PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS - 2007

THE PORT OF LOS ANGELES

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Prepared by:
STARCREST CONSULTING GROUP, LLC

THE PORT OF LOS ANGELES INVENTORY OF AIR EMISSIONS FOR CALENDAR YEAR 2007

Prepared for:

THE PORT OF LOS ANGELES

Prepared by:

Starcrest Consulting Group, LLC
P.O. Box 434
Poulsbo, WA 98370

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Authors:	Archana Agrawal, Consultant, Starcrest Guiselle Aldrete, Consultant, Starcrest Bruce Anderson, Principal, Starcrest Joseph Ray, Principal, Starcrest Mark Carlock, Consultant, Starcrest Sam Wells, Consultant, Starcrest
Contributors:	Steve Ettinger, Consultant, Starcrest Joyce Kristiansson, Consultant, Starcrest Lars Kristiansson, Consultant, Starcrest Rose Muller, Consultant, Starcrest Zorik Pirveysian, Consultant, Starcrest Jeff Reiter, Consultant, Starcrest
Document Preparation:	Denise Anderson, Consultant, Starcrest
Cover:	Melissa Silva, Principal, Starcrest

ACRONYMS AND ABBREVIATIONS

Act	Activity
AAPA	American Association of Port Authorities
ABS	American Bureau of Shipping
AMP	alternative maritime power
ANPRM	Advance Notice of Proposed Rulemaking
APL	American Presidents Line
APM	A. P. Moeller
AS	actual speed
ATB	articulated tug and barge
BACT	Best Available Control Technology
BAEI	Baseline Air Emissions Inventory
BNSF	Burlington Northern Santa Fe Railroad
BTH	Business Transportation and Housing Agency
BW	breakwater
CAAP	Clean Air Action Plan
Cal/EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CF	control factor
CHE	cargo handling equipment
CO	carbon monoxide
D	distance
DB	dynamic breaking
DF	deterioration factor
DMV	Department of Motor Vehicles
DMVT	daily vehicle miles of travel
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
DPM	diesel particulate matter
DR	deterioration rate
DWT	deadweight tonnage
E	emissions
EEIA	Energy and Environmental Analysis
EF	emission factor
EI	emissions inventory
EMD	(GE) Electromotive Division
EPA	U.S. Environmental Protection Agency

ACRONYMS AND ABBREVIATIONS (CONT'D)

FCF	fuel correction factor
g/bhp-hr	grams per brake horsepower-hour
g/day	grams per day
g/hr	grams per hour
g/kW-hr	grams per kilowatt-hour
g/mi	grams per mile
GHG	greenhouse gas
GM	goods movement
GMP	Goods Movement Plan
GVWR	gross vehicle weight rating
HC	hydrocarbons
HDDV	heavy-duty diesel vehicle
HDV	heavy-duty vehicle
HFO	heavy fuel oil
hp	horsepower
hrs	hours
HVAC	heating/ventilation/air conditioning
ICTF	Intermodal Container Transfer Facility
IFO	intermediate fuel oil
IMO	International Maritime Organization
ITB	integrated tug and barge
kW	kilowatt
L.A.	Los Angeles
LAXT	Los Angeles Export Terminal
l/cyl	liters per cylinder
lbs/day	pounds per day
LF	load factor
LLA	low load adjustment
Lloyd's	Lloyd's Register of Ships
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LSI	large spark ignited (engine)
M&N	Moffatt & Nichol Engineers
MaRex	Marine Exchange of Southern California
MCR	maximum continuous rated
MDO	marine diesel oil

ACRONYMS AND ABBREVIATIONS (CONT'D)

MGO	marine gas oil
MMA	Meyer, Mohaddes Associates, Inc.
MMGT	million gross ton-miles
MOU	Memorandum of Understanding
mph	miles per hour
MS	maximum speed
MTC	Marine Terminals Corporation
MY	model year
N	north
NAAQS	National Ambient Air Quality Standards
nm	nautical miles
NO_x	oxides of nitrogen
NPRM	Notice of Proposed Rulemaking
NYK	Nippon Yusen Kaisha
OBD	on-board diagnostics
OGV	ocean-going vessel
PCEEI	Pleasure Craft Exhaust Emissions Inventory
PCST	Pacific Cruise Ship Terminals
PHL	Pacific Harbor Line
PM	particulate matter
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PMSA	Pacific Merchant Shipping Association
POLB	Port of Long Beach
ppm	parts per million
PZ	precautionary zone
Reefer	refrigerated vessel
RH	relative humidity
RIA	Regulatory Impact Analysis
RO	residual oil
ROG	reactive organic gases
Ro-Ro	roll-on/roll-off
rpm	revolutions per minute
RSD	Regulatory Support Document
RTG	rubber tired gantry crane
RTL	rich text language

ACRONYMS AND ABBREVIATIONS (CONT'D)

S	sulfur
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SFC	specific fuel consumption
SO_x	oxides of sulfur
SoCAB	Southern California Air Basin
SPB	San Pedro Bay
SSA	Stevedoring Services of America
SUV	sport utility vehicle
T&M	tampering and mal-maintenance
TEU	twenty-foot equivalent unit
TICTF	Terminal Island Container Transfer Facility
TOG	total organic gases
tpd	tons per day
tpy	tons per year
UDDS	Urban Dynamometer Driving Schedule
U.S.	United States
ULCC	ultra large crude carriers
ULSD	ultra low sulfur diesel
UP	Union Pacific Railroad
USCG	U.S Coast Guard
VBP	vessel boarding program
VLCC	very large crude carrier
VLCS	very large cargo ship
VMT	vehicle miles of travel
VOCs	volatile organic compounds
VSR	vessel speed reduction
VTS	vessel traffic service
W	west
ZH	zero hour
ZMR	zero mile rate

EXECUTIVE SUMMARY

The Port of Los Angeles (the Port) shares San Pedro Bay with the neighboring Port of Long Beach (POLB). Together, the San Pedro Bay Ports comprise a significant regional and national economic engine for California and the United States (U.S.), through which more than 40% of all U.S. containerized trade flows. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will more than double by the year 2020. The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts (and, in particular, air quality impacts) that result from such trade. Therefore, in November 2006, the San Pedro Bay Ports adopted their landmark, joint Clean Air Action Plan (CAAP) designed to reduce the air health risks and emissions associated with port-related operations, while allowing port development to continue. In order to track CAAP progress, the Port has committed to develop annual inventories.

The Port released its first activity-based emissions inventory in 2004, documenting activity levels in the baseline year of 2001[1]. The 2001 baseline emissions inventory evaluated emissions for all Port terminals from five source categories: ocean-going vessels, harbor craft, off-road cargo handling equipment, railroad locomotives and on-road heavy-duty vehicles and evaluated operations at all Port terminals. In 2007, the Port released the 2005 Inventory of Air Emissions which was the first update to the baseline inventory and also the first of the annual inventories to follow. In July 2008, the Port released the 2006 Inventory of Air Emissions.

This study, the 2007 Inventory of Air Emissions, includes emissions estimates based on 2007 activity levels and annual comparisons for 2001, 2005, and 2006 emissions estimates to track progress. As in previous inventories, the following five source categories are included:

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

[1] *Port of Los Angeles 2001 Baseline Air Emissions Inventory,* 2004.

This study also includes emission estimates for greenhouse gases (GHGs) for port-related tenant operational sources. Exhaust emissions of the following pollutants have been estimated:

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

Methodology Overview

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

The geographical extent of the inventory is described in section 1 and in each source category section of the report. The geographical extent of the port-related emissions did not change from previous inventories and includes emissions from all source categories within the harbor district; emissions from rail locomotives and on-road trucks transporting cargo to or from the Port up to the cargo's first point of rest within the South Coast Air Basin (SoCAB) or up to the basin boundary, whichever comes first; and emissions from commercial marine vessels within the harbor and up to the study area boundary. Figure ES.1 shows the SoCAB boundary.

Figure ES.1: South Coast Air Basin Boundary

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

Figure ES.2: OGV Inventory Geographical Extent

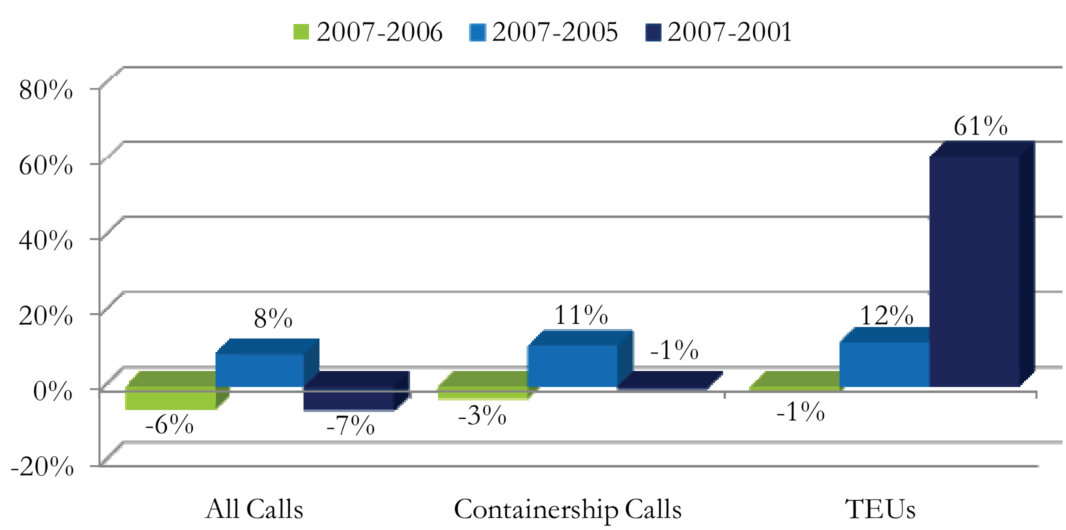
Findings

Table ES.1 and Figure ES.3 illustrate the differences in vessel calls and container cargo throughputs between 2001, 2005, 2006 and 2007. From 2006 to 2007, there was a 1% decrease in TEU throughput, the number of total calls decreased by 6%, and containership calls decreased by 3%. From 2005 to 2007, there was a 12% increase in TEU throughput, the number of total calls increased by 8%, and containership calls increased by 16%. From 2001 to 2007, the TEU throughput increased by 61%.

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

EI Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2007	2,538	1,575	8,355,038	5,305
2006	2,708	1,626	8,469,853	5,209
2005	2,341	1,423	7,484,625	5,260
2001	2,717	1,584	5,183,520	3,272
2007-2006	**-6%**	**-3%**	**-1%**	**2%**
2007-2005	**8%**	**11%**	**12%**	**1%**
2007-2001	**-7%**	**-1%**	**61%**	**62%**

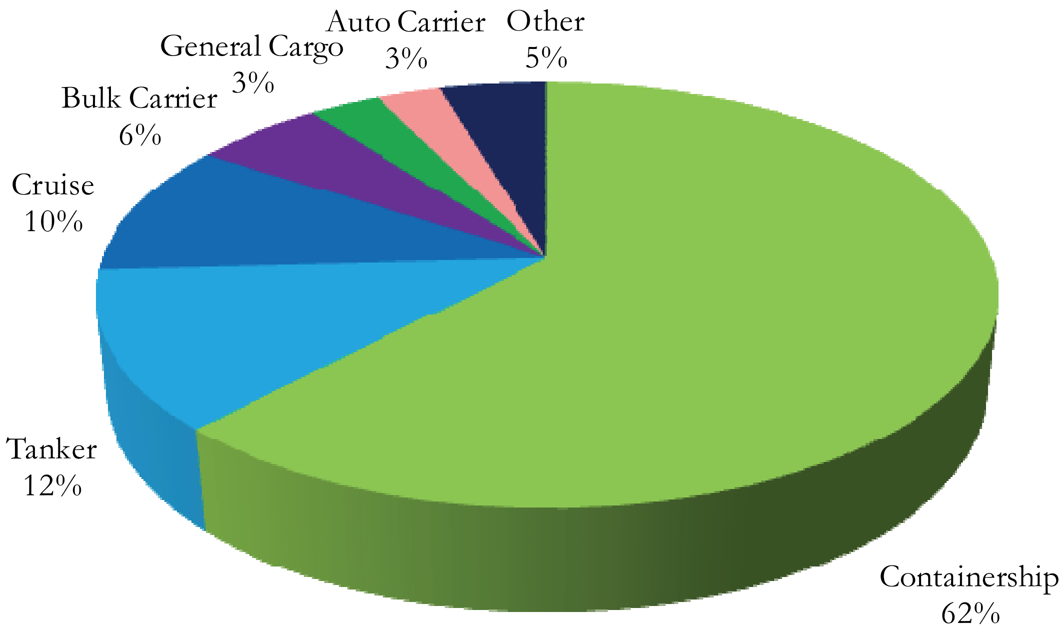
Figure ES.3: TEUs and Vessel Call Comparison, %



Ocean-going Vessels

Figure ES.4 shows that the majority of the vessels that called at the Port in 2007 are containerships (62%); followed by tankers (12%); cruise vessels (10%), bulk carriers (6%); general cargo (3%), and auto carriers (3%). The remaining 5% shown as others include reefers, RoRos, and miscellaneous vessels. Due to rounding, the percentages do not add up to 100%.

Figure ES.4: Distribution of Vessel Types by Inbound Calls



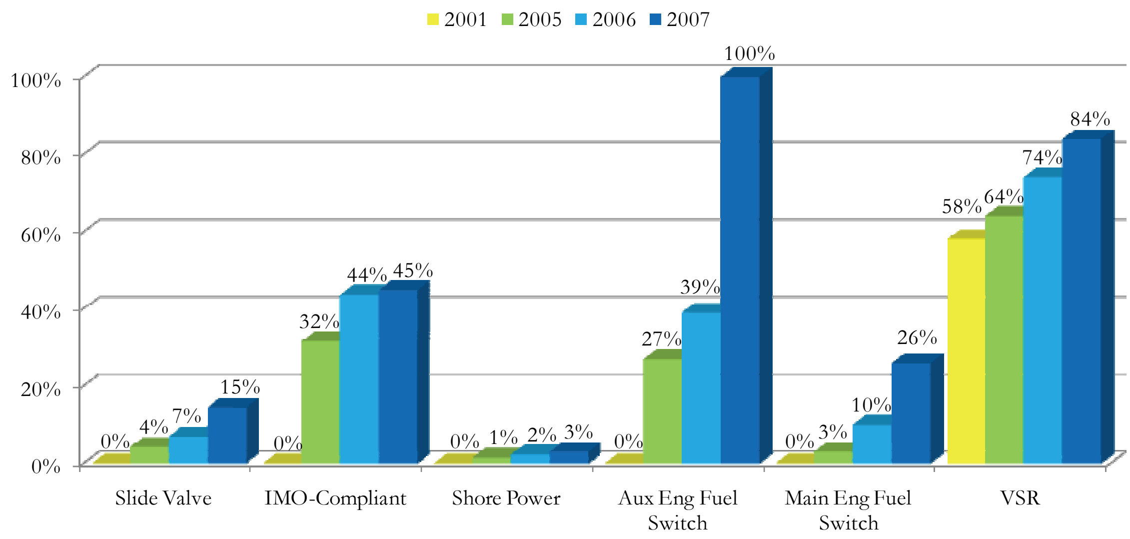
The various emission reduction strategies for ocean-going vessels are listed in Table ES.2 and Figure ES.5 and summarized below.

- The percent of calls with vessels that had fuel-efficient slide valves is 15% in 2007.
- The percent of calls with IMO-compliant vessels (model year 2000 and newer) is 45% in 2007.
- Shore Power (i.e. AMP Program) continued at berth 100 and began at YTI Terminals with one NYK vessel in 2007. The percent of total calls that used Shore Power was 3% for 2007.
- The percent of vessels that switched to a cleaner fuel for auxiliary engines at berth and near the coast is 100% in 2007 due to vessels voluntarily complying with the CARB auxiliary engine fuel rule that came into effect January 1, 2007 and was challenged in court.
- The percentage of vessel calls that switched to a cleaner fuel for main engines during transit is 26% in 2007 (percentage includes all cruise ship calls).
- In 2007, approximately 84% of total vessel calls complied with the VSR program.

Table ES.2: Emissions Reduction Strategies for OGVs

	Percent (%) of All Calls					
Year	**Slide Valve**	**IMO Compliant**	**Shore Power**	**Fuel Switch Aux Eng**	**Fuel Switch Main Eng**	**VSR**
2007	15%	45%	3%	100%	26%	84%
2006	7%	44%	2%	39%	10%	74%
2005	4%	32%	1%	27%	3%	64%
2001	0%	0%	0%	0%	0%	58%

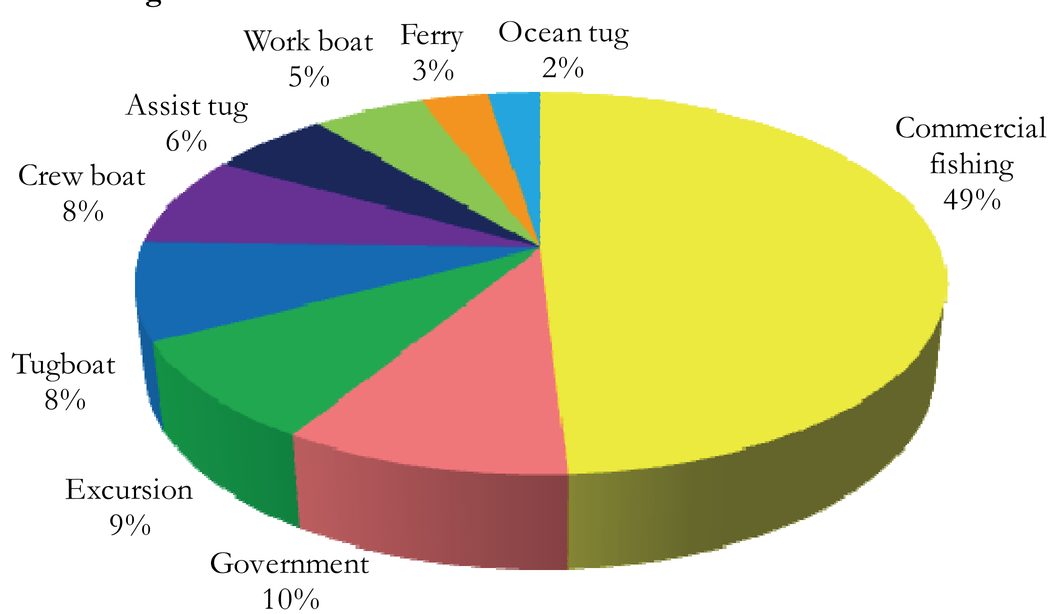
Figure ES.5: Emission Reduction Strategies for OGVs



Harbor Craft

Figure ES.6 presents the distribution of the 281 commercial harbor craft inventoried for the Port of Los Angeles in 2007.

Figure ES.6: 2007 Distribution of Commercial Harbor Craft



Approximately 27% of the main engines and 42% of the auxiliary engines have been replaced since 2001. Table ES.3 summarizes the percent distribution of engines based on engine standards. For this comparison, the following model years fall into the various Tiers:

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

Table ES.3: Harbor Craft Engine Standards Comparison by Tier

Year	Tier 0	Tier 1	Tier 2
2007	64%	27%	9%
2006	61%	29%	10%
2005	64%	30%	7%
2001	100%	0%	0%

In 2001, model year was not known for all engines, but it can be assumed that close to 100% of the harbor craft had engines in the Tier 0 range since the engine model year was probably 1999 or older. Between 2001 and 2005, many engines were replaced as a result of the Carl Moyer Program and Port-funded projects to reduce emissions in the harbor. In 2005, 64% of the engines were Tier 0 engines; 30% had Tier 1 engines and 7% had Tier 2 engines. In 2006, the percentage of Tier 0 engines was further reduced to 61% and the Tier 2 percentage increased to 10%. The increase in commercial fishing vessel count in 2007 may have increased the number of Tier 0 engines as compared to 2006.

Cargo Handling Equipment

Figure ES.7 presents the distribution of the 2,014 pieces of equipment inventoried at the Port for 2007. Out of all CHE inventoried at Port facilities for 2007, 50% were yard tractors, 26% were forklifts, seven percent were top handlers, five percent were RTG cranes, two percent were side handlers, one percent were sweepers and nice percent were other equipment.

Figure ES.7: 2007 Distribution of Port CHE by Equipment Type

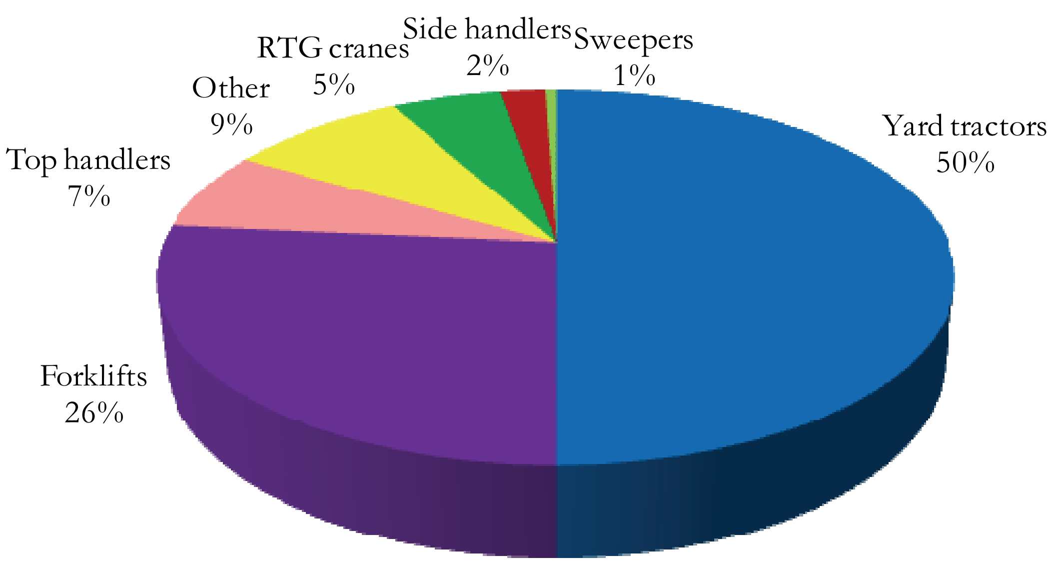


Table ES.4 summarizes the various engine power types for CHE, which include electric, liquefied natural gas (LNG), propane, gasoline, and diesel.

Table ES.4: CHE Engine Power Type Matrix

Equipment	Electric	LNG	Propane	Gasoline	Diesel
2007					
Forklifts	1	0	350	8	175
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	107
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	138
Yard tractors	0	2	58	0	947
Sweepers	0	0	0	2	9
Other	19	0	0	1	85
Total	**89**	**2**	**408**	**11**	**1,504**
2006					
Forklifts	0	0	355	8	191
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	103
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	134
Yard tractors	0	2	58	0	897
Sweepers	0	0	0	2	10
Other	19	0	0	0	104
Total	**88**	**2**	**413**	**10**	**1,482**
2005					
Forklifts	0	0	263	8	151
Wharf gantry cranes	67	0	0	0	0
RTG cranes	0	0	0	0	98
Side handlers	0	0	0	0	41
Top handlers	0	0	0	0	127
Yard tractors	0	0	53	0	848
Sweepers	0	0	0	3	8
Other	12	0	0	0	103
Total	**79**	**0**	**316**	**11**	**1,376**
2001					
Forklifts	0	0	116	4	80
Wharf gantry cranes	44	0	0	0	0
RTG cranes	0	0	0	0	34
Side handlers	0	0	0	0	37
Top handlers	0	0	0	0	74
Yard tractors	0	0	0	0	590
Sweepers	0	0	0	1	3
Other	0	0	0	0	70
Total	**44**	**0**	**116**	**5**	**888**

Table ES.5 summarizes the various emissions controls for diesel powered CHE by equipment counts and by percent total diesel equipment (found in the total equipment count column). It should be noted that emission controls can be used in combination with each other, therefore they cannot be added across to come up with total equipment count (control equipment counts are greater than total equipment counts).

Table ES.5: Diesel Powered Equipment Emissions Control Matrix

							% of Diesel Powered Equipment				
Equipment	**DOC Installed**	**On-Road Engines**	**DPF Installed**	**USLD Fuel**	**Emulsified Fuel**	**Total Diesel-Powered Equipment**	**DOC Installed**	**On-Road Engines**	**DPF Installed**	**USLD Fuel**	**Emulsified Fuel**
2007											
Forklifts	4	4	0	175	0	175	2%	2%	0%	100%	0%
RTG cranes	10	0	0	107	0	107	9%	0%	0%	100%	0%
Side handlers	13	0	0	43	0	43	30%	0%	0%	100%	0%
Top handlers	54	0	0	138	0	138	39%	0%	0%	100%	0%
Yard tractors	508	273	58	947	0	947	54%	29%	6%	100%	0%
Sweepers	0	1	0	9	0	9	0%	11%	0%	100%	0%
Other	0	3	0	85	0	85	0%	4%	0%	100%	0%
Total	**589**	**281**	**58**	**1,504**	**0**	**1,504**	**39%**	**19%**	**4%**	**100%**	**0%**
2006											
Forklifts	4	4	0	191	15	191	2%	2%	0%	100%	8%
RTG cranes	10	0	0	103	28	103	10%	0%	0%	100%	27%
Side handlers	13	0	0	43	10	43	30%	0%	0%	100%	23%
Top handlers	54	0	0	134	42	134	40%	0%	0%	100%	31%
Yard tractors	531	216	0	897	128	897	59%	24%	0%	100%	14%
Sweepers	0	1	0	10	0	10	0%	10%	0%	100%	0%
Other	0	5	0	104	0	104	0%	5%	0%	100%	0%
Total	**612**	**226**	**0**	**1,482**	**223**	**1,482**	**41%**	**15%**	**0%**	**100%**	**15%**
2005											
Forklifts	3	0	0	27	15	151	2%	0%	0%	18%	10%
RTG cranes	0	0	0	36	28	98	0%	0%	0%	37%	29%
Side handlers	14	0	0	16	10	41	34%	0%	0%	39%	24%
Top handlers	48	0	0	79	36	127	38%	0%	0%	62%	28%
Yard tractors	520	164	0	483	129	848	61%	19%	0%	57%	15%
Sweepers	0	0	0	0	0	8	0%	0%	0%	0%	0%
Other	0	1	0	65	0	103	0%	1%	0%	63%	0%
Total	**585**	**165**	**0**	**706**	**218**	**1,376**	**43%**	**12%**	**0%**	**51%**	**16%**
2001											
Forklifts	0	0	0	0	0	80	0%	0%	0%	0%	0%
RTG cranes	0	0	0	0	0	34	0%	0%	0%	0%	0%
Side handlers	0	0	0	0	0	37	0%	0%	0%	0%	0%
Top handlers	0	0	0	0	0	74	0%	0%	0%	0%	0%
Yard tractors	0	0	0	0	0	590	0%	0%	0%	0%	0%
Sweepers	0	0	0	0	0	3	0%	0%	0%	0%	0%
Other	0	0	0	0	0	70	0%	0%	0%	0%	0%
Total	**0**	**0**	**0**	**0**	**0**	**888**	**0%**	**0%**	**0%**	**0%**	**0%**

Rail Locomotives

Table ES.6 summarizes the rail TEU throughputs for total, on-dock, and near-dock rail activities. From 2005 to 2007, there was an 11% increase in total on-dock rail and a 16% increase in near-dock rail throughput.

Table ES.6: Rail TEU Throughput Comparison

	2005	2006	2007	% Change 2005-2007	% Change 2006-2007
Total Port Throughput	7,484,615	8,469,980	8,355,038	12%	-1%
Total On-Dock Rail	1,891,198	2,466,759	2,098,398	11%	-15%
% On-Dock	25%	29%	25%		
Near-Dock Rail(1)	555,694	653,321	643,919	16%	-1%
% Near-Dock	7%	8%	8%		

(1) Intermodal Container Transfer Facility (ICTF) - Emissions from rail cargo movements to/from this location are included in the Port's emissions inventory.

Heavy-duty Vehicles

At container terminals, the idling time improved by 5 minutes since 2006 and 10 minutes since 2005. Table ES.7 shows a decrease in total idling time from 2001 to 2007 (47%), 2005 to 2007 (23%) and 2006 to 2007 (21%). The decreasing idling time is due to three factors:

- The terminals modernized their gate system with optical character recognition (OCR) and added several queuing lines at the in and out gates which increased the efficiency at the gates and thus reduced idling time.
- Assembly Bill 2650 (known as the Lowenthal Bill), introduced in 2004, required that each marine terminal in California operate in a manner that does not cause the engines on trucks to idle or queue for more than 30 minutes while waiting to enter the gate into the marine terminal.
- Since July 2005, all marine terminals at POLA and POLB offer off-peak shifts on nights and weekends.

Table ES.7: HDV Idling Time Comparison, hours

EI Year	Total Idling Hours
2007	2,334,568
2006	2,962,463
2005	3,017,252
2001	4,404,847
2007-2006	-21%
2007-2005	-23%
2007-2001	-47%

Summary of 2007 Emission Estimates

The emission results for the Port of Los Angeles 2007 Inventory of Air Emissions are presented in this section. Table ES.8 summarizes the 2007 total port-related emissions in the South Coast Air Basin (SoCAB) by category in tons per year.

Table ES.8: 2007 Port-related Emissions by Category, tpy

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	416	333	333	6,142	3,718	587	267
Harbor craft	53	49	53	1,281	1	348	85
Cargo handling equipment	46	43	45	1,662	2	919	81
Rail locomotives	60	54	60	1,675	55	268	94
Heavy-duty vehicles	370	340	370	7,343	6	2,529	445
Total	**944**	**817**	**860**	**18,102**	**3,781**	**4,652**	**973**

DB ID457

The total port-related tenant greenhouse gas (GHG) emissions in SoCAB are summarized below. The GHG emissions summarized in Table ES.9 are in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton) used throughout the report. The CO_2 equivalent included is derived by multiplying the GHG emissions estimates by the following global warming potential (GWP)[2] values and then adding them together:

- CO_2 – 1
- CH_4 – 21
- N_2O – 310

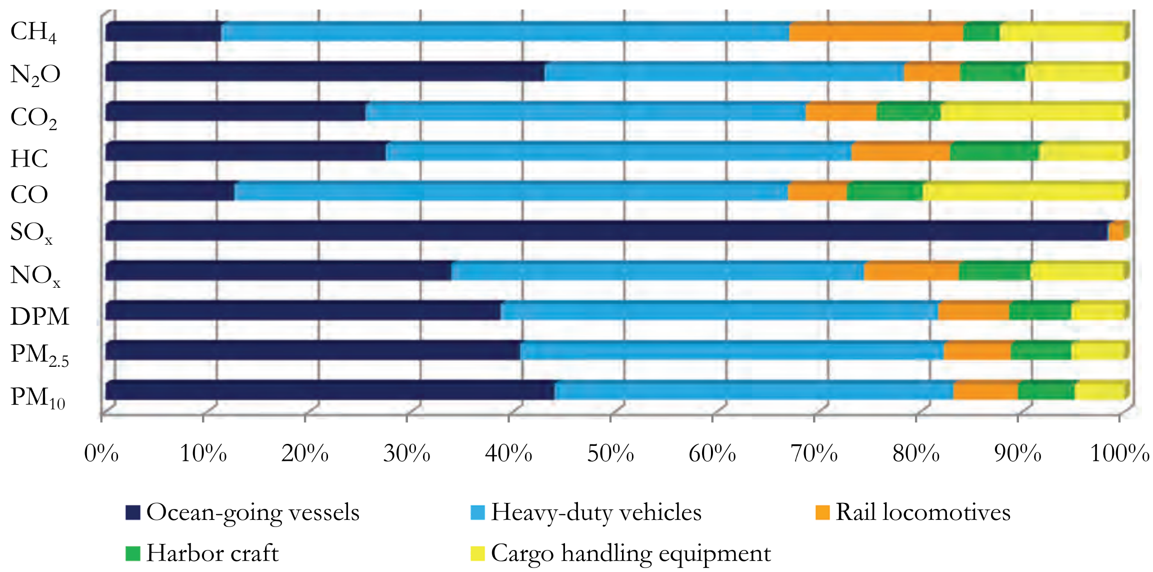
Table ES.9: 2007 Port-related GHG Emissions by Category, metric tons per year

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	334,121	328,217	19	5
Harbor craft	81,928	81,027	3	2
Cargo handling equipment	233,397	231,982	4	5
Rail locomotives	90,036	89,144	2	7
Heavy-duty vehicles	561,303	556,044	15	24
Total	**1,300,785**	**1,286,414**	**43**	**43**

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

Figure ES.8 shows the distribution of the 2007 total port-related emissions for each pollutant and category. Ocean-going vessels (roughly 40%) and heavy-duty trucks (roughly 40%) have the highest percentage of particulate matter emissions among the port-related sources. Approximately 99% of the SO_x emissions are attributed to ocean-going vessels. Heavy-duty trucks account for the majority of NO_x emissions (41%), CO emissions (54%), and hydrocarbon emissions (46%).

Figure ES.8: 2007 Port-related Emissions by Category, %



In order to put the Port-related emissions into context, the following figures compare the Port's contributions to the other sources in the South Coast Air Basin. The 2007 SoCAB emissions used for this comparison were interpolated from the 2005 and 2008 emissions listed in the 2007 Air Quality Management Program (AQMP)[3].

In the South Coast Air Basin, 9% of diesel particulate matter emissions, 5% of NO_x emissions, and 21% of SO_x emissions are attributed to port-related emissions from Port of Los Angeles. The port's percent contribution of DPM, NO_x, and SO_x within the SoCAB decreased in 2007 as compared to 2006 and 2005.

