The term of this MOU expired in 2004; the updated measure OGV1 continues and expands the VSR program by continuing the 12-knot VSR zone between Point Fermin and the 20 nm distance, and expanding it to 40 nm from Point Fermin. There are three primary implementation approaches for this measure: 1) continuation of the voluntary program, 2) incorporation of VSR requirements in new leases, and 3) CARB's VSR strategy. Parallel to the voluntary, incentive based strategies, compliance with the VSR program to 40 nm from Point Fermin will be negotiated into new and re-negotiated lease requirements. In addition, the ports intend to work closely with CARB to facilitate a statewide VSR program and ensure that the programs are aligned.

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

CAAP Measure- SPBP-OGV2; Reduction of At-Berth OGV Emissions
This measure requires the use of shore power to reduce hotelling emissions implemented at all container and cruise terminals and one liquid bulk terminal at the Port by 2014. This measure also requires demonstration and application of alternative emissions reduction technologies for ships that are not good candidate for shore power, to be facilitated through the Technology Advancement Program (TAP)[20].

CAAP Measures- SPBP-OGV3 and 4; OGV Low Sulfur Fuel for Auxiliary Engines, Auxiliary Boilers and Main Engines
This measure is designed to require the use of lower sulfur distillate fuels in the auxiliary and main engines and auxiliary boilers of OGVs within 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%. For vessel calls that are subject to these measures due to new lease agreements or renewal, the fuel switch emissions benefits will initially surpass the benefits of CARB's regulation in the region near the ports by requiring ≤0.2% sulfur MGO or MDO within 40 nm of Point Fermin. However, by January 1, 2014, CARB's regulation will surpass the CAAP measures, requiring the use of MGO or MDO with a sulfur content limit of 0.1% by weight in the main and auxiliary engines and boilers of all OGVs within 24-nm of the California coastline. All vessels are required to comply with CARB's regulation starting in 2014. CAAP measures require compliance with CARB's regulation.

As a further backstop to the ports' programs and the CARB regulation, the IMO adopted international requirements under MARPOL Annex VI in October 2008. These requirements put an enforceable global limit on marine fuel burned within 200 nm of the coastline including a limit on sulfur content to 3.5% by 2012, which will be further reduced to 0.5% sulfur by 2020, or 2025 at the latest, pending a technical review in 2018. In Emissions Control Areas (ECAs), sulfur content will be limited to 1.0% starting in August of 2012, and will be reduced further to 0.1% sulfur in 2015.

CAAP Measure- SPBP-OGV5 and 6; Cleaner OGV Engines and OGV Engine Emissions Reduction Technology Improvements and Environmental Ship Index (ESI) Program
Measure OGV5 seeks to maximize the early introduction and preferential deployment of vessels to the San Pedro Bay Ports with cleaner/newer engines meeting the new IMO NO_x standard for ECAs. Measure OGV6 focuses on reducing DPM and NO_x from the legacy fleet through identification and deployment of effective emission reduction technologies.

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[20] POLA and POLB, *www.cleanairactionplan.org/programs/tap*

In order to advance the goals of OGV5 and 6, the Port of Los Angeles Board of Harbor Commissioners approved the voluntary Environmental Ship Index (ESI) Program[21] in May 2012. ESI is an international clean ship indexing program developed through the International Association of Ports and Harbors (IAPH) World Ports Climate Initiative (WPCI). Operators registered under this program earn an ESI score for their vessels by using cleaner technology and practices that reduce emissions beyond the regulatory requirements set by the IMO. This program rewards vessel operators for reducing NO_x, SO_x and GHG emissions from their OGVs in advance of regulations including CARB's fuel switch regulation. This program also rewards operators for going beyond compliance by bringing their newest and cleanest vessels to the Port and demonstrating technologies onboard their vessels. After registering with ESI and the Los Angeles Harbor Department, the vessel operators are eligible to obtain three types of incentives which are additive. The ESI incentive amount based on the ESI score ranges between \$500 per call to \$1,250 per call. Under the OGV5 element, vessel operators who bring vessels with IMO rated Tier 2 and Tier 3 main engines will get rewarded with \$750 per call for bringing in Tier 2 vessel and \$3,250 per call for bringing in Tier 3 vessel. Under OGV6 element, vessel operators that demonstrate main engine DPM and NO_x reducing technologies get rewarded with \$750 per call. This program became effective on July, 1, 2012.

2.2 Harbor Craft

EPA's Emission Standards[22] for Harbor Craft Engines

On March 14, 2008, EPA finalized the latest regulation establishing new emission standards for new Category 1 and Category 2 diesel engines rated over 50 horsepower (hp) used for propulsion in most harbor craft. The new Tier 3 engine standards began phasing in starting in 2009. The more stringent Tier 4 engine standards, based on the application of high-efficiency catalytic after-treatment technologies, will phase in beginning in 2014 and will 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 Low Sulfur Fuel Requirement for Harbor Craft

In 2004, CARB adopted a low sulfur fuel requirement for harbor craft. Starting January 1, 2006 (in SCAQMD) harbor craft were 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 facilitates retrofitting harbor craft with emissions control devices such as diesel particulate filters (DPFs) that have the potential to reduce PM by an additional 85%.

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[21] POLA, *www.portoflosangeles.org/environment/ogv.asp*

[22] EPA, *www.epa.gov/otaq/standards/nonroad/marineci.htm*

CARB's Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft[23]

As an element of the Diesel Risk Reduction Plan and Goods Movement Plan, in November 2007, CARB adopted a regulation that reduces DPM and NO_x emissions from new and in-use commercial harbor craft operating in Regulated California Waters, i.e., internal waters, ports, and coastal waters within 24-nm of the California coastline. Under CARB's definition, commercial harbor craft includes tug boats, tow boats, ferries, excursion vessels, work boats, crew boats, and fishing vessels. This regulation implements stringent emission limits from auxiliary and propulsion engines installed in commercial harbor craft. In 2010, CARB adopted amendments to the regulation that added specific in-use requirements for crew/supply vessels.

All in-use, newly purchased, or replacement engines on those harbor craft covered by the regulation must meet EPA's most stringent emission standards per a compliance schedule set by CARB for in-use engines and from new engines at the time of purchase. 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 use control technology that represents the best available control technology in addition to an engine that meets the Tier 2 or Tier 3 EPA marine engine standards, as applicable, in effect at the time of vessel acquisition. For harbor craft with home ports in the SCAQMD, the compliance schedule is accelerated by two years, as compared to statewide requirements, in order to achieve the earlier emission benefits required in SCAQMD. The compliance schedule as listed in the 2007 regulation for in-use engine replacement was supposed to begin in 2009. However, CARB started enforcing it starting in August 2012 after the EPA approval was given in December 2011[24]. EPA's authorization to enforce CARB's regulation for crew/supply boats is still pending. As of May 2013, CARB had approved three marine engine rebuild kits[25] that can be used to meet Tier 2 standards.

CAAP Measure- SPBP-HC1- Performance Standards for Harbor Crafts

All harbor craft operating in the San Pedro Bay are required to comply with the CARB harbor craft regulation. In addition to the implementation of CARB's In-Use Harbor Craft regulation and the EPA's recently adopted Tier 3 and 4 standards, the ports are working towards a goal of repowering all harbor craft home based in the San Pedro Bay to Tier 3 levels, within five years after the Tier 3 engines become available and also requiring shore power. The ports also plan to accelerate harbor craft emission reductions through emerging technologies such as the hybrid tug, new more-efficient engine configurations, and alternative fuels, through incentives or voluntary measures.

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[23] CARB, *www.arb.ca.gov/regact/2010/chc10/chc10.htm*

[24] CARB, *www.arb.ca.gov/enf/advs/advs436.pdf*

[25] CARB, *www.arb.ca.gov/ports/marinevess/harborcraft/documents/alttech.pdf*

2.3 Cargo Handling Equipment

EPA Emission Standards for Non-Road Diesel Powered Equipment[26]

The EPA's and CARB's Tier 1, Tier 2, Tier 3, and Tier 4 (interim Tier 4 and final) emissions standards for non-road diesel engines require compliance with progressively more stringent standards for hydrocarbon, CO, DPM, and NO_x. Tier 4 standards for non-road diesel powered equipment complement the 2007+ on-road heavy-duty engine standards that require 90% reductions in DPM and NO_x compared to previous levels. In order to meet these standards, engine manufacturers have produced 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 begin phasing in with smaller engines in 2008 and will continue with the largest diesel engines to meet NO_x and PM standards in 2015. Currently, the interim Tier 4 standards include a 90% reduction in PM and a 60% reduction in NO_x.

CARB's Cargo Handling Equipment Regulation

In December 2005, CARB adopted a regulation designed to reduce emissions from cargo handling equipment (CHE) such as yard tractors and forklifts starting in 2007. The regulation called for the replacement or retrofit of existing engines with engines that use Best Available Control Technology (BACT). Beginning January 1, 2007, the regulation required 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 were required to be equipped with a certified on-road or off-road engine meeting the current model year standards in effect at the time the engine was added to the fleet. If the engine was pre-2004, then the highest-level available Verified Diesel Emission Control System (VDECS) was required to be installed within one year. In-use yard tractors were required to meet either 2007 or later certified on-road engine standards, Final Tier 4 off-road engine standards, or installed verified controls that would result in equivalent or fewer DPM and NO_x emissions than a Final Tier 4 off-road engine. In-use non-yard tractors were required to install the highest-level available VDECS and/or replace an on-road or off-road engine meeting the current model year standards. For all CHE, compliance dates were phased in beginning December 31, 2007, based on the age of the engine and number of equipment in each model year group. In September of 2011, CARB's board adopted an amendment[27] to the original regulation described above. The amendment included a new requirement for annual opacity measurement provided additional flexibility in the options needed to control CHE emissions.

CARB received EPA authorization to enforce the original Cargo Handling Equipment Regulation, including new and in-use engine emission limits in November 2011. As of March 2014, CARB has not received EPA's authorization to enforce opacity measurement requirements.

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[26] EPA, *www.epa.gov/otaq/standards/nonroad/nonroadci.htm*

[27] CARB, *www.arb.ca.gov/regact/2011/cargo11/cargo11.htm*

New Emission Standards, Test Procedures, for Large Spark Ignition (LSI) Engine Forklifts and Other Industrial Equipment

Since 2007, CARB has promulgated more stringent emissions standards for hydrocarbon and oxides of nitrogen combined (HC + NO_x), emissions test procedures for LSI engines with horsepower rating of 25 horsepower or greater. The stringent new engine emission standards and test procedures[28] were implemented in two phases. The first phase (2.0 g/hp-hr of HC + NO_x) was implemented for engines built between January 1, 2007 and December 31, 2009. The second phase (0.6 g/hp-hr of HC + NO_x) was implemented for engines built starting with January 1, 2010.

Fleet Requirements for Large Spark Ignition Engines[29]

Initially promulgated in 2007 and then amended in 2010, CARB established fleet average emissions requirements for the existing fleet for LSI engines with a horsepower rating of 25 horsepower or greater. The regulation also established verification procedures for manufacturers of retrofit emission control systems. The fleet requirements only apply to forklifts, sweepers/scrubbers, industrial tow tractors, and ground support equipment, agricultural and forest operations; boneyard, in-field, operations, retired, and service equipment.

The fleet requirements for HC + NO_x standards were phased in as follows: January 1, 2009, January 1, 2011 and January 1, 2013. The fleet average emission standards are specific to the type (forklift or non-forklifts) and size of the LSI fleet. CARB received USEPA's approval to enforce this regulation on April of 2012.

CAAP Measure- SPBP-CHE1- Performance Standards for CHE

This measure calls for CHE emission reductions beyond CARB's CHE regulation at the time of terminal lease renewal. As of 2007, all CHE purchases were required to meet the following performance standards of the cleanest available NO_x alternative-fueled engine meeting 0.01 grams per brake horsepower (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 were no engines available that meet 0.01 g/bhp-hr PM, then operators were required to purchase cleanest available engine for either fuel type and to install cleanest VDEC available.

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

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[28] CARB, *www.arb.ca.gov/regact/2008/lsi2008/lsi2008.htm*

[29] CARB, *www.arb.ca.gov/regact/2010/offroadlsi10/lsifinalreg.pdf*

2.4 Locomotives

EPA's Emission Standards for New and Remanufactured Locomotives and Locomotive Engines- Latest Regulation[30]
In March 1998, EPA adopted Tier 0 (1973-2001), Tier 1 (2002-2004), and Tier 2 (2005+) emission standards applicable to newly manufactured and remanufactured locomotives and locomotive engines. These standards required compliance with progressively more stringent standards for emissions of hydrocarbon, CO, NO_x, and DPM.

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."[31] 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%.

This regulation introduced two tiers of standards[32], 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 achieves 50% reduction in PM beyond the Tier 2 standard and became effective in 2011 for switching engines and 2013 for line haul engines. Tier 3 PM standards are 50% lower than Tier 2 PM emission standard. The longer-term Tier 4 emission standards that 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% reduction in NO_x and PM as compared to Tier 2 standards.

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

EPA's Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel
In 2012, the 15 ppm sulfur cap for locomotive and marine engine diesel fuel went into effect. This affects mainly interstate line-haul locomotives since there are stricter fuel regulations already in place in California for intrastate locomotives and marine diesel fuel.

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[30] EPA, *www.epa.gov/ dsys/pkg/FR-1998-04-16/pdf/98-7769.pdf*
[31] EPA, *www.epa.gov/otaq/regs/nonroad/420f08004.pdf*
[32] EPA, *www.epa.gov/otaq/standards/nonroad/locomotives.htm*

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% of the time within the borders of the state, based on hours of operation, miles traveled, or fuel consumption. Since January 1, 2007, statewide, intrastate locomotives have been required to use CARB off-road diesel fuel that has a sulfur content limit of 15 ppm sulfur and a lower aromatic content[33], mostly applicable to switchers. The use of fuel with lower sulfur and aromatics results in NO_x and DPM reductions. In addition, use of low sulfur fuel facilitates retrofitting locomotives with emissions control devices such as DPFs that have the 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 the two major Class 1 freight railroads operating in California. This MOU required Union Pacific Railroad (UP) and Burlington Northern Santa Fe Railway Company (BNSF) to concentrate their nation-wide introduction of Tier 2 locomotives preferentially within the SoCAB, which was estimated to achieve a 65% reduction in NO_x by 2010. In 2005, CARB entered into another MOU with UP and BNSF whereby these two railroads have agreed to phase out non-essential idling and install idling reduction devices, and identify and expeditiously repair locomotives that smoke excessively, and maximize the use of 15 ppm sulfur fuel.

June 2010 Proposed Railyard Commitments

In addition to the 1998 and 2005 MOUs between CARB and the Class 1 rail operators described above, in June 2010, CARB's staff proposed, on voluntary basis, railyard-specific commitments[34] with Class 1 operators to accelerate further DPM emission and risk reductions at four railyards in the South Coast Air Basin, including the Intermodal Container Transfer Facility (ICTF) located in the port area. The voluntary commitments were to establish reporting and tracking mechanisms and deadlines to accelerate reductions of DPM emissions. The rail commitments would have required Class 1 operators to reduce DPM emissions by 85% by 2020 relative to 2005 emission levels within the fence line of each of the four railyards. In December of 2013, CARB's Executive Officer decided not to approve the commitments instead proposed to initiate a comprehensive emissions reduction program for the entire freight sector including rail.[35] CARB will include these goals in the AB 32 Scoping Plan[36] update under sustainable freight strategy initiative and "Vision for Clean Air: A Framework for Air Quality and Climate Planning"[37] document which is CARB's vision for transition to zero- and near-zero emission technologies.

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[33] CARB, *www.arb.ca.gov/msprog/offroad/loco/loco.htm#intrastate*

[34] CARB, *www.arb.ca.gov/railyard/commitments/staffreport061710.pdf*

[35] CARB, *www.arb.ca.gov/railyard/commitments/commitments.htm*

[36] CARB, *www.arb.ca.gov/cc/scopingplan/scopingplan.htm*

[37] CARB, *www.arb.ca.gov/planning/vision/vision.htm*

CAAP Measure- SPBP-RL1- Pacific Harbor Line (PHL) Rail Switch Engine Modernization
This measure implements the switch locomotive engine modernization and emission reduction requirements included in the operating agreements between the ports and PHL. In 2010, PHL and the ports entered into a third amendment to their operating agreements which facilitated upgrade of the Tier 2 switcher locomotive fleet to meet "Tier 3-plus" standards. "Tier 3-plus" standards have PM emissions that exceed Tier 3 PM emission rates but do not meet Tier 4 standards. By the end of 2011, PHL upgraded all 17 of their Tier 2 switcher locomotives to meet "Tier 3-plus" standards.

CAAP Measure- SPBP-RL2- Class 1 Line-haul and Switcher Fleet Modernization
The focus of this measure is to identify the emission reductions associated with the CARB Class 1 railroads MOU and the 2008 EPA locomotive engine standards. The ultimate goal of this measure is that by 2023, all Class 1 locomotives entering the ports will meet emissions equivalent to Tier 3 locomotive standards.

CAAP Measure- SPBP-RL3- New and Redeveloped Near-Dock Rail Yards
This measure focuses on new and redeveloped near-dock rail facilities located on port properties. The goal of this measure is to incorporate the cleanest locomotive, CHE, and HDV technologies into near-dock rail operations. One of the major outcomes of this measure is to achieve significant reductions in locomotive emissions through the accelerated turnover of the existing locomotive fleet to newer, lower emitting models. The ports will work with regulatory agencies (EPA, CARB, and SCAQMD) and rail operators toward the goal of achieving a line-haul and switcher locomotive fleet with an emissions equivalent of 95% Tier 4 compliant engines operating within the ports by 2020, and statewide, as expeditiously as possible.

2.5 Heavy-Duty Vehicles

Emission Standards for New 2007+ On-Road Heavy-Duty Vehicles
In 2001, CARB adopted EPA's stringent emission standards for 2007+ HDVs, which would ultimately result in 90% reductions in emissions of NO_x and PM. This regulation required 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 and a phase-in of a 0.2 g/bhp-hr NO_x standard between 2007 and 2010. By 2010, all engines were 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. Between 2007 and 2010, on average, manufacturers produced 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 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 required manufacturers to install a system in HDVs to monitor virtually every emissions related component of the vehicle. The OBD regulation was 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 statewide regulation requiring that diesel fuel produced or offered for sale in California for use in any on-road or non-road vehicular diesel engine (with the exception of locomotive and marine diesel engines) contain no more than 15 ppm of sulfur (S) by weight, beginning in June 2006. This ultra-low sulfur diesel (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 2007, CARB's Board adopted a regulation to modernize the class 8 drayage truck fleet, trucks with gross vehicle weight rating greater than 33,000 pounds that operate 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 were to be retired or replaced with 1994 and newer MY engines. Furthermore, all drayage trucks with 1994 – 2003 MY engines were required to achieve an 85% PM emission reduction through the use of a CARB approved Level 3 VDEC.
2) By December 31, 2013, all trucks operating at California ports must comply with the 2007+ on-road heavy-duty truck engine standards.

In December 2010, CARB's Board acted on amendments that staff had proposed to the drayage truck regulation. It specifically included Class 7 drayage trucks with gross vehicle weight rating greater than 26,000 pounds and less than 33,001 pounds in the drayage truck regulation as follows: (a) to accelerate the filter requirement to January 1, 2012 for Class 7 drayage trucks in the SoCAB, and (b) to require Class 7 drayage trucks statewide to operate with 2007 or newer emission standard engines by January 1, 2014.

In addition, CARB expanded the definition of drayage trucks to include those non-compliant trucks that may not directly come to the ports to pick up or drop off cargo but that engage in moving cargo destined to or originated from port facilities to or from near-port facilities or rail yards. This practice, known as "dray-offs," reduces the effectiveness of the drayage truck regulation because otherwise non-compliant trucks still operate near the ports and rail yards.

CARB staff is proposing amendments to the current regulation to assist small fleets, low mileage fleets, and fleets operating exclusively in certain areas with cleaner air; provide new opportunities for fleet owners to access public incentive funds; and recognize fleet owners that made early investments to comply. These amendments were approved by CARB board during the April 2014 board hearing[38]. None of the amendments directly affect drayage truck requirements.

CARB's On-Road Heavy-Duty Diesel Vehicles (In-Use) Regulation

In December 2008, CARB adopted a regulation that places requirements on in-use HDVs operating throughout the state. Under the regulation, existing HDVs were required to be replaced with HDVs meeting the latest NO_x and PM Best Available Control Technology (BACT), or retrofitted to meet these levels. By January 1, 2021, all MY 2007 class 8 drayage trucks are required to meet NO_x and PM BACT (i.e. 2010+ EPA engine standards). MY 2008 and MY 2009 must be replaced with 2010+ engines by January 1, 2022 and January 1, 2023 respectively.

CARB's Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Regulation[39]

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

In December 2013, CARB board approved new regulations that aligned California's GHG emission standards and test procedures[40] adopted in 2008 with those of the federal Phase 1 GHG regulation[41]. Built upon phase 1 standards, EPA and National Highway Traffic Safety Administration (NHTSA) are working on proposing stricter GHG standards for new medium and heavy-duty engines and vehicles, called Phase 2[42]. These two federal agencies are expected to release Notice of Proposed Rule Making (NPRM) by March of 2015 and adoption of the regulation by 2016. This effort may include new national GHG emission reduction requirements for trailers. CARB staff is working closely with U.S. EPA and NHTSA to develop Phase 2.

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[38] CARB, *www.arb.ca.gov/msprog/onrdiesel/documents/faqamend14.pdf*

[39] CARB, *www.arb.ca.gov/cc/hdghg/hdghg.htm*

[40] CARB*, www.arb.ca.gov/cc/scopingplan/document/updatedscopingplan2013.htm, Appendix B, page 10*

[41] EPA, *www.epa.gov/otaq/climate/regs-heavy-duty.htm*

[42] EPA, *www.epa.gov/otaq/climate/regs-heavy-duty.htm*

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) that progressively banned older trucks from operating at the two ports. The ban was implemented in three phases as follows:

1) By October 1, 2008 – All pre-1989 trucks were banned from port services.
2) By January 1, 2010 – All 1989-1993 trucks along with un-retrofitted[43] 1994-2003 trucks were banned from port services.
3) By January 1, 2012 – All trucks that did not meet 2007 and later on-road heavy duty engine standards were banned from port services.

In January 2011, harbor commissioners from the Port of Los Angeles adopted a resolution that expanded this measure to include Class 7 drayage trucks and banned the "dray-off" practice under the Clean Truck Program.

2.6 Greenhouse Gases

Assembly Bill 32 (AB 32), the California Global Warming Solutions Act of 2006, established a first-in-the-world comprehensive program requiring CARB to develop regulatory and market mechanisms that would ultimately reduce GHG emissions to 1990 levels by the year 2020 and reduce emissions to 80% below 1990 levels by 2050. Mandatory caps began in 2013 for significant sources and were to be ratcheted down as needed to meet the 2020 goals.

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

In December 2008, CARB adopted the Climate Change Scoping Plan to achieve the reductions in GHG emissions mandated in AB 32. In February of 2014, CARB published the first update[44] of the Climate Change Scoping Plan (Scoping Plan) to be considered by its Board later this year. In the proposed Scoping Plan, CARB is proposing the 2020 statewide GHG emission limit of 431 million metric tons of carbon dioxide equivalent (MMT CO_2e). The initial Scoping Plan had a budget of 427 MMT CO_2e. The change in budget is due to revised global warming potential of greenhouse gases as suggested by United Nations Framework Convention on Climate Change (UNFCCC), international climate agencies. 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[45], including ports, and are expected to achieve a combined 3.5 million metric tons of carbon dioxide equivalent. Status of the proposed measures that were included in the original Scoping Plan affecting goods movement has been updated as follows[46]:

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

[44] CARB, *www.arb.ca.gov/cc/scopingplan/document/updatedscopingplan2013.htm*

[45] CARB, *www.arb.ca.gov/cc/scopingplan/sp_measures_implementation_timeline.pdf;* page 4

[46] CARB, *www.arb.ca.gov/cc/scopingplan/2013_update/appendix_b.pdf*

- T-2: Low Carbon Fuel Standards (LCFS) Regulation. It was adopted in 2009 setting low carbon intensity targets between 2011 and 2020 and requiring 10% reduction in GHG emissions intensity of transportation fuels used in California by at least 10% by 2020. CARB staff is proposing to re-adopt the LCFS regulation in 2014.
- T-5: Ship electrification at ports, previously adopted as regulation in December 2007
- T-6: Goods movement efficiency measures (Port Drayage Trucks regulation adopted in December 2007 and later amended in December 2010 to include class 7 trucks that were not covered under original regulation but found to be engaging in drayage activities at the ports; other measures under development)
- T-7: Heavy-Duty Vehicle GHG Emission Reduction. Previously adopted as regulation in December 2008 Harmonized with EPA and NHTSA Phase 1 standards, currently CARB is working with the two federal agencies to develop phase 2 standards.
- T-8: Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) approved in 2009 with a goal of accelerating the deployment of commercialized hybrid and zero-emission medium and heavy-duty vehicles in California. $5 million in additional HVIP funding was approved as part of the Air Quality Improvement Program (AQIP) Funding Plan for Fiscal Year 2013-14, along with an additional one time $10 million appropriation from the Legislature (Senate Bill 359; Corbett, Chapter 415, Statutes of 2013), and HVIP will re-launch in spring 2014.

2.7 Air Quality Management Plan (AQMP)

As part of the State Implementation Plan (SIP) process, the SCAQMD Governing Board adopted the final 2012 AQMP on December 7, 2012[47]. Currently, South Coast Air Basin is classified as nonattainment for the federal 24-hour $PM_{2.5}$ standards. The region has to achieve attainment by December 2014. Attainment of the 24-hour $PM_{2.5}$ standard should be demonstrated by 2014 without a 5-year extension option. The 2012 AQMP as mandated by the California Health & Safety Code must demonstrate achievement and maintenance of state and federal ambient air quality standards through adoption of all feasible measures. The 2012 AQMP is an integrated multi-pollutant plan that demonstrates strategies to attain the 24-hour $PM_{2.5}$ federal standard by 2014; provides an annual standard $PM_{2.5}$ SIP update and maintenance plan; and provides revisions to the 8-hour ozone SIP, including an update on "black box" measures for 8-hour ozone standard by 2023 and EPA's recently adopted a final rule for the implementation of 8-hour ozone standard of 75 ppb by 2032.

NO_x, SO_x, VOC, directly emitted $PM_{2.5}$, and ammonia are major contributors resulting in the formation of $PM_{2.5}$. In the 2012 AQMP, weighing factors in terms of the value in tons per day of emissions reductions relative to ambient concentration improvements of $PM_{2.5}$ are developed to aid in assessing various combination of different pollutant reduction to achieve the $PM_{2.5}$ goal in 2014. After demonstrating 2014 $PM_{2.5}$ attainment in 2014, the agencies (SCAQMD and CARB) are faced with next big challenge of demonstrating attainment of the 1997 and 2008 8-hour ozone standards in 2023 and 2032. The 2012 AQMP contains control measures that ensure SCAQMD's commitment to attain future ozone standards.

The SCAQMD will soon embark on the development of the 2016 AQMP. The 2016 AQMP will address EPA's recently revised annual PM standard change 15 $\mu g/m^3$ to 12 $\mu g/m^3$ by 2020 and the 8-hour 2023 and 2032 ozone standards.

2.8 Vision for Clean Air: A Framework for Air Quality and Climate Planning[48]

The Vision for Clean Air is a multi-pollutant (air quality and climate) planning draft document developed in collaboration by staff of CARB, SCAQMD and San Joaquin Valley Air Pollution Control District. This document is the framework to integrate strategies to meet Clean Air Act requirements as part of SIPs and AQMPs, AB 32 goals as well as Freight Transport planning at the same time. The goal is to find synergistic solutions that will satisfy varying requirements that the agencies face. The 2012 $PM_{2.5}$ AQMP draws upon the vision framework outlined in this document.

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[47] SCAQMD*, www.aqmd.gov/aqmp/2012aqmp/Final/index.html*

[48] CARB, *www.arb.ca.gov/planning/vision/vision.htm*

The Vision for Clean Air examines what needs to be done to meet both air quality and climate goals over time. This plan lays out several scenarios that will guide planners to determine combinations of current and future advanced technologies, energy, and efficiency assumptions needed to meet various SIPs, Health Risk, and climate goals between now and 2050. The following are the air quality goals used in the scenario development process:

- Achieve the 0.08 ppm 8-hour federal ozone standard by 2023 by reducing NO_x emissions by 80% from 2010 levels.
- Achieve the 0.075 ppm 8-hour federal ozone standard by 2032 by reducing NO_x emissions by 90% from 2010 levels.
- Reduce greenhouse gas emissions by 80% below 1990 levels by 2050. This is equivalent to 85% from today's levels.

The Freight Sector is one of the key areas included in the scenarios. It covers all five mobile sources operated at the ports. The scenarios highlight the acceleration of zero- and near-zero emissions technologies, fuels, and electrical energy generation from renewable sources and gains in operational efficiencies to meet state and local multi-pollutant goals and sustain economic growth.

2.9 Freight Transport, Ports, and Rail[49]

CARB, in partnership with other California agencies and industries, is leading the development of policies and programs to reduce congestion, and to address the environmental impacts resulting from growth in goods movement in California. CARB is involved in following major areas:

- Sustainable Freight Transport Initiative – Under this initiative, CARB will work with key partners to promote freight transport through near zero or zero emissions technologies and use of cleaner and renewable energy sources.
- Goods Movement Emission Reduction Program (Prop 1B) – This is a partnership between CARB and local agencies, such as air districts and seaports, to quickly reduce air pollution emissions and health risk from freight movement along California's trade corridors. Local agencies apply to CARB for funding and offer financial incentives to owners of equipment used in freight movement to upgrade to cleaner technologies.
- Port Activities – This pertains to various emissions reduction regulations that CARB has already promulgated or is working on to reduce emissions from ports sources.
- Rail Yard Activities – This pertains to implementing a number of measures to significantly reduce locomotive and railyard emissions in California, including regulations, enforceable agreements, and funding of clean technology.
- Goods Movement Plans - The California Business, Transportation & Housing Agency and the California Environmental Protection Agency have partnered to bring all stakeholders together to develop strategies that will reduce congestion and address the environmental impacts resulting from the growth of movement of goods in California.

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[49] CARB, *www.arb.ca.gov/html/gmpr.htm*

SECTION 3 OCEAN-GOING VESSELS

This section presenting emissions estimates for the ocean-going vessels (OGVs) source category is organized into following subsections: 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

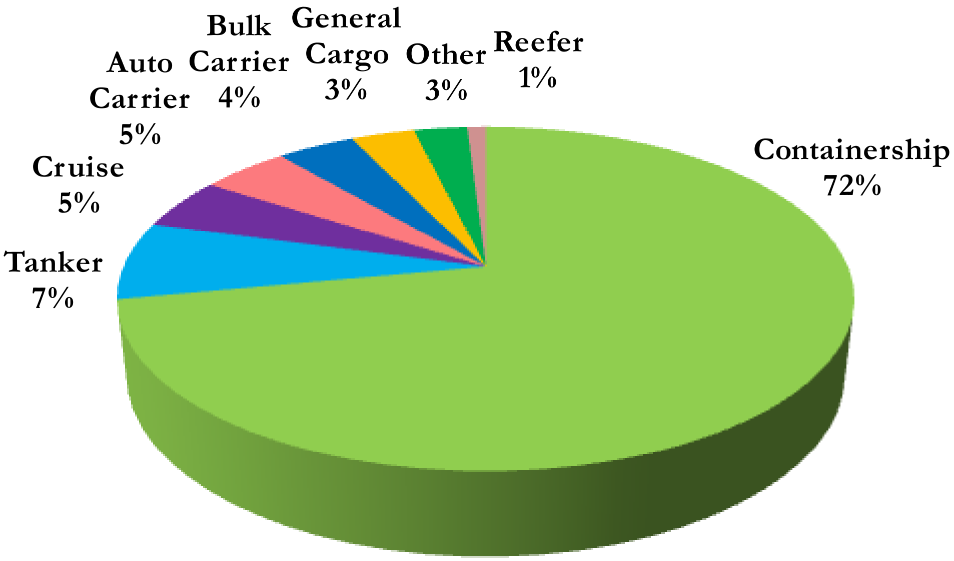
OGVs calling the Port in 2013, whether inbound from or outbound to the open ocean or shifting from neighboring POLB, are included in this inventory. OGVs calling only POLB or bypassing POLA without physically stopping at a Port dock have not been included. Harbor craft, including tugboats, ferries, excursion vessels, work and crew boats and commercial fishing vessels are discussed in Section 4. OGVs are categorized by the following main vessel types for purposes of this EI:

- Auto carrier
- Containership
- General cargo
- Refrigerated vessel (Reefer)
- Tanker
- Bulk carrier
- Cruise vessel
- Ocean-going tugboat (ATB/ITB)
- Miscellaneous

The ocean-going tugboats included in the OGV section are articulated tug barges (ATB) and integrated tug barges (ITB).

Based on MarEx data, there were 2,033 inbound vessel calls to the Port in 2013. Figure 3.1 shows the distribution of calls by vessel type. Containerships (72%) made the majority of the calls; followed by tankers (7%); cruise ships (5%); auto carriers (5%); bulk carriers (4%); general cargo (3%); other vessels including ocean-going tugboats (ATB/ITB) and miscellaneous vessels (3%); and reefer vessels (1%).

Figure 3.1: Distribution of Calls by Vessel Type



3.2 Geographical Delineation

The geographical domain of the 2013 Emissions Inventory for commercial marine vessels is the same overwater boundary as in previous EIs. The new expanded boundary[50] for the CARB OGV Fuel Regulation[51] is presented in Figure 3.2 along with the inventory boundary and the major shipping routes to POLA. The 24-nautical-miles (nm) boundary in the original regulation was expanded to 24-nm beyond the off-shore islands in late 2011.

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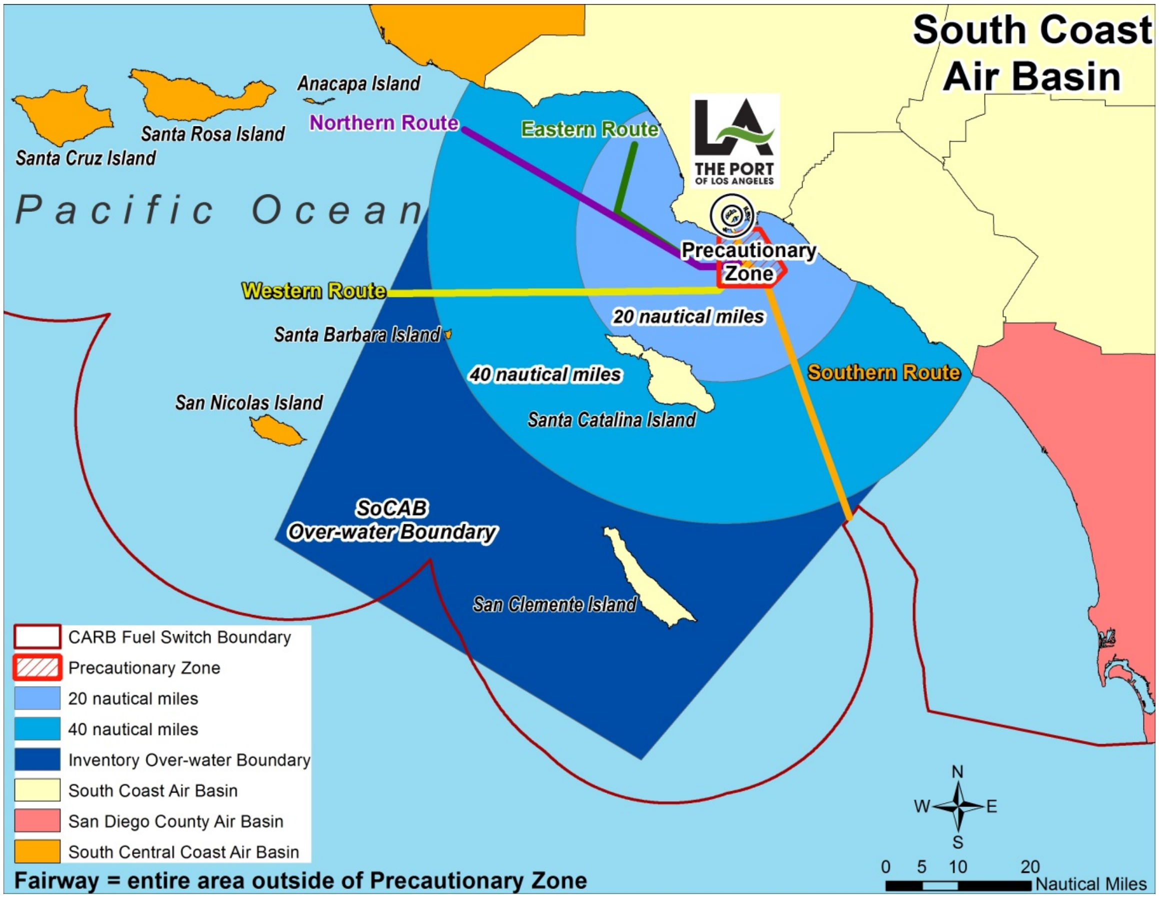
[50] CARB: *www.arb.ca.gov/ports/marinevess/documents/marinenote2011_2.pdf*

[51] CARB, *www.arb.ca.gov/ports/marinevess/documents/fuelogv13.pdf*

Figure 3.2: Geographical Extent and Major Shipping Routes



The precautionary zone (PZ) is a federally designated area where ships prepare to enter or exit the Port. In this zone the Los Angeles pilots are picked up for arrivals or dropped off for departures. It is mandatory for the ships to lower their speeds in the PZ for safety reasons primarily to navigate the close intermixing of coming and going ships through the Angels' Gate, and to safely transfer pilots to and from ships. The harbor is located north of the breakwater and is characterized by the slowest vessel speeds due to vessels maneuvering in constricted channels.

There are four primary shipping routes into the Port as designated by MarEx.[52] The Northern route is typically for West Coast United States/Canada and trans-Pacific/Asia voyages, the Eastern route is for transits to and from El Segundo Bay, the Southern route is for Central/South American and Oceania voyages, and the Western route, though traditionally was for Hawaiian and eastern Oceania voyages, but more recently it has also been used more and more by ships transiting from Asia. Each route is comprised of a designated inbound and outbound lane which is used to separate vessel traffic arriving and departing the Port. The

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[52] MarEx, *www.mxsocal.org*

distances for these routes from the PZ to the over-water inventory boundary and the distances of these routes from the breakwater (BW) to the PZ are listed in Table 3.1. These distances represent average distances traveled by ships for each route.

Table 3.1: Route Distances, nm

Route	PZ to Boundary Distance, nm		BW to PZ Distance, nm	
	Inbound	Outbound	Inbound	Outbound
Northern	43.3	42.4	8.6	7.6
Eastern	25.7	25.7	7.6	7.6
Southern	31.3	32.5	8.5	7.4
Western	40.0	40.0	8.6	8.6

As stated above, the CARB OGV Fuel Regulation expanded boundary, extending to beyond the outlying off-shore islands, was in effect for all of 2013. The original CARB OGV Fuel Regulation boundary was established on July 1, 2009, when CARB started to require ships to use distillate fuels instead of residual fuels when entering 24-nm of the California coastline. The original boundary included the entirety of some transit routes, but excluded segments of others. The expanded boundary includes entire transit of all routes. Prior to the 2009 regulation, the Northern route was the predominant route for trade with Asia and points north of San Pedro Bay. After the regulation became effective, the Western route (west of the Channel Islands) became the predominant shipping route for ships trading with Asia and points north of San Pedro Bay; presumably to avoid the CARB OGV Fuel Regulation compliance zone. Since the adjustment of the boundary in December 2011, ships have started to transition back to using the Northern route for trade with Asia. This shift in route selection is highlighted in Table 3.2.

Table 3.2: Route Distribution of Arrivals and Departures 2005-2013

Route	2005	2006	2007	2008	2009	2010	2011	2012	2013
North	64%	69%	64%	62%	45%	10%	7%	29%	33%
West	5%	5%	5%	6%	23%	58%	61%	39%	37%
South	30%	32%	30%	31%	31%	31%	31%	31%	30%
East	1%	1%	1%	1%	1%	1%	1%	1%	1%

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:

- MarEx data
- VSR Program speed data
- Los Angeles Pilot Service (Pilots) data
- IHS Fairplay (Lloyd's) - "Lloyd's Register"[53]
- Port Vessel Boarding Program (VBP) data
- Terminal data
- Tanker loading date
- Nautical charts and maps

3.4 Operational Profiles

Vessel movement activity is defined as the number of ship trips by trip type and segment. A trip type defines the ship's movement and the segment defines the geographical area that the ship is operating within. Vessel trip types include arrivals, departures, and shifts. Trip segments are defined: between the at-sea portion and the PZ of the transit route of the ship trip, the segments within the PZ, and the segments inside the breakwater. 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 segment and multiply it by the amount of time spent in that particular mode, which estimates energy demand expressed as load times unit of time, e.g., kilowatt-hour (kW-hr). Each vessel-by-vessel activity is analyzed by trip type and trip segment analysis for calendar year 2013. In addition to vessel movement activity, ships spend time at-anchorage and at-berth; however, no movement is associated with the vessel. Energy demand from the auxiliary engines and boilers is estimated for all related transit time as well as at-berth and/or at-anchorage.

