PORT OF LOS ANGELES
INVENTORY OF AIR EMISSIONS - 2014

THE PORT OF LOS ANGELES

Technical Report
ADP# 141007-514
September 2015

Prepared by:
STARCREST CONSULTING GROUP, LLC

INVENTORY OF AIR EMISSIONS FOR CALENDAR YEAR 2014

Prepared for:

THE PORT
OF LOS ANGELES

September 2015

Prepared by:

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

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The following individuals and their respective companies and organizations assisted with providing the technical and operational information described in this report, or by facilitating the process to obtain this information. This is the 10th Annual Inventory of Air Emissions and this endeavor would not have been possible without their assistance and support. We truly appreciate their time, effort, expertise, and cooperation. The Port of Los Angeles and Starcrest Consulting Group, LLC (Starcrest) would like to recognize all who contributed their knowledge and understanding to the operations of maritime industry-related facilities, commercial marine vessels, locomotives, and off-road/ on-road vehicles at the port facilities:

Megan Shahnazarian, American Marine
Robert Clark, APL Terminal
Stephen Larripa, APL Terminal
Nathan Surdin, APM Terminals
David Seep, Burlington Northern Santa Fe
Kevin Elizondo, California United Terminals
Greg Bombard, Catalina Express
David Scott, Conolly Pacific
Javier Montano, Foss Maritime
Mark Steifel, Harley Marine
Grant Westmoreland, Pacific Tugboat Service
Kim Stobie, Pasha Stevedoring & Terminals
Greg Peters, Pacific Harbor Line
Olenka Palomo, SA Recycling
Peter Balov, San Pedro Forklift
Michael Walsh, Seaway Company
Eric Wilson, Seaside Transportation Services
Geoffrey Romano, Seaside Transportation Services
Scott Axelson, TraPac
Stacey Collette, TraPac
Jon Germer, Union Pacific Railroad
Jose Flores, U.S. Water Taxi & Port Services
Mark Wheeler, West Basin Container Terminal
Jametta Barry, WWL Vehicle Services
Linda Frame, Yusen Terminals

ACKNOWLEDGEMENTS (CONT'D)

The Port of Los Angeles and Starcrest would like to thank the following regulatory agency staff who contributed, commented, and coordinated the approach and reporting of the emissions inventory:

Nicole Dolney, California Air Resources Board
Ed Eckerle, South Coast Air Quality Management District
Randall Pasek, South Coast Air Quality Management District
Francisco Donez, U.S. Environmental Protection Agency, Region 9

Starcrest would like to thank the following Port of Los Angeles staff members for assistance during the development of the emissions inventory:

Teresa Gioiello Pisano, Project Manager
Carter Atkins
Amber Coluso
Tim DeMoss
Lisa Wunder

Authors:	Archana Agrawal, Principal, Starcrest Guiselle Aldrete, Consultant, Starcrest Bruce Anderson, Principal, Starcrest Rose Muller, Consultant, Starcrest Joseph Ray, Principal, Starcrest
Contributors:	Steve Ettinger, Principal, Starcrest Jill Morgan, Consultant, Starcrest
Document Preparation:	Denise Anderson, Consultant, Starcrest
Cover:	Melissa Silva, Principal, Starcrest

Third party review:	Zorik Pirveysian, Integra Environmental Consulting, Inc.

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.

EXECUTIVE SUMMARY

The Port of Los Angeles (Port or POLA) annual activity-based emissions inventories serve as the primary tool to track the Port's efforts to reduce air emissions from maritime industry-related sources through implementation of measures identified in the San Pedro Bay Ports Clean Air Action Plan (CAAP) and regulations promulgated at the state and federal levels. Development of the annual air emissions estimates is coordinated with a technical working group (TWG) comprised of representatives from the Port, the Port of Long Beach, and the air regulatory agencies: U.S. Environmental Protection Agency, Region 9 (EPA), California Air Resources Board (CARB), and the South Coast Air Quality Management District (SCAQMD).

Summary of 2014 Activity and Emission Estimates

Table ES.1 presents the number of vessel calls and the container cargo throughput for calendar years 2005, 2013 and 2014.

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

Year	All Arrivals	Containership Arrivals	TEUs	Average TEUs/Call
2014	1,962	1,394	8,340,066	5,983
2013	2,033	1,463	7,867,863	5,378
2005	2,516	1,479	7,484,625	5,061
Previous Year (2014-2013)	**-3%**	**-5%**	**6%**	**11%**
CAAP Progress (2014-2005)	**-22%**	**-6%**	**11%**	**18%**

Table ES.2 summarizes the 2014 total maritime industry-related mobile source emissions of air pollutants in the SoCAB by the following categories: ocean-going vessels (OGVs), harbor craft (HC), cargo handling equipment (CHE), locomotives, and heavy-duty vehicles (HDV).

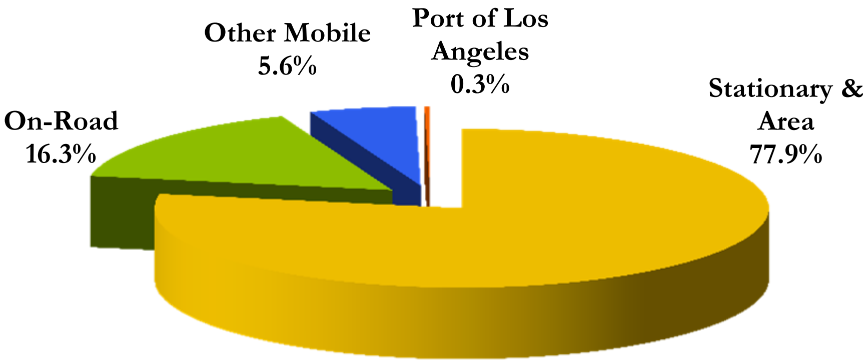
Table ES.2: 2014 Maritime Industry-related Emissions by Category

Category	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
Ocean-going vessels	71.5	66.5	59.1	3,607	120.5	334	164.9	214,950
Harbor craft	29.6	27.3	29.6	802	0.6	446	75.1	55,892
Cargo handling equipment	11.9	11.1	9.8	678	1.8	823	88.0	170,741
Locomotives	28.6	25.9	28.6	819	0.7	194	45.4	68,317
Heavy-duty vehicles	8.0	7.6	7.3	1,811	4.0	121	33.2	358,162
Total	**149.6**	**138.4**	**134.5**	**7,717**	**127.6**	**1,918**	**406.6**	**868,062**

DB ID457

In order to put the maritime industry-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 2014 SoCAB emissions are based on the 2012 AQMP Appendix III.[1] The category "Other Mobile" includes aircraft, trains, ships, commercial boats, recreational boats, off-road recreational vehicles, and off-road 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 are presented for exhaust emissions only.

Figure ES.1: 2014 PM_{10} Emissions in the South Coast Air Basin



---

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

Figure ES.2: 2014 $PM_{2.5}$ Emissions in the South Coast Air Basin

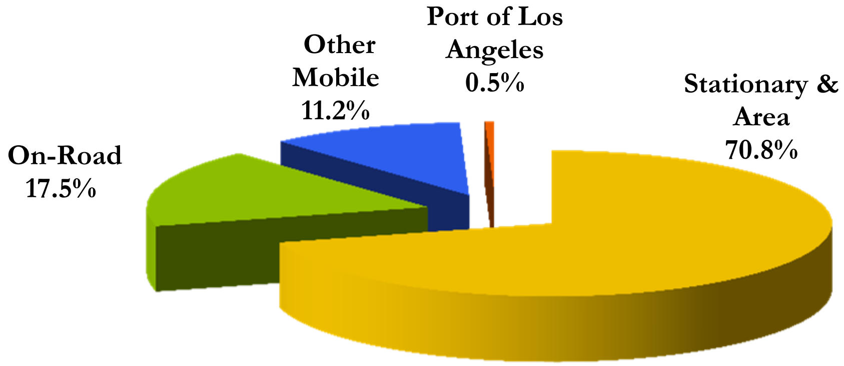


Figure ES.3: 2014 DPM Emissions in the South Coast Air Basin

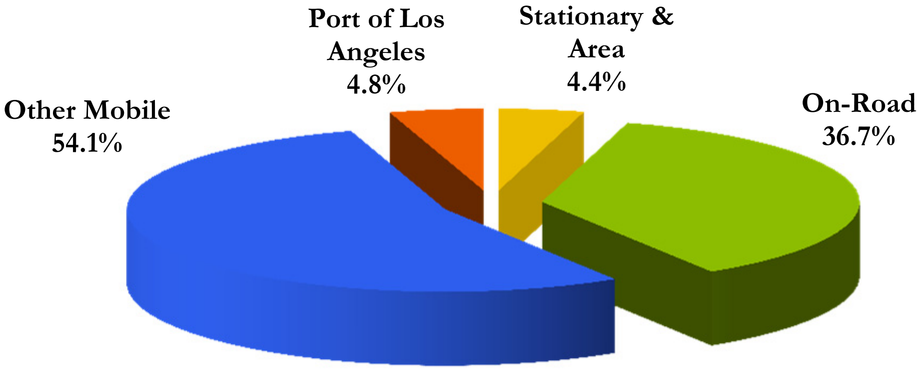


Figure ES.4: 2014 NO_x Emissions in the South Coast Air Basin

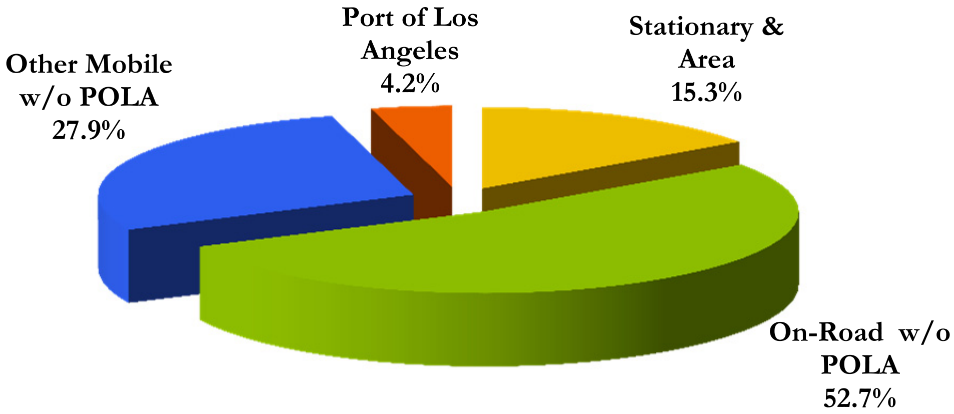


Figure ES.5: 2014 SO_x Emissions in the South Coast Air Basin

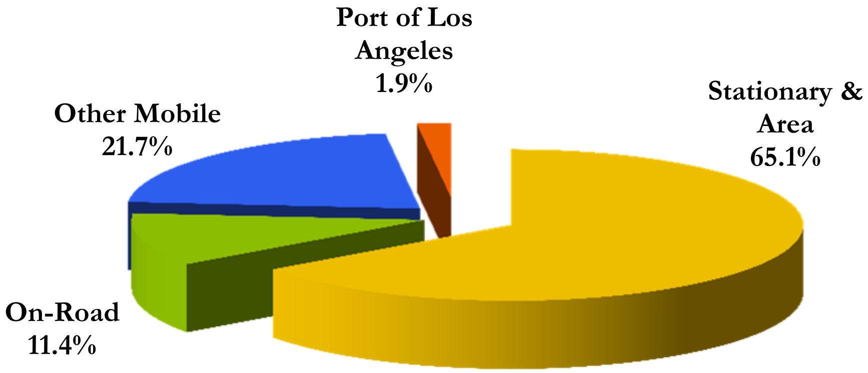


Figure ES.6 presents the decline of the maritime industry-related mobile source emissions in percentage of the total SoCAB emissions from 2005 to 2014. The Port's overall contribution to the SoCAB emissions has decreased significantly since 2005, primarily because of the implementation of various emission reduction programs by the Ports and regulatory agencies, and efficiency improvements from the maritime industry.

Figure ES.6: Port's Emission Contribution in the South Coast Air Basin

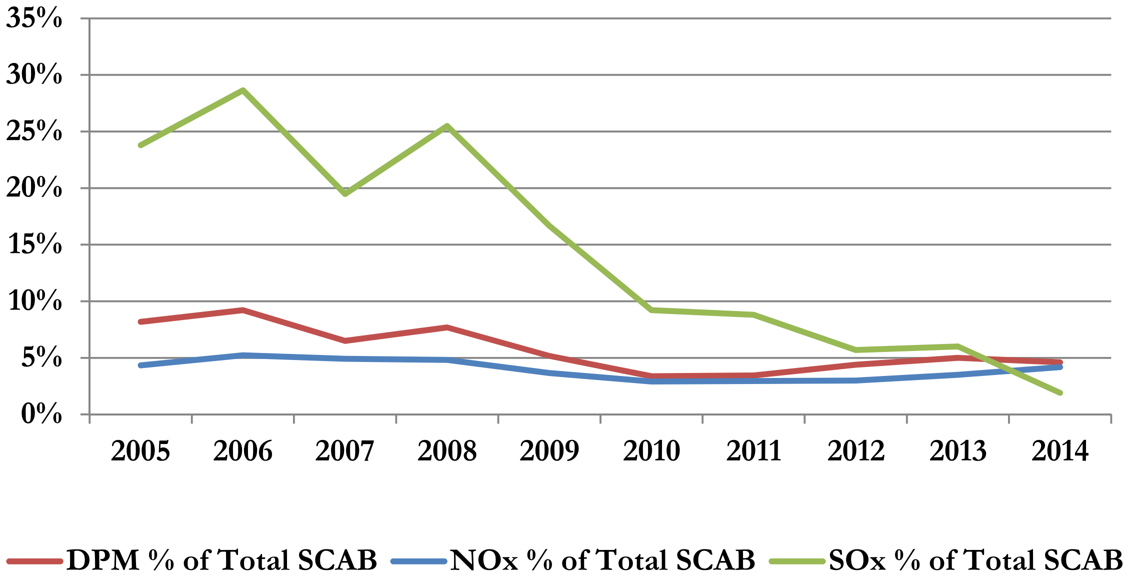


Table ES.3 presents the total net change in emissions from all source categories in 2014 as compared to the previous year and to 2005. An unusual temporary period of increased congestion that occurred in the fall 2014 and spring 2015 detrimentally impacted air emissions. This is clearly seen in the increase in anchorage calls by containerships, which typically do not spend time at the anchorages. In 2014, there was a 69% increase in containership anchorage calls compared to 2013 activity. Another development in 2014 was a 23% increase in cruise ship calls and an 18% increase in tanker calls compared to 2013 activity. In addition to the effects of the temporary period of increased congestion on OGV emissions, HDV emissions also increased overall compared with 2013 because of low turnover of the almost-new truck fleet that resulted from the implementation of the Clean Trucks Program. The average age of the trucks calling at Port terminals in 2014 was five years, a year older than the average age in 2013. This average age difference resulted in increased emissions due to deterioration, which occurs as truck engines accumulate mileage. These factors primarily impacted NO_x emissions and are the reasons NO_x emissions increased 5% compared to 2013. Section 9 provides further details relating to the increases.

Table ES.3: Maritime Industry-related Emissions Comparison

EI Year	**PM_{10} tons**	**$PM_{2.5}$ tons**	**DPM tons**	**NO_x tons**	**SO_x tons**	**CO tons**	**HC tons**	**CO_2e tonnes**
2014	150	138	135	7,717	128	1,918	407	868,062
2013	174	160	157	7,318	531	1,701	389	771,880
2005	960	830	884	16,159	4,947	3,773	856	1,029,445
Previous Year (2013-2014)	**-14%**	**-14%**	**-14%**	**5%**	**-76%**	**13%**	**5%**	**12%**
CAAP Progress (2005-2014)	**-84%**	**-83%**	**-85%**	**-52%**	**-97%**	**-49%**	**-53%**	**-16%**

Comparing 2014 emissions to previous year, PM and SO_x decreased, while the emissions for NO_x, CO, HC and CO_2e increased. In summary, the increase in emissions is primarily due to:

- Increased activity in 2014.
- Increased number of vessels at anchorage, which also increased the number of shifts.
- More time at berth and anchorage due to a temporary period of increased congestion starting in the fall of 2014 and continuing into the spring of 2015.
- Less fleet turnover for trucks and harbor craft in 2014.

Reductions were seen in all pollutants when comparing 2014 to 2005. Several factors contributed to lower emissions in 2014 compared to 2005. Major highlights by source category include:

- For OGV, the three primary reasons for emission reductions are: fuel switching, shore power, and VSR compliance. The CARB OGV Fuel Regulation was in effect and 2014 marked the first year for the Phase II requirement that all engines use fuel with 0.1% sulfur. For the CARB Regulation to reduce emissions at berth (i.e., shore power), 2014 was the first compliance year for certain vessel types. The vessel speed reduction (VSR) compliance and use of shore power at-berth continued to increase relative to previous years.
- For harbor craft, the emissions are lower than 2005 emissions due to the repowers that have occurred in the last few years as required by the CARB Harbor Craft Regulation. However, there were not as many repowers in 2014 as in recent previous years (2009-2013) due to the CARB Harbor Craft Regulation's phased compliance dates. By the end of 2013, most of the older pre-2000 MY engines had been repowered. From 2014 on, the 2000 and newer engines will continue to be repowered at a slower pace and with fewer reductions than the older engines provided.
- For CHE, implementation of CAAP measures and CARB's Cargo Handling Equipment Regulation, along with funding incentives, resulted in replacement of older equipment with cleaner units, retrofits, and repowers that led to lower emissions.
- For locomotives, the decreases in fleet-wide emissions from line haul locomotives are due to meeting the terms of the memorandum of understanding (MOU) with CARB, and the replacement of older switching locomotives with new low-emission and ultra-low emission switchers.
- For HDV, the 2012 implementation of the final phase of the Port's Clean Truck Program (CTP) resulted in significant turnover of older trucks to newer and cleaner trucks.

Table ES.4 summarizes the annualized emissions efficiencies for all five source categories. The overall emission efficiency in 2014 improved for all pollutants as compared to 2005. Compared to the previous year, there was a decrease in emissions efficiency for NO_x, CO, HC and CO_2e. In Table ES.4, a positive percentage means an increase in emissions efficiency.

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
2014	0.18	0.17	0.16	9.25	0.15	2.30	0.49	1,041
2013	0.22	0.20	0.20	9.30	0.67	2.16	0.49	981
2005	1.28	1.11	1.18	21.59	6.61	5.04	1.14	1,375
Previous Year (2013-2014)	**18%**	**15%**	**20%**	**1%**	**78%**	**-6%**	**0%**	**-6%**
CAAP Progress (2005-2014)	**86%**	**85%**	**86%**	**57%**	**98%**	**54%**	**57%**	**24%**

CAAP Standards and Progress

One of the main purposes of the annual inventories is to provide a progress update on achieving the San Pedro Bay CAAP Standards. These standards consist of the following emission reduction goals, using the 2005 published inventories as a 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.7 through ES.9 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. These figures provide context to the relative correlation between cargo throughput and emissions.

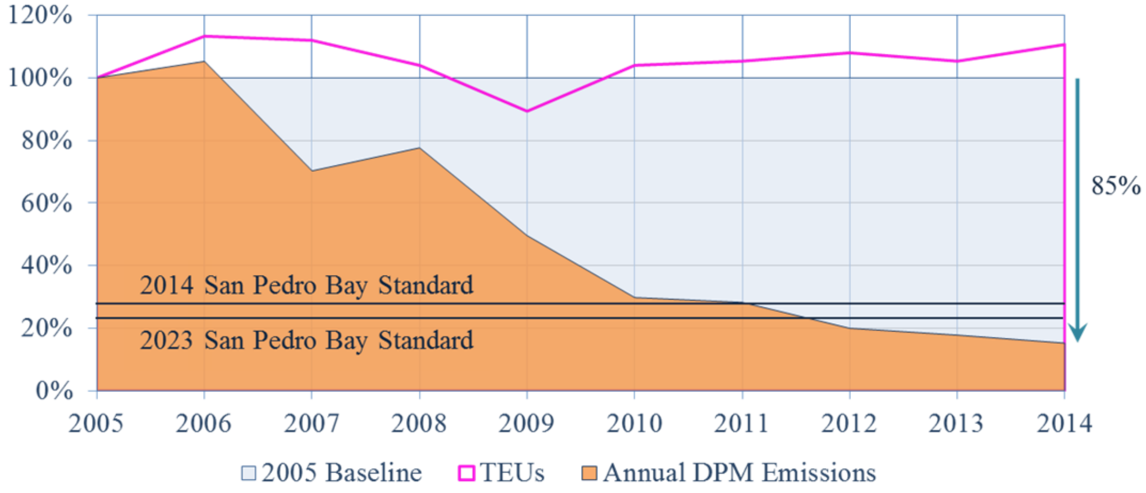
Due to the many emission reduction measures undertaken by the Port, as well as statewide and federal regulations and standards, the 2014 emission reduction standard has not only been met, but exceeded. Below is a summary of DPM, NO_x and SO_x percent reductions as compared to the 2014 emission reduction standards.