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

Figure ES.9: 2007 DPM Emissions in the South Coast Air Basin, %

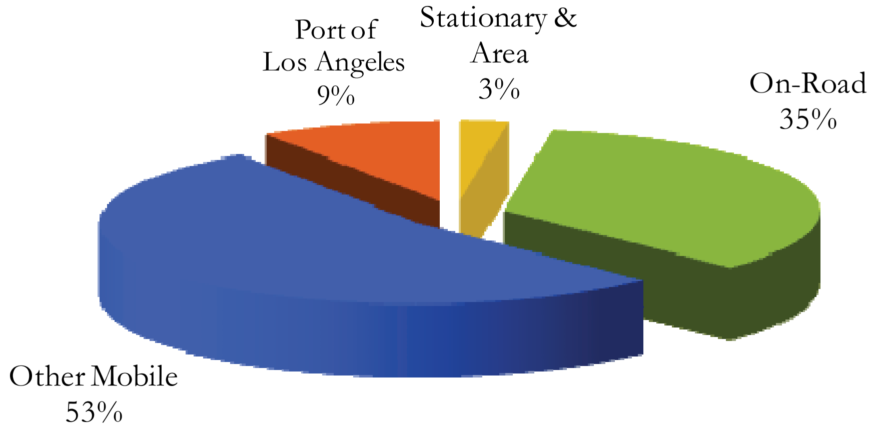


Figure ES.10: 2007 NO_x Emissions in the South Coast Air Basin, %

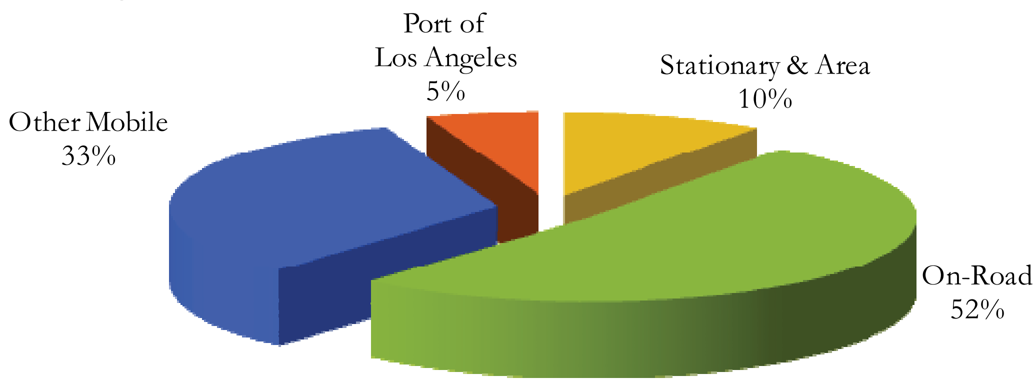


Figure ES.11: 2007 SO_x Emissions in the South Coast Air Basin, %

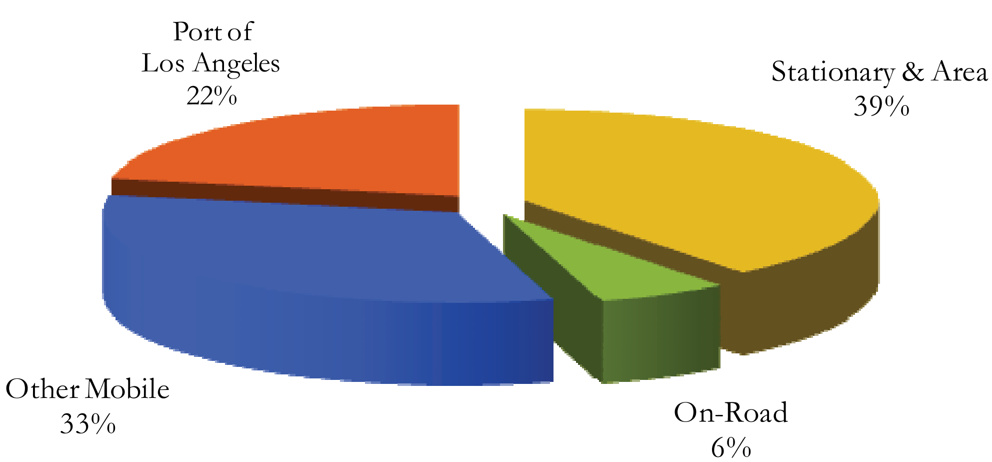


Table ES.10 present the total net change in emissions for all source categories in 2007 as compared to 2006, 2005 and 2001. Despite increased throughput activity since 2001, the 2007 port-wide PM and SO_x emissions in 2007 were lower than in previous years. NO_x, CO and hydrocarbon emissions increased when compared to 2001. Most of the emission reduction programs reduced particulate matter, thus the 14% to 20% PM emission reduction. The diesel engines are currently burning diesel fuel with lower sulfur content than in previous years, including the fuel switching for ocean-going vessels for their auxiliary engines and some main engines, and this has a direct impact on the SO_x emissions which have been reduced over 34%. The CO and hydrocarbon increases when comparing to 2001 are due to increase in activity; the new engine standards which have higher CO and HC emission rates; and the increase in propane engines in the inventory which have higher CO emissions than diesel engines.

Table ES.10: Port-wide Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	944	817	860	18,102	3,781	4,652	973
2006	1,177	1,011	1,080	19,962	5,729	4,969	1,100
2005	1,135	969	1,052	18,324	5,767	4,350	1,025
2001	1,089	917	na	16,119	6,330	3,451	837
2007-2006	**-20%**	**-19%**	**-20%**	**-9%**	**-34%**	**-6%**	**-12%**
2007-2005	**-17%**	**-16%**	**-18%**	**-1%**	**-34%**	**7%**	**-5%**
2007-2001	**-13%**	**-11%**	**na**	**12%**	**-40%**	**35%**	**16%**

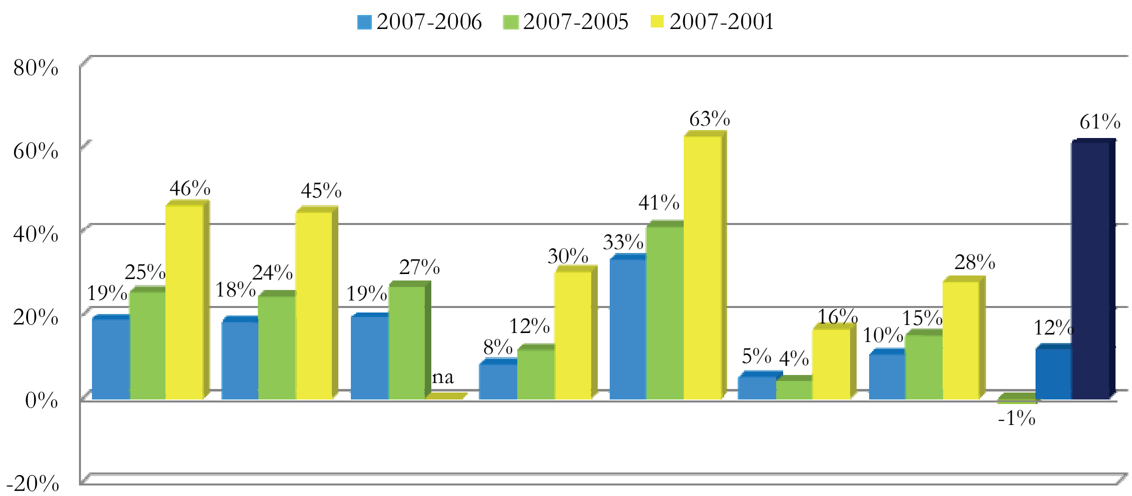
Table ES.11 summarizes the annualized emissions efficiencies (ie, emissions per container handled) of all five source categories in tons of pollutant per 10,000 TEU moved. In 2007, the overall port efficiency improved for all pollutants as compared to the previous years. A positive percentage means an increase in emission efficiency in Table ES.11 and Figure ES.12.

Table ES.11: Emissions Efficiency Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	1.1	1.0	1.0	21.7	4.5	5.6	1.2
2006	1.4	1.2	1.3	23.6	6.8	5.9	1.3
2005	1.5	1.3	1.4	24.5	7.7	5.8	1.4
2001	2.1	1.8	na	31.1	12.2	6.7	1.6
2007-2006	**19%**	**18%**	**19%**	**8%**	**33%**	**5%**	**10%**
2007-2005	**25%**	**24%**	**27%**	**12%**	**41%**	**4%**	**15%**
2007-2001	**46%**	**45%**	**na**	**30%**	**63%**	**16%**	**28%**

Figure ES.12 compares emissions efficiency changes between 2007 and all previous emission years. Emissions efficiencies improved for all pollutants.

Figure ES.12: Emissions Efficiency Comparison, 2007-2006, % Change



In summary, the 2007 emissions for all pollutants were reduced port-wide as compared to 2005 and 2006, except for CO. Also, despite a 61% increase in TEU throughput from 2001 to 2007, the PM and SO_x emissions decreased in 2007. Similar to the port-wide emissions, the emissions per container handled continued to decline (ie, emissions efficiency increased) in 2007 compared to 2006, 2005, and 2001 for all pollutants. In 2007, emissions from ocean-going vessels decreased because operators voluntarily complied with CARB's marine auxiliary engine fuel regulation that was in place for 2007. The cargo handling equipment emissions decreased in 2007 due mainly to equipment turnover. Harbor craft was the only source category to see slight increases in emissions in 2007 from 2006. Rail emissions decreased due to the replacement of old locomotives and the use of cleaner diesel fuels in 2007. Heavy-duty truck emissions decreased in 2007 from the 2006 emission levels due to equipment turnover, decrease in activity and the use of cleaner fuels.

In 2008, emissions are expected to continue decreasing due the implementation of CAAP programs such as the marine fuel incentive and the new truck program and there may be a slight decrease in activity due to expected lower TEU throughput.

SECTION 1 INTRODUCTION

The Port of Los Angeles (the Port) shares San Pedro Bay with the neighboring Port of Long Beach (POLB). Together, the San Pedro Bay Ports comprise a significant regional and national economic engine for California and the United States (U.S.), through which more than 40% of all U.S. containerized trade flows. The San Pedro Bay Ports customs district accounts for approximately $300 billion in annual trade. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will more triple by the year 2023. The economic benefits of the Ports are felt throughout the nation.

The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts (and, in particular, air quality impacts) that result from such trade. Therefore, in November 2006, the San Pedro Bay Ports adopted their landmark, joint Clean Air Action Plan (CAAP) designed to reduce health risks and emissions associated with port-related operations, while allowing port development to continue.

In order to track CAAP progress, the Port has committed to develop annual inventories of the port-related sources starting with the 2005 Inventory of Air Emissions. The detailed annual activity-based inventory, with associated emissions estimates, is a critical and integral component to the success of the CAAP. Activity-based inventories based on detailed data collected on activities that occurred in a specific time period provide the most detailed inventory of air emissions for port-related sources. Activity-based inventories not only provide a greater understanding of the nature and magnitude of emissions, but also help track progress for the many emission reduction strategies that the Port, a landlord port, and its tenants have undertaken.

1.1 Reason for Study

The Port released its first activity-based emissions inventory in 2004, documenting activity levels in the baseline year of 2001[4]. The 2001 baseline emissions inventory evaluated emissions for all Port terminals from five source categories: ocean-going vessels, harbor craft, off-road cargo handling equipment, railroad locomotives and on-road heavy-duty vehicles and evaluated operations at all Port terminals. In 2007, the Port released the 2005 Inventory of Air Emissions[5] which was the first update to the baseline inventory and also the first of the annual inventories to follow. In July 2008, the Port released the 2006 Inventory of Air Emissions[6]. This 2007 Inventory of Air Emissions provides the latest emissions inventory of port-related sources.

[4] *Port of Los Angeles 2001 Baseline Air Emissions Inventory,* 2004.
[5] *Port of Los Angeles Inventory of Air Emissions 2005*, September, 2007.
[6] *Port of Los Angeles Inventory of Air Emissions 2006*, July, 2008.

1.2 Goods Movement

Goods Movement (GM) has become a key issue associated with both growth of the California economy and the significant challenges to meeting the National Ambient Air Quality Standards (NAAQS) in the Southern California Air Basin (SoCAB). The Business, Transportation and Housing Agency (BTH) and the California Environmental Protection Agency (Cal/EPA) have jointly adopted a Goods Movement Action Plan (GMP)[7]. The GMP is intended to address GM related issues such as current and future infrastructure needs, impact on environment, adverse impact mitigation measures to protect public health and community concerns, public safety and security issues, and workforce development opportunities regarding goods movement. As stated in the GMP, it is the policy of this Administration to improve and expand California's goods movement industry and infrastructure in a manner which will:

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

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

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

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

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

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

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

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

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

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

A. Reduce total statewide international and domestic goods movement emissions to the greatest extent possible and at least back to 2002 levels by year 2010;

B. Reduce the statewide diesel particulate matter (PM) health risk from international and domestic goods movement 85 percent by year 2020;

C. Reduce NO_x emissions from international goods movement in the South Coast 30 percent from projected year 2015 levels, and 50 percent from projected year 2020 levels based on preliminary targets for attaining federal air quality standards;

D. Apply the emission reduction strategies for ports and goods movement statewide to aid all regions in attaining air quality standards; and

E. Make every feasible effort to reduce localized risk in communities adjacent to goods movement facilities as expeditiously as possible."[9]

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

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

1.3 Container Movements

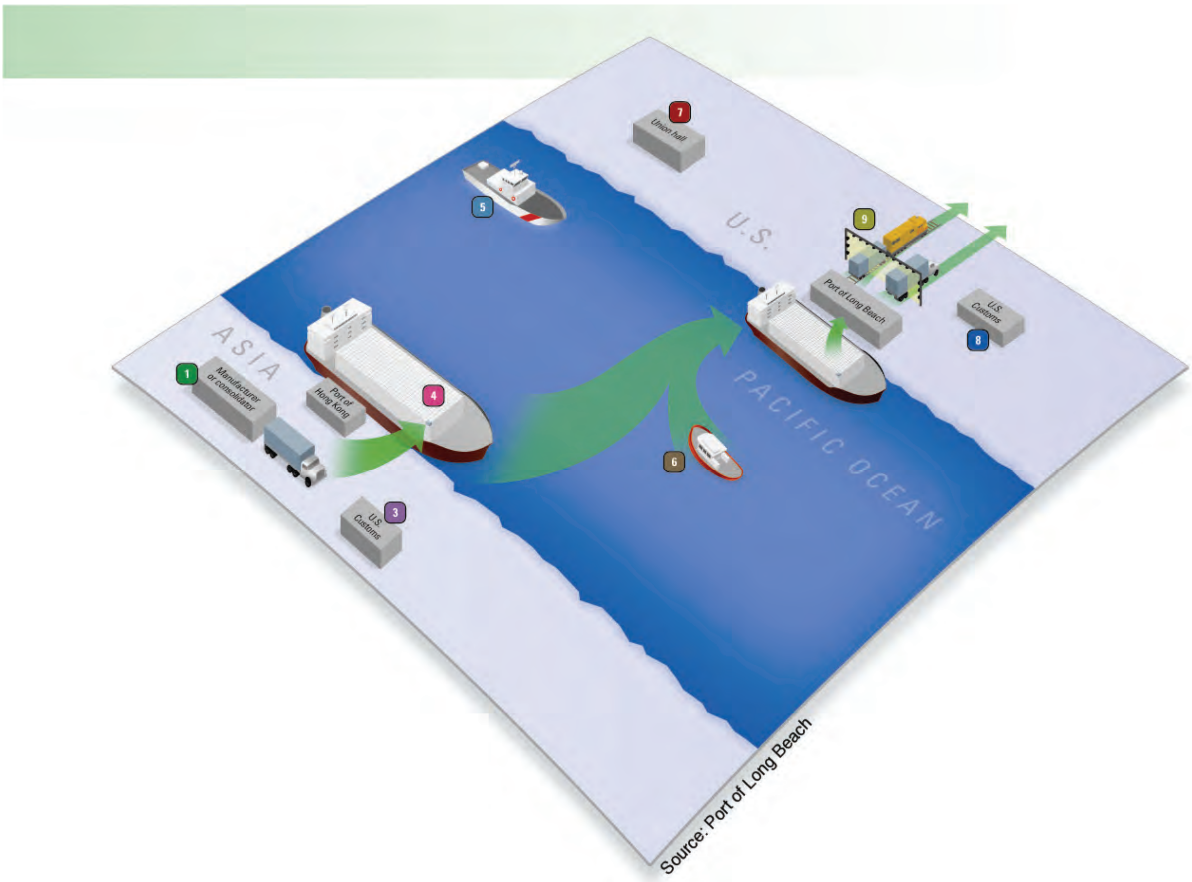
Container terminals and their associated cargo movements are complex intermodal operations that are critical to international trade. Containerized cargo has significantly increased the efficiency and capacity of the transportation system over the prior general cargo/break bulk cargo models (which still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

1.3.1 Overseas Container Transport

Imported cargo generally starts at an overseas manufacturer, supplier, or consolidation facility, where items are boxed and placed inside metal shipping containers. Containers generally come in two common sizes 20-foot or 1 twenty-foot equivalent (TEU), or 40-foot or two TEUs. Other sizes such as 45-foot and 53-foot are also used. The U.S. buyer may contact an industry professional known as a "freight forwarder," or logistics company, to coordinate landside transportation of the cargo. The container is then transported to a foreign port, assessed for possible security risks, and placed on board containership, which is specifically designed to carry containerized cargo. Containerships calling at the San Pedro Bay ports range from 2,000 to over 8,000 TEUs per ship. The containerships transport the containerized cargo to the Port, where it is unloaded, and forwarded to local or national destinations. Figure 1.1 presents the steps that are associated with overseas cargo movements[10].

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

Figure 1.1: Overseas Container Transport

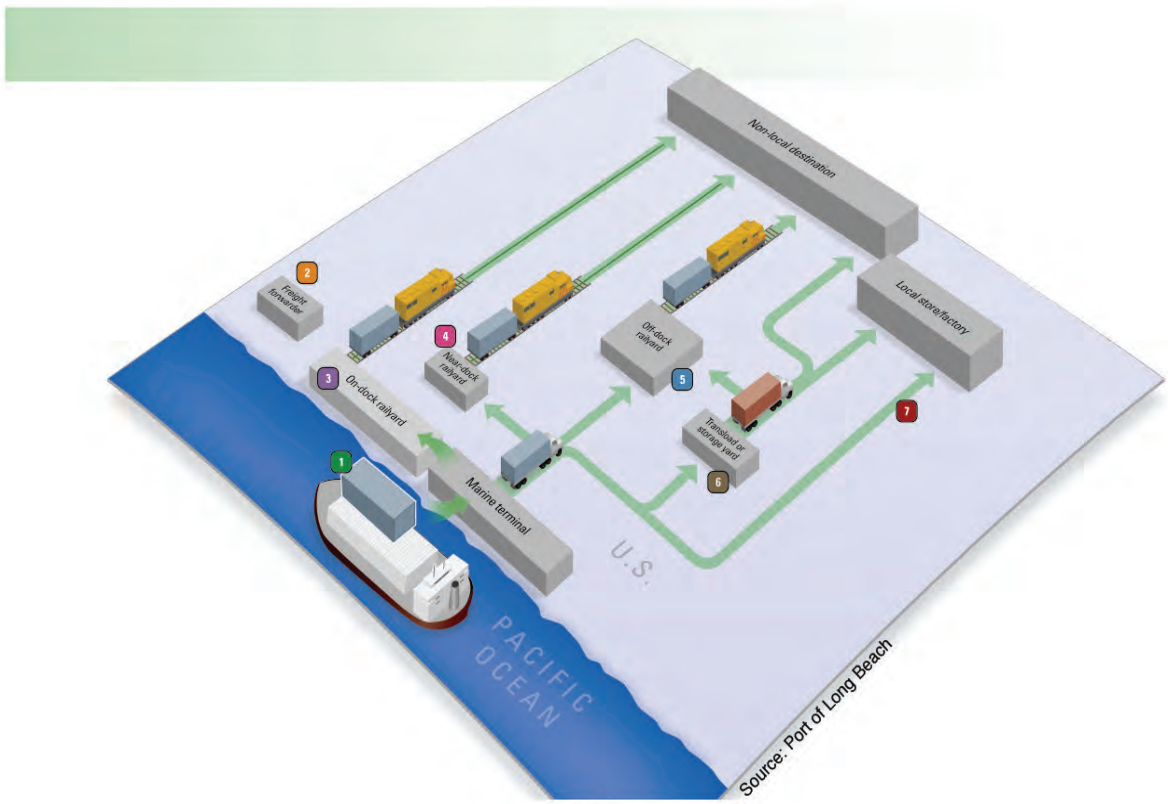


Key:
1) Product ordered
2) Container transported to foreign port (not shown)
3) Security check conducted by U.S. Customs agents based at foreign ports
4) Container loaded onboard containership
5) Coast Guard review conducted for ship, crew, and cargo manifests
6) Containership boarded and docked by a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

1.3.2 Import Container Transport

Once the ship arrives at the Port, the imported containers are either transported by train or by truck to their final destination, or to one of several intermediate destinations such as a railyard, warehouse, distribution center, or "transload" facility (a sorting, routing, and short-term storage facility). A container's final destination will determine exactly what path it will take once it leaves the dock. Figure 1.2 presents the steps that are associated with imported container cargo movements[11].

Figure 1.2: Import Container Transport



Key:

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

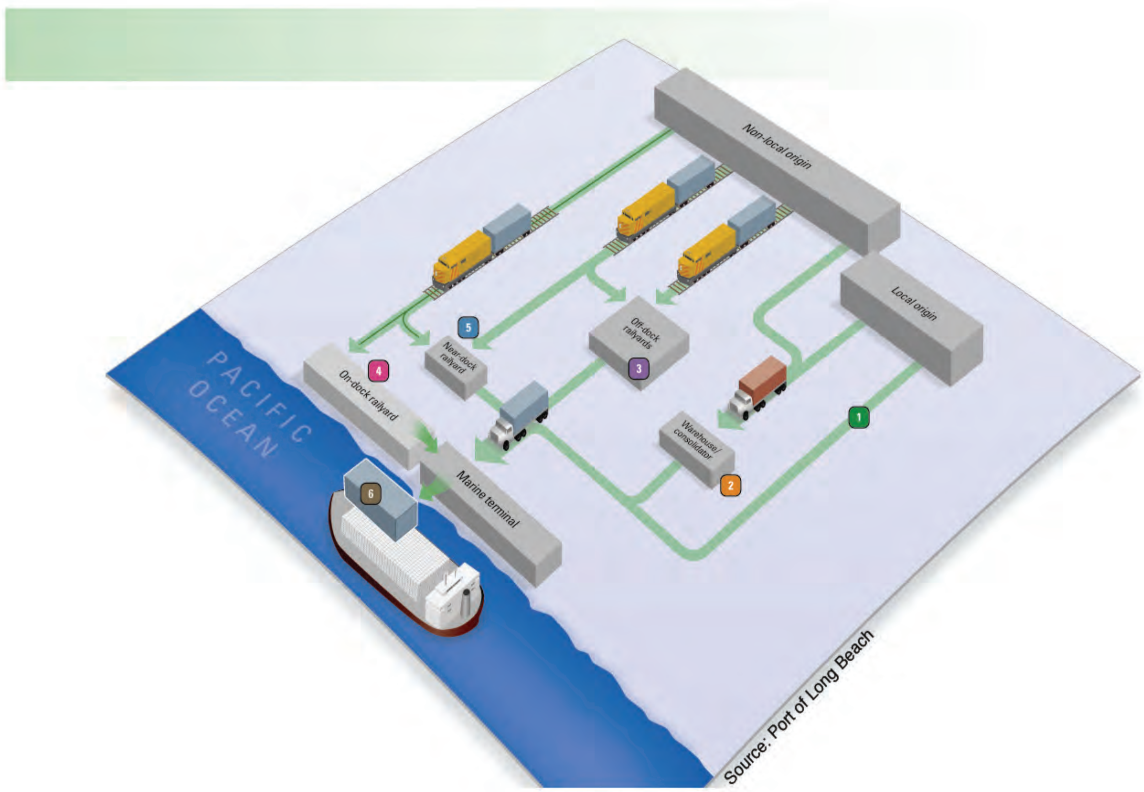
[11] Port of Long Beach, Cargo Movement in Focus, 2006.

6) Shipping containers are often moved initially to a "transload" facility where cargo is unloaded, sorted, and repackaged into larger-sized truck trailers. The cargo is then delivered from the facility to regional distribution centers, local stores, or off-dock railyards.

1.3.3 Export Container Transport

Export container cargo is similar to import containers; however, the flow is in the opposite direction. As with imported cargo, exported cargo may require multiple intermediate stops between its producer/manufacturer and the Port. Figure 1.3 presents the steps that are associated with exported container cargo movements[12].

Figure 1.3: Export Container Transport



Key:

1) Local origin cargo delivered directly to the marine terminal from the producer, manufacturer, or exporting company.
2) Local or non-local origin cargo delivered to a warehouse/consolidator where the cargo may be temporarily stored with other cargo bound for export. Cargo may also be transferred from domestic truck trailers to marine shipping containers.
3) Some non-local origin cargo shipped by rail and delivered to off-dock railyards where the cargo is placed onto truck for final delivery to marine terminals.
4) Some non-local origin cargo shipped by rail directly to the marine terminal where it is loaded onto a ship or stored temporarily for the appropriate ship to arrive.

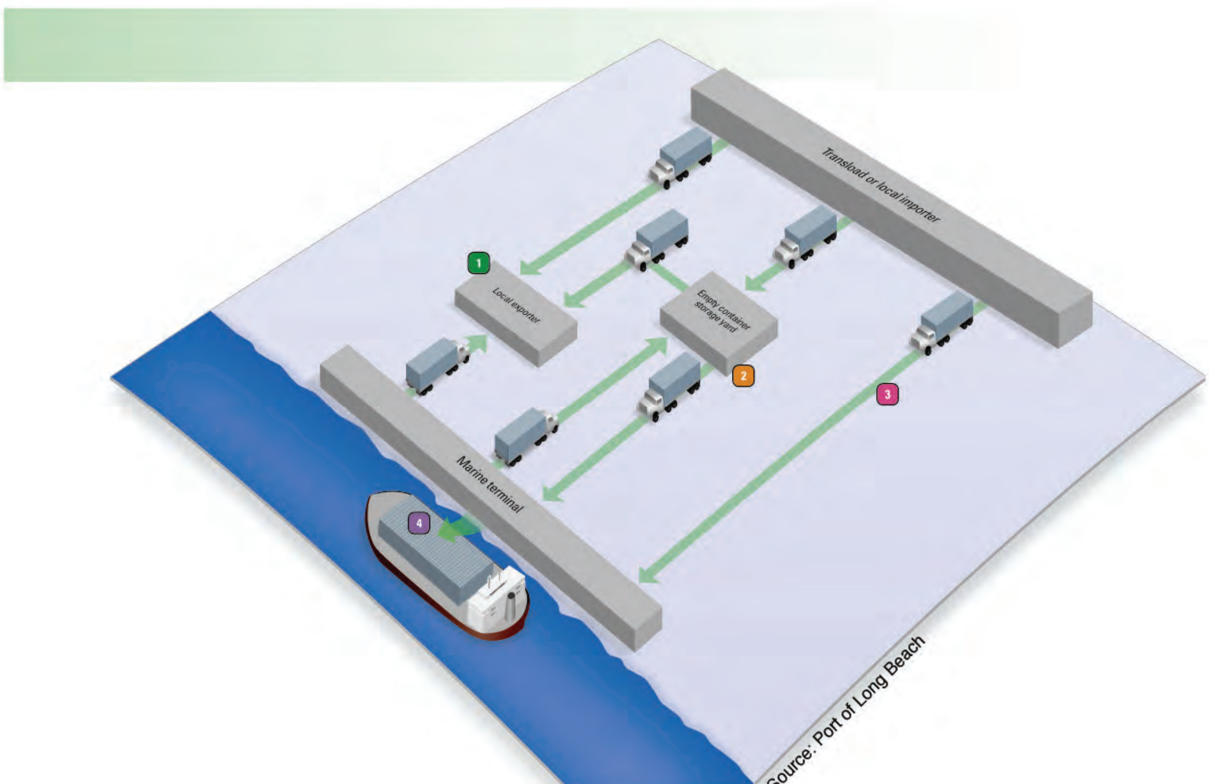
[12] Port of Long Beach, Cargo Movement in Focus, 2006.

5) Some non-local origin cargo shipped by rail to near-dock railyards, where the cargo is picked up by truck for a short trip to the marine terminal.
6) Vessel loading of export cargo conducted after the ship has been unloaded of its import cargo.

1.3.4 Empty Containers

Since the U.S. imports more goods than it exports, many empties are sent overseas to be reused or are used domestically for other purposes. Typically, about a third of the containers loaded onto a ship at the Port will be filled with cargo, while about two-thirds will be empty. The figure below diagrams the movement of empty containers after the delivery of full, imported containers to local businesses and/or transload facilities. Intermodal containers returning to the local area empty are not depicted; they would enter the system at the marine terminal or empty container storage yard.[13]

Figure 1.4: Empty Container Transport



Key
1) Empty container delivered to a local exporter to fill. Direct delivery of containers between importers and exporters is encouraged to reduce the number of truck trips a container takes in the South Coast.

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

2) Empty container delivered to container storage yard from a transload facility or local importer. From the storage yard, containers are moved by truck to the marine terminal for export or to a local exporter to be filled with cargo.
3) Empty container delivered directly from a transload facility or local importer to the marine terminal for export.
4) Empty container loaded onto a containership to be exported and reused overseas.

1.4 Scope of Study

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

1.4.1 Pollutants

Exhaust emissions of the following pollutants have been estimated:

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

Particulate matter

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

Diesel particulate matter

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

Oxides of nitrogen
Oxides of nitrogen is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Most oxides of nitrogen are colorless and odorless. NO_x forms when fuel is burned at high temperatures, as in a combustion process. Oxides of nitrogen are precursors for ground level ozone formation. Ozone is formed by a reaction involving hydrocarbon and nitrogen oxides in the presence of sunlight. The primary manmade sources of NO_x are motor vehicles, electric utilities and other sources that burn fuels. Exposure to NO_x has been connected to a range of respiratory diseases and infections. Exposure to ozone can cause difficulty in breathing, lung damage and reduced cardiovascular functions.

Total hydrocarbons
Hydrocarbons are organic compounds composed of carbon and hydrogen. Most hydrocarbons serve as fuels for the various sources found at Ports. Some examples of hydrocarbon fuels are the components of gasoline, diesel, and natural gas. Hydrocarbon emissions are formed due to the incomplete fuel combustion and fuel evaporation. A number of hydrocarbons are considered toxics which can cause cancer or other health problems. Hydrocarbons are precursor to ground level ozone formation which leads to smog in the atmosphere.

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

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

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

Each GHG differs in its ability to absorb heat in the atmosphere. Sometimes, estimates of greenhouse gas emissions are presented in units of carbon equivalents which weight each gas by its global warming potential (GWP) value. To normalize these values in a single greenhouse gas value, the GHG emissions estimates can be multiplied by the following values and then added together resulting in a single greenhouse gas value (CO_2 equivalent). The values are as follows[14]:

- CO_2 – 1
- CH_4 – 21
- N_2O - 310

1.4.2 Emission Sources

The scope includes the following five source categories:

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

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

1.4.3 Geographical Extent

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

Figure 1.5 shows the land area of active Port terminals in 2007. The geographical scope for cargo handling equipment is the terminals and facilities on which they operate.

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

Figure 1.5: Port Boundary Area of Study

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

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

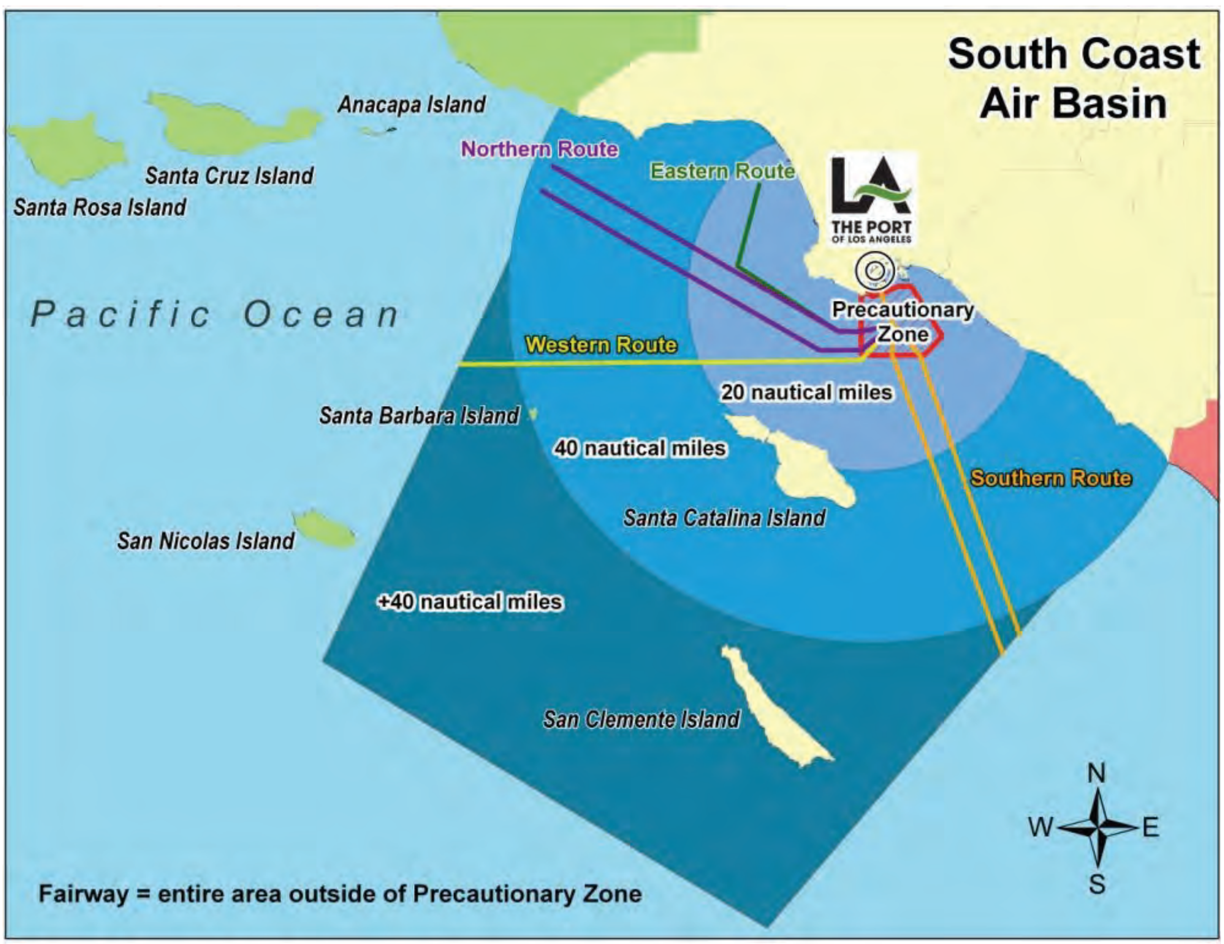
Figure 1.6: South Coast Air Basin Boundary

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

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

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

Figure 1.7: OGV Inventory Geographical Extent



1.5 General Methodology

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

In general, emissions estimates are quantified by multiplying units of activity (estimated using the activity and operational information described above) by an emission factor. Emission factors are standard values that express the mass of emissions in terms of a unit of activity. For example, some emission factors are expressed in terms of pounds of emissions (of a particular pollutant) per horsepower-hour. Horsepower-hours are the product of in-use horsepower times hours of operation. Emissions estimates can be calculated, then, by multiplying hours of operation per year (activity data) by in-use horsepower (operational information) by an emission factor (such as pounds per horsepower-hour) to provide a result of emissions in pounds of emissions per year. The actual calculations are often more complex than this example, because such parameters as in-use horsepower must be estimated as part of the calculations. In addition, the emission factors often vary depending on equipment-specific factors such as the model year and the accumulated hours of use, and fuel correction factors may need to be applied.