Vessel Activities and Operational Modes
Vessel activities are delineated from the following three data sources:

- MarEx activity data which defines each vessel's arrival, departure, and shift(s) as well as time(s) at-berth and/or anchorage
- MarEx speed data which defines each vessels speeds for the VSR Program at the 10, 15, 20, 25, 30, 35, and 40 nm using Automated Identification System (AIS) and radar data
- Los Angeles Pilot Service data for determining average transit times for harbor maneuvering

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[53] IHS markets this information as IHS Fairplay, see: *www.ihs.com/products/maritime-information/index.aspx*

Ship movements are tracked by MarEx as the following trip types:

- Arrivals - inbound trips from the inventory boundary to berth
- Departures - outbound trips from a berth or anchorage to the inventory boundary
- Shifts - inter-port, intra-port, and anchorage shifts

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 after the anchorage is a berth at POLA. A call is made up of an arrival to, shift(s) as applicable, and departure from the emissions inventory domain.

Table 3.3 presents the arrivals, departures, shifts and total movements (the summation of all three) for vessels at the Port in 2013. Arrivals and departures do not match because the activity is based on a calendar year. Tankers shift more than other vessel types while in port due to loading and off-loading practices. Similar to the trade pattern in previous year, the Port did not have roll-on/roll-off vessel calls. Some of the smaller container vessels made more calls in 2013 than in the previous year.

Table 3.3: Total OGV Movements

Vessel Type	Arrival	Departure	Shift	Total
Auto Carrier	94	94	14	202
Bulk	82	76	71	229
Bulk - Heavy Load	1	1	0	2
Container - 1000	109	109	8	226
Container - 2000	242	243	20	505
Container - 3000	101	100	7	208
Container - 4000	347	348	13	708
Container - 5000	127	126	5	258
Container - 6000	294	294	14	602
Container - 7000	34	34	0	68
Container - 8000	114	114	3	231
Container - 9000	95	96	1	192
Cruise	99	98	0	197
General Cargo	68	66	30	164
Ocean Tugboat (ATB/ITB)	56	56	58	170
Miscellaneous	1	1	0	2
Reefer	20	20	29	69
Tanker - Chemical	78	82	117	277
Tanker - Handysize	23	23	28	74
Tanker - Panamax	48	46	112	206
Total	**2,033**	**2,027**	**530**	**4,590**

DB ID693

The following vessel operational modes define the characteristics of a ship's operation within the emission inventory domain:

1. *Transit*	Transit or sea mode denotes a ship is operating in open water and is typically beyond the breakwater.
2. *Maneuvering*	Ship movements inside the breakwater. Additional power is typically brought online since the ship is traveling in restricted waters.
3. *At-Berth*	When a ship is stationary at the dock/berth and when cargo is loaded and unloaded.
4. *At-Anchorage*	When a ship is anchored inside or just outside the breakwater waiting for reassignment, an open berth, or requiring maintenance, etc.
5. *Shift*	When a ship moves from one berth to another within the Port or from/to POLB, or from/to an anchorage. A ship can have zero to many shifts per call.

Each call has an estimated maneuvering time associated as the vessel travels within the breakwater. Maneuvering times inside the breakwater are developed for each terminal based on Pilot's detail call data, which is aggregated to determine the average time ships spend maneuvering. Maneuvering times are terminal-specific transit averages derived from data from the Los Angeles Pilots. PZ transit times are based on the type of ship, the associated speed (see 3.5.3 below), and the distance traveled in the PZ between the breakwater and the boundary of the PZ.

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.

3.5 Emission Estimation Methodology

There are three typical sources that produce emissions from ships: propulsion power, auxiliary power, and steam production. Most ships calling the Port utilize diesel engines to provide propulsion and auxiliary power (all non-propulsion electrical needs). Steam is produced through the use of auxiliary boilers or generated by heat recovery from diesel engines.

In general, emissions are estimated as a function of vessel power demand with energy expressed in kW-hr 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 (see section 3.5.5), different fuel usage (see section 3.5.11) or emissions controls (see section 3.5.12) are then applied to the various activity data.

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

Equation 3.1

$$\boldsymbol{E_i = Energy_i \times EF \times FCF \times CF}$$

Where:

E_i = Emissions by mode
$Energy_i$ = Energy demand by mode, calculated using Equation 3.2 below as the energy output of the engine(s) or boiler(s) over the period of time, kW-hr
EF = Emission factor, expressed in terms of g/kW-hr
FCF = Fuel correction factor, dimensionless
CF = Control factor(s) for emission reduction technologies, dimensionless

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

Equation 3.2

$$\boldsymbol{Energy_i = Load \times Act}$$

Where:

$Energy_i$ = Energy demand by mode, kW-hr
Load = maximum continuous rated (MCR) times load factor (LF) for propulsion engine power (kW); reported operational load of the auxiliary engine(s), by mode (kW); or operational load of the auxiliary boiler, by mode (kW)
Act = activity, hours

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

3.5.1 Propulsion Engine Maximum (MCR) Continuous Rated Power

MCR is used to determine load by mode for propulsion engines. For this study, it is assumed that the Lloyd's 'Power' value is the best surrogate for MCR power and is reported in kilowatts. For diesel-electric configured ships, MCR is the combined rated electric propulsion motor(s) rating, in kW.

3.5.2 Propulsion Engine Load Factor

Load factor for propulsion engines is estimated using the ratio of actual speed compared to the ship's maximum rated speed. Propulsion engine load factor is estimated using the Propeller Law, which shows 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.

Equation 3.3

$$LF = (Speed_{Actual} / Speed_{Maximum})^3$$

Where:

LF = load factor, dimensionless
SpeedActual = actual speed, knots
SpeedMaximum = maximum speed, knots

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. At-berth and anchorage times are determined from MarEx activity data. The transit time within the PZ and the along the various routes 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.

Equation 3.4

$$Activity = D/Speed_{Actual}$$

Where:

Activity = activity, hours
D = distance, nautical miles
SpeedActual = actual ship speed, knots

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

Based on information obtained from the Pilots on operational speeds in the PZ by vessel class, the average speeds presented in Table 3.4, are assigned based on vessel type.

Table 3.4: Precautionary Zone Average Speed, knots

Vessel Type	Vessel Class	Average 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 Tugboat (ATB/ITB)	Slow	9.0
Reefer	Slow	9.0
Tanker	Slow	9.0

3.5.4 Propulsion Engine Emission Factors

The main engine emission factors used in this study were reported in the ENTEC 2002 study,[54] except for PM, CO and greenhouse gas emission factors. The PM emission factors for slow and medium speed diesel engines were provided by CARB[55]. An IVL 2004 study[56] was the source for the PM emission factors for gas turbine and steamship vessels, as well as the CO and greenhouse gas emission factors for CO_2, and N_2O. Per IVL 2004 study data, CH_4 were assumed to be 0.2% of HC emission factors. The emissions factors are based on residual fuel oil/ heavy fuel oil (HFO) which is intermediate fuel oil (IFO 380) or one with similar specifications, with an average sulfur content of 2.7%.

The two predominant propulsion engine types are:

- Slow speed diesel engines, having maximum engine speeds less than 130 rpm
- Medium speed diesel engines, having maximum engine speeds over 130 rpm (typically greater than 400 rpm and less than 2,000 rpm).

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[54] ENTEC, *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community, Final Report*, July 2002

[55] CARB, *A Critical Review of Ocean-Going Vessel Particulate Matter Emission Factors*, November 2007

[56] IVL, *Methodology for Calculating Emissions from Ships: Update on Emission Factors,* 2004. (IVL 2004)

Starting with the 2012 emissions inventory, after obtaining consensus from the Technical Working Group (TWG), the Port incorporated data from the IMO's Engine International Air Pollution Prevention Certificate (EIAPP) for propulsion and auxiliary engines into the annual emissions inventories. For ships with a valid propulsion engine EIAPP, the engine's actual NO_x emissions value (g/kW-hr) is used in place of the default NO_x emission factor, which is the same as the applicable engine's IMO Tier NO_x requirement. The expiration date of the International Air Pollution Prevention Certificate (IAPP) and EIAPP data is submitted by ship owner/operator, on a per ship basis, directly to the port or via the International Association of Ports and Harbors (IAPH) Environmental Ship Index (ESI) program.[57] EIAPP and IAPP data is submitted by the ship operator/owner to the ESI program and the Port gets updated data quarterly. EIAPP and IAPP certificate data were collected from several vessels during Vessel Boarding Program (VBP) visits. For 2013, there were 184 vessels that called the Port for which EIAPP data have been used instead of the default emission factors, which are presented in Tables 3.5 and 3.6.

Tables 3.5 and 3.6 list the default emission factors for propulsion engines using 2.7% sulfur HFO and 0.5% sulfur MDO (which was the CARB fuel switch fuel requirement in 2013). Consistent with the previous inventories and based on IVL 2004, a 6% benefit for NO_x has been taken for the difference between Tier 0 and Tier 1 engines. For example, for slow speed diesel engines using HFO, the Tier 0 NO_x emission factor is 18.1 g NO_x/kW-hr (IVL 2004) and the Tier 1 NO_x emission factor is 17.0 g NO_x/kW-hr, which represents a 6% reduction from a Tier 0 engine. To produce MDO based emission factors, the HFO emission factors are multiplied by a fuel correction factor (FCF), see Section 3.5.11, of 0.94 that represents the NO_x combustion differences between two types of fuel. For Tier 1, the 17.0 g NO_x/kW-hr HFO emission factor is multiplied by 0.94 which produces a Tier 1 MDO emission factor of 16.0 NO_x/kW-hr.

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[57] IAPH, *esi.wpci.nl/Public/Home*

Table 3.5: Emission Factors for OGV Propulsion Power using HFO and MDO, g/kW-hr

Engine Type	IMO Tier	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
HFO 2.7% Sulfur									
Slow speed diesel	Tier 0[58]	≤ 1999	1.50	1.20	1.50	18.1	10.5	1.4	0.6
Medium speed diesel	Tier 0	≤ 1999	1.50	1.20	1.50	14.0	11.5	1.1	0.5
Slow speed diesel	Tier 1	2000 – 2010	1.50	1.20	1.50	17.0	10.5	1.4	0.6
Medium speed diesel	Tier 1	2000 – 2010	1.50	1.20	1.50	13.0	11.5	1.1	0.5
Slow speed diesel	Tier 2	2011 – 2015	1.50	1.20	1.50	15.3	10.5	1.4	0.6
Medium speed diesel	Tier 2	2011 – 2015	1.50	1.20	1.50	11.2	11.5	1.1	0.5
Gas turbine	na	all	0.05	0.04	0.00	6.1	16.5	0.2	0.1
Steamship	na	all	0.80	0.64	0.00	2.1	16.5	0.2	0.1
MDO 0.5% Sulfur									
Slow speed diesel	Tier 0	≤ 1999	0.38	0.35	0.38	17.0	1.9	1.4	0.6
Medium speed diesel	Tier 0	≤ 1999	0.38	0.35	0.38	13.2	2.1	1.1	0.5
Slow speed diesel	Tier 1	2000 – 2010	0.38	0.35	0.38	16.0	1.9	1.4	0.6
Medium speed diesel	Tier 1	2000 – 2010	0.38	0.35	0.38	12.2	2.1	1.1	0.5
Slow speed diesel	Tier 2	2011 – 2015	0.38	0.35	0.38	14.4	1.9	1.4	0.6
Medium speed diesel	Tier 2	2011 – 2015	0.38	0.35	0.38	10.5	2.1	1.1	0.5
Gas turbine	na	all	0.01	0.01	0.00	5.7	3.1	0.2	0.1
Steamship	na	all	0.20	0.18	0.00	2.0	3.1	0.2	0.1

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[58] Tier 0 refers to all ships constructed prior to January 1, 2000 which did not have an IMO Tier requirement at the time of construction.

Table 3.6: GHG Emission Factors for OGV Propulsion Power using HFO and MDO, g/kW-hr

Engine	IMO Tier	Model Year	CO_2	N_2O	CH_4
HFO 2.7% Sulfur					
Slow speed diesel	Tier 0	≤ 1999	620	0.031	0.012
Medium speed diesel	Tier 0	≤ 1999	683	0.031	0.010
Slow speed diesel	Tier 1	2000 – 2010	620	0.031	0.012
Medium speed diesel	Tier 1	2000 – 2010	683	0.031	0.010
Slow speed diesel	Tier 2	2011 – 2015	620	0.031	0.012
Medium speed diesel	Tier 2	2011 – 2015	683	0.031	0.010
Gas turbine	na	all	970	0.080	0.002
Steamship	na	all	970	0.080	0.002
MDO 0.5% Sulfur					
Slow speed diesel	Tier 0	≤ 1999	589	0.029	0.012
Medium speed diesel	Tier 0	≤ 1999	649	0.029	0.010
Slow speed diesel	Tier 1	2000 – 2010	589	0.029	0.012
Medium speed diesel	Tier 1	2000 – 2010	649	0.029	0.010
Slow speed diesel	Tier 2	2011 – 2015	589	0.029	0.012
Medium speed diesel	Tier 2	2011 – 2015	649	0.029	0.010
Gas turbine	na	all	922	0.075	0.002
Steamship	na	all	922	0.075	0.002

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[59] prepared by Energy and Environmental Analysis, Inc. (EEAI) 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 (e.g. in the reduced speed zone.) While mass emissions, pounds per hour, tend to go down as vessel speeds and engine loads decrease, the emission factors, g/kW-hr increase. This is based on observations that compression-cycle combustion engines are less efficient at low loads.

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[59] EPA, *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data,* February 2000

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 (USCG). The low load effect was described in a study conducted for the EPA by ENVIRON.[60] Equation 3.5 is the equation developed by EEAI to generate emission factors for the range of load factors from 2% to <20% for each pollutant:

Equation 3.5

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

Where:

y = emissions, g/kW-hr
a = coefficient
b = intercept
x = exponent (negative)
fractional load = propulsion engine load factor (2% - <20%), derived by the Propeller Law, percent (see equation 3.3)

Table 3.7 presents the variables for equation 3.5.

Table 3.7: Low-Load Emission Factor Regression Equation Variables

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

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[60] EPA, *Commercial Marine Inventory Development,* July 2002

Table 3.8 presents the emission factors based on Equation 3.5 and variables in Table 3.7 at 2% to <20% loads.

Table 3.8: EEAI 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

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 EEAI emission factors by the emission factor at 20% load using Equation 3.6. This result 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

$$\boldsymbol{LLA\ (at\ x\ \%\ load)\ =\ y\ (at\ x\ \%\ load)\ /\ y\ (at\ 20\%\ load)}$$

Where:

LLA = Low load adjustment multiplier
x = engine load factor less than or equal to 20%
y = emission factor, g/kW-hr from equation 3.5 (see Table 3.8)

Table 3.9 lists the resulting low-load adjustment multipliers 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 does not apply at engine loads greater than 20%. For main engine loads below 20%, the LLA increases so as to reflect increased emissions on a g/kW-hr basis due to engine inefficiency. Low load emission factors do not apply to steamships or ships having gas turbines because the EPA study only observed an increase in emissions from diesel engines.

Table 3.9: Low Load Adjustment Multipliers for Emission Factors[61]

Load	PM	NO_x	SO_x	CO	HC	CO_2[62]	N_2O	CH_4
2%	7.29	4.63	1.00	9.70	21.18	1.00	4.63	21.18
3%	4.33	2.92	1.00	6.49	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	3.90	5.61	1.00	1.83	5.61
6%	2.04	1.60	1.00	3.26	4.35	1.00	1.60	4.35
7%	1.79	1.45	1.00	2.80	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	1.97	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

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

[62] CO_2 will change based on load across the entire engine load profile due to the changes in engine efficiencies with load. An update based on the latest available information is provided in the 2013 inventory.

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

$$\boldsymbol{EF = Base\ EF \times LLA}$$

Where:

EF = Resulting low load emission factor
Base EF = Emission factor for diesel propulsion engines (see Tables 3.5 and 3.6)
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 turned off for periods of time as the vessels are being maneuvered to their berths. During docking, when the ship is being positioned against the wharf, the assist tugboats do most of the work and the main engines are off. Main engine maneuvering loads are estimated using the Propeller Law, with the over-riding assumption that the lowest average engine load is 2%.

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

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

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

3.5.7 Propulsion Engine Defaults

All vessels that called the Port were able to be matched for main engine power ratings using the most current Lloyd's data and VBP information.

3.5.8 Auxiliary Engine Emission Factors

As discussed above in section 3.5.4, vessel-specific NO_x emission factors were calculated from EIAPP certificates that were collected from vessels participating in the ESI program or from VBP. For vessels that did not have an EIAPP certificate available, the default emission factors from the ENTEC 2002 and IVL 2004 (for CO and greenhouse gases) study were applied. The ENTEC 2002 and IVL 2004 auxiliary engine emission factors used in this study are presented in Tables 3.10 and 3.11. Similar to the propulsion engine emission factors, the 2.7% sulfur HFO base emission factors are multiplied by the appropriate pollutant FCF to calculate the 0.5% sulfur MDO emission factors (see 3.5.11).

Table 3.10: Emission Factors for Auxiliary Engines using HFO and MDO, g/kW-hr

Model Year	IMO Tier	PM_{10}	$PM_{2.5}$	DPM	NO_X	SO_x	CO[63]	HC
HFO 2.7% Sulfur								
≤ 1999	Tier 0	1.50	1.20	1.50	14.7	12.3	1.1	0.4
2000 - 2010	Tier 1	1.50	1.20	1.50	13.0	12.3	1.1	0.4
2011 - 2015	Tier 2	1.50	1.20	1.50	11.2	12.3	1.1	0.4
MDO 0.5% Sulfur								
≤ 1999	Tier 0	0.38	0.35	0.38	13.8	2.3	1.1	0.4
2000 - 2010	Tier 1	0.38	0.35	0.38	12.2	2.3	1.1	0.4
2011 - 2015	Tier 2	0.38	0.35	0.38	10.5	2.3	1.1	0.4

Table 3.11: GHG Emission Factors for Auxiliary Engines using HFO and MDO, g/kW-hr

Model Year	CO_2	N_2O	CH_4
HFO 2.7% Sulfur			
all	722	0.031	0.008
MDO 0.5% Sulfur			
all	686	0.029	0.008

3.5.9 Auxiliary Engine Load Defaults

The primary data source for auxiliary load data is from the VBP where data is collected on operations by mode for ships visited and their sister ships. The Lloyd's database contains limited auxiliary engine's installed power information nor information on use by mode, because neither the IMO nor the classification societies require vessel owners to provide this information. VBP data relating to auxiliary engine use is acquired by vessel type, by emission source, and by mode. When estimating auxiliary engine emissions the following hierarchy is

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[63] IVL 2004

followed: VBP data if the vessel has been boarded, VBP data if the vessel is a sister to a boarded vessel, and average auxiliary engine load defaults derived from VBP data. VBP data was utilized directly for 41% of all calls in 2013.

Typically, for those vessels not boarded, default average auxiliary engine loads are calculated using the VBP dataset. Table 3.12 summarizes the auxiliary engine load defaults by mode used for this study by vessel subtype.

Table 3.12: Average Auxiliary Engine Load Defaults, kW

Vessel Type	Sea	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	503	1,508	838	503
Bulk	255	675	150	255
Bulk - Heavy Load	255	675	150	255
Container - 1000	545	1,058	429	545
Container - 2000	981	2,180	1,035	981
Container - 3000	602	2,063	516	602
Container - 4000	1,434	2,526	1,161	1,434
Container - 5000	1,176	4,200	1,008	1,176
Container - 6000	1,425	2,178	986	1,425
Container - 7000	1,444	3,357	1,372	1,444
Container - 8000	1,416	3,158	980	1,416
Container - 9000	1,502	3,350	1,040	1,502
Cruise	5,104	8,166	5,104	5,104
General Cargo	516	1,439	722	516
ITB	79	208	102	79
MISC	72	191	42	72
Reefer	513	1,540	890	513
Tanker - Chemical	677	931	734	677
Tanker - Handysize	441	607	478	441
Tanker - Panamax	574	789	622	574

For diesel electric cruise ships, house load defaults are listed in Table 3.13. The auxiliary engine load defaults for the diesel electric cruise ships were obtained from VBP data and interviews with the cruise vessel industry and based on passenger capacity ranges.

Table 3.13: Diesel Electric Cruise Ship Average Auxiliary Engine Load Defaults, kW

Passenger Count	Sea	Maneuvering	Berth Hotelling
<1,500	3,500	3,500	3,000
1,500<2,000	7,000	7,000	6,500
2,000<2,500	10,500	10,500	9,500
2,500<3,000	11,000	11,000	10,000
3,000<3,500	11,500	11,500	10,500
3,500<4,000	12,000	12,000	11,000
4,000+	13,000	13,000	12,000

3.5.10 Auxiliary Boiler Emission Factors and Load Defaults

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 and steam. Boilers are typically not used during transit at sea since many vessels are equipped with an exhaust gas recovery system or "economizer" that uses heat of the main engine exhaust for heating fuel or water. Therefore, the boilers are not needed when the main engines are used while in transit. Vessel speeds for Port calls have been reduced in recent years due to increased compliance with the VSR program and VSR distance extending to 40 nm from 24 nm. Because of these lower speeds, it is reasonable to assume that auxiliary boilers are used during transit when the lower speeds result in the cooling of main engine exhausts, thereby making the vessels' economizers less effective. As such, it is assumed that auxiliary boilers operate when the main engine power load is less than 20% during maneuvering and transit. Tables 3.14 and 3.15 show the emission factors used for the auxiliary boilers based on ENTEC 2002 and IVL 2004 studies. Similar to the propulsion and auxiliary engine emission factors, the 2.7% sulfur HFO base emission factors are multiplied by the appropriate pollutant FCF to calculate the 0.5% sulfur MDO emission factors (see 3.5.11).

Table 3.14: Emission Factors for OGV Auxiliary Boilers using HFO and MDO, g/kW-hr

Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
HFO 2.7% Sulfur							
Steam boilers	0.8	0.64	0	2.1	16.5	0.2	0.1
MDO 0.5% Sulfur							
Steam boilers	0.2	0.18	0	2.0	3.1	0.2	0.1

Table 3.15: GHG Emission Factors for OGV Auxiliary Boilers using HFO and MDO, g/kW-hr

Type	CO_2	N_2O	CH_4
HFO 2.7% Sulfur			
Steam boilers	970	0.080	0.002
MDO 0.5% Sulfur			
Steam boilers	922	0.075	0.002

The boiler fuel consumption data collected from vessels during the VBP was converted to equivalent kilowatts using specific fuel consumption (SFC) factors found in the ENTEC 2002 study. The average SFC value based on residual fuel is 305 grams of fuel per kW-hour. The average kW for auxiliary boilers was calculated using the following equation.

Equation 3.8

$$\boldsymbol{Average\ kW\ =\ ((daily\ fuel/24)\ \times\ 1,000,000)/305}$$

Where:

Average kW = Average energy output of boilers, kW
daily fuel = Boiler fuel consumption, tonnes per day

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; however diesel electric cruise ships can utilize scavenged heat to provide steam needed during their dwell time inside the inventory boundary. Tankers provide steam for steam-powered liquid cargo pumps, steam powered inert gas fans, and to heat fuel for pumping. Ocean-going tugboats do not have boilers; therefore their boiler energy default is zero. As stated above, boilers are not typically used at sea during normal transit; therefore the boiler energy default at sea is zero, if main engine load is greater than 20%. If the main engine load is less than or equal to 20%, the maneuvering boiler load defaults shown in the table are used. These defaults are similar to hotelling defaults, except for the tankers.

As with auxiliary engines, the primary source of load data is from the VBP, and direct values for vessels boarded are used on an individual basis for vessels boarded and their sister ships. There is no load data from the Lloyds database by mode. For vessels not boarded nor have any sister vessels boarded through the VBP, average loads are developed by class from the data available from the VBP program.

Table 3.16: Auxiliary Boiler Load Defaults, kW

Vessel Type	Sea	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	253	253	253	253
Bulk	132	132	132	132
Bulk - Heavy Load	132	132	132	132
Container - 1000	241	241	241	241
Container - 2000	325	325	325	325
Container - 3000	474	474	474	474
Container - 4000	492	492	492	492
Container - 5000	630	630	630	630
Container - 6000	565	565	565	565
Container - 7000	538	538	538	538
Container - 8000	525	525	525	525
Container - 9000	547	547	547	547
Cruise	1,393	1,393	1,393	1,393
General Cargo	137	137	137	137
ITB	0	0	0	0
MISC	137	137	137	137
Reefer	255	255	255	255
Tanker - Chemical	371	371	3,000	371
Tanker - Handysize	371	371	3,000	371
Tanker - Panamax	371	371	3,000	371

Beginning in 2013, tanker activity data was collected to determine if a tanker was being loaded from shore-side or discharging liquid bulk during time at-berth. The two operations have significantly different auxiliary boiler loads, which are used to power cargo and ballasting pumps. The auxiliary boiler energy demand is less during vessel loading operations than it is during discharging. For 2005 and 2013 inventory estimates, if it was determined that a bulk liquid vessel was being loaded while at-berth, a lower auxiliary boiler load of 875 kW is applied instead of the default presented in Table 3.16, which assumes the vessel is discharging. In the 2014 emissions inventory, estimates in other interim years will be updated in a similar fashion for comparison.

3.5.11 Fuel Correction Factors

Fuel correction factors (FCF) apply when the actual fuel used is different from the fuel assumed to develop the emission factors. As discussed earlier, main, auxiliary and auxiliary boiler emission factors are based on heavy fuel oil (HFO) with an average 2.7% sulfur content. The North American Emissions Control Area (ECA) requires vessels within 200 nm of the US and Canadian coasts to operate on 1% S HFO. For 2013, as discussed previously, the expanded CARB Fuel Regulation boundary includes all traffic lanes within the inventory domain and therefore, the CARB required 0.5% sulfur marine diesel oil (MDO) is assumed to be the base default fuel. The exceptions to this policy include:

1) CARB exempted auxiliary boilers on specific tankers, which are assumed to use 1.0% sulfur fuel as required by the ECA for all of 2013. CARB issued several Essential Modification Executive Orders exempting individual vessels from the fuel use specifications described in the OGV Fuel Regulation for vessels. Vessels that were exempt demonstrated that it is not feasible to use the specified fuels in their auxiliary boilers unless essential modifications to the vessels are made. Vessels granted the exemptions are listed on CARB's website[64]. For the purpose of this inventory, vessels which were previously assigned CARB fuel exemptions for auxiliary boilers, were assigned HFO 1.0% S fuel at the start of the ECA in 2013. There were 10 tankers that called the Port in 2013 that were exempt for switching fuel for their auxiliary boilers.
2) For those vessels that participated in the International Association of Ports & Harbors Environmental Ship Index (ESI) program[65] in 2013, the actual sulfur mass weighted content of the fuel was used for 2012 and 2013, as available. For the purpose of this inventory, the maximum allowable actual fuel sulfur content is defaulted as 0.5% S MDO to be in line with the CARB OGV Fuel Regulation. The methodology used in the EI to calculate annual sulfur content was confirmed by CARB through Emissions Inventory Technical Working Group (TWG) discussions. Since 2012, the Port participated in ESI and started receiving specifics relating to mass and percent sulfur of the fuel purchased by year. From this data, a vessel specific, mass-weighted average sulfur content was calculated for HFO and MDO, for each year data was available.
3) Trapac's lease requires compliance with clause that 50% of the total annual vessel calls to Trapac will use 0.2% sulfur fuel in 2013. Therefore, the default fuel for vessels calling Trapac is 0.35% S MDO.

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[64] CARB, *http:/www.arb.ca.gov/ports/marinevess/ogv/ogveos.htm*

[65] IAPH, *esi.wpci.nl/Public/Home*

Table 3.17 lists a representative sample of the fuel correction factors for fuels with different sulfur contents identified from ESI data (there were over 340 fuel types identified used in 2013) and for the default fuel policies listed above. These dimensionless fuel correction factors are consistent with CARB's emission estimations methodology for ocean-going vessels.[66] CARB's Marine Emissions Model[67] has fuel correction factor for several combinations of fuel switching from the HFO level. Those fuel correction factors were used as is, and for additional fuel switching combination, FCF were interpolated. Fuel correction factors for switching fuel from HFO with average sulfur content of 2.7% by weight to other fuel types are shown in the table below. The pollutants listed in Table 3.17 are for PM, NO_x and SO_x. PM FCF is used for all of the PM pollutants including PM_{10}, $PM_{2.5}$ and DPM. NO_x FCF is used for NO_x and N_2O pollutants. The CO_2 FCF is 0.95 for all MDO/MGO fuels. The CO, HC and CH_4 FCF is 1.0 for all fuel types, including HFO and MDO/MGO.

Table 3.17: Sample Fuel Correction Factors

Actual Fuel Used	Sulfur Content by weight	PM	NO_x	SO_x	Actual Fuel Used	Sulfur Content by weight	PM	NO_x	SO_x
HFO	1.00%	0.73	1.00	0.370	MDO/MGO	0.34%	0.22	0.94	0.126
MDO/MGO	**0.50%**	**0.25**	**0.94**	**0.185**	MDO/MGO	0.33%	0.22	0.94	0.123
MDO/MGO	0.46%	0.24	0.94	0.170	MDO/MGO	0.32%	0.21	0.94	0.118
MDO/MGO	0.45%	0.24	0.94	0.167	MDO/MGO	0.30%	0.21	0.94	0.111
MDO/MGO	0.44%	0.24	0.94	0.163	MDO/MGO	0.27%	0.20	0.94	0.100
MDO/MGO	0.43%	0.24	0.94	0.159	MDO/MGO	0.26%	0.20	0.94	0.096
MDO/MGO	0.42%	0.23	0.94	0.156	MDO/MGO	0.25%	0.20	0.94	0.093
MDO/MGO	0.41%	0.23	0.94	0.152	MDO/MGO	0.24%	0.20	0.94	0.088
MDO/MGO	0.40%	0.23	0.94	0.148	MDO/MGO	0.23%	0.20	0.94	0.085
MDO/MGO	0.39%	0.23	0.94	0.146	MDO/MGO	0.22%	0.19	0.94	0.083
MDO/MGO	0.38%	0.23	0.94	0.141	MDO/MGO	0.21%	0.19	0.94	0.078
MDO/MGO	0.36%	0.22	0.94	0.133	MDO/MGO	0.20%	0.19	0.94	0.074
MDO/MGO	0.35%	0.22	0.94	0.130	MDO/MGO	0.19%	0.19	0.94	0.070

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[66] CARB, *www.arb.ca.gov/regact/2008/fuelogv08/fuelogv08.htm*

[67] CARB, *www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles*

3.5.12 Control Factors for Emission Reduction Technologies

Control factors are used to take into account the emissions benefits associated with emission reduction technologies installed on vessels/engines.

Shore side electrical power was used during 141 vessel calls representing about 7% of all vessel calls. At-berth emissions reduction of 95% in all pollutants for auxiliary engines emissions is assumed for ships that used shore side electrical power. This reduction estimate accounts for the time necessary to connect to and disconnect from the electrical power and start-up the auxiliary engines.

In past inventories, a PM and NO_x reduction was taken into account for fuel slide valves. Slide valve reductions are limited to two-stroke MAN main engines that are Tier 0 or Tier I. As part of the Technology Advancement Program (TAP), MAN Diesel & Turbo A/S, Mitsui Engineering & Shipbuilding CO., Ltd., POLA, and POLB conducted a test at the Mitsui Tamano Works in Japan to determine if slide valves provide emission reduction benefits when ships are traveling below 25% load, as ships do when they are in compliance with the VSR program. The test was completed and the results are currently being used to develop load-based control factors for NO_x, PM, $PM_{2.5}$, DPM, HC, and N_2O. The work will include working with MAN Diesel & Turbo A/S to determine the distribution of the type of valves typically used in two-stroke engines to help set baseline scenarios. The CFs will be developed in coordination with the TWG and incorporated in the 2014 inventory. For 2013, both ports decided to set the CFs for slide valves to 1.0 (essentially turning their reductions off) as to avoid taking credit for offsets that are not supported by the test results and to avoid setting an arbitrary interim CFs that would be changed in the next inventory. Once the new CFs have been developed and agreed upon with the TWG, they will be applied to 2014 inventory and all previous inventories.

3.5.13 Improvements to Methodology from Previous Years

The following improvements are implemented in OGV emission calculation methodology for the 2013 Emissions Inventory as compared to the 2012 emissions calculation methodology. It should be noted that changes were made in the updated estimates for 2005-2012, unless otherwise noted.

- Ship-specific SO_x fuel correction factors were developed for vessels participating in the ESI program. Mass weighted sulfur contents were used for HFO and MDO in place of the 0.5% sulfur CARB requirement when below 0.5% sulfur. Some vessels have multiple fuels for the ECA and CARB requirements and therefore the total MDO average for a vessel could be above the CARB requirement. ESI data does not say which fuel is being used where, therefore it's assumed that minimally all vessels are compliant with the CARB regulations, instead of picking the lowest sulfur fuel bunkered. This method was applied to both 2012 and 2013 estimates.
- Ship specific NO_x emission factors were used for main and auxiliary engines, where vessel-specific EIAPP Certificate data was available through the ESI program or the VBP.
- CO_2 emission factors for auxiliary engines were changed from 683 to 722. This revision is consistent with CARB methodology.
- Tanker loading data was incorporated to account for the differences in energy demand associated with the auxiliary boilers during vessel loading or discharging operations while at-berth. If a tanker is being loaded from the shore-side while at-berth, a lower auxiliary boiler load of 875 kW is applied, instead of the default (stated in Table 3.16) which assumes the vessel is discharging bulk liquids while at-berth.
- Hotelling time calculations were adjusted to account for a difference in the MarEx activity timestamp definition. It was determined that the arrival and departure timestamps from MarEx indicate the time that a vessel enters or leaves the harbor, rather than the time a vessel arrives or departs berth, which had been the previous interpretation. All hotelling time calculations (2005-2013) were adjusted to account for this difference.
- There were no slide valve emission reductions taken for 2005-2013.

3.6 Emission Estimates

The following tables present the estimated OGV emissions categorized in different ways, such as by engine type, by operating mode, and by vessel type. In order for the total emissions to be consistently displayed for each pollutant in all the tables, the individual values in each table column do not, in some cases, add up to the listed total in the table. This is because there are fewer decimal places displayed (for readability) than are included in the calculated totals. A summary of the ocean-going vessel emission estimates by vessel type for all pollutants for the year 2013 is presented in Table 3.18. The criteria pollutant emissions are in tons per year (tpy), while the greenhouse gas emissions are in tonnes.

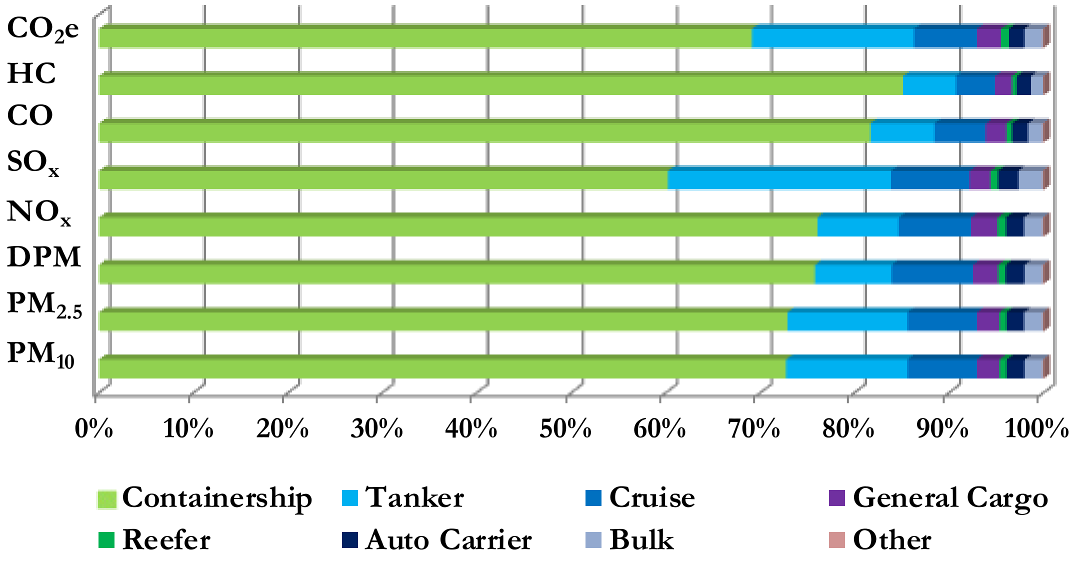
Table 3.18: 2013 Ocean-Going Vessel Emissions by Vessel Type

Vessel Type	**PM_{10} tpy**	**$PM_{2.5}$ tpy**	**DPM tpy**	**NO_x tpy**	**SO_x tpy**	**CO tpy**	**HC tpy**	**CO_2e tonnes**
Auto Carrier	1.95	1.81	1.80	66.9	11.4	7.1	3.2	3,181
Bulk	2.00	1.85	1.75	67.6	13.2	6.4	2.7	3,699
Bulk - Heavy Load	0.04	0.04	0.03	1.4	0.3	0.1	0.1	93
Container - 1000	2.03	1.88	1.90	85.0	5.2	10.5	5.0	4,280
Container - 2000	6.81	6.30	5.61	236.6	38.3	26.3	12.4	14,353
Container - 3000	3.52	3.28	3.07	131.7	14.1	16.4	8.4	6,880
Container - 4000	16.60	15.32	15.16	584.9	75.2	72.1	38.0	26,480
Container - 5000	8.90	8.27	7.92	282.6	46.5	35.7	19.4	13,686
Container - 6000	20.61	18.96	18.41	711.8	78.1	96.5	53.0	35,713
Container - 7000	1.93	1.73	1.72	80.2	3.5	10.7	5.8	4,108
Container - 8000	8.56	7.95	7.57	291.7	31.5	41.6	22.8	15,446
Container - 9000	7.30	6.74	6.50	254.3	27.7	34.4	17.9	13,712
Cruise	7.66	7.10	7.66	266.6	44.2	22.9	8.9	12,968
General Cargo	2.53	2.34	2.39	99.7	11.8	9.2	3.8	4,993
Ocean Tugboat (ATB/ITB)	0.65	0.60	0.65	21.2	3.7	1.9	0.8	1,047
Miscellaneous	0.02	0.02	0.02	0.8	0.1	0.1	0.0	40
Reefer	0.77	0.70	0.70	29.7	4.1	2.6	1.1	1,558
Tanker - Chemical	5.00	4.63	2.86	120.5	46.1	11.8	5.0	13,937
Tanker - Handysize	1.74	1.62	1.15	48.9	15.7	4.2	1.7	4,383
Tanker - Panamax	6.84	6.09	3.16	133.0	63.9	12.5	5.3	15,246
Total	**105.46**	**97.23**	**90.03**	**3,515.0**	**534.9**	**423.0**	**215.3**	**195,804**

DB ID692

Figure 3.3 shows percentage of emissions by vessel type for each pollutant. Containerships contributed the highest percentage of the emissions (approximately 60 to 85%), followed by tankers (approximately 5 to 22%), cruise ships (approximately 4 to 8%), general cargo, auto carrier, reefer, and bulk vessels. The "other" category includes ocean-going tugboats and miscellaneous vessels.

Figure 3.3: 2013 Ocean-Going Vessel Emissions by Vessel Type



3.6.1 Emission Estimates by Engine Type

Table 3.19 presents summaries of emission estimates by engine type in tons per year.

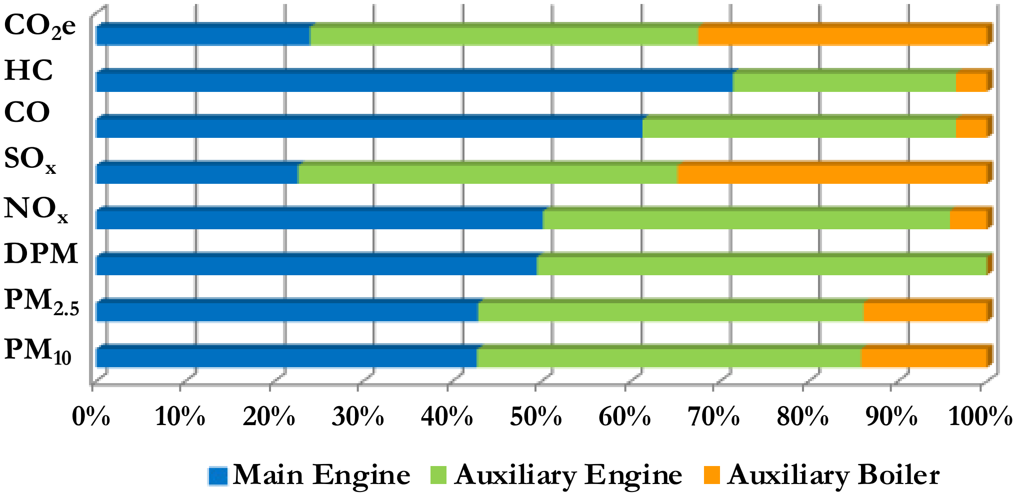
Table 3.19: 2013 Ocean-Going Vessel Emissions by Engine Type

Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
	tpy	tpy	tpy	tpy	tpy	tpy	tpy	tonnes
Main Engine	45.36	41.92	44.69	1,769.8	123.1	259.8	153.99	47,472
Auxiliary Engine	45.34	41.92	45.34	1,599.5	227.2	148.4	53.97	85,088
Auxiliary Boiler	14.76	13.39	0.00	145.7	184.6	14.7	7.36	63,244
Total	**105.46**	**97.23**	**90.03**	**3,515.0**	**534.9**	**423.0**	**215.3**	**195,804**

DB ID692

Figure 3.4 shows percentages of emissions by engine type for each pollutant. The majority of OGV emissions are associated with main and auxiliary diesel engines.