Table ES.5: Reductions as Compared to 2014 Emission Reduction Standard

Pollutant	2014 Actual Reductions	Emission Reduction Standard
DPM	85%	72%
NO_x	52%	22%
SO_x	97%	93%

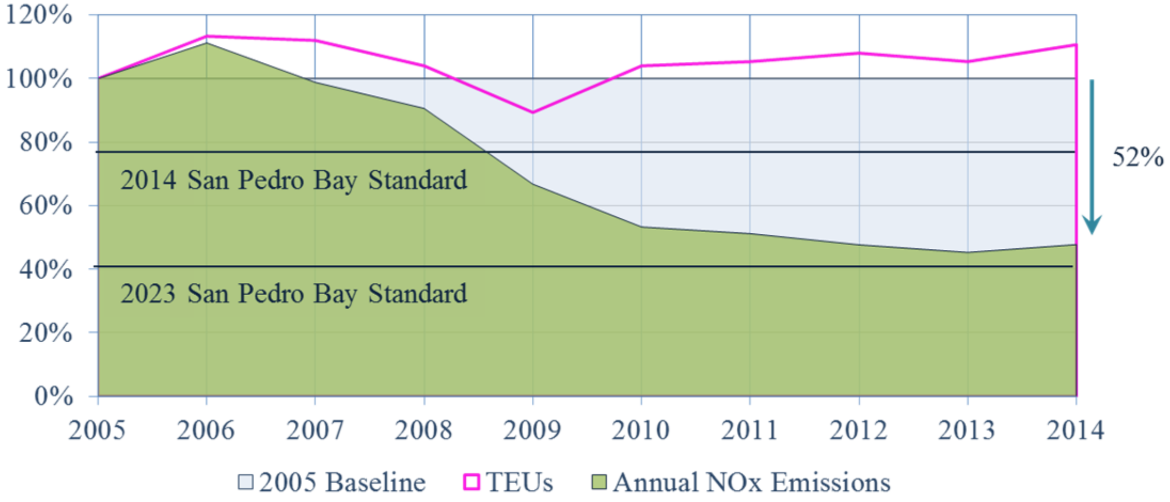
Figure ES.7 shows that the Port has surpassed the 2014 DPM emission reduction standards with an 85% emission reduction. In 2014, 0.1% sulfur fuel for OGVs from the CARB fuel rule was implemented and there was an increase in number of ships using shore-power due to the CARB shore power rule.

Figure ES.7: DPM Reductions to Date



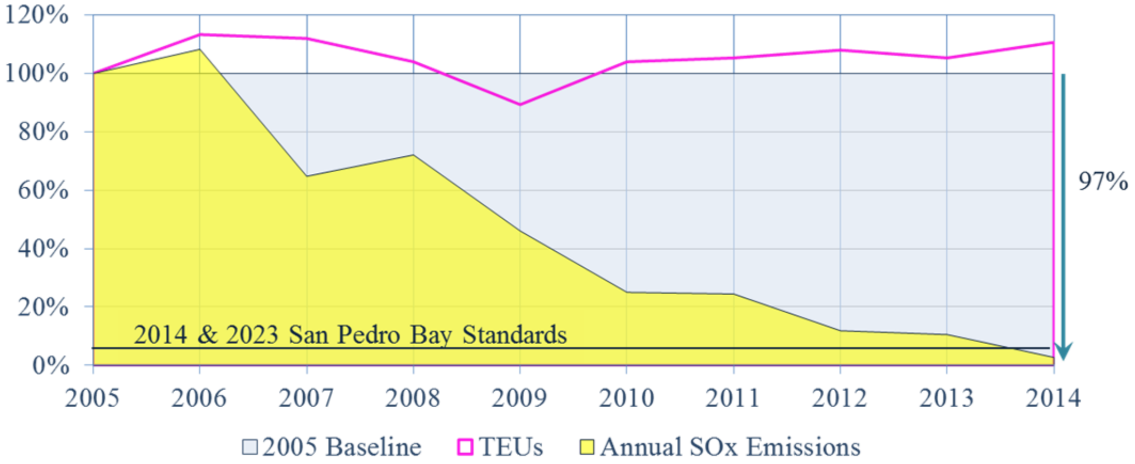
As demonstrated in Figure ES.8, the Port surpassed the 2014 NO_x mass emission reduction standard in 2014 with a 52% reduction.

Figure ES.8: NO_x Reductions to Date



By 2014, the Port surpassed the SO_x mass emission reduction standards with a 97% reduction. In 2014, 0.1% sulfur fuel for OGVs from the CARB fuel rule was implemented and there was an increase in number of ships using shore-power due to the CARB shore power rule.

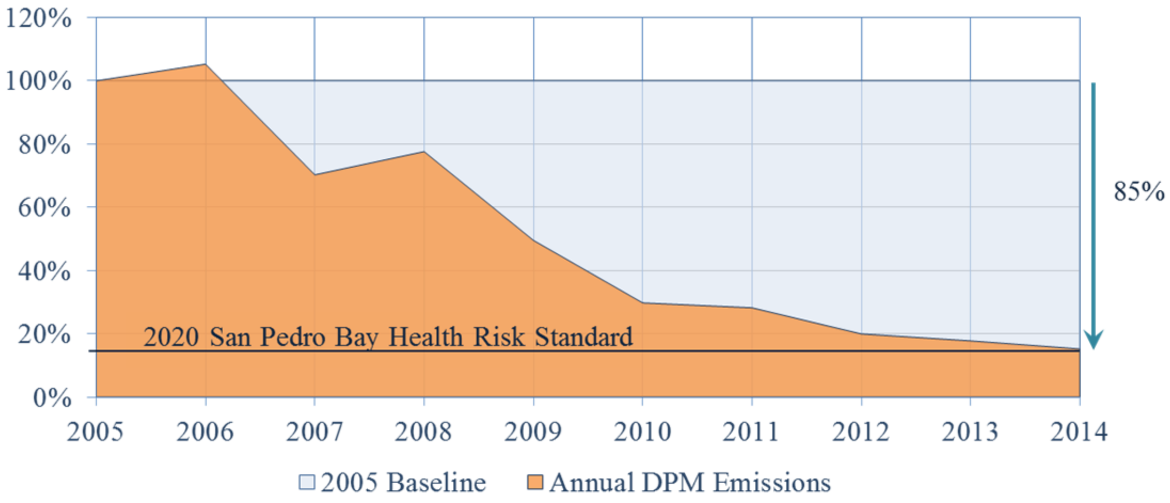
Figure ES.9: SO_x Reductions to Date



Health Risk Reduction Progress

Progress to-date on health risk reduction is determined by comparing the change in DPM mass emissions to the 2005 baseline. Figure ES.10 presents the progress of achieving the standard to date. By 2014, with an 85% reduction, the Port met the 2020 Health Risk Reduction Standard (85%).

Figure ES.10: Health Risk Reduction Benefits to Date



SECTION 1 INTRODUCTION

The Port of Los Angeles (Port or POLA) 2014 Inventory of Air Emissions study presents maritime industry-related emission estimates based on 2014 activity levels. The report includes a comparison of the estimated 2014 emissions with the 2005 baseline year and 2013 emission estimates to track the Port's emission reduction progress under the San Pedro Bay Ports Clean Air Action Plan (CAAP). 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)

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 estimates of greenhouse gases (GHGs) carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emitted from maritime industry-related tenant operational mobile sources. Because each greenhouse gas differs in the magnitude of its effect on the atmosphere, estimates of greenhouse gas emissions are presented in units of carbon dioxide equivalents, which weight each gas by its global warming potential (GWP) value relative to CO_2. For presentation purposes in the report, only CO_2e values are provided because they include all three GHGs in an equivalent measure to CO_2, which makes up by far the greatest mass of GHG emissions from the source categories included in this inventory. Estimates of greenhouse gas emissions are presented in units of carbon equivalents, which weight each gas by its global warming potential (GWP) value. To normalize these values into a single greenhouse gas value, CO_2e, the GHG emission estimates are multiplied by the following values and summed.[2]

- CO_2 – 1
- CH_4 – 25
- N_2O - 298

---

[2] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013*, April 2015.

The greenhouse gas emissions are presented in metric tons (tonnes) while the criteria pollutant emissions are shown in tons.

Geographical Domain

The geographical extent of the inventory includes emissions from the aforementioned maritime industry-related emission sources operating within the harbor district. For rail locomotives and on-road trucks, the domain extends from the Port up to the cargo's first point of rest within the South Coast Air Basin (SoCAB) or up to the SoCAB boundary, whichever comes first. For commercial marine vessels, the domain lies 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 1.1 shows the geographical extent of this inventory, and other overlapping regulatory boundaries.

Figure 1.1: Emissions Inventory Geographical Extent

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

This section summarizes the regulatory initiatives and port measures related to port activity. Almost all maritime industry-related emissions come from five emission source categories: OGVs, harbor craft, CHE, locomotives, and HDVs. 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 maritime industry-related air pollution and subsequently approved an update to the CAAP (2010 CAAP Update).

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 of Los Angeles and Long Beach's (Ports') commitments to significantly reduce the air quality impacts from port operations. Achievement and maintenance 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 have developed the following standard for reducing overall maritime industry-related health risk impacts, relative to 2005 emissions level:

- By 2020, reduce the population-weighted cancer risk of maritime industry-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 maritime industry-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.

Regulatory Programs by Source Category

The following section presents a list of current regulatory programs and CAAP measures by each major source category that help reduce emissions from the maritime industry in and around the port.

Table 2.1: OGV Emission Regulations, Standards and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
IMO	**NO_x Emission Standard for Marine Engines** *www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-%28NOx%29-%E2%80%93-Regulation-13.aspx*	NO_x	2011 – Tier 2 2016 – Tier 3	Auxiliary and propulsion engines over 130 kW output power on newly built vessels
IMO	**Low Sulfur Fuel Requirements for Marine Engines** *www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-%28SOx%29-%E2%80%93-Regulation-14.aspx*	DPM, PM, and SO_x	2012 ECA – 1% 2015 ECA – 0.1%	Significantly reduce emissions due to low sulfur content in fuel by creating Emissions Control Area (ECA)
IMO	**Energy Efficiency Design Index (EEDI) for International Shipping** *www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Technical-and-Operational-Measures.aspx*	CO_2 and other pollutants	2013	Promotes use of more energy efficient (less polluting) equipment and engines
EPA	**Emission Standards for Marine Diesel Engines above 30 Liters per Cylinder (Category 3 Engines); Aligns with IMO Annex VI marine engine NO_x standards and low sulfur requirement** *www.epa.gov/otaq/oceanvessels.htm#engine-fuel*	DPM, PM, NO_x, and SO_x	2011 – Tier 2 2016 – Tier 3	Auxiliary and propulsion category 3 on US flagged new built vessels and requires use of low sulfur fuel

Table 2.1: OGV Emission Regulations, Standards and Policies (cont'd)

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
CARB	**Regulation to Reduce Emissions from Diesel Auxiliary Engines on Ocean-Going Vessels While At-Berth at a California Port** *www.arb.ca.gov/regact/2007/shorepwr07/shorepwr07.htm* and *www.arb.ca.gov/ports/shorepower/forms/regulatoryadvisory/regulatoryadvisory12232013.pdf*	All	2014 – 50% 2017- 70% 2020 – 80%	Shore power (or equivalent) requirements. Vessel operators, based on fleet percentage visiting the port.
CARB	**Ocean-going Ship Onboard Incineration** *www.arb.ca.gov/ports/shipincin/shipincin.htm*	DPM, PM, and HC	2007	All vessels cannot incinerate within 3 nm of the California coast
SPBP CAAP	**CAAP Measure – OGV 1 Vessel Speed Reduction (VSR) Program** *www.cleanairactionplan.org/reports/documents.asp*	All	2008	Vessel operators within 20 nm and 40 nm of Point Fermin
SPBP CAAP	**CAAP Measure – OGV 2 Reduction of At-Berth OGV Emissions** *www.cleanairactionplan.org/reports/documents.asp* Reduction of At-Berth OGV Emissions	All	2014	Vessel operators and terminals
SPBP CAAP	**CAAP Measure – OGV 5 and 6 Cleaner OGV Engines and OGV Engine Emissions Reduction Technology Improvements and Environmental Ship Index (ESI) Program** *www.cleanairactionplan.org/reports/documents.asp* and *www.portoflosangeles.org/environment/ogv.asp*	DPM, PM, and NO_x	2012	Vessel operators who choose to participate in ESI and/or technology demonstrations.

Table 2.2: Harbor Craft Emission Regulations, Standards and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
EPA	**Emission Standards for Harbor Craft Engines** *www.epa.gov/otaq/marine.htm*	All	2009 – Tier 3 2014 – Tier 4 for 800 hp or greater	Commercial marine diesel engines with displacement less than 30 liters per cylinder
CARB	**Low Sulfur Fuel Requirement for Harbor Craft** *www.arb.ca.gov/regact/carblohc/carblohc.htm*	DPM, PM, NO_x, and SO_x	2006 – 15 ppm in SCAQMD area	Use of low sulfur diesel fuel in commercial harbor craft operating in SCAQMD
CARB	**Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft** *www.arb.ca.gov/regact/2010/chc10/chc10.htm*	DPM, PM, and NO_x	2009 to 2020 - schedule varies depending on engine model year	Most harbor craft with home port in SCAQMD must meet more stringent emissions limits according to a compliance schedule
SPBP CAAP	**CAAP Measure – HC 1 Performance Standards for Harbor Craft** *www.cleanairactionplan.org/reports/documents.asp*	All	Varies	Modernization of harbor craft operating at POLA upon lease renewal

Table 2.3: Cargo Handling Equipment Emission Regulations, Standards and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
EPA	**Emission Standards for Non-Road Diesel Powered Equipment** *www.epa.gov/otaq/standards/nonroad/nonroadci.htm*	All	2008-2015	All non-road equipment
CARB	**Cargo Handling Equipment Regulation** *http://www.arb.ca.gov/regact/2011/cargo11/cargo11.htm*	All	2007 through 2017	All Cargo handling equipment
CARB	**New Emission Standards, Test Procedures, for Large Spark Ignition (LSI) Engine Forklifts and Other Industrial Equipment** *www.arb.ca.gov/regact/2008/lsi2008/lsi2008.htm*	All	2007 – first phase 2010 – second phase	Emission standards for large spark-ignition engines with 25 hp or greater
CARB	**Fleet Requirements for Large Spark Ignition Engines** *www.arb.ca.gov/regact/2010/offroadlsi10/lsifinalreg.pdf*	All	2009 to 2013	More stringent emissions requirements for fleets of large spark-ignition engines equipment
SPBP CAAP	**CAAP Measure – CHE1 Performance Standards for CHE**	All	2007-2014	Turnover to Tier 4 cargo handling equipment per lease renewal agreement

Table 2.4: Locomotives Emission Regulations, Standards and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
EPA	**Emission Standards for New and Remanufactured Locomotives and Locomotive Engines- Latest Regulation** *www.epa.gov/otaq/standards/nonroad/locomotives.htm*	DPM and NO_x	2011 and 2013 – Tier 3 2015 – Tier 4	All new and remanufactured locomotive engines
EPA	**Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel** *www.epa.gov/otaq/fuels/dieselfuels/regulations.htm*	SO_x and PM	2010	All locomotive engines
CARB	**Low Sulfur Fuel Requirement for Intrastate Locomotives** *www.arb.ca.gov/msprog/offroad/loco/loco.htm#intrastate*	SO_x, NO_x, and PM	2007	Intrastate locomotives, mainly switchers
CARB	**Statewide 1998 and 2005 Memorandum of Understanding (MOUs)** *www.arb.ca.gov/msprog/offroad/loco/loco.htm#intrastate*	NO_x	2010	UP and BNSF locomotives
SPBP CAAP	**CAAP Measure – RL1** **Pacific Harbor Line (PHL) Rail Switch Engine Modernization**	PM	2010	PHL switcher engines
SPBP CAAP	**CAAP Measure – RL2** **Class 1 Line-haul and Switcher Fleet Modernization**	All	2023 – Tier 3	Class 1 locomotives at ports
SPBP CAAP	**CAAP Measure – RL3** **New and Redeveloped Near-Dock Rail Yards**	All	2020 – Tier 4	New near-dock rail yards

Table 2.5: Heavy-Duty Vehicles Emission Regulations, Standards and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
CARB/ EPA	**Emission Standards for New 2007+ On-Road Heavy-Duty Vehicles** *www.arb.ca.gov/msprog/onroadhd/reducstd.htm*	NO_x and PM	2007 2010	All new on-road diesel heavy-duty vehicles
CARB	**Heavy-Duty Vehicle On-Board Diagnostics (OBD and OBDII) Requirement** *www.arb.ca.gov/msprog/obdprog/section1971_1_clean2013.pdf*	NOx and PM	2010 +	All new on-road heavy-duty vehicles
CARB	**ULSD Fuel Requirement** *http://www.arb.ca.gov/regact/ulsd2003/ulsd2003.htm*	All	2006 - ULSD	All on-road heavy-duty vehicles
CARB	**Drayage Truck Regulation (amended in 2011 and 2014)**	All	Phase in started in 2009	All drayage trucks operating at California ports
CARB	**Low NO_x Software Upgrade Program 2007** *www.arb.ca.gov/msprog/hdsoftware/hdsoftware.htm*	NO_x	Starting 2005	1993 to 1998 on-road heavy-duty vehicles that operate in California
CARB	**Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Regulation** *www.arb.ca.gov/cc/hdghg/hdghg.htm*	CO_2	Phase 1 starting in 2012	Heavy-duty tractors that pull 53-foot+ trailers in CA
CARB	**Assembly Bill 32 requiring GHG reductions targets and Governor's Executive Order B – 30-15** *www.arb.ca.gov/cc/ab32/ab32.htm* *gov.ca.gov/news.php?id=18938*	CO_2	GHG emissions reduction goals in 2020	All operations in California
SPBP CAAP	**CAAP Measure – HDV1 Performance Standards for On-Road Heavy-Duty Vehicles; Clean Truck Program**	All	Phase in started in 2008	Requires on-road heavy-duty vehicles that operate at POLA to have 2007 or newer MY engines by 2012

Air Quality Management Plan (AQMP)

The 2016 AQMP is being developed to demonstrate attainment of the 2008 8-hour ozone standard by 2031, and show early action measures to attain the 1997 8-hour ozone standard that needs to be met by 2023.

As part of the State Implementation Plan (SIP) process, the SCAQMD Governing Board is currently developing 2016 AQMP for ozone attainment.[3] Based on 2014 and the 1st quarter of 2015, there were multiple days when South Coast Air Basin did not the attain 24-hour $PM_{2.5}$ National Ambient Air Quality standard of 35 µg/m^3. SCAQMD staff is proposing a formal request to EPA to reclassify Basin as a Serious Non - attainment Area for 24 - hour $PM_{2.5}$. If approved, SCAQMD will develop Serious Area 24 - hour $PM_{2.5}$ SIP as part of the 2016 AQMP.

---

[3] SCAQMD, *www.aqmd.gov/home/about/groups-committees/aqmp-advisory-group*

SECTION 3 OCEAN-GOING VESSELS

Source Description

Based on activity data obtained from the Marine Exchange of Southern California (MarEx), there were a total of 1,962 ocean-going vessels (OGVs, ships, or vessels) calls (arrivals not including shifts) to the Port in 2014. These vessels are grouped by the type of cargo they are designed to carry and fall into one of the following vessel categories or types:

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

From an emissions contribution perspective, the three predominant vessel types are: containerships, tankers, and cruise ships, with containerships being the predominant vessel category. Emission sources on all vessel categories include main engines (propulsion), auxiliary engines, and auxiliary boilers (boilers).

Emission Estimation Methodology and Enhancements

The methodology to estimate 2014 emissions from OGVs is the same as described in Section 3 of the Port of Los Angeles 2013 Air Emissions Inventory[4], with the following updates/enhancements which were incorporated for the 2014 emissions inventory:

- Emission factor adjustment (EFA) for MAN 2-stroke engines – based on tests with MAN Turbo Diesel A/S (MAN) and Mitsui Engineering & Shipbuilding Co., Ltd. (Mitsui)[5]
- Load adjustment factor (LAF) for MAN 2-stroke engines – replacing the dated Low Load Adjustment (LLA) factors
- Incorporated CARB shore power data – CARB provided vessel specific shore power times at berth
- Diesel-electric cruise ships – turned boilers on at berth during shore power events
- Conventional tankers – updated at-berth auxiliary boiler loads based on Vessel Boarding Program data
- Enhanced anchorage transit resolution

These updates and enhancements are discussed at the end of this section.

---

[4] *www.portoflosangeles.org/pdf/2013_Air_Emissions_Inventory_Full_Report.pdf*

[5] *www.cleanairactionplan.org/civica/filebank/blobdload.asp?BlobID=2571*

Table 3.1 presents the numbers of arrivals, departures, and shifts associated with vessels at the Port in 2014. It should be noted that there was a significant increase in the number of containership shifts from anchorage to berth, compared to 2013. Container ships typically don't arrive at an anchorage and then shift to berth; they typically arrive directly at berth as observed in the previous emissions inventories. This was due to the temporary period of increased congestion which increased the number of container shifts as compared to the previous year.

Table 3.1: 2014 Total OGV Activities

Vessel Type	Arrival	Departure	Shift	Total
Auto Carrier	60	59	10	129
Bulk	103	93	101	297
Bulk - Heavy Load	1	0	1	2
Container - 1000	81	81	24	186
Container - 2000	155	155	25	335
Container - 3000	84	83	21	188
Container - 4000	341	339	55	735
Container - 5000	128	128	18	274
Container - 6000	301	298	65	664
Container - 7000	32	32	2	66
Container - 8000	129	127	30	286
Container - 9000	67	66	8	141
Container - 10000	63	60	9	132
Container - 13000	13	14	2	29
Cruise	122	122	0	244
General Cargo	71	63	65	199
Ocean Tugboat (ATB/ITB)	20	20	25	65
Reefer	15	14	25	54
Tanker - Chemical	104	95	170	369
Tanker - Handysize	21	21	31	73
Tanker - Panamax	51	48	138	237
Total	**1,962**	**1,918**	**825**	**4,705**

DB ID693

Note: ATB – articulated tug-barge; ITB – integrated tug-barge

Geographical Domain

The geographical domain or overwater boundary for OGVs includes the berths and waterways in the Port proper and all vessel movements within the forty nautical mile (nm) arc from Point Fermin as shown in Figure 1.1. The northern boundary is the Ventura County line and the southern boundary is the Orange County line. It should be noted that overwater boundary extends further off the coast to incorporate the South Coast air quality modeling domain, although most of the vessel movements occur within the 40 nm arc.

Data and Information Acquisition

Similar to previous inventories, various sources of data and operational knowledge about the Port's marine activities are used to compile the data necessary to estimate emissions from OGV:

- Marine Exchange of Southern California
- Vessel Speed Reduction Program speed data
- Los Angeles Pilot Service (Pilots)
- IHS Fairplay (Lloyd's) - Lloyd's Register of Ships
- Port Vessel Boarding Program data
- CARB shore power data
- Port tanker loading data

Operational Profiles

Tables 3.2 and 3.3 summarize the hoteling times in hours at berth and at anchorage.