1.5.1 Ocean-Going Vessels

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

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

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

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

The emission estimates presented in the 2007 EI include the effects of the following emission reduction measures in place in 2007.

- The vessel speed reduction (VSR) program requiring 12 knots during transiting outside the harbor
- The use of alternative maritime power (AMP) at China Shipping's Berth 100 and by one NYK vessel calling at Yusen Terminals
- Switching to a lower sulfur fuel near the coast and at berth on a voluntary basis by shipping lines
- Newer vessels calling at the Port with cleaner and more fuel-efficient engines that meet or exceed standards set by the IMO
- New technologies added to vessels that reduce emissions such as fuel slide valves

1.5.2 Harbor Craft

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

- Assist tugboat
- Towboats and push boats
- Ferries
- Excursion vessels
- Crew boats
- Work boats
- Government vessels
- Commercial fishing vessels

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

1.5.3 Cargo Handling Equipment

Cargo handling equipment (CHE) consists of various types of equipment and vehicles that fall within the off-road designation and are used to move cargo within terminals and other off-road areas. The emission estimation methodology for this category followed CARB's CHE emissions estimation methodology based on CARB's OFFROAD[15] model methodology plus additional modifications[16] made by CARB's staff for CHE. Equipment operators and owners were interviewed and asked to supply updated information such as activity hours, size and model year of all of their CHE used at the port.

1.5.4 Railroad Locomotives

Railroad operations are typically described in terms of two different types of operations, line haul and switching. Line haul operations involve long-distance transportation of a whole (unit) train between the Port and points across the country, whereas switching is the local movement of individual railcars or train segments to prepare them for line haul or to distribute them to destination terminals upon their arrival in port. Different companies conduct switching (Pacific Harbor Line) and line haul (Burlington Northern Santa Fe, Union Pacific) operations within the port. The line haul companies also operate switching locomotives at off-port rail yards.

[15] CARB, OFFROAD, 2003. See *http://www.arb.ca.gov/msei/off-road/off-road.htm.*
[16] CARB, Appendix B, Emissions Inventory Methodology. See *http://www.arb.ca.gov/react/cargo2005/cargo2005.htm.*

The on-port switching company operates a dedicated fleet of locomotives, while the line haul locomotives that service the Port are part of a nation-wide fleet, meaning that individual locomotives are not assigned specifically to port or South Coast Air basin service. Therefore, the types of information available for these two types of activity differs for the on-port switching locomotives, information on each locomotive and its activity (e.g., fuel use and throttle notch setting) can be used to estimate emissions; whereas for the line haul locomotives the information is more general (e.g., in terms of fuel use per ton of cargo and total tons of cargo carried).

The EPA has published emissions information for switching and line haul locomotive operations in both throttle notch and fuel consumption modes, so this information was used to estimate emissions and to cross-check between the estimating methods.

1.5.5 Heavy-Duty Vehicles

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

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.
- Off-terminal Port operations, consisting of travel on public roads within the Port jurisdictional boundaries.
- On-road operations outside the Port boundaries but within the SoCAB. This includes travel within the boundaries of the adjacent Port of Long Beach, because the routes many trucks take run through both ports on the way to and from Port terminals.

For estimating on-road HDV emissions, activity information was developed by a traffic consultant using the trip generation and travel demand models that were used in the 2001 Baseline EI and in previous Port traffic studies.[17] For estimating on-terminal HDV emissions, terminal operators were interviewed with regards to on-terminal traffic patterns, including time spent waiting at the entry gate, time and distance on terminal while dropping off and/or picking up cargo, and time spent waiting at exit gates.

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

[17] Meyer, Mohaddes Associates, Inc., Ports of Long Beach/Los Angeles Transportation Study, June 2001; and Meyer, Mohaddes Associates, Inc., Port of Los Angeles Baseline Transportation Study, April 2004.

1.6 Methodology Comparison

In order to make a meaningful comparison between annual emission inventories, the same methodology must be used for estimating emissions. The present calendar year's emissions are compared to the previous calendar years' emissions using the same methodology. For each specific source category, if there was a methodological change in 2007 compared to those in previous years (i.e. 2006, 2005 and 2001) then the previous years' emissions were recalculated using the specific activity data for those years with the new 2007 methodology to provide a valid basis for comparison. If there was no change in methodology, then the emissions included in the previous inventory were used for the comparison. Methodological differences for 2007 vs. 2006 emissions inventories are:

OGV

- The methodology used in 2007 to estimate OGV emissions is the same as what was used in 2006 Inventory of Air Emissions, except for fuel correction factors (FCF) which were changed. Fuel correction factors (FCF) used for 2007 EI are based on CARB's marine auxiliary engine rule.

Harbor Craft

- The methodology used in 2007 to estimate harbor craft emissions is the same as what was used in 2006 Inventory of Air Emissions.

CHE

- The methodology used in 2007 to estimate cargo handling equipment emissions is the same as what was used in 2006 Inventory of Air Emissions.

Rail

- The methodology used in 2007 to estimate rail emissions is the same as what was used in 2006 Inventory of Air Emissions.

HDV

- The methodology used in 2007 to estimate heavy-duty truck emissions is the same as what was used in 2006 Inventory of Air Emissions, with the exception of N_2O EF change. The N_2O EF used for 2007 uses a gram per gallon N_2O emission rate for distillate fuels consistent with CARB's methodology.

1.7 Report Organization

This report presents the 2007 emissions and the methodologies used for each category in each of the following sections:

- Section 2 discusses regulatory and port measures
- Section 3 discusses ocean-going vessels
- Section 4 discusses harbor craft
- Section 5 discusses cargo handling equipment
- Section 6 discusses locomotives
- Section 7 discusses heavy-duty vehicles
- Section 8 discusses findings and results
- Section 9 compares 2007 emissions to previous years' emissions

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

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

2.1 Ocean-Going Vessels

Emissions Standard for Marine Propulsion Engines
The International Maritime Organization (IMO) adopted limits for NO_x in Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1997. These NO_x limits apply to marine engines over 130 kilowatts (kW) installed on vessels built on or after 2000. The current NO_x standards are from 17.0 g/kW-hr (for < 130 rpm) to 9.8 g/kW-hr (for $\geq$ 2000 rpm), depending upon the engine speed in rpm. The required number of countries ratified the Annex in May 2004 and it went into force for those countries in May of 2005. Engine manufacturers have been certifying engines to the Annex VI NO_x limits since 2000 as the standards are retroactive in other countries, once Annex VI is ratified. In April 2008, the Marine Environment Protection Committee of the IMO approved a recommendation for new MARPOL Annex VI sulfur limits for fuel and NO_x limits for engines. On July 21, 2008, President Bush signed into law the Maritime Pollution Protection Act of 2008, ratifying MARPOL Annex VI by the United States. On October 9, 2008, the IMO adopted new international standards for marine diesel engines and their fuels. The sulfur limits included in the approved amendment limit fuel sulfur to 1% in emissions control areas (ECAs) by 2010, with a global limit of 3.5% sulfur in 2012, down from the current 4.5% sulfur limit. These sulfur levels will be further reduced to 0.1% sulfur in ECAs by 2015 and 0.5% sulfur globally by 2020, or no later than 2025. Engine emission rate limits for NO_x for new builds are set at 14.4 g/kW-hr in 2011, down from 17.0 g/kW-hr for ships built between 2000 and 2010. The NO_x limit will be further reduced to 3.4 g/kW-hr in 2016 for ships operating in ECAs. Finally, existing ships built between 1990 and 2000, will be subject to a retrofit requirement, limiting NO_x to 17.0 g/kW-hr.

EPA's Final Regulation – Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters Per Cylinder (EPA 2008)[18]

This regulation, adopted on March 14, 2008, applies to all remanufactured and new-built auxiliary engines used on U.S. flagged ocean-going vessels. Engines covered are category 1 and 2 engines with greater than 800 horsepower (hp) rating less than 30 liter per cylinder (l/cyl) displacement. This is a three part regulation as follows:

1. Remanufactured engines – establishes more stringent emissions standards on existing engines when they are remanufactured. Depending upon the availability, these standards are applicable as early as 2008.
2. Tier 3 – more stringent emissions standards for new engines with phase-in starting in 2009. Tier 3 standards target PM and NO_x emissions based on currently available on-road and Tier 4 non-road technologies.
3. Tier 4 – most stringent emissions standards for new engines with phase-in starting in 2014. Tier 4 standards are based on highly efficient after-treatment catalyst technologies along with the use of ultra low sulfur fuel.

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

EPA is pursuing two parallel, related actions for establishing emission standards for Category 3 marine diesel engines: (1) EPA is a member of the United States delegation that is participating in negotiations at the International Maritime Organization (IMO) with regard to amendments to Annex VI that consider additional NO_x limits for new engines; additional sulfur content limits for marine fuel; methods to reduce PM emissions; potential NO_x and PM limits for existing engines; and potential volatile organic compounds (VOCs) limits for tankers. (2) In January 2003, EPA adopted Tier 1 standards for Category 3 marine engines, which went into effect in 2004, establishing NO_x standards based upon internationally negotiated emissions rates and readily available emissions-control technology. In November 2007, EPA issued an Advanced Notice of Proposed Rulemaking for new Tier 2 and Tier 3 national standards for Category 3 marine diesel engines. This rule would establish stricter standards for NO_x, in addition to standards for PM and SO_x. The currently proposed Tier 2 NO_x standards for new builds could begin in 2011, and could achieve a 15 to 25% reduction from the existing Tier 1 standard. The proposed Tier 3 NO_x standards could begin in 2016 and could reduce NO_x emissions 80% from the Tier 2 standards, while the vessels are operated in specially designated areas. Performance-based SO_x and PM standards could begin in 2011 and could be achieved through the use of 0.1% sulfur distillate fuel or after-treatment technologies such as SO_x scrubbers. Lastly, proposed NO_x emissions limits for existing vessels could reduce emissions by 15 to 20%.

[18] See: http://*www.epa.gov/otaq/regs/nonroad/420f08004.htm#exhaust,* (EPA 2008).

CAAP Measure- SPBP-OGV2; Reduction of At-Berth OGV Emissions

This measure requires the use of shore-power for reducing hotelling emissions implemented at all major container and cruise terminals at the Port of Los Angeles within five years. Through the Technology Advancement Program, this measure also requires demonstration and application of alternative emissions reduction technologies for ships not capable of shore power.

CAAP Measure- SPBP-OGV5; OGV Main &Auxiliary Engine Emissions Improvements

This measure provides for main and auxiliary engine emissions reductions that are validated through the Technology Advancement Program. The goal of this measure is to reduce main and auxiliary engine DPM, NO_x, and SO_x emissions by 90%. The first engine emissions reduction technology identified for this measure is the use of MAN B&W slide valves for main engines. The implementation mechanism for this measure is the terminal lease renewal.

CARB's Regulation to Reduce Emissions from Diesel Auxiliary Engines on Ocean going vessels While at Berth at a California Port[19]

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

Vessel Speed Reduction (VSR) Program

In May 2001, a Memorandum of Understanding (MOU) between the Port of Los Angeles, the Port of Long Beach, EPA Region 9, CARB, SCAQMD, the Pacific Merchant Shipping Association (PMSA), and the Marine Exchange of Southern California was signed. This MOU called for OGVs to voluntarily reduce speed to 12 knots at a distance of 20 nautical miles (nm) from Point Fermin. The term of this MOU expired in 2004; however, currently a significant number (roughly 84% in 2007) of the OGVs operating at the Port are abiding by VSR speeds within 20 nm from Point Fermin.

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

CAAP Measure – SPBP-OGV1; Vessel Speed Reduction (VSR) Program

The San Pedro Bay Ports Clean Air Action Plan adopted by the Ports of Los Angeles and Long Beach require 90% VSR compliance for OGVs that call on the Port. Reduction in speed demands less power on the main engine, which in turn reduces NO_x emissions and fuel usage.

CARB's Low Sulfur Fuel for Marine Auxiliary Engines, Main Engines and Auxiliary Boilers

On July 24, 2008, CARB adopted low sulfur fuel requirements for marine main engines, auxiliary engines and auxiliary boilers within 24 nm of the California coastline. The regulation required the use of marine gas oil (MGO) with a sulfur content less than 1.5% by weight or marine diesel oil (MDO) with a sulfur content of equal to, or less than 0.5% by weight. For auxiliary engines, the requirements start immediately following when the regulation becomes legally effective (expected by early 2009), and in main engines and boilers by July 1, 2009. The use of MGO or MDO with a sulfur content of equal to or less than 0.1 % will be required in all engines and boilers by January 1, 2012. The use of low sulfur fuel will reduce emissions of NO_x, DPM and SO_x.

CAAP Measures- SPBP-OGV3 and 4; OGV Main & Auxiliary Engine Fuel Standards

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

Low-Sulfur Fuel Incentive Program

In order to accelerate the emissions reductions from ocean-going Vessels, the ports of Long Beach and Los Angeles have adopted an incentive program to encourage vessel operators to discontinue the use of highly polluting bunker fuel in favor of cleaner, ≤0.2 percent low sulfur distillate fuel. The program will pay eligible shipping lines the difference between the cost of bunker fuel and the more expensive low-sulfur distillate when used in main engines provided that the vessels use low-sulfur distillate fuel in their auxiliary engines while at berth and comply with SPBP-OGV1 (the Vessel Speed Reduction program). This program encourages and accelerates the use of cleaner fuels in ocean-going vessels prior to the implementation of lease-based low-sulfur fuel agreements and prior to the start of international treaties, and U.S. Environmental Protection Agency or California Air Resources Board regulation requiring low-sulfur fuel use. This program will end on June 30, 2009, upon the expected implementation of statewide low sulfur fuel regulation.

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

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

2.2 Harbor Craft

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

CARB's Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft[20]
As a part of the Diesel Risk Reduction Plan and Goods Movement Plan, CARB has adopted a regulation in November 2007 that will reduce DPM and NO_x emissions from new and in-use commercial harbor crafts operating in Regulated California Waters (i.e., internal waters, ports, and coastal waters within 24 nm of California coastline). Under CARB's definition, commercial harbor crafts include tug boats, tow boats, ferries, excursion vessels, work boats, crew boats, and fishing vessels. This regulation requires stringent emission limits from auxiliary and propulsion engines installed in commercial harbor crafts. All in-use, newly purchased, or replacement engines must meet EPA's most stringent emission standards per a compliance schedule set by the CARB for in-use engines and from new engines at the time of purchase. In addition, the propulsion engines on all new ferries, with the capacity of more than 75 passengers, acquired after January 1, 2009, will be required to install control technology that represents the best available control technology in addition to an engine that meets the Tier 2 or Tier 3 U.S. EPA marine engine standards, as applicable, in effect at the time of vessel acquisition. For harbor craft with home ports in the SCAQMD, the compliance schedule is accelerated by two years (compared to statewide requirements) in order to achieve earlier emission benefits required in SCAQMD. The in-use emission limits only apply to ferries, excursion vessels, tug boats and tow boats. The compliance schedule for in-use engine replacement begins in 2009.

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

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

2.3 Cargo Handling Equipment

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

CARB's Cargo Handling Equipment Regulation
In December of 2005 CARB adopted a regulation designed to reduce emissions from CHE such as yard tractors and forklifts starting in 2007. The regulation calls for the replacement or retrofit of existing engines with engines that use Best Available Control Technology (BACT). Beginning January 1, 2007 the regulation requires newly purchased, leased, or rented yard tractors to be equipped with a 2007 or later on-road engine or a Final Tier 4 off-road engine. Newly purchased, leased or rented non-yard tractors must be equipped with a certified on-road or off-road engine meeting the current model year standards in effect at the time the engine is added to the fleet. If the engine is pre-2004, then the highest level available VDEC must be installed within one year. In-use yard tractors are required to meet either 2007 or later certified on-road engine standards, Final Tier 4 off-road engine standards, or install verified controls that will result in equivalent or fewer DPM and NO_x emissions than a Final Tier 4 off-road engine. In-use non-yard tractors must either install the highest level available VDEC and/or replace to an on-road or off-road engine meeting the current model year standards. For all CHE, compliance dates are phased-in beginning December 31, 2007, based on the age of the engine and number of equipment in each model year group.

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

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

2.4 Railroad Locomotives

EPA's Emissions Standards for New and Remanufactured Locomotives and Locomotive Engines- Latest Regulation[21]

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

In March 2008, EPA adopted its final regulation – "Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters per Cylinder"[22] When fully implemented, this rule will cut PM emissions from these engines by as much as 90% and NO_x emissions by as much as 80%.

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

- *Newly-Manufactured Locomotives:* The new Tier 3 emission standards will achieve 50 percent reduction in PM beyond the Tier 2 standard and will become effective in 2012. The longer term Tier 4 emission standards which are based on the application of high efficiency catalytic after-treatment technologies for NO_x and PM will become effective in 2015 and will achieve about 80 percent reduction in NO_x and PM compared to Tier 2 standards.
- *Remanufactured Locomotives:* The regulation also establishes emission standards for remanufactured Tier 0, 1, and 2 locomotives which would achieve 50 to 60 percent reduction in PM and 15 to 20 percent reductions in NO_x.

[21] See: *http://www.epa.gov/otaq/regs/nonroad/420f08004.htm.*
[22] EPA 2008.

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

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

2.5 Heavy-Duty Vehicles

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

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

Ultra-Low Sulfur Diesel (ULSD) Fuel Requirement

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

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

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

1. By December 31, 2009, all pre-1994 model year (MY) engines are to be retired or replaced with 1994 and newer MY engines. Furthermore, all drayage trucks with 1994 – 2003 MY engines will be required to achieve an 85 percent PM emission reduction through the use of an ARB approved Level 3 verified diesel emission control strategy (VDECS).
2. By December 31, 2013, all trucks operating at California ports must comply with the 2007+ on-road heavy-duty truck engine standards.

CAAP Measures- SPBP-HDV1- Performance Standards for On-Road Heavy-Duty Vehicles

Per the stated goals of the CAAP, the Ports of Los Angeles and Long Beach approved a tariff plan which progressively bans older trucks from operating at the two ports. The ban is implemented in three phases as follows:

1. By 1 October 2008 – All pre-1989 trucks are banned from ports services.
2. By 1 January 2010 – All 1989-1993 trucks along with un-retrofitted 1994-2003 trucks are banned from ports services.
3. By 1 January 2012 – All trucks that do not meet 2007and later on-road heavy duty engine standards are banned from ports services.

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

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

2.6 Greenhouse Gases

Assembly Bill 32 (AB32), the California Global Warming Solutions Act of 2006, establishes a first-in-the world comprehensive program requiring the CARB to develop regulatory and market mechanisms that will ultimately reduce green house gas (GHG) emissions to 1990 levels by the year 2020 and reduce emissions to 80 percent below 1990 levels by 2050. Mandatory caps will begin in 2012 for significant sources and ratchet down to meet the 2020 goals. In the interim, CARB will begin to measure the GHG emissions of industries determined to be significant sources of GHG emissions.

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

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

On October, 2008, CARB released a proposed Climate Change Scoping Plan to achieve the reductions in greenhouse gas (GHG) emissions mandated in AB 32. The AB 32 Scoping Plan contains the main strategies California will use to reduce the GHGs that cause climate change. Several of these measures are targeted at goods movement, including ports and are expected to achieve a combined 3.7 million metric tons of carbon dioxide equivalent. Proposed measures in the Scoping Plan include:

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

SECTION 3 OCEAN-GOING VESSELS

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

3.1 Source Description

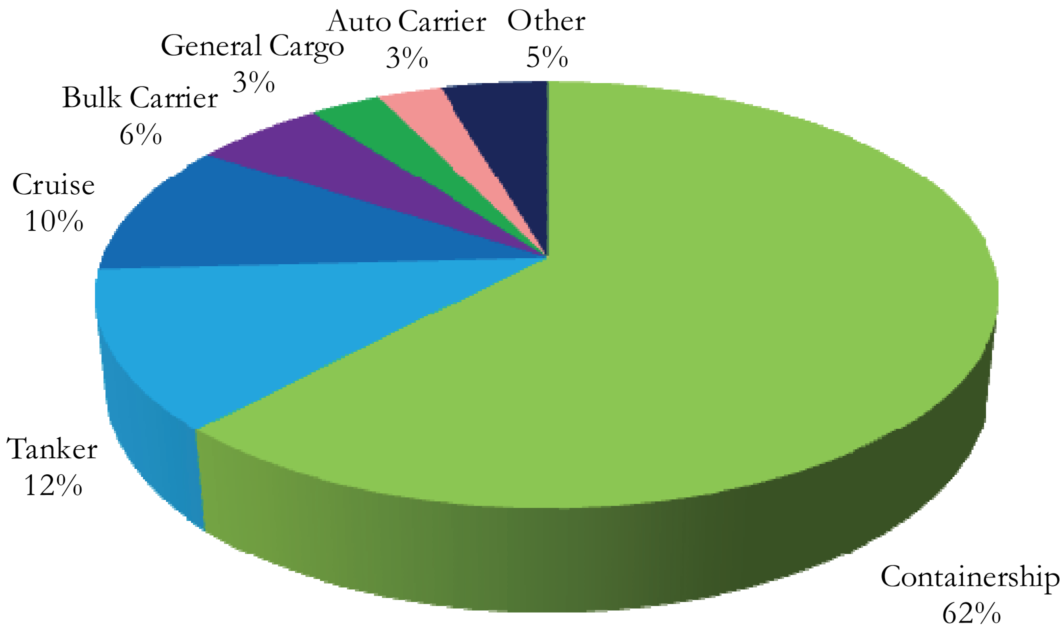
OGVs calling at the Port in 2007, whether inbound from the open ocean or transiting from neighboring POLB, are included. OGVs calling only at POLB or bypassing both ports without physically stopping at a Port dock have not been included. Harbor craft, including tugboats, excursion vessels, and other workboats, are discussed in Section 4.

Ocean-going vessels are categorized by the following main vessel types for purposes of this EI:

- Auto carrier
- Bulk carrier
- Containership
- Passenger cruise vessel
- General cargo
- Ocean-going tugboat
- Miscellaneous vessel
- Refrigerated vessel (Reefer)
- Roll-on roll-off vessel (RoRo)
- Tanker

Based on 2007 Marine Exchange data, there were 2,538 calls to the port in 2007. Figure 3.1 shows the percentage of inbound calls by vessel type. Containerships (62%) made the majority of the inbound calls; followed by tankers (12%); cruise ships (10%); bulk carriers (6%); general cargo (3%) and auto carriers (3%). Ocean tugs, reefers, RoRos and miscellaneous vessels, are included in the "other" category with 5% of the calls. Due to rounding, percentages may not add up to 100%.

Figure 3.1: Distribution of Vessel Types by Inbound Calls



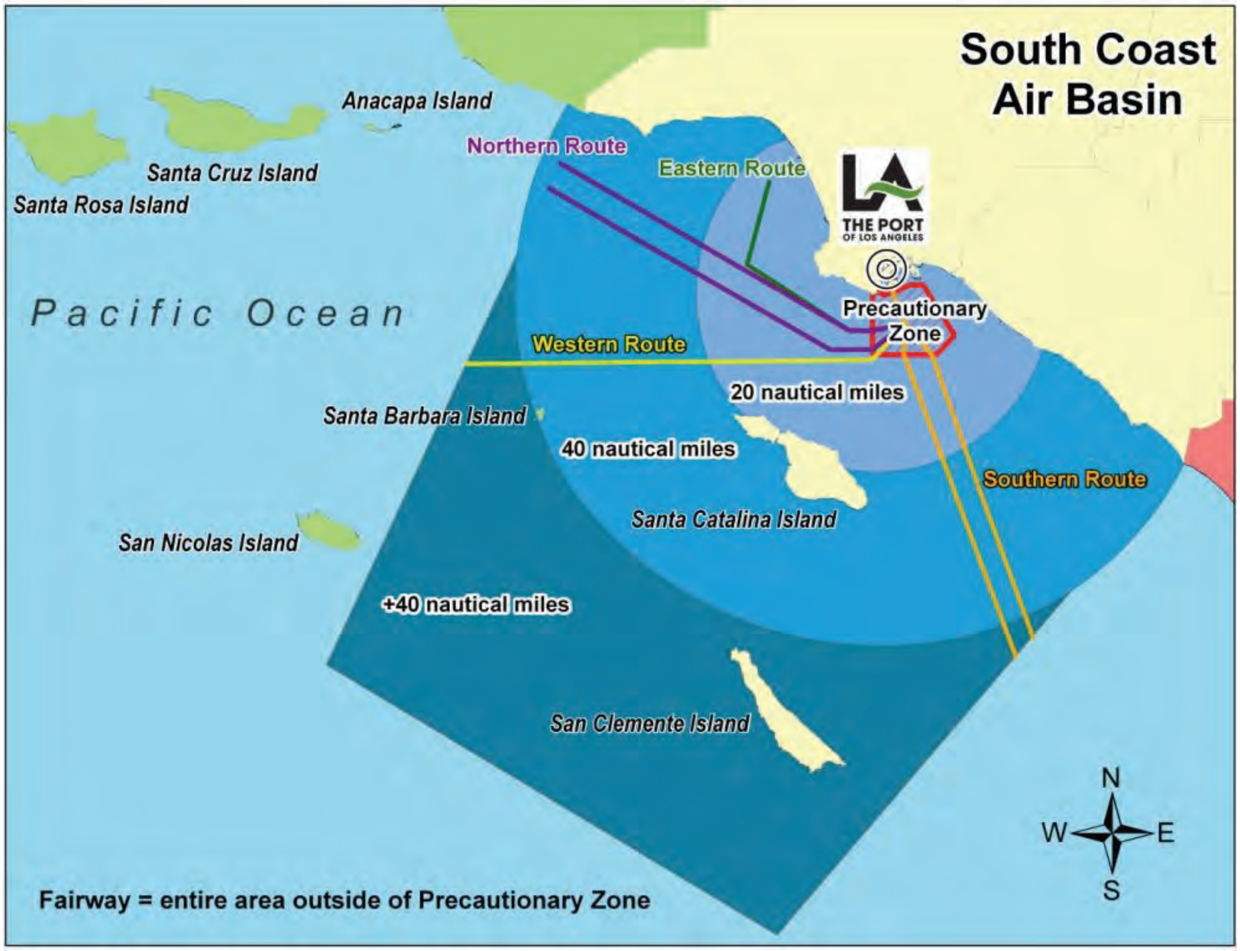
3.2 Geographical Delineation

The geographical extent of the emissions inventory for commercial marine vessels is the boundary for SoCAB. Figure 3.2 shows this portion of the study area as well as the major shipping routes. The Marine Exchange of Southern California (MarEx) ship routes were used along with their estimates of travel distances offshore from Point Fermin. These trip segments were organized into four routes (each comprised of both inbound and outbound traffic) reflecting north, east (El Segundo), west, and south routes, as designated by the MarEx.[23]

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

[23] Marine Exchange of California Vessel Tracking Service. See: *http://www.mxsocal.org/vessel-traffic-service.aspx.*

Figure 3.2: Geographical Extent, Fairway and Major Shipping Routes



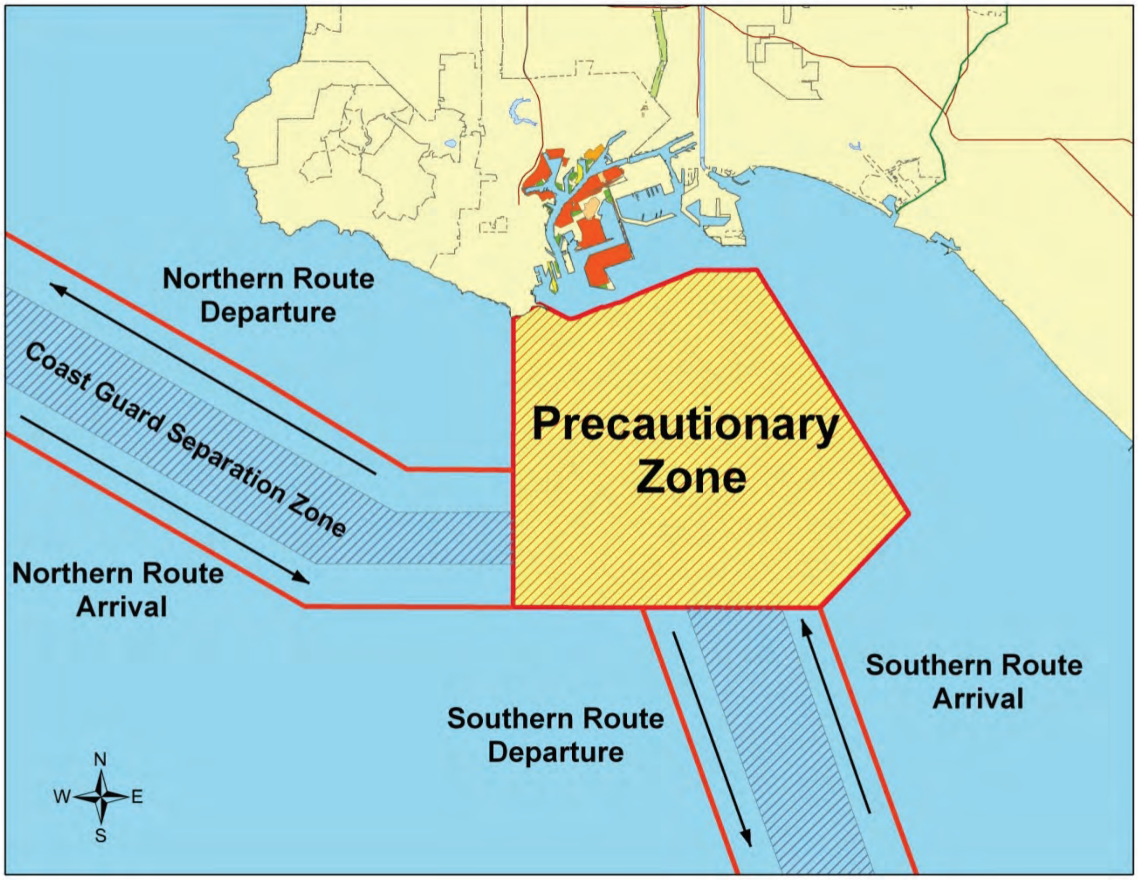
The distances in nautical miles (nm) for the various routes are listed in Table 3.1. The distances shown are from the precautionary zone (PZ) to the basin boundary and from the breakwater (BW) to the PZ.

Table 3.1: Route Distances, nm

Route	PZ to Boundary Distance, nm		BW to PZ Distance, nm	
	Inbound	Outbound	Inbound	Outbound
North	40.0	39.0	7.5	5.0
East	23.5	21.5	7.5	5.0
South	34.0	38.0	8.5	8.3
West	43.5	43.5	7.5	5.0

The PZ is a designated area where ships are preparing to enter or exit a port. In this zone the pilots are picked up or dropped off. Figure 3.3 shows the precautionary zone.

Figure 3.3: Precautionary Zone



The harbor is located within the breakwater and is characterized by the slowest vessel speeds. In the harbor, the vessels may be maneuvering to dock or undock or they may be hotelling while the cargo is loaded and/or unloaded.

3.3 Data and Information Acquisition

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

- Marine Exchange of Southern California
- Vessel Speed Reduction Program speed data
- Los Angeles Pilot Service
- Lloyd's Register of Ships
- Port Vessel Boarding Program data
- Nautical charts and maps

Each data source is detailed in the following subsections.

3.3.1 Marine Exchange of Southern California

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

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

- vessel types
- calculated hotelling time
- distribution of arrival and departure travel directions by route
- number of ship calls
- names of vessels
- vessel origination and destination

3.3.2 Vessel Speed Reduction Program Data

MarEx monitors OGV speeds over the four routes into and out of the Port as part of a VSR program that was started in May 2001. The actual speeds in the fairway are used and thus the full effect of the VSR program is taken into consideration for the fairway speeds.

3.3.3 Los Angeles Pilot Service

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

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

For the majority of the movements (roughly 85%), the maneuvering times were matched for each movement. For those movements that could not be matched, defaults were used for each mode, ship type and terminal based on average trip times. There were over 300 defaults for each of these modes, since ship type and terminal were also taken into consideration. The various modes are discussed in greater detail in Section 3.4.

3.3.4 Lloyd's Register of Ships

Lloyd's[24] is considered to be the leading resource for obtaining ship characteristics such as tonnage, speed, engine power plant configuration, age, and other parameters. The company is known as a classification society for the purpose of insuring many of the vessels on an international basis; for the vessels classified by Lloyd's the data are quite complete, however, for other ships using a different insurance certification authority, the data are less complete and/or accurate. Lloyd's was used for obtaining information such as main and auxiliary engine power and vessel speed ratings because it is the best available source of such information. The survey results from the Port of Los Angeles Vessel Boarding Program suggest that the current Lloyd's data are fairly accurate for propulsion horsepower and vessel speed.