Figure 3.4: 2013 Ocean-Going Vessel Emissions by Engine Type



3.6.2 Emission Estimates by Mode

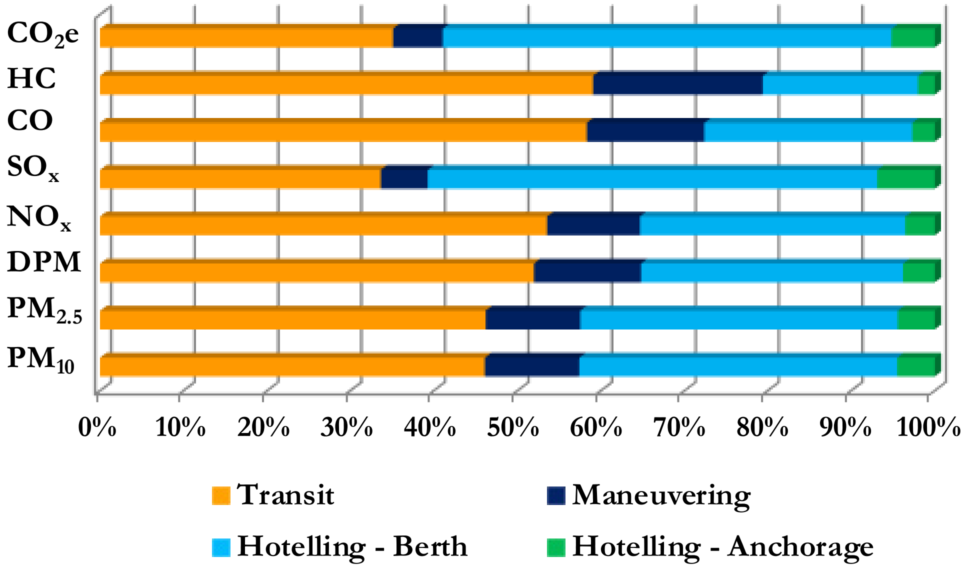
Table 3.20 presents summaries of emission estimates by the various modes in tons per year. For each mode, the engine type emissions are also listed. Hotelling at terminal berth and at-anchorage are listed separately. Transit and harbor maneuvering emissions include both berth and anchorage calls. Figure 3.5 shows results in percentages of emissions by mode.

Table 3.20: 2013 Ocean-Going Vessel Emissions by Mode

Mode	Engine Type	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
Transit	Main	37.58	34.73	36.93	1,518.3	115.9	213.2	114.8	44,519
Transit	Aux	9.87	9.12	9.87	351.1	50.0	32.1	11.7	18,402
Transit	Auxiliary Boiler	1.18	1.09	0.00	13.4	14.1	1.4	0.7	5,805
Total Transit		**48.63**	**44.94**	**46.80**	**1,882.8**	**180.0**	**246.7**	**127.2**	**68,725**
Maneuvering	Main	7.78	7.19	7.76	251.5	7.2	46.6	39.2	2,953
Maneuvering	Aux	3.79	3.50	3.79	135.2	18.8	12.5	4.5	7,143
Maneuvering	Auxiliary Boiler	0.34	0.31	0.00	3.7	4.1	0.4	0.2	1,593
Total Maneuvering		**11.91**	**11.00**	**11.55**	**390.4**	**30.1**	**59.4**	**43.9**	**11,689**
Hotelling - Berth	Main	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0
Hotelling - Berth	Aux	28.27	26.13	28.27	998.4	138.8	93.5	34.0	53,601
Hotelling - Berth	Auxiliary Boiler	11.92	10.84	0.00	119.0	149.4	12.0	6.0	51,626
Total Hotelling - Berth		**40.20**	**36.97**	**28.27**	**1,117.4**	**288.2**	**105.5**	**40.0**	**105,227**
Hotelling - Anchorage	Main	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0
Hotelling - Anchorage	Aux	3.41	3.16	3.41	114.7	19.6	10.4	3.8	5,944
Hotelling - Anchorage	Auxiliary Boiler	1.32	1.15	0.00	9.7	17.1	1.0	0.5	4,220
Total Hotelling - Anchorage		**4.73**	**4.31**	**3.41**	**124.4**	**36.6**	**11.3**	**4.3**	**10,164**
Total		**105.46**	**97.23**	**90.03**	**3,515.0**	**534.9**	**423.0**	**215.33**	**195,804**

DB ID694

Figure 3.5: 2013 Ocean-Going Vessel Emissions by Mode



3.7 Facts and Findings

Table 3.21 presents the number of vessel calls and the container cargo throughputs for calendar years 2005 through 2013. The average number of twenty-foot equivalent units (TEUs) per containership call was 9% lower than the prior year, but up 6% from the 2005 level demonstrating an overall increasing trend in TEU/call efficiency. On average, TEU density per call was the highest in 2012 than in any of the previous years.

Table 3.21: Container and Cargo Throughputs and Change

Year	All Arrivals	Containership Arrivals	TEUs	Average TEUs/Call
2013	2,033	1,463	7,867,863	5,378
2012	1,968	1,370	8,077,714	5,896
2011	2,072	1,376	7,940,511	5,771
2010	2,035	1,355	7,831,902	5,780
2009	2,010	1,355	6,748,995	4,981
2008	2,241	1,459	7,849,985	5,380
2007	2,528	1,577	8,355,038	5,298
2006	2,707	1,632	8,469,853	5,190
2005	2,516	1,479	7,484,625	5,061
Previous Year (2013-2012)	**3%**	**7%**	**-3%**	**-9%**
CAAP Progress (2013-2005)	**-19%**	**-1%**	**5%**	**6%**

Figure 3.6 presents the trends in the total throughput in TEUs, vessel calls and TEUs/call for 2005 to 2013. The TEUs/container call efficiency decreased 9% in 2013 as shown in Figure 3.7. The average TEUs/container call efficiency was at its peak in 2012 and the lowest in 2009 due to low TEU throughput caused by the economic downturn.

Figure 3.6: Container and Cargo Throughput Trend

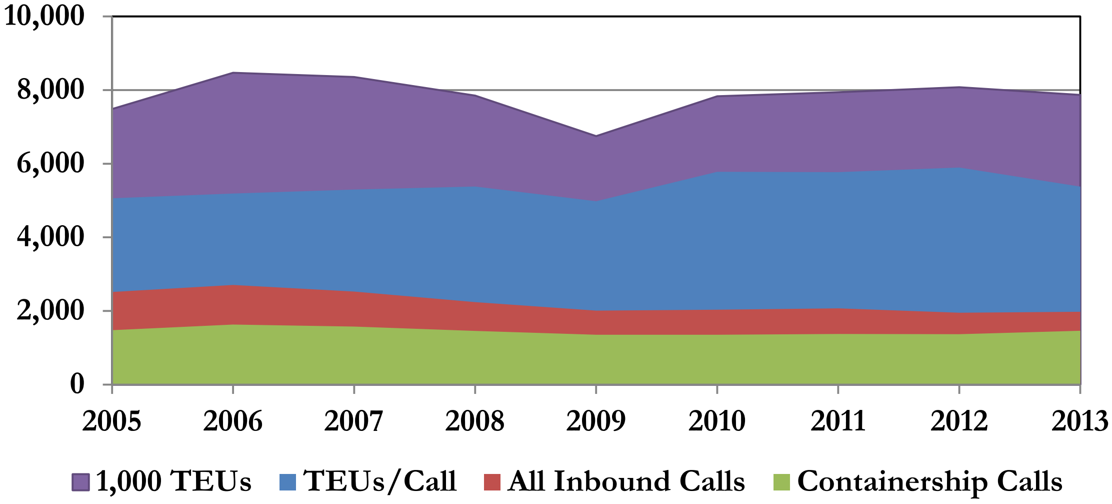
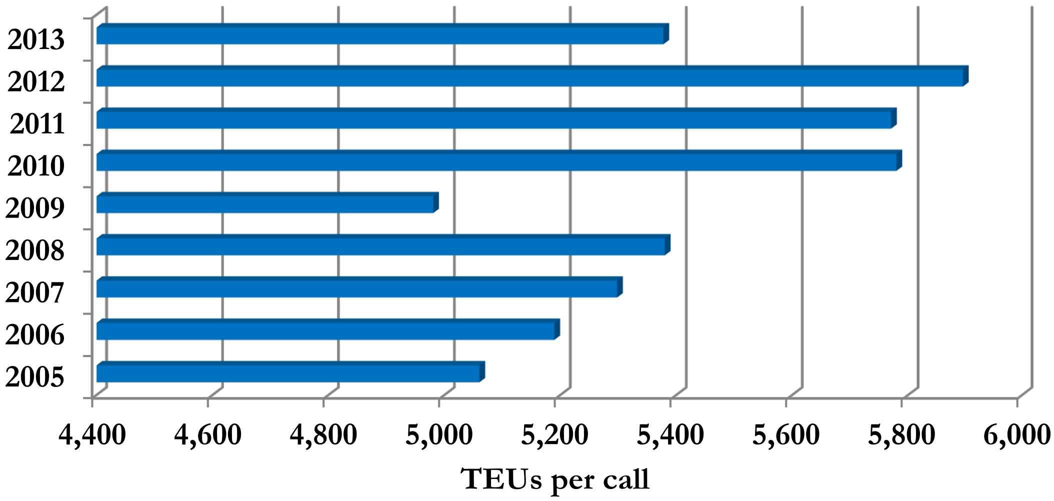


Figure 3.7: TEU Throughput per Call



3.7.1 Flags of Convenience

Most OGVs are foreign flagged ships, whereas harbor craft are almost exclusively domestic. Approximately 96% of the OGVs that visited the Port were registered outside the U.S. Although only 4% of the individual OGVs are registered in the U.S., they comprised 11% of all calls. This is most likely because the U.S. flagged OGVs make shorter, more frequent stops along the west coast. Figures 3.8 and 3.9 show the breakdown of the ships' registered country (i.e., flag of registry) for discrete vessels and by the number of calls, respectively. Please note that due to decimal rounding, some of the pie charts come out less than 100%.

Figure 3.8: Flag of Registry, Discrete Vessels

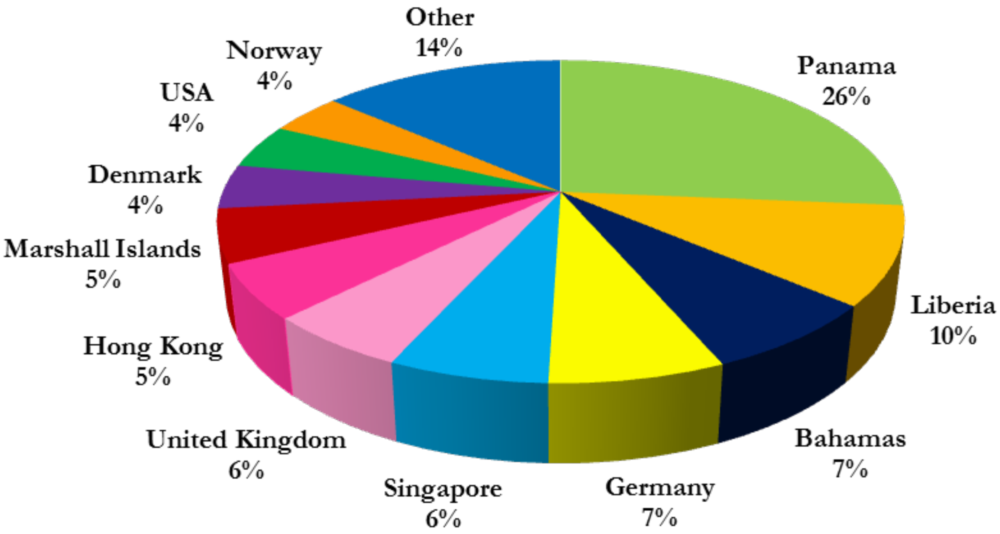
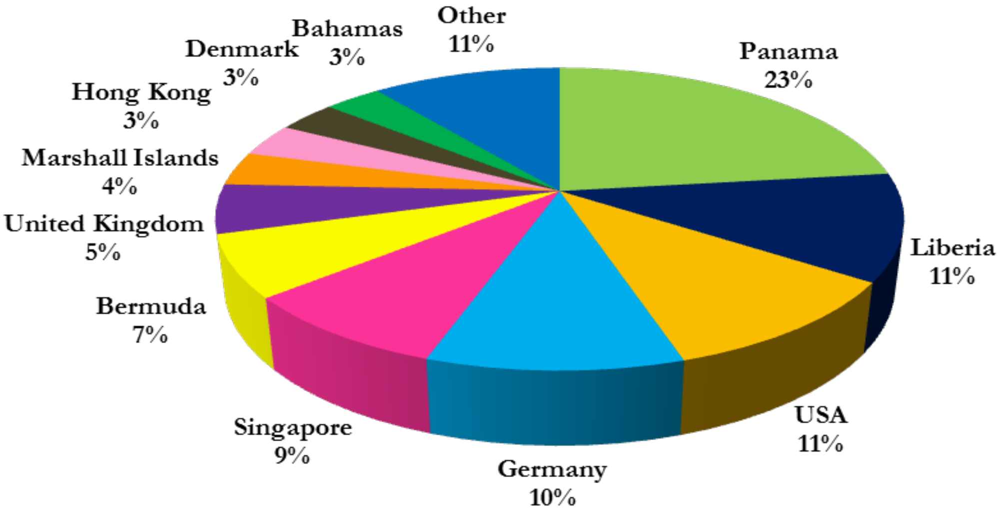


Figure 3.9: Flag of Registry, Vessel Calls



3.7.2 Next and Last Port of Call

Figures 3.10 and 3.11 summarize the next (to) port and last (from) port, respectively, for vessels that called in 2013.

Figure 3.10: Next (To) Port

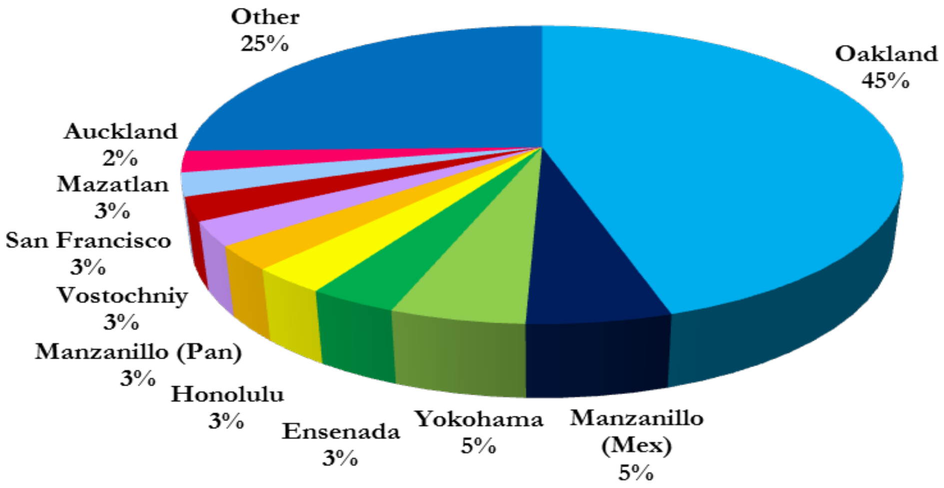
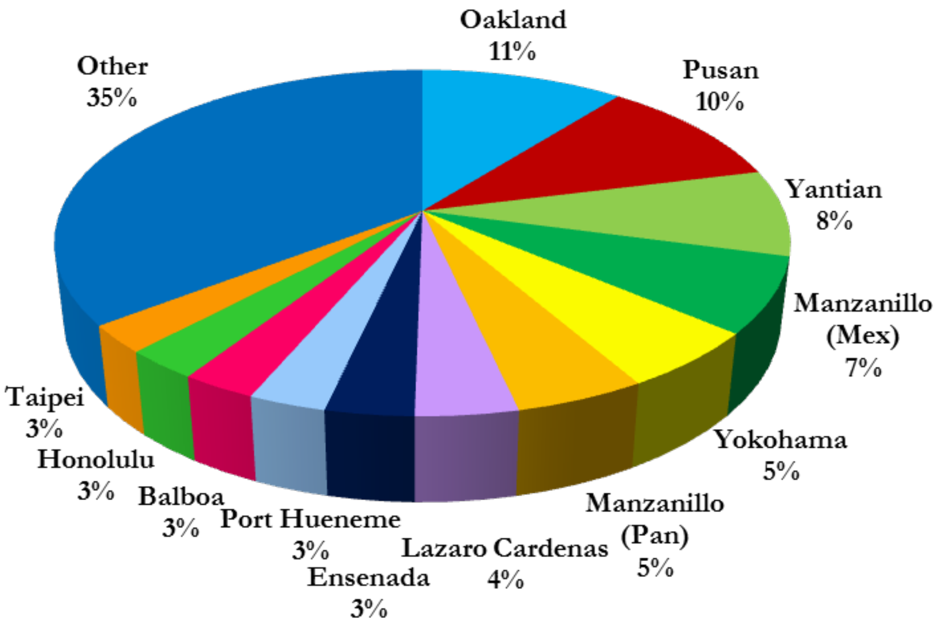


Figure 3.11: Last (From) Port



3.7.3 Vessel Characteristics

Table 3.22 summarizes the vessel and engine characteristics averages by vessel type from the Lloyd's dataset. The year built, DWT, speed, and main engine power ratings are averages based on the specific vessels that called the Port in 2013. Due to the large number of containerships and tankers that call the Port and their variety, the vessels were divided by vessel types. For some vessel types, there was no data available for certain characteristics and these are labeled "na."

Table 3.22: Vessel Type Average Characteristics

				Average		
Vessel Type	**Year Built**	**Age (Years)**	**DWT (tonnes)**	**Max Speed (knots)**	**Main Eng (kW)**	**Aux Eng (kW)**
Auto Carrier	2004	9	25,048	19.7	12,930	3,198
Bulk	2007	6	50,582	14.3	8,249	2,036
Bulk - Heavy Load	1986	27	na	14.5	10,297	na
Container - 1000	2007	6	14,587	20.1	16,727	5,400
Container - 2000	2004	9	38,640	22.0	22,576	5,830
Container - 3000	2006	7	45,510	22.5	29,424	3,900
Container - 4000	2001	12	60,853	24.0	40,479	6,938
Container - 5000	2001	12	67,460	25.1	52,364	8,136
Container - 6000	2007	6	79,123	25.1	61,214	11,138
Container - 7000	2006	7	78,704	25.3	58,355	11,980
Container - 8000	2008	5	101,000	25.4	67,547	11,473
Container - 9000	2008	5	na	24.9	64,818	11,520
Cruise	2002	11	6,849	21.6	52,184	14,108
General Cargo	2002	11	43,747	15.5	9,903	2,752
Ocean Tugboat (ATB/ITB)	1999	14	798	na	7,421	na
Miscellaneous	1991	22	na	15.0	13,129	na
Reefer	1992	21	12,499	19.1	9,350	3,400
Tanker - Chemical	2007	6	26,663	14.8	8,323	2,653
Tanker - Handysize	2004	9	45,728	14.7	8,696	1,838
Tanker - Panamax	2004	9	70,610	14.9	11,573	2,587

DB ID695

Starting in 2012, the method of assigning vessel year was updated to be based on keel laid date, as opposed to engine year which was used in previous inventories. The resulting vessel year, as assigned by keel laid date, is used when assigning vessel tiers. This adjustment was made because Tier 2 vessels or vessels with a keel laid date on or after January 1, 2011, were present in this inventory.

Figures 3.12 through 3.16 show the various vessel type characteristics.

Figure 3.12: Average Age of Vessels, years

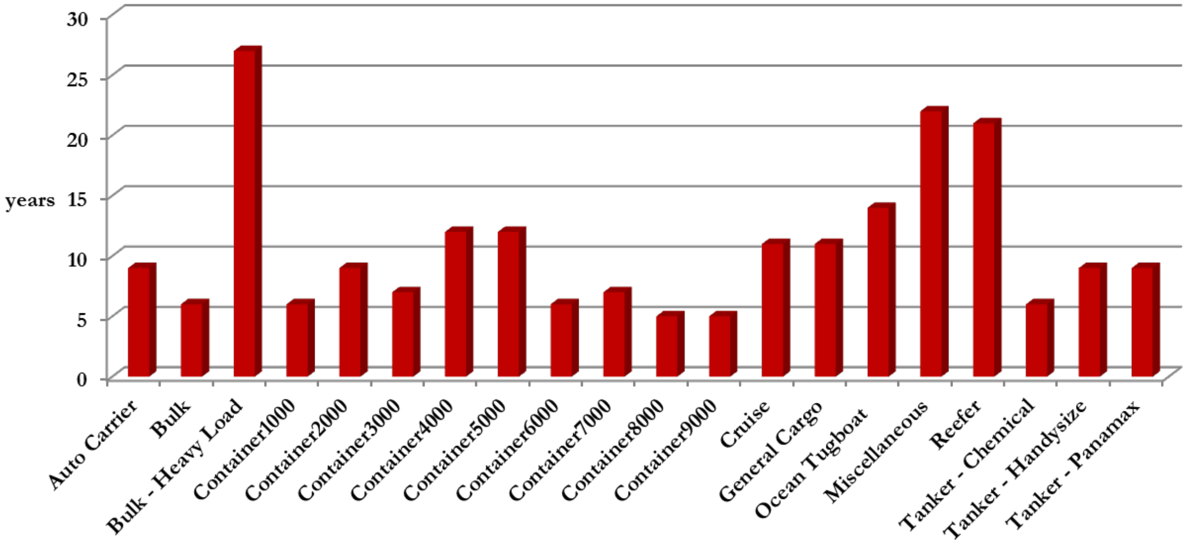


Figure 3.13: Average Maximum Rated Sea Speed, knots

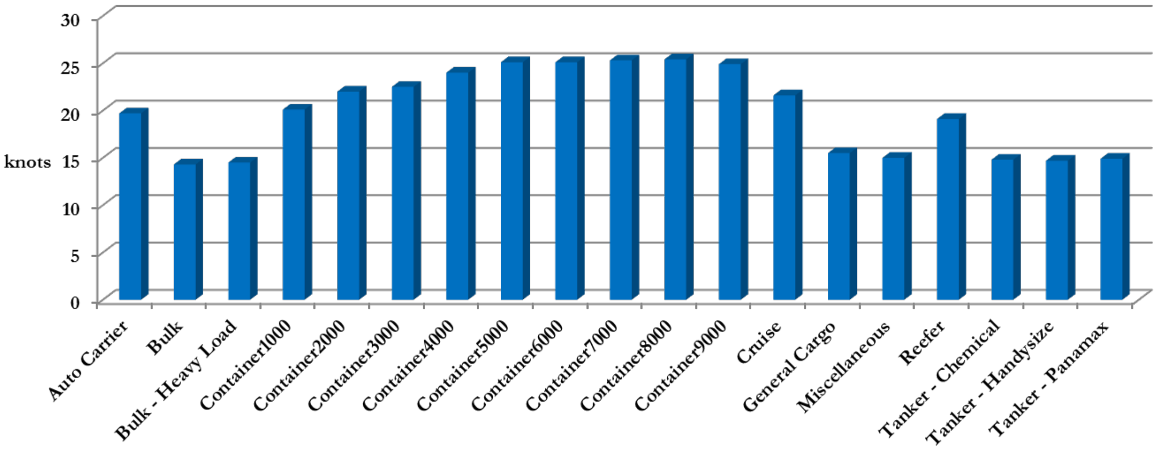


Figure 3.14: Average Deadweight, tons

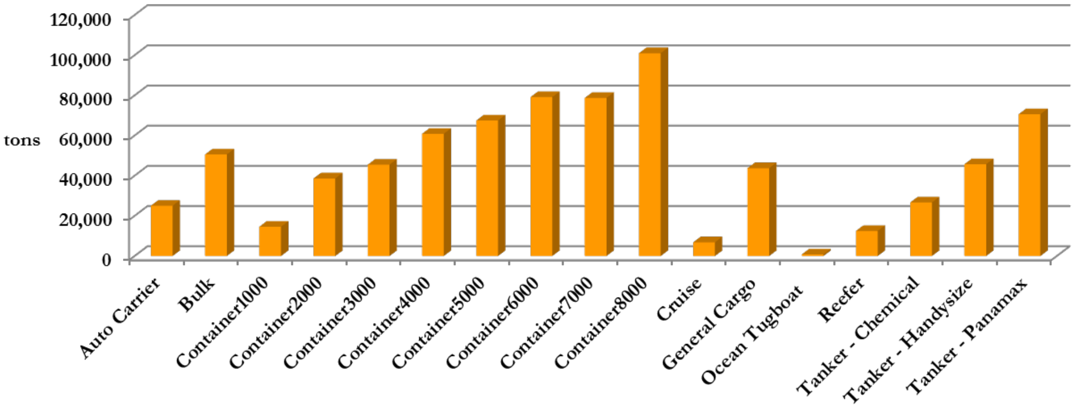


Figure 3.15: Average Main Engine Total Installed Power, kilowatts

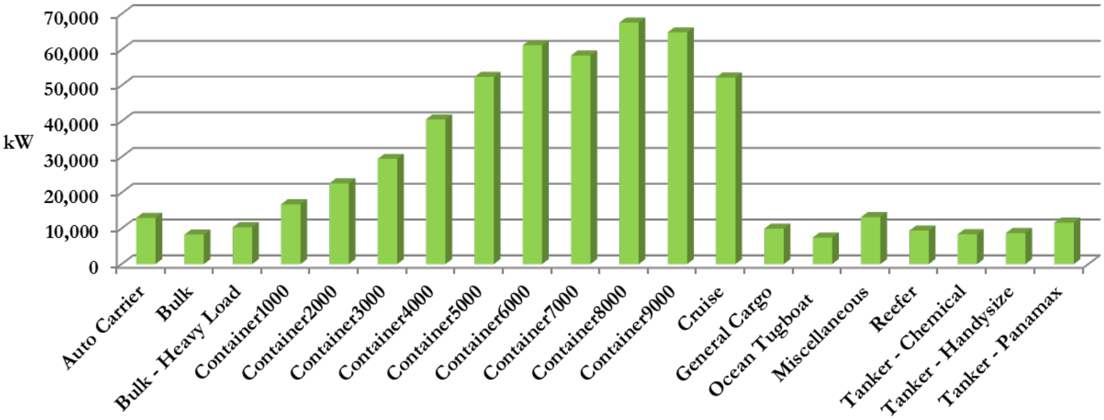
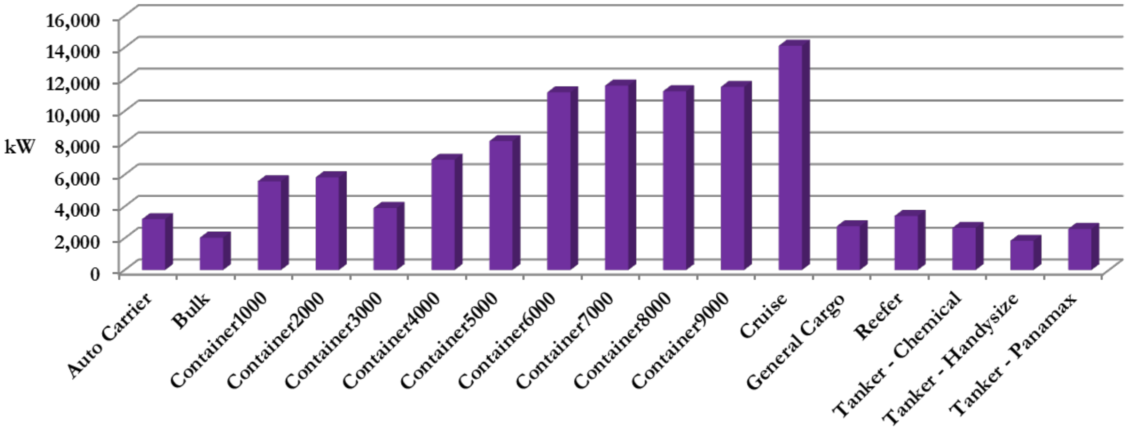


Figure 3.16: Average Auxiliary Engine Total Installed Power, kilowatts



3.7.4 Hotelling Time At-Berth and Anchorage

Tables 3.23 and 3.24 summarize the berth and anchorage hotelling times, respectively. Note that for vessels using AMP, the hotelling times represent the time that the diesel auxiliary engines are operating during hotelling and not the total at-berth dwell time.

Table 3.23: Hotelling Times At-Berth by Vessel Type, hours

Vessel Type	Berth Hotelling Time, hours		
	Min	Max	Avg
Auto Carrier	2.5	47.8	16.8
Bulk	8.8	162.5	69.7
Bulk - Heavy Load	319.8	319.8	319.8
Container - 1000	8.7	33.3	20.2
Container - 2000	5.1	90.0	24.5
Container - 3000	3.0	82.5	39.5
Container - 4000	7.1	76.5	30.0
Container - 5000	6.6	85.2	45.0
Container - 6000	10.5	121.5	59.5
Container - 7000	44.9	84.6	62.3
Container - 8000	23.1	133.8	78.3
Container - 9000	36.3	111.5	73.3
Cruise	3.1	35.2	10.4
General Cargo	10.9	157.9	52.7
Ocean Tugboat (ATB/ITB)	10.7	52.6	28.9
Miscellaneous	44.1	44.1	44.1
Reefer	3.4	97.4	27.2
Tanker - Chemical	11.3	75.6	30.9
Tanker - Handysize	15.0	115.6	44.6
Tanker - Panamax	15.4	99.5	41.8

DB ID705

Table 3.24 shows the range and average of hotelling times at-anchorage with the actual vessel counts for each vessel subtype that visited the anchorages.

Table 3.24: Hotelling Times at Anchorage by Vessel Type, hours

Vessel Type	Min	Max	Avg	Vessel Count
Auto Carrier	5.0	16.0	9.0	2
Bulk	2.3	149.0	29.6	46
Container - 1000	3.1	13.7	8.3	4
Container - 2000	2.7	40.6	15.6	6
Container - 3000	1.6	4.7	3.2	2
Container - 4000	2.4	309.1	34.5	12
Container - 5000	31.6	31.6	31.6	1
Container - 6000	3.7	22.2	9.6	9
Container - 8000	2.9	3.3	3.1	2
General Cargo	2.8	106.3	38.2	17
Ocean Tugboat (ATB/ITB)	0.4	179.9	21.0	5
Reefer	0.8	0.8	0.8	1
Tanker - Chemical	2.7	591.5	27.0	39
Tanker - Handysize	2.3	153.4	39.6	8
Tanker - Panamax	2.1	640.4	73.0	40

DB ID705

3.7.5 Frequent Callers

For purpose of this discussion, a frequent caller is a vessel that made six or more calls in one year. The vessels that called a berth at the Port were included, while the vessels that only went to anchorage were not. Table 3.25 shows the percentage of repeat vessels. Container vessels, cruise ships, auto carriers, and handysize tankers had the highest percentage of frequent callers. Reefer, general cargo, ocean tugs, and bulk vessels are not frequent callers.

Table 3.25: Count and Percentage of Frequent Callers

Vessel Type	Frequent Vessels	Total Vessels	Percent Frequent Vessels
Auto Carrier	5	43	12%
Bulk	0	77	0%
Bulk - Heavy Load	0	1	0%
Container - 1000	10	13	77%
Container - 2000	21	35	60%
Container - 3000	10	19	53%
Container - 4000	22	84	26%
Container - 5000	10	25	40%
Container - 6000	24	55	44%
Container - 7000	3	8	38%
Container - 8000	9	27	33%
Container - 9000	3	26	12%
Cruise	3	22	14%
General Cargo	2	41	5%
Ocean Tugboat (ATB/ITB)	2	7	29%
Miscellaneous	0	1	0%
Reefer	0	15	0%
Tanker - Chemical	3	58	5%
Tanker - Handysize	1	8	13%
Tanker - Panamax	0	41	0%
Total	**128**	**606**	
Average			**21%**

DB ID706

SECTION 4 HARBOR CRAFT

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

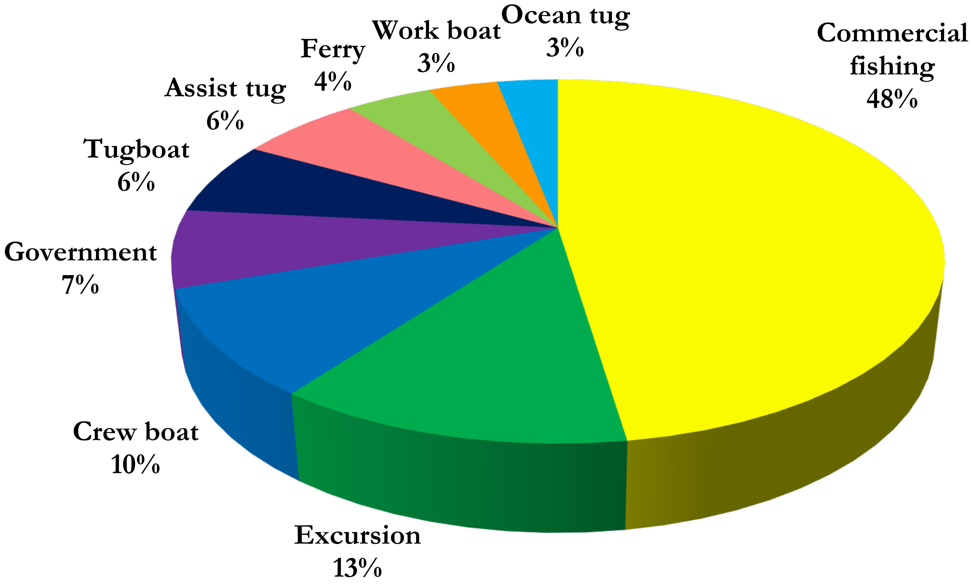
4.1 Source Description

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

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

Recreational vessels are not considered to be commercial harbor craft; therefore their emissions are not included in this inventory. Figure 4.1 presents the distribution of the 231 commercial harbor craft inventoried for the Port in 2013. Commercial fishing vessels by count represent 48% of the harbor craft inventoried, followed by excursion vessels (13%), crew boats (10%), government vessels (7%), tugboats (6%), assist tugs (6%), ferries (4%), work boats (3%), and ocean tugs (3%).

Figure 4.1: Distribution of 2013 Commercial Harbor Craft by Vessel Type



Ocean tugs included in this section are different from the integrated tug barge (ITB) and articulated tug barge (ATB) discussed in the ocean-going section of this report. ITB and ATB are seen as specialized single vessels 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 at the Port, but may make frequent calls with barges. They are different from harbor tugboats because their engine loads are higher than harbor tugboats, which tend to idle more in-between jobs. Tugboats are typically home-ported in San Pedro Bay harbor and primarily operate within the harbor area, but can also operate outside the harbor based on work assignments.

4.2 Geographical Delineation

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

Figure 4.2: Geographical Extent of Harbor Craft Inventory

4.3 Data and Information Acquisition

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

- Vessel owners and/or operators
- Port Wharfingers data for commercial fishing vessels at Port-owned berths
- SCAQMD Carl Moyer Program for engine repower information, when the data is not readily available from owner (e.g. commercial fishing vessels)

The operating parameters of interest include the following:

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

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

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

Commercial fishing vessels:
  - Port Wharfingers for Berth 73 and Fish Harbor vessels

Ferry vessels:
  - Catalina Express
  - Seaway Co. of Catalina

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

Work boats:
- Pacific Tugboat Services
- Jankovich

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

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

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

It should be noted that engine specific information for individual commercial fishing vessels is not readily available due to difficulty in contacting the commercial fishing vessel operators. The Port's data from the Wharfinger Division were used to identify the commercial fishing vessels moored at the Port-owned marinas and to determine the total number of vessels compared to prior years. The engine power and activity hours for these vessels were primarily based on CARB's commercial harbor craft survey results, with limited information obtained from some vessel operators.

4.4 Operational Profiles

Commercial harbor craft companies were identified and contacted to obtain the operating parameters for their vessels. Tables 4.1 and 4.2 summarize the main and auxiliary engine data, respectively, for each vessel type. The averages by vessel type have been used as defaults for vessels for which the model year, horsepower, or operating hour information is missing. Operational hours for the vessels that were not conducted at the Port for the entire year reflect the partial time they operated at the Port during the 2013 calendar year. The engine count includes old and new engines for those specific vessels that were repowered during the year 2013 and provided 2013 activity hours worked by both old and new engines. The majority of repowers that occurred in 2013 only include new engine data either because it was repowered at the beginning of the year or the owner did not have the detailed information (i.e. month of repower) as in the case of commercial fishing vessels. For vessels that were at the port, there were 23 repowers in 2013.

This emissions inventory covers harbor craft that operate in the Port of Los Angeles harbor most of the time. There are a number of companies that operate harbor craft in both the Ports of Los Angeles and Long Beach harbors. The activity hours for the vessels that are common to both ports reflect work performed during 2013 for the Port of Los Angeles harbor only.

Table 4.1: 2013 Summary of Propulsion Engine Data by Vessel Category

Harbor	Vessel	Engine	Model year			Horsepower			Annual Operating Hours		
Craft Type	**Count**	**Count**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Assist tug	14	29	1980	2012	2003	600	2,540	1,908	91	2,163	1,197
Commercial fishing	110	116	1957	2012	1999	50	350	217	200	1,300	885
Crew boat	22	51	2003	2012	2009	180	1,450	535	0	1,545	527
Excursion	29	57	1972	2012	2005	150	530	359	275	2,400	1,428
Ferry	10	24	2003	2013	2009	600	2,300	1,875	600	1,200	1,063
Government	16	29	1988	2012	2004	68	1,800	534	0	1,014	303
Ocean tug	7	14	1991	2012	2003	805	3,385	1,942	200	1,500	846
Tugboat	15	30	2001	2012	2008	200	1,500	683	0	780	358
Work boat	8	15	2005	2013	2010	135	1,000	509	120	2,000	983
Total	**231**	**365**									

DB ID423

Table 4.2: 2013 Summary of Auxiliary Engine Data by Vessel Category

Harbor	Vessel	Engine	Model year			Horsepower			Annual Operating Hours		
Craft Type	**Count**	**Count**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Assist tug	14	31	1980	2013	2007	67	450	179	75	3,486	1,226
Commercial fishing	110	36	1957	2012	2006	10	40	26	100	1,200	625
Crew boat	22	21	1980	2012	2007	11	76	48	0	1,871	669
Excursion	29	32	1966	2012	2004	7	54	41	275	2,400	1,444
Ferry	10	16	2003	2013	2009	18	120	60	300	1,200	750
Government	16	11	2003	2012	2006	50	400	204	20	887	190
Ocean tug	7	15	1991	2012	2004	60	253	117	200	977	583
Tugboat	15	21	2005	2012	2009	22	107	48	0	636	291
Work boat	8	12	1968	2013	2002	27	101	59	0	2,000	639
Total	**231**	**195**									

DB ID422

Harbor craft engines with known model year and horsepower are categorized according to their respective EPA marine engine standards. In the case where engine information gathered from harbor craft operators fails to identify the specific EPA certification standards or "tier" level, the tier level is assumed for that engine based on emission standards.[68] Table 4.3 summarizes various tier definitions which have been updated from the previous inventory. These assumptions are consistent with CARB's harbor craft emission factors, which follow the same model year grouping as EPA emissions standards for marine engines.

Table 4.3: Harbor Craft Marine Engine EPA Tier Levels

EPA Tier Level	Marine Engine Model Year Range	Horsepower Range
Tier 0	1999 and older	All
Tier 1	2000 to 2003	≤ 500 hp
Tier 1	2000 to 2006	> 500 hp
Tier 2	2004 up to Tier 3	≤ 500 hp
Tier 2	2007 up to Tier 3	> 500 hp
Tier 3	2009 and newer	0 to 120 hp
Tier 3	2013 and newer	> 120 to 175 hp
Tier 3	2014 and newer	> 175 to 500 hp
Tier 3	2013 and newer	> 500 to 750 hp
Tier 3	2012 to 2017	> 750 to 1,900 hp
Tier 3	2013 to 2016	> 1,900 to 3,300 hp
Tier 3	2014 to 2016	> 3,300 hp

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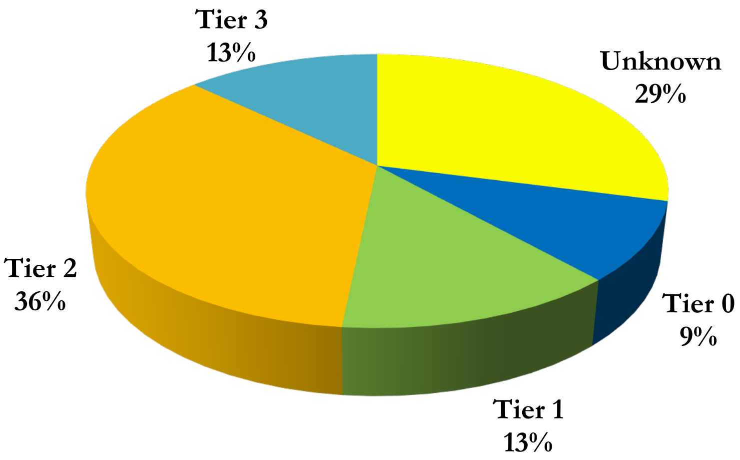
[68] CFR (Code of Federal Regulation), 40 CFR, subpart 94.8 for Tier 1 and 2 and subpart 1042.101 for Tier 3

Figure 4.3 provides the population distribution of all harbor craft propulsion and auxiliary engines operating at the Port in 2013. If model year and/or horsepower information are not available, the engines are classified as "unknown".