Table 3.2: 2014 Hotelling Times at Berth, hours

Vessel Type	Berth Hotelling Time, hours		
	Min	Max	Avg
Auto Carrier	2.9	44.5	17.1
Bulk	4.2	254.8	74.0
Bulk - Heavy Load	123.3	123.3	123.3
Container - 1000	1.9	96.0	24.2
Container - 2000	3.8	97.2	31.3
Container - 3000	1.7	93.8	44.9
Container - 4000	1.2	132.8	25.1
Container - 5000	0.5	144.4	43.9
Container - 6000	0.3	303.3	51.2
Container - 7000	0.9	154.6	44.9
Container - 8000	1.4	359.8	51.2
Container - 9000	1.3	218.7	70.8
Container - 10000	0.3	309.4	68.6
Container - 13000	13.3	182.7	110.6
Cruise	3.0	35.9	7.8
General Cargo	6.6	155.2	63.4
Ocean Tugboat (ATB/ITB)	14.2	46.7	29.1
Reefer	5.0	80.2	28.0
Tanker - Chemical	12.8	107.7	33.1
Tanker - Handysize	14.3	90.0	31.9
Tanker - Panamax	14.7	84.5	40.9

Table 3.3: 2014 Hotelling Times at Anchorage, hours

Vessel Type	Min	Max	Avg	Vessel Count
Auto Carrier	26.3	40.8	33.5	2
Bulk	1.5	303.2	57.0	68
Bulk - Heavy Load	24.4	24.4	24.4	1
Container - 1000	2.4	264.8	28.5	7
Container - 2000	2.3	136.3	35.2	9
Container - 3000	1.0	145.8	43.7	9
Container - 4000	2.0	256.5	59.3	30
Container - 5000	1.3	236.3	111.3	10
Container - 6000	3.1	344.9	56.3	25
Container - 7000	16.2	26.0	21.1	2
Container - 8000	3.4	226.5	61.0	10
Container - 9000	1.1	111.3	33.6	7
Container - 10000	1.7	419.8	114.9	7
Container - 13000	0.0	0.0	0.0	0
Cruise	0.0	0.0	0.0	0
General Cargo	3.0	356.6	69.0	28
Ocean Tugboat (ATB/ITB)	1.5	92.9	12.8	4
Reefer	4.9	28.0	17.3	3
Tanker - Chemical	1.4	274.8	32.6	60
Tanker - Handysize	2.9	149.4	44.7	6
Tanker - Panamax	1.5	640.8	53.0	46

The only vessels not to call at anchorage in 2014 were the Container 13000 and cruise vessels.

Table 3.4 presents the auxiliary engine load defaults by vessel type, by mode used to estimate emissions. Values in this table are based on Vessel Boarding Program and it should be noted that the cruise defaults are for non-diesel-electric ships. Diesel-electric cruise ship defaults are presented in Table 3.5.

Table 3.4: Average Auxiliary Engine Load Defaults (except for Diesel-Electric Cruise Vessels), kW

Vessel Type	Transit	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	1,725	3,367	900	1,725
Container - 6000	1,453	2,197	990	1,453
Container - 7000	1,444	3,357	1,372	1,444
Container - 8000	1,494	2,753	902	1,494
Container - 9000	1,501	2,942	1,037	1,501
Container - 10000	2,300	2,350	1,450	2,300
Container - 13000	1,865	3,085	982	1,865
Cruise	7,058	9,718	5,353	7,058
General Cargo	516	1,439	722	516
Ocean Tug (ATB/ITB)	79	208	102	79
Reefer	513	1,540	890	513
Tanker - Chemical	658	890	816	658
Tanker - Handysize	537	601	820	537
Tanker - Panamax	561	763	623	561

Table 3.5: 2014 Diesel-Electric Cruise Vessel Auxiliary Engine Defaults, kW

Passenger Range	Transit	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

Table 3.6 presents the load defaults for the auxiliary boilers by vessel type and by mode. Based on recent Vessel Boarding Program data, it was identified that the auxiliary boilers are turned on for diesel-electric cruise ships because the heat recovery systems are not effective while the ship is on shore power. In addition, it was identified that the average load for the auxiliary boilers for tankers being loaded at-berth was ~875 kW. Finally, the auxiliary boiler at-berth load for diesel-electric tankers was adjusted for just providing the house load and not associated with cargo movements.

Table 3.6: Auxiliary Boiler Load Defaults, kW

Vessel Type	Transit	Maneuvering	Berth Hotelling	Anchorage Hotelling
Auto Carrier	253	351	351	351
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	545	547	547	547
Container - 6000	577	573	573	573
Container - 7000	538	551	551	551
Container - 8000	650	531	531	531
Container - 9000	475	475	475	475
Container - 10000	708	708	708	708
Container - 13000	599	599	599	599
Cruise	1,482	1,482	1,482	1,482
General Cargo	137	137	137	137
Ocean Tug (ATB/ITB)	0	0	0	0
Reefer	255	255	255	255
Tanker - Chemical	371	371	821	371
Tanker - Handysize	371	371	2,586	371
Tanker - Panamax	371	371	3,293	371
Tanker - All Diesel-Electric	0	145	220	220

Note - Auxiliary boiler load used for all tankers while being loaded at-berth is 875 kW

Updates to the Emissions Estimation Methodology

In advance of the North American Emissions Control Area, 2014 was the start of CARB's final fuel standard for ships in California waters and required 0.1% sulfur marine gas oil (MGO. It was assumed that except for those vessels that participated in the Port's ESI program, all vessels that came to the Port defaulted to the CARB regulation. In addition, several tanker exemptions for auxiliary boilers expired at the end of 2013 so all tanker emissions were assumed to be in compliance with the CARB fuel requirements. Emissions for those vessels that participated in the ESI program are based on actual sulfur content of the fuel reported as a requirement of the ESI program, which in many instances was lower than 0.1%. Tables 3.7 and 3.8 present the emission factors corresponding to 0.1% sulfur fuel used to estimate emissions.

Table 3.7: Propulsion/Boiler Engine Emission Factors for 0.1% S MGO Fuel (g/kW-hr)

Engine	IMO Tier	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
Slow speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	17.0	0.39	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	13.2	0.43	1.1	0.5	649	0.029	0.01
Slow speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	16.0	0.39	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	12.2	0.43	1.1	0.5	649	0.029	0.01
Slow speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	14.4	0.39	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	10.5	0.43	1.1	0.5	649	0.029	0.01
Slow speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	3.4	0.39	1.4	0.6	589	0.029	0.012
Medium speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	2.6	0.43	1.1	0.5	649	0.029	0.01
Gas turbine	na	all	0.01	0.01	0.00	5.7	0.61	0.2	0.1	922	0.075	0.002
Steamship	na	all	0.14	0.13	0.00	2.0	0.61	0.2	0.1	922	0.075	0.002

Table 3.8: Auxiliary Engine Emission Factors for 0.1% S MGO Fuel (g/kW-hr)

Engine	IMO Tier	Model Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
High speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	10.9	0.46	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 0	≤ 1999	0.26	0.24	0.26	13.8	0.46	1.1	0.4	686	0.029	0.008
High speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	9.8	0.46	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 1	2000 – 2010	0.26	0.24	0.26	12.2	0.46	1.1	0.4	686	0.029	0.008
High speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	7.7	0.46	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 2	2011 – 2015	0.26	0.24	0.26	10.5	0.46	1.1	0.4	686	0.029	0.008
High speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	2.0	0.46	0.9	0.4	656	0.029	0.008
Medium speed diesel	Tier 3	≥ 2016	0.26	0.24	0.26	2.6	0.46	1.1	0.4	686	0.029	0.008

The low load adjustment (LLA) regression equation variables are provided in Table 3.9 for reference. Starting in 2014, the LLA factors presented in Table 3.10 are only applied to 2-stroke non-MAN propulsion engines.

Table 3.9: Low Load Adjustment 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	0.1548	0.8378
HC	1.5	0.3859	0.0667

Table 3.10: 2-Stroke non-MAN Propulsion Engines Low Load Adjustment Factors

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

Starting in 2014, the emissions for MAN 2-stroke propulsion (main) engines were adjusted as a function of engine load using test data from the San Pedro Bay Ports' (SPBP) *MAN Slide Valve Low-Load Emissions Test Final Report* (Slide Valve Test)[6] completed under the SPBP Technology Advancement Program in conjunction with MAN and Mitsui. The following enhancements are incorporated into the emissions estimates for applicable propulsion engines based on the findings of the study and coordinated with the Technical Working Group[7]:

- The emission factor adjustment (EFA) is applied to pollutants for which test results were significantly different in magnitude than the base emission factors used in the inventory. A slide valve EFA (EFA_{SV}) is applied only to vessels equipped with slide valves (SV), which include 2004 or newer MAN 2-stroke engines and vessels identified in VBP as having slide valves. A conventional nozzle (C3) EFA (EFA_{C3}) is used for all other MAN 2-stroke engines, which would be older than 2004 vessels.

EFAs were developed by compositing the test data into the E3 duty cycle load weighting, and comparing them to the E3-based EFs used in the inventories. The following EFAs are used:

a. NO_x: $EFA_{SV} = 1.0$ $EFA_{C3} = 1.0$
b. PM: $EFA_{SV} = 1.0$ $EFA_{C3} = 1.0$
c. THC: $EFA_{SV} = 0.43$ $EFA_{C3} = 1.0$
d. CO: $EFA_{SV} = 0.59$ $EFA_{C3} = 0.44$
e. CO_2: $EFA_{SV} = 1.0$ $EFA_{C3} = 1.0$

- Load adjustment factor (LAF) was calculated and applied to the EF x EFA across all loads (0% to 100%). The LAF is pollutant based and valve specific (SV or C3), using the same criteria as stated above for EFA. The adjusted equation for estimating OGV MAN propulsion engine emissions is:

$$Ei = MCR\ (kW) \times\ engine\ load(\%) \times EF(\frac{g}{kW - hr}) \times EFA \times LAF_i \times FCF \times CF$$

Where,

Ei = Emission by load i, g
MCR = maximum continuous rating, kW
engine $load_i$ = % of MCR being used in mode i, %
EF = default emission factor (E3 duty cycle), g/kW-hr
EFA = emission factor adjustment, dimensionless
LAF_i = test-based EF_i (by valve type and pollutant) at load i / test-based composite EF (E3 duty cycle), dimensionless
FCF = fuel correction factor, dimensionless
CF = control factor for any emission reduction program, dimensionless

---

[6] As referenced in the Emission Estimating Methodology and Enhancements Section.
[7] Made up of POLA, Port of Long Beach, CARB, South Coast Air Quality Management District, and EPA

Tables 3.11 and 3.12 present the LAFs used across the entire engine load range.

Table 3.11: Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1%	0.36	0.36	0.36	1.90	1.00	0.12	1.36	1.00	1.90	1.36
2%	0.37	0.37	0.37	1.86	1.00	0.12	1.32	1.00	1.86	1.32
3%	0.38	0.38	0.38	1.82	1.00	0.12	1.28	1.00	1.82	1.28
4%	0.38	0.38	0.38	1.78	1.00	0.12	1.24	1.00	1.78	1.24
5%	0.39	0.39	0.39	1.74	1.00	0.12	1.20	1.00	1.74	1.20
6%	0.40	0.40	0.40	1.70	1.00	0.12	1.17	1.00	1.70	1.17
7%	0.41	0.41	0.41	1.67	1.00	0.12	1.14	1.00	1.67	1.14
8%	0.41	0.41	0.41	1.63	1.00	0.12	1.11	1.00	1.63	1.11
9%	0.42	0.42	0.42	1.60	1.00	0.12	1.08	1.00	1.60	1.08
10%	0.43	0.43	0.43	1.57	1.00	0.12	1.05	1.00	1.57	1.05
11%	0.44	0.44	0.44	1.53	1.00	0.26	1.02	1.00	1.53	1.02
12%	0.45	0.45	0.45	1.50	1.00	0.39	0.99	1.00	1.50	0.99
13%	0.45	0.45	0.45	1.47	1.00	0.52	0.97	1.00	1.47	0.97
14%	0.46	0.46	0.46	1.45	1.00	0.64	0.94	1.00	1.45	0.94
15%	0.47	0.47	0.47	1.42	1.00	0.75	0.92	1.00	1.42	0.92
16%	0.48	0.48	0.48	1.39	1.00	0.85	0.90	1.00	1.39	0.90
17%	0.49	0.49	0.49	1.37	1.00	0.95	0.88	1.00	1.37	0.88
18%	0.49	0.49	0.49	1.34	1.00	1.04	0.86	1.00	1.34	0.86
19%	0.50	0.50	0.50	1.32	1.00	1.12	0.84	1.00	1.32	0.84
20%	0.51	0.51	0.51	1.30	1.00	1.20	0.82	1.00	1.30	0.82
21%	0.52	0.52	0.52	1.28	1.00	1.27	0.81	1.00	1.28	0.81
22%	0.53	0.53	0.53	1.26	1.00	1.34	0.79	1.00	1.26	0.79
23%	0.54	0.54	0.54	1.24	1.00	1.40	0.78	1.00	1.24	0.78
24%	0.54	0.54	0.54	1.22	1.00	1.46	0.76	1.00	1.22	0.76
25%	0.55	0.55	0.55	1.20	1.00	1.51	0.75	1.00	1.20	0.75

Table 3.11 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
26%	0.56	0.56	0.56	1.19	1.00	1.55	0.74	1.00	1.19	0.74
27%	0.57	0.57	0.57	1.17	1.00	1.59	0.73	1.00	1.17	0.73
28%	0.58	0.58	0.58	1.16	1.00	1.63	0.72	1.00	1.16	0.72
29%	0.59	0.59	0.59	1.14	1.00	1.66	0.71	1.00	1.14	0.71
30%	0.60	0.60	0.60	1.13	1.00	1.68	0.70	1.00	1.13	0.70
31%	0.60	0.60	0.60	1.12	1.00	1.70	0.70	1.00	1.12	0.70
32%	0.61	0.61	0.61	1.10	1.00	1.72	0.69	1.00	1.10	0.69
33%	0.62	0.62	0.62	1.09	1.00	1.74	0.69	1.00	1.09	0.69
34%	0.63	0.63	0.63	1.08	1.00	1.75	0.68	1.00	1.08	0.68
35%	0.64	0.64	0.64	1.07	1.00	1.75	0.68	1.00	1.07	0.68
36%	0.65	0.65	0.65	1.06	1.00	1.75	0.68	1.00	1.06	0.68
37%	0.66	0.66	0.66	1.05	1.00	1.75	0.67	1.00	1.05	0.67
38%	0.67	0.67	0.67	1.05	1.00	1.75	0.67	1.00	1.05	0.67
39%	0.68	0.68	0.68	1.04	1.00	1.74	0.67	1.00	1.04	0.67
40%	0.69	0.69	0.69	1.03	1.00	1.73	0.67	1.00	1.03	0.67
41%	0.70	0.70	0.70	1.03	1.00	1.72	0.67	1.00	1.03	0.67
42%	0.70	0.70	0.70	1.02	1.00	1.71	0.68	1.00	1.02	0.68
43%	0.71	0.71	0.71	1.02	1.00	1.69	0.68	1.00	1.02	0.68
44%	0.72	0.72	0.72	1.01	1.00	1.67	0.68	1.00	1.01	0.68
45%	0.73	0.73	0.73	1.01	1.00	1.65	0.69	1.00	1.01	0.69
46%	0.74	0.74	0.74	1.00	1.00	1.62	0.69	1.00	1.00	0.69
47%	0.75	0.75	0.75	1.00	1.00	1.60	0.70	1.00	1.00	0.70
48%	0.76	0.76	0.76	1.00	1.00	1.57	0.70	1.00	1.00	0.70
49%	0.77	0.77	0.77	0.99	1.00	1.54	0.71	1.00	0.99	0.71
50%	0.78	0.78	0.78	0.99	1.00	1.51	0.71	1.00	0.99	0.71

Table 3.11 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
51%	0.79	0.79	0.79	0.99	1.00	1.48	0.72	1.00	0.99	0.72
52%	0.80	0.80	0.80	0.99	1.00	1.45	0.73	1.00	0.99	0.73
53%	0.81	0.81	0.81	0.99	1.00	1.41	0.74	1.00	0.99	0.74
54%	0.82	0.82	0.82	0.99	1.00	1.38	0.75	1.00	0.99	0.75
55%	0.83	0.83	0.83	0.98	1.00	1.35	0.75	1.00	0.98	0.75
56%	0.84	0.84	0.84	0.98	1.00	1.31	0.76	1.00	0.98	0.76
57%	0.85	0.85	0.85	0.98	1.00	1.27	0.77	1.00	0.98	0.77
58%	0.86	0.86	0.86	0.98	1.00	1.24	0.78	1.00	0.98	0.78
59%	0.87	0.87	0.87	0.98	1.00	1.20	0.80	1.00	0.98	0.80
60%	0.88	0.88	0.88	0.98	1.00	1.16	0.81	1.00	0.98	0.81
61%	0.89	0.89	0.89	0.98	1.00	1.13	0.82	1.00	0.98	0.82
62%	0.90	0.90	0.90	0.98	1.00	1.09	0.83	1.00	0.98	0.83
63%	0.91	0.91	0.91	0.99	1.00	1.06	0.84	1.00	0.99	0.84
64%	0.92	0.92	0.92	0.99	1.00	1.02	0.85	1.00	0.99	0.85
65%	0.93	0.93	0.93	0.99	1.00	0.98	0.87	1.00	0.99	0.87
66%	0.94	0.94	0.94	0.99	1.00	0.95	0.88	1.00	0.99	0.88
67%	0.95	0.95	0.95	0.99	1.00	0.92	0.89	1.00	0.99	0.89
68%	0.97	0.97	0.97	0.99	1.00	0.88	0.91	1.00	0.99	0.91
69%	0.98	0.98	0.98	0.99	1.00	0.85	0.92	1.00	0.99	0.92
70%	0.99	0.99	0.99	0.99	1.00	0.82	0.93	1.00	0.99	0.93
71%	1.00	1.00	1.00	0.99	1.00	0.79	0.95	1.00	0.99	0.95
72%	1.01	1.01	1.01	0.99	1.00	0.76	0.96	1.00	0.99	0.96
73%	1.02	1.02	1.02	0.99	1.00	0.74	0.98	1.00	0.99	0.98
74%	1.03	1.03	1.03	0.99	1.00	0.71	0.99	1.00	0.99	0.99
75%	1.04	1.04	1.04	0.99	1.00	0.69	1.00	1.00	0.99	1.00

Table 3.11 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Slide Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
76%	1.05	1.05	1.05	0.99	1.00	0.66	1.02	1.00	0.99	1.02
77%	1.06	1.06	1.06	0.99	1.00	0.64	1.03	1.00	0.99	1.03
78%	1.07	1.07	1.07	0.99	1.00	0.63	1.05	1.00	0.99	1.05
79%	1.09	1.09	1.09	0.99	1.00	0.61	1.06	1.00	0.99	1.06
80%	1.10	1.10	1.10	0.99	1.00	0.60	1.08	1.00	0.99	1.08
81%	1.11	1.11	1.11	0.99	1.00	0.58	1.09	1.00	0.99	1.09
82%	1.12	1.12	1.12	0.99	1.00	0.57	1.10	1.00	0.99	1.10
83%	1.13	1.13	1.13	0.98	1.00	0.57	1.12	1.00	0.98	1.12
84%	1.14	1.14	1.14	0.98	1.00	0.56	1.13	1.00	0.98	1.13
85%	1.15	1.15	1.15	0.98	1.00	0.56	1.15	1.00	0.98	1.15
86%	1.16	1.16	1.16	0.98	1.00	0.56	1.16	1.00	0.98	1.16
87%	1.18	1.18	1.18	0.97	1.00	0.56	1.18	1.00	0.97	1.18
88%	1.19	1.19	1.19	0.97	1.00	0.57	1.19	1.00	0.97	1.19
89%	1.20	1.20	1.20	0.96	1.00	0.58	1.20	1.00	0.96	1.20
90%	1.21	1.21	1.21	0.96	1.00	0.59	1.22	1.00	0.96	1.22
91%	1.22	1.22	1.22	0.95	1.00	0.61	1.23	1.00	0.95	1.23
92%	1.23	1.23	1.23	0.95	1.00	0.63	1.24	1.00	0.95	1.24
93%	1.25	1.25	1.25	0.94	1.00	0.65	1.25	1.00	0.94	1.25
94%	1.26	1.26	1.26	0.93	1.00	0.67	1.27	1.00	0.93	1.27
95%	1.27	1.27	1.27	0.93	1.00	0.70	1.28	1.00	0.93	1.28
96%	1.28	1.28	1.28	0.92	1.00	0.73	1.29	1.00	0.92	1.29
97%	1.29	1.29	1.29	0.91	1.00	0.77	1.30	1.00	0.91	1.30
98%	1.31	1.31	1.31	0.90	1.00	0.81	1.31	1.00	0.90	1.31
99%	1.32	1.32	1.32	0.89	1.00	0.85	1.32	1.00	0.89	1.32
100%	1.33	1.33	1.33	0.88	1.00	0.90	1.34	1.00	0.88	1.34