The company Fairplay has the rights to Lloyd's ship data and sells the software containing information on commercial marine vessels, which include ocean-going vessels. Lloyd's data used in this report was obtained in February 2008. The worldwide fleet of OGVs was assembled in a common database and a query was completed to match with the MarEx vessel data. There was nearly a 100% match between the Lloyd's data and MarEx data (some integrated and articulated tug barges were not found in Lloyd's).

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

Another source of ship data that was used only for the ocean tugs which are integrated and articulated tug barges (ITB and ATB), was the American Bureau of Shipping (ABS), a major classification society. Data obtained included engine information for the ocean-going tugboats such as horsepower.

3.3.5 Vessel Boarding Program Survey Data

The best source of local activity data and ship parameters is from the individuals who own and/or operate the vessels. The Vessel Boarding Program (VBP) was an in-depth survey of OGVs during which Starcrest consultants actually rode on the ship and interviewed the ship's executive and engineering staff, usually the Captain and Chief Engineer.

Building on previous boardings conducted by the Port of Los Angeles, Port of Long Beach and Starcrest, this inventory includes the information from previous boardings, new data received from companies and new boardings conducted since the last inventory. Figure 3.4 presents the percent of vessels by vessel type for the vessels boarded at the Port of Los Angeles between 2003 and 2008.

Figure 3.4: Percent by Vessel Type of Vessels Boarded in 2003-2008

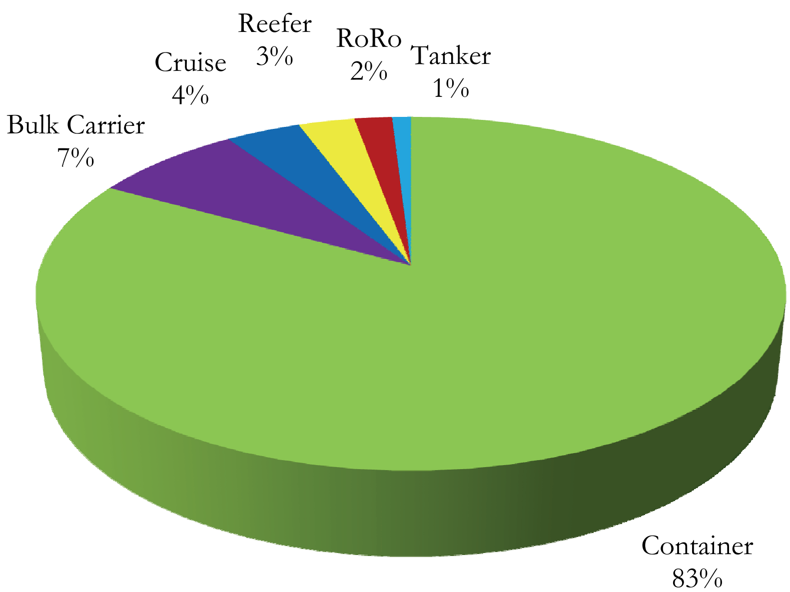


Table 3.2 summarizes the Port of Los Angeles VBP statistics.

Table 3.2: Port of Los Angeles Vessel Boarding Program Statistics

Count	Type
214	Boardings
53	Arrivals
113	At berth
47	Departures
28	Shipping lines
137	Vessels

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

Table 3.3: Vessel Boarding Program Statistics

Number of Vessels	Program
137	Port of Los Angeles
41	Port of Long Beach
32	Puget Sound
303	Data provided without boarding
513	**Vessels Total**

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

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

The specific values used for emission estimation methodology are discussed in Section 3.5. Other data collected and findings are summarized in Section 3.7. For main engine data, the match with Lloyd's and ABS data was 100%, so defaults for main engine power were not required

Auxiliary Engine Data

Due to the fact that auxiliary engine information is usually not provided to Lloyd's by vessel owners since it is not required by IMO or the classification societies, Lloyd's contains minimal auxiliary engine information. For the 2007 vessels that called at the Port, 14% of the discrete vessels had matching auxiliary engine information found in Lloyd's data and an additional 21% of the data came from the information gathered by vessel boardings and sister ships. Table 3.4 provides a summary by vessel type. Approximately 65% of the vessels required use of average defaults for auxiliary engine power. See section 3.5.9 for auxiliary engine default discussion.

Table 3.4: Auxiliary Engine Information from VBP and Lloyd's Data

Vessel Type	VBP	Sister Ships	Lloyds	Default	Total
Auto Carrier	0	0	0	33	33
Bulk - General	2	0	7	100	109
Bulk - Heavy Load	0	0	2	0	2
Bulk Wood Chips	0	0	0	2	2
Container - 1000	7	0	3	30	40
Container - 2000	3	2	0	15	20
Container - 3000	7	3	2	12	24
Container - 4000	37	23	18	34	112
Container - 5000	19	16	1	31	67
Container - 6000	8	3	8	7	26
Container - 7000	12	2	3	4	21
Container - 8000	0	0	1	2	3
Cruise	0	0	9	13	22
General Cargo	3	5	3	31	42
Ocean Tug	3	0	0	5	8
Miscellaneous	0	0	1	2	3
Reefer	6	0	5	18	29
RoRo	0	0	1	1	2
Tanker - General	0	0	15	57	72
Tanker - Chemical	0	0	2	30	32
Tanker - Crude - Aframax	0	0	2	1	3
Tanker - Crude - Handyboat	0	0	0	3	3
Tanker - Crude - Panamax	0	0	5	5	10
Tanker - Oil Products	2	0	18	72	92
Total	**109**	**54**	**106**	**508**	**777**
Percentage of total	**14%**	**7%**	**14%**	**65%**	**100%**

DB ID477

3.4 Operational Profiles

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

- MarEx trip tables which define arrivals, departures, and shifts
- MarEx speed tables which define speeds for the VSR Program at 10, 15 and 20 nautical miles
- Los Angeles Pilot Services data which provide transit times for harbor maneuvering

Before processing the data, the column headings were checked and date/time stamps were put into a standard format. Pre-processing also involved creation of a new MarEx variable to calculate elapsed time for the purposes of calculating hotelling time. The calculation involved subtracting departure time from arrival time while at berth or anchorage. Ship movements are tracked by MarEx as to:

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

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

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

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

There are three broad categories of shifts:

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

Table 3.5 presents the arrivals, departures, shifts and total movements for vessels at the Port in 2007. Arrivals and departures do not match because the activity is based on a calendar year.

Table 3.5: Total OGV Movements for 2007

Vessel Type	Arrival	Departure	Shift	Total
Auto Carrier	69	68	11	148
Bulk	135	103	142	380
Bulk - Heavy Load	2	2	3	7
Bulk Wood Chips	3	3	1	7
Container - 1000	234	235	44	513
Container - 2000	104	104	8	216
Container - 3000	127	127	22	276
Container - 4000	537	533	62	1,132
Container - 5000	329	313	32	674
Container - 6000	160	160	16	336
Container - 7000	80	80	11	171
Container - 8000	4	1	3	8
Cruise	256	255	1	512
General Cargo	77	75	55	207
Ocean Tug	65	54	69	188
Miscellaneous	2	1		3
Reefer	47	44	52	143
RoRo	1	3	1	5
Tanker	105	61	195	361
Tanker - Chemical	33	28	47	108
Tanker - Crude - Aframax	3	3	2	8
Tanker - Crude - Handyboat	4	3	7	14
Tanker - Crude - Panamax	13	9	39	61
Tanker - Oil Products	148	96	277	521
LA Total	**2,538**	**2,361**	**1,100**	**5,999**

DB ID451

3.5 Methodology

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

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

$$E = Energy \times EF \times FCF$$ Equation 3.1

Where:

E = Emissions from the engine(s)
Energy = Energy demand, in kW-hrs, calculated using Equation 2.2 below as the energy output of the engine (or engines) over the period of time
EF = Emission factor, usually expressed in terms of g/kW-hr
FCF = Fuel correction factor

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

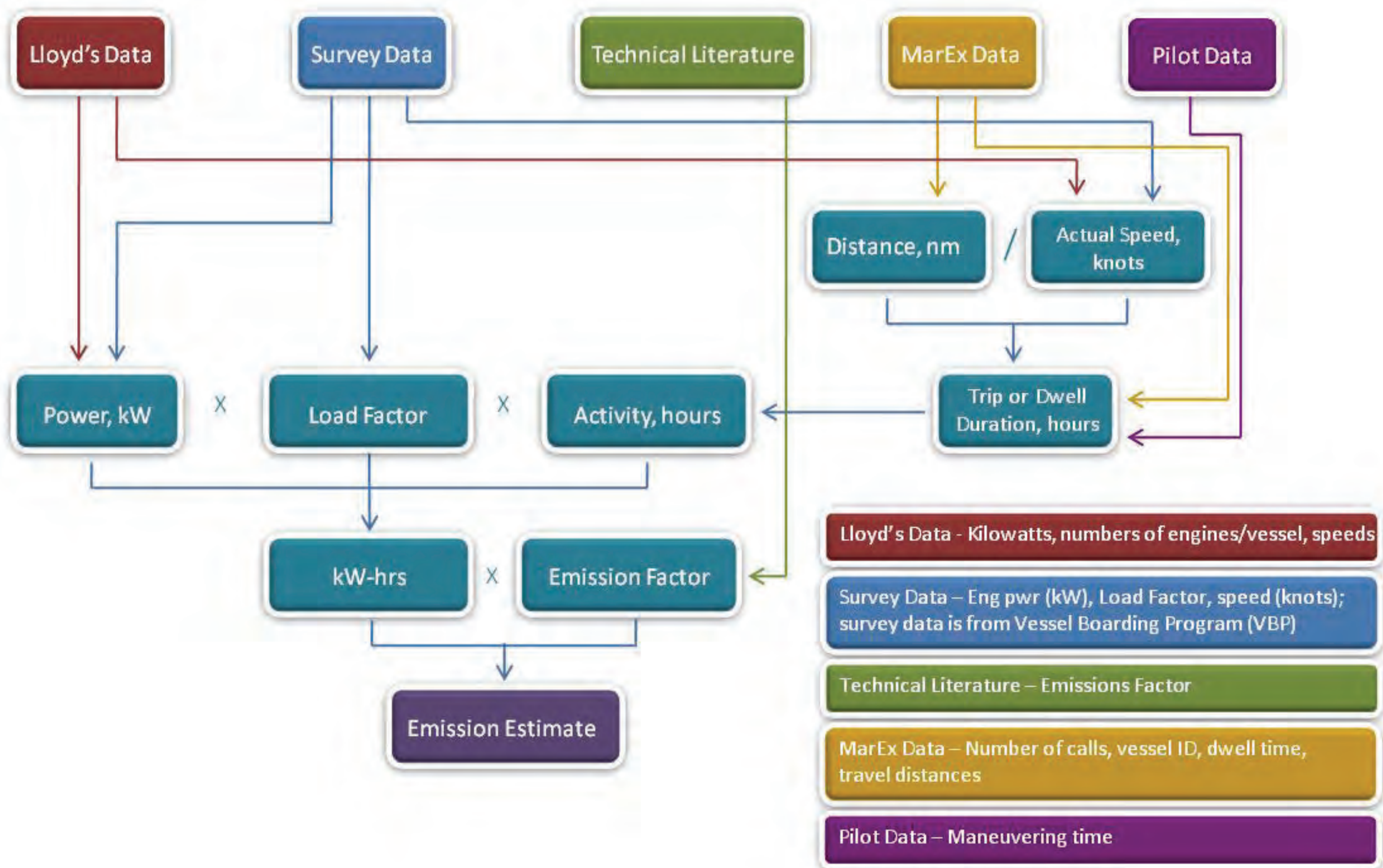
$$Energy = MCR \times LF \times Act$$ Equation 3.2

Where:

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

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

Figure 3.5: Propulsion Engine Emission Estimation Flow Diagram



3.5.1 Propulsion Engine Maximum Continuous Rated Power

MCR power is defined as the manufacturer's tested engine power; for this study, it is assumed that the Lloyd's 'Power' value is the best surrogate for MCR power. The international specification is to report MCR in kilowatts, and it is related to the highest power available from a ship engine during average cargo and sea conditions. However, operating a vessel at 100% of its MCR power is very costly from a fuel consumption and engine maintenance perspective, so most operators limit their maximum power to about 80% of MCR.

3.5.2 Propulsion Engine Load Factor

Load factor is expressed as the ratio of a vessel's power output at a given speed to the vessel's MCR power. As suggested above, at normal service speed, a ship probably has a load factor of close to 80%. For intermediate speeds, the Propeller Law is used to estimate ship propulsion engine loads, based on the theory that propulsion power varies by the cube of speed.

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

Where:

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

3.5.3 Propulsion Engine Activity

Activity is measured in hours of operation. Actual in-harbor maneuvering and transit times were taken from Pilot data. The VSR program requests vessels to travel at or below 12 knots when the vessel is 20 nm out. Vessel speeds are recorded by the Marine Exchange for zones called 10, 15 and 20. The zones are estimated by radius distance from Point Fermin, so the distances are in the 10, 15 and 20 nm range made by the concentric circles, but the actual distance is not exactly 10, 15, and 20. The VSR speed data is used instead of averages for the fairway extending to approximately 20 miles. For the at-sea portion not covered by VSR actual speed data, transit times were estimated by dividing distance traveled by ship speed.

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

Where:

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

The PZ uses assigned speeds based on VBP data, as found in Table 3.6.

Table 3.6: Precautionary Zone Speed, knots

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

DB ID472

3.5.4 Propulsion Engine Emission Factors

The main engine emission factors used in this study were reported in a 2002 ENTEC study,[25] except for PM emission factors which were provided by CARB. The greenhouse gas emission factors for CO_2, CH_4 and N_2O were reported in an IVL 2004 study.[26] Vessels are assumed to operate their main engines on residual oil (RO) which is intermediate fuel oil (IFO 380) or one with similar specifications, with an average sulfur content of 2.7%. This is supported by information collected during the VBP and 2005 CARB survey; exceptions are made for those vessels that use a different fuel other than residual fuel. The two predominant propulsion engine types are:

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

The emission factors for propulsion power using residual fuel are listed below. Table 3.8 includes emission factors for the greenhouse gases carbon dioxide, methane, and nitrogen dioxide.

[25]ENTEC, *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community, Final Report*, July 2002. Prepared for the European Commission.(ENTEC 2002).
[26] IVL, *Methodology for Calculating Emissions from Ships: Update on Emission Factors"*. Prepared by IVL Swedish Environmental Research Institute for the Swedish Environmental Protection Agency.

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

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

DB ID454

Table 3.8: GHG Emission Factors for OGV Propulsion Power using Residual Oil, g/kW-hr

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

DB ID453

3.5.5 Propulsion Engines Low Load Emission Factors

In general terms, diesel-cycle engines are not as efficient when operated at low loads. An EPA study[27] prepared by Energy and Environmental Analysis, Inc. (EEIA) established a formula for calculating emission factors for low engine load conditions such as those encountered during harbor maneuvering and when traveling slowly at sea such as in the reduced speed zone. While mass emissions (e.g., pounds per hour) tend to go down as vessel speeds and engine loads decrease, the emission factors (e.g., g/kW-hr) increase. This is based on observations that compression-cycle combustion engines are less efficient at low loads. Low load emission factor equations were developed from EPA emission factors for marine vessels at full load. These equations work well to describe the low-load effect where emission rates can increase, based on a limited set of data from Lloyd's Maritime Program and the U.S.

[27] EEIA for Sierra Research, for EPA, *Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data,* February 2000. Sierra Research work assignment No. 1-10. EPA420-R-002.

Coast Guard. The low load effect was first described in a study conducted for the EPA in 2002.[28] The equation is based on the variables provided in Table 3.9.

Table 3.9: Low-Load Emission Factor Regression Equation Variables as Modified

Pollutant	Exponent	Intercept (b)	Coefficient (a)
PM	1.5	0.25	0.0059
NO_x	1.5	10.45	0.1255
CO	1.0	0.15	0.8378
HC	1.5	0.36	0.0667

DB ID476

The equation was used to generate emission factors for the entire range of load factors from 2% to 20% for each pollutant, as follows:

$$\mathbf{y = a(fractional\ load)^{-x} + b} \qquad \text{Equation 3.5}$$

Where:

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

Each of the 20 EEIA factors was divided by the emission factor at 20% EEAI load. This resulted in positive numbers, since emissions increased as load decreased. At 20% load, the value was exactly 1.0 since it was divided into itself. These numbers are called low-load adjustment factors (LLA) and are listed in Table 3.10. The LLA multipliers are then applied to any at sea emission factor. The database then computes the resulting emission factor for each pollutant. Low load emission factors are not applied to steamships or ships having gas turbines because the EPA study only observed rise in factors for diesel engines.

[28] EPA, *Commercial Marine Inventory Development,* July 2002. EPA 420-R-02-019. (IVL 2004).

Table 3.10: Low Load Adjustment Multipliers for Emission Factors

Load	PM	NO_x	SO_x	CO	HC	CO_2	CH_4	N_2O
2%	7.29	4.63	1.00	9.68	21.67	1.00	21.67	4.63
3%	4.33	2.92	1.00	6.46	11.95	1.00	11.95	2.92
4%	3.09	2.21	1.00	4.86	7.87	1.00	7.87	2.21
5%	2.44	1.83	1.00	3.89	5.73	1.00	5.73	1.83
6%	2.04	1.60	1.00	3.25	4.43	1.00	4.43	1.60
7%	1.79	1.45	1.00	2.79	3.59	1.00	3.59	1.45
8%	1.61	1.35	1.00	2.45	2.99	1.00	2.99	1.35
9%	1.48	1.27	1.00	2.18	2.56	1.00	2.56	1.27
10%	1.38	1.22	1.00	1.96	2.23	1.00	2.23	1.22
11%	1.30	1.17	1.00	1.79	1.98	1.00	1.98	1.17
12%	1.24	1.14	1.00	1.64	1.78	1.00	1.78	1.14
13%	1.19	1.11	1.00	1.52	1.61	1.00	1.61	1.11
14%	1.15	1.08	1.00	1.41	1.48	1.00	1.48	1.08
15%	1.11	1.06	1.00	1.32	1.36	1.00	1.36	1.06
16%	1.08	1.05	1.00	1.24	1.27	1.00	1.27	1.05
17%	1.06	1.03	1.00	1.17	1.19	1.00	1.19	1.03
18%	1.04	1.02	1.00	1.11	1.12	1.00	1.12	1.02
19%	1.02	1.01	1.00	1.05	1.05	1.00	1.05	1.01
20%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

DB ID475

3.5.6 Propulsion Engine Harbor Maneuvering Loads

Main engine loads within a harbor tend to be very light, especially when coasting on the way into port. During docking, when the ship is being positioned against the wharf, the assist tugboats do most of the work. Estimation of main engine maneuvering loads is the composite of several factors, such as:

- 2% load during docking
- 15 minute docking duration (based on VBP observations)
- variable loads with inbound and outbound speeds
- docking and harbor transit loads combined by percent time-in-mode

Docking and harbor transits are two subsets of what is called "maneuvering." The docking aspect is fairly routine with the exception that some ships require extra backing and turning, either on entry or exit. The port pilot data and VBP support these generalities, although maneuvering times vary by port, terminal, and ship type. Thus docking is about 2% load, but the harbor transit load has to be calculated by the Propeller Law.

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

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

Results are then weighted together by percentage of time in docking and harbor transit modes. Results of that operation are shown in Table 3.11. The departure load is typically higher than the arrival load because the engine power is used to leave the dock, while the vessel usually coasts in on arrival.

Table 3.11: Composite Harbor Maneuvering Loads

Vessel Type	Max. Rated Speed	Arrival Load	Departure Load
Auto Carrier	19	4.4%	5.7%
Bulk	14	3.7%	11.6%
Container – 1000	19	4.1%	5.0%
Container – 2000	21	3.3%	4.3%
Container – 3000	22	2.9%	3.9%
Container - 4000	24	2.3%	3.1%
Container – 5000	25	2.1%	2.8%
Container – 6000	25	2.1%	2.8%
Container – 7000	25	2.1%	2.8%
Container – 8000	25	2.2%	2.9%
Cruise	22	3.1%	3.9%
General Cargo	16	3.0%	9.6%
Ocean Tug	14	4.1%	13.3%
Miscellaneous	16	3.0%	9.4%
Reefer	19	2.8%	4.8%
RoRo	21	2.3%	4.4%
Tanker	15	3.4%	11.4%

DB ID478

3.5.7 Propulsion Engine Defaults

All the vessels that called the Port in 2007 were able to be matched for main engine power using the most current Lloyd's data, along with VBP information, and ABS data for ocean tugs. Therefore, no defaults were used for main engine power.

3.5.8 Auxiliary Engine Emission Factors

The ENTEC auxiliary engine emission factors used in this study are presented in Table 3.12. For medium speed engines built after the year 2000, the 13.0 g/kW-hr NO_X emission factor is used.

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

Engine	MY	PM_{10}	$PM_{2.5}$	DPM	NO_X	SO_x	CO[29]	HC
Medium speed	<= 1999	1.5	1.2	1.5	14.7	12.3	1.1	0.4
Medium speed	2000+	1.5	1.2	1.5	13.0	12.3	1.1	0.4

DB ID456

Table 3.13: GHG Emission Factors for Auxiliary Engines using Residual Oil, g/kW-hr

Engine	MY	CO_2	CH_4	N_2O
Medium speed	all	683	0.008	0.031

3.5.9 Auxiliary Engine Defaults

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

In addition to maximum power demand, loads were profiled as well. Vessels do not use the total auxiliary engine installed power when at sea, during hotelling and during maneuvering. For each mode and vessel type, a different number of engines may be used and at varying loads depending on several factors, such as weather and number of reefers onboard. Hotelling load is primarily what is needed to meet the power needs of the lights, heating/ventilation/air conditioning (HVAC) systems, communications, computers, ship cranes, pumps, reefer load, and various other power demands while the vessel is at dock. Maneuvering is generally the highest auxiliary load mode for OGVs as the bow thrusters need to be available and used in spurts. The fairway or open sea is generally where the lowest auxiliary loads are found as additional auxiliary power is not required for maneuvering and many vessels

[29] IVL 2004.

have shaft generators and exhaust turbine generators that help provide power to the ship in an effort to reduce operating costs through lower fuel consumption.

From the inception of the VBP, the average or typical number of auxiliary engines used and the corresponding load at sea, during maneuvering and at berth has been studied to gain a better understanding of how the auxiliary engines are used in relation to the total power installed. The load default in kilowatts is based on the percent load which takes into account the average number of actual engines used and their load. Another way to view auxiliary engine load is to see it as the kilowatts used from the total power available. Table 3.14 summarizes the total power and load defaults used for this study by vessel subtype. Cruise ships do not have default values available since each cruise ship is different.

Table 3.14: Auxiliary Engine Power and Load Defaults

Vessel Type	Total Aux Eng Power (kW)	Auxiliary Engines Load Defaults (kW)		
		Sea	Maneuvering	Hotelling
Auto Carrier	3,728	559	1,678	969
Bulk - General	1,842	313	829	184
Bulk - Heavy Load	1,218	207	548	122
Bulk Self-Discharging	2,905	494	1,307	291
Bulk Wood Chips	1,842	313	829	184
Container - 1000	3,587	466	1,794	646
Container - 2000	4,413	574	2,207	794
Container - 3000	5,216	678	2,608	939
Container - 4000	7,543	981	3,772	1,358
Container - 5000	8,111	1,054	4,056	1,460
Container - 6000	12,963	1,685	6,482	2,333
Container - 7000	13,259	1,724	6,630	2,387
Container - 8000	11,980	1,557	5,990	2,156
Cruise	na	na	na	na
General Cargo	2,424	412	1,091	541
Ocean Tug	190	32.3	85.5	42
Miscellaneous	2412	410	1,085	538
Reefer	3,199	480	1,440	1,024
Ro/Ro	6,740	1,011	3,033	1,752
Tanker - General	3,167	760	1,045	823
Tanker -Chemical	2,987	717	986	777
Tanker - Crude - Aframax	2,364	567	780	615
Tanker - Crude - Handyboat	1,900	456	627	494
Tanker - Crude - Panamax	2,793	670	922	726
Tanker - Oil Products	2,539	609	838	660
Tankers (Diesel/Electric)	1,985	476	655	516

DB ID471

3.5.10 Auxiliary Boilers

In addition to the auxiliary engines that are used to generate electricity for on-board uses, most OGVs have one or more boilers used for fuel heating and for producing hot water. Boilers are typically not used during transit at sea since many vessels are equipped with an exhaust gas recovery system or "economizer" that uses exhaust for heating purposes and therefore the boilers are not needed when the main engines are used. Boilers are only assumed to be used at reduced speeds, such as during maneuvering and when the vessel is at Port and the main engines are shut down.

Table 3.15 and 3.16 shows the emission factors used for the steam boilers based on ENTEC's emission factors for steam boilers (ENTEC 2002).

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

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

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

Engine	CO_2	CH_4	N_2O
Steam boilers	970	0.002	0.08

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

Average kW = ((daily fuel/24) x 1,000,000)/305 Equation 3.6

Auxiliary boiler energy defaults in kilowatts used for each vessel type are presented in Table 3.17. The cruise ships and tankers (except for diesel electric tankers) have much higher auxiliary boiler usage rates than the other vessel types. Cruise ships have higher boiler usage due to the number of passengers and need for hot water. Tankers provide steam for steam-powered liquid pumps, inert gas in fuel tanks, and to heat fuel for pumping. Ocean tugboats do not have boilers; therefore their boiler energy default is zero. As mentioned earlier, boilers are not typically used at sea; therefore the boiler energy default at sea is zero. The auxiliary boiler energy defaults were further refined due to additional collected data from Vessel Boarding Program and are therefore different from the defaults used in previous inventories.

Table 3.17: Auxiliary Boiler Energy Defaults

Vessel Type	Boiler Energy Defaults (kW)		
	Sea	Maneuvering	Hotelling
Auto Carrier	0	278	278
Bulk - General	0	109	109
Bulk - Heavy Load	0	109	109
Bulk Self-Discharging	0	109	109
Bulk Wood Chips	0	109	109
Container - 1000	0	232	232
Container - 2000	0	200	200
Container - 3000	0	504	504
Container - 4000	0	501	501
Container - 5000	0	615	615
Container - 6000	0	664	664
Container - 7000	0	460	460
Container - 8000	0	751	751
Cruise	0	1,000	1,000
General Cargo	0	252	252
Ocean Tug	0	0	0
Miscellaneous	0	371	371
Reefer	0	464	464
Ro/Ro	0	278	278
Tanker - General	0	371	3,000
Tanker -Chemical	0	371	3,000
Tanker - Crude - Aframax	0	371	3,000
Tanker - Crude - Handyboat	0	371	3,000
Tanker - Crude - Panamax	0	371	3,000
Tanker - Oil Products	0	371	3,000
Tankers (Diesel/Electric)	0	346	346

DB ID470

3.5.11 Fuel Correction Factors

Fuel correction factors are used to adjust the emission rates from the fuel. As discussed earlier, emission factors were given for engines using residual fuel with an average 2.7% sulfur content and marine diesel oil with an average 1.5% sulfur content. Table 3.18 lists the fuel correction factors which are consistent with CARB's fuel correction factors used for their emission estimations methodology for ocean-going vessels[30]. Some of the FCF are different from those used in previous inventory due to the use of CARB's latest FCF.

Table 3.18: Fuel Correction Factors

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

DB ID455

CARB's marine auxiliary engine fuel regulation that went into effect in 2007 required vessel operators to use marine diesel oil (MDO) or marine gas oil (MGO) with sulfur content of equal or less than 0.5% sulfur by weight within 24 nm from California. The vessel operators voluntarily complied with the regulation throughout 2007 despite court appeals. This regulation did not apply to auxiliary boilers.

Therefore, this 2007 inventory takes into account 100% of the vessels' auxiliary engines burning marine diesel fuel less than 0.5% sulfur within 24 nm from California coast and while at berth. In 2007, 26 vessels (3% of all vessels) used shore power at berth for a total of 82 calls (3% of total calls).

Per the CARB marine auxiliary engine fuel regulation, the cruise ships, which have medium speed diesel engines, burned marine diesel fuel on all their engines within 24 nm from California coast and while at berth, regardless if the engines were used for propulsion or auxiliary load. In addition to cruise ships switching fuels for their propulsion engines, a major vessel carrier voluntarily burned 0.1% sulfur on all of their vessels' main engines and auxiliary engines.

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

In summary, the following observations can be made of vessels that called at the Port in 2007 and burned a lower sulfur fuel:

- 100% of vessel calls with auxiliary engines using marine diesel fuel (less than 0.5% S)
- The percentage of vessel calls that switched to a cleaner fuel for main engines during transit is 26%

3.5.12 Emission Reduction Technologies

Control factors can also be used for emission reduction technologies that the vessel may have. One such technology for marine main engines is the fuel slide valve. This new type of fuel valve leads to better combustion process, less smoke, and lower fuel consumption which results in reduced overall emissions for NO_x (30% reduction) and PM (25% reduction). Some companies are retrofitting vessels with MAN B&W main engines in their fleet with the fuel slide valve. Since the slide valves are on a vessel by vessel basis, the inventory may not have captured all the vessels that have been retrofitted with slide valves. The newer MAN B&W engines (2005+ model year) have the fuel slide valve. The emission reductions used for the slide valves are based on MAN B&W Diesel A/S emission measurements of marine vessel *Sine Maersk*.

In 2007, fuel slide valves were used by 128 vessels that made almost 370 calls to the Port. This includes the 2005 and newer vessels with MAN B&W engines and the known vessels that retrofitted their main engines with the fuel slide valve.

3.6 Emission Estimates

A summary of the ocean-going vessel emission estimates by vessel type for all pollutants for the year 2007 is presented in Tables 3.19 and 3.20.

Table 3.19: 2007 Ocean-Going Vessel Emissions by Vessel Type, tpy

Vessel Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto Carrier	**5.3**	**4.3**	**4.9**	**73.3**	**39.1**	**6.5**	**2.9**
Bulk	12.1	9.7	10.5	191.0	102.9	16.6	6.8
Bulk - Heavy Load	0.5	0.4	0.2	6.6	6.3	0.5	0.2
Bulk Wood Chips	0.3	0.2	0.2	4.7	2.3	0.4	0.2
Bulk	**12.8**	**10.2**	**10.9**	**202.3**	**111.6**	**17.5**	**7.2**
Container - 1000	16.9	13.5	14.8	222.4	147.2	19.9	8.5
Container - 2000	10.3	8.2	6.9	128.5	111.6	11.9	5.2
Container - 3000	21.2	16.9	18.2	286.6	165.7	26.0	12.0
Container - 4000	106.1	84.9	96.5	1,486.9	755.4	145.9	70.4
Container - 5000	76.3	61.0	65.7	988.8	612.8	105.6	51.3
Container - 6000	44.7	35.7	38.9	714.6	327.1	70.6	32.7
Container - 7000	17.4	13.9	15.5	335.3	134.8	35.5	16.2
Container - 8000	0.9	0.7	0.7	11.3	7.8	1.2	0.6
Containership	**293.7**	**235.0**	**257.1**	**4,174.4**	**2,262.3**	**416.5**	**196.8**
Cruise	**25.6**	**20.5**	**22.5**	**832.3**	**215.3**	**70.5**	**28.0**
General Cargo	**8.0**	**6.4**	**6.7**	**112.7**	**72.0**	**9.6**	**4.0**
Ocean Tugboat	**1.2**	**1.0**	**1.2**	**59.7**	**5.3**	**5.2**	**2.3**
Miscellaneous	**0.1**	**0.1**	**0.1**	**1.6**	**0.6**	**0.1**	**0.1**
Reefer	**4.3**	**3.5**	**4.0**	**83.1**	**32.6**	**6.9**	**2.8**
RoRo	**0.2**	**0.1**	**0.2**	**3.3**	**1.2**	**0.3**	**0.1**
Tanker - General	20.5	16.4	8.8	199.0	298.3	17.8	7.6
Tanker - Chemical	5.9	4.7	2.5	50.2	88.0	4.5	2.0
Tanker - Crude - Aframax	0.6	0.5	0.4	6.0	8.1	0.5	0.2
Tanker - Crude - Handyboat	1.0	0.8	0.4	9.4	13.6	0.8	0.4
Tanker - Crude - Panamax	3.9	3.1	1.5	34.1	59.9	3.3	1.4
Tanker - Oil Products	32.7	26.2	12.3	300.2	509.8	27.1	11.6
Tanker	**64.6**	**51.7**	**25.8**	**599.0**	**977.7**	**54.1**	**23.3**
Total	**415.8**	**332.6**	**333.4**	**6,141.6**	**3,717.7**	**587.4**	**267.5**

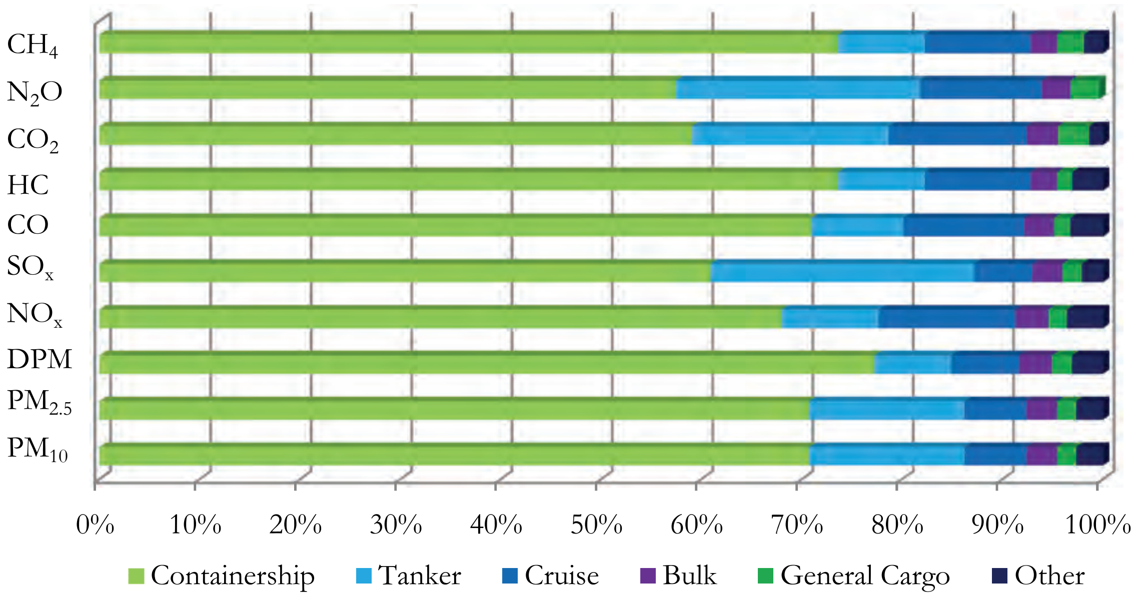
DB ID121

Table 3.20: Summary of 2007 Ocean-Going Vessel GHG Emissions by Vessel Type, tpy

Vessel Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auto Carrier	**3,385.0**	**3,329.3**	**0.2**	**0.1**
Bulk	10,594.9	10,424.6	0.5	0.1
Bulk - Heavy Load	581.0	569.8	0.0	0.0
Bulk Wood Chips	262.2	258.0	0.0	0.0
Bulk	**11,438.1**	**11,252.3**	**0.6**	**0.1**
Container - 1000	12,784.9	12,575.4	0.7	0.2
Container - 2000	9,465.8	9,284.3	0.6	0.1
Container - 3000	14,353.4	14,095.4	0.8	0.2
Container - 4000	69,690.7	68,492.4	3.8	1.4
Container - 5000	54,278.7	53,334.2	3.0	1.0
Container - 6000	37,576.1	36,940.6	2.0	0.7
Container - 7000	18,151.2	17,873.6	0.9	0.3
Container - 8000	697.6	684.4	0.0	0.0
Containership	**216,998.5**	**213,280.3**	**11.7**	**3.9**
Cruise	**50,195.4**	**49,420.2**	**2.5**	**0.6**
General Cargo	**6,449.7**	**6,340.1**	**0.3**	**0.1**
Ocean Tugboat	**2,241.9**	**2,208.4**	**0.1**	**0.0**
Miscellaneous	**79.5**	**78.3**	**0.0**	**0.0**
Reefer	**4,132.5**	**4,068.9**	**0.2**	**0.1**
RoRo	**165.6**	**163.4**	**0.0**	**0.0**
Tanker - General	22,471.6	21,996.8	1.5	0.2
Tanker - Chemical	6,300.0	6,165.0	0.4	0.0
Tanker - Crude - Aframax	546.6	535.0	0.0	0.0
Tanker - Crude - Handyboat	1,045.9	1,024.0	0.1	0.0
Tanker - Crude - Panamax	4,372.4	4,278.3	0.3	0.0
Tanker - Oil Products	37,710.5	36,898.3	2.6	0.2
Tanker	**72,447.0**	**70,897.4**	**5.0**	**0.5**
Total	**367,533.2**	**361,038.3**	**20.6**	**5.3**

Figure 3.6 shows percentage of emissions by vessel type for each pollutant. Containerships have the highest percentage of the emissions (approximately 60 to 70%) for the vessels, followed by tankers (approximately 10 to 25%), cruise ships (approximately 10%), bulk and general cargo. The "other" category includes ocean-going tugboats and miscellaneous vessels.