Figure 4.3: Distribution of Harbor Craft Engines by Engine Standards



4.5 Emissions Estimation Methodology

The emissions calculation parameters, methodologies, and equations are described in this section. Emissions were estimated on a per engine basis, i.e., the main and auxiliary engines emissions were estimated individually. In order to ensure consistency, the Port's harbor craft emissions calculations methodology is primarily based on CARB's latest harbor craft emissions calculations methodology, with the exceptions noted in this section.[69]

4.5.1 Emissions Calculation Equations

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

Equation 4.1

$$E = Power \times Activity \times LF \times EF \times FCF$$

Where:

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

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[69] CARB, *Appendix B: Emissions Estimation Methodology for Commercial Harbor Craft Operating in California*, 2007

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

Equation 4.2

$$\boldsymbol{EF = ZH + (DR \times Cumulative\ Hours)}$$

Where:

ZH = zero-hour emission rate for a given engine size category and model year when the engine is new and there is no component malfunctioning, g/hp-hr or g/kW-hr
DR = deterioration rate (rate of change of emissions as a function of equipment age), g/hp-hr2 or g/kW-hr2
Cumulative hours = total number of hours the engine has been in use and calculated as annual operating hours times age of the engine, hours

The equation for the deterioration rate is:

Equation 4.3

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

Where:

DR = deterioration rate, g/hp-hr2 or g/kW-hr2
DF = deterioration factor, percent increase in emissions at the end of the useful life, percent
ZH = zero-hour emission rate for a given engine size category and model year when the engine is new and there is no component malfunctioning, g/hp-hr or g/kW-hr
Cumulative hours at the end of useful life = annual operating hours times useful life in years, hours

Per CARB, useful life for harbor craft is defined as the age at which 50% of the engines are retired from the fleet. It is assumed that all the engines will be retired at the age of twice the useful life.

4.5.2 Emission Factors, Deterioration Factors and Useful Life

Zero hour emission factors, deterioration factors, and useful life for commercial harbor craft are based on CARB's latest methodology, with the exception of greenhouse gas emission factors and the SO_x emission factor.

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

Equation 4.4

$$SOx\ EF = S\ content \times \frac{molecular\ mass\ of\ SO_2}{atomic\ mass\ of\ S} \times BSFC$$

Where:

SOx EF = Emission factor for SOx, g/hp-hr
S content = sulfur content of the fuel, ppm
BSFC = brake specific fuel consumption, g/hp-hr

Greenhouse gas emissions factors for harbor craft are continuously evolving as more researches are conducted and reviewed; therefore some variability in emission factors is recommended and used by different groups. Emission factors for CO_2, CH_4, and N_2O are sourced from the 2004 IVL study for this inventory, and are listed in Appendix B[70]. The IVL study establishes the CH_4 emission factor as 2% of the hydrocarbon emission factor. Tables 4.4 and 4.5 provide the CARB deterioration factors and useful life for harbor craft engines, respectively.

Table 4.4: Engine Deterioration Factors for Harbor Craft Diesel Engines

Power Range (hp)	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
25-50	0.31	0.06	0.00	0.41	0.51	0.00	0.00	0.00
51-250	0.44	0.14	0.00	0.16	0.28	0.00	0.00	0.00
>250	0.67	0.21	0.00	0.25	0.44	0.00	0.00	0.00

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[70] IVL, 2004

Table 4.5: Useful Life by Harbor Craft Type and Engine Type, years

Harbor Craft Type	Auxiliary Engines	Main Engines
Assist tug	23	21
Commercial fishing	15	21
Crew boat	28	28
Excursion	20	20
Ferry	20	20
Government	25	19
Ocean tug	25	26
Tugboat	23	21
Work boat	28	28

DB ID703

4.5.3 Fuel Correction Factors

Fuel correction factors are applied to adjust the emission rates for changes in fuel properties. For this inventory, fuel correction factors were used to account for ULSD use by all harbor craft. Fuel correction factors used for NO_X, HC, and PM take into account the properties of California diesel fuel, which is different from EPA diesel fuel. Table 4.5 summarizes the fuel correction factors used for harbor craft. The FCF for SO_x reflects the change from diesel fuel with an average sulfur content of 350 ppm to ULSD (15 ppm). Due to the lack of any additional information, it was reasonable to assume that the fuel correction factor for NO_x is also applicable to N_2O emissions, and the fuel correction factor for HC is also applicable to CH_4 emissions.

Table 4.6: 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	0.04	1.00	0.72	1.00	0.93	0.72
1996 to 2010	0.80	0.948	0.04	1.00	0.72	1.00	0.948	0.72
2011 and newer	0.852	0.948	0.04	1.00	0.72	1.00	0.948	0.72

4.5.4 Load Factors

Engine load factor is used in emissions calculations to reflect the fact that, on average, engines are not used at their maximum power rating. Table 4.7 summarizes the average engine load factors that are used in this inventory for the various harbor craft types for their propulsion and auxiliary engines. All of the dimensionless load factors by vessel type and engine type are the same as what was used for the previous inventory.

Table 4.7: Load Factors

Harbor Craft Type	Auxiliary Engines	Main Engines
Assist tug	0.43	0.31
Commercial fishing	0.43	0.27
Crew boat	0.32	0.38
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	0.32	0.38

DB ID426

Note the 31% engine load factor for assist tugboats is based on actual vessels' main engine load readings published in the Port's 2001 emissions inventory, and is not consistent with the 50% engine load used in CARB's latest methodology.[71] CARB uses 43% engine load for most of the auxiliary engines as listed in Table 4.7, except for tugboats, crew boats, and work boats. Except for crew boats and work boats which have been modified to 32% to reflect CARB's recently-revised auxiliary engine load for crew boats and work boats[72], the Port uses 43% engine load for most auxiliary engines, including assist tugs,

4.5.5 Improvements to Methodology from Previous Year

The emissions calculation methodology and the emission rates are same as the ones used to estimate harbor craft emissions for the Port's 2012 EI.

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[71] CARB, *Emissions Estimation Methodology for Commercial Harbor Craft Operating in California, Appendix B*, 2012

[72] CARB, *www.arb.ca.gove/ports/marineves/harborcraft/documents/amdendcseidoc050410.xls*

4.6 Emission Estimates

The following tables present the estimated harbor craft emissions. In order for the total emissions to be consistently displayed for each pollutant, the individual values in each table column do not, in some cases, add up to the listed total in the table. This is because there are fewer decimal places displayed (for readability) than are included in the calculated total. Table 4.8 summarizes the estimated 2013 harbor craft emissions by vessel type and engine type.

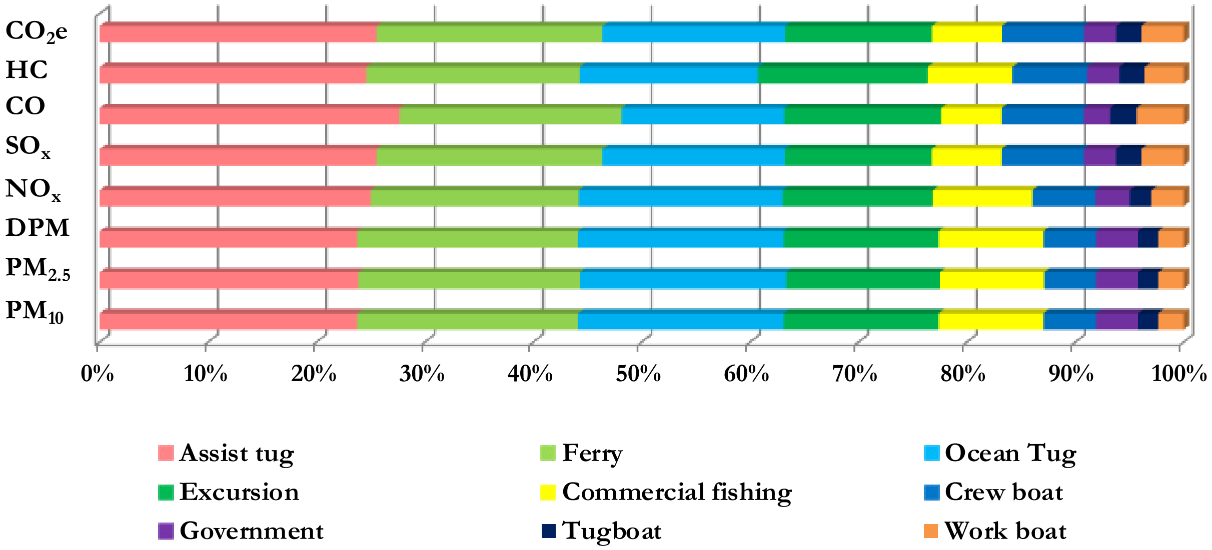
Table 4.8: 2013 Harbor Craft Emissions by Vessel and Engine Type

Harbor Craft Type	Engine Type	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
Assist Tug	Auxiliary	0.48	0.44	0.48	14.2	0.0	11.2	1.8	1,297
	Propulsion	5.80	5.36	5.80	162.1	0.1	91.7	13.9	10,984
Assist Tug Total		**6.28**	**5.80**	**6.28**	**176.3**	**0.1**	**102.9**	**15.7**	**12,281**
Commercial Fishing	Auxiliary	0.09	0.08	0.09	1.6	0.0	1.5	0.6	130
	Propulsion	2.47	2.26	2.47	63.2	0.0	19.2	4.4	2,972
Commercial Fishing Total		**2.56**	**2.34**	**2.56**	**64.8**	**0.0**	**20.7**	**5.0**	**3,102**
Crew boat	Auxiliary	0.07	0.06	0.07	1.3	0.0	1.0	0.3	113
	Propulsion	1.21	1.10	1.21	39.6	0.0	27.0	4.1	3,524
Crew boat Total		**1.28**	**1.16**	**1.28**	**40.9**	**0.0**	**28.0**	**4.4**	**3,637**
Excursion	Auxiliary	0.31	0.28	0.31	5.2	0.0	4.5	1.7	409
	Propulsion	3.47	3.17	3.47	92.4	0.1	49.3	8.3	6,100
Excursion Total		**3.78**	**3.45**	**3.78**	**97.6**	**0.1**	**53.8**	**10.0**	**6,509**
Ferry	Auxiliary	0.07	0.07	0.07	1.6	0.0	1.3	0.4	139
	Propulsion	5.32	4.90	5.32	133.9	0.1	74.9	12.2	9,882
Ferry Total		**5.39**	**4.97**	**5.39**	**135.5**	**0.1**	**76.2**	**12.6**	**10,021**
Government	Auxiliary	0.03	0.03	0.03	0.9	0.0	0.6	0.1	74
	Propulsion	0.99	0.91	0.99	21.7	0.0	8.5	1.8	1,367
Government Total		**1.02**	**0.94**	**1.02**	**22.6**	**0.0**	**9.1**	**1.9**	**1,441**
Ocean Tug (Line Haul)	Auxiliary	0.14	0.13	0.14	3.2	0.0	2.1	0.4	235
	Propulsion	4.87	4.49	4.87	129.3	0.1	53.7	10.1	7,853
Ocean Tug		**5.01**	**4.62**	**5.01**	**132.5**	**0.1**	**55.8**	**10.5**	**8,087**
Tugboat	Auxiliary	0.03	0.03	0.03	0.7	0.0	0.5	0.2	61
	Propulsion	0.47	0.43	0.47	13.3	0.0	8.6	1.3	1,048
Tugboat Total		**0.50**	**0.46**	**0.50**	**14.0**	**0.0**	**9.1**	**1.5**	**1,109**
Work boat	Auxiliary	0.03	0.03	0.03	0.7	0.0	0.6	0.2	64
	Propulsion	0.59	0.54	0.59	20.3	0.0	15.6	2.1	1,817
Work boat Total		**0.62**	**0.57**	**0.62**	**21.0**	**0.0**	**16.2**	**2.3**	**1,881**
Harbor Craft Total		**26.44**	**24.31**	**26.44**	**705.2**	**0.5**	**371.8**	**63.9**	**48,067**

DB ID427

Figure 4.4 shows that approximately 24-28% of the Port's harbor craft emissions are attributed to assist tugs, 19-21% to ferries, 15-19% to ocean tugs, 14-16% to excursion vessels, 6-10% to commercial fishing, 5-8% to crew boats, 2-4% to work boats, 2% to tugboats, and 2-4% to government vessels.

Figure 4.4: 2013 Harbor Craft Emissions Distribution



SECTION 5 CARGO HANDLING EQUIPMENT

This section presents emissions estimates for the cargo handling equipment (CHE) source category, and is organized into six subsections: 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

The CHE category includes equipment that moves cargo (including containers, general cargo, and bulk cargo) to and from marine vessels, railcars, and on-road trucks. The equipment is typically operated at marine terminals or at rail yards and not on public roadways. This inventory includes cargo handling equipment fueled by diesel, gasoline, propane, liquefied natural gas (LNG), and electricity. Due to the diversity of cargo handled by the Port's terminals, there is a wide range of equipment types. The majority of cargo handling equipment can be classified into one of the following equipment types:

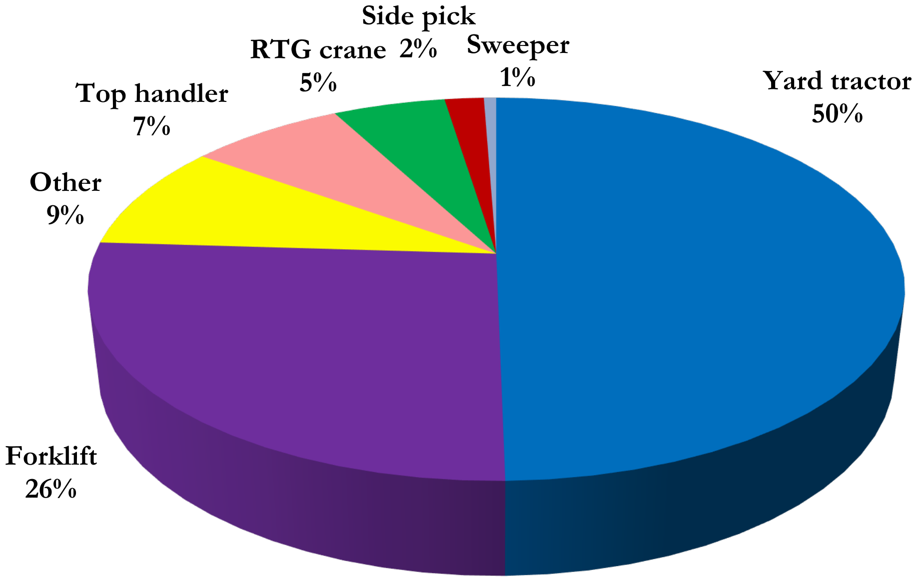
- Forklift
- Rubber tired gantry (RTG) crane
- Side pick
- Sweeper
- Top handler
- Yard tractor
- Other

The "Other" category contains the following equipment types:

- Bulldozer
- Crane
- Loader
- Man lift
- Material handler
- Miscellaneous (portable shear, cone truck)
- Pallet jack
- Rail pusher
- Rail mounted gantry (RMG) crane
- Skid steer loader
- Trucks (fuel, utility, water, vacuum)
- Wharf crane

Figure 5.1 presents the population distribution of the 2,149 pieces of equipment inventoried at the Port for calendar year 2013. The forklift category covers all engine types, including electric forklifts. The 9% for other equipment includes pieces of equipment that are not typical CHE as well as electric equipment (other than electric forklifts which are included in the forklift category).

Figure 5.1: 2013 CHE Count Distribution by Equipment Type



5.2 Geographical Delineation

Figure 5.2 presents the geographical delineation for container, dry bulk, break bulk, liquid bulk, auto, and cruise terminals that operate cargo handling equipment, as well as those equipment at UP's Intermodal Containers Transfer Facility (ICTF) and smaller facilities located within Port boundaries and covered under the port's jurisdiction. Following is the list of the terminals identified in Figure 5.2, by major cargo type, included in the inventory:

Container Terminals:

- Berth 100: West Basin Container Terminal (China Shipping)
- Berths 121-131: West Basin Container Terminal (Yang Ming)
- Berths 136-139: Trans Pacific Container Terminal (Trapac)
- Berths 212-225: Yusen Container Terminal (YTI)
- Berths 226-236: Seaside Terminal (Evergreen)
- Berths 302-305: Global Gateway South (APL)
- Berths 401-404: Pier 400 (A. P. Moeller-Maersk [APM] Terminals)
- Berths 405-405: California United Terminals

Break-Bulk Terminals:

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

Dry Bulk Terminals:

- California Sulfur
- LA Grain
- Berths 165-166: Rio Tinto/Borax

Liquid Terminals:

- Berths 118-119: Kinder Morgan
- Berths 148-151: ConocoPhillips
- Berths 163: NuStar Energy
- Berth 164: Valero
- Berths 167-169: Shell Oil
- Berths 187-191: Vopak
- Berths 238-240: ExxonMobil

Auto Terminal:

- Berths 195-199: WWL Vehicle Services Americas

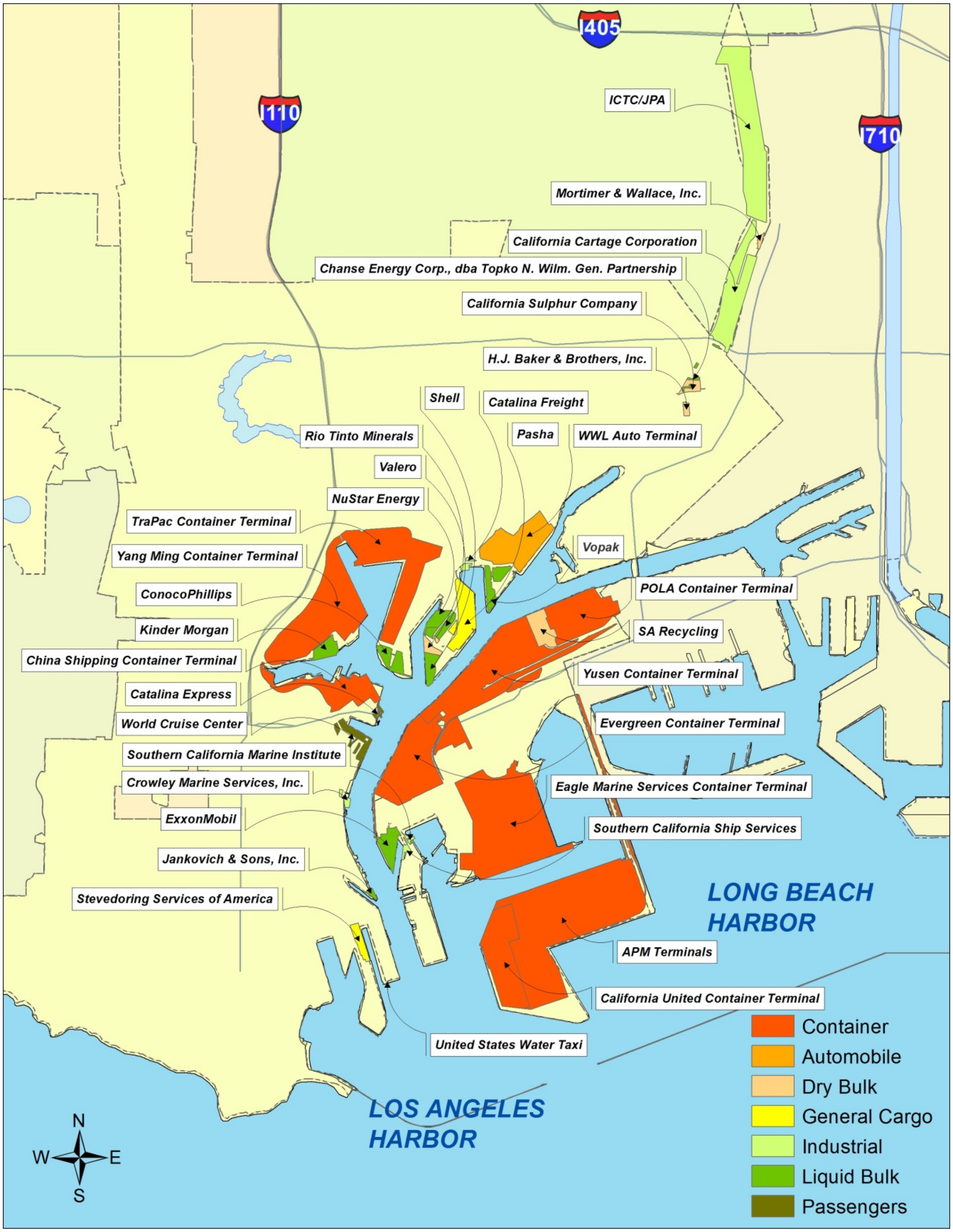
Cruise Terminal:

- Berths 91-93: World Cruise Center

Other Facilities:

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

Figure 5.2: Geographical Boundaries for Cargo Handling Equipment



5.3 Data and Information Acquisition

For each terminal or facility, the maintenance and/or cargo handling equipment operating staff were contacted either in person, by e-mail or by telephone to obtain count and activity information on the equipment specific to their terminal's or facility's operation for calendar year 2013. The CHE information items requested are listed below:

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

It should be noted that not all information requested is readily available. When there are gaps for the data needed to estimate emissions, such as engine power, activity hours, and model year, averages are used as defaults. Section 5.4 lists the averages by equipment type used for missing data. The terminal operators have installed various emission control technologies, and purchased on-road engines equipped yard tractors in order to comply with CARB's CHE regulation. This emission reduction measure is further discussed in Section 5.4.

5.4 Operational Profiles

Table 5.1 summarizes the cargo handling equipment data collected from the terminals and facilities for the calendar year 2013. The table includes the count of all equipment as well as the range and the average of horsepower, model year, and annual operating hours by equipment type for equipment with known operating parameters. The averages by CHE engine and fuel type were used as defaults for the missing information.

The table includes the characteristics of main and small auxiliary engines (20 kW) for RTGs in the RTG crane row, and these averages are not used as defaults for either the main or auxiliary engine. The count column is equipment count, not engine count. For the electric-powered equipment shown in the table, "na" denotes "not applicable" for engine size, model year and operating hours.

Table 5.1: 2013 CHE Engine Characteristics for All Terminals

Equipment	Engine Type	Count	Power (hp)			Model Year			Annual Activity Hours		
			Min	Max	Average	Min	Max	Average	Min	Max	Average
Bulldozer	Diesel	3	200	310	255	2006	2007	2007	224	404	311
Crane	Diesel	9	130	950	287	1969	2010	1992	50	1,606	549
Pallet jack	Electric	7	na	na	na	na	na	na	na	na	na
Wharf crane	Electric	76	na	na	na	na	na	na	0	3,501	417
Excavator	Diesel	1	371	371	371	2010	2010	2010	443	443	443
Forklift	Diesel	159	59	350	161	1979	2013	2006	0	2,926	377
Forklift	Electric	11	na	na	na	na	na	na	0	1,825	389
Forklift	Gasoline	8	45	45	45	2010	2012	2011	0	2,056	833
Forklift	Propane	387	32	200	74	1975	2013	1998	0	2,763	581
Loader	Diesel	15	55	430	287	1989	2013	2003	0	4,377	983
Loader	Electric	3	na	na	na	na	na	na	na	na	na
Man lift	Diesel	16	48	87	72	1989	2012	2004	0	631	210
Man lift	Electric	3	na	na	na	na	na	na	na	na	na
Material handler	Diesel	12	322	475	395	1999	2011	2007	0	3,424	1,625
Miscellaneous	Diesel	7	37	268	70	2007	2009	2009	837	3,362	2,100
Rail pusher	Diesel	3	130	200	175	2000	2012	2005	0	603	201
RMG cranes	Electric	10	na	na	na	na	na	na	0	1,675	1,048
RTG crane	Diesel	108	27	779	462	1995	2013	2006	0	4,669	1,575
Side pick	Diesel	34	125	330	227	1992	2012	2005	0	2,839	1,182
Skid steer loader	Diesel	8	45	94	65	1994	2012	2003	0	1,027	247
Sweeper	Diesel	9	37	260	129	1995	2008	2003	0	1,023	351
Sweeper	Gasoline	2	205	205	205	2002	2005	2004	313	2,660	1,487
Top handler	Diesel	160	250	375	308	1990	2013	2006	0	3,676	1,789
Truck	Diesel	21	185	540	310	1975	2012	2003	131	2,642	1,191
Yard tractor	Diesel	874	170	250	221	1995	2013	2008	0	4,596	1,521
Yard tractor	Gasoline	6	362	362	362	2012	2012	2012	0	248	51
Yard tractor	LNG	17	230	230	230	2009	2010	2010	284	2,470	987
Yard tractor	Propane	180	174	231	199	2000	2011	2007	16	2,451	1,707
Total count		**2,149**									

DB ID228

Table 5.2 presents the percentage of cargo handling equipment at container terminals (72%) as compared to the total Port equipment.

Table 5.2: 2013 Container Terminal CHE Compared to Total CHE

Equipment	Total Count	Container Terminal Count	Percent of Total
Forklift	565	134	24%
RTG crane	108	99	92%
Side pick	34	30	88%
Top handler	160	158	99%
Yard tractor	1,077	1,002	93%
Sweeper	11	7	64%
Other	194	114	59%
Total	**2,149**	**1,544**	**72%**

DB ID233

The characteristics of the CHE engines at the Port's container terminals are summarized in Table 5.3.

Table 5.3: 2013 CHE Engines Characteristics for Container Terminals

Equipment	Engine Type	Count	Power (hp)			Model Year			Annual Activity Hours		
			Min	Max	Average	Min	Max	Average	Min	Max	Average
Pallet jack	Electric	7	na	na	na	na	na	na	na	na	na
Wharf crane	Electric	76	na	na	na	na	na	na	0	3,501	417
Forklift	Diesel	44	115	330	186	1979	2013	2006	0	2,926	780
Forklift	Electric	1	na	na	na	na	na	na	439	439	439
Forklift	Gasoline	4	na	na	na	2010	2012	2011	171	2056	870
Forklift	Propane	85	46	165	105	1985	2013	2002	0	1214	284
Man Lift	Diesel	6	80	87	86	2000	2006	2003	85	346	207
Rail pusher	Diesel	1	200	200	200	2000	2000	2000	0	0	0
RMG cranes	Electric	10	na	na	na	na	na	na	0	1,675	1,048
RTG crane	Diesel	99	27	779	475	1998	2013	2006	0	3,568	1,556
Side pick	Diesel	30	125	330	239	2001	2012	2006	60	2,839	1,292
Sweeper	Diesel	5	100	240	135	1995	2008	2004	0	1,023	417
Sweeper	Gasoline	2	205	205	205	2002	2005	2004	313	2660	1487
Top handler	Diesel	158	250	375	307	1990	2013	2006	0	3,676	1,798
Truck	Diesel	14	185	275	233	1975	2008	2002	131	2,642	992
Yard tractor	Diesel	822	170	250	224	2002	2013	2008	0	3,824	1,478
Yard tractor	Propane	180	174	231	199	2000	2011	2007	16	2,451	1,707
Total count		**1,544**									

DB ID229

Table 5.4 presents the characteristics of the CHE engines at the Port's four break-bulk terminals.

Table 5.4: 2013 CHE Engines Characteristics for Break-Bulk Terminals

Equipment	Engine Type	Count	Power (hp)			Model Year			Annual Activity Hours		
			Min	Max	Average	Min	Max	Average	Min	Max	Average
Bulldozer	Diesel	3	200	310	255	2006	2007	2007	224	404	311
Crane	Diesel	3	205	950	467	1969	2010	1991	50	1,606	650
Excavator	Diesel	1	371	371	371	2010	2010	2010	443	443	443
Forklift	Diesel	98	59	350	159	1993	2013	2007	0	2,282	186
Forklift	Electric	1	na	na	na	na	na	na	na	na	na
Forklift	Propane	3	40	100	68	1989	2007	1998	111	268	196
Loader	Diesel	11	55	430	319	1996	2013	2005	0	4,377	1,252
Loader	Electric	3	na	na	na	na	na	na	na	na	na
Man lift	Diesel	6	49	80	68	2002	2012	2009	0	372	207
Man lift	Electric	3	na	na	na	na	na	na	na	na	na
Material handler	Diesel	12	322	475	395	1999	2011	2007	0	3,424	1,625
Miscellaneous	Diesel	1	268	268	268	2007	2007	2007	837	837	837
Rail pusher	Diesel	2	130	194	162	2004	2012	2008	0	603	302
Side pick	Diesel	2	152	152	152	2000	2000	2000	0	0	0
Skid steer loader	Diesel	4	45	74	61	2004	2012	2008	70	1,027	470
Sweeper	Diesel	3	96	260	151	2000	2008	2003	236	554	358
Top handler	Diesel	1	375	375	375	2004	2004	2004	902	902	902
Truck	Diesel	7	210	540	465	1995	2012	2006	136	2,593	1,590
Yard tractor	Diesel	6	200	200	200	2008	2008	2008	418	579	510
Yard tractor	Gasoline	6	362	362	362	2012	2012	2012	0	248	51
Total count		**176**									

DB ID231

Table 5.5 presents the characteristics of the CHE engines at the Port's three dry bulk terminals. The actual engine data was not provided for the propane forklift; therefore, "not available" is listed for hp and average model year.

Table 5.5: 2013 CHE Engines Characteristics for Dry Bulk Terminals

Equipment	Engine Type	Count	Power (hp)			Model Year			Annual Activity Hours		
			Min	Max	Average	Min	Max	Average	Min	Max	Average
Forklift	Propane	1	na	na	na	na	na	na	43	43	43
Loader	Diesel	1	110	110	110	2009	2009	2009	964	964	964
Yard tractor	Diesel	4	250	250	250	1995	1995	1995	652	1,741	1,126
Total count		**6**									

DB ID230

There were also 39 pieces of cargo handling equipment operated at the Port's cruise, auto and liquid bulk terminals, which included seven forklifts at the auto terminal, three forklifts at the liquid bulk terminals, and 29 forklifts at the cruise terminal.

In addition to these other terminals, there are also several other facilities within the Port boundary, which were included in this inventory but did not fit into the typical marine terminal categories listed above. These other facilities/tenants include smaller facilities and UP's ICTF. Table 5.6 presents the characteristics of the CHE at these other facilities.

Table 5.6: 2013 CHE Engines Characteristics for Other Facilities

Equipment	Engine Type	Count	Power (hp) Min	Power (hp) Max	Power (hp) Average	Model Year Min	Model Year Max	Model Year Average	Annual Activity Hours Min	Annual Activity Hours Max	Annual Activity Hours Average
Crane	Diesel	6	130	244	198	1987	2004	1993	58	780	499
Forklift	Diesel	10	65	155	111	1991	2006	1998	0	1,250	610
Forklift	Propane	279	32	150	67	1975	2008	1996	0	2,763	690
Loader	Diesel	3	96	310	239	1989	2006	1995	0	0	0
Man lift	Diesel	4	48	80	63	1989	2007	1997	0	631	220
Miscellaneous	Diesel	6	37	37	37	2009	2009	2009	1,530	3,362	2,311
RTG crane	Diesel	9	137	350	293	1995	2012	2005	0	4,669	1,824
Side pick	Diesel	2	136	136	136	1992	1995	1994	875	875	875
Skid steer loader	Diesel	4	54	94	69	1994	2001	1999	0	96	24
Sweeper	Diesel	1	37	37	37	1999	1999	1999	0	0	0
Top handler	Diesel	1	325	325	325	2006	2006	2006	1,235	1,235	1,235
Yard tractor	Diesel	42	173	250	175	1998	2005	2005	0	4,596	2,534
Yard tractor	LNG	17	230	230	230	2009	2010	2010	284	2,470	987
Total count		**384**									

DB ID232

Table 5.7 is a summary of the emission reduction technologies utilized in cargo handling equipment. The 2013 CHE inventory includes 182 units with diesel oxidation catalysts (DOCs), 187 units retrofitted with verified diesel particulate filters (DPFs), 1 RTG crane equipped with REGEN Flywheel system (Vycon), and a total of 708 yard tractors and 15 trucks equipped with on-road certified engines. In 2013, BlueCAT retrofits were used on 225 LPG forklifts which reduces emissions for large-spark ignition equipment. In this inventory, there are also 29 level 2 DPFs installed on RTG cranes in addition to the 15 level 3 DPFs listed in table 5.7 for RTG cranes.

Table 5.7: 2013 Count of CHE Emission Reduction Technologies

Equipment	DOC Installed	On-Road Engines	DPF Installed	Vycon Installed	ULSD Fuel	BlueCAT LSI Equip
Forklift	3	0	24	0	159	225
RTG crane	8	0	15	1	108	0
Side pick	7	0	7	0	34	0
Top handler	0	0	116	0	160	0
Yard tractor	164	708	4	0	874	0
Sweeper	0	0	2	0	9	0
Other	0	15	19	0	95	0
Total	**182**	**723**	**187**	**1**	**1,439**	**225**

DB ID234

Thirty three percent of equipment inventoried were not equipped with diesel engines but were powered by propane, gasoline, and LNG engines or electric motors. Specifically, a total of 567 pieces of equipment were powered with propane engines, 16 were powered with gasoline engines, 17 were LNG-powered, and 110 were electric-powered (Table 5.8).

Table 5.8: 2013 Count of CHE Engine by Fuel Type

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
Forklift	11	0	387	8	159	565
Electric wharf crane	76	0	0	0	0	76
RTG crane	0	0	0	0	108	108
Side pick	0	0	0	0	34	34
Top handler	0	0	0	0	160	160
Yard tractor	0	17	180	6	874	1,077
Sweeper	0	0	0	2	9	11
Other	23	0	0	0	95	118
Total	**110**	**17**	**567**	**16**	**1,439**	**2,149**

DB ID235

Table 5.9 summarizes the distribution of diesel cargo handling equipment equipped with off-road engines by off-road diesel engine standards[73] (Tier 0, 1, 2, 3 and 4i) based on model year and horsepower range. The table shows the use of on-road diesel engines on off-road yard tractors to comply with CARB's CHE regulation. The on-road engines are generally lower in emissions than the off-road diesel engines of the same model year. Apart from the on-road yard tractors, there are other equipment types, such as terminal trucks that have on-road engines that are included in the CHE inventory. As shown in Table 5.9, with the implementation of the Port's CAAP measure for CHE and CARB's In-Use CHE regulation, CHE with cleaner on-road engines continue to represent a significant portion of all diesel-powered equipment at the Port. The Unknown Tier column shown in the table represents equipment with missing horsepower or model year information necessary for Tier level classifications. The table does not reflect the fact that some of the engines may be cleaner than the Tier level they are certified because of use of the emissions control devices such as DOCs and DPFs.

Table 5.9: 2013 Count of Diesel Equipment by Type and Engine Standards

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4i	On-road Engine	Unknown Tier	Total Diesel CHE
Yard tractor	4	3	132	6	21	708	0	874
Forklift	15	25	32	31	47	0	9	159
Top handler	4	21	54	58	14	0	9	160
Other	11	15	13	24	14	15	3	95
RTG crane	2	16	39	22	29	0	0	108
Side pick	2	4	14	11	0	0	3	34
Sweeper	1	3	2	2	0	0	1	9
Total	**39**	**87**	**286**	**154**	**125**	**723**	**25**	**1,439**
Percent	**3%**	**6%**	**20%**	**11%**	**9%**	**50%**	**2%**	

DB ID878

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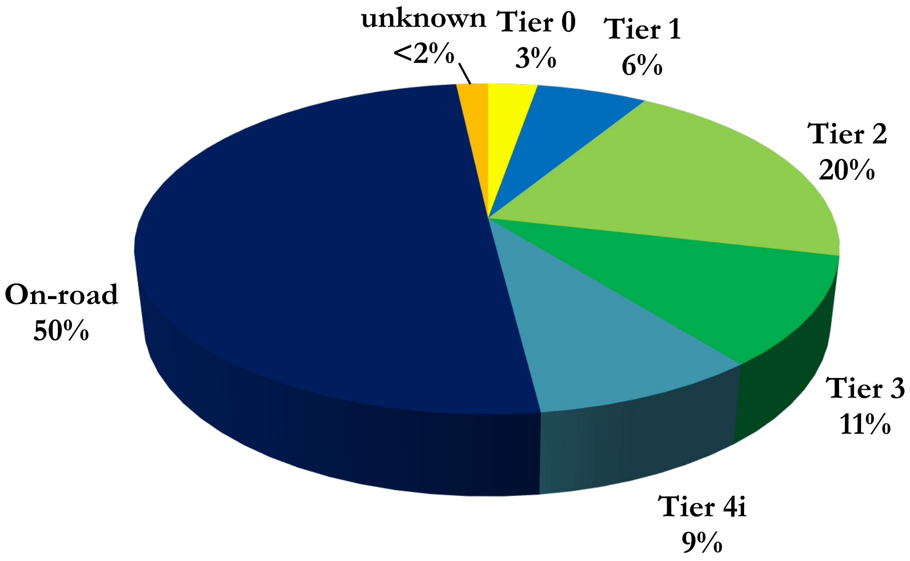
[73] EPA, *Nonroad Compression-Ignition Engines- Exhaust Emission Standards,* June 2004

Figure 5.3 presents the distribution of diesel equipment by off-road and on-road engine standards. Due to rounding, the distribution may not add up to 100%.

Figure 5.3: 2013 Distribution of Diesel Equipment by Engine Standards



5.5 Emissions Estimation Methodology

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

Equation 5.1

$$E = Power \times Activity \times LF \times EF \times FCF \times CF$$

Where:

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

The emission factor is a function of the zero hour emission rates by fuel type (diesel, propane or liquefied natural gas), by CHE engine type (off-road or on-road) for the CHE engine model year (in the absence of any malfunction or tampering of engine components that can change emissions), deterioration rate (DR), and cumulative hours. The deterioration rate reflects the fact that the engine's base emissions (zero hour emission rates) change as the equipment is used, due to wear of various engine parts or reduced efficiency of emission control devices. The cumulative hours reflect the equipment's total operating hours. The emission factor is calculated as:

Equation 5.2

$$\boldsymbol{EF = ZH + (DR \times Cumulative\ Hours)}$$

Where:

ZH = zero-hour emission rate by fuel type by CHE engine type for a given horsepower category and model year, g/hp-hr or g/kW-hr
DR = deterioration rate (rate of change of emissions as a function of CHE engine age), g/hp-hr2 or g/kW-hr2
Cumulative hours = number of hours the CHE engine has been in use and calculated as annual operating hours times age of the CHE engine, hours

5.5.1 Emission Factors

The zero hour emission rates and deterioration rates (DR) for cargo handling equipment are consistent with CARB's latest emissions calculations methodology and emission rates used to estimate CHE emissions[74]. CARB's latest ZH and DR are consistent with OFFROAD 2007. These emission rates are same as used for the Port's 2012 CHE EI[75].

ZH and DR vary by engine horsepower and model year to reflect the fact that depending upon the size of the engines, different engine technologies and emission standards are applicable. ZH and DR 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 liquefied petroleum gas (LPG) engines certified to LSI emission standards
- Liquefied natural gas (LNG) engines based on actual emissions test data, and adjusted to either diesel or gasoline emission standards depending upon the MY and certification of the engine. Due to lack of data, there are no DR for LNG engines.

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[74] CARB, *Amendments to the Regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards, Appendix B*, August 2011

[75] POLA, *www.portoflosangeles.org/pdf/2011_Air_Emissions_Inventory.pdf*

5.5.2 Load Factor and Fuel Correction Factors

Load factor is defined as the ratio of average power used by an equipment during normal operation as compared to its maximum rated power. It accounts for the fact that engines are generally not used at their maximum power rating continually during normal operation. Equipment-specific load factors used in this study are the same as those used in previous EIs. Load factors for CHE are primarily based on CARB's methodology, except for RTG cranes and yard tractors which were updated based on joint studies conducted by the Ports of Los Angeles and Long Beach in consultation with CARB. Specifically, the yard tractor load factor[76] of 39% has been used since the 2006 EI report, and the 20% load factor for RTG cranes[77] has been used since the 2008 EI report. Table 5.10 lists the dimensionless load factor by equipment type.

Table 5.10: CHE Load Factors

Port Equipment	Load Factor
RTG crane	0.20
Crane	0.43
Excavator	0.55
Forklift	0.30
Top handler, side pick, reach stacker	0.59
Man lift, truck, other with off-road engine	0.51
Truck, other with on-road engine	0.51
Sweeper	0.68
Loader	0.55
Yard tractor, off-road engine	0.39
Yard tractor, on-road engine	0.39

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[76] POLA and POLB, *Yard Tractor Load Factor Study Addendum*, December 2008

[77] POLA and POLB, *Rubber Tired Gantry Crane Load Factor Study*, November 2009

Table 5.11 lists the dimensionless fuel correction factors for ULSD fuel.[78] The base emission factors are based on the diesel fuel in use at the time the factors were developed and are adjusted by the following fuel correction factors to reflect the characteristics of ULSD. The FCF for SO_x reflects the change from diesel fuel with a sulfur content of 140 ppm to ULSD of 15 ppm.

Table 5.11: Fuel Correction Factors for ULSD

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1995 and older	0.720	0.930	0.110	1.000	0.720	1.000	0.930	0.720
1996 to 2010	0.800	0.948	0.110	1.000	0.720	1.000	0.948	0.720
2011 and newer	0.852	0.948	0.110	1.000	0.720	1.000	0.948	0.720

Table 5.12 shows the dimensionless fuel correction factors for gasoline engines.[79] LNG and propane engines have no FCF.