Table 3.12: Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1%	0.84	0.84	0.84	1.91	1.00	1.38	2.53	1.00	1.91	2.53
2%	0.83	0.83	0.83	1.86	1.00	1.36	2.45	1.00	1.86	2.45
3%	0.83	0.83	0.83	1.82	1.00	1.34	2.37	1.00	1.82	2.37
4%	0.82	0.82	0.82	1.77	1.00	1.33	2.30	1.00	1.77	2.30
5%	0.82	0.82	0.82	1.72	1.00	1.31	2.23	1.00	1.72	2.23
6%	0.81	0.81	0.81	1.68	1.00	1.29	2.16	1.00	1.68	2.16
7%	0.81	0.81	0.81	1.64	1.00	1.28	2.10	1.00	1.64	2.10
8%	0.80	0.80	0.80	1.60	1.00	1.26	2.03	1.00	1.60	2.03
9%	0.80	0.80	0.80	1.56	1.00	1.25	1.97	1.00	1.56	1.97
10%	0.79	0.79	0.79	1.52	1.00	1.24	1.91	1.00	1.52	1.91
11%	0.79	0.79	0.79	1.49	1.00	1.22	1.86	1.00	1.49	1.86
12%	0.78	0.78	0.78	1.45	1.00	1.21	1.80	1.00	1.45	1.80
13%	0.78	0.78	0.78	1.42	1.00	1.20	1.75	1.00	1.42	1.75
14%	0.78	0.78	0.78	1.39	1.00	1.19	1.70	1.00	1.39	1.70
15%	0.77	0.77	0.77	1.36	1.00	1.18	1.65	1.00	1.36	1.65
16%	0.77	0.77	0.77	1.33	1.00	1.17	1.61	1.00	1.33	1.61
17%	0.77	0.77	0.77	1.30	1.00	1.16	1.56	1.00	1.30	1.56
18%	0.77	0.77	0.77	1.28	1.00	1.15	1.52	1.00	1.28	1.52
19%	0.76	0.76	0.76	1.25	1.00	1.14	1.48	1.00	1.25	1.48
20%	0.76	0.76	0.76	1.23	1.00	1.13	1.44	1.00	1.23	1.44
21%	0.76	0.76	0.76	1.20	1.00	1.13	1.41	1.00	1.20	1.41
22%	0.76	0.76	0.76	1.18	1.00	1.12	1.37	1.00	1.18	1.37
23%	0.76	0.76	0.76	1.16	1.00	1.11	1.34	1.00	1.16	1.34
24%	0.75	0.75	0.75	1.14	1.00	1.10	1.31	1.00	1.14	1.31
25%	0.75	0.75	0.75	1.12	1.00	1.10	1.28	1.00	1.12	1.28

Table 3.12 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
26%	0.75	0.75	0.75	1.11	1.00	1.09	1.25	1.00	1.11	1.25
27%	0.75	0.75	0.75	1.09	1.00	1.08	1.22	1.00	1.09	1.22
28%	0.75	0.75	0.75	1.07	1.00	1.08	1.20	1.00	1.07	1.20
29%	0.75	0.75	0.75	1.06	1.00	1.07	1.17	1.00	1.06	1.17
30%	0.75	0.75	0.75	1.05	1.00	1.07	1.15	1.00	1.05	1.15
31%	0.75	0.75	0.75	1.03	1.00	1.06	1.13	1.00	1.03	1.13
32%	0.75	0.75	0.75	1.02	1.00	1.06	1.11	1.00	1.02	1.11
33%	0.75	0.75	0.75	1.01	1.00	1.05	1.09	1.00	1.01	1.09
34%	0.75	0.75	0.75	1.00	1.00	1.05	1.08	1.00	1.00	1.08
35%	0.76	0.76	0.76	0.99	1.00	1.04	1.06	1.00	0.99	1.06
36%	0.76	0.76	0.76	0.98	1.00	1.04	1.05	1.00	0.98	1.05
37%	0.76	0.76	0.76	0.98	1.00	1.03	1.04	1.00	0.98	1.04
38%	0.76	0.76	0.76	0.97	1.00	1.03	1.02	1.00	0.97	1.02
39%	0.76	0.76	0.76	0.96	1.00	1.02	1.01	1.00	0.96	1.01
40%	0.76	0.76	0.76	0.96	1.00	1.02	1.00	1.00	0.96	1.00
41%	0.77	0.77	0.77	0.95	1.00	1.01	0.99	1.00	0.95	0.99
42%	0.77	0.77	0.77	0.95	1.00	1.01	0.99	1.00	0.95	0.99
43%	0.77	0.77	0.77	0.94	1.00	1.01	0.98	1.00	0.94	0.98
44%	0.78	0.78	0.78	0.94	1.00	1.00	0.97	1.00	0.94	0.97
45%	0.78	0.78	0.78	0.94	1.00	1.00	0.97	1.00	0.94	0.97
46%	0.78	0.78	0.78	0.94	1.00	0.99	0.96	1.00	0.94	0.96
47%	0.79	0.79	0.79	0.94	1.00	0.99	0.96	1.00	0.94	0.96
48%	0.79	0.79	0.79	0.93	1.00	0.98	0.96	1.00	0.93	0.96
49%	0.79	0.79	0.79	0.93	1.00	0.98	0.96	1.00	0.93	0.96
50%	0.80	0.80	0.80	0.93	1.00	0.98	0.96	1.00	0.93	0.96

Table 3.12 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
51%	0.80	0.80	0.80	0.94	1.00	0.97	0.95	1.00	0.94	0.95
52%	0.81	0.81	0.81	0.94	1.00	0.97	0.95	1.00	0.94	0.95
53%	0.81	0.81	0.81	0.94	1.00	0.96	0.95	1.00	0.94	0.95
54%	0.82	0.82	0.82	0.94	1.00	0.96	0.95	1.00	0.94	0.95
55%	0.82	0.82	0.82	0.94	1.00	0.96	0.96	1.00	0.94	0.96
56%	0.83	0.83	0.83	0.94	1.00	0.95	0.96	1.00	0.94	0.96
57%	0.84	0.84	0.84	0.95	1.00	0.95	0.96	1.00	0.95	0.96
58%	0.84	0.84	0.84	0.95	1.00	0.95	0.96	1.00	0.95	0.96
59%	0.85	0.85	0.85	0.95	1.00	0.94	0.96	1.00	0.95	0.96
60%	0.86	0.86	0.86	0.95	1.00	0.94	0.97	1.00	0.95	0.97
61%	0.86	0.86	0.86	0.96	1.00	0.93	0.97	1.00	0.96	0.97
62%	0.87	0.87	0.87	0.96	1.00	0.93	0.97	1.00	0.96	0.97
63%	0.88	0.88	0.88	0.96	1.00	0.93	0.98	1.00	0.96	0.98
64%	0.89	0.89	0.89	0.97	1.00	0.93	0.98	1.00	0.97	0.98
65%	0.89	0.89	0.89	0.97	1.00	0.92	0.98	1.00	0.97	0.98
66%	0.90	0.90	0.90	0.98	1.00	0.92	0.99	1.00	0.98	0.99
67%	0.91	0.91	0.91	0.98	1.00	0.92	0.99	1.00	0.98	0.99
68%	0.92	0.92	0.92	0.98	1.00	0.91	0.99	1.00	0.98	0.99
69%	0.93	0.93	0.93	0.99	1.00	0.91	1.00	1.00	0.99	1.00
70%	0.94	0.94	0.94	0.99	1.00	0.91	1.00	1.00	0.99	1.00
71%	0.94	0.94	0.94	0.99	1.00	0.91	1.00	1.00	0.99	1.00
72%	0.95	0.95	0.95	1.00	1.00	0.91	1.01	1.00	1.00	1.01
73%	0.96	0.96	0.96	1.00	1.00	0.91	1.01	1.00	1.00	1.01
74%	0.97	0.97	0.97	1.00	1.00	0.91	1.01	1.00	1.00	1.01
75%	0.98	0.98	0.98	1.01	1.00	0.90	1.01	1.00	1.01	1.01

Table 3.12 (continued): Load Adjustment Factors for MAN 2-Stroke Propulsion Engines with Conventional Valves

Load	PM	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
76%	0.99	0.99	0.99	1.01	1.00	0.90	1.01	1.00	1.01	1.01
77%	1.00	1.00	1.00	1.01	1.00	0.90	1.01	1.00	1.01	1.01
78%	1.01	1.01	1.01	1.01	1.00	0.91	1.01	1.00	1.01	1.01
79%	1.03	1.03	1.03	1.02	1.00	0.91	1.01	1.00	1.02	1.01
80%	1.04	1.04	1.04	1.02	1.00	0.91	1.01	1.00	1.02	1.01
81%	1.05	1.05	1.05	1.02	1.00	0.91	1.01	1.00	1.02	1.01
82%	1.06	1.06	1.06	1.02	1.00	0.91	1.01	1.00	1.02	1.01
83%	1.07	1.07	1.07	1.02	1.00	0.92	1.01	1.00	1.02	1.01
84%	1.08	1.08	1.08	1.02	1.00	0.92	1.00	1.00	1.02	1.00
85%	1.10	1.10	1.10	1.02	1.00	0.92	1.00	1.00	1.02	1.00
86%	1.11	1.11	1.11	1.02	1.00	0.93	0.99	1.00	1.02	0.99
87%	1.12	1.12	1.12	1.02	1.00	0.93	0.99	1.00	1.02	0.99
88%	1.13	1.13	1.13	1.02	1.00	0.94	0.98	1.00	1.02	0.98
89%	1.15	1.15	1.15	1.01	1.00	0.95	0.97	1.00	1.01	0.97
90%	1.16	1.16	1.16	1.01	1.00	0.95	0.97	1.00	1.01	0.97
91%	1.17	1.17	1.17	1.01	1.00	0.96	0.96	1.00	1.01	0.96
92%	1.19	1.19	1.19	1.00	1.00	0.97	0.94	1.00	1.00	0.94
93%	1.20	1.20	1.20	1.00	1.00	0.98	0.93	1.00	1.00	0.93
94%	1.22	1.22	1.22	0.99	1.00	0.99	0.92	1.00	0.99	0.92
95%	1.23	1.23	1.23	0.99	1.00	1.01	0.91	1.00	0.99	0.91
96%	1.24	1.24	1.24	0.98	1.00	1.02	0.89	1.00	0.98	0.89
97%	1.26	1.26	1.26	0.97	1.00	1.03	0.87	1.00	0.97	0.87
98%	1.28	1.28	1.28	0.97	1.00	1.05	0.86	1.00	0.97	0.86
99%	1.29	1.29	1.29	0.96	1.00	1.07	0.84	1.00	0.96	0.84
100%	1.31	1.31	1.31	0.95	1.00	1.08	0.82	1.00	0.95	0.82

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 2014 is presented in Table 3.13. The criteria pollutant emissions are in tons per year (tpy), while the greenhouse gas emissions are in tonnes per year.

Table 3.13: 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	0.8	0.8	0.7	45.7	1.6	4.1	1.8	2,296
Bulk	1.9	1.8	1.7	100.2	4.1	8.1	3.3	5,834
Bulk - Heavy Load	0.0	0.0	0.0	0.6	0.0	0.1	0.0	41
Container - 1000	1.1	1.1	1.0	77.9	1.4	4.9	1.9	3,956
Container - 2000	3.5	3.3	2.7	165.5	7.0	14.8	6.5	11,894
Container - 3000	1.9	1.8	1.5	113.3	3.3	8.3	4.1	6,619
Container - 4000	11.3	10.5	10.1	581.3	15.9	62.7	32.7	27,785
Container - 5000	5.5	5.1	4.7	282.3	7.3	29.3	15.2	14,900
Container - 6000	11.0	10.2	8.7	681.7	15.6	49.8	26.5	37,470
Container - 7000	1.4	1.3	1.2	64.7	1.2	8.7	4.7	3,569
Container - 8000	5.1	4.7	4.0	261.7	7.4	26.4	15.5	15,417
Container - 9000	3.6	3.3	3.1	153.2	5.3	19.8	10.8	8,982
Container - 10000	3.6	3.3	2.6	149.3	6.6	16.0	9.3	11,611
Container - 13000	0.8	0.8	0.7	39.6	1.2	3.3	2.1	2,859
Cruise	7.5	7.0	7.3	362.2	13.5	31.8	12.3	18,891
General Cargo	2.8	2.6	2.6	137.4	4.3	12.5	5.1	7,657
Ocean Tugboat (ATB/ITB)	0.2	0.1	0.2	7.4	0.3	0.7	0.3	364
Reefer	0.5	0.4	0.4	23.8	0.9	2.1	0.9	1,273
Tanker - Chemical	3.9	3.6	3.0	175.8	9.0	15.1	5.6	12,882
Tanker - Handysize	1.0	0.9	0.7	41.2	2.4	3.5	1.4	3,432
Tanker - Panamax	4.0	3.8	2.1	142.7	12.1	12.5	4.9	17,218
Total	**71.5**	**66.5**	**59.1**	**3,607.4**	**120.5**	**334.4**	**164.9**	**214,950**

DB ID692

Table 3.14 presents summaries of emission estimates by engine type in tons per year.

Table 3.14: Ocean-Going Vessel Emissions by Engine 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
Main Engine	24.4	22.7	23.9	1,790.0	27.0	161.2	99.54	49,084
Auxiliary Engine	35.1	32.7	35.1	1,640.1	51.4	155.2	56.43	88,912
Auxiliary Boiler	11.9	11.1	0.0	177.4	42.1	18.0	8.99	76,954
Total	**71.5**	**66.5**	**59.1**	**3,607.4**	**120.5**	**334.4**	**164.9**	**214,950**

DB ID692

Table 3.15 presents summaries of emission estimates by the various modes in tons per year. For each mode, the engine type emissions are also listed. At-berth hotelling and at-anchorage hotelling are listed separately. Transit and harbor maneuvering emissions include both berth and anchorage calls.

Table 3.15: 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	20.9	19.4	20.4	1,591.7	25.5	135.2	76.7	46,193
Transit	Aux	7.9	7.4	7.9	372.5	11.6	35.0	12.7	20,062
Transit	Auxiliary Boiler	0.9	0.8	0.0	13.2	2.9	1.3	0.7	5,733
Total Transit		**29.7**	**27.6**	**28.3**	**1,977.4**	**40.0**	**171.6**	**90.1**	**71,989**
Maneuvering	Main	3.5	3.3	3.5	198.3	1.5	26.0	22.9	2,891
Maneuvering	Aux	2.7	2.6	2.7	128.2	4.0	12.1	4.4	6,954
Maneuvering	Auxiliary Boiler	0.2	0.2	0.0	3.6	0.8	0.4	0.2	1,554
Total Maneuvering		**6.5**	**6.0**	**6.3**	**330.1**	**6.3**	**38.5**	**27.5**	**11,399**
Hotelling at-berth	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Hotelling at-berth	Aux	17.5	16.3	17.5	811.5	25.4	77.3	28.1	44,312
Hotelling at-berth	Auxiliary Boiler	9.2	8.6	0.0	137.4	32.4	13.9	7.0	59,601
Total Hotelling at-berth		**26.7**	**24.9**	**17.5**	**948.9**	**57.8**	**91.3**	**35.1**	**103,913**
Hotelling at-anchorage	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Hotelling at-anchorage	Aux	7.0	6.5	7.0	327.9	10.4	30.7	11.2	17,584
Hotelling at-anchorage	Auxiliary Boiler	1.6	1.5	0.0	23.2	6.0	2.4	1.2	10,064
Total Hotelling at-anchorage		**8.5**	**8.0**	**7.0**	**351.1**	**16.4**	**33.0**	**12.3**	**27,649**
Total		**71.5**	**66.5**	**59.1**	**3,607.4**	**120.5**	**334.4**	**164.9**	**214,949**

DB ID694

SECTION 4 HARBOR CRAFT

This section presents emissions estimates for the commercial harbor craft source category, including source descriptions, geographical domain, data acquisition, operational profiles, emissions estimation methodology and emission estimates.

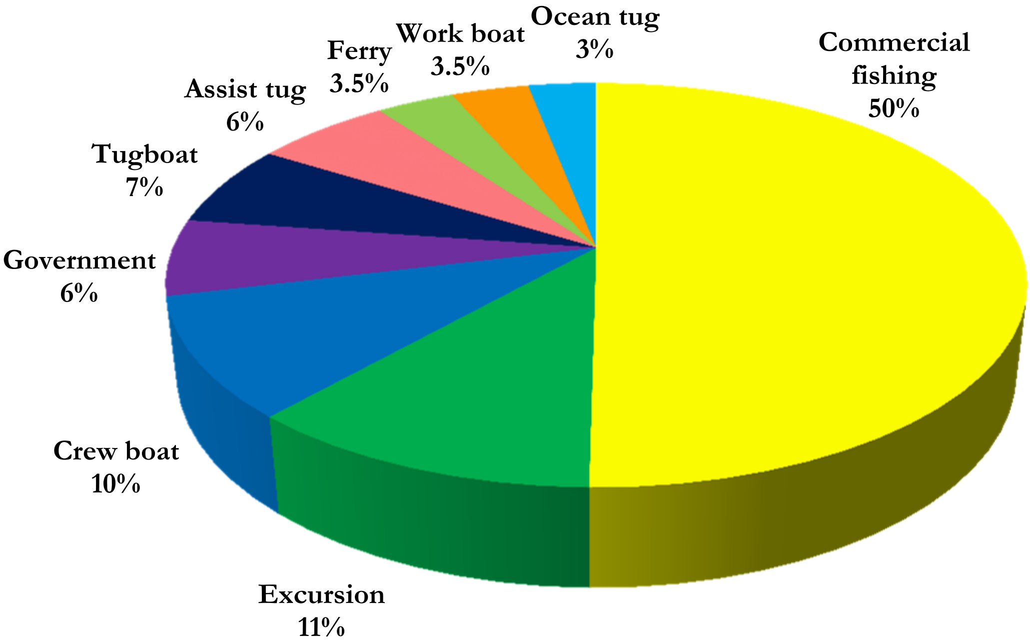
Source Description

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 229 commercial harbor craft inventoried for the Port in 2014.

Figure 4.1: Distribution of 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 tugboats because their engine loads are higher than 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.

Geographical Domain

The geographical domain for harbor craft is the same as that for ocean-going vessels.

Data and Information Acquisition

Commercial harbor craft companies were contacted to obtain key operational parameters for their vessels. These include:

- Vessel type
- Engine count
- Engine horsepower (or kilowatts) for main and auxiliary engines
- Engine model year
- Operating hours in calendar year 2014
- Vessel repower information

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.

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 2014 for the Port of Los Angeles harbor only.

Table 4.1: 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	65	2,197	1,462
Commercial fishing	115	121	1957	2012	2000	50	300	208	200	1,300	885
Crew boat	22	51	2003	2012	2009	180	1,450	535	0	2,392	884
Excursion	26	51	1960	2014	2003	150	550	367	0	2,400	1,280
Ferry	8	20	2003	2013	2010	1,800	2,300	2,125	600	1,200	1,080
Government	14	25	1993	2012	2005	68	1,770	569	0	1,212	334
Ocean tug	7	14	1991	2012	2003	805	3,385	1,942	200	2,176	982
Tugboat	15	30	2001	2013	2009	235	1,500	680	85	2,000	597
Work boat	8	15	2005	2013	2010	135	1,000	505	62	3,861	1,394
Total	**229**	**356**									

DB ID423

Table 4.2: 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	29	1980	2013	2007	67	450	182	9	4,068	1,732
Commercial fishing	115	36	1957	2012	2006	10	40	26	100	1,200	625
Crew boat	22	21	1980	2012	2007	11	76	48	0	2,215	1,079
Excursion	26	30	1972	2014	2007	7	74	40	0	4,000	1,611
Ferry	8	16	2003	2013	2009	18	120	69	300	750	694
Government	14	15	2002	2012	2004	50	1555	594	17	650	161
Ocean tug	7	15	1991	2012	2004	60	253	117	200	1,433	658
Tugboat	15	23	2005	2012	2009	22	107	47	70	2,000	456
Work boat	8	12	1968	2013	2002	27	101	59	1	3,412	1,543
Total	**229**	**197**									

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 fail to identify the specific EPA certification standards or "tier" level, the tier level is assumed for that engine based on engine model year and horsepower.[8] 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

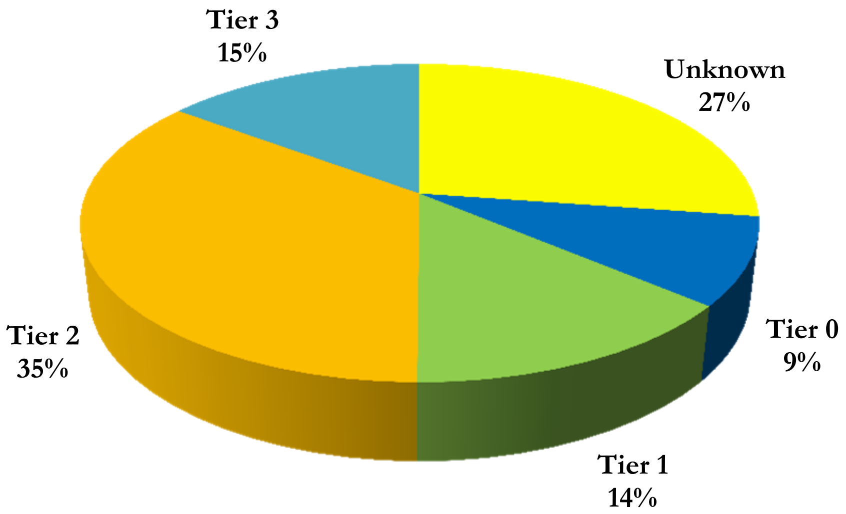
EPA Tier Level	Marine Engine Model Year Range	Horsepower Range
Tier 0	1999 and older	All
Tier 1	2000 to 2003	< 500 hp
Tier 1	2000 to 2006	> 500 hp
Tier 2	2004 up to Tier 3	< 500 hp
Tier 2	2007 up to Tier 3	> 500 hp
Tier 3	2009 and newer	0 to 120 hp
Tier 3	2013 and newer	> 120 to 175 hp
Tier 3	2014 and 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

---

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

Figure 4.2 provides the population distribution of all harbor craft propulsion and auxiliary engines operating at the Port in 2014. If model year and/or horsepower information are not available, the engines are classified as "unknown".

Figure 4.2: Distribution of Harbor Craft Engines by Engine Standards



Emissions Estimation Methodology

The emissions calculation methodology and the emission rates are same as the ones used to estimate harbor craft emissions for the Port's 2013 EI[9]. Harbor craft emissions are estimated for each engine individually, based on the engine's model year, power rating, and annual hours of operation. The Port's harbor craft emission calculation methodology is similar to the methodology used by the CARB emissions inventory for commercial harbor craft operating in California[10].

---

[9] *www.portoflosangeles.org/environment/studies_reports.asp*

[10] CARB, *Commercial Harbor Craft Regulatory Activities*, Appendix B: Emissions Estimation Methodology for Commercial Harbor Craft Operating in California. *www.arb.ca.gov/msei/chc-appendix-b-emission-estimates-ver02-27-2012.pdf.*

Emission Estimates

Table 4.4 summarizes the estimated 2014 harbor craft emissions by vessel 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 table. This is because there are fewer decimal places displayed (for readability) than are included in the calculated total. The criteria pollutants are listed as tons per year while the CO_2e values are listed as tonnes (metric tons) per year.