Figure 3.6: 2007 Ocean-Going Vessel Emissions by Vessel Type, %



3.6.1 Emission Estimates by Engine Type

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

Table 3.21: 2007 Ocean-Going Vessel Emissions by Engine Type, tpy

Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auxiliary Engine	74.9	59.9	74.9	2,768.0	417.3	235.7	85.7
Auxiliary Boiler	78.9	63.1	0.0	207.1	1,625.9	19.7	9.9
Main Engine	262.0	209.6	258.4	3,166.5	1,674.5	331.9	171.9
Total	**415.8**	**332.6**	**333.4**	**6,141.6**	**3,717.7**	**587.4**	**267.5**

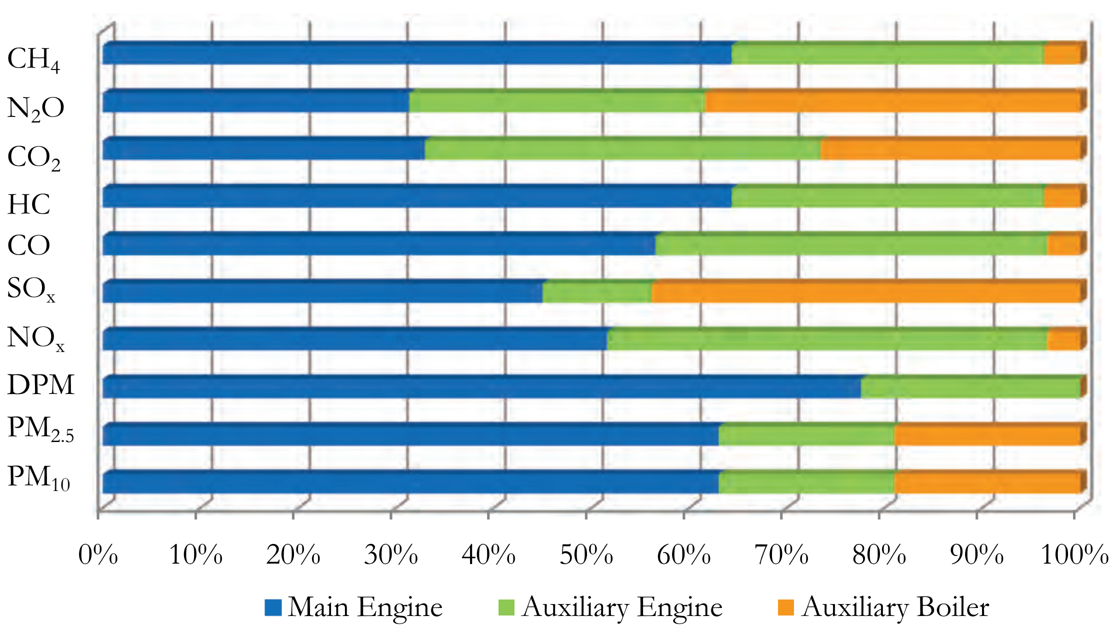
DB ID118

Table 3.22: 2007 Ocean-Going Vessel GHG Emissions by Engine Type, tpy

Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auxiliary Engine	148,346.2	146,374.3	6.2	1.7
Auxiliary Boiler	98,131.9	95,681.5	7.9	0.2
Main Engine	121,055.1	118,982.6	6.5	3.4
Total	**367,533.2**	**361,038.3**	**20.6**	**5.3**

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

Figure 3.7: 2007 Ocean-Going Vessel Emissions by Engine Type, %



3.6.2 Emission Estimates by Mode

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

Figure 3.8: 2007 Ocean-Going Vessel Emissions by Mode

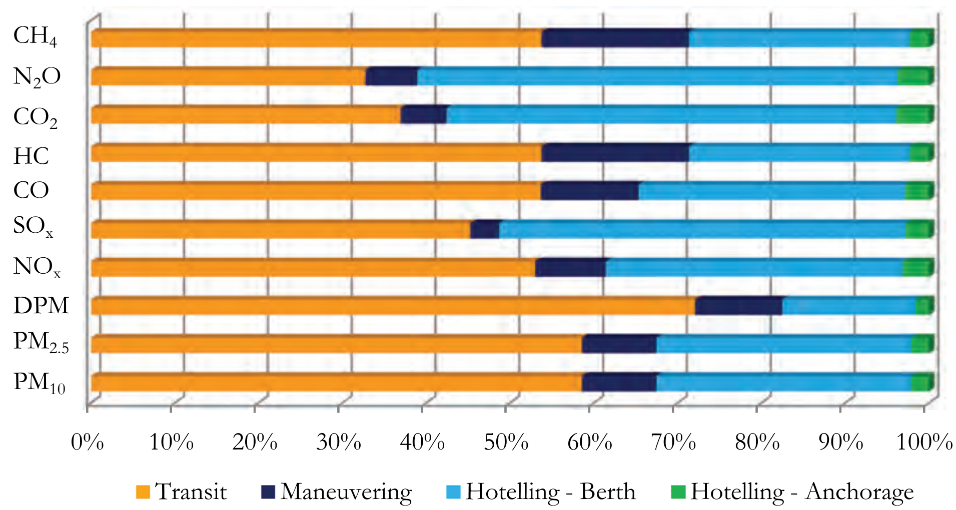


Table 3.23: 2007 Ocean-Going Vessel Emissions by Mode, tpy

Mode	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Transit	Aux	9.4	7.5	9.4	338.5	54.5	28.8	10.5
Transit	Auxiliary Boiler	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transit	Main	234.3	187.5	230.9	2,913.8	1,630.5	286.2	133.3
Total Transit		**243.7**	**195.0**	**240.2**	**3,252.3**	**1,685.0**	**315.0**	**143.8**
Maneuvering	Aux	7.0	5.6	7.0	258.9	39.3	22.1	8.0
Maneuvering	Auxiliary Boiler	2.1	1.7	0.0	5.6	44.1	0.5	0.3
Maneuvering	Main	27.6	22.1	27.6	252.7	44.0	45.7	38.6
Total Maneuvering		**36.8**	**29.5**	**34.6**	**517.2**	**127.4**	**68.3**	**46.9**
Hotelling - Berth	Aux	53.2	42.5	53.2	1,986.4	290.9	168.9	61.4
Hotelling - Berth	Auxiliary Boiler	73.2	58.6	0.0	192.3	1,509.6	18.3	9.2
Hotelling - Berth	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling - Berth		**126.4**	**101.1**	**53.2**	**2,178.7**	**1,800.5**	**187.2**	**70.6**
Hotelling - Anchorage	Aux	5.4	4.3	5.4	184.3	32.6	16.0	5.8
Hotelling - Anchorage	Auxiliary Boiler	3.5	2.8	0.0	9.2	72.2	0.9	0.4
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Hotelling - Anchorage		**8.9**	**7.1**	**5.4**	**193.5**	**104.8**	**16.8**	**6.2**
Total		**415.8**	**332.6**	**333.4**	**6,141.6**	**3,717.7**	**587.4**	**267.5**

DB ID448

Table 3.24: 2007 Ocean-Going Vessel Greenhouse Gas Emissions by Mode, tpy

Mode	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Transit	Aux	18,113.3	17,872.5	0.8	0.2
Transit	Auxiliary Boiler	0.0	0.0	0.0	0.0
Transit	Main	117,464.3	115,553.4	6.0	2.7
Total Transit		**135,577.6**	**133,426.0**	**6.7**	**2.9**
Maneuvering	Aux	13,908.6	13,723.8	0.6	0.2
Maneuvering	Auxiliary Boiler	2,664.7	2,598.2	0.2	0.0
Maneuvering	Main	3,590.8	3,429.2	0.5	0.8
Total Maneuvering		**20,164.2**	**19,751.1**	**1.3**	**0.9**
Hotelling - Berth	Aux	106,285.1	104,872.3	4.5	1.2
Hotelling - Berth	Auxiliary Boiler	91,112.3	88,837.1	7.3	0.2
Hotelling - Berth	Main	0.0	0.0	0.0	0.0
Total Hotelling - Berth		**197,397.4**	**193,709.4**	**11.8**	**1.4**
Hotelling - Anchorage	Aux	10,039.2	9,905.7	0.4	0.1
Hotelling - Anchorage	Auxiliary Boiler	4,354.9	4,246.2	0.4	0.0
Hotelling - Anchorage	Main	0.0	0.0	0.0	0.0
Total Hotelling - Anchorage		**14,394.1**	**14,151.9**	**0.8**	**0.1**
Total		**367,533.2**	**361,038.3**	**20.6**	**5.3**

3.7 Facts and Findings

Information gathered during the data collection process, but not necessarily used for emissions calculations, is summarized in this subsection. Table 3.25 summarizes the number of calls and total TEUs handled by the Port in 2001, 2005, 2006 and 2007. It was another record year with about 8.4 million total TEUs handled at the Port in 2007.

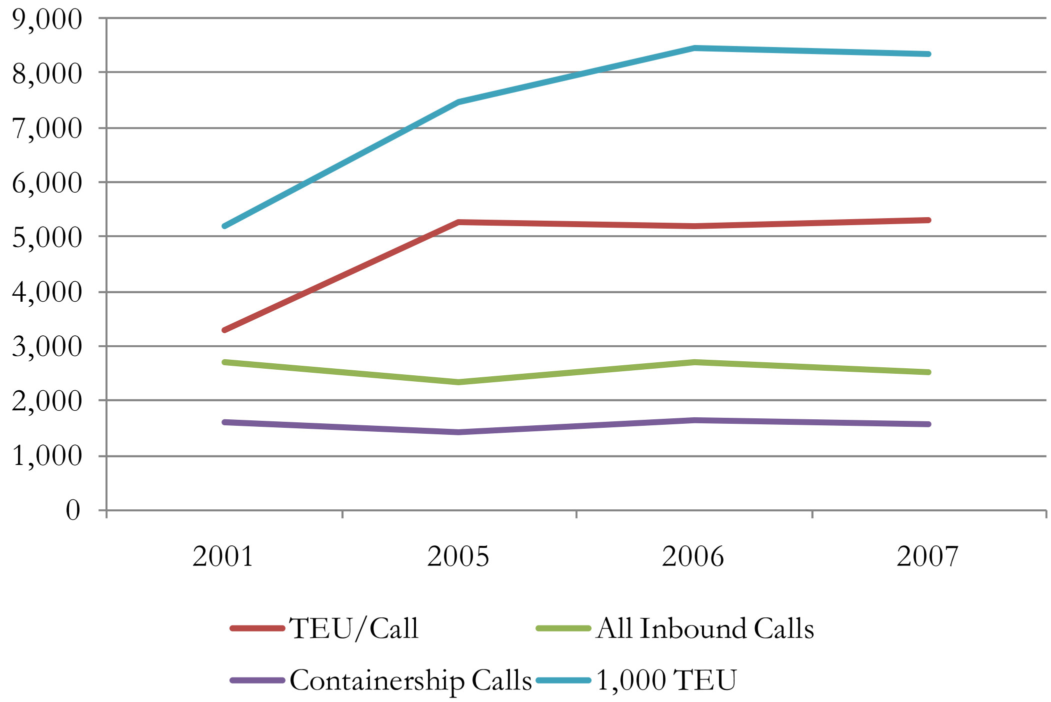
Table 3.25: TEUs per vessel call in 2007, 2006, 2005 and 2001

Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2001	2,717	1,584	5,183,520	3,272
2005	2,341	1,423	7,484,625	5,260
2006	2,708	1,626	8,469,853	5,209
2007	2,538	1,575	8,355,038	5,305

DB ID452

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

Figure 3.9: Vessel Call and TEU Trend



3.7.1 Flags of Convenience

Most OGVs are foreign flagged ships, whereas harbor vessels are almost exclusively domestic. Over 97% of the OGVs that visited the Port of Los Angeles in 2007 were registered outside the U.S. Although only 3% of the individual OGVs are registered in the U.S., they comprised 9% of all calls. This is most likely because the U.S. flagged OGVs make shorter, more frequent stops along the west coast.

Figures 3.10 and 3.11 show the breakdown of the ships' registered country (i.e., flag of registry) for discrete vessels and by the number of calls, respectively. Approximately 30 other flags of registry were not included in the pie charts separately and are included together as "other" category.

Figure 3.10: Flag of Registry, Discrete Vessel

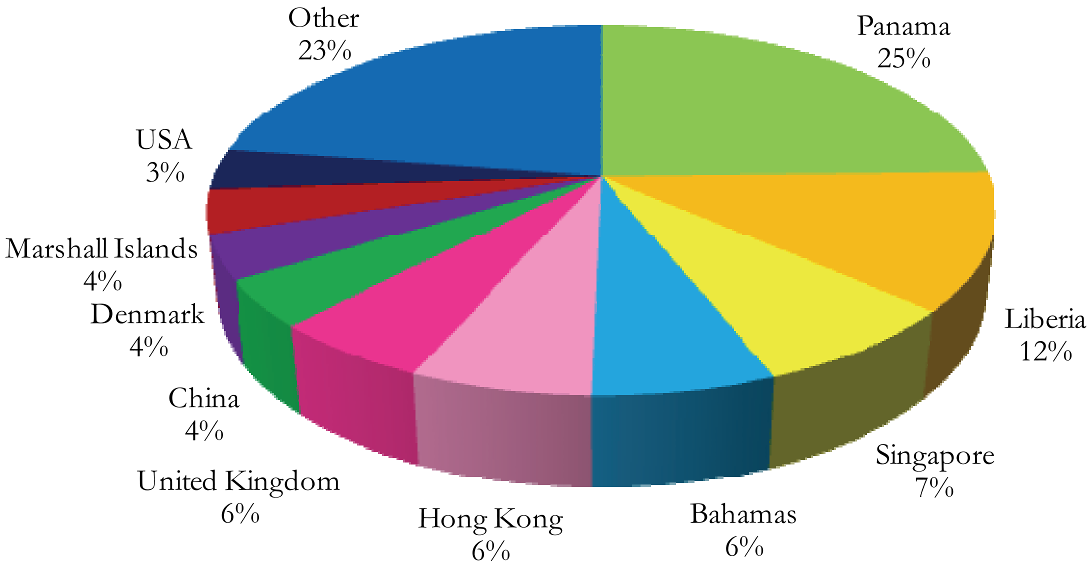
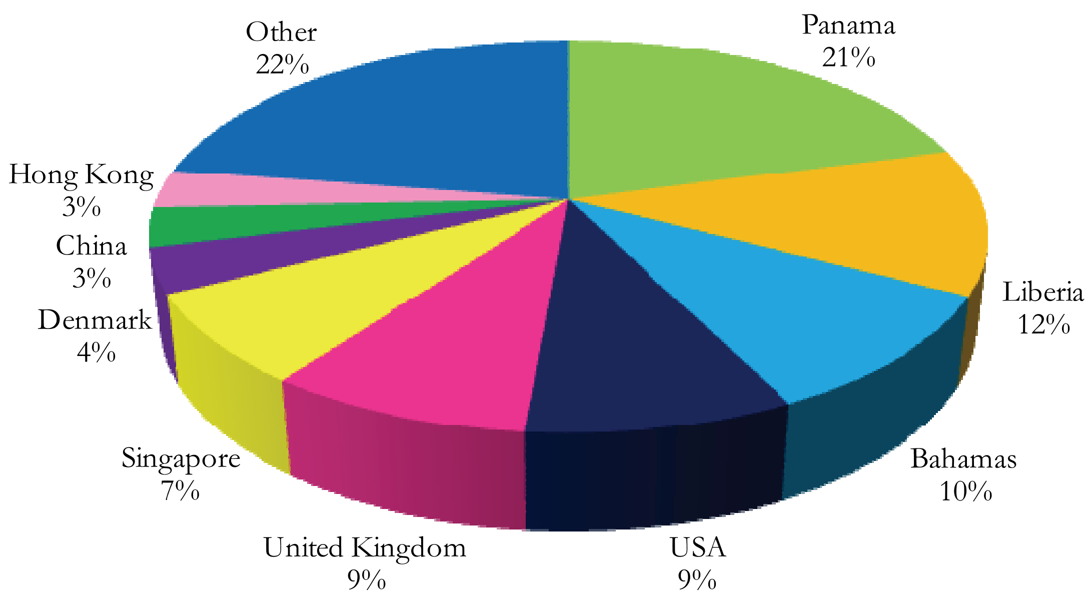


Figure 3.11: Flag of Registry, Vessel Call



3.7.2 Next and Last Port of Call

Figures 3.12 and 3.13 summarize the next (to) port and last (from) port, respectively, for vessels that called in 2007. The other category contains about 150 ports that had less than 2% each.

Figure 3.12: Next (To) Port

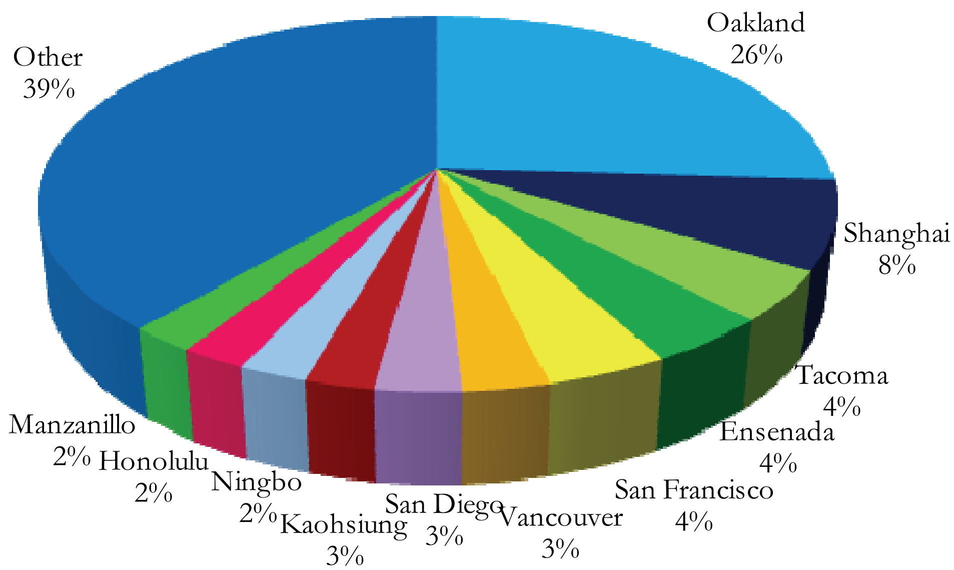
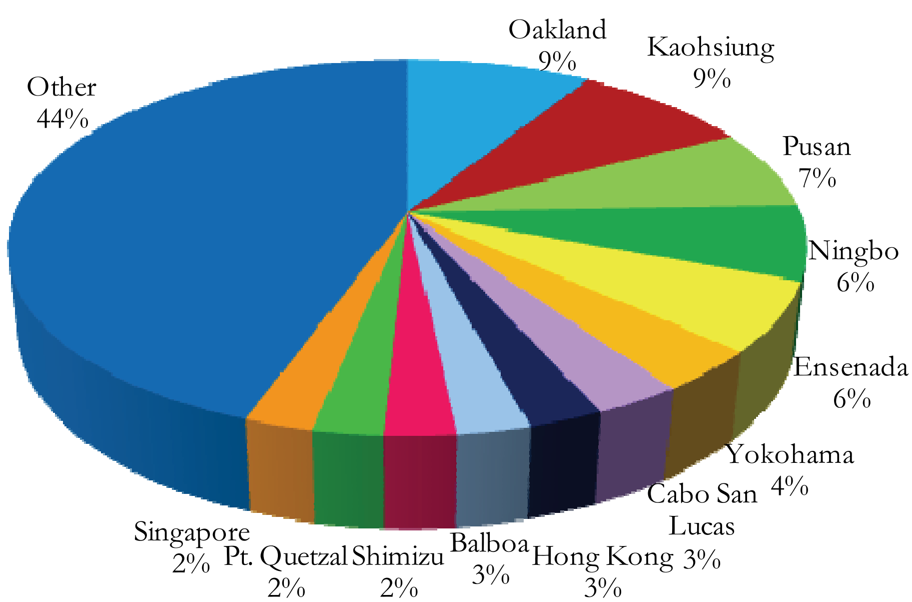


Figure 3.13: Last (From) Port



3.7.3 Vessel Characteristics

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

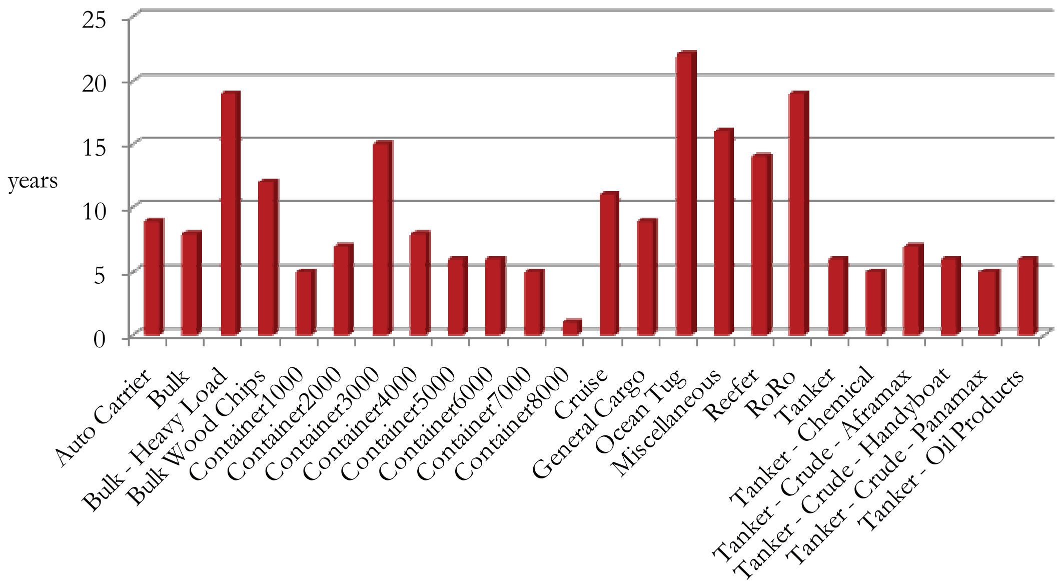
Table 3.26: Vessel Type Characteristics for Vessels that Called the Port in 2007

Vessel Type	Average Year Built	Age (Years)	DWT (tons)	Speed (knots)	Main Eng (kW)	Aux Eng (kW)
Auto Carrier	1998	9	16,177	19.2	11,394	3,728
Bulk	1999	8	44,053	14.6	8,094	1,883
Bulk - Heavy Load	1988	19	9,183	13.9	4,482	1,186
Bulk Wood Chips	1995	12	40,222	15.1	6,357	1,842
Container - 1000	2002	5	16,873	18.7	11,667	3,308
Container - 2000	2000	7	34,561	21.3	21,335	4,519
Container - 3000	1992	15	46,371	22.6	29,669	4,756
Container - 4000	1999	8	58,361	24.5	44,286	7,615
Container - 5000	2001	6	66,977	25.2	51,739	8,012
Container - 6000	2001	6	80,384	24.9	58,450	12,828
Container - 7000	2002	5	94,523	25.1	56,037	13,572
Container - 8000	2006	1	103,872	25.2	68,501	11,955
Cruise	1996	11	8,638	21.7	31,197	10,399
General Cargo	1998	9	41,228	15.7	9,759	2,423
Ocean Tug	1985	22	28,320	12.8	7,673	369
Miscellaneous	1991	16	1,269	16.9	12,411	1,616
Reefer	1993	14	11,819	19.1	9,114	3,337
RoRo	1988	19	23,028	16.6	15,755	7,437
Tanker	2001	6	41,675	14.9	8,989	3,039
Tanker - Chemical	2002	5	31,893	15.1	7,596	3,048
Tanker - Crude - Aframax	2000	7	103,761	15.0	13,040	2,520
Tanker - Crude - Handyboat	2001	6	41,839	14.9	8,875	3,049
Tanker - Crude - Panamax	2002	5	69,807	14.8	11,775	2,783
Tanker - Oil Products	2001	6	49,878	14.7	9,269	2,571

DB ID460

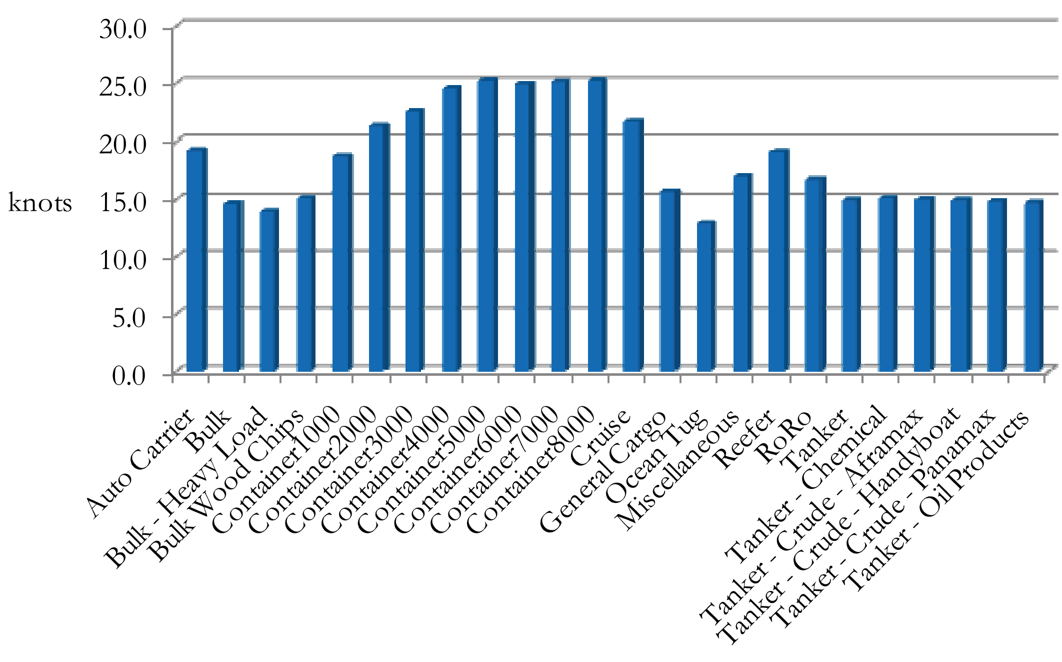
The larger containerships and tankers (Aframax and Panamax) that called the Port have newer vessels.

Figure 3.14: Average Age of Vessels that Called the Port of Los Angeles in 2007, years



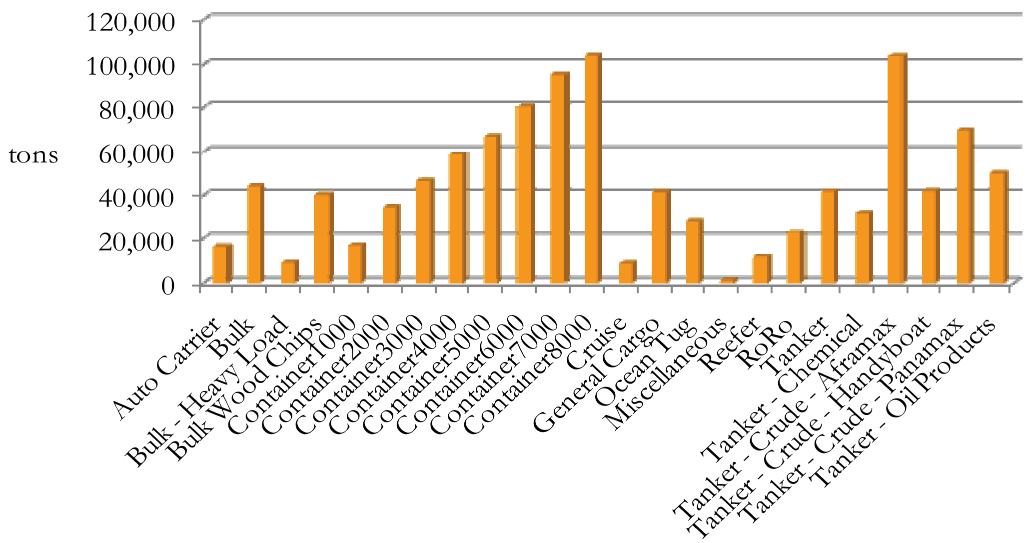
Containerships and cruise ships have the highest maximum rated speeds.

Figure 3.15: Average Maximum Rated Sea Speed of Vessels that Called the Port in 2007, knots



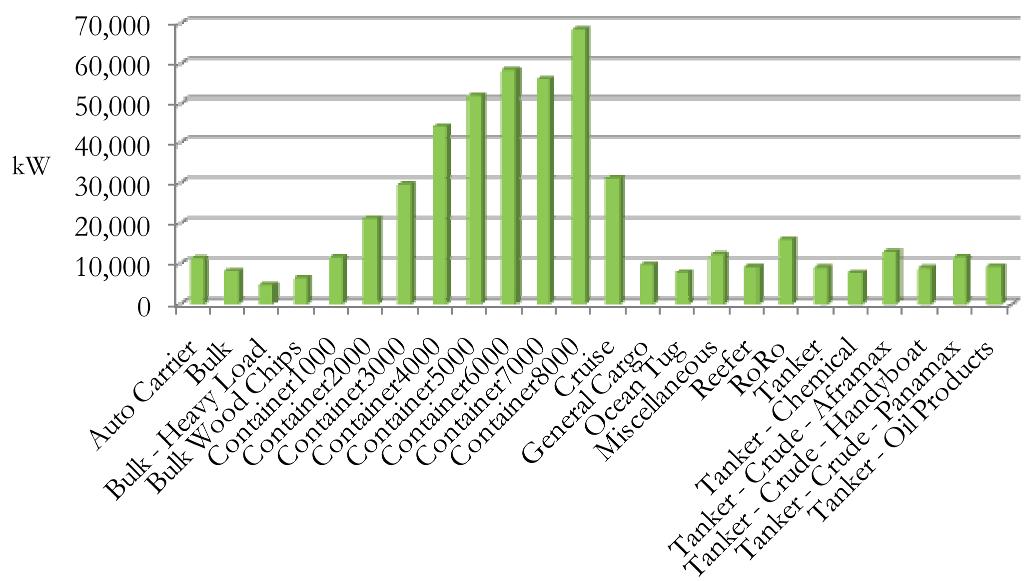
The largest containerships (7000+TEU) and the Aframax Tankers have the largest average deadweight tonnage among the various vessel types, while cruise ships, reefer, and RoRos weigh the least.