Table 5.12: Fuel Correction Factors for Gasoline

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1997 and older	1.000	0.867	1.000	0.795	0.850	1.000	0.867	0.850
1998 and newer	1.000	0.977	1.000	1.000	1.000	1.000	0.977	1.000

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[78] CARB, *www.arb.ca.gov/msei/offroad/techmemo/arb_offroad_fuels.pdf*

[79] CARB, *www.arb.ca.gov/msei/offroad/techmemo/arb_offroad_fuels.pdf*

5.5.3 Control Factors

Control factors were applied to reflect the change in emissions due to the use of various emissions reduction technologies. Table 5.13 shows the emission reduction percentages for the various technologies used on port equipment. The control factor is applied to the baseline emissions to estimate the remaining emissions, and is one minus the emission reduction in decimal; for example, a 70% reduction has a control factor of 0.3.

Table 5.13: CHE Emission Reduction Percentages

Technology	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
Nett BlueCat- LSI	0%	0%	0%	85%	na	0%	85%	na	0%	0%
DOC	30%	30%	30%	0%	na	70%	70%	na	0%	70%
DPF level 3	85%	85%	85%	0%	na	0%	0%	na	0%	0%
DPF level 2	50%	50%	50%	0%	na	0%	0%	na	0%	0%
Vycon's REGEN	25%	25%	25%	30%	15%	0%	0%	15%	30%	0%

DB ID474

The emissions reductions associated with the various emissions strategies have been either verified or developed in consultation with CARB.

- DOC: Provided by CARB in a memorandum to the Port
- DPF: CARB verified technology[80], level 2 and level 3
- Vycon: CARB verified technology[81]
- Nett BlueCAT 300™: CARB verified technology for off-road LSI equipment[82]

5.5.4 Improvements to Methodology from Previous Year

The emissions calculation methodology and the emission rates are the same as those used to estimate CHE emissions for the Port's 2012 EI.

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[80] CARB, *www.arb.ca.gov/diesel/verdev/vt/cvt.htm*

[81] CARB, *www.arb.ca.gov/diesel/verdev/vt/cvt.htm*

[82] CARB, *www.ar.ca.gov/msprog/offroad/orspark/verdev.htm*

5.6 Emission Estimates

The following tables present the estimated CHE emissions by terminal type, equipment type and engine type. In order for the total emissions to be consistently displayed for each pollutant, the individual values in each table column do not, in some cases, add up to the listed total in the tables. This is because there are fewer decimal places displayed (for readability) than are included in the calculated total.

Tables 5.14 and 5.15 provide a summary of cargo handling equipment emissions by terminal type.

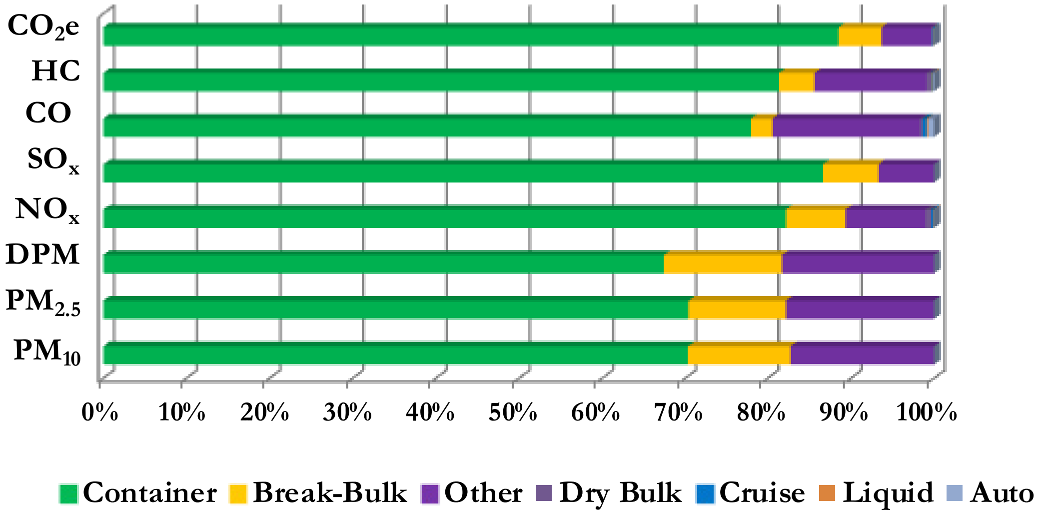
Table 5.14: 2013 CHE Emissions by Terminal Type

Terminal Type	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
Auto	0.0	0.0	0.0	0.1	0.0	5.2	0.1	35
Break-Bulk	1.8	1.6	1.8	48.8	0.1	17.9	3.4	7,205
Container	10.2	9.5	8.5	557.3	1.3	539.7	58.3	122,661
Cruise	0.0	0.0	0.0	1.5	0.0	3.4	0.1	113
Dry Bulk	0.0	0.0	0.0	4.9	0.0	1.9	0.4	286
Liquid	0.0	0.0	0.0	0.5	0.0	1.1	0.1	73
Other	2.5	2.4	2.3	65.1	0.1	123.6	10.7	8,260
Total	**14.6**	**13.5**	**12.7**	**678.1**	**1.44**	**692.9**	**73.1**	**138,632**

DB ID237

Figure 5.4 presents the percentage of CHE emissions by terminal type. Container terminals account for roughly 70% of the Port's CHE PM emissions, 82% of the NO_x emissions, 89% of the SO_x emissions, 78% of the CO, 80% of the HC emissions, and 88% of the GHG emissions are attributed to the container terminals. Break-bulk terminals and other terminals and facilities account for the remainder of the emissions.

Figure 5.4: 2013 CHE Emissions by Terminal Type



Tables 5.15 present the emissions by cargo handling equipment type and engine type.

Table 5.15: 2013 CHE Emissions by Equipment and Engine Type

Equipment	Engine	PM$_{10}$ tpy	PM$_{2.5}$ tpy	DPM tpy	NO$_x$ tpy	SO$_x$ tpy	CO tpy	HC tpy	CO$_2$e tonnes
Bulldozer	Diesel	0.0	0.0	0.0	0.4	0.0	0.1	0.0	77
Crane	Diesel	0.2	0.2	0.2	5.9	0.0	2.0	0.3	530
Excavator	Diesel	0.0	0.0	0.0	0.2	0.0	0.1	0.0	52
Forklift	Diesel	0.4	0.3	0.4	12.5	0.0	7.2	0.8	1,858
Forklift	Gasoline	0.0	0.0	0.0	0.2	0.0	11.5	0.1	72
Forklift	Propane	0.3	0.3	0.0	16.9	0.0	104.6	4.1	2,794
Loader	Diesel	0.5	0.4	0.5	17.1	0.0	3.5	0.8	1,543
Man Lift	Diesel	0.0	0.0	0.0	0.6	0.0	0.5	0.0	69
Material handler	Diesel	0.6	0.5	0.6	13.4	0.0	5.4	1.2	2,517
Miscellaneous	Diesel	0.1	0.1	0.1	1.9	0.0	1.8	0.1	219
Rail Pusher	Diesel	0.0	0.0	0.0	0.1	0.0	0.1	0.0	34
RTG Crane	Diesel	1.7	1.6	1.7	76.6	0.1	21.8	4.7	10,498
Side pick	Diesel	0.7	0.6	0.7	25.9	0.0	6.3	1.3	3,187
Skid Steer Loader	Diesel	0.0	0.0	0.0	0.3	0.0	0.3	0.0	34
Sweeper	Diesel	0.1	0.1	0.1	1.4	0.0	0.7	0.1	221
Sweeper	Gasoline	0.0	0.0	0.0	4.0	0.0	17.7	0.9	307
Top handler	Diesel	2.0	1.8	2.0	213.3	0.3	65.4	15.3	29,766
Truck	Diesel	0.6	0.5	0.6	11.8	0.0	6.1	0.9	2,498
Yard tractor	Diesel	5.9	5.4	5.9	212.3	0.8	157.2	12.1	65,538
Yard tractor	Gasoline	0.0	0.0	0.0	0.1	0.0	1.0	0.0	32
Yard tractor	LNG	0.0	0.0	0.0	1.1	0.0	0.1	3.6	747
Yard tractor	Propane	1.6	1.6	0.0	62.0	0.0	279.4	26.4	16,038
Total		**14.6**	**13.5**	**12.7**	**678.1**	**1.44**	**692.9**	**73.1**	**138,632**

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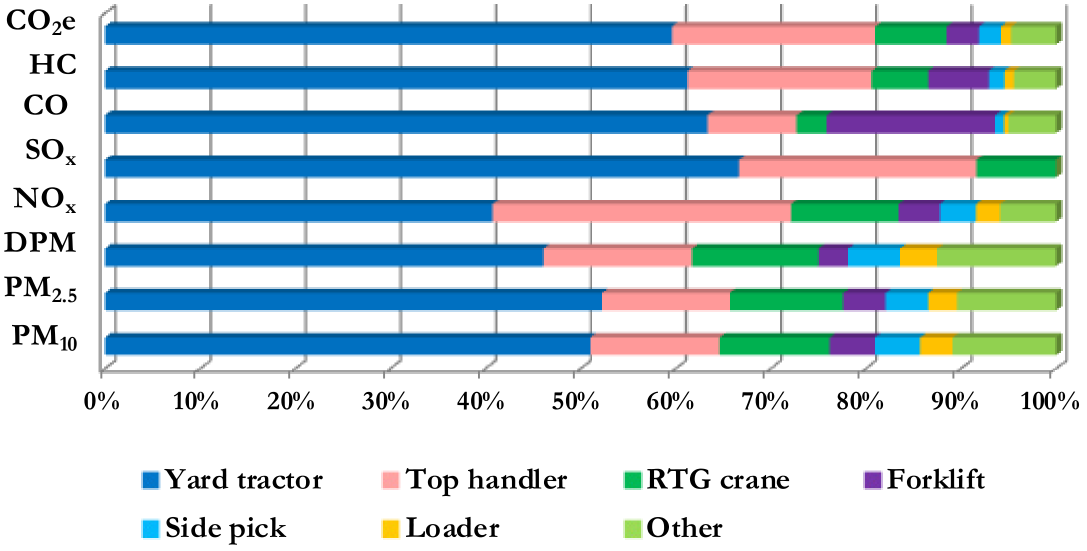
Figure 5.5 presents the percentage of cargo handling equipment emissions by equipment type. Yard tractors contribute to roughly 51% of the cargo handling equipment PM emissions, 41% of the NO_x emissions, 57% of the SO_x emissions, 63% of the CO emissions, 58% of the HC emissions, and 60% of the GHG emissions. Top handlers, forklifts, RTG cranes, side picks and loaders follow in emissions. "Other" equipment refers to bulldozer, crane, man lift, rail pusher, skid steer loader, sweeper, off-road truck, and miscellaneous equipment.

Figure 5.5: 2013 CHE Emissions by Equipment Type



SECTION 6 LOCOMOTIVES

This section presents emissions estimates for the railroad locomotive source category, and is organized into six subsections: 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 by train over long distances. Line haul operations occur at or near 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." Outbound rail cargo is also referred to as eastbound, and inbound rail cargo is also referred to as westbound.

The Port is served by three railway companies:

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

These railroads primarily transport intermodal (containerized) freight, with lesser amounts of dry bulk, liquid bulk, and car-load (also known as 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 company size and revenues.

Locomotives used for line haul operations are typically equipped with large, powerful engines of 3,000 to 4,300 hp or more, while switch engines are smaller, typically having one or more engines totaling 1,200 to 3,000 hp. Figures 6.1 and 6.2 illustrate typical line haul and switching locomotives, respectively, in use at the Port. The locomotives used in switching service at the Port by PHL, and at the near-Port railyard operated by UP, are new, low-emitting locomotives specifically designed for switching duty.

Figure 6.1: Typical Line Haul Locomotive

Figure 6.2: 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 SoCAB 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. The port-related train movements and emissions up to the SoCAB boundary are included in the inventory. The inventory does not include 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.

Figure 6.3: Port Area Rail Lines

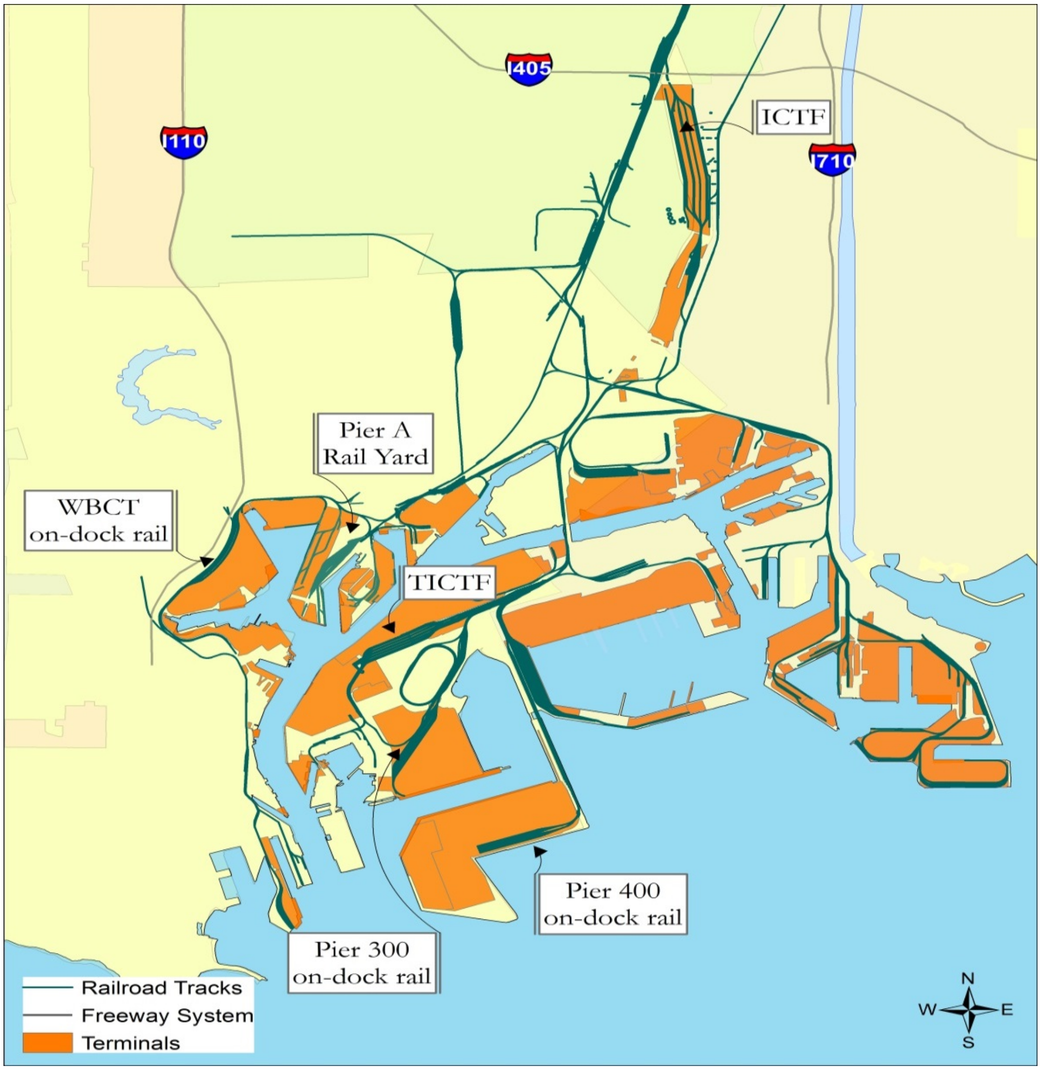


Figure 6.4: Air Basin Major Intermodal Rail Routes

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:

- Input from railroad operators
- Port cargo statistics
- Previous emissions studies
- Published information sources[83]

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[83] For example, EPA, *Emission Factors for Locomotives*: EPA-420-F-09-025, Office of Transportation and Air Quality, April 2009 and Regulatory Support Document: EPA Office of Mobile Sources, *Locomotive Emission Standards Regulatory Support Document,* April 1998, revised, both published as background to EPA's locomotive rule-making processes. Also, information provided by the Class 1 railroads to the ARB to document their compliance with the ARB/railroad MOU and made available by ARB on their website: *www.arb.ca.gov/railyard/1998agree/1998agree.htm.*

PHL has previously provided a record of each of its locomotives including the fuel used per month in each locomotive. For reasons beyond their control PHL was not able to provide specific fuel use information relative to 2013 so the fuel usage in 2012 was apportioned to their locomotives to estimate 2013 fuel usage. The UP railway company operating the ICTF, which is on Port property and operates as a joint powers authority of the Port and POLB, also provided information on their switch engines. Certain information related to line haul locomotive fleets has been obtained from railroad companies' Internet websites, the Surface Transportation Board of the U.S. Department of Transportation, and the MOU compliance page of the ARB's website. Additionally, terminal operators and Port departments have provided information on Port rail operations that provides an additional level of understanding of data and overall line haul rail operations.

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

6.4 Operational Profiles

The following subsections presents operational information for the rail system, locomotives, and trains.

6.4.1 Rail System

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

Outbound Trains

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

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

Inbound Trains

In-bound trains carrying cargo or empty containers that are all destined for the same terminal are delivered directly to that terminal by the Class 1 railroads if the receiving terminal has the track space to accommodate all of the cars at one time. Trains carrying cargo that are bound for multiple terminals within one or both ports are staged by the Class 1 railroads at several locations, where they are broken up, typically by PHL, and delivered to their destination terminals. Inbound trains are also delivered to off-Port locations such as the Watson Yard, the ICTF operated by UP, the Dolores Yard, and the Manuel Yard.

Of the off-port locations noted above, 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 and the POLB.

Alameda Corridor

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

Figure 6.5 illustrates the route of the Alameda Corridor and the routes it has replaced.

Figure 6.5: Alameda Corridor

Switching

Switching locomotives deliver and pick up railcars transporting containers, liquid and dry bulk materials, and general cargo to and from terminals at the Port. Switching operations take place around the clock, seven days per week, although weekend activity is generally lighter 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 in- or outbound for the same destinations, into contiguous segments of the train, and to ensure proper train dynamics. Train dynamics can include, for example, locating railcars carrying hazardous materials the appropriate minimum distance from the locomotives, and properly distributing the train's weight. Although there is a defined schedule of shifts that perform the same basic tasks, there is little consistency or predictability to the work performed during a given shift or at a particular time.

Specific Rail Activities

Locomotive activities of the Class 1 railway companies consist of:

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

Locomotive switching activities consist of:

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

6.4.2 Locomotives and Trains

Locomotives operate differently from other types of mobile sources with respect to how they transmit power from engine to wheels. While most mobile sources use a physical coupling such as a transmission to transfer power from the engine to the wheels, a locomotive's engine turns a generator or alternator powering an electric motor that, in turn, powers the locomotive's wheels. The physical connection of the engine, transmission, and wheels of a typical mobile source means that the engine's speed varies with the vehicle's speed through a fixed set of gear ratios, resulting in the highly transient operating conditions that characterize mobile source operations, particularly regarding engine speed and load. 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 motor 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; this operating condition is somewhat different from idling. Switch engines typically do not utilize dynamic braking.

Line Haul Locomotives

Line haul locomotives are operated at 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 dedicated for Port calls other than each Class 1 railroads' nation-wide fleets.

Both UP and BNSF are party to a Memorandum of Understanding (MOU) with CARB that came into force in 2010 by which the railroads agreed to meet specified fleet-wide average emission rates from their line haul and switching locomotives operating in the SoCAB, on a weighted average basis (i.e., the average applies to switching as well as line haul locomotives). Under the MOU, the railroads have reported information to CARB regarding their fleet average emissions for each year since 2010, and CARB has made the information from 2010 through 2012 available on their website. The information submitted by the railroads on their line haul locomotives that operated in the SoCAB during 2012 has been included in the emission factors and emission estimates presented below. While not specific to 2013 (since the 2013 information has not been made available in time for this report), the information is the latest that is currently available, and represents an improvement over the default assumptions that have been used in previous emissions inventories. More details on the MOU submittals and how they were used are provided in subsection 6.5.2 below.

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 an engineer in one of the locomotives can operate every engine in the set in unison.

Switching Locomotives
Most switching within the Port is conducted by PHL. PHL's fleet in 2013 consisted of 17 Tier 3+ locomotives and 6 low-emitting genset locomotives. Each low-emitting genset locomotive, also known as multi-engine genset switcher is powered by a set of three relatively small diesel engines and generators rather than one large engine. These multi-engine genset units emit less than Tier 3 emission levels of most pollutants. The Class 1 railroads also operate low-emission 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 26 or more double-stack railcars, each railcar consisting of five platforms. Each platform is capable of carrying up to four TEUs of containerized cargo; i.e., most platforms can carry up to two 40-foot containers. With this configuration the capacity of a 26-railcar train is 520 TEUs or about 290 containers at an average ratio of 1.8 TEUs/container. As a practical matter, not all platforms carry four TEUs because not all platforms are double stacked with two 40-foot containers; the current capacity or "density" is estimated to be approximately 95%, meaning, for example, a 26-car train would carry 520 TEUs x 95% = 494 TEUs or about 274 containers.

In developing off-port line haul locomotive emission estimates, the following assumptions were made regarding the typical make-up of trains traveling the Alameda Corridor and beyond: 26 double-stack railcars, 95% density, for a capacity of 494 TEUs or 274 containers (average). For consistency over time, these assumptions are generally consistent with information developed for the No Net Increase Task Force's evaluation of 2005 Alameda Corridor locomotive activities, with adjustments for changes in train makeup over time. 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. Assumptions are made regarding the length and/or capacity of trains are increased or decreased at the off-port rail yards prior to or after interstate travel to or from the Port. At the off-port yards outbound freight is consolidated into fewer, longer trains and inbound freight is broken up for delivery to terminals. Therefore the number of trains entering and leaving the Port is higher than the number of trains traveling the Alameda Corridor.

6.5 Emissions Estimation Methodology

The following subsections provide a description of the methods used to estimate emissions from switching and line haul locomotives operating within the Port and in the SoCAB. Emissions have been estimated using the information provided by the railroads and the terminals, and from published information sources such as the EPA's "Emission Factors for Locomotives"[84] and their Regulatory Support Document (RSD),[85] both were published as background to EPA's locomotive rule-making processes. For on-Port switching operations, the fuel use information provided by the switching company has been used along with EPA and manufacturer information on emission rates. Off-Port switching emissions have been estimated using 2005 fuel use data for the ICTF previously provided by UP, scaled to the decrease in facility throughput between 2005 and 2013. While not a specific calendar-year fuel consumption measurement, it has been noted that UP consistently provides fuel use estimates based on EPA-published fuel consumption figures rather than providing actual fueling totals, likely because of difficulties in identifying specific fuel subtotals related to the ICTF. For this reason, scaling past fuel consumption estimates to changes in throughput is a reasonable and consistent way of estimating changes in fuel consumption and emissions from year to year. For the limited line haul operations at 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 first developed for the 2005 emissions inventory, with an update to the average container weight starting with the 2012 emissions inventory.

Different calculation methods are required for the different types of locomotive activity because different types of information are 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, emission factors from the EPA documents cited above, and information published by the locomotive manufacturers. The calculations estimate horsepower-hours worked by each locomotive based on fuel consumption in gallons per year, and combine the horsepower-hour estimates with emission factors in terms of grams of emissions per horsepower-hour (g/hp-hr). Fuel usage is converted to horsepower-hours using conversion factors that equate horsepower-hours to gallon of fuel (hp-hr/gal):

Equation 6.1

$$\boldsymbol{Annual\ work\ in\ hphr\ per\ year} = \frac{\boldsymbol{gallons}}{\boldsymbol{year}} \times \frac{\boldsymbol{hphr}}{\boldsymbol{gallon}}$$

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[84] EPA, *EPA-420-F-09-025*, April 2009

[85] EPA, *Locomotive Emission Standards Regulatory Support Document,* April 1998, revised

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

Equation 6.2

$$E = \frac{\textbf{Annual work} \times EF}{(453.59\ g/lb \times 2{,}000\ lb/ton)}$$

Where:

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

EPA in-use emission factors for Tier 3 locomotives have been used for the 17 Tier 3+ locomotives. Emission factors for PM_{10}, $PM_{2.5}$, and DPM from the Tier 3+ locomotive engines have been based on the EPA emission certification level of the engines, which is lower than the Tier 3 standard. Manufacturer's published emission rates have been used for the six genset switchers, which operate with three diesel engines originally certified to EPA Tier 3 nonroad engine standards. Emission rates published by the locomotives' manufacturer, National Railway Equipment Co. (NRE), have been used instead of the Tier 3 nonroad standards because differences in duty cycle between nonroad and locomotive operation make the nonroad standards less appropriate. The ICTF switching emissions have been calculated using the genset emission factors noted above based on UP's MOU compliance submission to the ARB, and statements made by UP representatives, which together indicate that the switchers are most likely genset units.

The EPA and NRE emission factors cover particulate, NO_x, CO, and HC emissions. SO_x emission factors have been developed to reflect the use of 15 ppm ULSD using a simplified mass balance approach. This approach assumes that all of the sulfur 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 a reasonable approximation of SO_x. The following example shows the calculation of the SO_x emission factor.

Equation 6.3

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

In this calculation, 15 ppm S is written as 15 g S per million g of fuel. The value of 15.2 hp-hr/gallon of fuel is the average brake specific fuel consumption (BSFC) noted in EPA's technical literature on locomotive emission factors (EPA, 2009). Two grams of SO_2 is emitted for each gram of sulfur in the fuel because the atomic weight of sulfur is 32 while the molecular weight of SO_2 is 64, meaning that the mass of SO_2 is two times that of sulfur. The BSFC value of 15.2 hp-hr/gallon is used for the Tier 3+ locomotives. An evaluation of information released by NRE on the fuel consumption of the genset switchers indicates a BSFC of 17.9 hp-hr/gallon for those locomotives. This indicates that they are more fuel efficient and thus can perform more work output (i.e., hp-hr) for a given amount of fuel. Emission factors based on fuel consumption (such as SO_x and CO_2) reflect the different BSFC values.

Greenhouse gas emission factors from EPA references[86] have been used to estimate emissions of the greenhouse gases CO_2, CH_4, and N_2O from 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 the Tier 3 and genset switching locomotives are listed in Tables 6.1 and 6.2.

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

Locomotive Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Tier 3 Locomotives	0.036	0.033	0.036	4.5	0.006	1.83	0.26
Genset Locomotives	0.05	0.05	0.05	3.37	0.005	1.51	0.04

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

Locomotive Type	CO_2	N_2O	CH_4
Tier 3 Locomotives	678	0.017	0.050
Genset Locomotives	578	0.015	0.050

The activity measure used in the switching emission estimates is total horsepower-hours of activity, derived from the locomotive-specific fuel use estimates for the on-port switching, and an estimate of off-port switching fuel use derived from information provided earlier by UP for the ICTF rail yard that is located on Port property.

PHL operates at both the Port and POLB. While some of the shifts are focused on activities at only one of the ports, other shifts may work at 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 boundary. One method was developed 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 one port exclusively or in both ports, resulting in a split of 69% of activity within the Port and 31% within the POLB. The same apportionment has been maintained for the current inventory. The difference between the two ports' allocations is so great in part because PHL's main yard is within the Port, so almost all work shifts involve at least some activity within the Port.

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[86] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012,* Draft February 2014

Rail cargo from both ports is handled at the off-dock ICTF, and the complexities of the rail system are such that apportionment of activity (and emissions) between the two ports is difficult. The previous baseline emissions inventories used an allocation of 55% POLA and 45% POLB – this allocation has been maintained for the current inventories because it still seems a reasonable assumption, given that the Port's overall TEU throughput represented about 54% of the two ports' combined throughput in 2013.

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 Emission Factors

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 and/or empty containers. The information used in developing these estimates has been obtained from the Port and the Port's 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 first used for the 2001 baseline emissions inventory and subsequent inventories.

Emission factors have been developed from various sources, including the information submitted by the railroads to ARB to demonstrate compliance with the MOU,[87] EPA's recent documentation (EPA-420-F-09-025, cited above) representing EPA's estimates of emissions from line haul locomotives by engine tier level, and an EPA publication on greenhouse gas emissions. [88]

To the extent possible, the MOU compliance data was used to develop the emission factors, since this data is the most location-specific information available. The data was used directly to develop the NOx emission factor (based on submitted NOx emission rates). The information on engine tier level frequency was used to develop emission factors for particulate, HC, and CO emissions. In the most recent compliance submittal available from ARB (2012), the railroads reported information by locomotive tier level: pre-Tier 0, Tier 0, Tier 1, Tier 2, and ultra-low emission locomotives (ULEL). The information included, for each tier level, the number of locomotives that worked in the South Coast Air Basin in 2012, the megawatt-hours (MW-hr) expended by the locomotives while in the basin, the percentage of MW-hr in each tier level, and the weighted average NO_x emissions in grams per horsepower hour (g/hp-hr). The railroads calculated a fleet average NO_x emission rate using the rates by tier level and the percentage of MW-hr in each tier level. In addition, UP used "ULEL credits" to achieve the required 5.5 g/hp-hr composite emission rate.

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[87] CARB, *www.arb.ca.gov/railyard/1998agree/1998agree.htm, as cited above*

[88] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012,* April 2014

The method used to adapt the railroads' NOx emissions data to the development of a NOx emission factor for the ports' 2013 emissions inventories was to calculate a composite NOx emission rate using the MW-hr totals by tier level reported by both railroads for their 2012 compliance reports (the most recently available year during inventory preparations). The MW-hr contributed by ULELs were not included because these locomotives are dedicated switchers and should not be part of the line haul emission factor calculations. While the railroads operate some switchers that are not ULELs, nonetheless they are included in the MW-hr totals for their applicable tier levels because it is not possible to remove their contribution to the MW-hr totals. The number of such switchers is insignificant compared to the number of line haul locomotives that visited the South Coast Air Basin in 2013, so they are not expected to have significantly influenced the resulting composite emission factors. Table 6.3 presents the MOU compliance information submitted[89] by both railroads and the composite of both railroads' pre-Tier 0 through Tier 2 locomotive NOx emissions, showing a weighted average NO_x emission factor of 5.92 g/hp-hr.[90]

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[89] Notes from railroads' MOU compliance submissions:

1. For more information on the U.S. EPA locomotive emission standards please visit. *www.epa.gov/oms/locomotives.htm.*
2. Number of locomotives is the sum of all individual locomotives that visited or operated within the SCAB at any time during 2012.
3. Many locomotives are certified to emission levels cleaner than the U.S. EPA emission standards or tiers. For the purposes of this table, a locomotive's actual certified emission level is grouped with the required tier level. Within each tier, the Weighted Average NOx Emission Level is calculated by multiplying each individual locomotive's actual certification level by its megawatt-hours of operation.
4. The Tier Contribution is calculated by multiplying the %MW-hr by Tier Level by the Weighted Average NOx Emission Level.

[90] EPA Office of Transportation and Air Quality, *Emission Factors for Locomotives*, EPA-420-F-09-025, April 2009

Table 6.3: MOU Compliance Data, MW-hr and g NOx/hp-hr

Engine Tier[1]	Number of Locomotives[2]	Megawatt -Hours (MW-hr)	%MW-hr by Tier Level	Wt'd Avg NOx (g/hp-hr)	Tier Contribution To Fleet Avg[4] (g/hp-hr)
BNSF					
Pre-Tier 0	0	0	0%	0	0.0
Tier 0	162	7,406	3%	7.8	0.3
Tier 1	683	40,493	19%	7.4	1.4
Tier 2	942	119,682	55%	5.0	2.7
Tier 3	220	16,117	7%	4.6	0.3
ULEL	91	34,092	16%	3.8	0.6
Total BNSF	**2,098**	**217,790**	**100%**		**5.3**
UP					
Pre-Tier 0	80	1,507	1%	12.6	0.1
Tier 0	2,507	62,861	28%	7.9	2.2
Tier 1	1,333	29,650	13%	6.7	0.9
Tier 2	1,456	113,984	50%	5.1	2.6
Tier 3	241	6,682	3%	4.9	0.1
ULEL	71	11,548	5%	2.5	0.1
Total UP	**5,688**	**226,232**	**100%**		**6.0**
			ULEL Credit Used		0.5
			UP Fleet Average		**5.5**
Both RRs, excluding ULELs and ULEL credits					
Pre-Tier 0	80	1,507	0%	12.6	0.05
Tier 0	2,669	70,267	18%	7.9	1.39
Tier 1	2,016	70,143	18%	7.1	1.25
Tier 2	2,398	233,666	59%	5.0	2.96
Tier 3	461	22,799	6%	4.7	0.27
Total both	**7,624**	**398,382**	**100%**		**5.92**

As noted in the text above and shown in Table 6.3, UP used ULEL credits established under the MOU as part of their compliance demonstration. These credits were not used in developing the line haul locomotive NO$_x$ emission factor. Only the data on Pre-Tier 0 and Tiers 0 through 3 locomotives were used, as shown in the lower part of Table 6.3.

Emission factors for particulate matter (PM_{10}, $PM_{2.5}$, and DPM), HC, and CO were calculated using the tier-specific emission rates for those pollutants published by EPA[91] to develop weighted average emission factors and the MW-hr figures provided in the railroads' submissions. These results are presented in Table 6.4. The composites were calculated by multiplying each tier's emission factor by that tier's percentage of total MW-hr, and summing the results for all tiers. For example, the PM_{10} tier-specific emission factor is 0.32 g/hp-hr for pre-tier 0 (uncontrolled), Tier 0, and Tier 1 locomotive engines, and 0.18 g/hp-hr for Tier 2 engines. Each tier's emission factor was multiplied by the corresponding percentage of MW-hr (18% for Tier 0, 18% for Tier 1, etc.) with the results entered under the "Fleet Composite" column for PM_{10}. The composite PM_{10} emission factor was calculated by summing the four values in that column. The other pollutants in the table were calculated in a similar manner.

Table 6.4: Fleet MW-hr and PM, HC, CO Emission Factors, g/hp-hr

Engine Tier	MW-hr	% of MW-hr	EPA Tier-specific			Fleet Composite		
			PM_{10}	HC	CO	PM_{10}	HC	CO
			g/hp-hr			g/hp-hr		
Pre-Tier 0	1,507	0%	0.32	0.48	1.28	0.00	0.00	0.01
Tier 0	70,267	18%	0.32	0.48	1.28	0.06	0.09	0.23
Tier 1	70,143	18%	0.32	0.47	1.28	0.06	0.08	0.23
Tier 2	233,666	59%	0.18	0.26	1.28	0.11	0.15	0.75
Tier 3	22,799	6%	0.08	0.13	1.28	0.01	0.01	0.07
Totals	**398,382**	**100%**				**0.22**	**0.33**	**1.28**

The SO_x emission factor has been estimated from assumed fuel sulfur content values using the same mass balance equation as 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 reasonably conservative assumptions derived from information provided by the Class 1 railroads. Inbound trains are assumed to use the fuel they were filled with before entering California while outbound trains are assumed to refuel with ULSD before departing the SoCAB, such that 90% of the outbound fuel is ULSD and 10% is the residual amount of out-of-state fuel. The out-of-state fuel is assumed to contain 43 ppm S, consistent with EPA assumptions,[92] while the ULSD limit of 15 ppm S is used for the in-state fuel.

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[91] EPA, *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines*, Table 3.4-8a. May 2004

Table 6.5 summarizes the emission factors discussed above, presented in units of g/hp-hr.

Table 6.5: 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	0.22	0.20	0.22	5.92	0.009	1.28	0.33

The same information sources for greenhouse gases have been used for line haul locomotives as for switching locomotives, described above. Table 6.6 lists the greenhouse gas emission factors derived from the EPA reference.

Table 6.6: GHG Emission Factors for Line Haul Locomotives, g/hp-hr

	CO_2	N_2O	CH_4
EF, g/bhp-hr	494	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 average number of locomotives involved on-port line haul railroad moves, and the average duration of incoming and outgoing port trips. The same approach was taken for the previous emissions inventories. The estimated number of trains per year, the average number of locomotives per train, and the estimated number of on-port hours per train have been multiplied together to calculate total locomotive hours per year. This activity information is summarized in Table 6.7. While most of the rail cargo, and the basis for these estimates, center on container traffic, the local switching railroad has reported that they prepare an average of one train per day of non-container cargo for transport out of the San Pedro Bay Ports area. Assuming that a similar number of trains are inbound, and that the total number has an even split between both ports, the number of trains per year includes an average of one non-container train every other day in each direction for an annual total of 365 additional non-container trains for each port.

Table 6.7: Estimated On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Total
Number of trains/year	3,251	3,158	6,409
Number of locomotives/train	3	3	NA
Hours on Port/trip	1.0	2.5	NA
Locomotive hours/year	9,753	23,685	33,438

DB ID487

The average load factor for a typical line haul locomotive calling 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 6.8. 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 available to enable the development of an average on-port load factor. In the table, DB is short for dynamic braking. .

Table 6.8: 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:			**0.28**

To estimate the total number of horsepower-hours for the year, the estimated number of locomotive hours for the Port is multiplied by average locomotive horsepower and the average load factor discussed above:

Equation 6.4

$$\mathbf{33,438\ \mathit{locomotive}\frac{\mathit{hours}}{\mathit{year}}\times 4,000\frac{\mathit{hp}}{\mathit{locomotive}}\mathit{x}\times 0.28 = 37.5\ \mathit{million\ hp - hr}\ (\mathit{rounded})}$$

Emission estimates for on-port line haul locomotive activity have been calculated by multiplying this estimate of horsepower-hours by the emission factors listed in Tables 6.5 and 6.6 in terms of g/hp-hr.

Out-of-Port Line Haul Emissions

Line haul locomotive activity between the Port and the SoCAB 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.

Four components of locomotive activity have been estimated to develop the off-port emission estimates: number of trains, average weight of each train, distances traveled within the SoCAB, and the amount of fuel used per ton-mile of train activity. The average number of port-related trains is estimated to be approximately 27 per day through the Alameda Corridor[93] including non-container trains discussed above, based on the average train capacities discussed above, on average 274 containers per train, and the two San Pedro Bay Ports' 2013 intermodal throughputs. The gross weight, including locomotives, railcars, and freight, of a typical train is estimated to have been 7,276 tons in 2013, using the assumptions listed in Table 6.9. The distance assumptions are 21 miles for the Alameda Corridor and 84 miles between the north end of the Alameda Corridor and the SoCAB boundary.

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[93] Overall Alameda Corridor traffic for 2013 was an average of 45 per day. This includes non-port-related traffic; *www.acta.org/PDF/CorridorTrainCounts.pdf*

Gross ton-miles in millions have been calculated by multiplying together the number of trains, the gross weight per train, and the miles traveled, as illustrated in Table 6.10. 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. This average has been derived from information reported by the railroads to the U.S. Surface Transportation Board in an annual report known as the "R-1."[94] 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 0.985 gallons of fuel per thousand gross ton-miles. The 2012 annual reports were the latest available when the emission factor and activity data were compiled, so these reported values have been used as the basis of the 2013 fuel consumption factor. Also listed in Table 6.10 is the estimated total of out-of-port horsepower-hours, calculated by multiplying the fuel use by the fuel use conversion factor of 20.8 hp-hr/gal.

Table 6.9: Assumptions for Gross Weight of Trains

Train Component	**Approximate Weight (lbs)**	**Weight (short tons)**	**Number per train**	**Weight (short tons)**
Locomotive	420,000	210	4	840
Railcar (per double-stack platform)	40,000	20	130	2,600
Container		14	274	3,836
Total weight per train, gross tons				**7,276**

Table 6.10: Gross Ton-Mile, Fuel Use, and hp-hr Estimate

	Distance (miles)	**Trains per year**	**MMGT per year**	**MMGT-miles per year**
Alameda Corridor	21	5,180	38	798
Central LA to Air Basin Boundary	84	5,180	38	3,192
Million gross ton-miles (MMGT)				**3,990**
Estimated gallons of fuel (millions)				**3.93**
Estimated million hp-hr				**81.7**

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

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[94] Union Pacific, *Class I Railroad Annual Report R-1 to the Surface Transportation Board for the Year Ending Dec. 31, 2011* and BNSF, *Class I Railroad Annual Report R-1 to the Surface Transportation Board for the Year Ending Dec. 31, 2011, www.stb.dot.gov/econdata.nsf/FinancialData?OpenView*

6.5.3 Improvements to Methodology from Previous Years

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The Port continues to use the most recent, locally-specific data available, including MOU compliance data reflective of actual recent line haul fleet mix characteristics. Upcoming international rules on the weighing of containers during shipment will ultimately provide a more robust estimate of the average weight of containers shipped by rail.

6.6 Emission Estimates

A summary of estimated emissions from locomotive operations related to the Port is presented below in Table 6.11. These emissions include operations within the Port and port-related emissions outside the Port out to the boundary of the SoCAB. The criteria pollutants are listed as tons per year while the CO_2e values are listed as tonnes (metric tons) per year.

In order for the total emissions to be consistently displayed for each pollutant, the individual values in the table entries do not, in some cases, add up to the totals listed in the table. This is because there are fewer decimal places displayed (for readability) than are included in the calculated totals.