Table 4.4: Harbor Craft Emissions by Vessel and Engine Type

Harbor Craft Type	Engine Type	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
Assist Tug	Auxiliary	0.7	0.6	0.7	22.4	0.0	17.8	2.9	2,028
	Propulsion	8.0	7.4	8.0	212.3	0.2	113.1	18.1	13,524
Assist Tug Total		**8.7**	**8.0**	**8.7**	**234.7**	**0.2**	**130.8**	**21.0**	**15,552**
Commercial Fishing	Auxiliary	0.1	0.1	0.1	1.6	0.0	1.6	0.6	130
	Propulsion	2.4	2.2	2.4	54.2	0.0	19.0	4.3	2,961
Commercial Fishing Total		**2.5**	**2.3**	**2.5**	**55.8**	**0.0**	**20.5**	**4.9**	**3,091**
Crew boat	Auxiliary	0.1	0.1	0.1	2.5	0.0	2.0	0.5	201
	Propulsion	2.2	2.0	2.2	63.8	0.1	38.8	6.2	5,207
Crew boat Total		**2.3**	**2.1**	**2.3**	**66.3**	**0.1**	**40.8**	**6.7**	**5,408**
Excursion	Auxiliary	0.2	0.2	0.2	4.6	0.0	3.8	1.5	385
	Propulsion	3.2	3.0	3.2	80.0	0.1	38.9	7.1	4,838
Excursion Total		**3.5**	**3.2**	**3.5**	**84.6**	**0.1**	**42.7**	**8.5**	**5,222**
Ferry	Auxiliary	0.1	0.1	0.1	1.8	0.0	1.4	0.4	153
	Propulsion	4.1	3.8	4.1	118.6	0.1	80.7	11.8	9,665
Ferry Total		**4.2**	**3.9**	**4.2**	**120.4**	**0.1**	**82.0**	**12.2**	**9,817**
Government	Auxiliary	0.1	0.1	0.1	3.2	0.0	1.7	0.3	220
	Propulsion	1.0	0.9	1.0	22.3	0.0	9.4	1.9	1,440
Government Total		**1.1**	**1.1**	**1.1**	**25.5**	**0.0**	**11.0**	**2.3**	**1,661**
Ocean Tug (Line Hau	Auxiliary	0.2	0.1	0.2	3.9	0.0	2.6	0.5	292
	Propulsion	5.5	5.0	5.5	156.2	0.1	72.7	12.7	9,994
Ocean Tug		**5.6**	**5.2**	**5.6**	**160.1**	**0.1**	**75.3**	**13.2**	**10,286**
Tugboat	Auxiliary	0.1	0.1	0.1	1.3	0.0	1.0	0.4	116
	Propulsion	0.6	0.5	0.6	19.5	0.0	15.5	2.1	1,759
Tugboat Total		**0.6**	**0.6**	**0.6**	**20.8**	**0.0**	**16.5**	**2.5**	**1,874**
Work boat	Auxiliary	0.1	0.1	0.1	1.8	0.0	1.5	0.5	159
	Propulsion	0.9	0.9	0.9	31.8	0.0	24.4	3.3	2,822
Work boat Total		**1.0**	**0.9**	**1.0**	**33.6**	**0.0**	**25.9**	**3.8**	**2,981**
Harbor Craft Total		**29.6**	**27.3**	**29.6**	**801.8**	**0.6**	**445.6**	**75.1**	**55,892**

DB ID427

SECTION 5 CARGO HANDLING EQUIPMENT

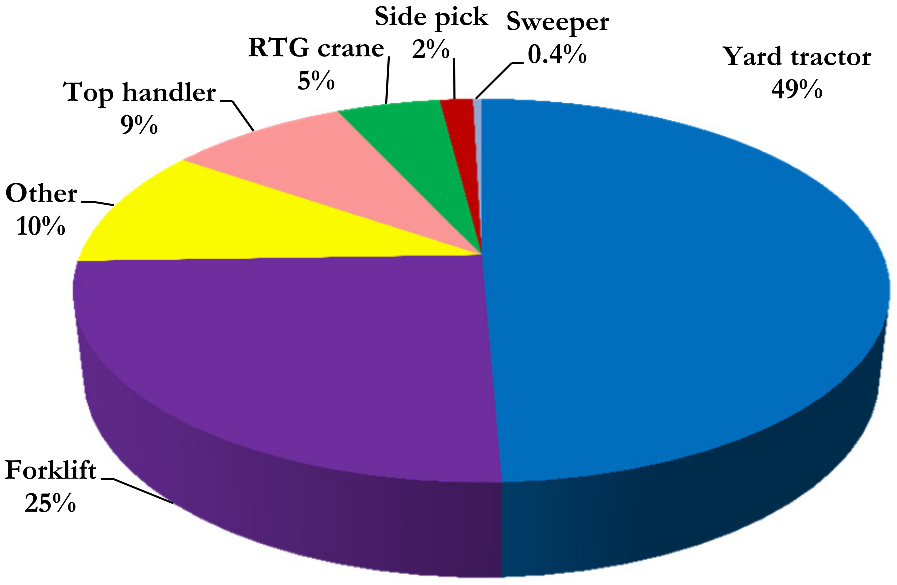
This section presents emissions estimates for the CHE source category, including source descriptions, geographical domain, data acquisition, operational profiles, emissions estimation methodology and emission estimates.

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.

Figure 5.1 presents the population distribution of the 2,156 pieces of equipment inventoried at the Port for calendar year 2014. The 10% for other equipment includes pieces of equipment that are not typical CHE.

Figure 5.1: CHE Count Distribution by Equipment Type



Geographical Domain

The geographical domain for CHE is the terminals within the port.

Data and Information Acquisition

The maintenance and/or CHE operating staff of each terminal were contacted in person or by e-mail or telephone to obtain equipment count and activity information on the CHE specific to their terminal's operation for the 2014 calendar year:

Operational Profiles

Table 5.1 summarizes the cargo handling equipment data collected from the terminals and facilities for the calendar year 2014. 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. Instead the separate averages for main and auxiliary engines are used for the RTG cranes. 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: 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	24	298	178
Crane	Diesel	9	130	950	287	1969	2010	1992	42	1,173	469
Pallet jack	Electric	7	na	na	na	na	na	na	na	na	na
Wharf crane	Electric	84	na	na	na	na	na	na	0	3,440	478
Excavator	Diesel	1	371	371	371	2010	2010	2010	0	0	0
Forklift	Diesel	121	59	350	164	1985	2014	2008	0	2,957	807
Forklift	Electric	10	na	na	na	na	na	na	0	1,825	421
Forklift	Gasoline	8	45	45	45	2010	2012	2011	0	2,188	962
Forklift	Propane	403	32	200	75	1975	2014	1999	0	2,763	574
Loader	Diesel	13	55	430	249	1989	2014	2005	0	3,915	1,053
Loader	Electric	3	na	na	na	na	na	na	na	na	na
Man lift	Diesel	16	48	152	77	1989	2012	2004	0	788	251
Man lift	Electric	3	na	na	na	na	na	na	na	na	na
Material handler	Diesel	13	322	475	389	1999	2011	2007	0	3,388	1,053
Miscellaneous	Diesel	9	25	268	55	2007	2013	2011	411	2,210	1,458
Miscellaneous	Electric	1	na	na	na	na	na	na	na	na	na
Rail pusher	Diesel	2	194	200	197	2000	2012	2006	0	162	81
RMG cranes	Electric	10	na	na	na	na	na	na	0	1,754	1,196
RTG crane	Diesel	106	27	779	484	1998	2013	2007	0	5,256	2,054
Side pick	Diesel	34	125	330	227	1992	2012	2005	65	2,910	1,080
Skid steer loader	Diesel	8	45	94	65	1994	2012	2003	0	722	148
Straddle carrier	Diesel	17	425	425	425	2013	2013	2013	100	3,055	2,161
Sweeper	Diesel	7	37	260	133	1995	2008	2002	0	507	333
Sweeper	Gasoline	2	205	205	205	2002	2005	2004	313	2,660	1,487
Top handler	Diesel	183	250	375	317	1998	2014	2008	0	4,010	2,136
Truck	Diesel	19	185	540	341	2001	2012	2007	0	2,241	960
Yard tractor	Diesel	865	170	250	227	1995	2014	2009	0	4,237	1,816
Yard tractor	Gasoline	2	362	362	362	2012	2012	2012	687	959	823
Yard tractor	LNG	17	230	230	230	2009	2010	2010	284	2,470	987
Yard tractor	Propane	180	174	231	199	2000	2011	2007	0	3,477	1,957
Total count		**2,156**									

DB ID228

Table 5.2 is a summary of the emission reduction technologies utilized in cargo handling equipment.

Table 5.2: Count of CHE Emission Reduction Technologies

Equipment	DOC Installed	On-Road Engines	DPF Installed	Vycon Installed	ULSD Fuel	BlueCAT LSI Equip
Forklift	0	0	28	0	121	224
RTG crane	7	0	12	1	106	0
Side pick	0	0	16	0	34	0
Top handler	0	0	110	0	183	0
Yard tractor	92	830	4	0	865	0
Sweeper	0	0	2	0	7	0
Other	0	11	20	0	110	0
Total	**99**	**841**	**194**	**1**	**1,426**	**224**

DB ID234

Table 5.3 shows the distribution of equipment by fuel type.

Table 5.3: Count of CHE Engine by Fuel Type

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
Forklift	10	0	403	8	121	542
Electric wharf crane	84	0	0	0	0	84
RTG crane	0	0	0	0	106	106
Side pick	0	0	0	0	34	34
Top handler	0	0	0	0	183	183
Yard tractor	0	17	180	2	865	1,064
Sweeper	0	0	0	2	7	9
Other	24	0	0	0	110	134
Total	**118**	**17**	**583**	**12**	**1,426**	**2,156**

DB ID235

Table 5.4 summarizes the distribution of diesel cargo handling equipment equipped with off-road engines by off-road diesel engine standards[11] (Tier 0, 1, 2, 3, 4i and 4) based on model year and horsepower range. The table includes the use of on-road diesel engines on yard tractors to comply with CARB's CHE regulation. 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.

The "Unknown" Tier column shown in the table represents equipment with missing horsepower or model year information necessary for Tier level classifications. For the first time, Tier 4 engines are included in the table.

Table 5.4: Count of Diesel Equipment by Type and Engine Standards

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4i	Tier 4	On-road Engine	Unknown Tier	Total Diesel CHE
Yard tractor	4	1	30	0	0	0	830	0	865
Forklift	12	2	12	31	55	0	0	9	121
Top handler	0	19	47	58	22	15	0	22	183
Other	11	12	13	27	27	7	11	2	110
RTG crane	0	14	28	22	42	0	0	0	106
Side pick	2	9	9	11	0	0	0	3	34
Sweeper	1	3	1	2	0	0	0	0	7
Total	**30**	**60**	**140**	**151**	**146**	**22**	**841**	**36**	**1,426**
Percent	**2%**	**4%**	**10%**	**11%**	**10%**	**1.5%**	**59%**	**2.5%**	

DB ID878

Emissions Estimation Methodology

The emissions calculation methodology used to estimate CHE emissions is consistent with CARB's latest methodology for estimating emissions from CHE[12] and is same described in detail in Section 5 of the Port's 2013 EI[13]. For gasoline and LNG engines, the emission rates were updated based on new data provided by CARB.

---

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

[12] CARB, Appendix B: Emission Estimation Methodology for Cargo Handling Equipment Operating at Ports and Intermodal Rail Yards in California at *www.arb.ca.gov/regact/2011/cargo11/cargoappb.pdf, viewed 22 July 2015*

[13] *www.portoflosangeles.org/environment/studies_reports.asp*

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 5.5 and 5.6 provide a summary of cargo handling equipment emissions by terminal type. The criteria pollutants are listed as tons per year while the CO_2e values are listed as tonnes (metric tons) per year.

Table 5.5: CHE Emissions by Terminal Type

Terminal Type	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
Auto	0.0	0.0	0.0	0.1	0.0	1.6	0.1	34
Break-Bulk	1.0	1.0	1.0	32.3	0.1	18.6	2.3	6,062
Container	10.2	9.5	8.3	610.1	1.6	698.4	75.6	154,350
Cruise	0.0	0.0	0.0	2.1	0.0	4.0	0.2	153
Dry Bulk	0.0	0.0	0.0	4.9	0.0	1.9	0.4	286
Liquid	0.0	0.0	0.0	0.6	0.0	1.2	0.1	73
Other	0.6	0.6	0.4	28.0	0.1	97.1	9.3	9,783
Total	**11.9**	**11.1**	**9.8**	**678.0**	**1.80**	**822.9**	**88.0**	**170,741**

DB ID237

Tables 5.6 present the emissions by cargo handling equipment type and engine type.

Table 5.6: CHE Emissions by Equipment and Engine Type

Equipment	Engine	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
Bulldozer	Diesel	0.0	0.0	0.0	0.2	0.0	0.1	0.0	40
Crane	Diesel	0.2	0.2	0.2	4.7	0.0	1.6	0.3	411
Excavator	Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Forklift	Diesel	0.3	0.3	0.3	15.3	0.0	12.1	1.1	2,811
Forklift	Gasoline	0.0	0.0	0.0	0.2	0.0	4.3	0.3	83
Forklift	Propane	0.3	0.3	0.0	18.5	0.0	96.2	4.8	2,929
Loader	Diesel	0.2	0.2	0.2	7.9	0.0	2.6	0.5	1,150
Man Lift	Diesel	0.0	0.0	0.0	0.9	0.0	0.6	0.1	90
Material handler	Diesel	0.4	0.4	0.4	9.8	0.0	3.7	0.8	1,734
Miscellaneous	Diesel	0.0	0.0	0.0	0.8	0.0	0.8	0.0	132
Rail Pusher	Diesel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
RTG Crane	Diesel	1.9	1.7	1.9	93.1	0.2	30.1	6.1	14,428
Side pick	Diesel	0.7	0.7	0.7	27.2	0.0	7.0	1.7	2,969
Skid Steer Loader	Diesel	0.0	0.0	0.0	0.2	0.0	0.1	0.0	22
Straddle Carrier	Diesel	0.0	0.0	0.0	4.7	0.0	3.5	0.4	1,790
Sweeper	Diesel	0.0	0.0	0.0	1.1	0.0	0.6	0.1	146
Sweeper	Gasoline	0.0	0.0	0.0	4.3	0.0	18.6	0.9	307
Top handler	Diesel	2.2	2.0	2.2	236.2	0.5	88.9	18.9	41,495
Truck	Diesel	0.3	0.2	0.3	7.2	0.0	3.7	0.5	1,725
Yard tractor	Diesel	3.6	3.3	3.6	161.1	1.0	171.8	11.7	79,274
Yard tractor	Gasoline	0.0	0.0	0.0	0.1	0.0	2.3	0.0	172
Yard tractor	LNG	0.0	0.0	0.0	1.1	0.0	0.1	3.6	745
Yard tractor	Propane	1.8	1.8	0.0	83.4	0.0	374.2	36.1	18,278
Total		**11.9**	**11.1**	**9.8**	**678.0**	**1.80**	**822.9**	**88.0**	**170,741**

DB ID237

SECTION 6 LOCOMOTIVES

This section presents emissions estimates for the railroad locomotives source category, including source description, geographical domain, data and information acquisition, operational profiles, the emissions estimation methodology, and the emissions estimates.

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)

BNSF and UP provide line haul service to and from the Port and also operate switching services at their off-port locations, while PHL performs most of the switching operations within the Port. 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. The locomotives used in switching service at the Port by PHL, and at the near-port railyard operated by UP, are primarily new, low-emitting locomotives specifically designed for switching duty.

Geographical Domain

The specific activities included in this emissions inventory are movements of cargo within port boundaries, and directly to or from port-owned properties such as terminals and on-port rail yards, within and to the boundary of the SoCAB. The inventory does not include rail movements of cargo that occur solely outside the port, such as off-port rail yard switching, and movements that neither begin or end at a port property, such as east-bound line hauls that initiate in central Los Angeles intermodal yards. Please refer to Section 1 for a description of the geographical domain of the emissions inventory with regard to locomotive operations.

Data and Information Acquisition

To estimate emissions associated with maritime industry-related activities of locomotives operating within the port and outside the port to the boundary of the SoCAB, information has been obtained from:

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

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 in the SoCAB. Upcoming international rules on the weighing of containers during shipment, currently slated for implementation in 2016,[14] will ultimately provide a more robust estimate of the average weight of containers shipped by rail. This will result in more accurate estimates of train weights, which form the basis of the line haul emission estimates.

Operational Profiles

The goods movement rail system in terms of the activities that are carried out by locomotive operators is the same as described in detail in Section 6 of the Port's 2013 EI report.

---

[14] For information see*: www.worldshipping.org/industry-issues/safety/cargo-weight* and *www.worldshipping.org/industry-issues/safety/SOLAS_CHAPTER_VI_Regulation_2_Paragraphs_4-6.pdf*

Improvements to Methodology

As a means of using locally-specific data to validate inventory methods, duty cycle information obtained for several switching locomotives used at the Port by PHL was compared with the default EPA average duty cycle. The comparison is depicted graphically in Figures 6.1 and 6.2, which illustrate the average percent of time in each throttle notch setting of the switching locomotives operating on the Port and of the locomotives tested by EPA. Figure 6.1 includes locomotive idling time, and shows that PHL's switchers have a similar pattern but idle somewhat more than the EPA average and have lower percentages of operating time in the throttle notch settings that are used when the locomotive is moving railcars. One reason for higher idling time might be the need to wait for passage of line haul locomotives, which have right-of-way priority on the tracks, in the busy port setting. Power demand is at its lowest level during idling, resulting in the lowest emission levels at these times.

Figure 6.1: Distribution of Time in Throttle Notch Setting including Idle, %

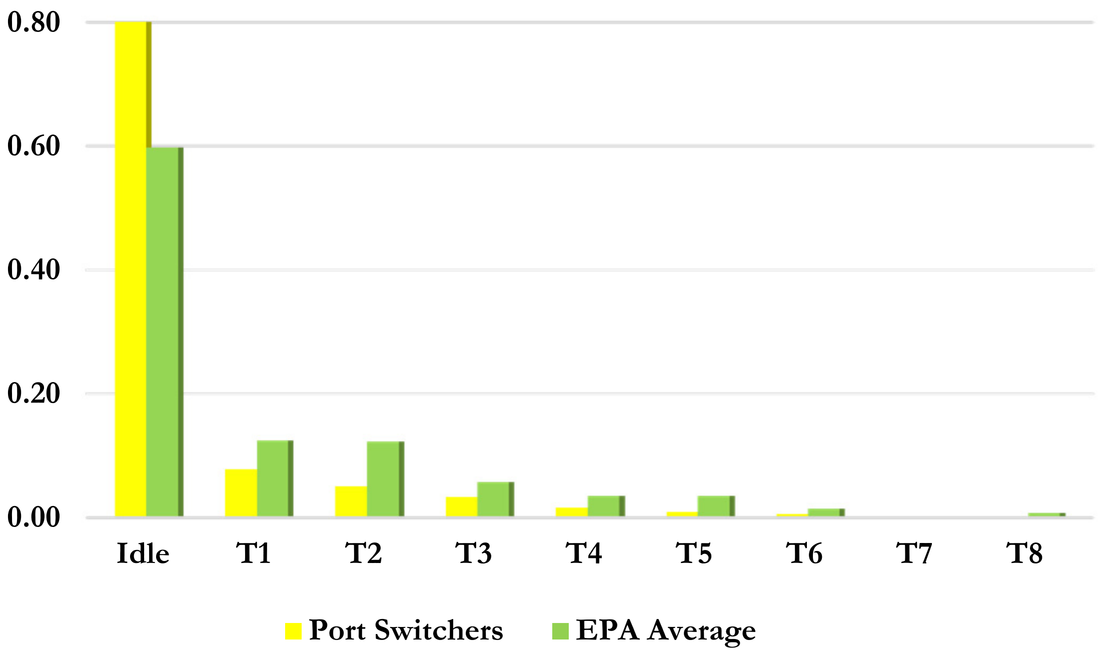
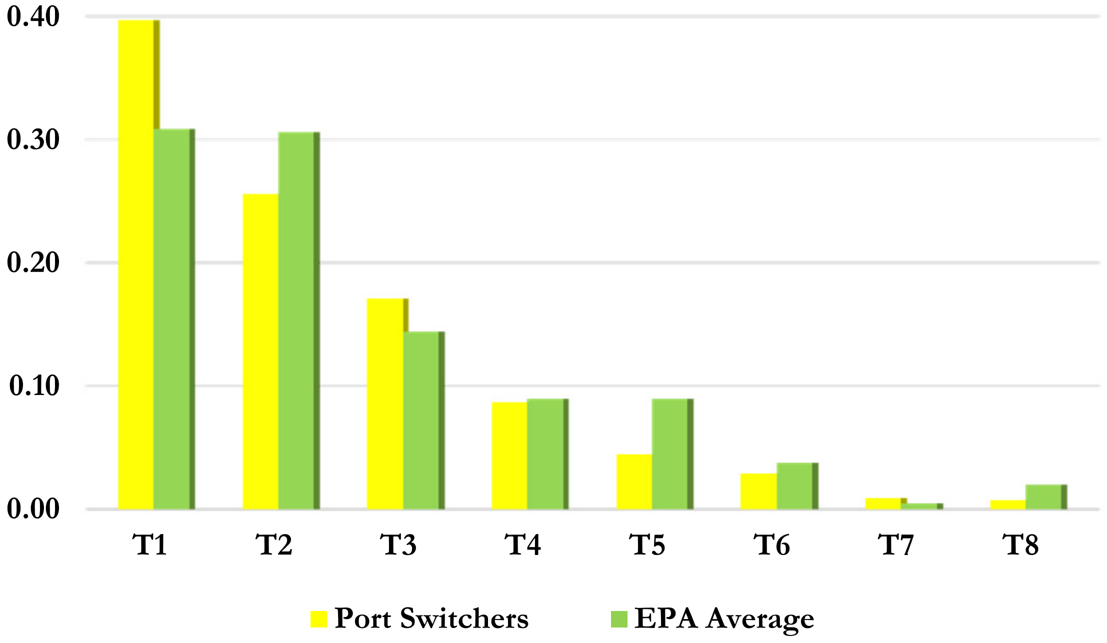


Figure 6.2 excludes idling time from the evaluation, showing that, while still similar in frequency distribution, the PHL switchers tend to spend comparatively more time in the first (lowest) notch setting than the EPA average and less time in notch position 2, as well as less time in most of the higher notch settings. Reasons for the lower operating percentages at higher notch settings may include speed being limited in the busy port setting, and the relatively flat terrain of the port area, requiring lower applications of power to make the required moves. Given the general similarity between the PHL duty cycle and the EPA average and the lack of readily available notch-specific emission factors for the types of locomotives employed by PHL, no changes to the emission factors have been made.