Figure 3.16: Average Deadweight of Vessels that Called the Port in 2007, tons



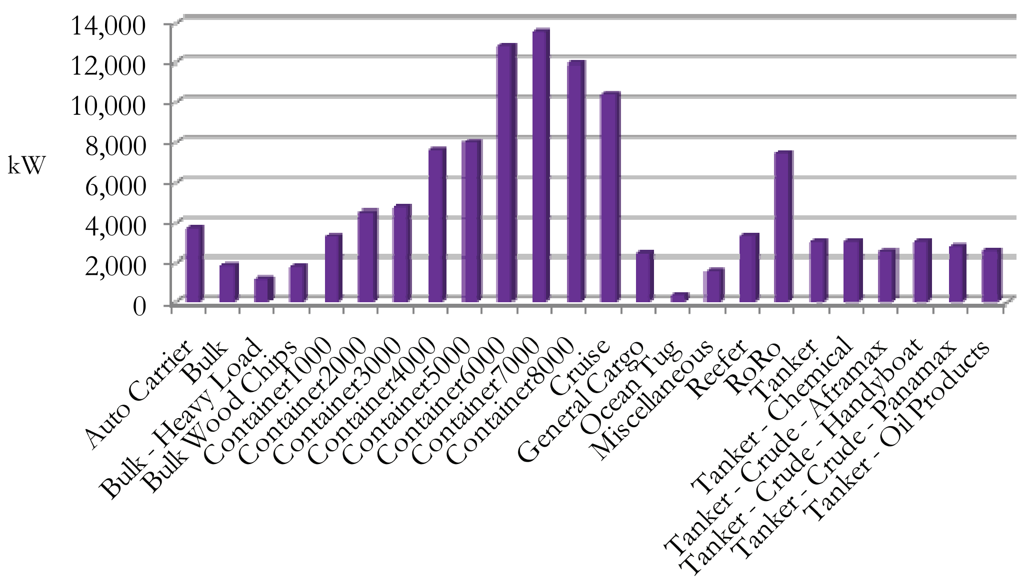
Containerships have the highest main engine total installed power, followed by cruise ships.

Figure 3.17: Average Main Engine Total Installed Power of Vessels that Called the Port in 2007, kilowatts



The 6000+ TEU containerships and cruise ships have the highest auxiliary engine total installed power.

Figure 3.18: Average Auxiliary Engine Total Installed Power of Vessels that Called the Port in 2007, kilowatts



3.7.4 Hotelling Time at Berth and Anchorage

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

Table 3.27: Hotelling Times at Berth for Vessels that Called the Port in 2007 by Vessel Type

Vessel Type	Berth Hotelling Time, hours Min	Max	Avg
Auto Carrier	7.5	48.3	19.5
Bulk	5.6	930.7	87
Bulk - Heavy Load	104.2	383.3	250.3
Bulk Wood Chips	90.7	201.1	132.4
Container - 1000	6.4	373.1	29.8
Container - 2000	13.8	74.6	39.5
Container - 3000	11.3	147.3	51.5
Container - 4000	8.2	120.5	41
Container - 5000	9.2	110.4	60.8
Container - 6000	37.4	130.7	63.4
Container - 7000	3.4	86.7	60.9
Container - 8000	26.4	96.8	71.4
Cruise	5.6	108.2	12.8
General Cargo	8.5	192.3	48.9
Ocean Tug	14.9	88.9	32
Miscellaneous	46.9	46.9	46.9
Reefer	3.2	678.3	35.9
RoRo	24.5	26.9	25.7
Tanker	7.3	82.8	30.2
Tanker - Chemical	8.1	69.3	27.5
Tanker - Crude - Aframax	27.7	37.9	34
Tanker - Crude - Handyboat	23.8	50.5	36.3
Tanker - Crude - Panamax	19.8	72.5	36.2
Tanker - Oil Products	6.5	85.7	35.8

DB ID204

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

Table 3.28: 2007 Hotelling Times at Anchorage by Vessel Type

	Anchorage Hotelling Time, hours			
Vessel Type	**Min**	**Max**	**Avg**	**Vessel Count**
Auto Carrier	1.1	32.8	9.8	10
Bulk	1.3	202.8	30.7	98
Bulk - Heavy Load	2.8	144.2	73.5	2
Bulk Wood Chips	61.2	61.2	61.2	1
Container - 1000	1.3	61.6	9.9	34
Container - 2000	2.7	11.6	6.0	4
Container - 3000	1.4	29.3	8.8	15
Container - 4000	0.8	34.9	5.9	48
Container - 5000	1.5	30.1	6.9	25
Container - 6000	1.5	7.5	3.2	15
Container - 7000	1.5	3.5	2.1	4
Container - 8000	1.5	4.8	2.7	3
Cruise	0.0	0.0	0.0	0
General Cargo	1.4	90.8	30.7	23
ITB	1.3	333.4	41.3	41
MISC	0.0	0.0	0.0	0
Reefer	2.2	44.8	11.0	11
RoRo	0.0	0.0	0.0	0
Tanker	0.7	262.3	30.5	139
Tanker - Chemical	0.9	73.5	14.8	30
Tanker - Crude - Aframax	4.8	6.9	5.8	2
Tanker - Crude - Handyboat	3.7	173.2	41.0	6
Tanker - Crude - Panamax	2.3	75.2	24.1	26
Tanker - Oil Products	0.5	444.8	44.9	189

DB ID449

3.7.5 Frequent Callers

For purpose of this discussion, a frequent caller is a vessel that made six or more calls in one year. The vessels that made a call to a berth at the Port were included, while the vessels that only went to anchorage were not. Table 3.29 shows the percentage of repeat vessels. Container vessels, cruise ships and ocean tugs had the highest percentage of frequent callers in 2007. Tankers, reefer vessels, RoRos, general cargo and bulk vessels are not frequent callers.

Table 3.29: Percentage of Frequent Callers in 2007

Vessel Type	Frequent Vessels	Total Vessels	Percent Frequent Vessels
Auto Carrier	3	33	9%
Bulk	0	109	0%
Bulk - Heavy Load	0	2	0%
Bulk Wood Chips	0	2	0%
Container - 1000	18	40	45%
Container - 2000	6	20	30%
Container - 3000	11	24	46%
Container - 4000	38	112	34%
Container - 5000	27	67	40%
Container - 6000	13	26	50%
Container - 7000	0	21	0%
Container - 8000	0	3	0%
Cruise	8	22	36%
General Cargo	1	42	2%
ITB	4	8	50%
Miscellaneous	0	3	0%
Reefer	0	29	0%
RoRo	0	2	0%
Tanker	2	72	3%
Tanker - Chemical	0	32	0%
Tanker - Crude - Aframax	0	3	0%
Tanker - Crude - Handyboat	0	3	0%
Tanker - Crude - Panamax	0	10	0%
Tanker - Oil Products	2	92	2%
Total	**133**	**777**	
Average			**17%**

SECTION 4 HARBOR CRAFT

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

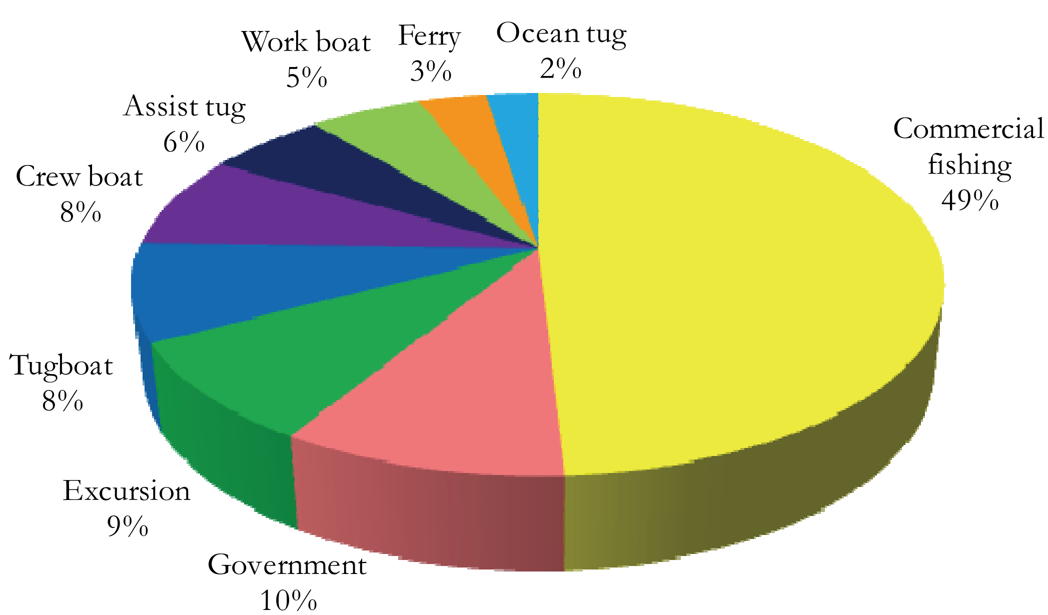
4.1 Source Description

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

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

Recreational vessels are not considered to be commercial harbor craft; therefore their emissions are not included in this study. Figure 4.1 presents the distribution of the 281 commercial harbor craft inventoried for the Port in 2007. Commercial fishing vessels represent 49% of the harbor craft inventoried, followed by the government vessels (10%), excursion vessels (9%), harbor tugboats (8%), crew boats (7%), assist tugs (6%), work boats (5%), ferries (3%), and ocean tugs (2%).

Figure 4.1: Distribution of 2007 Commercial Harbor Craft for Port of Los Angeles



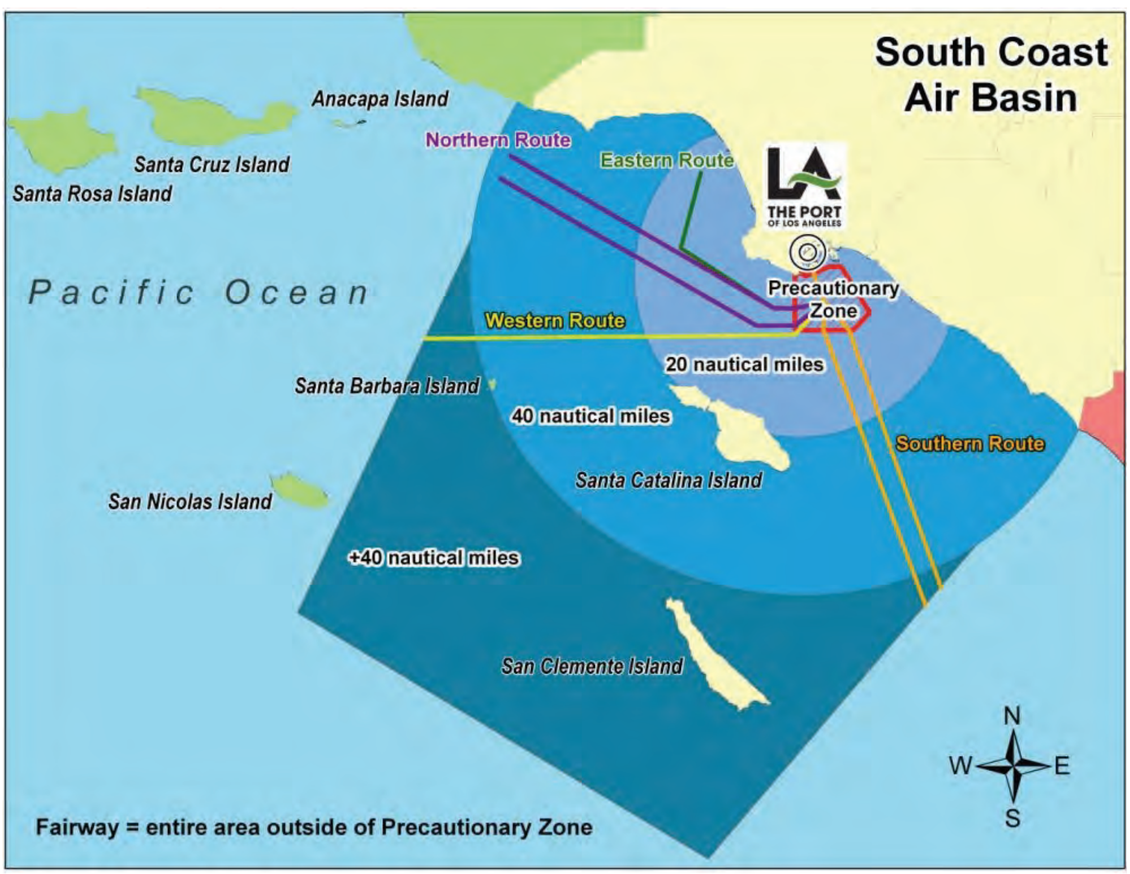
Ocean tugboats included in this section are different from the integrated tug barge (ITB) and articulated tug barge (ATB) included in the ocean-going section of this study. ITB and ATB are seen as a specialized single vessel and are included in the marine exchange data for ocean-going vessels. The ocean tugs in this section are not rigidly connected to the barge and are typically not home-ported here, but may make frequent calls with barges. They are separated from harbor tugboats because their engine loads are higher than harbor tugs which tend to idle more in-between jobs.

This inventory covers harbor craft that operate in the Port of Los Angeles most of the time. There are a number of companies that operate harbor craft in both the Ports of Los Angeles and Long Beach harbors. The activity hours for the vessels that are common to both ports reflect work performed during 2007 for the Port of Los Angeles harbor only.

4.2 Geographical Delineation

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

Figure 4.2: Geographical Extent of Harbor Craft Inventory



4.3 Data and Information Acquisition

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

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

The operating parameters of interest included the following:

- Vessel type
- Number, type and horsepower (or kilowatts) of main engine(s)
- Number, type and horsepower (or kilowatts) of auxiliary engines
- Activity hours
- Annual fuel consumption
- Qualitative information regarding how the vessels are used in service
- Engine model year
- Replaced engines
- Emission reduction strategies such as: alternative fuels, retrofits with after-treatment, and shore power

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

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

Commercial fishing vessels:
- Berth 73 and Fish Harbor, Port-owned marinas

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

Government Vessels:

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

Workboats:

- Clean Coastal Waters
- Pacific Tugboat Services
- Jankovich

Crewboats:

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

Assist tugboats and harbor tugs:

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

Harbor and ocean tugs:

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

4.4 Operational Profiles

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

Tables 4.1 and 4.2 summarize the main and auxiliary engine data, respectively, for each vessel type. The tables below include engine specific information obtained from operators of the vessels included in this inventory. The averages by vessel type in these tables were used as defaults for vessels where the model year, horsepower, or operating activity hour information was missing. The operational hours for some of the vessels that were not at the Port the full year reflect the partial time they worked in the harbor for the 2007 calendar year. For those vessels with "na", there was not enough data to include a model year minimum, maximum and average model year. The following defaults were used for "na" in the tables below:

- For commercial fishing and workboat propulsion engines, an average of 1996 model year
- For commercial fishing, government and workboat auxiliary engines, an average of 1997 model year

Table 4.1: Main Engine Data by Vessel Category

			Propulsion Engines								
Harbor	Number	Engine	Model year			Horsepower			Annual Operating Hours		
Vessel Type	Vessels	Count	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Assist tug	16	32	1982	2005	1997	1,250	2,540	2023	150	2,500	1,667
Commercial fishing	138	145	na	2004	na	50	940	235	200	4,000	1,591
Crew boat	22	49	1970	2004	1995	210	1,400	400	0	1,805	636
Excursion	24	44	1959	2004	1995	150	530	358	350	6,600	2,150
Ferry	9	20	1997	2004	2002	600	2,300	1830	750	1,200	1,115
Government	27	37	1963	2003	1996	24	1,800	421	25	1,200	448
Ocean tug	7	14	1968	2002	1988	800	2,000	1430	50	750	261
Tugboat	23	45	1974	2006	1999	200	2,000	844	0	3,066	759
Work boat	15	29	na	2005	na	200	800	394	26	2,000	318
Total	**281**	**415**									

DB ID423

Table 4.2: Auxiliary Engine Data by Vessel Category

			Auxiliary Engines								
Harbor	Number	Engine	Model year			Horsepower			Annual Operating Hours		
Vessel Type	Vessels	Count	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Assist tug	16	32	1982	2005	2000	115	200	138	113	3,221	1,741
Commercial fishing	138	23	na	2004	na	10	195	78	100	4,500	1,621
Crew boat	22	20	1964	2004	1985	11	300	98	100	1,600	670
Excursion	24	26	1981	2003	1997	7	54	39	125	6,600	2,197
Ferry	9	12	2000	2003	2002	18	120	57	750	750	750
Government	27	11	na	2003	na	50	400	197	20	300	162
Ocean tug	7	14	1968	2003	1990	60	150	93	50	750	261
Tugboat	23	31	1970	2006	2000	22	95	53	0	3,066	839
Work boat	15	13	na	2003	na	13	83	33	26	2,000	519
Total	**281**	**182**									

DB ID422

Table 4.3 summarizes the time spent in harbor (55%), at 25 miles out (35%) and up to the basin boundary (10%) for all harbor craft.

Table 4.3: Allocation of Time Spent by Harbor Craft Type

Harbor Vessel Type	Harbor	Up to 25 Miles	Up to Basin Boundary
Assist tug	99%	1%	0%
Commercial fishing	10%	50%	40%
Crew boat	51%	49%	0%
Excursion	35%	57%	13%
Ferry	38%	60%	3%
Government	80%	13%	8%
Ocean tug	50%	25%	25%
Tugboat	81%	15%	4%
Work boat	54%	46%	0%
Average	**55%**	**35%**	**10%**

DB ID424

Harbor vessel owners and operators were asked to identify replaced engines from their fleet. In addition, lists of replaced engines with funding from the Port, Carl Moyer program and other state-funded programs were reviewed to identify vessels with replaced engines. The following observations can be made of the 2007 harbor craft inventory for replaced engines.

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

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

Table 4.4 shows that for 2007, 27% of all main engines in harbor crafts that operated at the Port had replaced engines. There was no change overall in the percent replaced engines from the previous year. Most of the engine replacements that account for the 27% occurred between the 2001 and 2005 inventories. In 2006 and 2007, few engine replacements occurred.

Table 4.4: Count of Replaced Main Engines

	Propulsion Engines		
Harbor Vessel Type	**Engine Count**	**Engines Repowered**	**Repowered Engines, %**
Assist tug	32	5	16%
Commercial fishing	145	22	15%
Crew boat	49	21	43%
Excursion	44	17	39%
Ferry	20	18	90%
Government	37	2	5%
Ocean tug	14	6	43%
Tugboat	45	19	42%
Work boat	29	4	14%
Total	**415**	**114**	**27%**

DB ID199

Figure 4.3 shows the distribution of the 114 replaced main engines by vessel type. Of the total 114 main engines replaced to date, 22 were for commercial fishing representing 19% of all main engines replaced.

Figure 4.3: Distribution of Replaced Main Engines by Vessel Type

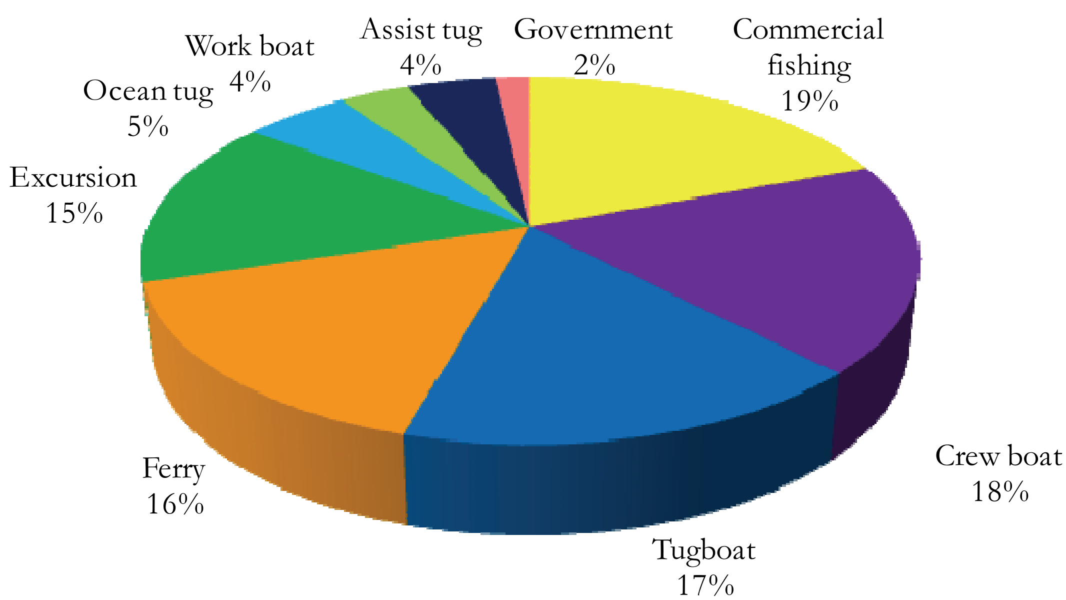


Table 4.5 shows that for 2007, 42% of all auxiliary engines in harbor craft that operated at the Port had replaced engines. There was no change overall in the percent replaced engines

from the previous year. Similar to the main engines, most engine replacements occurred between the 2001 and 2005 inventories. For some vessel types, there are fewer replaced engines in 2007 than previous year due to the fact that some vessels leave the harbor and different vessels may take their place, as is the case with commercial fishing vessels.

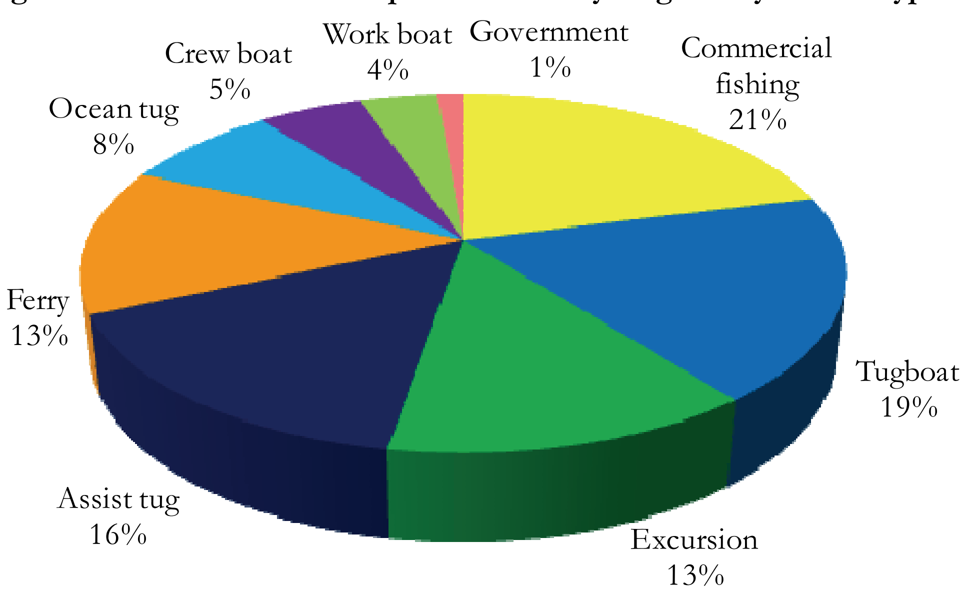
Table 4.5: Count of Replaced Auxiliary Engines

	Auxiliary Engines		
Harbor Vessel Type	**Engine Count**	**Engines Repowered**	**Repowered Engines, %**
Assist tug	32	12	38%
Commercial fishing	23	16	70%
Crew boat	20	4	20%
Excursion	26	10	38%
Ferry	12	10	83%
Government	11	1	9%
Ocean tug	14	6	43%
Tugboat	31	14	45%
Work boat	13	3	23%
Total	**182**	**76**	**42%**

DB ID425

Figure 4.4 shows the distribution of the 76 replaced auxiliary engines by vessel type. Of the total 76 auxiliary engines replaced to date, 16 were for commercial fishing representing 21% of all main engines replaced.

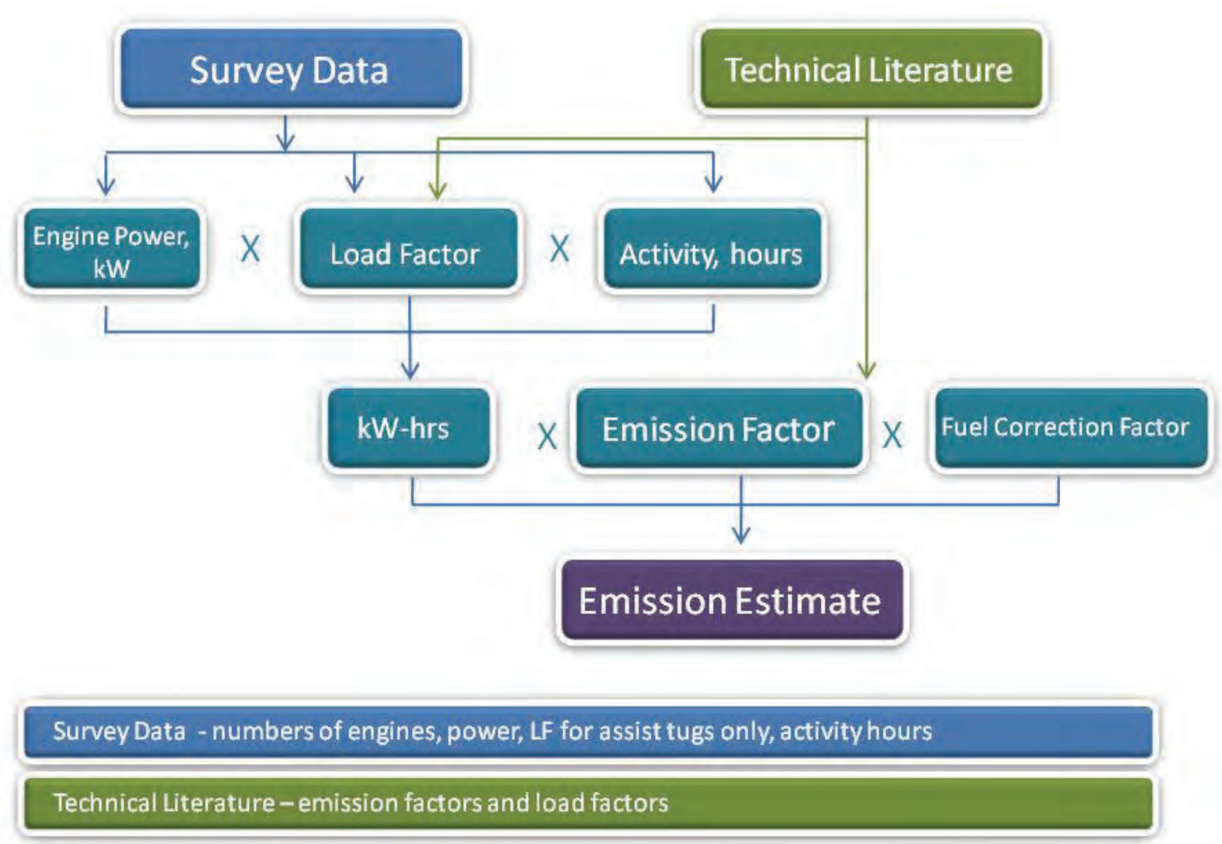
Figure 4.4: Distribution of Replaced Auxiliary Engines by Vessel Type



4.5 Methodology

The emission factors, engine load factors, and emission equations are described in this section. The flow chart in Figure 4.5 graphically breaks down the steps taken to estimate the harbor vessel emissions. Survey data mainly includes the data collected from vessel owners for each main and auxiliary engine. Technical literature was required for the emission factors and load factors which are discussed further in this section. Emissions were estimated on a per engine basis, i.e., the main and auxiliary engines for each vessel were estimated for each vessel.

Figure 4.5: Harbor Craft Emission Estimation Flow Chart



4.5.1 Emission Equations

The basic equation used to estimate harbor vessel emissions is:

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

Where:

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

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

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

Where:

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

The equation for the deterioration rate is:

Equation 4.3

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

Where:

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

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

4.5.2 Deterioration Factors, Useful Life and Emission Factors

In order to be consistent, the Port's harbor craft emissions calculations methodology is similar to CARB's recent harbor craft emissions calculations methodology[31], CARB's deterioration rates, useful life, and zero hour emission factors for commercial harbor craft were used, with the exception of greenhouse gas emission factors. The source for the CO_2 and N_2O emission factors is IVL[32]. The CH_4 emission factor is 2% of the hydrocarbon emission factor.

Table 4.6: Engine Deterioration Factors for Harbor Craft Diesel Engines

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

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

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

4.5.3 Fuel Correction Factors

Fuel correction factors were used to take into account the use of ULSD fuel used by all harbor craft in 2007. Fuel correction factors used for NO_X, HC, and PM take into account California diesel fuel which is different from EPA diesel fuel. Table 4.8 summarizes the fuel correction factors used for harbor craft.

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

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

Table 4.8: Fuel Correction Factors for ULSD

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

DB ID446

4.5.4 Load Factors

Engine load factor represents the load applied to an engine or the percent of rated engine power that is applied during the engine's normal operation. Table 4.9 summarizes the average engine load factors that were used in this inventory for the various harbor vessel types for their propulsion and auxiliary engines.

Table 4.9: Load Factors

DB ID426

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

The 31% engine load factor for assist tugboats is based on actual vessel engine load readings published in the 2001 Port emissions inventory and is not consistent with the 50% engine load used in CARB's latest methodology[33]. The other vessel type load factors are consistent with CARB's latest methodology with one other exception - the tugboat auxiliary engine load factor. CARB uses 43% engine load for all auxiliary engines as listed in Table 3.8, except for 31% used for the auxiliary engines of tugboats. The Port uses 43% for all auxiliary engines, including the tugboats and assist tugboats.

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

4.6 Emission Estimates

Table 4.10 and 4.11 summarizes the 2007 estimated emissions for harbor craft vessels by vessel type and engine type.

Table 4.10: 2007 Commercial Harbor Craft Emissions by Engine Type, tpy

Vessel Type	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Assist Tug	Auxiliary	1.2	1.2	1.2	25.3	0.0	12.4	2.6
	Propulsion	17.1	15.8	17.1	431.8	0.2	109.4	25.3
Assist Tug Total		**18.3**	**16.9**	**18.3**	**457.1**	**0.2**	**121.8**	**28.0**
Commercial Fishing	Auxiliary	0.6	0.6	0.6	11.1	0.0	7.0	1.5
	Propulsion	5.8	5.3	5.8	154.3	0.1	35.8	9.3
Commercial Fishing Total		**6.4**	**5.9**	**6.4**	**165.3**	**0.1**	**42.8**	**10.8**
Crewboat	Auxiliary	0.4	0.3	0.4	6.8	0.0	3.3	0.8
	Propulsion	3.8	3.5	3.8	95.5	0.0	23.4	6.0
Crewboat Total		**4.1**	**3.8**	**4.1**	**102.3**	**0.0**	**26.7**	**6.8**
Excursion	Auxiliary	0.7	0.6	0.7	8.8	0.0	6.4	1.8
	Propulsion	6.1	5.6	6.1	148.8	0.1	40.2	10.2
Excursion Total		**6.8**	**6.2**	**6.8**	**157.6**	**0.1**	**46.6**	**12.0**
Ferry	Auxiliary	0.1	0.1	0.1	1.7	0.0	1.0	0.3
	Propulsion	6.6	6.0	6.6	150.5	0.1	42.0	10.5
Ferry Total		**6.7**	**6.1**	**6.7**	**152.2**	**0.1**	**43.0**	**10.8**
Government	Auxiliary	0.0	0.0	0.0	1.0	0.0	0.4	0.1
	Propulsion	1.6	1.5	1.6	38.2	0.0	9.7	2.6
Government Total		**1.7**	**1.5**	**1.7**	**39.3**	**0.0**	**10.0**	**2.7**
Ocean Tug (Line Haul)	Auxiliary	0.1	0.1	0.1	2.1	0.0	0.9	0.2
	Propulsion	1.9	1.8	1.9	52.1	0.0	13.2	3.0
Ocean Tug		**2.0**	**1.9**	**2.0**	**54.2**	**0.0**	**14.1**	**3.2**
Tugboat	Auxiliary	0.4	0.4	0.4	6.0	0.0	3.6	1.0
	Propulsion	5.1	4.7	5.1	123.7	0.1	32.4	8.2
Tugboat Total		**5.6**	**5.1**	**5.6**	**129.7**	**0.1**	**36.0**	**9.2**
Workboat	Auxiliary	0.1	0.1	0.1	1.5	0.0	0.9	0.2
	Propulsion	1.0	0.9	1.0	22.1	0.0	5.8	1.5
Workboat Total		**1.1**	**1.0**	**1.1**	**23.6**	**0.0**	**6.7**	**1.8**
Harbor craft Total		**52.7**	**48.5**	**52.7**	**1,281.3**	**0.7**	**347.8**	**85.2**

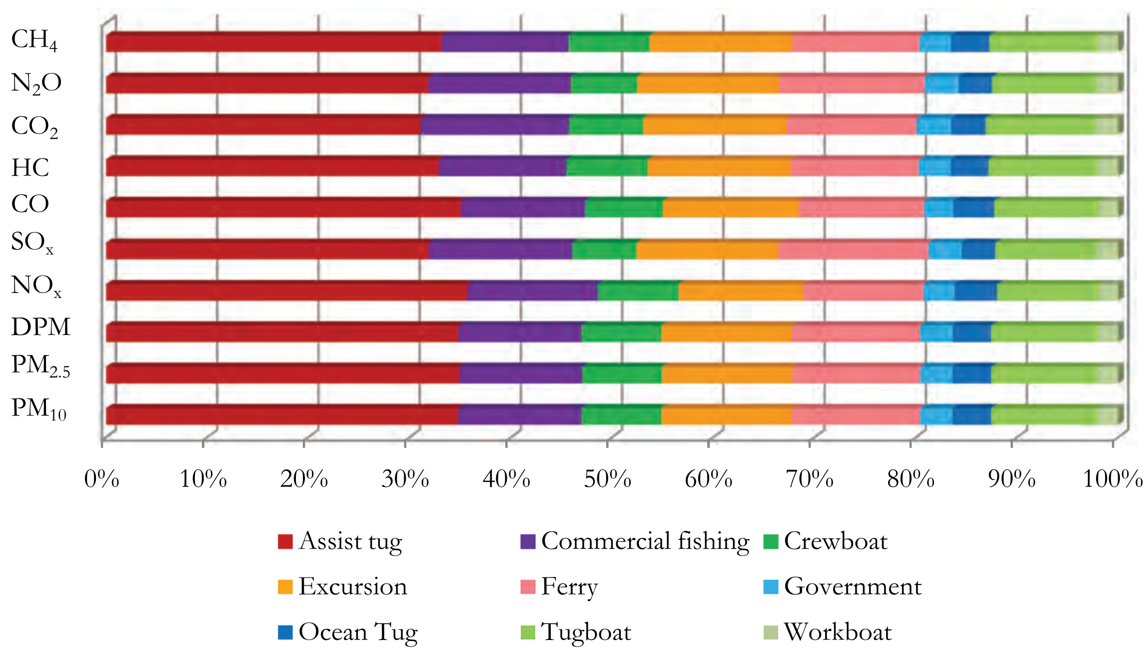
DB ID427

Table 4.11: 2007 Commercial Harbor Craft GHG Emissions by Engine Type, tpy

Vessel Type	Engine Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Assist Tug	Auxiliary	2,219.7	2,193.5	0.1	0.1
	Propulsion	25,793.8	25,503.9	0.9	0.5
Assist Tug Total		**28,013.5**	**27,697.5**	**1.0**	**0.6**
Commercial Fishing	Auxiliary	1,183.5	1,170.2	0.0	0.0
	Propulsion	12,006.0	11,880.6	0.4	0.2
Commercial Fishing Total		**13,189.5**	**13,050.8**	**0.4**	**0.2**
Crewboat	Auxiliary	645.0	639.4	0.0	0.0
	Propulsion	5,947.8	5,887.8	0.2	0.1
Crewboat Total		**6,592.8**	**6,527.2**	**0.2**	**0.1**
Excursion	Auxiliary	841.6	832.1	0.0	0.0
	Propulsion	11,939.2	11,809.8	0.4	0.2
Excursion Total		**12,780.7**	**12,641.9**	**0.4**	**0.2**
Ferry	Auxiliary	146.9	145.1	0.0	0.0
	Propulsion	11,431.0	11,290.6	0.4	0.2
Ferry Total		**11,577.9**	**11,435.8**	**0.4**	**0.2**
Government	Auxiliary	90.1	89.1	0.0	0.0
	Propulsion	3,018.4	2,986.1	0.1	0.1
Government Total		**3,108.5**	**3,075.3**	**0.1**	**0.1**
Ocean Tug (Line Haul)	Auxiliary	131.8	130.4	0.0	0.0
	Propulsion	2,924.3	2,893.1	0.1	0.1
Ocean Tug		**3,056.1**	**3,023.5**	**0.1**	**0.1**
Tugboat	Auxiliary	543.9	537.5	0.0	0.0
	Propulsion	9,237.8	9,142.0	0.3	0.2
Tugboat Total		**9,781.7**	**9,679.5**	**0.3**	**0.2**
Workboat	Auxiliary	129.4	127.8	0.0	0.0
	Propulsion	1,890.4	1,870.4	0.1	0.0
Workboat Total		**2,019.7**	**1,998.2**	**0.1**	**0.0**
Harbor craft Total		**90,120.6**	**89,129.6**	**3.1**	**1.7**

Figure 4.6 shows that approximately 35% of the Port's harbor craft emissions are attributed to assist tugs, 13% to ferries, 13% to excursion vessels, 12% to commercial fishing, 11% to tugboats, 8% to crewboats, 4% to ocean tugs, 3% to government vessels, and 2% to workboats.