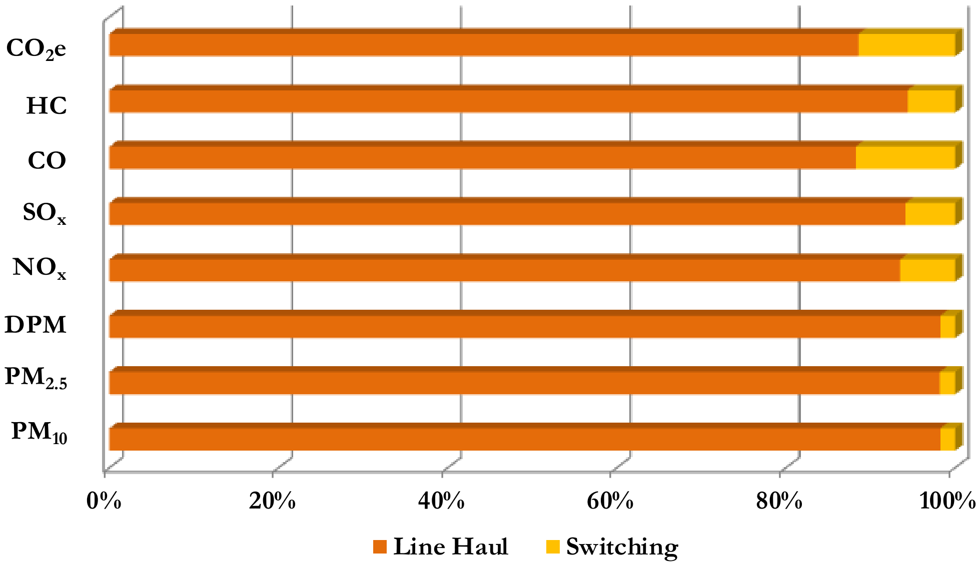
Table 6.11: 2013 Port-Related Locomotive Operations Estimated Emissions

	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
Switching	0.5	0.5	0.5	53.7	0.1	22.3	2.6	7,641
Line Haul	28.8	26.2	28.8	774.4	1.2	167.4	43.2	59,329
Total	**29.3**	**26.6**	**29.3**	**828.1**	**1.3**	**189.7**	**45.7**	**66,969**

DB ID696

Figure 6.6 depicts the distribution of emissions with line haul emissions accounting for roughly 88% to 98% of the total locomotive emissions.

Figure 6.6: 2013 Distribution of Locomotive Emissions by Category



SECTION 7 HEAVY-DUTY VEHICLES

This section presents emissions estimates for the heavy-duty vehicles (HDV) source category, and is organized into six subsections: 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 marine terminals. Trucks deliver cargo to both 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.

While most of the trucks that service the Port's terminals are diesel-fueled vehicles, alternatively-fueled trucks, primarily those fueled by liquefied natural gas (LNG), made approximately 9.4% of the terminal calls in 2013, according to the Port's Clean Truck Program (CTP) activity records and the Port Drayage Truck Registry (PDTR). Vehicles using fuel other than diesel fuel do not emit diesel particulate matter, so the diesel particulate emission estimates presented in this inventory have been adjusted to take the alternative-fueled trucks into account.

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 and Figure 7.2 shows a typical container trucks transporting containers.

Figure 7.1: Truck with Container

Figure 7.2: Trucks on Terminal

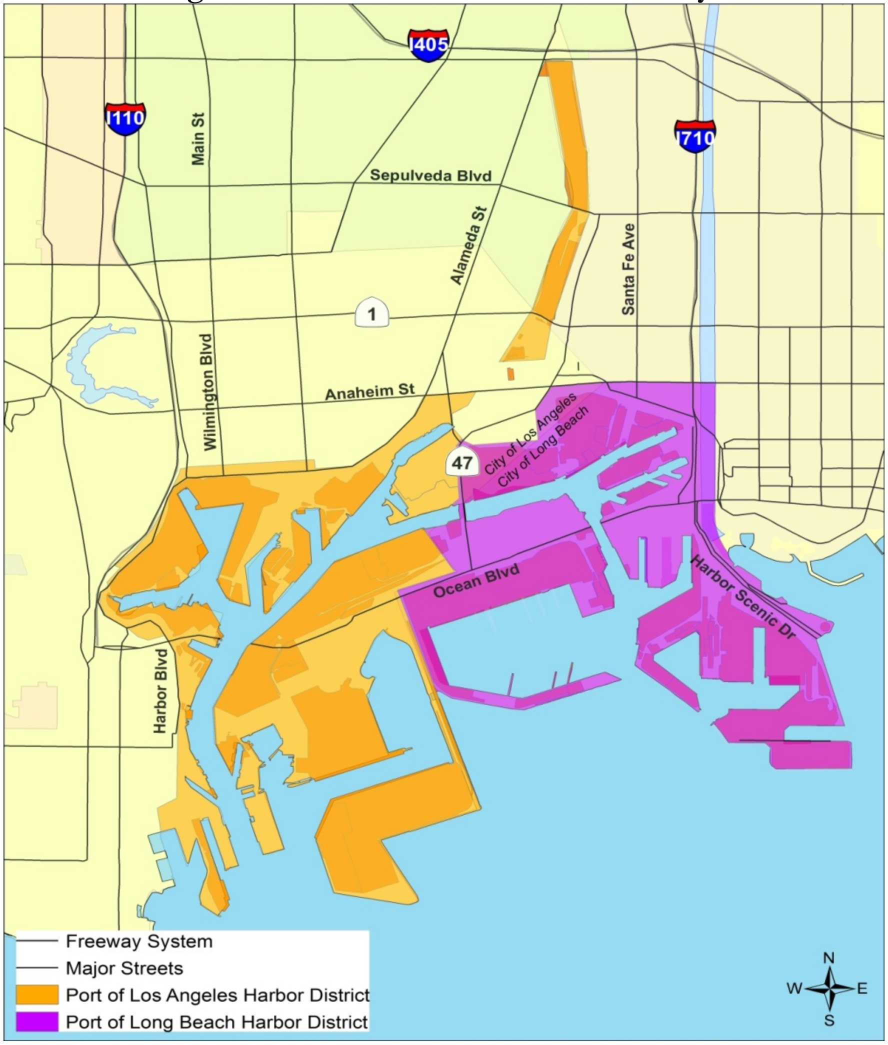
7.2 Geographical Delineation

The two major geographical components of truck activities have been evaluated for this inventory:

- 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 within the SoCAB. This includes travel on public roads within the Port's boundaries.

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 (San Pedro Bay ports). 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 three basic sources: port and terminal activity records, terminal contacts, and computer modeling of on-road HDV traffic volumes, distances, and speeds. These information sources are discussed below.

7.3.1 On-Terminal

The Port collected information regarding on-terminal truck activity during in-person and/or telephone interviews with terminal personnel. This information included gate operating schedules, on-terminal speeds, time and distance traveled on the terminal while dropping off and/or picking up loads, time spent idling at the entry and exit gates, and total number of truck calls to the terminal during the year. 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.

The Port also collected information on the individual trucks that called at the container terminals through CTP and Ports Drayage Truck Registry (PDTR) records in order to develop the distribution of calls by engine model year. This distribution was used in developing the composite emission factors as discussed below in 7.5 Emissions Estimation Methodology.

7.3.2 On-Road

The Port developed estimates of truck activity on the public roads inside and outside the Port. To do this, the Port used trip generation and travel demand models that have been used in the previous Port emissions inventories to estimate the volumes (number of trucks) and average speeds on roadway segments between defined intersections. Output from the trip generation model (number of truck trips) was also used as a component of the container terminals' on-terminal emission estimates.

The Port developed the trip generation model in part to forecast the number of truck trips associated with container terminals. The primary input to the trip generation model for the current emissions inventory consists of each container terminal's average daily container throughput in 2013.

The results of the trip generation model were input to a regional travel demand model used for transportation planning by the Southern California Association of Governments (SCAG), a federally designated Metropolitan Planning Organization for the SoCAB area. The travel demand model predicts truck travel patterns and estimates the number of trucks traveling over roadways in the region. The model estimates the movements of port-related trucks on their way from the Port until they make their first stop, whether for delivery of a container to a customer or to a transloading facility, or to the boundary of the SoCAB.

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

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

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

7.4 Operational Profiles

The activity profiles for on-terminal and on-road truck traffic below are developed based on the modeling data and terminal information collected as described in the previous subsection.

7.4.1 On-Terminal

Table 7.2 illustrates the range and average of reported container terminal operating characteristics of on-terminal truck activities at Port container terminals, while Table 7.3 shows similar summary data for the non-container terminals and facilities. The total numbers of terminal calls in 2013 were 3,447,199 associated with the Port's container terminals and 1,222,842 associated with the non-container facilities. The total number of container terminal calls is based on the trip generation model described above, while non-container terminal calls were obtained from the terminal operators.

Table 7.2: 2013 Summary of Reported Container Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	15	1.5	0.17	0.90	0.13
Minimum	10	0.9	0.08	0.27	0.00
Average	12.5	1.3	0.12	0.47	0.04

Table 7.3: 2013 Summary of Reported Non-Container Facility Operating Characteristics

	Speed (mph)	Distance (miles)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	20	1.3	0.08	0.37	0.05
Minimum	5	0.02	0.00	0.00	0.00
Average	8	0.5	0.03	0.10	0.01

Table 7.4 presents further detail on the on-terminal operating parameters, listing total estimated miles traveled and hours of idling on-terminal and waiting at entry gates. Terminals are listed by type. For those facilities with zero VMT, it is due to the facility being idle during the inventory calendar year.

Table 7.4: 2013 Estimated On-Terminal VMT and Idling Hours by Terminal

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	1,467,773	1,047,011
Container	936,260	355,779
Container	748,698	184,679
Container	699,176	298,315
Container	498,893	299,336
Container	324,937	172,217
Auto	1,463	995
Break Bulk	28,405	6,391
Break Bulk	6,250	4,000
Break Bulk	1	1.5
Dry Bulk	2,600	832
Dry Bulk	1,250	375
Liquid Bulk	3,156	379
Liquid Bulk	18	0
Other	655,684	295,058
Other	273,991	40,045
Other	188,369	27,531
Other	67,600	8,320
Other	10,140	1,352
Other	520	910
Other	40	320
Total	**5,915,221**	**2,743,844**

7.4.2 On-Road

Figure 7.4 presents a regional map of the major area roadways. The daily traffic estimates are based on average week-day activity during an average month over these roads and on the regional network of smaller, local roads. The daily activities 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 Emissions Estimation Methodology

This section discusses how the emission estimates were developed for HDVs serving the Port. A general equation for estimating the emissions inventory for a fleet of on-road vehicles can be expressed as:

Equation 7.1

$$\boldsymbol{E = Pop \times Act \times BER \times CorF}$$

Where:

E = Emissions (tons/year)
Pop = Population (number of vehicles of a particular model year in the fleet)
Act = Activity (average number of miles driven per truck, hours of idle operation)
BER = Basic Emission Rate (amount of pollutant emitted per unit of activity for vehicles of that model year), g/mile
CorF = Correction Factor (adjustment to BER for specific assumptions of activity and/or atmospheric conditions), dimensionless

The emissions from all model years are summed to complete the fleet emission estimates. In practice the fleet estimates are prepared by combining the base emission rates and correction factors for all model years in such a way as to develop a single set of composite emission factors that represent the fleet's distribution of model years. Population and activity are also combined to estimate total fleet activity, and the activity and emission factors are combined to estimate fleet emissions. The process is described in the following paragraphs.

7.5.1 Overview of the HDV Emissions Calculation Methodology

A model developed by CARB, named the EMission FACtor version 2011 (EMFAC2011) model has been used to develop the HDV emission factors underlying the emissions inventory. EMFAC2011 is an update to previous versions of the EMFAC series of on-road emission estimating models. EMFAC2011 models the basic emission rate (in grams per mile) as a constant value (over time) with a "zero mile rate" (ZMR) or intercept representing the emissions of the vehicle when new or like-new (well maintained and un-tampered), plus a "deterioration rate" (DR) or slope representing the gradual increase in the emission rate over time as a function of use (the engine's cumulative mileage). For heavy-duty trucks the deterioration rate is expressed as grams per mile traveled per 10,000 accumulated miles (g/mi/10k mi).

Equation 7.2

$$\boldsymbol{BER = ZMR + (DR \times CM / 10{,}000)}$$

Where:

BER = Basic Emission Rate (amount of pollutants emitted per unit of activity for vehicles of that model year), g/mile
ZMR = Zero Mile Rate (emissions of the vehicle when new or like-new), g/mile
DR = Deterioration Rate (slope representing the gradual increase in the emission rate over time as a functions of use), g/mi/10K miles
CM = Cumulative Mileage (total miles on the vehicle since new), miles

Emission rates for each model year and speed that are obtained from CARB's web-based database, which has been established as part of the EMFAC2011 update, are already adjusted for the correction factors included in Equation 7.1 to reflect vehicle specific activity such as speed, type and quality of fuel burned, and specific ambient conditions such as temperature and relative humidity. The EMFAC2011 database query for the 2013 inventory utilized the South Coast Air Basin factors.

CARB has published idle emission factors expressed in grams per hour (g/hr) that are used in estimating the idle emissions from HDVs operating at the Port. The idle emission factors are multiplied by the estimated total hours of idle operation to derive the ton-per-year emission estimates.

CARB has developed "low idle" and "high idle" emission rates to represent emissions from different types of truck idling. The "low idle" rates were used in developing the emissions inventory for the Port because the low idle rates are "indicative of a truck in queue to either pick up or drop off a shipment," whereas the "high idle" rates are intended to "reflect activity associated with truck stops, rest areas, and distribution centers" rather than normal port operations.[95]

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[95] CARB, *www.arb.ca.gov/msei/emfac2011-technical-documentation-final-updated-0712-v03.pdf* and *www.arb.ca.gov/msei/onroad/techmemo/revised_hhddt_emission_factors_and_speed_corr_factors.pdf*

The low idle emission factors are presented in Table 7.5.

Table 7.5: Low Idle Emission Rates, g/hr

Model Years	HC	CO	NO_x	PM	CO_2
Pre-1987	18.648	28.4	42.501	3.4272	4,271
1987-90	10.944	23.4	65.286	1.7136	4,507
1991-93	8.712	21.5	72.912	1.2816	4,610
1994-97	6.9696	19.8	79.329	0.9576	4,713
1998-02	5.2272	17.8	85.653	0.6624	4,846
2003-06	4.2984	16.6	88.815	0.5184	4,934
2007-09	4.2984	16.6	27.9	0.0576	4,934
2010+	4.2984	16.6	27.9	0.0576	4,934

Because the EMFAC model does not produce emission factors for N_2O or speed-specific emission factors for SO_x, gram-per-mile emission factors, factors for these emissions have been developed using a mass balance approach for SO_x and a gram-per-gallon emission factor from CARB for N_2O. The following equation has been used to derive the SO_x emission factor.

Equation 7.3

$$SO_x\ emissions\left(\frac{g}{mile}\right) = \frac{(15\ g\ S/1,000,000\ g\ fuel) \times (3,220\ g/gallon) \times (2\ g\ SO_x\ /g\ S)}{(5.80\ miles/gallon)}$$

The emission calculations are based on the use of ULSD (15 ppm S) diesel fuel. The weight of a gallon of diesel fuel is assumed to be 7.1 pounds or 3,220 grams (7.1 lbs x 453.59 g/lb). Based on the EMFAC2011 model, the 2013 fleet average fuel economy of the heavy-heavy duty diesel fleet was calculated to be 5.80 miles per gallon.

The N_2O emission factor has been calculated using the following equation:

Equation 7.4

$$N_2O\ emissions\ (g/mile) = \frac{(0.3316\ g\ N_2O/gallon)}{(5.80\ miles/gallon)}$$

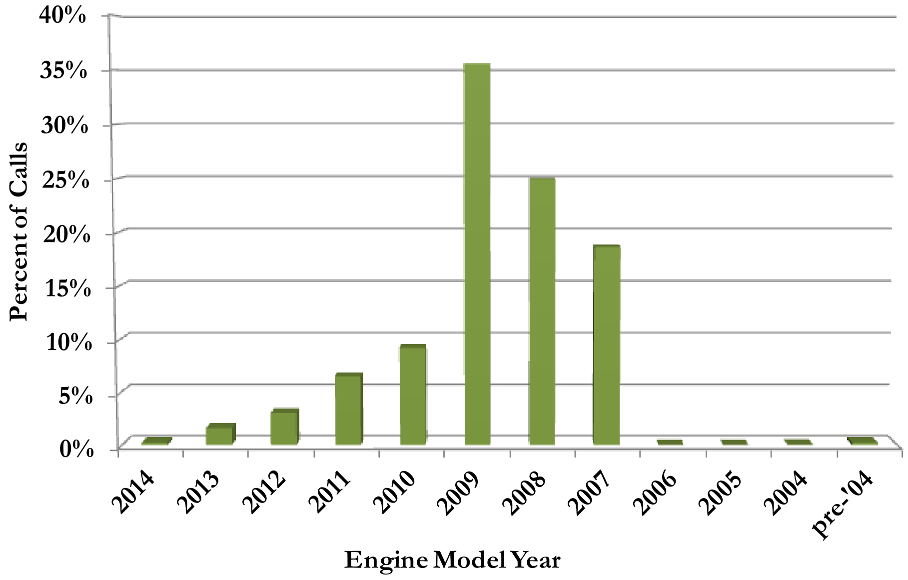
As noted in the introduction to this section, a DPM adjustment factor was developed to account for trucks that use a fuel other than diesel, because only diesel-fueled trucks emit DPM. The adjustment factor was applied by multiplying the factor by the PM_{10} emission factors. The adjustment factor was developed by evaluating the number of calls made by each fuel type and each model year of truck. The fuel types were diesel (90.6% of calls), full LNG (7.9% of calls), and Westport LNG, which burn approximately 10% diesel and 90% LNG (1.5% of calls). There were an insignificant number of calls by "other" fuel type trucks which were most likely CNG or gasoline that made up approximately 0.02% of calls; these calls were evaluated as LNG calls. The DPM adjustment factor effectively removes 100% of the PM from calls made by trucks fueled with 100% LNG and 90% of the PM from trucks that use 90% LNG and 10% diesel.

7.5.2 Model Year Distribution

Because vehicle emissions vary according to the vehicle's model year and age, the activity level of trucks within each model year is an important part of developing emission estimates. As an improvement to the data that underlies the Port's emissions inventories, the 2013 model year distribution for the current emissions inventory is based on call data originating from the RFID data associated with the CTP, which tracked over 5.6 million truck calls made to both San Pedro Bay ports in 2013, and engine model year data drawn from the PDTR, which contains model year information on all trucks registered to do business at the Port's container terminals. Under the Port's Clean Truck Program, each container terminal has installed a system to read and record the RFID number of each registered truck that enters the terminal. Trucks that are not registered but are otherwise eligible to enter are provided a "day pass" that is also recorded by the terminal. These records of truck entries were matched up with the truck characteristics data in the PDTR to develop the overall engine model year distribution of trucks calling at the Port. In addition to providing the number of calls made by each engine model year, the PDTR data also includes each vehicle's fuel type, from which the DPM adjustment factor was developed for non-diesel fueled vehicles as discussed at the beginning of this section.

The distribution of truck fleet's engine model years by calls, which was used to develop the composite emission factors as discussed below, is presented in Figure 7.5. The call weighted average engine age of the Port-related fleet in 2013 was approximately 4 years, older than the 3-year average in 2012 because there was very little turnover in the almost-new fleet.

Figure 7.5: 2013 Engine Model Year Distribution of the Heavy-Duty Truck Fleet



7.5.3 Speed-Specific Emission Factors

The model year and speed specific gram-per-mile emission rates are composited to reflect the distribution of truck calls by engine model year within the fleet of trucks calling at Port terminals, with a single emission factor for each 5-mile-per-hour speed increment representing the distribution of model years using the call-weighted model year distribution discussed in the previous subsection. A single set of pollutant specific gram-per-hour idle emission rates has also been derived using the distribution of truck calls by engine model year.

Emissions of SO_x and N_2O have been estimated as described above; idling emission rates of these substances have been based on an average fuel consumption rate of 0.48 gallons of diesel per hour during idling, derived from an analysis of the idling CO_2 emission factor established by CARB. Tables 7.6 and 7.7 summarize the speed-specific emission factors developed as described above and used to estimate emissions. The units are in grams per mile, except for the idle emission factors (0 mph), which are in grams per hour of idling.

Table 7.6: Speed-Specific Composite Emission Factors, g/hr and g/mi

Speed Range (mph)	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	Units
0 (Idle)	0.0595	0.0547	0.0541	28.0441	0.0385	16.6047	4.3025	g/hr
1 - 5	0.0917	0.0844	0.0834	18.8977	0.0167	7.9843	3.1759	g/mi
6 - 10	0.082	0.0754	0.0746	14.1912	0.0167	4.9809	1.8477	g/mi
11 - 15	0.0731	0.0673	0.0665	10.6692	0.0167	2.8955	0.9389	g/mi
16 - 20	0.0644	0.0592	0.0586	8.0614	0.0167	1.5741	0.4033	g/mi
21 - 25	0.0612	0.0563	0.0557	7.2318	0.0167	1.4838	0.3521	g/mi
26 - 30	0.0605	0.0557	0.0551	6.526	0.0167	1.42	0.3068	g/mi
31 - 35	0.0622	0.0572	0.0566	5.9427	0.0167	1.3828	0.2675	g/mi
36 - 40	0.0665	0.0612	0.0605	5.4815	0.0167	1.3723	0.234	g/mi
41 - 45	0.0734	0.0675	0.0668	5.1431	0.0167	1.3884	0.2065	g/mi
46 - 50	0.0827	0.0761	0.0753	4.9273	0.0167	1.431	0.1849	g/mi
51 - 55	0.0945	0.0869	0.086	4.8352	0.0167	1.5004	0.1693	g/mi
56 - 60	0.1089	0.1002	0.0991	4.8643	0.0167	1.5963	0.1595	g/mi
61 - 65	0.1258	0.1157	0.1145	5.0183	0.0167	1.7188	0.1557	g/mi
66 - 70	0.1452	0.1336	0.1321	5.301	0.0167	1.868	0.1579	g/mi

Table 7.7: Speed-Specific GHG Emission Factors, g/hr and g/mi

Speed Range (mph)	CO_2	N_2O	CH_4	Units
0 (Idle)	4,934	0.1592	0.2531	g/hr
1 - 5	4,074	0.0572	0.1868	g/mi
6 - 10	3,365	0.0572	0.1087	g/mi
11 - 15	2,763	0.0572	0.0552	g/mi
16 - 20	2,180	0.0572	0.0237	g/mi
21 - 25	2,034	0.0572	0.0207	g/mi
26 - 30	1,909	0.0572	0.0180	g/mi
31 - 35	1,806	0.0572	0.0157	g/mi
36 - 40	1,723	0.0572	0.0138	g/mi
41 - 45	1,662	0.0572	0.0121	g/mi
46 - 50	1,622	0.0572	0.0109	g/mi
51 - 55	1,604	0.0572	0.0100	g/mi
56 - 60	1,606	0.0572	0.0094	g/mi
61 - 65	1,630	0.0572	0.0092	g/mi
66 - 70	1,675	0.0572	0.0093	g/mi

The emission factors presented in Tables 7.6 and 7.7 have been multiplied by the on-road and on-terminal VMT and on-terminal idling hours to yield the overall on-road and on-terminal emissions, that are presented below in subsection 7.6, Emission Estimates.

7.5.4 Improvements to Methodology from Previous Years

The following improvements to the data and methodology underlying the emission calculations were made in this inventory compared to the previous EI. Refer to Section 9 for a comparison of 2013 emissions with previous years' emissions.

- The trip generation model and the travel demand model that estimate the number of truck trips and vehicle activity on public roads were enhanced and updated with current data related to terminal operations and on-road travel.

These enhancements do not represent a change of methodology, but improvements in estimating methods that better reflect current port and terminal operations.

7.6 Emission Estimates

The estimates of 2013 HDV emissions are presented in this section. As discussed above, on-terminal emissions are based on terminal-specific information such as the number of trucks passing through the terminal and the distance they travel on-terminal, and the Port-wide totals are the sum of the terminal-specific estimates. The on-road emissions have been estimated for Port trucks using travel demand model results to estimate how many miles in total the trucks travel along defined roadways in the SoCAB on the way to their first cargo drop-off point. The on-terminal estimates include the sum of driving and idling emissions calculated separately. The idling emissions are likely to be somewhat over-estimated because the idling estimates are based on the entire time that trucks are on terminal (except for driving time), which does not account for times that trucks are turned off while on terminal. No data source has been identified that would provide a reliable estimate of the average percentage of time the trucks' engines are turned off while on terminal. The on-road estimates include idling emissions as a normal part of the driving cycle because the average speeds include estimates of normal traffic idling times, and the emission factors are designed to take this into account.

In order for the total emissions to be consistently displayed for each pollutant, the individual values in each table column do not, in some cases, add up to the listed total in the tables. This is because there are fewer decimal places displayed for readability than are included in the calculated total.

Emission estimates for HDV activity associated with Port terminals and other facilities are presented in the following tables. Table 7.8 summarizes emissions from HDVs associated with all Port terminals.

Table 7.8: 2013 HDV Emissions

Activity Location	VMT	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
On-Terminal	5,915,221	0.7	0.6	0.6	165	0.1	75.9	22.1	31,763
On-Road	193,138,565	16.9	15.6	15.4	1,076	3.6	302.5	41.6	321,831
Total	**199,053,786**	**17.6**	**16.2**	**16.0**	**1,240.8**	**3.8**	**378.3**	**63.8**	**353,594**

Table 7.9 presents HDV emissions associated with container terminal activity separately from emissions associated with other Port terminals and facilities.

Table 7.9: 2013 HDV Emissions Associated with Container Terminals

Activity Location	VMT	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
On-Terminal	4,675,735	0.6	0.5	0.5	135.4	0.1	62.5	18.0	25,997
On-Road	178,442,933	15.6	14.4	14.2	994.2	3.4	279.4	38.5	297,430
Total	**183,118,668**	**16.2**	**14.9**	**14.7**	**1,129.6**	**3.5**	**341.9**	**56.5**	**323,427**

Table 7.10 presents emissions associated with other Port terminals and facilities separately.

Table 7.10: 2013 HDV Emissions Associated with Other Port Terminals

Activity Location	VMT	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
On-Terminal	1,239,486	0.1	0.1	0.1	29.9	0.0	13.3	4.2	5,766
On-Road	14,695,632	1.3	1.2	1.2	81.3	0.3	23.0	3.1	24,401
Total	**15,935,118**	**1.4**	**1.3**	**1.3**	**111.2**	**0.3**	**36.3**	**7.3**	**30,167**

SECTION 8 SUMMARY OF 2013 EMISSION RESULTS

The emission results for the Port of Los Angeles 2013 Inventory of Air Emissions are presented in this section. Table 8.1 summarizes the 2013 total port-related emissions in the South Coast Air Basin by category.

Table 8.1: 2013 Port-related Emissions by Category

Category	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
Ocean-going vessels	105	97	90	3,515	535	423	215	195,804
Harbor craft	26	24	26	705	1	372	64	48,067
Cargo handling equipment	15	14	13	678	1	693	73	138,632
Locomotives	29	27	29	828	1	190	46	66,969
Heavy-duty vehicles	18	16	16	1,241	4	378	64	353,594
Total	**193**	**178**	**174**	**6,967**	**542**	**2,056**	**462**	**803,066**

DB ID457

The greenhouse gas emissions are in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton), which is typically used throughout the report for criteria pollutants. The CO_2e values are derived by multiplying the GHG emissions estimates by their respective GWP[96] values (1 for CO_2, 310 for N_2O, 21 for CH_4), then adding them together.

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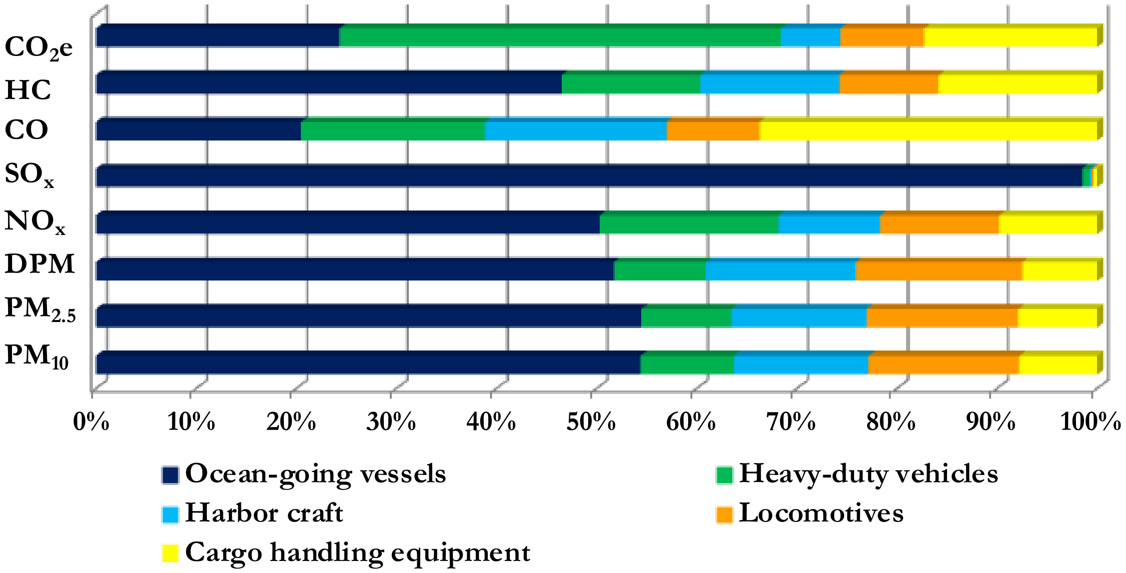
[96] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*, April 2013

Figure 8.1 shows the distribution of 2013 total port-related emissions of each pollutant from each source category. OGV (52%), locomotives (17%), and harbor craft (15%) contributed the highest percentage of DPM emissions among the port-related sources. Approximately 99% of the SO_x emissions were emitted from OGV. OGV (50%) and HDV (18%) accounted for the majority of NO_x emissions. CHE (34%), ocean-going vessels (21%), harbor craft (18%) and HDV (18%) accounted for the majority of CO emissions. OGV (47%) and CHE (16%) accounted for the majority of hydrocarbon emissions.

Figure 8.1: 2013 Port-related Emissions by Category



Tables 8.2 through 8.4 present DPM, NO_x and SO_x emissions in the context of port-wide and air basin-wide emissions by source category and subcategory. For example, Table 8.2 shows that containerships' DPM emissions were 68 tons per year in 2013, representing 75% of the total OGV emissions (source category), 39% of the total port-related emissions, and 1.9% of all emissions in the SoCAB (based on SoCAB emissions reported in the 2013 Air Quality Management Plan). In 2013, the OGV source category as a whole contributed 90 tons of DPM representing 52% of the Port's overall DPM emissions and 2.5% of SoCAB DPM emissions. The bottom of the table highlighted in grey shows that the Port's total DPM emissions constituted approximately 4.8% of the SoCAB DPM emissions. The other two tables similarly present NO_x and SO_x emissions.

Table 8.2: 2013 DPM Emissions by Category and Percent Contribution

Category	Subcategory	DPM Emissions	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	1.8	2%	1%	0.0%
OGV	Bulk vessel	1.8	2%	1%	0.0%
OGV	Containership	67.9	75%	39%	1.9%
OGV	Cruise	7.7	9%	4%	0.2%
OGV	General cargo	2.4	3%	1%	0.1%
OGV	Ocean tugboat	0.6	1%	0%	0.0%
OGV	Miscellaneous	0.0	0%	0%	0.0%
OGV	Reefer	0.7	1%	0%	0.0%
OGV	Tanker	7.2	8%	4%	0.2%
OGV	**Subtotal**	**90**	**100%**	**52%**	**2.5%**
Harbor Craft	Assist tug	6.28	24%	4%	0.2%
Harbor Craft	Harbor tug	0.50	2%	0%	0.0%
Harbor Craft	Commercial fishing	2.56	10%	1%	0.1%
Harbor Craft	Ferry	5.4	20%	3%	0.1%
Harbor Craft	Ocean tugboat	5.0	19%	3%	0.1%
Harbor Craft	Government	1.0	4%	1%	0.0%
Harbor Craft	Excursion	3.8	14%	2%	0.1%
Harbor Craft	Crewboat	1.3	5%	1%	0.0%
Harbor Craft	Work boat	0.6	2%	0%	0.0%
Harbor Craft	**Subtotal**	**26**	**100%**	**15%**	**0.7%**
CHE	RTG crane	1.7	14%	1%	0.0%
CHE	Forklift	0.4	3%	0%	0.0%
CHE	Top handler, side pick	2.7	21%	2%	0.1%
CHE	Other	2.1	16%	1%	0.1%
CHE	Yard tractor	5.9	46%	3%	0.2%
CHE	**Subtotal**	**13**	**100%**	**7%**	**0.4%**
Locomotives	Switching	0.5	2%	0%	0.0%
Locomotives	Line haul	29	98%	16%	0.8%
Locomotives	**Subtotal**	**29**	**100%**	**17%**	**0.8%**
HDV	On-Terminal	0.6	4%	0%	0.0%
HDV	On-Road	15	96%	9%	0.4%
HDV	**Subtotal**	**16**	**100%**	**9%**	**0.4%**
Port	**Total**	**174**		**100%**	**4.8%**
SoCAB AQMP	**Total**	**3,604**			

Table 8.3: 2013 NO_x Emissions by Category and Percent Contribution

		NO_x	Percent NO_x Emissions of Total		
Category	**Subcategory**	**Emissions**	**Category**	**Port**	**SoCAB AQMP**
OGV	Auto carrier	66.9	2%	1%	0.0%
OGV	Bulk vessel	69.0	2%	1%	0.0%
OGV	Containership	2,658.7	76%	38%	1.3%
OGV	Cruise	266.6	8%	4%	0.1%
OGV	General cargo	99.7	3%	1%	0.0%
OGV	Ocean tugboat	21.2	1%	0%	0.0%
OGV	Miscellaneous	0.8	0%	0%	0.0%
OGV	Reefer	29.7	1%	0%	0.0%
OGV	Tanker	302.4	9%	4%	0.2%
OGV	**Subtotal**	**3,515**	**100%**	**50%**	**1.8%**
Harbor Craft	Assist tug	176	25%	2.5%	0.1%
Harbor Craft	Harbor tug	14	2%	0.2%	0.0%
Harbor Craft	Commercial fishing	65	9%	0.9%	0.0%
Harbor Craft	Ferry	136	19%	1.9%	0.1%
Harbor Craft	Ocean tugboat	133	19%	1.9%	0.1%
Harbor Craft	Government	23	3%	0.3%	0.0%
Harbor Craft	Excursion	98	14%	1.4%	0.0%
Harbor Craft	Crewboat	41	6%	0.6%	0.0%
Harbor Craft	Work boat	21	3%	0.3%	0.0%
Harbor Craft	**Subtotal**	**705**	**100%**	**10%**	**0.4%**
CHE	RTG crane	77	11%	1.1%	0.0%
CHE	Forklift	30	4%	0.4%	0.0%
CHE	Top handler, side pick	239	35%	3.4%	0.1%
CHE	Other	57	8%	0.8%	0.0%
CHE	Yard tractor	275	41%	4.0%	0.1%
CHE	**Subtotal**	**678**	**100%**	**10%**	**0.3%**
Locomotives	Switching	54	6%	0.8%	0.0%
Locomotives	Line haul	774	94%	11.1%	0.4%
Locomotives	**Subtotal**	**828**	**100%**	**12%**	**0.4%**
HDV	On-Terminal	165	13%	2%	0.1%
HDV	On-Road	1,076	87%	15%	0.5%
HDV	**Subtotal**	**1,241**	**100%**	**18%**	**0.6%**
Port	**Total**	**6,967**		**100%**	**3.5%**
SoCAB AQMP	**Total**	**200,035**			

Table 8.4: 2013 SO_x Emissions by Category and Percent Contribution

		SO_x	Percent SO_x Emissions of Total		
Category	**Subcategory**	**Emissions**	**Category**	**Port**	**SoCAB AQMP**
OGV	Auto carrier	11.4	2%	2%	0.1%
OGV	Bulk vessel	13.5	3%	3%	0.2%
OGV	Containership	320.2	60%	59%	3.6%
OGV	Cruise	44.2	8%	8%	0.5%
OGV	General cargo	11.8	2%	2%	0.1%
OGV	Ocean tugboat	3.7	1%	1%	0.0%
OGV	Miscellaneous	0.1	0%	0%	0.0%
OGV	Reefer	4.1	1%	1%	0.0%
OGV	Tanker	125.8	24%	23%	1.4%
OGV	**Subtotal**	**535**	**100%**	**99%**	**6.0%**
Harbor Craft	Assist tug	0	26%	0.0%	0.0%
Harbor Craft	Harbor tug	0	2%	0.0%	0.0%
Harbor Craft	Commercial fishing	0	6%	0.0%	0.0%
Harbor Craft	Ferry	0	21%	0.0%	0.0%
Harbor Craft	Ocean tugboat	0	17%	0.0%	0.0%
Harbor Craft	Government	0	3%	0.0%	0.0%
Harbor Craft	Excursion	0	14%	0.0%	0.0%
Harbor Craft	Crewboat	0	8%	0.0%	0.0%
Harbor Craft	Work boat	0	4%	0.0%	0.0%
Harbor Craft	**Subtotal**	**1**	**100%**	**0%**	**0.0%**
CHE	RTG crane	0	8%	0.0%	0.0%
CHE	Forklift	0	2%	0.0%	0.0%
CHE	Top handler, side pick	0	26%	0.1%	0.0%
CHE	Other	0	6%	0.0%	0.0%
CHE	Yard tractor	1	57%	0.2%	0.0%
CHE	**Subtotal**	**1**	**100%**	**0%**	**0.0%**
Locomotives	Switching	0	6%	0.0%	0.0%
Locomotives	Line haul	1	94%	0.2%	0.0%
Locomotives	**Subtotal**	**1**	**100%**	**0%**	**0.0%**
HDV	On-Terminal	0	3%	0%	0.0%
HDV	On-Road	3	97%	1%	0.0%
HDV	**Subtotal**	**3**	**100%**	**1%**	**0.0%**
Port	**Total**	**542**		**100%**	**6.1%**
SoCAB AQMP	**Total**	**8,893**			

In order to put the port-related emissions into context, the following figures and tables compare the Port's contributions to the total emissions in the South Coast Air Basin by major emission source category. The 2013 SoCAB emissions are based on the 2012 AQMP Appendix III.[97] Due to rounding, the percentages may not total 100%.