Figure 6.2: Distribution of Time in Throttle Notch Settings 1 through 9, %



Emissions Estimation Methodology

The emissions calculation methodology used to estimate locomotive emissions is consistent with the methodology described in detail in Section 6 of the Port's 2013 EI.[15] Below are tables that are specific to this 2014 EI.

---

[15] *http://www.portoflosangeles.org/environment/studies_reports.asp*

Table 6.1 presents the MOU compliance information submitted by both railroads and the composite of both railroads' pre-Tier 0 through Tier 3 locomotive NO_x emissions for calendar year 2013, showing a weighted average NO_x emission factor of 5.71 g/hphr.[16] The 2013 reports were used instead of the 2014 because of the timing of the inventory data collection phase and of the posting of the compliance reports by CARB. While the 2014 compliance reports were available before finalization of this EI report the standard practice of using the prior year compliance year was followed. Review of the 2014 compliance report showed an insignificant 0.3% difference in emission factors between the two years. The emission factors based on the 2014 compliance report will be used for the 2015 EI.

Table 6.1: MOU Compliance Data, MWhrs and g NO_x/hp-hr

Tier	Number of Locomotives	Megawatt-Hours (MWhrs)	%MWhrs by Tier Level	Wt'd Avg NO_x (g/bhp-hr)	Tier Contribution to Fleet Average (g/bhp-hr)
BNSF					
Pre-Tier 0	156	1,261	0.6%	11.2	0.06
Tier 0	363	10,332	5%	7.8	0.37
Tier 1	967	41,453	19%	7.4	1.41
Tier 2	1,118	133,351	61%	4.7	2.88
Tier 3	407	31,101	14%	4.6	0.66
ULEL	0	0	0%	-	-
Total BNSF	**3,011**	**217,498**	**100%**		**5.4**
UP					
Pre-Tier 0	44	394	0.2%	12.7	0.03
Tier 0	2,352	54,575	29%	7.7	2.22
Tier 1	1,533	26,022	14%	6.8	0.94
Tier 2	1,535	77,486	41%	5.1	2.09
Tier 3	426	20,792	11%	4.6	0.51
ULEL	71	9,918	5%	2.5	0.13
Total UP	**5,961**	**189,187**	**100%**		**5.9**
			ULEL Credit Used		0
			UP Fleet Average		**5.9**
Both RRs, excluding ULELs and ULEL credits					
Pre-Tier 0	200	1,655	0%	11.6	0.05
Tier 0	2,715	64,907	16%	7.7	1.26
Tier 1	2,500	67,475	17%	7.2	1.22
Tier 2	2,653	210,837	53%	4.8	2.58
Tier 3	833	51,893	13%	4.6	0.60
Total both	**8,901**	**396,767**	**100%**		**5.71**

---

[16] Notes from railroads' MOU compliance submissions:

1. For more information on the U.S. EPA locomotive emission standards please visit. *http://www.epa.gov/oms/locomotives.htm.*
2. Number of locomotives is the sum of all individual locomotives that visited or operated within the SoCAB at any time during 2013.

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[17] to develop weighted average emission factors using the MW-hr figures provided in the railroads' submissions. These results are presented in Table 6.2.

Table 6.2: Fleet MWhrs and PM, HC, CO Emission Factors, g/hp-hr

Engine Tier	MWhr	% of MWhr	EPA Tier-specific PM_{10}	EPA Tier-specific HC	EPA Tier-specific CO	Fleet Composite PM_{10}	Fleet Composite HC	Fleet Composite CO
			g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr
Pre-Tier 0	1,655	0%	0.32	0.48	1.28	0.00	0.00	0.01
Tier 0	64,907	16%	0.32	0.48	1.28	0.05	0.08	0.21
Tier 1	67,475	17%	0.32	0.47	1.28	0.05	0.08	0.22
Tier 2	210,837	53%	0.18	0.26	1.28	0.10	0.14	0.68
Tier 3	51,893	13%	0.08	0.13	1.28	0.01	0.02	0.17
Totals	**396,767**	**100%**				**0.21**	**0.32**	**1.28**

Table 6.3 summarizes the emission factors for line haul locomotives, presented in units of g/hp-hr. The greenhouse gas emission factors are unchanged from the 2013 EI.

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

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
EF, g/bhp-hr	0.21	0.19	0.21	5.71	0.005	1.28	0.32	494	0.013	0.040

---

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

On-Port Line Haul Emissions

The number of trains per year, locomotives per train, and on-port hours per train are multiplied together to calculate total locomotive hours per year. This activity information is summarized in Table 6.4.

Table 6.4: 2014 Estimated On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Total
Trains per Year	3,006	2,900	5,906
Locomotives per Train	3	3	N/A
Hours on Port per Trip	1	2.5	N/A
Locomotive Hours per Year	9,018	21,750	30,768

Out-of-Port Line Haul Emissions

For out-of-port line haul estimates, the following table has updated values for the 2014 EI. Table 6.5 lists the estimated total of out-of-port horsepower-hours, calculated by multiplying the fuel use by the fuel consumption conversion factor of 20.8 hp-hr/gal.

Table 6.5: 2014 Gross Ton-Mile, Fuel Use, and Horsepower-hour Estimate

	Distance miles	Trains /year	MMGT per year	MMGT-miles per year
Alameda Corridor	21	5,506	40	840
Central LA to Air Basin Boundary	84	5,506	40	3,360
Million gross ton-miles				**4,200**
Estimated gallons of fuel (millions)				**4.17**
Estimated million horsepower-hours				**86.7**

Emission Estimates

A summary of estimated emissions from locomotive operations related to the Port is presented below in Table 6.1. These emissions include operations within the port and maritime industry-related emissions outside the port out to the boundary of the SoCAB. The "maritime industry-related" off-port activity is associated with cargo movements having either their origin or termination at the port. Emissions resulting from the movement of cargo originating or terminating at one of the off-port rail yards are not included. 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 6.6: Locomotive Operations Estimated Emissions

	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
Switching	0.5	0.5	0.5	55	0.07	22.7	2.6	7,756
Line Haul	28.1	25.4	28.1	764	0.67	171.3	42.8	60,561
Total	**28.6**	**25.9**	**28.6**	**819**	**0.74**	**194.0**	**45.4**	**68,317**

DB ID696

SECTION 7 HEAVY-DUTY VEHICLES

This section presents emissions estimates for the HDV source category, including source description, geographical domain, data and information acquisition, operational profiles, the emissions estimation methodology, and the emissions estimates.

Source Description

Heavy-duty vehicles (specifically heavy-duty 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 drayage. 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 8.2% of the terminal calls in 2014, 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 chassis, 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.

Geographical Domain

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 also includes travel on public roads within the Port boundaries and those of the adjacent POLB.

Data and Information Acquisition

The procedure to collect drayage truck related activity data is the same as described in Section 7 of the Port's 2013 EI report.

Operational Profiles

Operational profiles were developed for on-terminal truck activity using data and information collected from terminal operators. The on-road truck activity profiles were developed using trip generation and travel demand models to estimate the number of on-road vehicle miles traveled (VMT).

Table 7.1 illustrates the range and average of reported container terminal operating characteristics of on-terminal truck activities at port container terminals, while Table 7.2 shows similar summary data for the non-container terminals and facilities. The total numbers of terminal calls in 2014 were 3,609,063 associated with the port's container terminals and 1,276,417 associated with the non-container facilities. The total number of container terminal calls is based on the trip generation model on which truck travel estimates are based, while non-container terminal calls were obtained from the terminal operators.

Table 7.1: 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	0.40	0.00
Average	12.5	1.3	0.12	0.57	0.04

Table 7.2: 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 7.3 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.

Table 7.3: Estimated On-Terminal VMT and Idling Hours by Terminal

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	1,531,941	1,092,785
Container	1,022,531	456,730
Container	826,268	286,439
Container	763,491	458,095
Container	479,382	362,200
Container	313,596	166,206
Auto	1,463	995
Break Bulk	20,094	4,521
Break Bulk	18,530	11,859
Dry Bulk	2,600	832
Dry Bulk	1,250	375
Liquid Bulk	3,250	390
Liquid Bulk	18	0
Other	680,554	306,249
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	**6,205,625**	**3,226,153**

Emissions Estimation Methodology

The general emissions estimating methodology for the Port's on-road truck fleet is the same as described in section 7.0 of the Port's 2013 EI report. Differences are discussed below.

The major change underlying the emission calculations in this inventory compared to the previous EI was a change in emission factor model as released by CARB. EMFAC2014, which replaced the previously used EMFAC2011, "represents ARB's current understanding of motor vehicle travel activities and their associated emission levels."[18] Because the new model version contains numerous changes based on CARB's latest information, previous years' emissions have been re-estimated using the EMFAC2014 emission factors for each previous calendar year. Refer to Section 9 for a comparison of 2014 emissions with previous years' emissions.

Table 7.4 summarizes the speed-specific emission factors used to estimate emissions.

Table 7.4: 2014 Speed-Specific Composite Exhaust Emission Factors

Speed Range (mph)	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4	Units
0 (Idle)	0.0113	0.0108	0.0104	39.444	0.0484	3.3618	1.2028	5,167	0.1662	0.0707	g/hr
5	0.0781	0.0747	0.0719	19.414	0.0176	5.028	1.3979	3,548	0.0631	0.1108	g/mi
10	0.07	0.067	0.0644	16.58	0.0176	4.0706	1.1279	3,163	0.0631	0.0894	g/mi
15	0.0595	0.0569	0.0547	12.989	0.0176	2.8562	0.7829	2,674	0.0631	0.0621	g/mi
20	0.0524	0.0501	0.0482	10.627	0.0176	2.0595	0.5589	2,350	0.0631	0.0443	g/mi
25	0.0475	0.0455	0.0437	9.42	0.0176	1.5144	0.4099	2,140	0.0631	0.0325	g/mi
30	0.0438	0.0419	0.0403	8.7245	0.0176	1.1234	0.3033	1,994	0.0631	0.024	g/mi
35	0.0408	0.039	0.0375	8.204	0.0176	0.8352	0.2246	1,879	0.0631	0.0178	g/mi
40	0.0384	0.0367	0.0353	7.7953	0.0176	0.6231	0.1665	1,787	0.0631	0.0132	g/mi
45	0.0364	0.0348	0.0335	7.4614	0.0176	0.4672	0.1236	1,710	0.0631	0.0098	g/mi
50	0.0348	0.0333	0.032	7.1837	0.0176	0.353	0.0921	1,644	0.0631	0.0073	g/mi
55	0.0336	0.0321	0.0309	6.952	0.0176	0.2697	0.069	1,588	0.0631	0.0055	g/mi
60	0.0331	0.0316	0.0304	6.8518	0.0176	0.2371	0.0599	1,562	0.0631	0.0047	g/mi
65	0.0331	0.0316	0.0304	6.8811	0.0176	0.2371	0.0599	1,562	0.0631	0.0047	g/mi
70	0.0331	0.0316	0.0304	6.893	0.0176	0.2371	0.0599	1,562	0.0631	0.0047	g/mi

---

[18] *www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-v1_0_7-release-notice.pdf*

Along with the release of EMFAC2014, CARB published information on short-term emissions from model-year 2010 and newer trucks equipped with selective catalytic converters (SCR) when they start up from cold or after not running for more than approximately 30 minutes. When started under these cold-start and warm-start conditions, HDVs equipped with SCR emit higher-than-normal amounts of NO_x until the catalyst in the converter reaches optimum operating temperature. Not all 2010+ trucks are equipped with SCR; many have an exhaust gas recirculation (EGR) system which does not cause start emissions. Because the prevalence of EGR-equipped trucks decreases with each new model year, CARB has developed average emission factors for each model year of truck starting with 2010 which have been used to estimate start emissions for the HDVs in this EI and in the comparison years in which 2010 or newer trucks called at Port terminals (i.e., calendar years 2009 and later). The start emissions contribute a very small amount of NO_x, approximately 1.8% of overall HDV NO_x emissions in the 2014 EI.

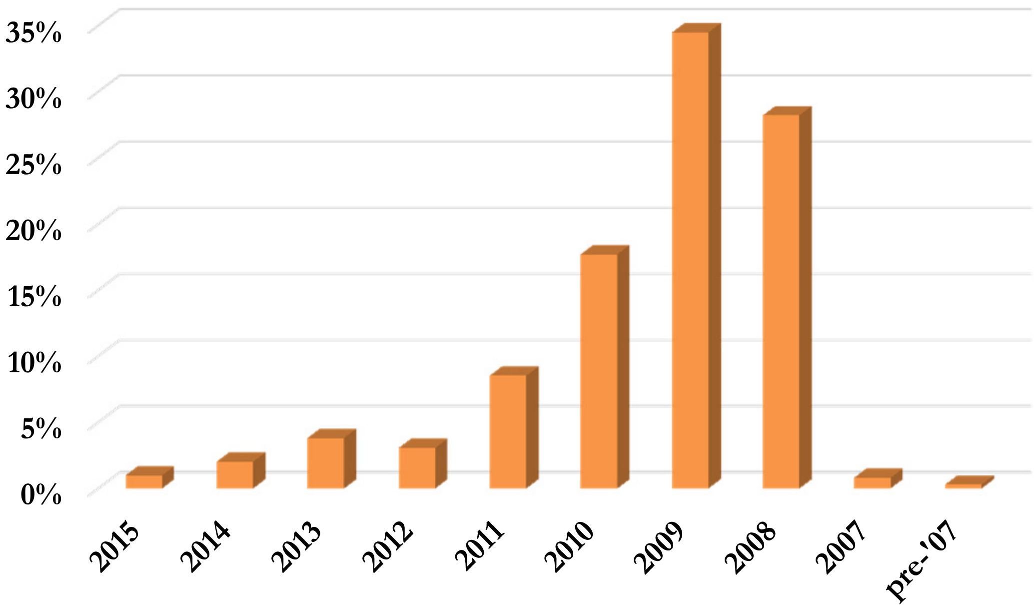
A further change resulting from the use of EMFAC2014 and the estimation of start emissions for 2010 and newer model year trucks is the return to body model year as the basis of analysis as opposed to engine model year, which had been used for the past few EIs as a means of accounting for trucks that were equipped with engines one or more model years older than their body model year. With EMFAC2014 and the start emission factors for 2010+ model year trucks, CARB has accounted for the differences between body model year and engine model year such that body model year is the appropriate characteristic to match against CARB's model year-specific emission factors. The 2014 and previous-year estimates presented in this EI are based on body model year distributions.

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. The 2014 model year distribution for the current emissions inventory is based on call data originating from radio frequency identification (RFID) data, which tracked over 5.6 million truck calls made to the Port of Los Angeles and the Port of Long Beach in 2014, as well as model year data drawn from the Port Drayage Truck Registry (PDTR). The PDTR contains model year information on all registered drayage trucks serving the Port and the fuel type used by each truck, from which an adjustment factor was developed for non-diesel fueled vehicles. The RFID data provided the number of calls made by each model year of truck.

The distribution of the truck fleet's model years by calls, which was used to develop the composite emission factors listed above, is presented in Figure 7.1. The call weighted average age of the trucks calling at San Pedro Bay port terminals in 2014 was approximately 5 years, older than the 4-year average in 2013 because there was very little turnover in the almost-new fleet.

Figure 7.1: Model Year Distribution of the Heavy-Duty Truck Fleet



Emission Estimates

The estimates of 2014 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 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 7.5 summarizes emissions from HDVs associated with all port terminals.

Table 7.5: HDV Emissions

Activity Location	VMT	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
On-Terminal	6,205,625	0.5	0.5	0.4	239.6	0.3	35.0	10.6	34,853
On-Road	191,070,574	7.5	7.2	6.9	1,571.2	3.7	85.8	22.6	323,309
Total	**197,276,199**	**8.0**	**7.6**	**7.3**	**1,810.9**	**4.0**	**120.9**	**33.2**	**358,162**

Table 7.6 presents HDV emissions associated with container terminal activity separately from emissions associated with other port terminals and facilities.

Table 7.6: HDV Emissions Associated with Container Terminals

Activity Location	VMT	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
On-Terminal	4,937,208	0.4	0.4	0.4	201.6	0.2	28.8	8.8	29,044
On-Road	175,856,465	6.9	6.6	6.3	1,444.4	3.4	79.2	20.8	297,671
Total	**180,793,673**	**7.3**	**7.0**	**6.7**	**1,646.0**	**3.7**	**108.0**	**29.6**	**326,715**

Table 7.7 presents emissions associated with other port terminals and facilities separately.

Table 7.7: HDV Emissions Associated with Other Port Terminals

Activity Location	VMT	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
On-Terminal	1,268,417	0.1	0.1	0.1	38.0	0.0	6.3	1.9	5,810
On-Road	15,214,109	0.6	0.6	0.5	126.8	0.3	6.6	1.7	25,637
Total	**16,482,526**	**0.7**	**0.7**	**0.6**	**164.9**	**0.3**	**12.9**	**3.6**	**31,447**

SECTION 8 SUMMARY OF 2014 EMISSION RESULTS

Table 8.1 summarizes the 2014 total maritime industry-related emissions associated with the Port of Los Angeles 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.

Table 8.1: Emissions by Source Category

Category	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
Ocean-going vessels	71.5	66.5	59.1	3,607	120.5	334	164.9	214,950
Harbor craft	29.6	27.3	29.6	802	0.6	446	75.1	55,892
Cargo handling equipment	11.9	11.1	9.8	678	1.8	823	88.0	170,741
Locomotives	28.6	25.9	28.6	819	0.7	194	45.4	68,317
Heavy-duty vehicles	8.0	7.6	7.3	1,811	4.0	121	33.2	358,162
Total	**149.6**	**138.4**	**134.5**	**7,717**	**127.6**	**1,918**	**406.6**	**868,062**

DB ID457

Table 8.2: DPM Emissions by Category and Percent Contribution

Category	Subcategory	DPM Emissions	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
OGV	Auto carrier	0.7	1%	1%	0.0%
OGV	Bulk vessel	1.7	3%	1%	0.1%
OGV	Containership	40.3	68%	30%	1.4%
OGV	Cruise	7.3	12%	5%	0.3%
OGV	General cargo	2.6	4%	2%	0.1%
OGV	Ocean tugboat	0.2	0%	0%	0.0%
OGV	Miscellaneous	0.0	0%	0%	0.0%
OGV	Reefer	0.4	1%	0%	0.0%
OGV	Tanker	5.8	10%	4%	0.2%
OGV	**Subtotal**	**59**	**100%**	**44%**	**2.0%**
Harbor Craft	Assist tug	8.7	29%	6%	0.3%
Harbor Craft	Harbor tug	0.6	2%	0%	0.0%
Harbor Craft	Commercial fishing	2.5	9%	2%	0.1%
Harbor Craft	Ferry	4.2	14%	3%	0.1%
Harbor Craft	Ocean tugboat	5.6	19%	4%	0.2%
Harbor Craft	Government	1.1	4%	1%	0.0%
Harbor Craft	Excursion	3.5	12%	3%	0.1%
Harbor Craft	Crewboat	2.3	8%	2%	0.1%
Harbor Craft	Work boat	1.0	3%	1%	0.0%
Harbor Craft	**Subtotal**	**30**	**100%**	**22%**	**1.0%**
CHE	RTG crane	1.9	19%	1%	0.1%
CHE	Forklift	0.3	3%	0%	0.0%
CHE	Top handler, side pick	2.9	29%	2%	0.1%
CHE	Other	1.2	12%	1%	0.0%
CHE	Yard tractor	3.6	37%	3%	0.1%
CHE	**Subtotal**	**10**	**100%**	**7%**	**0.3%**
Locomotives	Switching	0.5	2%	0%	0.0%
Locomotives	Line haul	28	98%	21%	1.0%
Locomotives	**Subtotal**	**29**	**100%**	**21%**	**1.0%**
HDV	On-Terminal	0.4	6%	0%	0.0%
HDV	On-Road	7	94%	5%	0.2%
HDV	**Subtotal**	**7**	**100%**	**5%**	**0.3%**
Port	**Total**	**134**		**100%**	**4.6%**
SoCAB AQMP	**Total**	**2,916**			

Table 8.3: 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	46	1%	1%	0.0%
OGV	Bulk vessel	101	3%	1%	0.1%
OGV	Containership	2,571	71%	33%	1.4%
OGV	Cruise	362	10%	5%	0.2%
OGV	General cargo	137	4%	2%	0.1%
OGV	Ocean tugboat	7	0%	0%	0.0%
OGV	Miscellaneous	0	0%	0%	0.0%
OGV	Reefer	24	1%	0%	0.0%
OGV	Tanker	360	10%	5%	0.2%
OGV	**Subtotal**	**3,607**	**100%**	**47%**	**2.0%**
Harbor Craft	Assist tug	235	29%	3.0%	0.1%
Harbor Craft	Harbor tug	21	3%	0.3%	0.0%
Harbor Craft	Commercial fishing	56	7%	0.7%	0.0%
Harbor Craft	Ferry	120	15%	1.6%	0.1%
Harbor Craft	Ocean tugboat	160	20%	2.1%	0.1%
Harbor Craft	Government	26	3%	0.3%	0.0%
Harbor Craft	Excursion	85	11%	1.1%	0.0%
Harbor Craft	Crewboat	66	8%	0.9%	0.0%
Harbor Craft	Work boat	34	4%	0.4%	0.0%
Harbor Craft	**Subtotal**	**802**	**100%**	**10%**	**0.4%**
CHE	RTG crane	93	14%	1.2%	0.1%
CHE	Forklift	34	5%	0.4%	0.0%
CHE	Top handler, side pick	263	39%	3.4%	0.1%
CHE	Other	42	6%	0.5%	0.0%
CHE	Yard tractor	246	36%	3.2%	0.1%
CHE	**Subtotal**	**678**	**100%**	**9%**	**0.4%**
Locomotives	Switching	55	7%	0.7%	0.0%
Locomotives	Line haul	764	93%	9.9%	0.4%
Locomotives	**Subtotal**	**819**	**100%**	**11%**	**0.4%**
HDV	On-Terminal	240	13%	3%	0.1%
HDV	On-Road	1,571	87%	20%	0.9%
HDV	**Subtotal**	**1,811**	**100%**	**23%**	**1.0%**
Port	**Total**	**7,717**		**100%**	**4.2%**
SoCAB AQMP	**Total**	**184,770**			