Figure 4.6: Harbor Craft Emission Distribution



SECTION 5 CARGO HANDLING EQUIPMENT

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

5.1 Source Description

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

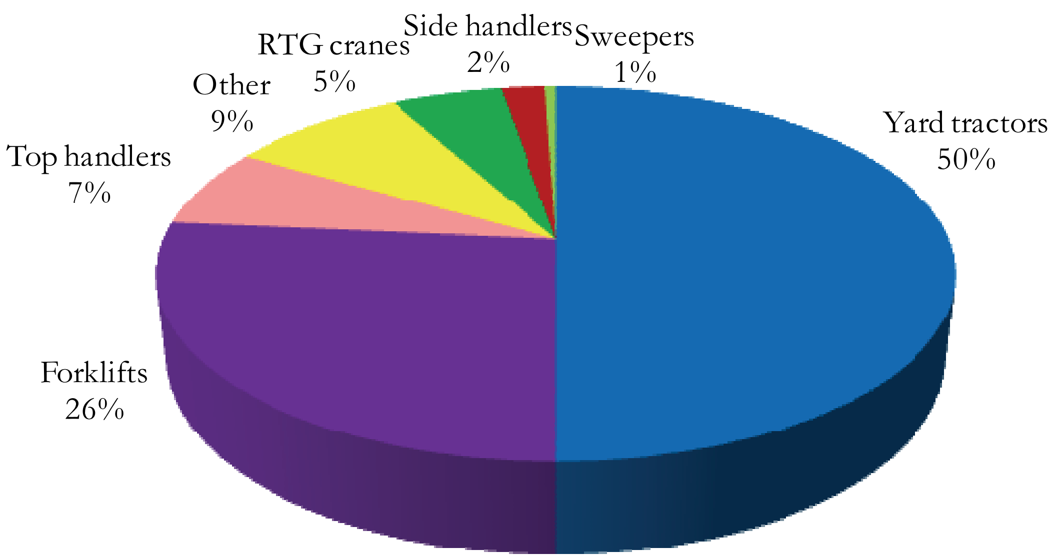
- Forklift
- Rubber tired gantry (RTG) crane
- Side handler
- Sweeper
- Top handler
- Yard tractor
- Other

The "Other" category contains the following:

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

Figure 5.1 presents the distribution of the 2,014 pieces of equipment inventoried at the Port for 2007. Out of all CHE inventoried at Port facilities, 50% were yard tractors, 26% were forklifts, seven percent were top handlers, five percent were RTG cranes, two percent were side handlers, one percent were sweepers and nine percent were other equipment (listed above).

Figure 5.1: Distribution of 2007 Port CHE by Equipment Type



5.2 Geographical Delineation

The 2007 CHE EI consist of equipment from following terminals: container; dry bulk; break bulk; liquid bulk; auto; cruise ship; and equipment from Union Pacific (UP) Intermodal Container Transfer Facility (ICTF) and smaller facilities located within Port boundaries. Figure 5.2 presents a map illustrating the geographical delineation for CHE.

Figure 5.2: CHE EI Geographical Boundaries

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

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

Break-Bulk Terminals:
- Berths 49-53, 87-89, 153-155 and 174-181: Pasha Stevedoring Terminals
- Berths 54-55: Stevedore Services of America (SSA)
- Berths 153-155: Crescent Warehouse Company
- Berths 210-211: SA Recycling

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

Liquid Terminals:
- Berths 70-71: Westway
- Berths 118-119: Kinder Morgan
- General Petroleum
- Berths 187-191: Vopak
- Berths 167-169: Equillon/Shell Oil
- Berths 238-240: ExxonMobil
- Berths 148-151: ConocoPhillips
- Ultramar/Valero

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

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

Other Facilities:

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

5.3 Data and Information Acquisition

The terminal's maintenance and/or CHE operating staff were contacted either in person or by telephone to obtain information on the CHE specific to their terminal's operation for calendar year 2007. Information collected for each piece of equipment is listed below:

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

5.4 Operational Profiles

Table 5.1 summarizes the data collected in 2007. The table includes equipment count, horsepower, model year, and annual operating hours for each equipment type. The table does not include the count or characteristics of auxiliary engines (20 kW) for 30 RTG. The main engines for these RTGs are included in the table.

Table 5.1: CHE Characteristics for All Terminals, 2007

Equipment	Count	Power (horsepower)			Model Year			Annual Operating Hours		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Bulldozer	3	140	460	247	1985	2006	1992	11	2,000	727
Crane	12	130	750	256	1965	2004	1985	257	3,141	908
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf crane	69	na	na	na	na	na	na	na	na	na
Excavator	7	85	428	379	1980	2002	1996	1,000	5,358	3,239
Forklift	534	40	330	103	1968	2007	1997	0	2,970	961
Loader	16	96	430	263	1972	2006	1994	200	5,588	1,661
Man Lift	18	48	87	77	1989	2006	1999	68	1,136	352
Rail Pusher	3	130	200	170	1993	2004	1999	30	354	154
RMG cranes, electric	12	na	na	na	na	na	na	na	na	na
RTG crane	107	180	685	523	1983	2007	2003	0	3,906	1,697
Side pick	43	136	330	191	1990	2007	2000	42	3,048	1,316
Skid steer loader	9	30	94	54	1994	2004	2001	20	1,443	692
Sweeper	11	35	205	109	1995	2005	2000	55	1,251	494
Top handler	138	174	350	286	1972	2007	2000	0	4,637	2,029
Truck	18	97	493	329	1975	2007	1994	0	2,543	807
Yard tractor	1,007	150	270	205	1987	2007	2002	0	8,247	2,130
Total count	**2,014**									

DB ID228

Approximately two-thirds of all CHE equipment at the Port are used by container terminals. Table 5.2 shows the percentage of container terminal CHE as compared to the total Port CHE.

Table 5.2: 2007 Percentage of Container Terminal CHE as Compared to Total CHE

Equipment	Total Count	Container Terminal Count	Percent
Forklift	534	93	17%
RTG crane	107	97	91%
Side pick	43	40	93%
Top handler	138	133	96%
Yard tractor	1,007	895	89%
Sweeper	11	6	55%
Other	174	105	60%
Total	**2,014**	**1,369**	**68%**

DB ID233

The equipment characteristics for the CHE found at the Port's container terminals are summarized in Table 5.3.

Table 5.3: CHE Characteristics for Container Terminals, 2007

Container Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Electric pallet jack	7	na	na	na	na	na	na	na	na	na
Electric wharf cranes	69	na	na	na	na	na	na	na	na	na
Forklift	93	45	275	140	1975	2007	1999	0	2,970	554
Man Lift	8	80	87	84	1995	2006	2000	100	276	178
Rail Pusher	2	180	200	190	1993	2000	1997	30	77	54
RMG cranes, electric	12	na	na	na	na	na	na	na	na	na
RTG crane	97	27	685	424	1983	2007	2003	0	3,716	1,583
Side pick	40	152	330	194	1990	2007	2000	42	3,048	1,389
Sweeper	6	100	205	149	1995	2005	2001	88	864	491
Top handler	133	250	335	287	1987	2007	2001	0	4,637	2,072
Truck	7	100	250	218	1975	2006	1999	50	1,598	583
Yard tractor	895	170	270	208	1987	2007	2002	0	8,247	2,035
Total count	**1,369**									

DB ID229

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

Table 5.4: CHE Characteristics for Break-Bulk Terminals, 2007

Break Bulk Terminals		Power (horsepower)			Model Year			Annual Operating Hours		
Equipment	Count	Min	Max	Average	Min	Max	Average	Min	Max	Average
Bulldozer	3	140	460	247	1985	2006	1992	11	2,000	727
Crane	6	150	750	314	1965	1986	1978	257	3,141	1,062
Excavator	7	85	428	379	1980	2002	1996	1,000	5,358	3,239
Forklift	166	40	330	140	1979	2006	1995	11	2,508	676
Loader	11	98	430	290	1972	2003	1993	281	5,588	2,027
Man lift	7	60	80	73	1996	2002	1999	68	1,136	620
Rail pusher	1	130	130	130	2004	2004	2004	354	354	354
Side pick	2	152	152	152	2000	2000	2000	67	94	81
Skid steer loader	5	30	45	42	2003	2004	2003	1,026	1,443	1,209
Sweeper	4	35	96	67	1996	2002	2000	156	1,251	607
Top handler	3	174	250	225	1979	1990	1986	200	297	259
Truck	9	210	493	409	1975	2007	1990	0	2,543	1,278
Yard tractor	16	177	215	188	2000	2007	2002	0	5,785	1,645
Total count	**240**									

DB ID231

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

Table 5.5: CHE Characteristics for Dry Bulk Terminal Equipment, 2007

Dry Bulk Terminals Equipment	Count	Power (horsepower) Min	Max	Average	Model Year Min	Max	Average	Annual Operating Hours Min	Max	Average
Forklift	2	65	65	65	1991	2001	1996	350	440	395
Loader	5	96	310	205	1989	2006	1995	200	1,040	856
Man Lift	2	48	76	62	1989	1995	1992	120	200	160
Skid Steer Loader	3	54	94	67	2001	2001	2001	20	50	30
Sweeper	1	37	37	37	1999	1999	1999	55	55	55
Yard tractor	4	250	250	250	1995	1995	1995	2,080	2,080	2,080
Total count	**17**									

DB ID230

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

Table 5.6: CHE Characteristics for Other Terminals, 2007

Other Terminals Equipment	Count	Power (horsepower) Min	Max	Average	Model Year Min	Max	Average	Annual Operating Hours Min	Max	Average
Crane	6	130	244	198	1987	2004	1993	600	847	754
Forklift	273	41	178	65	1968	2006	1997	16	1,458	1,390
Fuel Truck	2	97	370	234	1979	1997	1988	365	365	365
Man lift	1	80	80	80	1998	1998	1998	250	250	250
RTG crane	10	250	350	300	1988	2006	1998	1,029	3,906	3,135
Side Pick	1	136	136	136	1992	1992	1992	875	875	875
Skid steer loader	1	75	75	75	1994	1994	1994	96	96	96
Top handler	2	350	350	350	1988	1995	1992	2,252	2,252	2,252
Yard tractor	92	150	250	179	1995	2005	2003	100	5,721	3,145
Total count	**388**									

DB ID232

The 2007 inventory includes 589 pieces of equipment installed with diesel oxidation catalysts (DOC), and 273 yard tractors equipped with certified on-road engines. All terminals used ULSD fuel for the 1,504 pieces of diesel equipment. Emulsified fuel was not used in 2007 due to supplier unavailability. Diesel particulate filters (DPF) which are a level 3 verified technology were installed in 58 yard tractors in 2007. The number of DOC went down slightly from 2006 and this may be due to equipment turnover.

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

Table 5.7: Summary of 2007 CHE Emission Reduction Technologies

Equipment	DOC Installed	On-Road Engines	DPF Installed	USLD Fuel	Total Diesel-Powered Equipment	% of Diesel Powered Equipment DOC Installed	On-Road Engines	DPF Installed	USLD Fuel
2007									
Forklifts	4	4	0	175	175	2%	2%	0%	100%
RTG cranes	10	0	0	107	107	9%	0%	0%	100%
Side handlers	13	0	0	43	43	30%	0%	0%	100%
Top handlers	54	0	0	138	138	39%	0%	0%	100%
Yard tractors	508	273	58	947	947	54%	29%	6%	100%
Sweepers	0	1	0	9	9	0%	11%	0%	100%
Other	0	3	0	85	85	0%	4%	0%	100%
Total	**589**	**281**	**58**	**1,504**	**1,504**	**39%**	**19%**	**4%**	**100%**

DB ID234

Twenty five percent of equipment inventoried was not equipped with a diesel engine; a total of 408 pieces of equipment were powered with propane engines, 11 were powered with gasoline engines, and two yard tractors were equipped with liquefied natural gas (LNG) engines as listed on Table 5.8.

Table 5.8: 2007 Count of Engine Types

Equipment	Electric	LNG	Propane	Gasoline	Diesel
2007					
Forklifts	1	0	350	8	175
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	107
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	138
Yard tractors	0	2	58	0	947
Sweepers	0	0	0	2	9
Other	19	0	0	1	85
Total	**89**	**2**	**408**	**11**	**1,504**

DB ID235

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

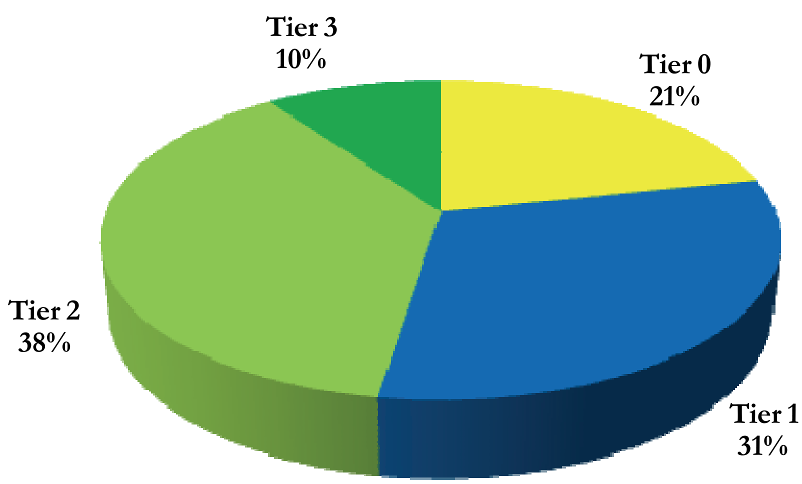
- 12 electric cranes
- 7 electric pallet jacks
- 1 electric forklift
- 69 electric wharf cranes (the large ship to shore cranes at container terminals)

Table 5.9 and Figure 5.3 summarize the distribution of diesel equipment by the engine standards which are based on model year and horsepower range. Approximately 21% of the CHE are Tier 0, 31% are Tier 1, 38% are Tier 2, and 10% are Tier 3.

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

Equipment Type	Tier 0	Tier 1	Tier 2	Tier 3
Yard tractors	122	324	381	120
Forklifts	88	49	32	6
Top handlers	31	37	55	15
Other	54	13	14	4
RTG cranes	15	15	74	3
Side handlers	12	21	9	1
Sweepers	3	5	1	0
Total	**325**	**464**	**566**	**149**

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



5.5 Methodology

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

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

Where:

E = emissions, tons
Pop = population of equipment
EF = emission factor, grams of pollutant per horsepower-hour (g/hp-hr)
HP = rated horsepower for the equipment
LF = load factor (ratio of average load used during normal operations as compared to full load at maximum rated horsepower)
Act = equipment activity, hours of use
FCF = fuel correction factor to reflect changes in fuel properties that have occurred over time
CF = control factor to reflect changes in emissions due to installation of emission reduction technologies or use of alternative fuels not originally included in the emissions factors

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

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

Where:

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

5.5.1 Emission Factors

The zero hour emission rates used are consistent with the OFFROAD model. The ZH emission rates are a function of fuel, model year and horsepower group as defined in the OFFROAD model.

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

- diesel engines certified to off-road diesel engine emission standards
- diesel engines certified to on-road diesel emission standards
- gasoline and LPG engines certified to large spark ignited engine (LSI) emission standards
- LNG engine emission factors are based on recent testing of LNG yard tractors[34]

The equation for the deterioration rate is:

Equation 5.3

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

Where:

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

5.5.2 Load Factor, Useful Life, and Deterioration Rates

Load factor is defined as the ratio of average load experienced by the equipment during normal operation as compared to full load at maximum rated horsepower. It accounts for the fact that in their normal operations, engines are not used at their maximum horsepower rating. Equipment specific load factors are the same as those used for the 2006 EI which include the updated yard tractor LF. A 2006 in-field study conducted by the Port in consultation with CARB's staff supported a lower load factor for the yard tractors operating at ports. Based on actual test data collected, the Port is using a load factor of 39% for yard tractors, as compared to the previous load factor of 65%.

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

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

Table 5.10: CHE Useful Life and Load Factors

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

Table 5.11 lists the deterioration factors by horsepower group.

Table 5.11: Deterioration Factors by Horsepower Group

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

DB ID445

5.5.3 Control Factors

Control factors were used to reflect the change in emissions due to the use of various emissions reduction technologies. Table 5.12 shows the emission reduction percentages provided by CARB for the various technologies used by the Port equipment. The control factor is 1 minus the emission reduction in decimal; for example, a 70% reduction has a control factor of 0.3.

Table 5.12: CHE Emission Reductions Percentages

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

DB ID474

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

- DOC: CEC Report (Air Quality Implications of Backup Generators in California Volume Two: Emission Measurements From Controlled and Uncontrolled Backup Generators)[35]
- DPF: CARB verified technology[36]
- Vycon: CARB verified technology[37]

Table 5.13 lists the fuel correction factors for ULSD fuel.

Table 5.13: Fuel Correction Factors

Equipment MY	PM	NO_x	SO_x	CO	HC	CO_2	N_2O	CH_4
1995 and older	0.72	0.93	0.043	1	0.72	1	0.93	0.72
1996 and newer	0.80	0.95	0.043	1	0.72	1	0.95	0.72

DB ID444

5.6 Emission Estimates

CHE emissions estimates are broken down by terminal type and equipment type. A summary of the CHE emission in tons per year by terminal type for 2007 is presented in Tables 5.14 and 5.15.

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

Table 5.14: 2007 CHE Emissions by Terminal Type, tpy

Terminal Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Auto	0.0	0.0	0.0	0.2	0.0	1.5	0.1
Break-Bulk	6.7	6.2	6.6	196.6	0.1	126.3	14.6
Container	32.7	30.4	32.0	1,222.1	1.6	480.6	36.4
Cruise	0.3	0.3	0.3	9.9	0.0	16.3	1.8
Dry Bulk	0.7	0.7	0.7	13.8	0.0	5.2	1.1
Liquid	0.1	0.0	0.0	2.0	0.0	3.4	0.2
Other	5.3	5.0	5.0	217.1	0.2	286.2	27.0
Total	**45.8**	**42.6**	**44.6**	**1,661.6**	**1.8**	**919.5**	**81.2**

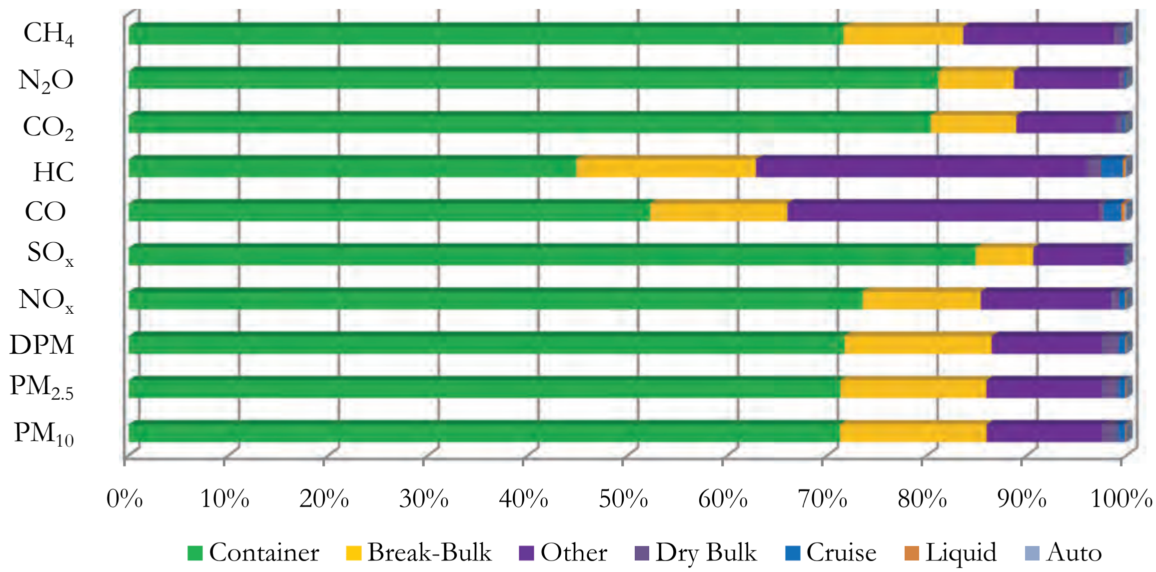
DB ID450

Table 5.15: 2007 CHE GHG Emissions by Terminal Type, tpy

Terminal Type	CO_2 Equivalent	CO_2	N_2O	CH_4
Auto	20.7	20.7	0.0	0.0
Break-Bulk	21,914.7	21,791.6	0.4	0.7
Container	206,439.7	205,187.5	3.8	4.1
Cruise	812.3	809.5	0.0	0.0
Dry Bulk	1,710.5	1,701.3	0.0	0.1
Liquid	147.7	147.3	0.0	0.0
Other	25,691.4	25,522.0	0.5	0.9
Total	**256,737.1**	**255,179.9**	**4.6**	**5.8**

Figure 5.4 presents the percentage of cargo handling equipment emissions by terminal type. Roughly 70% of the Port's CHE PM emissions, 74% of the NO_x emissions, 85% of the SO_x emissions, 52% of the CO and 45% hydrocarbon emissions are attributed to the container terminals. Break-bulk terminals and other type of facilities account for the remainder of the emissions. The facilities with propane forklifts and equipment with alternative fuels have higher CO and hydrocarbon emissions.

Figure 5.4: 2007 CHE Emissions by Terminal Type, %



Tables 5.16 and 5.17 present the emissions by equipment type.

Table 5.16: 2007 CHE Emissions by Equipment Type, tpy

DB ID237

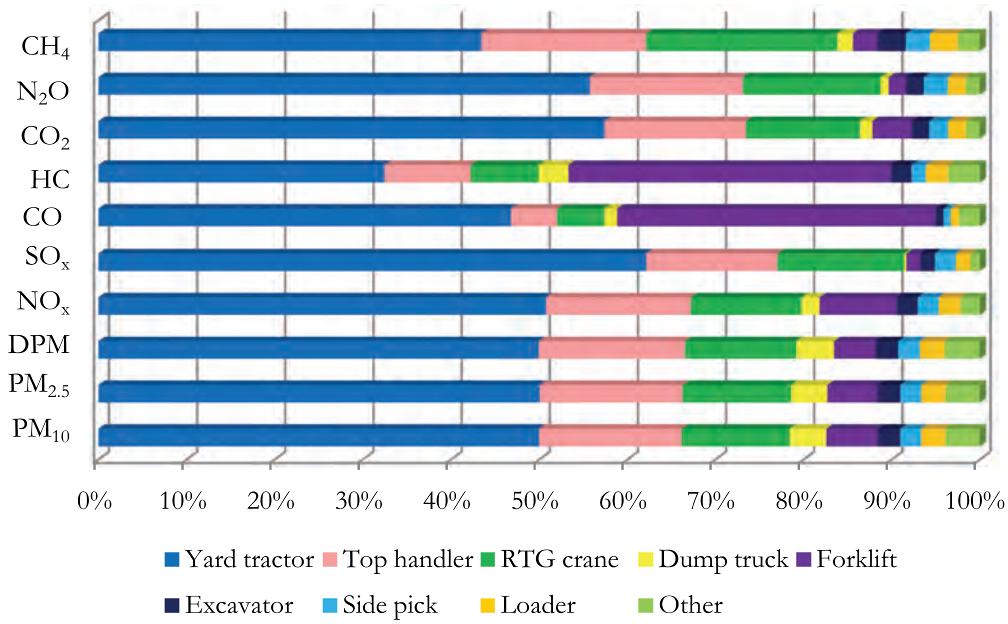
Port Equipment	Engine Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Bulldozer	Diesel	0.1	0.1	0.1	1.5	0.0	0.6	0.1
Crane	Diesel	1.1	1.0	1.1	22.1	0.0	9.1	1.6
Dump Truck	Diesel	1.9	1.8	1.9	33.9	0.0	13.6	2.7
Excavator	Diesel	1.2	1.1	1.2	39.0	0.0	8.2	1.9
Forklift	Diesel	2.1	1.9	2.1	38.5	0.0	15.6	2.8
Forklift	Gasoline	0.0	0.0	0.0	7.2	0.0	19.4	1.7
Forklift	Propane	0.6	0.5	0.0	100.3	0.0	297.2	25.2
Fuel Truck	Diesel	0.2	0.1	0.2	3.8	0.0	1.2	0.2
Fuel Truck	Gasoline	0.0	0.0	0.0	1.1	0.0	2.0	0.2
Loader	Diesel	1.3	1.2	1.3	40.7	0.0	8.5	2.1
Man Lift	Diesel	0.2	0.2	0.2	2.1	0.0	1.1	0.2
Rail Pusher	Diesel	0.0	0.0	0.0	0.2	0.0	0.1	0.0
Rub-trd Gantry Crane	Diesel	5.6	5.2	5.6	208.9	0.3	48.9	6.3
Side pick	Diesel	1.1	1.0	1.1	39.8	0.0	7.5	1.3
Skid Steer Loader	Diesel	0.1	0.1	0.1	0.9	0.0	0.7	0.2
Sweeper	Diesel	0.1	0.1	0.1	1.5	0.0	0.8	0.2
Sweeper	Gasoline	0.0	0.0	0.0	1.4	0.0	6.2	0.2
Top handler	Diesel	7.4	6.9	7.4	272.9	0.3	48.3	7.9
Water Truck	Diesel	0.1	0.1	0.1	2.5	0.0	0.4	0.1
Yard tractor	Diesel	22.3	20.7	22.3	796.1	1.1	174.8	18.0
Yard tractor	LNG	0.0	0.0	0.0	0.5	0.0	0.0	0.4
Yard tractor	Propane	0.7	0.6	0.0	46.7	0.0	255.2	8.0
Total		**45.8**	**42.6**	**44.6**	**1,661.6**	**1.8**	**919.5**	**81.2**

Table 5.17: 2007 CHE GHG Emissions by Equipment Type, tpy

Port Equipment	Engine Type	CO_2	N_2O	CH_4
Bulldozer	Diesel	356.9	0.0	0.0
Crane	Diesel	2,022.8	0.0	0.1
Dump Truck	Diesel	3,651.2	0.0	0.1
Excavator	Diesel	5,031.3	0.1	0.2
Forklift	Diesel	4,715.6	0.1	0.2
Forklift	Gasoline	313.3	0.0	0.0
Forklift	Propane	6,322.4	0.0	0.0
Fuel Truck	Diesel	509.9	0.0	0.0
Fuel Truck	Gasoline	57.3	0.0	0.0
Loader	Diesel	5,190.9	0.1	0.2
Man Lift	Diesel	254.1	0.0	0.0
Rail Pusher	Diesel	27.8	0.0	0.0
Rub-trd Gantry Crane	Diesel	32,984.9	0.7	1.3
Side pick	Diesel	5,508.8	0.1	0.2
Skid Steer Loader	Diesel	115.8	0.0	0.0
Sweeper	Diesel	213.4	0.0	0.0
Sweeper	Gasoline	194.1	0.0	0.0
Top handler	Diesel	40,933.6	0.8	1.1
Water Truck	Diesel	304.0	0.0	0.0
Yard tractor	Diesel	139,003.3	2.6	2.5
Yard tractor	LNG	94.9	0.0	0.0
Yard tractor	Propane	7,373.6	0.0	0.0
Total		**255,179.9**	**4.6**	**5.8**

Figure 5.5 presents the percentage of cargo handling equipment emissions by equipment type. Yard tractors attribute for roughly 50% of the PM and NO_x emissions, 62% of the SO_x emissions, 47% of the CO emissions, 32% of the hydrocarbon emissions.

Figure 5.5: 2007 CHE Emissions by Equipment Type, %



SECTION 6 RAILROAD LOCOMOTIVES

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

6.1 Source Description

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

Locomotives used for line haul operations are typically large, powerful engines of 3,000 to 4,000 hp or more, while switch engines are smaller, typically having 1,200 to 3,000 hp engines. Older line haul locomotives have often been converted to switch duty as newer line haul locomotives with more horsepower have become available. Figures 6.1 and 6.2 illustrate typical line haul and switching locomotives, respectively, in use at the Port. Note that the switching locomotives in use at the Port, some of which date to the 1950s, were replaced with new, low-emitting locomotives during 2007 as part of an agreement among the Ports of Los Angeles and Long Beach and the Pacific Harbor Line, owners/operators of the switchers.

The Port is served by three railway companies:

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

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

Figure 6.1: Typical Line Haul Locomotive

Figure 6.2: New PHL Switching Locomotive

6.2 Geographical Delineation

Figure 6.3 illustrates the rail track system serving both ports, and Figure 6.4 presents a broader view of the major rail routes in the air basin that are used to move port-related intermodal cargo.

Figure 6.3: Port Area Rail Lines

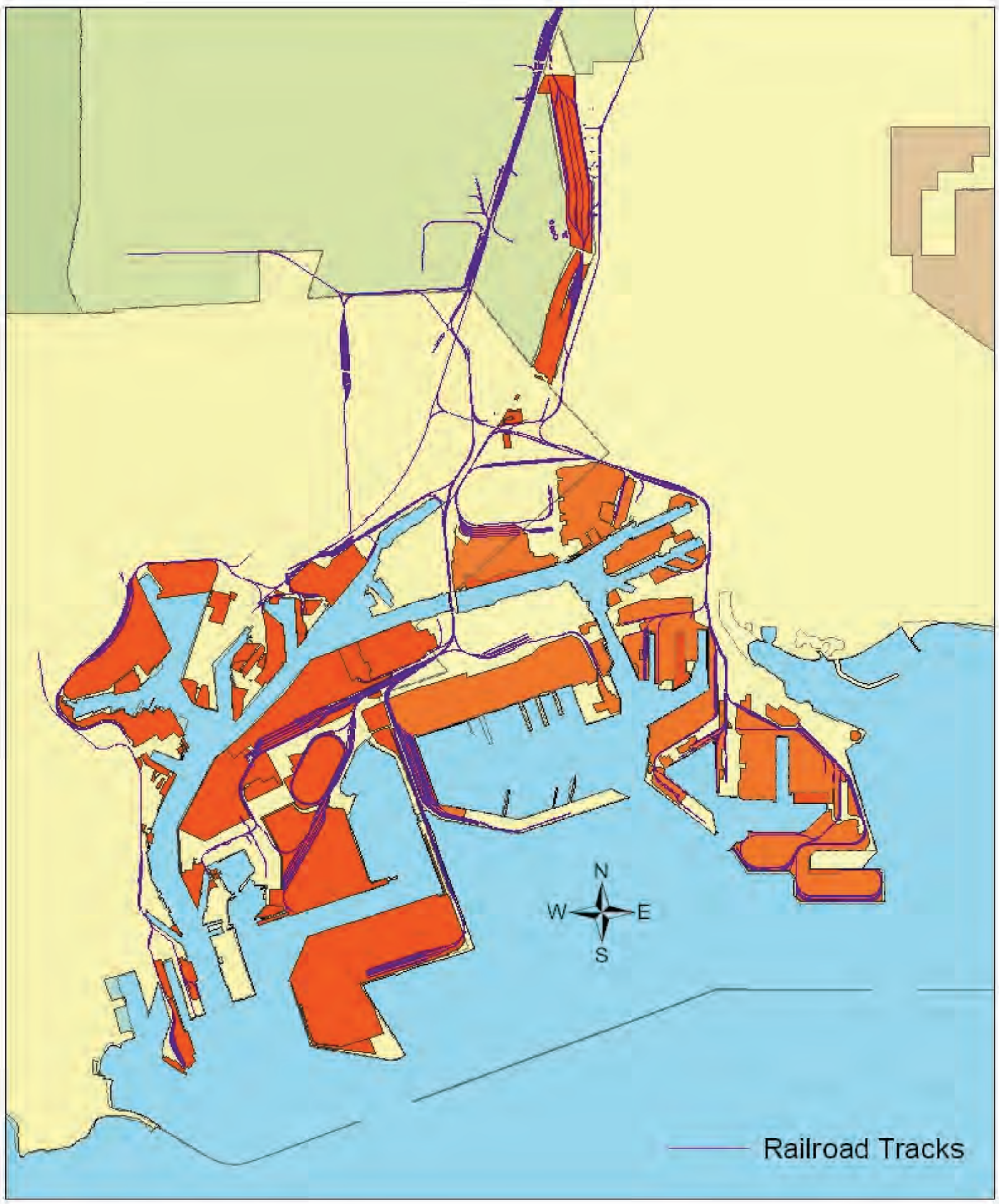


Figure 6.4: Air Basin Major Intermodal Rail Routes

6.3 Data and Information Acquisition

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

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

PHL has previously provided data in the form of files downloaded from their locomotives' electronic event recorders. Similar to the "black boxes" installed in aircraft, the event recorders maintain a record of several locomotive operating parameters on a second-by-second basis, including throttle notch setting, locomotive speed, and direction of travel. The recorders have limited storage capacity and typically maintain two to three days of data with the oldest data being overwritten as new data is accumulated. PHL provided a download from each of its locomotives covering the same approximate 2-day period of operation. The railroad also provided a record of fuel used in each of its locomotives.