Figure 8.2: 2013 PM_{10} Emissions in the South Coast Air Basin

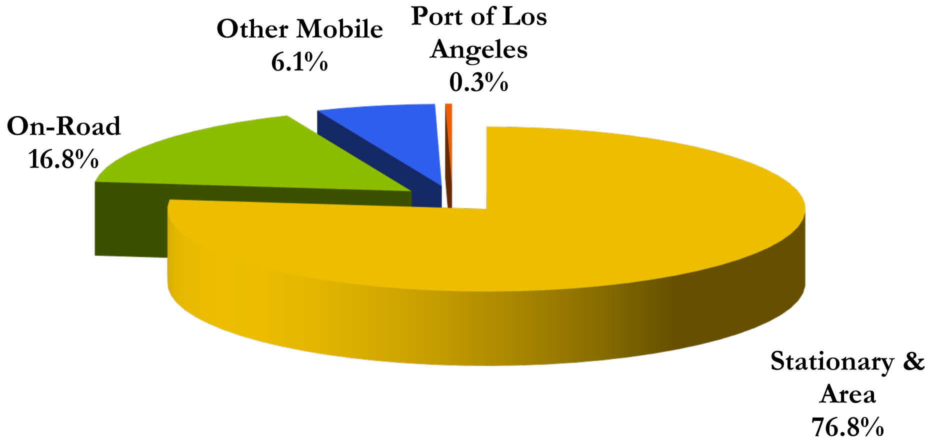
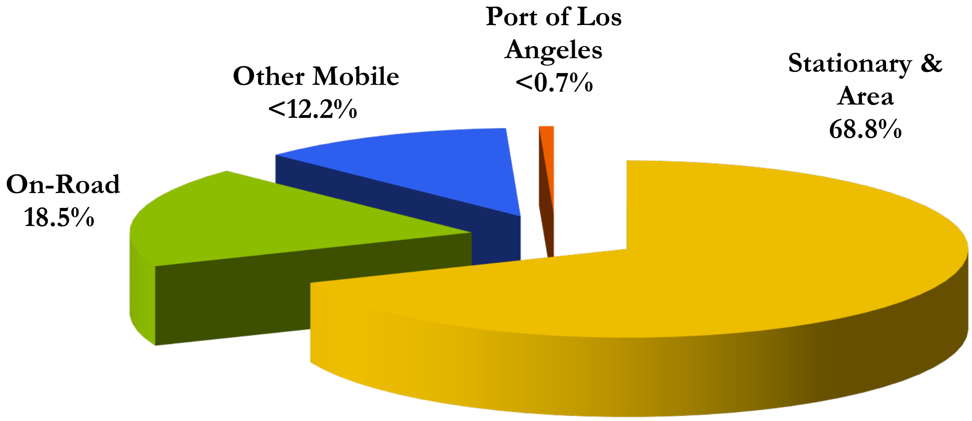


Figure 8.3: 2013 $PM_{2.5}$ Emissions in the South Coast Air Basin



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[97] SCAQMD, *Final 2012 AQMP Appendix III, Base & Future Year Emissions Inventories*, February 2013

Figure 8.4: 2013 DPM Emissions in the South Coast Air Basin

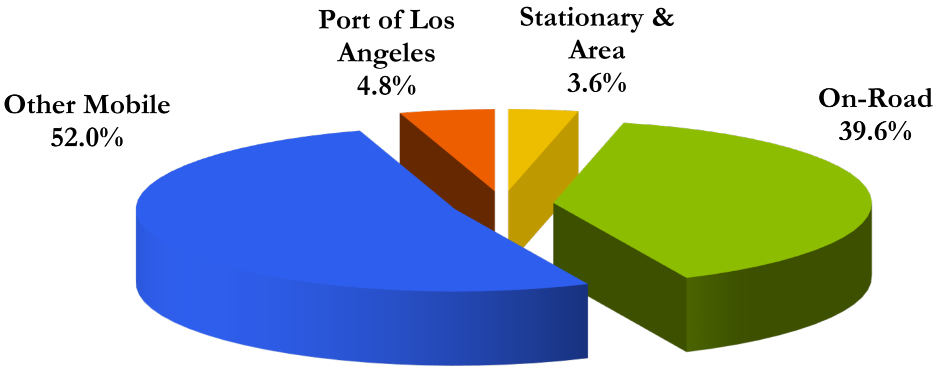


Figure 8.5: 2013 NO_x Emissions in the South Coast Air Basin

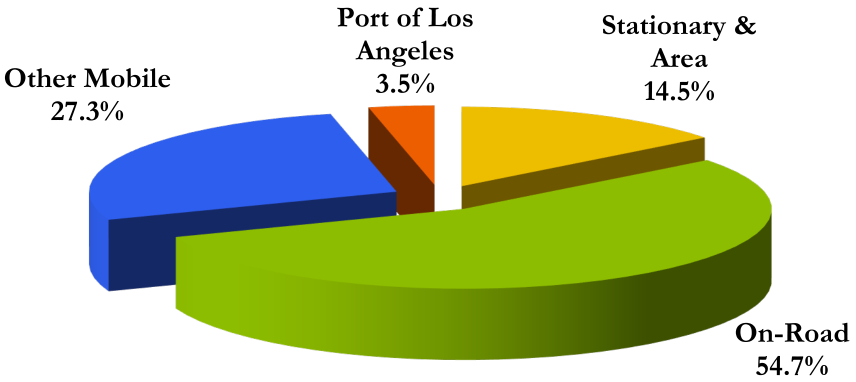


Figure 8.6: 2013 SO_x Emissions in the South Coast Air Basin

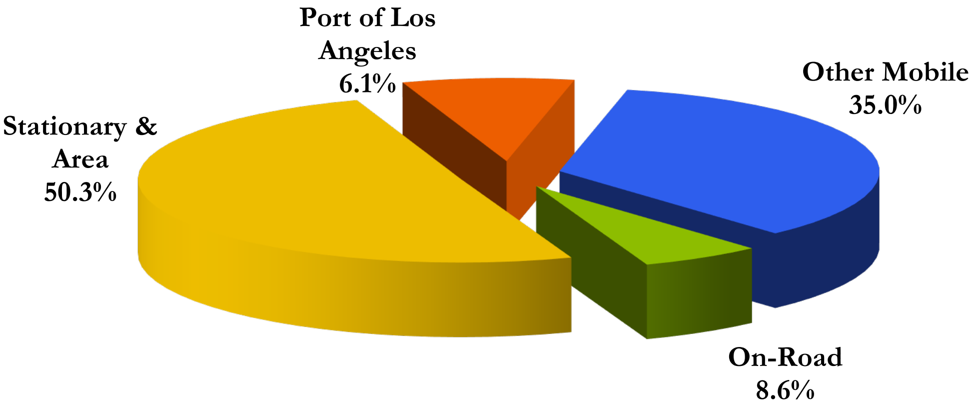
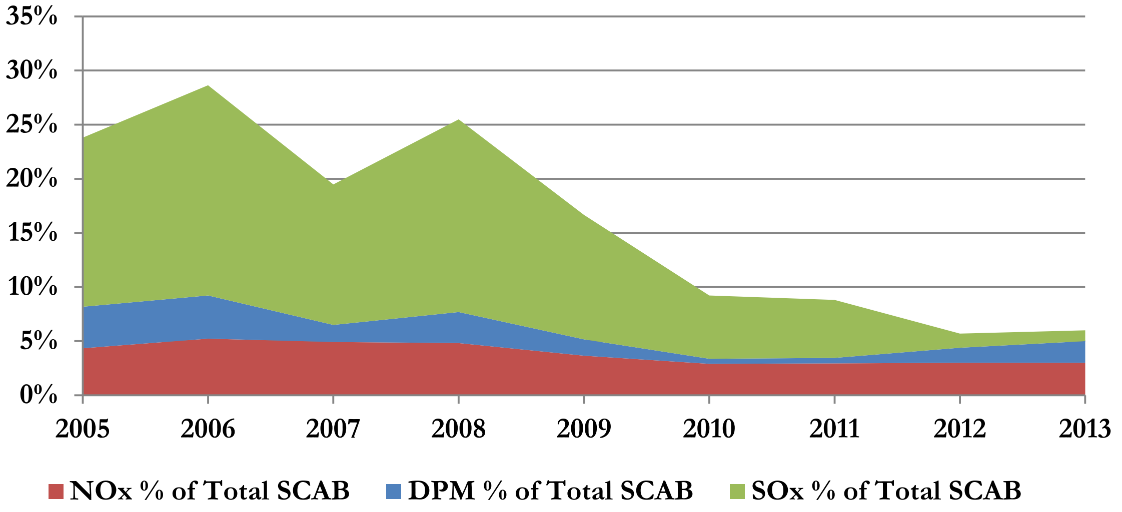


Figure 8.7 presents a comparison of the port-related mobile source emissions to the total SoCAB emissions from 2005 to 2013. As indicated, the Port's overall contribution to the SoCAB emissions has decreased significantly since 2005 primarily because of the implementation of various emission reduction programs.

Figure 8.7: Port's Emissions Contribution in the South Coast Air Basin



SECTION 9 COMPARISON OF 2013 AND PREVIOUS YEARS' FINDINGS AND EMISSION ESTIMATES

This section compares 2013 emissions to those in 2012, 2011, 2010, 2009, 2008, 2007, 2006, and 2005 calendar years, in terms of overall, and for each emission source category. Comparisons by emission source categories are addressed in separate subsections in table and chart formats, which explain the findings and differences in emissions.

The tables and charts in this section also summarize the percent change from the previous year (2013 vs 2012) and for the CAAP Progress (2013 vs2005) using current methodology for emissions comparison. CAAP progress is tracked by comparing emissions each year to 2005 emission; 2005 is considered the baseline year for CAAP.

9.1 2013 Comparisons

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

Methodological differences between 2013 and Previous Year Inventory of Air Emissions

The methodologies used for developing the 2013 inventory changed from prior year inventories for ocean-going vessels, so the prior years' emissions have been recalculated to reflect the updated methodology for OGV. Sections 9.1.1 through 9.1.5 present the source category comparisons across years (2005 to 2013).

Port-wide Overview of Activity and Emissions Changes

Table 9.1 presents the number of vessel calls and the container cargo throughputs for calendar years 2005 through 2013. Compared to 2005, in 2013 the TEUs increased by 5% and containership calls decreased by 1% while the TEUs/containership-call efficiency improved by 6%. Comparing 2013 to the previous year, the number of TEUs decreased by 3% and the number of container ship calls increased by 7%.

Table 9.1: Container and Cargo Throughputs Change, Calls, and TEUs

Year	All Arrivals	Containership Arrivals	TEUs	Average TEUs/Call
2013	2,033	1,463	7,867,863	5,378
2012	1,968	1,370	8,077,714	5,896
2011	2,072	1,376	7,940,511	5,771
2010	2,035	1,355	7,831,902	5,780
2009	2,010	1,355	6,748,995	4,981
2008	2,241	1,459	7,849,985	5,380
2007	2,528	1,577	8,355,038	5,298
2006	2,707	1,632	8,469,853	5,190
2005	2,516	1,479	7,484,625	5,061
Previous Year (2013-2012)	**3%**	**7%**	**-3%**	**-9%**
CAAP Progress (2013-2005)	**-19%**	**-1%**	**5%**	**6%**

Table 9.2 presents a comparison of OGV containership calls from 2013 to 2005; this comparison highlights the general trend toward larger vessels.

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

Category	2013	2012	2011	2010	2009	2008	2007	2006	2005
Container - 1000	109	41	78	116	115	176	237	218	202
Container - 2000	242	256	192	191	165	96	104	149	185
Container - 3000	101	46	6	28	90	142	127	201	296
Container - 4000	347	289	318	302	294	368	537	515	398
Container - 5000	127	232	312	322	359	341	328	289	215
Container - 6000	294	291	263	149	138	199	160	181	131
Container - 7000	34	19	5	91	106	99	80	78	52
Container - 8000	114	93	147	145	78	30	4	1	0
Container - 9000	95	98	55	11	10	8	0	0	0
Container - 11000	0	5	0	0	0	0	0	0	0

DB ID693

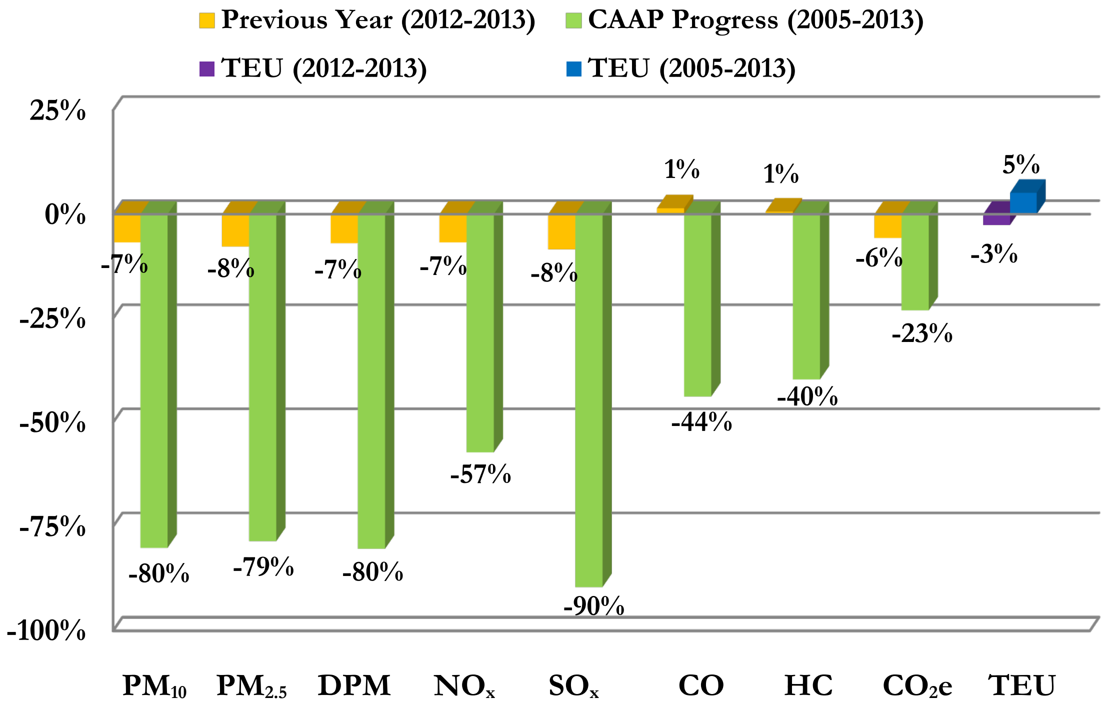
Table 9.3 presents the total net change in emissions from all source categories in 2013 as compared to previous years. From 2012 to 2013, there was a 3% decrease in throughput, while emissions of DPM decreased by 7%, NO_x decreased by 7%, and SO_x decreased by 8%. CO and hydrocarbons increased by 1% from 2012 to 2013. Between 2005 and 2013 there was a 5% increase in throughput, yet emissions of DPM decreased by 80%, NO_x decreased by 57%, SO_x decreased by 90%, CO decreased by 44%, and HC decreased by 40%. GHG emissions decreased 6% in 2013 compared to 2012 and decreased by 23% when compared to 2005, mainly due to better efficiency and CAAP and regulatory measures that have GHG emission reduction co-benefits.

Table 9.3: Port-wide Emissions Comparison

EI Year	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
2013	193	178	174	6,967	542	2,056	462	803,066
2012	207	193	187	7,473	592	2,027	459	851,560
2011	295	263	266	8,062	1,269	2,033	480	838,077
2010	310	276	282	8,231	1,299	1,988	472	843,824
2009	494	428	451	10,884	2,386	2,615	557	888,075
2008	764	656	696	15,016	3,718	3,452	716	1,021,509
2007	727	637	633	16,366	3,340	3,649	774	1,088,238
2006	1,044	893	945	18,483	5,611	4,175	863	1,223,555
2005	972	829	886	16,278	5,186	3,657	766	1,043,983
Previous Year (2012-2013)	**-7%**	**-8%**	**-7%**	**-7%**	**-8%**	**1%**	**1%**	**-6%**
CAAP Progress (2005-2013)	**-80%**	**-79%**	**-80%**	**-57%**	**-90%**	**-44%**	**-40%**	**-23%**

Figure 9.1 shows the percent change in port-wide emissions since the previous year and CAAP progress since 2005.

Figure 9.1: Port-wide Emissions Change



Figures 9.2 through 9.4 show the emission trends for 2005 to 2013 in DPM, NO_x and SO_x emissions from the ocean-going vessels, heavy-duty vehicles, harbor craft, locomotives, and cargo handling equipment emission source categories. As indicated, emissions from all categories have generally decreased over the years, primarily due to the implementation of the Port's emission reduction programs as well as promulgation of emissions reduction regulations. There are some spikes in emissions due to throughput level changes and changes in regulations and control measures.

As shown in Figure 9.2, OGVs contribute to the majority of DPM emissions. DPM emissions from all categories have decreased between 2005 and 2013. OGV and HDV emissions have significantly decreased in recent years primarily due to the Port's VSR, CARB's fuel regulation and the Port's Clean Truck Program.

Figure 9.2: DPM Emissions Comparison by Category, tpy

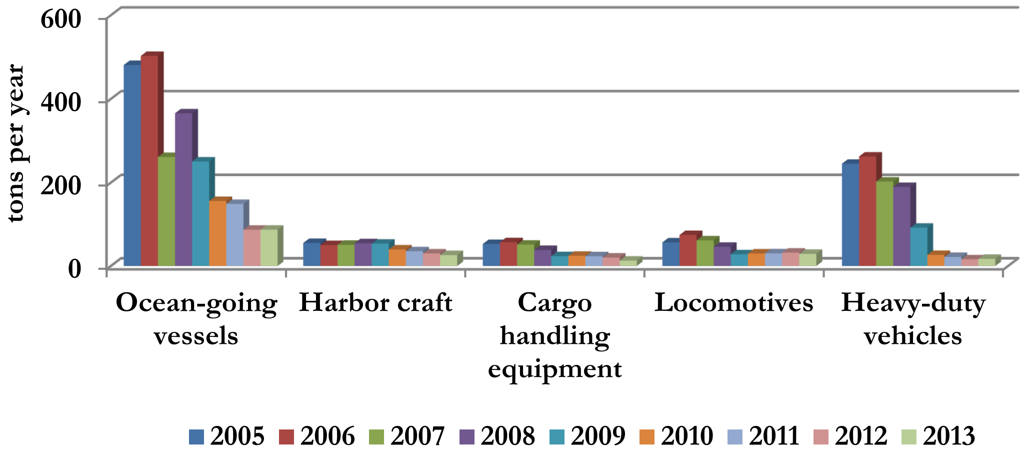


Figure 9.3 illustrates that emissions of NO_x from HDVs were lowered significantly due to the Clean Truck Program, which has been active since 2009. Currently, OGVs dominate the port-related NO_x emissions. NO_x emissions have shown a downward trend over the last several years.

Figure 9.3: NO_x Emissions Comparison by Category, tpy

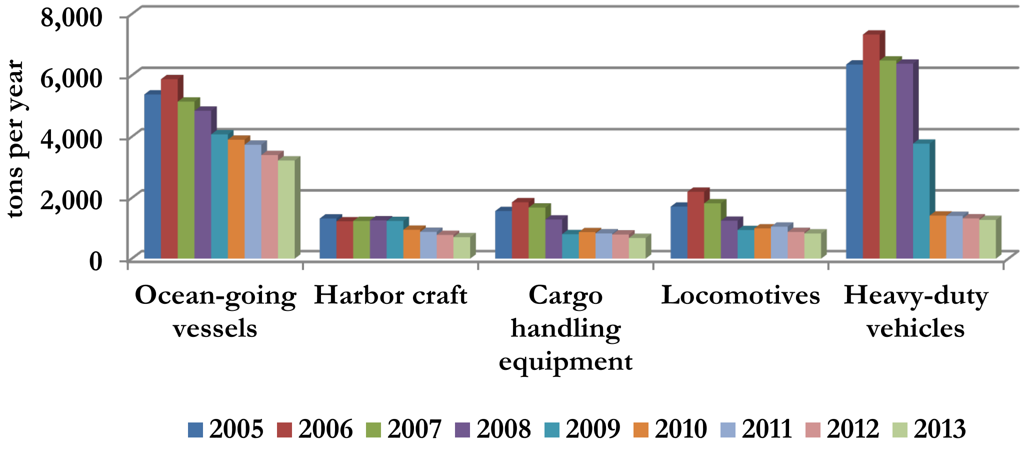


Figure 9.4 shows that OGVs are by far the largest SO_x emissions contributors at the Port. This is because SO_x emissions are produced from the sulfur in the fuel burned by engines and OGV engines typically burn fuels with relatively high sulfur content while the other source categories use fuels that have much lower sulfur content. In 2009, the CARB fuel regulation went into effect mid-year which resulted in significant reduction in OGV SO_x emissions starting in 2009 and continuing through 2013. The other source categories have switched to using ultra low sulfur diesel (ULSD) with a sulfur content of 15 parts per million (ppm).

Figure 9.4: SO_x Emissions Comparison by Category, tpy

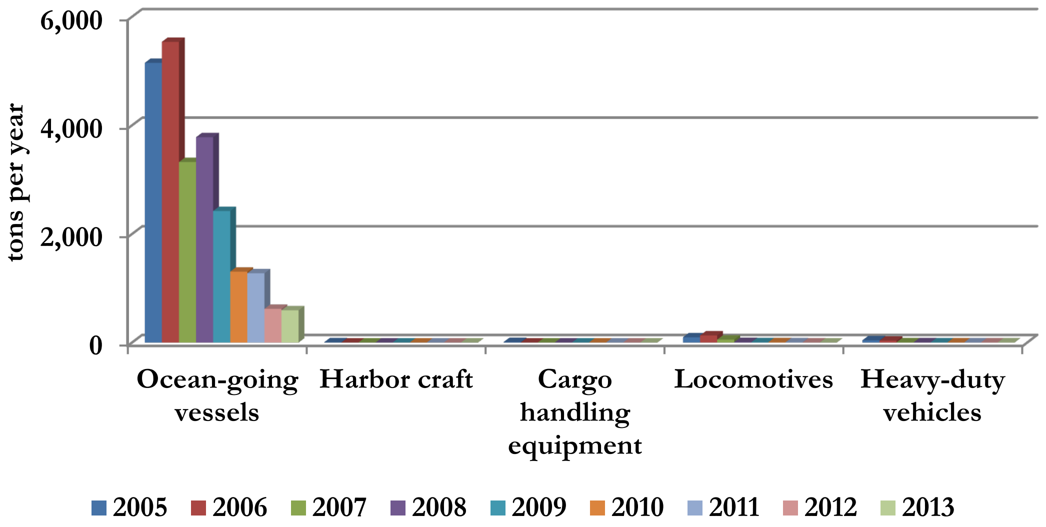


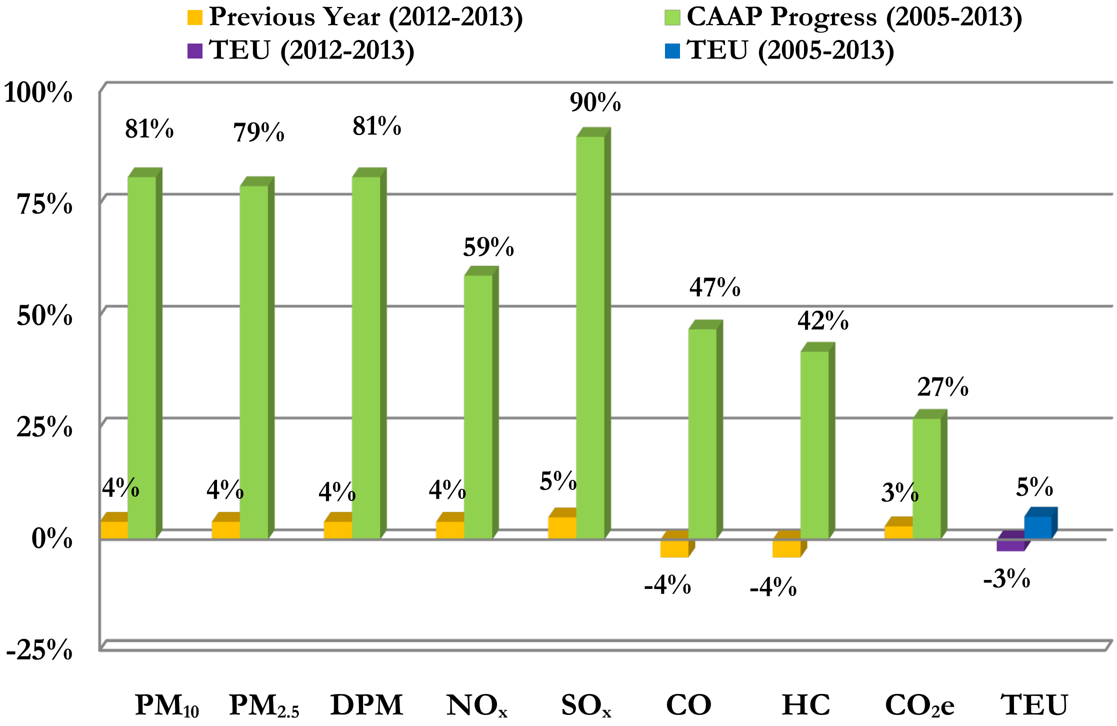
Table 9.4 and Figure 9.5 compare emissions efficiency changes in 2013 as compared to 2005 and 2012. A positive percent change for the emissions efficiency comparison means an improvement in efficiency. The overall port emissions efficiency in 2013 improved for all pollutants, as compared to 2005.

Table 9.4: Port-wide Emissions Efficiency Metric, tons/10,000 TEUs

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2013	0.25	0.23	0.22	8.85	0.69	2.61	0.59	1,020
2012	0.26	0.24	0.23	9.25	0.73	2.51	0.57	1,054
2005	1.30	1.11	1.18	21.75	6.93	4.89	1.02	1,395
Previous Year (2012-2013)	**4%**	**4%**	**4%**	**4%**	**5%**	**-4%**	**-4%**	**3%**
CAAP Progress (2005-2013)	**81%**	**79%**	**81%**	**59%**	**90%**	**47%**	**42%**	**27%**

The purple bar in Figure 9.5 represents the TEU throughput change from the previous year (a 3% decrease) and the blue bar represents the TEU throughput change when compared with 2005 (a 5% increase).

Figure 9.5: Port-wide Changes in Emissions Efficiency Metric



9.1.1 Ocean-Going Vessels

There were improvements to the ocean-going vessels emission calculation methodology in this inventory compared to the 2012 methodology. The following improvements were implemented in OGV emission calculation methodology for the 2013 emissions inventory compared to the 2012 emissions calculation methodology.

- There were no slide valve emission reductions taken for 2005-2013.
- CO_2 emission factors for auxiliary engines were changed from 683 to 722 g/kW-hr. This revision is consistent with CARB methodology.
- Hotelling time calculations were adjusted to account for a difference in the MarEx activity timestamp definition. It was determined that the arrival and departure timestamps indicate the time that a vessel enters or leaves the harbor, rather than the time a vessel arrives or departs berth, which had been the previous interpretation. The hotelling time calculations were adjusted to account for this difference.
- Tanker loading data was incorporated to account for the difference in demand on the auxiliary boiler during loading or discharging operations while at-berth. If a tanker is loading liquid bulk while at-berth, a lower auxiliary boiler load of 875 kW is applied.
- Ship-specific SO_x fuel correction factors were developed for vessels participating in the ESI program. Mass weighted sulfur contents were used for HFO and MDO in place of the 0.5% sulfur CARB requirement when below 0.5% sulfur. Some vessels have multiple fuels for the ECA and CARB requirements and therefore the total MDO average for a vessel could be above the CARB requirement. ESI data does not say which fuel is being used where, therefore it's assumed that minimally all vessels are compliant with the CARB regulations, instead of picking the lowest sulfur fuel bunkered. This method was applied to both 2012 and 2013 estimates.
- Ship specific NO_x emission factors were used for main and auxiliary engines, where vessel-specific EIAPP Certificate data was available through the ESI program or the VBP.

The various emission reduction strategies for ocean-going vessels are listed in Table 9.5. The table lists the percentage of calls that participated in the strategy each year from 2005 through 2013. The following emission reductions strategies are listed:

- Shore Power refers to vessel calls using shore power at-berth, instead of running their diesel-powered auxiliary engines;
- VSR refers to the vessels reducing their transit speed to 12 knots or lower within 20 and 40 nm of the Port;
- Fuel Switch for auxiliary and main engines refers to vessel calls switching to lower sulfur fuel to comply with CARB's marine fuel regulation;
- ESI refers to the number of vessel calls using ship-specific SO_x fuel correction factors that were developed and used based on fuel quality data provided as part of the ESI program.
- EIAPP refers to the number of vessel calls using ship-specific NO_x emission factors for main and auxiliary engines, where vessel specific EIAPP Certificate data was available through the ESI program or the VBP.
- IMO Tier I refers to calls by vessels meeting or exceeding IMO's Tier I standard (2000 and newer vessels);
- IMO Tier II refers to calls by vessels meeting or exceeding IMO's Tier II standard

For the fuel switch columns, Table 9.5 shows the percentage of calls where the fuel was switched from residual fuel to low sulfur fuel associated with vessel operators' voluntary actions, CARB auxiliary engine fuel regulation (mid-2009 - 2013), and the Port's Fuel Incentive Program prior to CARB fuel regulation (2005 – mid-2009).

Table 9.5: OGV Emission Reduction Strategies

Year	Shore Power	VSR 20 nm	VSR 40 nm	Fuel Switch Main Eng	Fuel Switch Aux Eng	ESI	EIAPP Main Eng	EIAPP Aux Eng	IMO Tier I	IMO Tier II
2013	7%	97%	83%	100%	100%	45%	45%	44%	76%	3%
2012	5%	97%	80%	99%	99%	70%	68%	67%	81%	1%
2011	4%	92%	70%	100%	100%	0%	0%	0%	66%	0%
2010	3%	91%	63%	100%	100%	0%	0%	0%	66%	0%
2009	3%	90%	48%	78%	78%	0%	0%	0%	60%	0%
2008	2%	90%	42%	38%	63%	0%	0%	0%	48%	0%
2007	3%	85%	na	24%	100%	0%	0%	0%	48%	0%
2006	2%	73%	na	13%	33%	0%	0%	0%	46%	0%
2005	2%	65%	na	7%	27%	0%	0%	0%	34%	0%

DB ID1731

Prior to the CARB OGV Fuel Regulation, the Northern route was the predominant route for trade with Asia and points north of San Pedro Bay. After the regulation became effective, the Western route (west of the Channel Islands) became the predominant shipping route for ships trading with Asia and points north of San Pedro Bay, presumably to avoid the CARB OGV Fuel Regulation compliance zone. Since the adjustment of the boundary in December 2011, ships have started to transition back to using the Northern route for trade with Asia. This shift in route selection is highlighted Table 9.6.

Table 9.6: Annual Percentage Distribution of Calls by Route

Route	2008	2009	2010	2011	2012	2013
Northern	62%	45%	10%	7%	29%	33%
Western	6%	23%	58%	61%	39%	37%
Southern	31%	31%	31%	31%	31%	30%
Eastern	1%	1%	1%	1%	1%	1%

Table 9.7 presents the engine activity in terms of total kW-hrs. In 2013, the total engine activity decreased by 1% compared to previous year and decreased by 30% compared to 2005.

Table 9.7: OGV Power Comparison, kW-hr

Year	All Engines Total kW-hr	Main Eng Total kW-hr	Aux Eng Total kW-hr	Boiler Total kW-hr
2013	277,232,895	76,621,551	133,849,128	66,762,217
2012	280,397,204	80,206,752	128,702,949	71,487,503
2005	396,011,061	115,859,074	187,824,526	92,327,461
Previous Year (2013-2012)	**-1%**	**-4%**	**4%**	**-7%**
CAAP Progress (2013-2005)	**-30%**	**-34%**	**-29%**	**-28%**

Table 9.8 compares the OGV emissions for calendar years 2005 through 2013 in tons per year and as a percent change in 2013 compared to 2012 and 2005. Reductions in OGV emissions are mainly attributed to the Port's VSR program (all pollutants), continuous transition to larger vessels (less calls/activity), and CARB marine fuel regulation (PM, NO_x and SO_x) which became effective July 2009 and was enforced throughout all of 2010–2013, and had a new expanded boundary in 2012. The expanded boundary resulted in significant reductions for 2013 OGV emissions.

Table 9.8: OGV Emissions Comparison

EI Year	**PM_{10}** tpy	**$PM_{2.5}$** tpy	**DPM** tpy	**NO_x** tpy	**SO_x** tpy	**CO** tpy	**HC** tpy	**CO_2e** tonnes
2013	105	97	90	3,515	535	423	215	195,804
2012	107	99	89	3,698	582	419	207	204,508
2011	181	159	156	3,895	1,257	442	218	222,707
2010	185	162	161	3,997	1,286	442	215	224,960
2009	295	245	254	4,128	2,373	433	208	226,178
2008	434	352	367	4,840	3,701	477	224	257,403
2007	360	298	267	5,139	3,278	516	239	299,036
2006	599	482	501	5,867	5,442	556	252	337,057
2005	561	450	476	5,326	5,031	492	221	299,407
Previous Year (2012-2013)	**-2%**	**-2%**	**1%**	**-5%**	**-8%**	**1%**	**4%**	**-4%**
CAAP Progress (2005-2013)	**-81%**	**-78%**	**-81%**	**-34%**	**-89%**	**-14%**	**-3%**	**-35%**

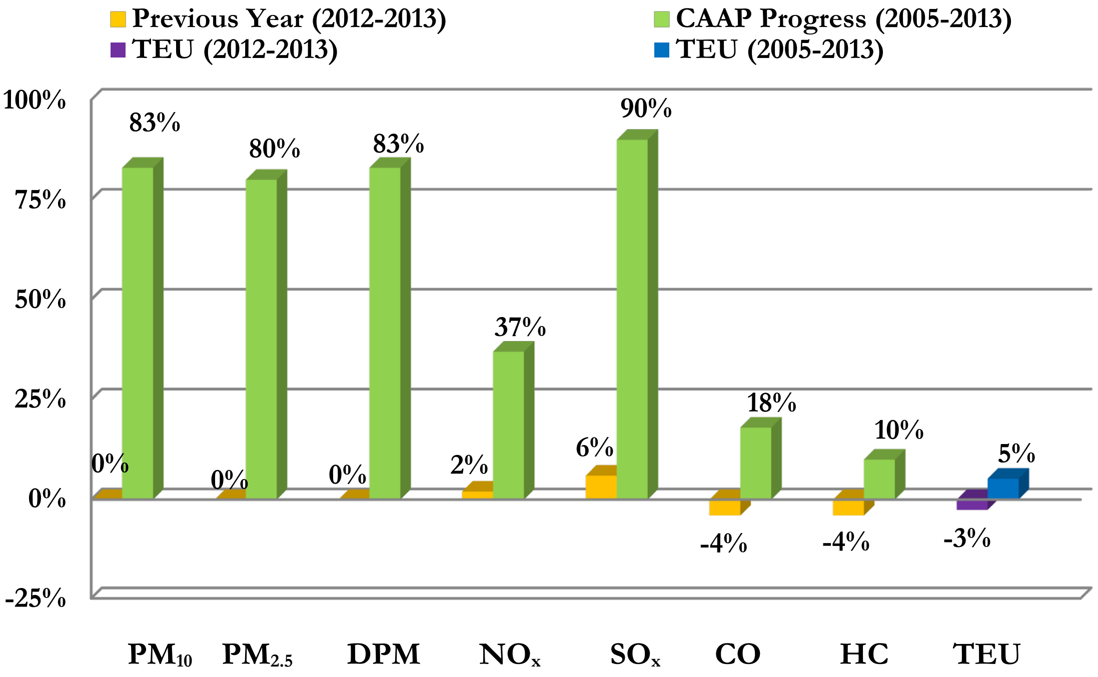
Table 9.9 and Figure 9.6 show the emissions efficiency changes between 2012 and 2013 and between 2005 and 2013. A positive percent change for the emissions efficiency comparison means an improvement in efficiency. As indicated, emissions efficiency improved for all pollutants in 2013, as compared to 2005.

Table 9.9: OGV Emissions Efficiency Metric Comparison, tons/10,000 TEUs

EI Year	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**NO_x**	**SO_x**	**CO**	**HC**
2013	0.13	0.12	0.11	4.47	0.68	0.54	0.27
2012	0.13	0.12	0.11	4.58	0.72	0.52	0.26
2005	0.75	0.60	0.64	7.12	6.73	0.66	0.30
Previous Year (2012-2013)	**0%**	**0%**	**0%**	**2%**	**6%**	**-4%**	**-4%**
CAAP Progress (2005-2013)	**83%**	**80%**	**83%**	**37%**	**90%**	**18%**	**10%**

The purple bar represents the TEU throughput change from the previous year (3% decrease) and the blue bar represents the TEU throughput change when compared to 2005 (5% increase).

Figure 9.6: OGV Emissions Efficiency Metric Change



9.1.2 Harbor Craft

The methodology used to estimate harbor craft emissions for this 2013 Inventory did not change from the methodology used in the 2012 inventory.

Table 9.10 summarizes the number of harbor craft inventoried for 2005, 2012 and 2013. Overall, the total vessel count decreased by 1% from 2012 to 2013 and by 19% between 2005 and 2013.

Table 9.10: Harbor Craft Count Comparison

Harbor Vessel Type	2013	2012	2005
Assist tug	14	14	16
Commercial fishing	110	112	156
Crew boat	22	22	14
Excursion	29	30	24
Ferry	10	10	9
Government	16	17	26
Ocean tug	7	6	7
Tugboat	15	15	19
Work boat	8	8	14
Total	**231**	**234**	**285**

DB ID196

Table 9.11 summarizes the percent distribution of engines based on EPA's engine standards. As expected, the percentage of Tier 2 and Tier 3 engines has continued to increase due to the introduction of newer vessels with newer engines into the fleet and replacements of existing higher-emitting engines with cleaner engines.

For this comparison, the Tier 1, 2 and 3 categorization of engines for the Port's harbor craft inventory is based on EPA's emission standards for marine engines[98]. Tier 0 engines are unregulated engines built prior to the promulgation of the EPA emission standards. Unknown engines are those missing model year, horsepower, or both.

Table 9.11: Harbor Craft Engine Standards Comparison by Tier

Year	Tier 0	Tier 1	Tier 2	Tier 3	Unknown
2013	9%	13%	36%	13%	29%
2012	11%	16%	34%	9%	30%
2005	15%	33%	3%	0%	49%

DB ID1631

Table 9.12 summarizes the overall activity level of harbor craft (measured as a product of the rated engine size in kW, annual operating hours and load factors) decreased by 4% in 2013 compared to the previous year and decreased by 15% compared to 2005.

Table 9.12: Harbor Craft Comparison

Year	Vessel Count	Engine Count	Total kW-hrs
2013	231	560	72,523,263
2012	234	564	75,937,993
2005	285	578	85,398,148
Previous Year (2012-2013)	**-1%**	**-1%**	**-4%**
CAAP Progress (2005-2013)	**-19%**	**-3%**	**-15%**

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[98] Code of Federal Regulation, *40 CFR, subpart 94.8 for Tier 1 and 2 and subpart 1042.101 for Tier 3*

Table 9.13 shows the harbor craft activity comparison by vessel type for calendar years 2005, 2012 and 2013. Between 2012 and 2013, the overall decrease is due to decreases in activity for assist tugs, commercial fishing, tugboats and excursion vessels. Compared to 2005, activity levels of commercial fishing and tugboat decreased significantly in 2013.

Table 9.13: Harbor Craft Activity Comparison by Type, million kW-hr

Vessel Type	2013	2012	2005
Assist Tug	18.5	25.2	25.2
Commercial Fishing	4.7	5.2	14.1
Crew boat	5.5	5.0	2.4
Excursion	9.8	10.5	11.5
Ferry	15.1	14.4	13.1
Government	2.2	2.1	3.0
Ocean Tug	12.2	7.9	3.1
Tugboat	1.7	3.0	11.4
Work boat	2.8	2.8	1.6
Total	**72.5**	**75.9**	**85.4**

Table 9.14 shows the emissions comparisons for calendar years 2005 to 2013 for harbor craft.

Table 9.14: Harbor Craft Emission Comparison

Year	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
2013	26	24	26	705	0.5	372	64	48,067
2012	30	28	30	780	0.6	386	68	50,330
2011	35	32	35	879	0.6	382	72	51,901
2010	40	36	40	950	0.6	364	75	51,613
2009	54	49	54	1,238	0.6	380	89	55,399
2008	55	50	55	1,260	0.6	368	89	55,088
2007	51	47	51	1,239	0.6	337	82	56,875
2006	50	46	50	1,228	0.6	336	82	56,145
2005	55	51	55	1,320	6.3	365	87	57,199
Previous Year (2012-2013)	**-13%**	**-13%**	**-13%**	**-10%**	**-4%**	**-4%**	**-6%**	**-4%**
CAAP Progress (2005-2013)	**-52%**	**-52%**	**-52%**	**-47%**	**-91%**	**2%**	**-27%**	**-16%**

DB ID427

In 2013, emissions for all pollutants decreased when compared to 2012 and 2005, except for CO which increased by 2% in 2013 when compared to 2005. The decrease in emissions is due to the decrease in overall harbor craft activity and the introduction of newer engines in the harbor craft fleet. In 2013, there was a continued reduction in PM and NO_x emissions due to a cleaner fleet (vessel repowers and brand new vessels). The ninety one percent decrease in SO_x emissions between 2005 and 2013 is due to the fact that very few harbor craft used low sulfur fuel in 2005, whereas in 2013 all harbor craft had switched to ULSD fuel use.

The increase in CO is more directly related to an increase in Tier 2 and Tier 3 engines that have higher CO emission rates compared to pre-Tier 2. Due to a stringency of PM and (NO_x + HC) standards of Tier 2 engines, less stringent Tier 2 CO standards were adopted which resulted in higher CO emission rates. From 2010 to 2013, there has been an increase in Tier 2 and Tier 3 engines due to accelerated vessel repowers seen in late 2009 to 2013, and also due to new vessels bought by companies.

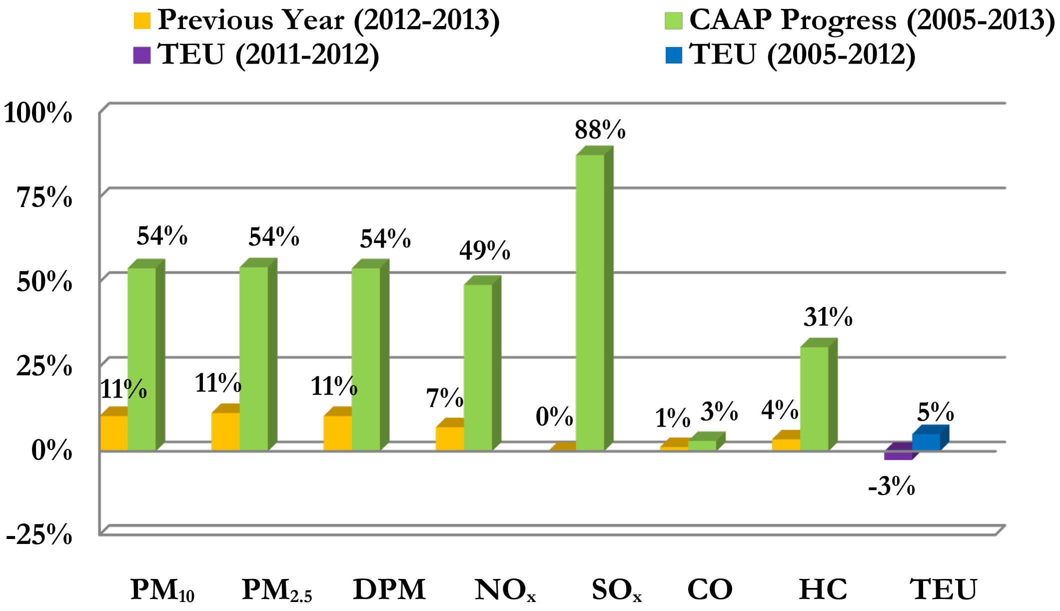
Table 9.15 shows the emissions efficiency changes in 2013 from 2005 and 2012. It should be noted that total harbor craft emissions were used for this efficiency comparison although emissions from several harbor craft types (e.g., commercial fishing vessels) are not dependent on container throughput. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.15: Harbor Craft Emissions Efficiency Metric Comparison, tons/10,000 TEUs

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2013	0.03	0.03	0.03	0.90	0.00	0.47	0.08
2012	0.04	0.04	0.04	0.97	0.00	0.48	0.08
2005	0.07	0.07	0.07	1.76	0.01	0.49	0.12
Previous Year (2012-2013)	**11%**	**11%**	**11%**	**7%**	**0%**	**1%**	**4%**
CAAP Progress (2005-2013)	**54%**	**54%**	**54%**	**49%**	**88%**	**3%**	**31%**

Figure 9.7 shows the harbor craft emissions efficiency comparisons between 2013 and 2012 and between 2013 and 2005 for CAAP progress. The purple bar represents the TEU throughput change from the previous year (3% decrease) and the blue bar represents the TEU throughput change when compared to 2005 (5% increase).