Table 8.4: 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	1.6	1%	1%	0%
OGV	Bulk vessel	4.2	3%	3%	0%
OGV	Containership	72.2	60%	57%	1%
OGV	Cruise	13.5	11%	11%	0%
OGV	General cargo	4.3	4%	3%	0%
OGV	Ocean tugboat	0.3	0%	0%	0%
OGV	Miscellaneous	0.0	0%	0%	0%
OGV	Reefer	0.9	1%	1%	0%
OGV	Tanker	23.5	19%	18%	0%
OGV	**Subtotal**	**120**	**100%**	**94%**	**2%**
Harbor Craft	Assist tug	0.2	28%	0%	0%
Harbor Craft	Harbor tug	0.0	3%	0%	0%
Harbor Craft	Commercial fishing	0.0	6%	0%	0%
Harbor Craft	Ferry	0.1	18%	0%	0%
Harbor Craft	Ocean tugboat	0.1	19%	0%	0%
Harbor Craft	Government	0.0	3%	0%	0%
Harbor Craft	Excursion	0.1	9%	0%	0%
Harbor Craft	Crewboat	0.1	10%	0%	0%
Harbor Craft	Work boat	0.0	3%	0%	0%
Harbor Craft	**Subtotal**	**0.6**	**100%**	**0%**	**0%**
CHE	RTG crane	0.2	9%	0%	0%
CHE	Forklift	0.0	2%	0%	0%
CHE	Top handler, side pick	0.5	28%	0%	0%
CHE	Other	0.1	5%	0%	0%
CHE	Yard tractor	1.0	56%	1%	0%
CHE	**Subtotal**	**1.8**	**100%**	**1%**	**0%**
Locomotives	Switching	0.1	13%	0%	0%
Locomotives	Line haul	0.7	88%	1%	0%
Locomotives	**Subtotal**	**0.8**	**100%**	**1%**	**0%**
HDV	On-Terminal	0.3	7%	0%	0%
HDV	On-Road	3.7	93%	3%	0%
HDV	**Subtotal**	**4.0**	**100%**	**3%**	**0%**
Port	**Total**	**128**		**100%**	**1.9%**
SoCAB AQMP	**Total**	**6,716**			

In order to put the maritime industry-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 2014 SoCAB emissions are based on the 2012 AQMP Appendix III.[19] Due to rounding, the percentages may not total 100%.

Figure 8.1: PM_{10} Emissions in the South Coast Air Basin

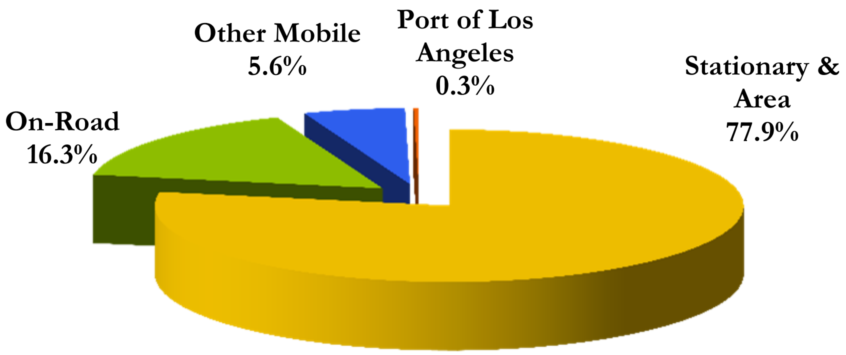
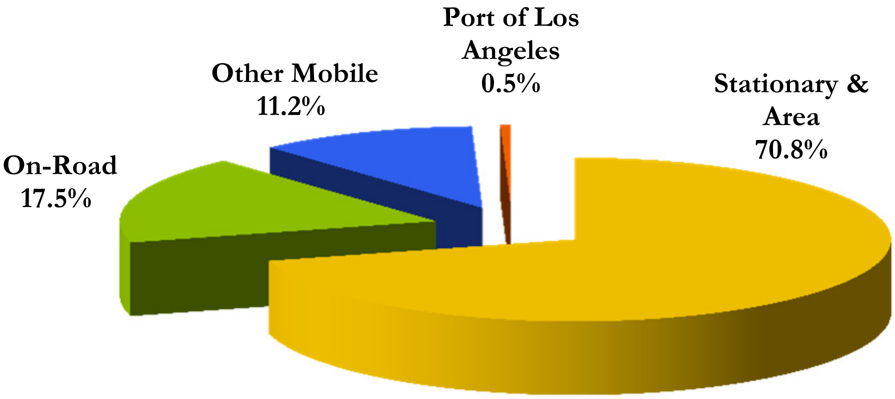


Figure 8.2: $PM_{2.5}$ Emissions in the South Coast Air Basin



---

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

Figure 8.3: DPM Emissions in the South Coast Air Basin

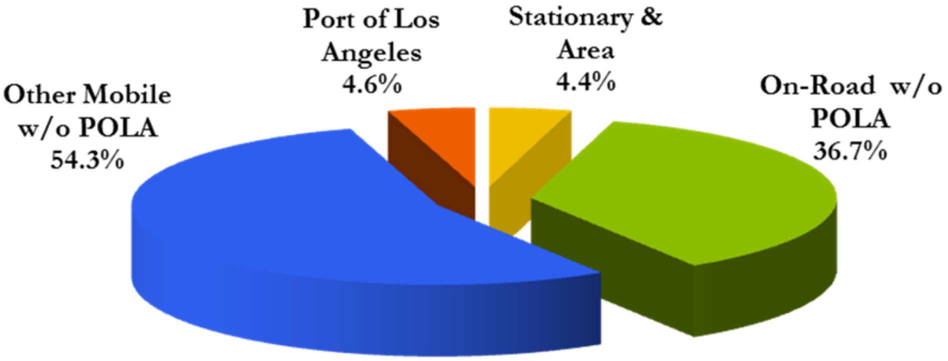


Figure 8.4: NO_x Emissions in the South Coast Air Basin

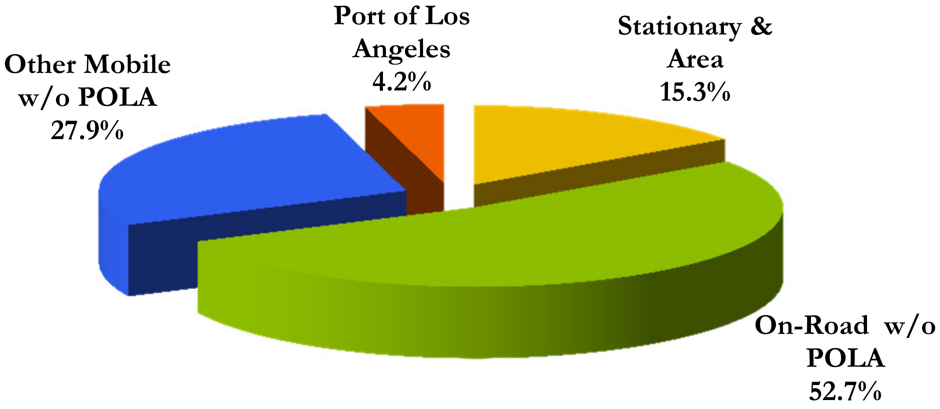


Figure 8.5: SO_x Emissions in the South Coast Air Basin

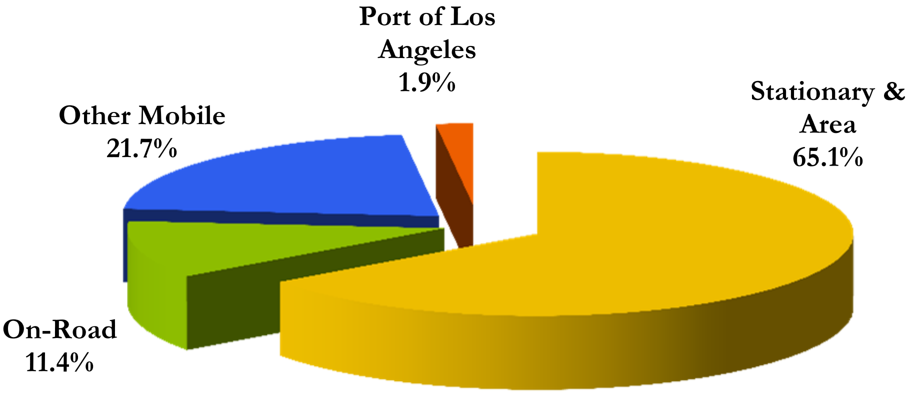
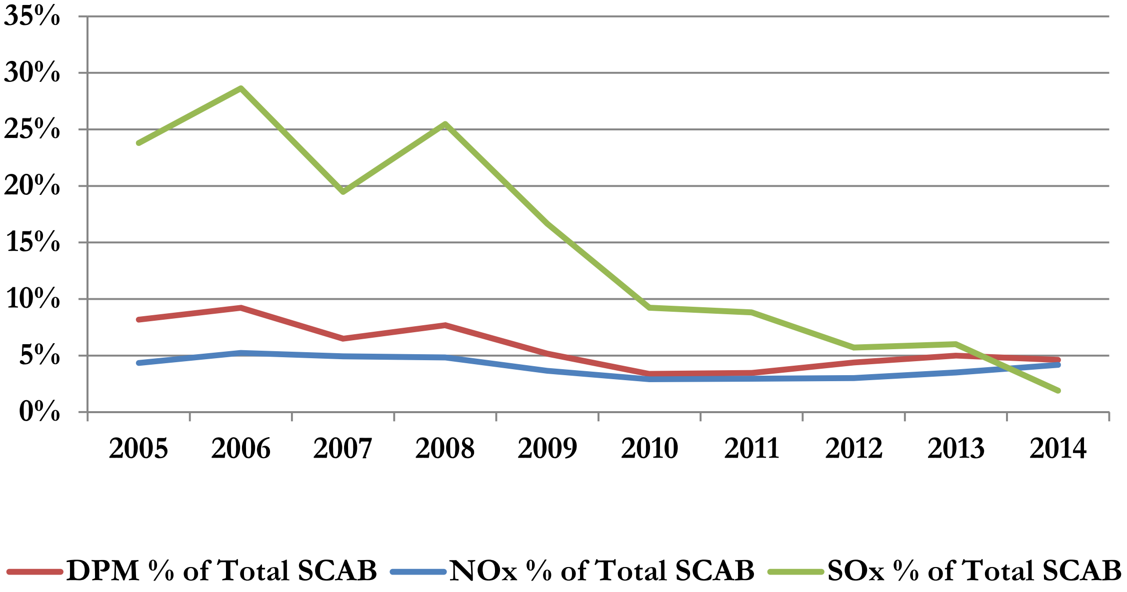


Figure 8.6 presents a comparison of the maritime industry-related mobile source emissions associated with the Port to the total SoCAB emissions from 2005 to 2014.

Figure 8.6: Emissions Contribution in the South Coast Air Basin



SECTION 9 COMPARISON OF 2014 AND PREVIOUS YEARS' FINDINGS AND EMISSION ESTIMATES

This section compares 2014 emissions to those in the previous year and in 2005, in terms of overall emissions, and for each source category. Comparisons by emission source categories are addressed in separate subsections in table and chart formats, with the explanation of the findings and differences in emissions.

The tables and charts in this section also summarize the percent change from the previous year (2014 vs 2013) and for the CAAP Progress (2014 vs 2005) using 2014 methodology for emissions comparison. CAAP progress is tracked by comparing emissions each year to 2005 emissions, because 2005 is considered the baseline year for CAAP.

Table 9.1 compares emissions efficiency in 2014 as compared to 2005 and 2013. A positive percent change for the emissions efficiency comparison means an improvement in efficiency.

Table 9.1: Emissions Efficiency Metric, tons/10,000 TEUs

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2014	0.18	0.17	0.16	9.25	0.15	2.30	0.49	1,041
2013	0.22	0.20	0.20	9.30	0.67	2.16	0.49	981
2005	1.28	1.11	1.18	21.59	6.61	5.04	1.14	1,375
Previous Year (2013-2014)	**18%**	**15%**	**20%**	**1%**	**78%**	**-6%**	**0%**	**-6%**
CAAP Progress (2005-2014)	**86%**	**85%**	**86%**	**57%**	**98%**	**54%**	**57%**	**24%**

Ocean-Going Vessels

There were improvements and changes to the ocean-going vessels emission calculation methodology in this inventory compared to the 2013 methodology. The improvements implemented in OGV emission calculation methodology for the 2014 emissions inventory are discussed in section 3 of this report. The enhanced 2014 Vessel Boarding Program data relating to conventional (non-diesel electric tankers) was used to update the previous years' auxiliary boiler loads at-berth.

The various emission reduction strategies implemented for ocean-going vessels are listed in Table 9.2. The table lists the percentage of calls that participated in the strategy each year from 2005 through 2014. The following OGV 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;
- 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

Table 9.2: OGV Emission Reduction Strategies

Year	Shore Power	VSR 20 nm	VSR 40 nm	ESI	EIAPP Main Eng	EIAPP Aux Eng	IMO Tier I	IMO Tier II
2014	35%	95%	84%	53%	56%	54%	83%	12%
2013	7%	97%	83%	45%	45%	44%	78%	3%
2005	2%	65%	na	0%	0%	0%	34%	0%

DB ID1731

Fuel switching from HFO fuel to low sulfur content MGO/MDO fuel is also a major emission reduction strategy for OGV. In 2005, fuel switching was voluntary and only 7% of main engines and 27% of auxiliary engines switched fuel. In 2014, all vessels switched fuel (100%) to 0.1% sulfur content MGO to comply with Phase II of CARB's marine fuel regulation.

Table 9.3 presents the engine activity in terms of total kW-hrs. In 2014, the total engine activity increased by 7% compared to the previous year and decreased by 24% compared to 2005. The increase in activity as compared to the previous year is due to the temporary period of increased congestion in the latter part of 2014 which caused vessels to wait at berth or anchorage for longer periods of time than normal.

Table 9.3: 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
2014	288,414,192	78,920,946	127,971,227	81,522,019
2013	270,785,116	76,619,803	132,802,980	61,362,333
2005	381,330,780	112,023,146	188,086,884	81,220,750
Previous Year (2014-2013)	**7%**	**3%**	**-4%**	**33%**
CAAP Progress (2014-2005)	**-24%**	**-30%**	**-32%**	**0.4%**

Table 9.4 compares the OGV emissions for calendar years 2014, the previous year and 2005. Reductions in OGV emissions are mainly attributed to the CARB shore power regulation (all pollutants), CARB marine fuel regulation (PM, NO_x and SO_x), the Port's VSR program (all pollutants), and continuous transition to larger vessels, which results in fewer vessel calls for a given cargo throughput.

Table 9.4: OGV Emissions Comparison

EI Year	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
2014	71	66	59	3,607	120	334	165	214,950
2013	97	90	83	3,528	524	365	182	191,255
2005	546	439	471	5,248	4,789	485	219	286,438
Previous Year (2013-2014)	**-27%**	**-26%**	**-29%**	**2%**	**-77%**	**-8%**	**-9%**	**12%**
CAAP Progress (2005-2014)	**-87%**	**-85%**	**-87%**	**-31%**	**-97%**	**-31%**	**-25%**	**-25%**

Key observations from the table above:

1. From 2013 to 2014, there was a net increase in OGV emissions of 79 tons of NO_x (2% increase) and an increase of 23,965 metric tons of CO_2e (12% increase).
2. While CO_2e increased by 12%, NO_x only increased by 2%; this is primarily due to the offsetting nature of shore power vs. activity increases, reductions due to ESI NO_x, and changes in tier distribution.

The OGV emissions are dominated by containerships, tankers, and then cruise ships. The total calls, as well as the calls for containerships, tankers, and cruise ships are provided in Table 9.5. Note that total calls and containership calls are lower (while TEUs grew by 6%) and tankers and cruise calls increased.

Table 9.5: Containership, Tanker and Cruise Ship Calls Comparison

	Year	Arrival	Change
Total Calls	2014	1,962	-3%
	2013	2,033	
Container Calls	2014	1,394	-5%
	2013	1,463	
Tanker Calls	2014	176	18%
	2013	149	
Cruise Calls	2014	122	23%
	2013	99	

Key drivers for NO_x and CO_2e emissions increase between 2013 and 2014 are:

1. Increases in containership emissions are driven solely by the increase in anchorage emissions.
    a. Container anchorage emissions increased 1,351% for both NO_x (166 tons) and CO_2e (13,354 mt) from 2013 to 2014. This was due to the temporary period of increased congestion during the latter half of 2014.
2. Increases in tanker emissions were driven by increased activity in 2014.
    a. Tanker at-berth emissions increased by 33% for NO_x (33 tons) and 20% for CO_2e (3,255 mt) from 2013 to 2014.
    b. Tanker anchorage emissions increased by 25% for NO_x (23 tons) and 20% for CO_2e (1,550 mt) from 2013 to 2014.
    c. Tanker transit emissions increased by 17% for NO_x (15 tons) and 13% for CO_2e (419 mt) from 2013 to 2014.
    d. Total tanker emissions increased by 23% for NO_x (68 tons) and 18% for CO_2e (5,126 mt) from 2013 to 2014.
3. Increases in cruise emissions were driven by increased activity in 2014.
    a. Cruise at-berth emissions increased by 35% for NO_x (30 tons) and 55% for CO_2e (2,353 mt) from 2013 to 2014.
    b. Cruise transit emissions increased by 27% for NO_x (45 tons) and 31% for CO_2e (2,447 mt) from 2013 to 2014.
    c. Total cruise emissions increased by 30% for NO_x (84 tons) and 39% for CO_2e (5,341 mt) from 2013 to 2014.

Table 9.6 shows the emissions efficiency changes between 2013 and 2014 and between 2005 and 2014. A positive percent change for the emissions efficiency comparison means an improvement in efficiency.

Table 9.6: OGV Emissions Efficiency Metric Comparison, tons/10,000 TEUs

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2014	0.09	0.08	0.07	4.33	0.14	0.40	0.20
2013	0.12	0.11	0.11	4.48	0.67	0.46	0.23
2005	0.73	0.59	0.63	7.02	6.40	0.65	0.29
Previous Year (2013-2014)	**25%**	**27%**	**36%**	**3%**	**79%**	**13%**	**13%**
CAAP Progress (2005-2014)	**88%**	**81%**	**83%**	**36%**	**90%**	**29%**	**21%**

Harbor Craft

The methodology used to estimate harbor craft emissions for this 2014 Inventory did not change from the methodology used in the previous year inventory.

Table 9.7 summarizes the number of harbor craft inventoried for 2005, 2013 and 2014. Overall, the total vessel count decreased by 1% from 2013 to 2014 and decreased by 20% between 2005 and 2014.

Table 9.7: Harbor Craft Count Comparison

Harbor Vessel Type	2014	2013	2005
Assist tug	14	14	16
Commercial fishing	115	110	156
Crew boat	22	22	14
Excursion	26	29	24
Ferry	8	10	9
Government	14	16	26
Ocean tug	7	7	7
Tugboat	15	15	19
Work boat	8	8	14
Total	**229**	**231**	**285**

DB ID196

Table 9.8 summarizes the percent distribution of engines based on EPA's engine standards. As expected, the percentage of 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.

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[20]. 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 9.8: Harbor Craft Engine Standards Comparison by Tier

Year	Tier 0	Tier 1	Tier 2	Tier 3	Unknown
2014	9%	14%	35%	15%	27%
2013	9%	13%	36%	13%	29%
2005	15%	33%	3%	0%	49%

DB ID1631

Table 9.9 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), which increased by 17% in 2014 compared to the previous year and decreased by 2% compared to 2005.

Table 9.9: Harbor Craft Comparison

Year	Vessel Count	Engine Count	Total kW-hrs
2014	229	553	84,543,960
2013	231	558	72,287,694
2005	285	578	86,105,024
Previous Year (2013-2014)	**-1%**	**-1%**	**17%**
CAAP Progress (2005-2014)	**-20%**	**-4%**	**-2%**

---

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

Table 9.10 shows the harbor craft activity comparison by vessel type for calendar years 2014, the previous year, and 2005. Between 2013 and 2014, the overall increase is due to increases in activity for assist tugs, crew boats, ocean tugs, tugboats and work boats vessels. Compared to 2005, activity levels of commercial fishing and tugboat decreased significantly in 2014.

Table 9.10: Harbor Craft Activity Comparison by Type, million kW-hr

Vessel Type	2014	2013	2005
Assist Tug	23.5	18.5	25.2
Commercial Fishing	4.7	4.7	14.1
Crew boat	8.2	5.5	2.4
Excursion	7.7	9.8	11.5
Ferry	14.9	15.1	13.1
Government	2.5	2.2	3.0
Ocean Tug	15.6	12.2	3.1
Tugboat	2.8	1.7	11.4
Work boat	4.5	2.8	1.6
Total	**84.4**	**72.5**	**85.4**

Table 9.11 shows the emissions comparisons for calendar 2014, the previous year, and 2005 for harbor craft. In 2014, emissions for all pollutants increased as compared to the previous year. The increase is due to fewer turnovers in the vessel fleet and increased activity in 2014.

Table 9.11: Harbor Craft Emission Comparison

Year	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
2014	30	27	30	802	0.6	446	75	55,892
2013	26	24	26	704	0.5	370	64	47,790
2005	55	51	55	1,318	6.3	364	87	56,925
Previous Year (2013-2014)	**12%**	**12%**	**12%**	**14%**	**17%**	**20%**	**18%**	**17%**
CAAP Progress (2005-2014)	**-47%**	**-47%**	**-47%**	**-39%**	**-90%**	**22%**	**-14%**	**-2%**

DB ID427

Compared to 2005, emissions decreased except for CO. 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 the 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 2014, 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 9.12 shows the emissions efficiency changes in 2014 from 2005 and 2013. 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 9.12: Harbor Craft Emissions Efficiency Metric Comparison, tons/10,000 TEUs

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2014	0.04	0.03	0.04	0.96	0.00	0.53	0.09	67
2013	0.03	0.03	0.03	0.89	0.00	0.47	0.08	61
2005	0.07	0.07	0.07	1.76	0.01	0.49	0.12	76
Previous Year (2013-2014)	**-6%**	**-7%**	**-6%**	**-8%**	**0%**	**-13%**	**-11%**	**-10%**
CAAP Progress (2005-2014)	**51%**	**52%**	**51%**	**45%**	**88%**	**-10%**	**23%**	**12%**

Cargo Handling Equipment

The methodology used to estimate CHE emissions for the 2014 Inventory of Air Emissions did not change from the methodology used in the previous year inventory, except for the use of updated emission rates for gasoline and LNG engines.

Table 9.13 shows that while the number of units of cargo handling equipment remained almost the same, there was a 24% increase 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 2014 as compared to 2013. The greater increase in activity per TEU (17%) compared to the TEU increase (6%) may be due to the inefficiencies introduced in 2014 during the temporary period of increased congestion.

From 2005 to 2014, there was a 21% increase in population and 26% increase in activity level.

Table 9.13: CHE Count and Activity Comparison

Year	Count	Activity (kW-hr)	TEU	Activity per TEU
2014	2,156	218,404,636	8,340,066	261,876
2013	2,149	176,622,201	7,868,582	224,425
2005	1,782	173,108,397	7,484,624	231,285
Previous Year (2013-2014)	**0%**	**24%**	**6%**	**17%**
CAAP Progress (2005-2014)	**21%**	**26%**	**11%**	**13%**

Table 9.14 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 9.14: Count of CHE Engine Type

Equipment	Electric	LNG	Propane	Gasoline	Diesel	Total
2014						
Forklift	10	0	403	8	121	542
Electric wharf crane	84	0	0	0	0	84
RTG crane	0	0	0	0	106	106
Side pick	0	0	0	0	34	34
Top handler	0	0	0	0	183	183
Yard tractor	0	17	180	2	865	1,064
Sweeper	0	0	0	2	7	9
Other	24	0	0	0	110	134
Total	**118**	**17**	**583**	**12**	**1,426**	**2,156**
	5.5%	**0.8%**	**27.0%**	**0.6%**	**66.1%**	
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%**	
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 9.15 summarizes the number and percentage of diesel-powered CHE with various emission controls by equipment type in 2014, the previous year and 2005. 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. 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.
- ULSD has been used by all diesel equipment since 2006. For 2005, ULSD was used by some diesel equipment, but not all.

Table 9.15: Count of CHE Diesel Equipment Emissions Control Matrix

Equipment	DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel	Total Diesel-Powered Equipment	% of Diesel Powered Equipment DOC Installed	On-Road Engines	DPF Installed	ULSD Fuel
2014									
Forklift	0	0	28	121	121	0%	0%	23%	100%
RTG crane	7	0	12	106	106	7%	0%	11%	100%
Side pick	0	0	16	34	34	0%	0%	47%	100%
Top handler	0	0	110	183	183	0%	0%	60%	100%
Yard tractor	92	830	4	865	865	11%	96%	0%	100%
Sweeper	0	0	2	7	7	0%	0%	29%	100%
Other	0	11	20	110	110	0%	10%	18%	100%
Total	**99**	**841**	**194**	**1,426**	**1,426**	**7%**	**59%**	**14%**	**100%**
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%**
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 9.16 compares the total number of cargo handling equipment units with off-road diesel engines (meeting Tier 0, 1, 2, 3 4i, and 4 off-road diesel engine standards) and those equipped with on-road diesel engines for 2014, the previous year and 2005. 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. 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, Tier 3, and 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, 4i, and 4 engines were not available in 2005; therefore, "NA" is used for comparison of current year to 2005 for these engine categories. Tier 4 was not available in 2013 either. Tier 4 engines are included for the first time in the 2014 inventory.

Table 9.16: Count of CHE Diesel Engine Tier and On-road Engine

Year	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4i	Tier 4	On-road Engine	Unknown Tier	Total Diesel
2014	30	60	140	151	146	22	841	36	1,426
2013	39	87	286	154	125	0	723	25	1,439
2005	256	582	360	0	0	0	165	13	1,376
Previous Year (2013-2014)	**-23%**	**-31%**	**-51%**	**-2%**	**17%**	**NA**	**16%**	**44%**	**-1%**
CAAP Progress (2005-2014)	**-88%**	**-90%**	**-61%**	**NA**	**NA**	**NA**	**410%**	**177%**	**4%**

DB ID878

Table 9.17 shows the cargo handling equipment emissions comparisons for 2014, the previous year and 2005. Compared to the previous year, the PM emissions decreased, while the other pollutants remained the same or increased despite equipment turnover. The emissions increased for some pollutants due to the fact that the impact of increased activity in 2014 was greater than the reduction in emission due to equipment turnover. The reductions in 2014 emissions compared to 2005 emissions are largely due to the implementation of the Port's CHE measures and CARB's CHE regulation. The efforts resulted in the introduction of newer equipment with cleaner engines and the installation of emission controls.

Table 9.17: CHE Emissions Comparison

Year	**PM_{10} tons**	**$PM_{2.5}$ tons**	**DPM tons**	**NO_x tons**	**SO_x tons**	**CO tons**	**HC tons**	**CO_2e tonnes**
2014	12	11	10	678	2	823	88	170,741
2013	15	14	13	677	1	679	71	138,349
2005	54	50	53	1,573	9	822	92	134,621
Previous Year (2013-2014)	**-18%**	**-18%**	**-23%**	**0%**	**25%**	**21%**	**24%**	**23%**
CAAP Progress (2005-2014)	**-78%**	**-78%**	**-81%**	**-57%**	**-81%**	**0%**	**-5%**	**27%**

Table 9.18 shows the emissions efficiency changes in 2014 from 2005 and 2013. A positive percentage change for the emissions efficiency comparison means an improvement in efficiency.

Table 9.18: CHE Emissions Efficiency Metric Comparison, tons/10,000 TEUs

Year	**PM_{10}**	**$PM_{2.5}$**	**DPM**	**NO_x**	**SO_x**	**CO**	**HC**	**CO_2e**
2014	0.014	0.013	0.012	0.813	0.002	0.987	0.105	205
2013	0.019	0.017	0.016	0.861	0.002	0.863	0.090	176
2005	0.072	0.066	0.071	2.102	0.013	1.099	0.123	180
Previous Year (2013-2014)	**36%**	**31%**	**33%**	**6%**	**0%**	**-13%**	**-14%**	**-14%**
CAAP Progress (2005-2014)	**81%**	**80%**	**83%**	**61%**	**85%**	**10%**	**15%**	**-14%**

Locomotives

The methodology used to estimate locomotive emissions in this 2014 Inventory is the same as that used in the previous year inventory. Table 9.19 shows the throughput comparisons for locomotives for 2014, the previous year, and 2005.

Table 9.19: Throughput Comparison, million TEUs

Throughput	2005	2013	2014
Total	7.48	7.87	8.34
On-dock lifts	1.02	1.11	1.19
On-dock TEUs	1.84	2.00	2.15
% On-Dock	25%	25%	26%

Table 9.20 shows the locomotive emission estimates for calendar years 2014, the previous year, and 2005. Compared to 2005, the decrease in emissions is due in part to PHL's and UP's fleet turnover to the latest ultra-low emissions switching locomotives, and the use of ULSD. In addition, the railroads' compliance with the MOU contributed towards the significant NO_x and PM emission reductions. CO_2e emissions have been reduced since 2005 despite the increase in rail throughput through the freight movement efficiency improvements implemented by the railroads and terminals. The CO_2e increase from 2013 to 2014 was lower than the increase in rail activity.

Table 9.20: Locomotive Emission Comparison

Year	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
2014	29	26	29	819	0.8	194	45	68,317
2013	29	27	29	828	1.0	190	46	66,830
2005	57	53	57	1,712	98.0	237	89	82,201
Previous Year (2013-2014)	**-1%**	**-4%**	**-1%**	**-1%**	**-20%**	**2%**	**-1%**	**2%**
CAAP Progress (2005-2014)	**-50%**	**-51%**	**-50%**	**-52%**	**-99%**	**-18%**	**-49%**	**-17%**

DB ID428

Table 9.21 shows the emissions efficiency changes in 2014 from the previous year and 2005. A positive percentage for the emissions efficiency comparison means an improvement in efficiency. For the previous year comparison (2014 vs. 2013), emissions efficiency improved for all pollutants, except SO_x, which did not change. For the CAAP progress (2014 vs. 2005), emissions efficiencies have improved for all pollutants.

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

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2014	0.03	0.03	0.03	0.98	0.00	0.23	0.05	82
2013	0.04	0.03	0.04	1.05	0.00	0.24	0.06	85
2005	0.08	0.07	0.08	2.29	0.13	0.32	0.12	110
Previous Year (2013-2014)	**8%**	**9%**	**8%**	**7%**	**0%**	**3%**	**7%**	**4%**
CAAP Progress (2005-2014)	**55%**	**56%**	**55%**	**57%**	**99%**	**27%**	**55%**	**25%**

Heavy-Duty Vehicles

The major change underlying the emission calculations in this inventory compared to the previous EI was a change in emission factor model as released by CARB. EMFAC2014, which replaced the previously used EMFAC2011, "represents ARB's current understanding of motor vehicle travel activities and their associated emission levels."[21] Because the new model version contains numerous changes based on ARB's latest information, all previous calendar year EI's emissions have been re-estimated using the EMFAC2014 emission factors for those years for comparison with 2014.

Along with the release of EMFAC2014, ARB published information on short-term emissions from model-year 2010 and newer trucks equipped with catalytic converters when they start up from cold or after not running for more than approximately 30 minutes. When started under these cold-start and warm-start conditions, HDVs equipped with a catalytic converter emit higher-than-normal amounts of NO_x until the catalyst in the converter reaches optimum operating temperature. ARB has developed average emission factors for each model year of truck starting with 2010 which have been used to estimate start emissions for the HDVs in this EI and in the comparison years in which 2010 or newer trucks called at Port terminals (i.e., calendar years 2009 and later). No model year 2010 or newer trucks were present in the 2005 baseline year. The start emissions contribute a very small amount of NO_x, approximately 1.6% of overall HDV NO_x emissions in the 2014 EI.

---

[21] See *http://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-v1_0_7-release-notice.pdf*

A further change resulting from the use of EMFAC2014 and the estimation of start emissions for 2010 and newer model year trucks is the return to body model year as the basis of analysis as opposed to engine model year, which had been used for the past few EIs as a means of accounting for trucks that were equipped with engines one or more model years older than their body model year. With EMFAC2014 and the start emission factors for 2010+ model year trucks, ARB has accounted for the differences between body model year and engine model year such that body model year is the appropriate characteristic to match against ARB's model year-specific emission factors. The 2014, the previous year and 2005 estimates presented in this EI are based on body model year distributions.

Table 9.22 shows the total port-wide idling time based on information provided by the terminal operators which, as noted previously, relates to time spent on terminal that may not solely be time spent idling. Total idling time increased by 22% from the previous year and by 7% since 2005.

Table 9.22: HDV Idling Time Comparison, hours

Year	**Total Idling Time (hours)**
2014	3,226,153
2013	2,640,628
2005	3,017,252
Previous Year (2013-2014)	**22%**
CAAP Progress (2005-2014)	**7%**

Table 9.23 summarizes the average age of the truck fleet in 2014, the previous year and 2005. The average age of the trucks visiting the Port was 5 years in 2014.

Table 9.23: Fleet Weighted Average Age, years

Year	**Call-Weighted Average Age (years)**
2014	5
2013	4
2005	11

Table 9.24 summarizes the HDV emissions for 2014, the previous year and 2005. The HDV emissions of all pollutants have decreased significantly from 2005 largely due to increasingly stringent on-road engine emission standards and the implementation of the CTP. The increases between 2013 and 2014 are due in part to increased TEU throughput, but also to the fleet being, in general, a year older in 2014 than in 2013 as noted in Table 9.23.

Table 9.24: HDV Emissions Comparison

Year	PM_{10} tons	$PM_{2.5}$ tons	DPM tons	NO_x tons	SO_x tons	CO tons	HC tons	CO_2e tonnes
2014	8.0	7.6	7.3	1,811	4	121	33	358,162
2013	6.5	6.2	5.9	1,580	4	96	27	327,656
2005	248	238	248	6,307	45	1,865	368	469,260
Previous Year (2013-2014)	**23%**	**23%**	**24%**	**15%**	**9%**	**25%**	**25%**	**9%**
CAAP Progress (2005-2014)	**-97%**	**-97%**	**-97%**	**-71%**	**-91%**	**-94%**	**-91%**	**-24%**

Table 9.25 illustrates the changes in emissions in average grams per mile between 2005 and 2014. The units of grams per mile are used because they show the changes independent of changes in throughput or vehicle mileage, which can complicate the comparisons. The figures have been calculated by dividing overall HDV emissions by overall miles traveled, and including idling emissions as well as emissions from driving at various speeds, on-terminal and on-road. Particulate emissions have been reduced most dramatically, followed by the other pollutants except for CO_2e, which is strongly tied to fuel consumption, which has not changed significantly since 2005. The CTP and engine emission standards are responsible for most reductions, including the particulate and NO_x decreases, while fuel sulfur standards, specifically the introduction of ultra-low sulfur diesel fuel (ULSD), are responsible for the SO_x reduction.

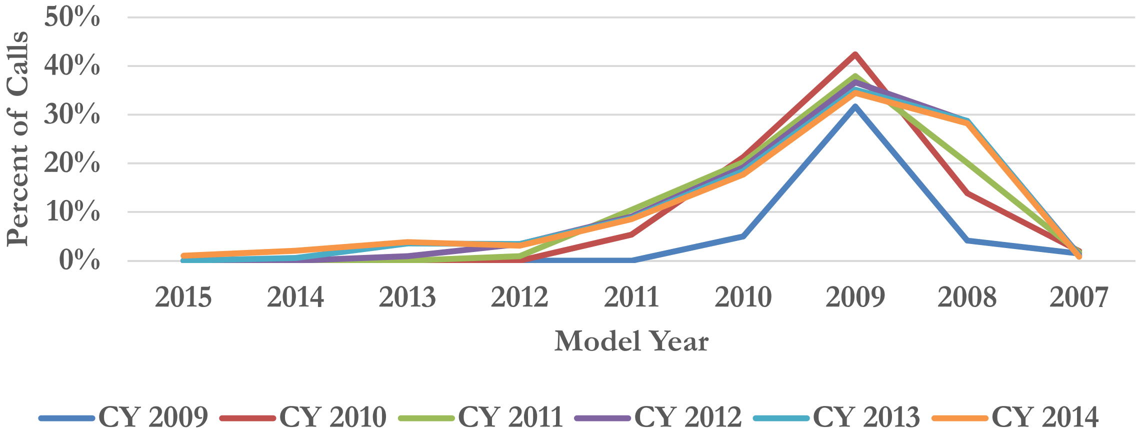
Table 9.25: Fleet Average Emissions, g/mile

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2014	0.037	0.035	0.034	8.33	0.018	0.56	0.15	1,647
2013	0.032	0.031	0.029	7.85	0.018	0.48	0.13	1,627
2005	0.846	0.809	0.846	21.48	0.153	6.35	1.25	1,598
% Change (2013-2014)	**14%**	**14%**	**15%**	**6%**	**1%**	**16%**	**16%**	**1%**
% Change (2005-2014)	**-96%**	**-96%**	**-96%**	**-61%**	**-88%**	**-91%**	**-88%**	**3%**

Despite the decreases from 2005, Table 9.25 shows that fleet average emission rates increased by 1% to 16% between 2013 and 2014, reversing the downward trends seen in previous years. These increases occurred primarily because the fleet was, in general, a year older in 2014 than in 2013. With a large cohort of fairly new trucks brought into the fleet in response to the CTP, especially 2009 model year trucks, turnover is moving forward at a slower rate. The EMFAC2014 model used to estimate gram-per-mile emission factors increases each model year's emissions in successive calendar years to account for the "deterioration" of emissions performance as a vehicle accumulates miles. This results in increasing emissions per mile of travel for the fleet as a whole. Increases in modeled emissions will continue to occur until fleet turnover reduces the 2009 model year peak shown below and evens out the model year distribution with a higher proportion of newer trucks.

Figure 9.1 illustrates the HDV model year distribution for calendar years 2009 through 2014, showing the peak of 2009 model year trucks that largely persists in each calendar year.

Figure 9.1: Model Year Distribution



To further illustrate the effect of deterioration on modeled emission factors, Table 9.26 lists the EMFAC2014 emission factors for NO_x and PM_{10} (other pollutants similar) for model year 2009 trucks in calendar years 2012, 2013, and 2014 at the 40 mph speed point. The NO_x emission factor increased by 7% and the PM_{10} emission factor increased by 13% between calendar year 2013 and calendar year 2014, the two most recent inventory years. These increases are typical of the year-to-year increases attributed to deterioration by the EMFAC2014 model, and show how the emissions from a fleet that is fairly static in model year composition will increase year to year.

Table 9.26: EMFAC2014 Emission Factors Illustrating Effect of Deterioration

Region	Cal Yr	Veh Class	Mdl Yr	Speed	Fuel	Emission factors g/mile NO_x	PM_{10}
South Coast	2014	T7 POLA	2009	40	DSL	9.3479	0.0398
South Coast	2013	T7 POLA	2009	40	DSL	8.7109	0.0354
South Coast	2012	T7 POLA	2009	40	DSL	8.1379	0.0313
Change 2013-2014						**7%**	**13%**

Table 9.27 shows the emissions efficiency changes for HDVs. A positive percentage for the emissions efficiency comparison means an improvement in efficiency. Comparing 2014 to 2005 for CAAP progress, HDV emissions efficiency has improved for all pollutants. Comparing 2014 to the previous year, emissions efficiency for HDVs decreased for most pollutants, consistent with the emission increases discussed above.

Table 9.27: HDV Emissions Efficiency Metrics Comparison, tons/10,000 TEUs

Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	CO_2e
2014	0.010	0.009	0.009	2.171	0.005	0.14	0.04	429
2013	0.008	0.008	0.007	2.008	0.005	0.12	0.03	416
2005	0.332	0.318	0.332	8.432	0.060	2.49	0.49	683
Previous Year (2013-2014)	**-25%**	**-13%**	**-29%**	**-8%**	**0%**	**-17%**	**-33%**	**-3%**
CAAP Progress (2005-2014)	**97%**	**97%**	**97%**	**74%**	**92%**	**94%**	**92%**	**37%**

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. This 10th Annual Inventory of Air Emissions has special significance as it coincides with the first CAAP standards milestone year. These standards consist of the following emission reduction goals, compared to the 2005 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

Due to the many emission reduction measures undertaken by the Port, as well as statewide and federal regulations and standards, the 2014 emission reduction standard has not only been met, but exceeded. Below is a summary for DPM, NO_x and SO_x percent reductions as compared to the 2014 emission reduction standards.

Table 9.28: Reductions as Compared to 2014 Emission Reduction Standard

Pollutant	2014 Actual Reductions	Emission Reduction Standard
DPM	85%	72%
NO_x	52%	22%
SO_x	97%	93%

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 2014, using current year methodology.

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

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ocean-Going Vessels	471	496	262	364	248	153	148	87	83	59
Harbor Craft	55	50	51	55	53	39	35	30	26	30
Cargo Handling Equipmen	53	57	51	38	24	25	23	20	13	10
Locomotives	57	74	61	46	28	30	30	32	29	29
Heavy-Duty Vehicles	248	254	196	183	85	16	12	7	6	7
Total	**884**	**931**	**621**	**686**	**438**	**263**	**250**	**176**	**157**	**134**
% Cumulative Change		**5%**	**-30%**	**-22%**	**-50%**	**-70%**	**-72%**	**-80%**	**-82%**	**-85%**

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

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ocean-Going Vessels	5,248	5,772	5,090	4,836	4,121	4,003	3,899	3,597	3,528	3,607
Harbor Craft	1,318	1,226	1,237	1,258	1,236	947	877	777	704	802
Cargo Handling Equipmen	1,573	1,864	1,688	1,294	805	874	830	793	677	678
Locomotives	1,712	2,202	1,821	1,246	940	996	1,052	877	828	819
Heavy-Duty Vehicles	6,307	6,906	6,127	6,006	3,687	1,791	1,615	1,661	1,580	1,811
Total	**16,159**	**17,970**	**15,963**	**14,640**	**10,790**	**8,611**	**8,273**	**7,704**	**7,318**	**7,717**
% Cumulative Change		**11%**	**-1%**	**-9%**	**-33%**	**-47%**	**-49%**	**-52%**	**-55%**	**-52%**

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

Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ocean-Going Vessels	4,789	5,116	2,998	3,653	2,302	1,290	1,236	588	524	120
Harbor Craft	6	1	1	1	1	1	1	1	1	1
Cargo Handling Equipmen	9	2	2	2	1	2	2	2	1	2
Locomotives	98	132	55	9	7	7	6	3	1	1
Heavy-Duty Vehicles	45	50	5	5	4	4	4	4	4	4
Total	**4,947**	**5,300**	**3,061**	**3,670**	**2,315**	**1,303**	**1,247**	**597**	**531**	**128**
% Cumulative Change		**7%**	**-38%**	**-26%**	**-53%**	**-74%**	**-75%**	**-88%**	**-89%**	**-97%**