Figure 9.7: Harbor Craft Emissions Efficiency Metric Change



9.1.3 Cargo Handling Equipment

The methodology used to estimate CHE emissions for the 2013 Inventory of Air Emissions did not change from the methodology used in the 2012 inventory.

Table 9.16 shows there was a 5% increase in the number of units of cargo handling equipment and a 5% decrease in the overall activity level (measured as total kW-hrs, the product of the rated engine size in kW, annual operating hours and load factors) in 2013 as compared to 2012. From 2005 to 2013, there was a 21% increase in population and 2% increase in activity level.

Table 9.16: CHE Count and Activity Comparison

Year	Count	Activity (kW-hr)
2013	2,149	176,621,278
2012	2,048	186,667,747
2005	1,782	173,169,439
Previous Year (2012-2013)	**5%**	**-5%**
CAAP Progress (2005-2013)	**21%**	**2%**

Table 9.17 summarizes the numbers of pieces of cargo handling equipment using various engine and power types, including electric, liquefied natural gas (LNG), diesel, propane, and gasoline.

Table 9.17: Count of CHE Engine Type

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
2013						
Forklift	11	0	387	8	159	565
Electric wharf crane	76	0	0	0	0	76
RTG crane	0	0	0	0	108	108
Side pick	0	0	0	0	34	34
Top handler	0	0	0	0	160	160
Yard tractor	0	17	180	6	874	1,077
Sweeper	0	0	0	2	9	11
Other	23	0	0	0	95	118
Total	**110**	**17**	**567**	**16**	**1,439**	**2,149**
	5.1%	**0.8%**	**26.4%**	**0.7%**	**67.0%**	
2012						
Forklift	11	0	382	7	138	538
Electric wharf crane	74	0	0	0	0	74
RTG crane	0	0	0	0	109	109
Side pick	0	0	0	0	38	38
Top handler	0	0	0	0	150	150
Yard tractor	0	17	180	6	815	1,018
Sweeper	0	0	0	2	10	12
Other	23	0	0	0	86	109
Total	**108**	**17**	**562**	**15**	**1,346**	**2,048**
	5.3%	**0.8%**	**27.4%**	**0.7%**	**65.7%**	
2005						
Forklift	0	0	263	8	151	422
Electric wharf crane	67	0	0	0	0	67
RTG crane	0	0	0	0	98	98
Side pick	0	0	0	0	41	41
Top handler	0	0	0	0	127	127
Yard tractor	0	0	53	0	848	901
Sweeper	0	0	0	3	8	11
Other	12	0	0	0	103	115
Total	**79**	**0**	**316**	**11**	**1376**	**1,782**
	4.4%	**0.0%**	**17.7%**	**0.6%**	**77.2%**	

DB ID235

Table 9.18 summarizes the number and percentage of diesel powered CHE with various emission controls by equipment type in 2005, 2012 and 2013. The emission controls for CHE include: DOC retrofits, DPF retrofits, on-road engines (CHE equipped with on-road certified engines instead of off-road engines), use of ULSD with a maximum sulfur content of 15 ppm, and emulsified fuel. Several items to note include:

- Since some emission controls can be used in combination with others, the number of units of equipment with controls (shown in Table 9.18) cannot be added across to come up with the total equipment count (counts of equipment with controls would be greater than the total equipment counts).
- With implementation of the Port's CAAP measure for CHE and CARB's CHE regulation, the relative percentage of cargo handling equipment equipped with new on-road engines increased when compared to 2005.
- Mainly due to equipment turnover, the DOCs count have decreased since 2005 as older equipment with DOCs were replaced with newer equipment that did not require the use of DOCs.
- Emulsified fuel has not been used since 2006 due to supplier unavailability.
- ULSD has been used by all diesel equipment since 2006. For 2005, ULSD was used by some diesel equipment, but not all.

Table 9.18: Count of CHE Diesel Equipment Emissions Control Matrix

						% of Diesel Powered Equipment			
Equipment	**DOC Installed**	**On-Road Engines**	**DPF Installed**	**ULSD Fuel**	**Total Diesel-Powered Equipment**	**DOC Installed**	**On-Road Engines**	**DPF Installed**	**ULSD Fuel**
2013									
Forklift	3	0	24	159	159	2%	0%	15%	100%
RTG crane	8	0	15	108	108	7%	0%	14%	100%
Side pick	7	0	7	34	34	21%	0%	21%	100%
Top handler	0	0	116	160	160	0%	0%	73%	100%
Yard tractor	164	708	4	874	874	19%	81%	0%	100%
Sweeper	0	0	2	9	9	0%	0%	22%	100%
Other	0	15	19	95	95	0%	16%	20%	100%
Total	**182**	**723**	**187**	**1,439**	**1,439**	**13%**	**50%**	**13%**	**100%**
2012									
Forklift	3	0	18	138	138	2%	0%	13%	100%
RTG crane	10	0	30	109	109	9%	0%	28%	100%
Side pick	13	0	1	38	38	34%	0%	3%	100%
Top handler	21	0	78	150	150	14%	0%	52%	100%
Yard tractor	221	608	4	815	815	27%	75%	0%	100%
Sweeper	0	0	0	10	10	0%	0%	0%	100%
Other	0	15	14	86	86	0%	17%	16%	100%
Total	**268**	**623**	**145**	**1,346**	**1,346**	**20%**	**46%**	**11%**	**100%**
2005									
Forklift	3	0	0	27	151	2%	0%	0%	18%
RTG crane	0	0	0	36	98	0%	0%	0%	37%
Side pick	14	0	0	16	41	34%	0%	0%	39%
Top handler	48	0	0	79	127	38%	0%	0%	62%
Yard tractor	520	164	0	483	848	61%	19%	0%	57%
Sweeper	0	0	0	0	8	0%	0%	0%	0%
Other	0	1	0	65	103	0%	1%	0%	63%
Total	**585**	**165**	**0**	**706**	**1,376**	**43%**	**12%**	**0%**	**51%**

DB ID234

Table 9.19 compares the total number of cargo handling equipment units with off-road diesel engines (meeting Tier 0, 1, 2, 3 and 4i off-road diesel engine standards) and those equipped with on-road diesel engines from 2005 to 2013 and 2012 to 2013. Since classification of engine standards is based on the engine's model year and horsepower, equipment with missing horsepower or model year information are listed separately under the Unknown Tier column in this table. As indicated, over the last five years, implementation of the CAAP's CHE measure and CARB's CHE regulation have resulted in a steady increase in the prevalence of newer and cleaner equipment (i.e., primarily Tier 2 and Tier 3 with a few Tier 4i) replacing the older and higher-emitting equipment (Tier 0 and Tier 1). In addition, the number of units with on-road engines, which are even cleaner than Tier 3 off-road engines, has significantly increased since 2005.

Note that Tier 3 and Tier 4i engines were not available in 2005; therefore, "NA" is used for comparison of current year to 2005 for these engine categories.

Table 9.19: Count of CHE Diesel Engine Tier and On-road Engine

Year	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4i	On-road Engine	Unknown Tier	Total Diesel
2013	39	87	286	154	125	723	25	1,439
2012	56	112	354	149	39	623	13	1,346
2005	256	582	360	0	0	165	13	1,376
Previous Year (2012-2013)	**-30%**	**-22%**	**-19%**	**3%**	**221%**	**16%**	**92%**	**7%**
CAAP Progress (2005-2013)	**-85%**	**-85%**	**-21%**	**NA**	**NA**	**338%**	**92%**	**5%**

DB ID878

To track CAAP progress, Table 9.20 shows the cargo handling equipment emissions comparisons for calendar years 2005 to 2013 in tons per year, and as a percent change in 2013 compared to 2012 and 2005. As shown, in general, the emissions of all pollutants have decreased over the years, except for CO and HC emissions which increased slightly in 2013 as compared to 2012. Compared to 2012, emissions decreased in 2013 due to fleet turnover resulting in a higher percent of Tier 4 engines. The 2013 emissions decreased significantly compared to 2005 emissions due to the implementation of the Port's CHE measures and CARB's CHE regulation. The efforts also resulted in the introduction of newer equipment with cleaner engines and the installation of emission controls.

Table 9.20: CHE Emissions Comparison

Year	**PM_{10} tpy**	**$PM_{2.5}$ tpy**	**DPM tpy**	**NO_x tpy**	**SO_x tpy**	**CO tpy**	**HC tpy**	**CO_2e tonnes**
2013	15	14	13	678	2	693	73	138,632
2012	21	20	20	793	2	650	69	146,046
2011	25	23	23	831	2	664	69	145,409
2010	26	24	25	872	2	656	66	145,113
2009	25	23	24	804	1	770	61	130,227
2008	40	37	38	1,289	2	807	69	152,175
2007	52	48	51	1,681	2	953	91	160,112
2006	58	54	57	1,856	2	1,021	105	171,668
2005	54	50	53	1,566	9	825	87	134,952
Previous Year (2012-2013)	**-32%**	**-32%**	**-36%**	**-14%**	**-6%**	**7%**	**6%**	**-5%**
CAAP Progress (2005-2013)	**-73%**	**-73%**	**-76%**	**-57%**	**-84%**	**-16%**	**-16%**	**3%**

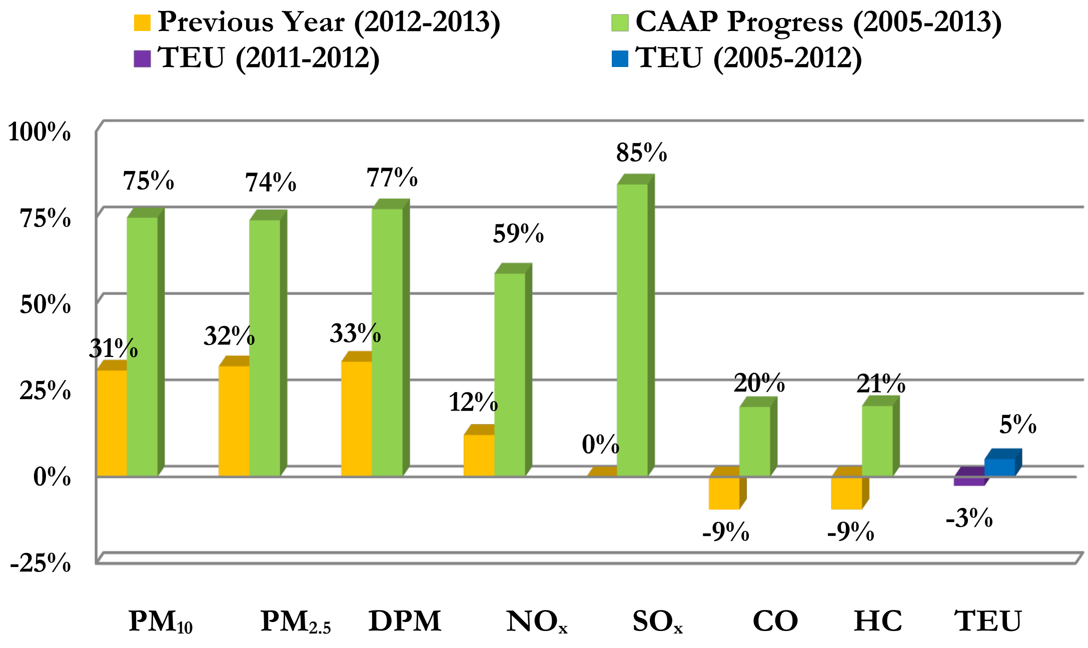
Table 9.21 shows the emissions efficiency changes in 2013 from 2005 and 2012. From 2012 to 2013, there was a 3% decrease in TEU throughput, and a 12-33% improvement in efficiency for NO_x and PM pollutants. SO_x efficiency did not change from previous year and there was a decrease in efficiency for CO and HC. From 2005 to 2013, there was a 5% increase in TEU throughput, and a 20% to 85% improvement in emissions efficiency, depending on pollutant. A positive percentage change for the emissions efficiency comparison means an improvement in efficiency.

Table 9.21: CHE Emissions Efficiency Metric Comparison, tons/10,000 TEUs

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2013	0.02	0.02	0.02	0.86	0.00	0.88	0.09
2012	0.03	0.03	0.02	0.98	0.00	0.80	0.09
2005	0.07	0.07	0.07	2.09	0.01	1.10	0.12
Previous Year (2012-2013)	**31%**	**32%**	**33%**	**12%**	**0%**	**-9%**	**-9%**
CAAP Progress (2005-2013)	**75%**	**74%**	**77%**	**59%**	**85%**	**20%**	**21%**

Figure 9.8 shows the CHE emissions efficiency comparisons between 2013 and 2012 and between 2013 and 2005 for the CAAP progress. The purple bar represents the TEU throughput change from the previous year (3% decrease) and the blue bar represents the TEU throughput change when compared to 2005 (5% increase).

Figure 9.8: CHE Emissions Efficiency Metric Change



9.1.4 Locomotives

The methodology used to estimate locomotive emissions in this 2013 Inventory is the same as that used in the 2012 inventory. Table 9.22 shows the throughput comparisons for locomotives for 2005, 2012, and 2013. Compared to the previous year, there was a 3% decrease in total TEU throughput and a 1% decrease in on-dock TEUs. Compared to 2005, there has been a 5% increase in total TEU and a 9% increase in on-dock TEU.

Table 9.22: Throughput Comparison, million TEUs

Throughput[99]	2005	2012	2013
Total	7.48	8.08	7.87
On-dock lifts	1.02	1.18	1.11
On-dock TEUs	1.84	2.13	2.00
% On-Dock	25%	26%	25%

Table 9.23 shows the locomotive emissions estimate for calendar years 2005 through 2013. The decrease in on-dock throughput from 2012 contributed to the decrease in emissions from previous year. Compared to 2005, the decrease in emissions is due to cleaner line haul locomotives in response to fleet turnover and compliance with the MOU, PHL's and UP's fleet turnover to the latest ultra-low emissions switching locomotives, and the use of ULSD. In particular, the railroads' compliance with the MOU contributed towards the significant NO_x emission reductions. CO_2 emissions have been reduced despite the increase in rail throughput through the freight movement efficiency improvements implemented by the railroads and terminals.

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[99] On-dock lifts as reported by the terminals, on-dock TEUs calculated from on-dock lifts and average 1.8 TEU/lift, % on-dock rail calculated by dividing million on-dock TEUs by million total TEUs.

Table 9.23: Locomotive Emission Comparison

Year	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
2013	29	27	29	828	1	190	46	66,969
2012	32	30	32	877	3	198	50	70,011
2011	30	28	30	1,052	6	196	55	69,505
2010	30	27	30	996	7	177	54	61,594
2009	28	26	28	940	7	160	51	55,629
2008	46	43	46	1,246	9	226	72	78,768
2007	61	57	61	1,821	55	268	98	93,130
2006	74	69	74	2,202	132	320	119	109,879
2005	57	53	57	1,712	98	237	89	82,372
Previous Year (2012-2013)	**-9%**	**-10%**	**-9%**	**-6%**	**-67%**	**-4%**	**-8%**	**-4%**
CAAP Progress (2005-2013)	**-49%**	**-49%**	**-49%**	**-52%**	**-99%**	**-20%**	**-48%**	**-19%**

DB ID428

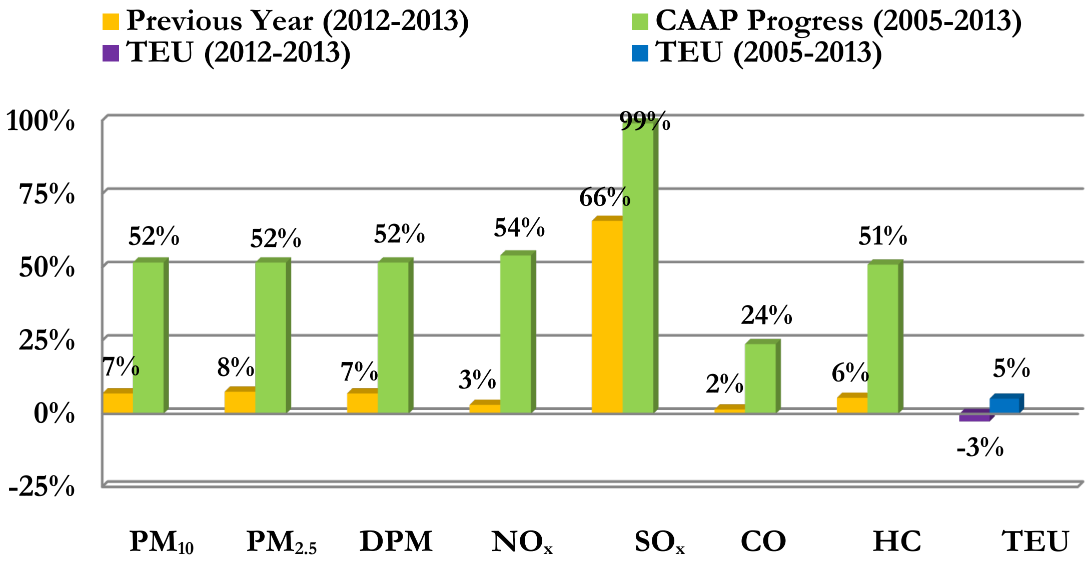
Table 9.24 and Figure 9.9 show the emissions efficiency changes in 2013 from 2005 and 2012. A positive percentage for the emissions efficiency comparison means an improvement in efficiency. For the previous year comparison (2013 vs. 2012), emission efficiency improved for NO_x, SO_x, and HC. For the CAAP progress (2013 vs. 2005), emission efficiencies have improved for all pollutants.

Table 9.24: Locomotive Emissions Efficiency Metric Comparison, tons/10,000 TEUs

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2013	0.04	0.03	0.04	1.05	0.00	0.24	0.06
2012	0.04	0.04	0.04	1.09	0.00	0.25	0.06
2005	0.08	0.07	0.08	2.29	0.13	0.32	0.12
Previous Year (2012-2013)	**7%**	**8%**	**7%**	**3%**	**66%**	**2%**	**6%**
CAAP Progress (2005-2013)	**52%**	**52%**	**52%**	**54%**	**99%**	**24%**	**51%**

The purple bar represents the TEU throughput change from the previous year (3% decrease) and the blue bar represents the TEU throughput change when compared to 2005 (5% increase).

Figure 9.9: Locomotive Emissions Efficiency Metric Change



9.1.5 Heavy-Duty Vehicles

In 2013, the transportation model of terminal operations and on-road travel developed by the Port in conjunction with other Port projects continued to be improved. This does not represent a change of methodology, but an improvement in estimating methods that better reflect current port and terminal operations.

Table 9.25 shows the total port-wide idling time based on information provided by the terminal operators. Total idling time decreased from 2012 by 8% and 9% since 2005.

Table 9.25: HDV Idling Time Comparison, hours

Year	Total Idling Time (hours)
2013	2,743,844
2012	2,977,008
2005	3,017,252
Previous Year (2012-2013)	**-8%**
CAAP Progress (2005-2013)	**-9%**

Table 9.26 summarizes the average age of the port-related fleet for 2013, 2012 and 2005. The average engine age of the trucks visiting the Port is 4 years.

Table 9.26: Port-related Fleet Weighted Average Age, years

Year	Call-Weighted Average Age (years)
2013	4
2012	3
2005	11

Table 9.27 summarizes the HDV emissions from 2005 to 2013 and the percent change in 2013 compared to previous year and 2005. The HDV emissions of all pollutants have decreased significantly from 2005 due to the implementation of the CTP. The CTP continues to be the most significant contributor to HDV emission reductions. Despite the lower throughput and VMT in 2013, PM emissions increased slightly from the previous year due to the limited fleet turnover,, which resulted in the EMFAC model adding a year of deterioration to most of the fleet. The NO_x emissions were lower than previous year due to the small increase in percentage of 2010+ engines which have lower NO_x emissions as compared to 2007 to 2009 MY HDV engines.

Table 9.27: HDV Emissions Comparison

Year	PM_{10} tpy	$PM_{2.5}$ tpy	DPM tpy	NO_x tpy	SO_x tpy	CO tpy	HC tpy	CO_2e tonnes
2013	18	16	16	1,241	4	378	64	353,594
2012	17	16	16	1,325	4	374	65	380,665
2011	23	21	22	1,406	4	348	66	348,555
2010	29	26	27	1,417	4	349	63	360,544
2009	92	84	92	3,774	4	873	148	420,642
2008	189	174	189	6,381	5	1,575	262	478,075
2007	203	186	203	6,485	5	1,575	264	479,085
2006	262	241	262	7,329	35	1,942	306	548,807
2005	245	225	245	6,354	42	1,737	281	470,053
Previous Year (2012-2013)	**2%**	**2%**	**3%**	**-6%**	**-7%**	**1%**	**-2%**	**-7%**
CAAP Progress (2005-2013)	**-93%**	**-93%**	**-93%**	**-80%**	**-91%**	**-78%**	**-77%**	**-25%**

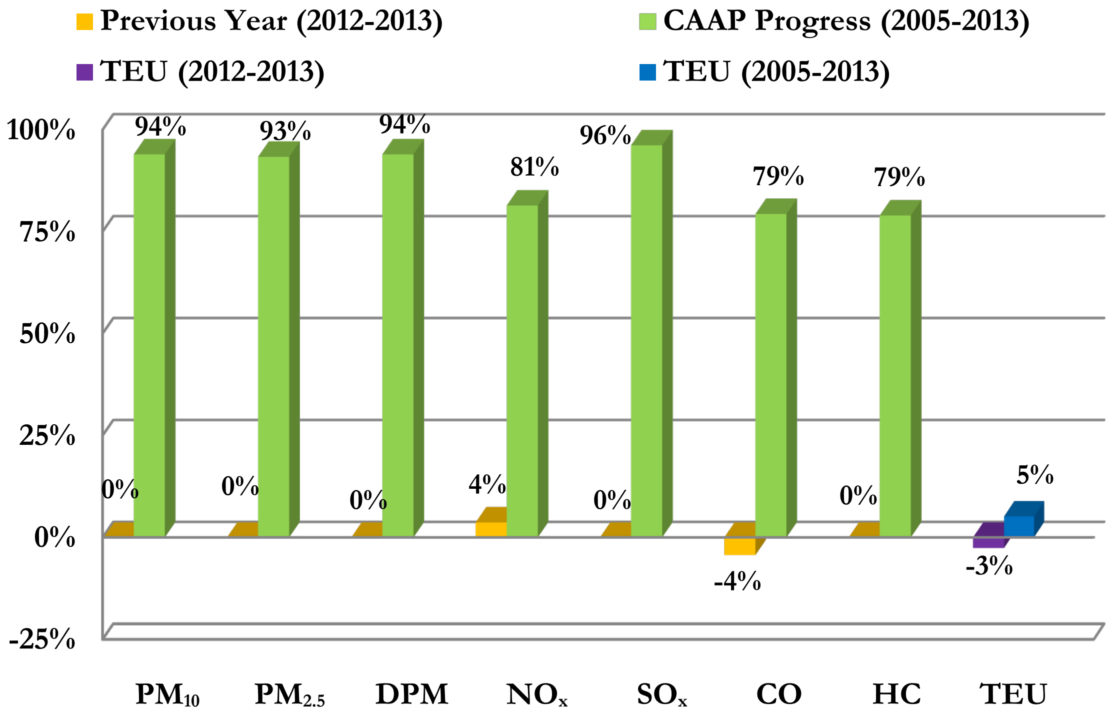
Table 9.28 and Figure 9.10 show the emissions efficiency changes. A positive percentage for the emissions efficiency comparison means an improvement in efficiency. Comparing 2013 to 2005 for CAAP progress, HDV emission efficiency has improved for all pollutants. Comparing 2013 to 2012, emission efficiency for HDV remained the same for most pollutants, except CO.

Table 9.28: HDV Emissions Efficiency Metrics Comparison, tons/10,000 TEUs

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2013	0.02	0.02	0.02	1.58	0.01	0.48	0.08
2012	0.02	0.02	0.02	1.64	0.01	0.46	0.08
2005	0.33	0.30	0.33	8.49	0.05	2.32	0.38
Previous Year (2012-2013)	**0%**	**0%**	**0%**	**4%**	**0%**	**-4%**	**0%**
CAAP Progress (2005-2013)	**94%**	**93%**	**94%**	**81%**	**96%**	**79%**	**79%**

The purple bar represents the TEU throughput change from the previous year (3% decrease) and the blue bar represents the TEU throughput change when compared to 2005 (5% increase).

Figure 9.10: HDV Emissions Efficiency Metric Change



9.2 CAAP Standards and Progress

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

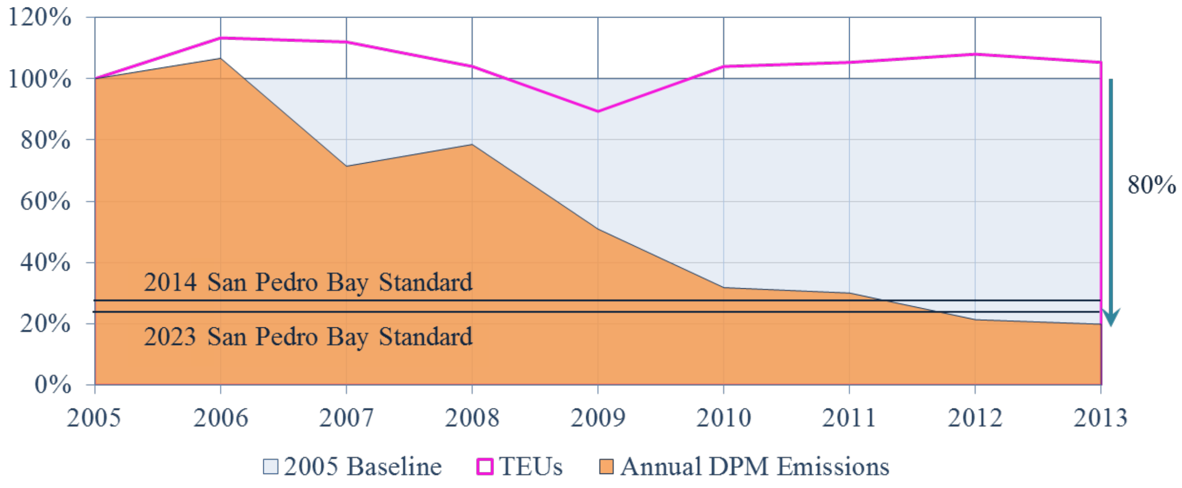
- Emission Reduction Standard:
    - By 2014, achieve emission reductions of 72% for DPM, 22% for NO_x, and 93% for SO_x
    - By 2023, achieve emission reductions of 77% for DPM, 59% for NO_x, and 93% for SO_x
- Health Risk Reduction Standard: 85% reduction by 2020

The Emission Reduction Standards are represented as a percentage reduction of emissions from 2005 levels, and are tied to the regional SoCAB attainment dates for the federal $PM_{2.5}$ and ozone ambient air quality standards in the 2007 AQMP. Tables 9.29 through 9.31 show the standardized estimates of emissions by source category for calendar years 2005 through 2013, using current year methodology. Figures 9.11 through 9.13 present the 2005 baseline emissions and the year to year percent change in emissions with respect to the 2005 baseline emissions, as well as present the 2014 and 2023 standards to provide a snapshot of progress to-date towards meeting those standards. In Figure 9.11, DPM emissions reductions are presented as a surrogate for $PM_{2.5}$ reductions since DPM is directly related to $PM_{2.5}$ emissions (equivalent of PM_{10} emissions from diesel-powered sources). In Figure 9.12, NO_x emissions reductions are presented since NO_x is a precursor to the ambient ozone formation and it also contributes to the formation of $PM_{2.5}$. SO_x emissions reductions are presented in Figure 9.13 because of the contribution of SO_x to $PM_{2.5}$ emissions.

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

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ocean-going vessels	476	501	267	367	254	161	156	89	90
Harbor craft	55	50	51	55	54	40	35	30	26
Cargo handling equipment	53	57	51	38	24	25	23	20	13
Locomotives	57	74	61	46	28	30	30	32	29
Heavy-duty vehicles	245	262	203	189	92	27	22	16	16
Total	**886**	**945**	**633**	**696**	**451**	**282**	**266**	**187**	**174**
% Cumulative Change		**7%**	**-29%**	**-21%**	**-49%**	**-68%**	**-70%**	**-79%**	**-80%**

Figure 9.11: DPM Reductions to Date

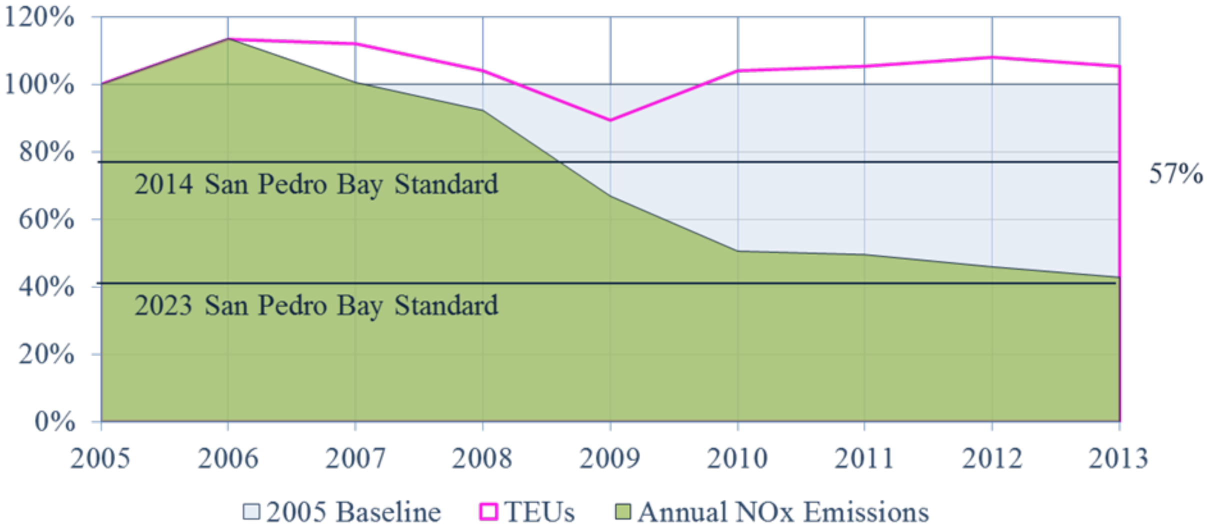


As presented above, the Port exceeded the 2014 and 2023 DPM emission reduction standards with 80% reduction. Starting in 2006 and again in 2009, correlation of DPM emissions with cargo throughput has been disassociated due to the implementation of CAAP measures, promulgation of CARB regulations, and system wide efficiencies that have been introduced by Port's logistics chain partners operate in the inventory's geographical domain. It's anticipated in 2014 that this disassociation will again widen with the implementation of 0.1% sulfur fuel for OGVs from the CARB fuel rule, and the increase number of ships being shore-powered under the CARB shore power rule, as well as continued efficiency improvements from the operators.

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

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ocean-going vessels	5,326	5,867	5,139	4,840	4,128	3,997	3,895	3,698	3,515
Harbor craft	1,320	1,228	1,239	1,260	1,238	950	879	780	705
Cargo handling equipment	1,566	1,856	1,681	1,289	804	872	831	793	678
Locomotives	1,712	2,202	1,821	1,246	940	996	1,052	877	828
Heavy-duty vehicles	6,354	7,329	6,485	6,381	3,774	1,417	1,406	1,325	1,241
Total	**16,278**	**18,483**	**16,366**	**15,016**	**10,884**	**8,231**	**8,062**	**7,473**	**6,967**
% Cumulative Change		**14%**	**1%**	**-8%**	**-33%**	**-49%**	**-50%**	**-54%**	**-57%**

Figure 9.12: NO_x Reductions to Date

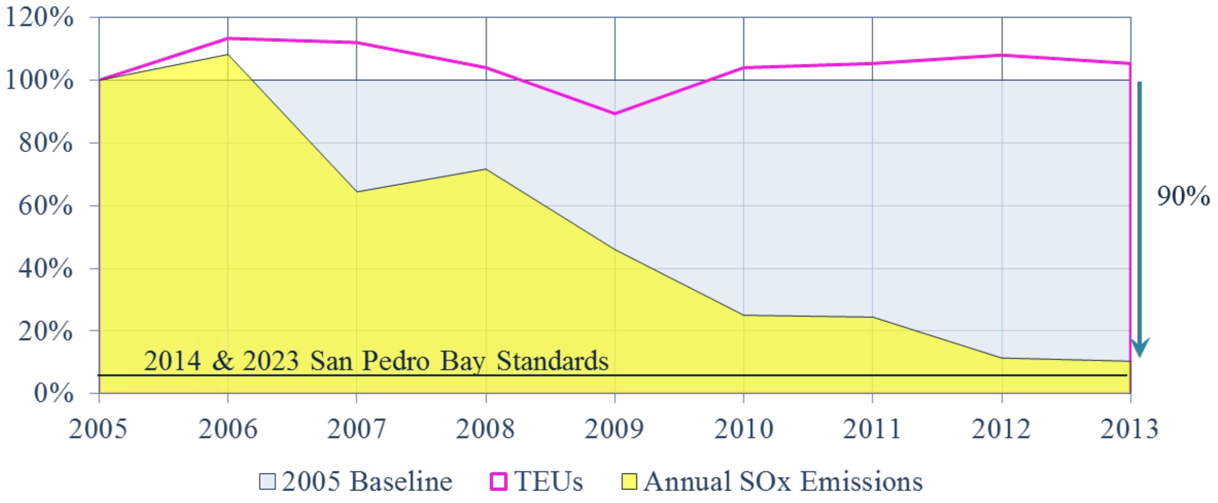


As presented above, the Port is exceeding the 2014 NO_x mass emission reduction standard in 2013 and has nearly met the 2023 emission reduction standard. Starting in 2007 and again in 2009, correlation of NO_x emissions with cargo throughput has been disassociated due to the implementation of CAAP measures, promulgation of CARB regulations, and system wide efficiencies that have been introduced by Port's logistics chain partners, especially HDV owners, operated in the inventory's geographical domain. It's anticipated in 2014 that this disassociation will again widen with the increase number of ships being shore-powered under the CARB shore power rule, as well as continued efficiency improvements from the operators.

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

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ocean-going vessels	5,031	5,442	3,278	3,701	2,373	1,286	1,257	582	535
Harbor craft	6	1	1	1	1	1	1	1	1
Cargo handling equipment	9	2	2	2	1	2	2	2	1
Locomotives	98	132	55	9	7	7	6	3	1
Heavy-duty vehicles	42	35	5	5	4	4	4	4	4
Total	**5,186**	**5,611**	**3,340**	**3,718**	**2,386**	**1,299**	**1,269**	**592**	**542**
% Cumulative Change		**8%**	**-36%**	**-28%**	**-54%**	**-75%**	**-76%**	**-89%**	**-90%**

Figure 9.13: SO_x Reductions to Date



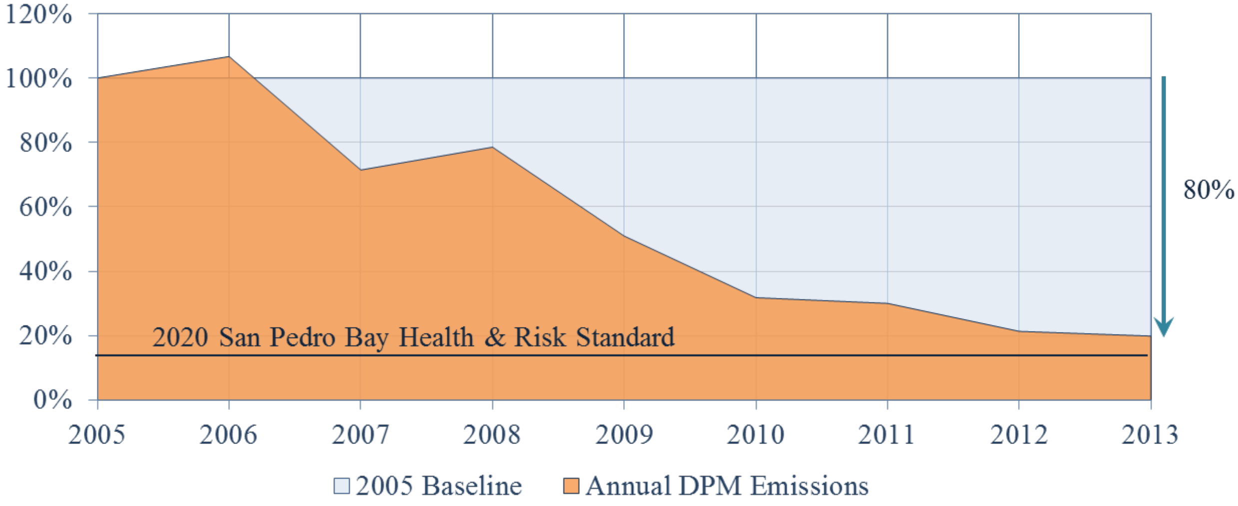
As presented above, the Port has made significant progress towards meeting the SO_x mass emission reduction standard. Starting in 2006 and again in 2009, correlation of SO_x emissions with cargo throughput has been disassociated due to the implementation of CAAP measures, CARB regulations, and system wide efficiencies that have been introduced by owners of OGVs calling the port. Because OGV is the predominant source category contributing to SO_x emission, it's anticipated in 2014 that this disassociation will again widen with the implementation of 0.1% sulfur fuel for OGVs from the CARB fuel rule and the increase number of ships being shore-powered under the CARB shore power rule, as well as continued efficiency improvements from the OGV operators.

Health Risk Reduction Progress

As described in Section 2 of the 2010 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. It should be noted that the use of DPM emissions as a surrogate for health risk reductions is to track relative progress. A more detailed health risk assessment will be prepared by the Port outside the scope of this EI.

Progress to-date on health risk reduction is determined by comparing the change in DPM mass emissions to the 2005 baseline. Figure 9.14 presents the progress towards achieving the standard to date. By 2013, with an 80% reduction, the Port is nearly 95% of the way towards meeting the 2020 Health Risk Reduction Standard (85%).

Figure 9.14: Health Risk Reduction Benefits to Date



SECTION 10 LOOKING FORWARD

Port-related mobile source emissions have continued to decrease over the last several years due in part to the reduced cargo throughput (reflective of global economic conditions) as well as the implementation of the CAAP and regulatory programs. In 2014, the TEU throughput will likely increase from the previous year as evidenced from the TEU throughput levels in the first six months of 2014. The 2014 EI will reflect the Port's actual throughput level in 2014 and the net emissions benefits associated with the implementation of CAAP measures and regulatory programs. In addition, consistent with the Port's EI development process, the latest available emission factors and methods will be incorporated into the 2014 EI.

The following is a brief description of the anticipated impacts of control programs and measures in 2014 for each category, which will result in further reduction of emissions from these port-related sources:

Ocean-Going Vessels

Continued implementation of CAAP measures, including the use of shore power for vessels at-berth and the Port's vessel speed reduction program, will result in significant emission benefits. Continued reductions from ships participating in the Port's ESI incentive program will further reduce DPM, NO_x, and SO_x. In 2014, CARB's marine fuel regulation requiring the use of lower sulfur fuel in main and auxiliary engines and auxiliary boilers will lower the limit to 0.1% S fuel resulting in additional reductions. Also starting January 1, 2014, CARB's ships at-berth regulation commences, although it is expected to have a slow start as vessel fleets and terminals may not be ready to shore power at the beginning of 2014. This at-berth regulation will have an impact as the year progresses and in future years.

Harbor Craft

Under the CARB regulation for commercial harbor craft, in-use, newly purchased, or replacement engines in crew boats, commercial fishing vessels, ferries, excursion vessels, tug boats, and tow boats must meet EPA's most stringent emission standards per a compliance schedule set by CARB for in-use engines and for new engines at the time of purchase. For harbor craft with home ports in the SoCAB, the compliance schedule for in-use engine replacements will continue in a phased-in approach.

Cargo Handling Equipment

The continued implementation of the CAAP measure and CARB's in-use regulation for cargo handling equipment will result in emissions benefits due to the replacement of existing older equipment with newer and cleaner equipment powered by on-road engines or the cleanest engine available.

Locomotives

The 1998 memorandum of understanding (MOU) among the Class 1 railroads (UP and BNSF), CARB, and EPA requires the accelerated introduction of cleaner locomotives in SoCAB. Specifically, the MOU required BNSF and UP to achieve fleet-wide average NO_x emission rates meeting EPA's Tier 2 line haul emission standard for their locomotives operating in SoCAB by 2010, a goal that the railroads have met, according to documentation they provided to CARB and that CARB released through their website. Additional reductions in subsequent years will be slower now that the MOU is in force but further reductions will occur as the railroads continue to turn over their nation-wide fleets.

Heavy-Duty Vehicles

Implementation of the Clean Trucks Program has resulted in significant emission reductions due to replacement of older trucks with newer ones that meet more stringent emission standards. The final ban, which restricted pre-2007 trucks, came into effect January 1, 2013. In future years, the Port will continue the efforts to increase the population of alternatively powered trucks serving the Port, which will reduce emissions of DPM and, depending on the fuel source or technology employed, may reduce emissions of other pollutants.