The line haul railway company operating a rail yard on Port property, Intermodal Container Transfer Facility (ICTF) also provided information on their switch engines, including representative fuel usage. In addition, railroad personnel were interviewed for an overview of their operations in the area. As stated previously, certain information related to line haul locomotive fleets has been obtained from railroad companies' Internet websites. Additionally, terminal operators and Port departments have provided information on Port rail operations that provides an additional level of understanding of overall line haul rail operations.

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

The specific activities included in the emission estimates include movement of cargo within Port boundaries, or directly to or from port-owned properties (such as terminals and on-port rail yards). Rail movements of cargo that occur solely outside the port, such as switching at off-port rail yards, and movements that do not either initiate or end at a Port property (such as east-bound line hauls that initiate in central Los Angeles intermodal yards) are not included.

6.4 Operational Profiles

6.4.1 Rail System

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

Outbound Trains

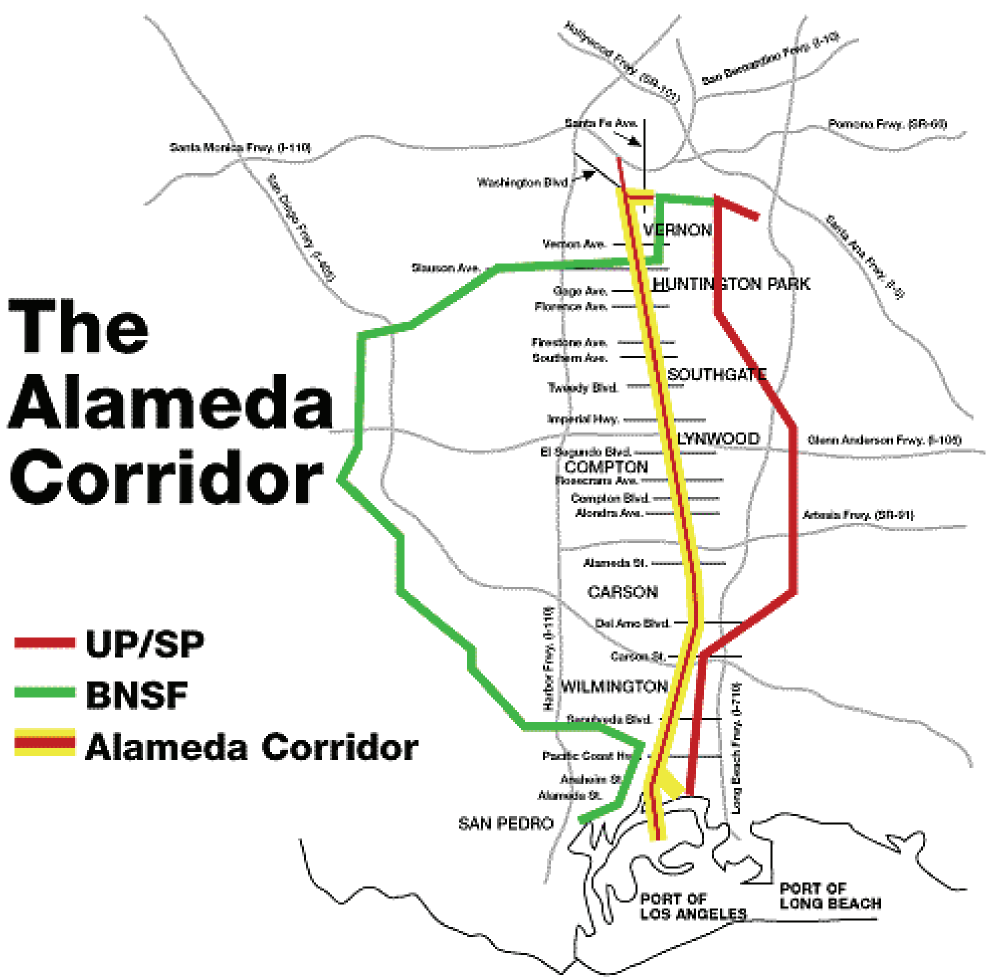
The assembly of outbound trains occurs in one of three ways. Container terminals with sufficient track space build trains on-terminal, using flat cars that have remained on site after the off-loading of inbound containers or those brought in by one of the railroads. Alternatively, containers can be trucked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

Within the Port, complete trains can be built at the terminals servicing Yang Ming and American Presidents Line (APL). In addition, the Terminal Island Container Transfer Facility (TICTF) is shared by Nippon Yusen Kaisha (NYK) and Evergreen as a location to build trains. Trains are also built outside of the Port at the Watson Yard, the Dolores Yard, and the Manuel Yard, and at locations within the POLB. If containers to be transported by rail are not loaded onto railcars at the Port, they are typically hauled by truck (drayed) to off-port locations operated by the line haul railroads. The containers are loaded onto railcars at these locations.

Alameda Corridor

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

Figure 6.5: Alameda Corridor



Inbound Trains

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

Switching

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

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

Specific Activities

Locomotive activities of the Class 1 railway companies consist of:

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

Locomotive switching activities consist of:

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

6.4.2 Locomotives and Trains

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

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

Line Haul Locomotives

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

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

Basic specifications of UP locomotives were obtained from the railroad's Internet website.[38] The UP website lists approximately 6,500 line haul locomotives in the company's nation-wide fleet, with an average power rating of 3,655 horsepower. Most of the locomotives are six-axle units, the remainder being four-axle units. Six-axle locomotives are generally more powerful than four-axle locomotives. Most of the UP locomotives calling on the Port are six-axle, 4,000-horsepower Electromotive Division (EMD) SD70s.

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

Switching Locomotives

Most switching within the Port is conducted by PHL. Early in 2006, PHL, the Port, and the Port of Long Beach concluded an agreement whereby the two ports helped fund the replacement of PHL's locomotives with new locomotives meeting Tier 2 locomotive emission standards. Many of the locomotives purchased under this agreement were delivered during 2007, so the year was a transition period for the PHL switching fleet, as their new locomotives were placed into service and the older ones were retired. A total of 33 locomotives were used at some point during the year, including 20 of the older locomotives, 11 new PHL locomotives, and two evaluation units. PHL evaluated a hybrid diesel/electric switcher and a unit running on a set of relatively small diesel engines and generators rather than one large engine (known as a multi-genset switcher). Several of the new locomotives are of the multi-genset design.

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

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

Train Configuration
Container trains are the most common type of train seen at the Port. While equipment configurations vary, these trains are typically made up of up to 25 double-stack railcars, each railcar consisting of five platforms capable of carrying up to four TEUs of containerized cargo (e.g., most platforms can carry up to two 40-foot containers). With this configuration the capacity of a train is 500 TEUs or about 278 containers at an average ratio of 1.8 TEU/container. As a practical matter not all platforms carry four TEUs because not all platforms are double stacked with two 40-foot containers; the current capacity or "density" is approximately 85% (meaning, for example, a 25-car train would carry 500 TEUs x 85% = 425 TEUs).

In developing off-port line haul locomotive emission estimates, the following assumptions were made regarding the typical make-up of trains traveling the Alameda Corridor and beyond: 24 double-stack railcars, 85% density, for a capacity of 408 TEUs or 227 containers (average). These assumptions are consistent with information developed for the No Net Increase Task Force's evaluation of 2005 Alameda Corridor locomotive activities.[39] The estimated number of railcars per train has been increased to 24 from the 23 assumed for the 2006 emissions inventory based on the Alameda Corridor Transportation Authority's report that there were fewer trains running on the Corridor because there were more containers per train in 2007 than in 2006.[40] Average train capacity assumptions for on-port emission estimates are lower based on reported container throughput and weekly/annual train information provided by Port terminals. It is assumed that train sizes are adjusted in the off-port rail yards prior to or after interstate travel to or from the Port.

6.5 Methodology

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

Emissions have been estimated using the information provided by the railroads and the terminals, and from published information sources such as the EPA's Regulatory Support Document (RSD) published as background to EPA's locomotive rule-making process.[41] For in-Port switching operations, the throttle notch data and fuel use information provided by the switching companies have been used along with EPA data on emission rates by throttle notch. Off-Port switching emissions have been estimated using 2005 fuel use data previously provided by the railroad company operating the ICTF, scaled to the increase in facility throughput between 2006 and 2007. For the limited line haul operations in the Port,

[39] Personal communication, Art Goodwin, Alameda Corridor Transportation Authority, with Starcrest Consulting Group, LLC, February 2005.
[40] http://www.acta.org/corridor_performance_train_counts.htm, "Number of Trains Running on the Alameda Corridor"
[41] EPA Office of Mobile Sources, *Locomotive Emission Standards Regulatory Support Document,* April 1998, revised.

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

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

6.5.1 Switching Emissions

Emissions from PHL's on-port switching operations have been based on their reported locomotive fuel use, site-specific throttle notch frequencies for their older locomotives, and emission factors from the EPA documents cited above. EPA in-use emission factors for Tier 2 locomotives were used for the new locomotives because the throttle notch data is not specific to those locomotives, which may have a different average duty cycle from the older units.

The calculations for PHL locomotives were developed to derive emission factors in terms of grams per horsepower-hour that take into account the site-specific throttle notch information provided by PHL. The 2006 methodology was unchanged for 2007 since the fleet of older locomotives did not change substantially between 2006 and 2007, and the latter year was a transition year between the older fleet and the new replacement locomotives. First, the characteristics of the PHL fleet operating in 2006 were evaluated to develop a fleet average horsepower rating. Because several locomotives normally operate as coupled pairs, these pairs were considered as one "locomotive" when developing the averages. Table 6.1 lists the "in-use" rated horsepower characteristics of the fleet. Note that each locomotive pair as mentioned above is counted as one locomotive in this table, hence the total of 17 at the bottom of the table.

Table 6.1: Horsepower Characteristics of PHL Locomotives (old fleet)

Locomotive Model	Engine Model	Number	Each	Rated Horsepower In Use	Total
Pair of SW-1200s	12-567-C	1	1,200	2,400	2,400
Pair of SW-1200s	12-567-C/BC	1	1,200	2,400	2,400
Single SW-1200	12-567-C	1	1,200	1,200	1,200
SD-18	16-567-D3	4	1,800	1,800	7,200
SD-20	16-567-D1	1	2,000	2,000	2,000
SD-20	16-567-CE	2	2,000	2,000	4,000
SD-20	16-645-E	1	2,000	2,000	2,000
SD-20	16-645-CE	1	2,000	2,000	2,000
GP-7/GP-9 Pair	16-567-C/BC	1	1,750/1,500	3,250	3,250
SD-38-2	16-645-E	2	2,000	2,000	4,000
SD-40T	16-645-E3	2	3,000	3,000	6,000
Total		17			36,450
Average locomotive horsepower:					**2,144**

Next, the average notch-specific horsepower values for the "average" switch locomotive operated by this company have been calculated by multiplying the average rated horsepower value by notch-specific percentages derived from the EPA's RSD cited above. The percentages represent the fraction of total rated horsepower that is produced in each throttle setting. This process is illustrated in the example below, for throttle notch setting 1, with results for all throttle settings shown in Table 6.3.

83 hp / 1,750 hp = 0.047, or 4.7% Equation 6.1

2,144 hp x 0.047 = 101 hp

In this example, the average notch 1 power in the RSD data is 83 hp, which is divided by the average rated power of the locomotives tested for the RSD, 1,750 hp. The result is 0.047, or 4.7%; this means that 4.7% of the power of the average locomotive (in the RSD dataset) is used at throttle notch position 1. The next step is to multiply the average horsepower rating of the locomotives doing switch duty at the Port (2,144 hp) by the percentage of power used by the RSD locomotives. This result is 101 horsepower, meaning that the switch engines in use at the Port use an average of 101 hp while in throttle notch position 1.

This calculation is repeated for each throttle notch position, as shown in Table 6.2.

Table 6.2: Calculation of Notch-Specific In-Use Horsepower

Notch	RSD Power in Notch, bhp	% of Avg. Rated bhp	Avg. in-use Power, bhp
DB	67	3.8%	81
Idle	14	0.8%	17
1	83	4.7%	101
2	249	14.2%	304
3	487	27.8%	596
4	735	42.0%	900
5	1,002	57.3%	1,229
6	1,268	72.5%	1,554
7	1,570	89.7%	1,923
8	1,843	105.3%	2,258
Average RSD hp:	**1,750**	**Avg. local hp:**	**2,144**

(Note: in these tables, "DB" refers to "dynamic braking," a feature of some locomotives' operation that does not apply to this switching locomotive fleet. The term is included because it is part of the published EPA data set.)

The next step is to develop notch-weighted hourly emission rates, first by using the in-use horsepower values described above to convert the RSD average switching emission rates from g/hp-hr to pounds per hour (lbs/hr). The conversion is calculated as follows:

Equation 6.2

$$(g/hp\text{-}hr \times hp) / (453.6\ g/lb) = lb/hr$$

The two sets of emission rates (g/hp-hr and lb/hr) are presented in Tables 6.3 and 6.4, where the values in Table 6.4 have been obtained by multiplying those in Table 6.3 by the in-use horsepower figures presented in Table 6.2.

For example, for NO_X emissions and throttle notch setting 1, the Table 6.3 value of 16.63 g/bhp-hr is multiplied by the notch position 1 horsepower value of 101 hp in Table 6.2 and divided by 453.6 g/lb to result in an estimate of 3.70 lb/hr as shown in Table 6.4. This calculation is repeated for each throttle notch position, as shown in Table 6.4.

Table 6.3: Horsepower-Based Emission Factors from RSD

Notch	PM g/bhp-hr	NO_x g/bhp-hr	CO g/bhp-hr	HC g/bhp-hr
DB	1.05	40.20	8.49	3.98
Idle	2.26	77.70	16.81	9.18
1	0.29	16.63	2.56	1.49
2	0.37	12.26	1.51	0.67
3	0.34	13.09	0.83	0.43
4	0.26	14.27	0.57	0.37
5	0.24	15.10	0.53	0.38
6	0.29	15.88	0.67	0.40
7	0.25	16.37	1.26	0.44
8	0.29	16.15	2.97	0.47

Table 6.4: Hourly Notch-Specific Emission Rates

Notch	PM lb/hr	NO_x lb/hr	SO_x lb/hr	CO lb/hr	HC lb/hr
DB	0.19	7.18	0.001	1.52	0.71
Idle	0.08	2.91	0.0002	0.63	0.34
1	0.06	3.70	0.001	0.57	0.33
2	0.25	8.22	0.003	1.01	0.45
3	0.44	17.20	0.006	1.09	0.56
4	0.51	28.32	0.009	1.12	0.72
5	0.64	40.92	0.012	1.43	1.03
6	0.98	54.40	0.016	2.29	1.37
7	1.08	69.41	0.019	5.33	1.86
8	1.42	80.38	0.023	14.80	2.34

Table 6.4 also includes hourly emission rates of SO_x that have been estimated on the basis of a mass balance approach and a ULSD fuel sulfur content of 15 ppm by weight. The mass balance approach assumes that the sulfur (S) in the fuel is converted to SO_2 and emitted during the combustion process. While the mass balance approach calculates SO_2 specifically, it is used as a reasonable approximation of SO_x. The following example shows the calculation for throttle notch position 1.

Equation 6.3

$$\frac{15 \text{ lbs S}}{1{,}000{,}000 \text{ lbs fuel}} \times \frac{0.336 \text{ lbs fuel}}{\text{hp-hr}} \times \frac{2 \text{ lbs } SO_2}{\text{lb S}} \times 101 \text{ hp} = 0.001 \text{ lbs } SO_2/\text{hr}$$

In this calculation, 15 ppm S is written as 15 lbs S per million lbs of fuel. The value of 0.336 lbs fuel/hp-hr is average brake-specific fuel consumption derived from EPA's technical literature on locomotive emission factors. Two pounds of SO_2 is emitted for each pound of sulfur in the fuel because the atomic weight of sulfur is 32 while that of SO_2 is 64, meaning that the weight of an amount of sulfur doubles when it is expressed as SO_2. Finally, the average in-use horsepower value for throttle notch position 1 is 101 hp, as presented in Table 6.2. This calculation was carried out for each throttle notch position; the results are shown in Table 6.4.

A notch-weighted average emission rate has been estimated using time-in-notch percentages developed from the event recorder data provided by PHL. Each hourly value in Table 6.4 is multiplied by the percentage corresponding to the respective notch setting. The percentages and resulting fractional emission rates are shown in Table 6.5. Because the time-in-notch fractions together represent all of the locomotives' operating time, the products obtained from the multiplication of pounds per hour by time fraction can be summed to provide a notch-weighted hourly emission rate that is representative of the average locomotive (or pair of locomotives) operating with an average site-specific throttle notch distribution.

Continuing the example of NO_X emissions for throttle notch position 1, the 3.70 lb/hr from Table 6.4 is multiplied by the notch position 1 percentage of 5.9% (or 0.059) listed in Table 6.6 under "wt'd avg % in mode" to obtain the value of 0.22.

$$3.70 \text{ lb/hr} \times 0.059 = 0.22$$

Equation 6.4

Each of the hourly rates in Table 6.4 is similarly multiplied by the percentage corresponding to each throttle notch position. The results are summed for each pollutant to calculate weighted average emission rates.

Table 6.5: Time-in-Notch and Weighted Average Emission Rates

Notch	wt'd avg % in mode	PM % x lb/hr	NO_x % x lb/hr	SO_x % x lb/hr	CO % x lb/hr	HC % x lb/hr
DB	0.0%	0.00	0.00	0.000	0.00	0.00
Idle	67.4%	0.05	1.96	0.0001	0.42	0.23
1	5.9%	0.004	0.22	0.0001	0.03	0.02
2	7.7%	0.02	0.63	0.0002	0.08	0.03
3	6.7%	0.03	1.16	0.0004	0.07	0.04
4	5.3%	0.03	1.49	0.0005	0.06	0.04
5	3.0%	0.02	1.24	0.0004	0.04	0.03
6	2.0%	0.02	1.11	0.0003	0.05	0.03
7	0.9%	0.01	0.64	0.0002	0.05	0.02
8	1.1%	0.02	0.88	0.0003	0.16	0.03
Weighted average lb/hr		**0.20**	**9.33**	**0.0024**	**0.97**	**0.46**

These lb/hr emission rates were converted to g/hp-hr emission factors using an estimate of the average in-use horsepower developed from the weighted average percent time in mode (Table 6.5) and the average notch-specific in-use horsepower (Table 6.2), as summarized in Table 6.6 below. The percentage of time in each notch setting is multiplied by the average power at that notch – the results are summed for all notches to estimate the overall average in-use horsepower level.

Table 6.6: Estimate of Average In-Use Horsepower

Notch	Site-specific wt'd avg % in mode	Avg. in-use Power, bhp	% x bhp
DB	0.0%	81	0.0
Idle	67.4%	17	11.5
1	5.9%	101	5.9
2	7.7%	304	23.4
3	6.7%	596	40.1
4	5.3%	900	47.5
5	3.0%	1,229	37.1
6	2.0%	1,554	31.7
7	0.9%	1,923	17.7
8	1.1%	2,258	24.7
Weighted average horsepower			**240**

To develop the g/hp-hr emission factors, the lb/hr rates shown in the bottom row of Table 6.5 were multiplied by 453.6 (to convert pounds to grams) and divided by the 240 horsepower average shown in Table 6.6. These emission factors, labeled "PHL Existing Fleet" in Table 5.7 below, are appropriate for older the on-port switching locomotives burning ULSD fuel.

As noted above, PHL also took delivery of several of their new locomotives that are certified to EPA Tier 2 emission levels. The emission factors for the existing PHL fleet that were developed as described above are not these locomotives because they emit less than the older locomotives. Instead, Tier 2 emission factors from EPA's Regulatory Support Document cited above were used in the emission calculations in place of the emission factors developed for PHL's existing fleet of older locomotives. The off-port switcher emission factors are baseline (generic before-control) factors from EPA's Regulatory Support Document. In addition to the emission factors discussed above, greenhouse gas emission factors from EPA references[42] were used to estimate emissions of greenhouse gases CO_2, CH_4, and N_2O from all locomotives. Emission factors for all switching locomotives, including those used for the off-port switching activity, are listed in Tables 6.7 and 6.8.

Table 6.7: Switching Emission Factors, g/hp-hr

Fuel or Locomotive Type	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
PHL Existing Fleet	0.38	0.35	0.38	17.6	0.005	1.83	0.87
Off-Port Switchers	0.44	0.40	0.44	17.40	0.005	1.83	1.01
PHL Tier 2	0.21	0.19	0.21	7.30	0.005	1.83	0.52

Table 6.8: GHG Switching Emission Factors, g/hp-hr

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

[42] CO_2 - Tables A-28 and A-36, page A-39, Annex 2 of the report (EPA #430-R-07-002, April 2007) entitled: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*; CH_4 and N_2O - Table A 101, page A-120 in Annex 3 of the same report.

EPA's RSD does not include emission factors for $SO_{x.}$ Table 6.7 includes an estimate of SO_x emissions based on PHL's use of ULSD fuel with a sulfur content of 15 ppm. Additionally, all particulate emissions are assumed to be PM_{10} and DPM; $PM_{2.5}$ emissions have been estimated as 92% of PM_{10} emissions.

The activity measure used in the switching emission estimates is total horsepower-hours of activity, derived from the locomotive-specific fuel use data provided by PHL for the on-port switching, and an estimate of off-port switching fuel use derived from information provided earlier by the railroad operating the off-dock rail yard that is located on Port property. For the off-dock rail yard, the reported 2006 fuel usage was multiplied by the ratio of 2007 to 2006 container throughput reported by the railroad (696,129/706,293 or a decrease of 1.4%, using the assumption that switching activity varies linearly with container throughput).

As an example of how fuel use was used to estimate total hp-hrs, a total of 10,000 gallons of fuel per year would be divided by the fuel use factor of 0.048 gallons per hp-hr (gal/hp-hr) to produce an estimate of 208,333 hp-hrs. This would be multiplied by the g/hp-hr emission factors to estimate the mass of emissions over the year.

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

Rail cargo from both the Port of Los Angeles and the Port of Long Beach are handled at the off-dock ICTF, and the complexities of the rail system are such that apportionment of activity (and emissions) between the two ports is difficult. The previous baseline emissions inventories used an allocation of 55% Port of Los Angeles and 45% Port of Long Beach – this allocation has been maintained for the current inventories because it still seems a reasonable assumption, given that the Port of Los Angeles' overall TEU throughput represented about 53% of the two ports' combined throughput in 2007. Regardless of apportionment, the sum of the two ports' emissions represents all of the estimated switching emissions from locomotives operated at the ICTF.

6.5.2 Line Haul Locomotive Emissions

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

The number of locomotive trips in the Port has been estimated by evaluating cargo movements, percentage of cargo transported by rail, and typical number of locomotives per train, using a methodology similar to that used for the 2001 baseline emissions inventory. Emission factors have been taken from EPA's RSD documentation representing EPA's projected 2007 nationwide fleet of line haul locomotives, as shown in Tables 6.9 and 6.10. The emission factors are presented in terms of grams per horsepower-hour (g/hp-hr) as listed in the RSD documentation.

The SO_x emission factor has been estimated from assumed fuel sulfur content values using a mass balance equation similar to the switching locomotives calculation. For line haul locomotives, which enter and leave California to pick up and deliver transcontinental rail cargo and typically refuel while in the SoCAB, the calculations are based on the use of 50% ULSD fuel from SoCAB refueling and 50% higher sulfur fuel from out-of-state sources. Because new fuel sulfur requirements were phased in beginning in mid-2007, the calculations were based on half the year at 3,500 ppm S (as used in previous emissions inventories) and half the year at 350 ppm S. Table 6.10 lists the greenhouse gas emission factors from EPA reference[43].

Table 6.9: Emission Factors for Line Haul Locomotives, g/hp-hr

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
EF, g/bhp-hr	0.29	0.26	0.29	7.61	0.30	1.28	0.44

Table 6.10: GHG Emission Factors for Line Haul Locomotives, g/hp-hr

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

[43] CO_2 - Tables A-28 and A-36, page A-39, Annex 2 of the report (EPA #430-R-07-002, April 2007) entitled: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*; CH_4 and N_2O - Table A 101, page A-120 in Annex 3 of the same report.

On-Port Line Haul Emissions

On-port line haul locomotive activity has been estimated through an evaluation of the amount of cargo reported by the terminals to be transported by rail and their reported average or typical number of trains per week or per year. These numbers have been combined with assumptions regarding the number of locomotives, on average, that are involved with on-port line haul railroad moves, and the average duration of incoming and outgoing port trips, similar to the approach taken for the 2001 baseline emissions inventory. The number of trains per year, locomotives per train, and on-port hours per train were multiplied together to calculate a total of locomotive hours per year. While most of the rail cargo, and the basis for these estimates centers on container traffic, the local switching railroad has reported that they prepare an average of one train per day of cargo other than containers for transport out of the San Pedro Bay Ports area. It has been assumed that a similar number of trains are inbound, and that the total number has an even split between both ports. Therefore, the number of trains per year includes an average of one non-container train every other day in each direction (for an annual total of 366 additional trains for each port).

Table 6.11: On-Port Line Haul Locomotive Activity

Activity Measure	Inbound	Outbound	Totals
Number of trains/year	4,266	5,409	9,675
Number of locomotives/train	3	3	NA
Hours on Port/trip	1.0	2.5	NA
Locomotive hours/year	12,798	40,568	53,366

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

Table 6.12: Estimated Average Load Factor

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

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

Equation 6.5

53,366 locomotive hours/year x 4,000 horsepower/locomotive x 0.28

= 59.8 million horsepower-hours (rounded)

Emission estimates for on-port line haul locomotive activity were calculated by multiplying this estimate of horsepower-hours by the emission factors listed in Tables 6.9 and 6.10 in terms of g/hp-hr.

Out-of-Port Line Haul Emissions

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

The four components to locomotive activity that were estimated to develop the off-port emission estimates are the number of trains, the average weight of each train, the distances traveled within the South Coast Air Basin, and the amount of fuel used per ton-mile of train activity. Using the average train capacities discussed above (average 227 containers per train) and the two San Pedro Bay Ports' 2007 intermodal throughputs, the average number of port-related trains was estimated to be 35 per day through the Alameda Corridor[44] including non-container trains discussed above. The gross weight (including locomotives, railcars, and freight) of a typical train was estimated to be 5,646 tons, using the assumptions in Table 6.13. The distance assumptions are 21 miles for the Alameda Corridor and 84 miles between the northern end of the Alameda Corridor to the Air Basin boundary. The latter distance is an average of the east and south routes taken by UP trains and the east route taken by most BNSF trains, weighted by the percentage distribution of freight reported in the 2001 baseline emissions inventory, as shown in Table 6.14 (information from 2001 was used because information from both railroads was not available for the 2005 inventory period). Gross ton-miles were calculated by multiplying together the number of trains, the gross weight per train, and the miles traveled, as summarized in Table 6.15. This table also shows the estimated total fuel usage, estimated by multiplying the gross tons by the average 2001 fuel consumption factor for the two line haul railroads (1.328 gallons of fuel per thousand gross ton-miles), as reported in the 2001 baseline emissions inventory. The railroads' fuel consumption factors may have been lower in 2007 than in 2001, but the railroads declined to provide the 2007 factors for publication, citing confidentiality. The use of the average of their 2001 factors (which have been published in the Port's baseline inventory) will produce a conservatively high estimate of fuel use. Also listed in Table 6.15, is the estimated total out-of-port horsepower-hours, calculated by dividing the fuel use by the fuel use factor of 0.048 gal/hp-hr.

Table 6.13: Assumptions for Gross Weight of Trains

Train Component	Approx. Weight lbs	Weight tons (short)	Number per train	Weight tons (short)
Locomotive	420,000	210	4	840
Railcar (per double-stack platform)	40,000	20	120	2,400
Container		10.6	227	2,406
Total weight per train, gross tons				**5,646**

[44] Overall Alameda Corridor traffic for 2005 was an average of 55 per day. This includes non-port-related traffic; See: *www.acta.org/PDF/CorridorTrainCounts.pdf.*

Table 6.14: Train Travel Distance Assumptions

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

Table 6.15: Gross Ton-Mile, Fuel Use, and Horsepower-hour Estimate

	Distance miles	Trains per year	MMGT per year	MMGT-miles per year
Alameda Corridor	21	6,895	39	819
Central LA to Air Basin Boundary	84	6,895	39	3,276
Million gross ton-miles				**4,095**
Estimated gallons of fuel (millions)				**5.4**
Estimated million horsepower-hours				**113**

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

6.6 Emission Estimates

A summary of estimated emissions from locomotive operations related to the Port is presented below in Tables 6.16 and 6.17. These emissions include operations within the Port and Port-related emissions outside the Port out to the boundary of the South Coast Air Basin. The distribution of emissions is presented graphically in the figure below which shows line haul emissions accounting for 85% to 90% of the total locomotive emissions.

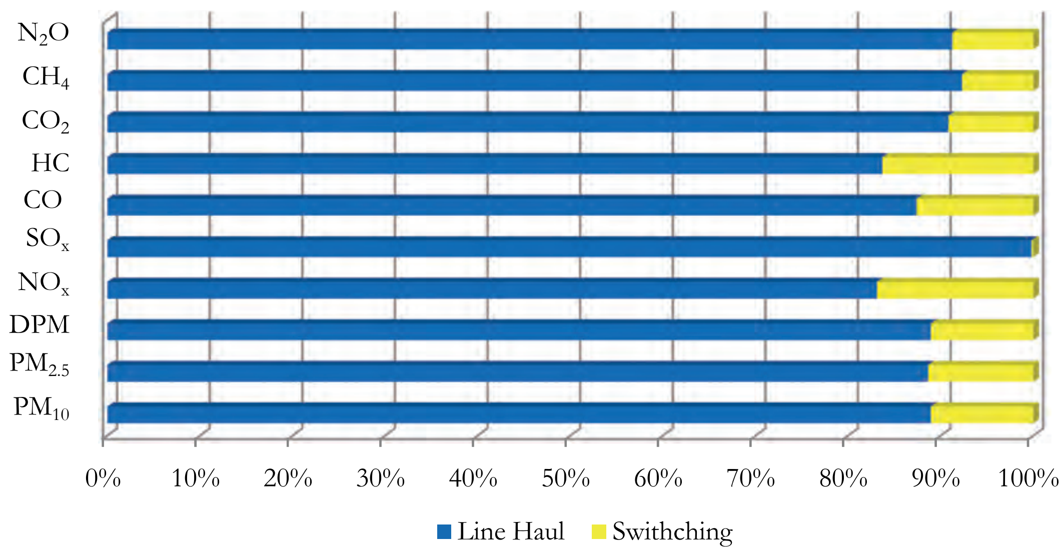
Table 6.16: Port-Related Locomotive Operations Estimated Emissions, tpy

	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Switching	6.6	6.1	6.6	282.8	0.1	33.8	15.3
Line Haul	53.0	47.6	53.0	1,391.9	54.9	234.1	78.6
Total	**59.7**	**53.6**	**59.7**	**1,674.7**	**55.0**	**267.9**	**94.0**

Table 6.17: GHG Port-Related Locomotive Operations Estimated Emissions, tpy

	CO_2	N_2O	CH_4
Switching	8,984	0.2	0.7
Line Haul	89,075	2.4	7.3
Total	**98,059**	**2.6**	**8.1**

Figure 6.6: Distribution of Locomotive Emissions by Category, %



SECTION 7 HEAVY-DUTY VEHICLES

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

7.1 Source Description

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

This report deals exclusively with diesel-fueled HDVs, as there were few, if any, gasoline-fueled or alternatively-fueled counterparts in use in 2007. The most common configuration of HDV is the articulated tractor-trailer (truck and semi-trailer) having five axles, including the trailer axles. The most common type of trailer in the study area is the container trailer, built to accommodate standard-sized cargo containers. Additional trailer types include tankers, boxes, and flatbeds. A tractor traveling without an attached trailer is called a "bobtail."(no trailer load) A tractor pulling an unloaded container trailer chassis is known simply as a "chassis." These vehicles are all classified as heavy HDVs regardless of their actual weight because the classification is based on gross vehicle weight rating (GVWR), which is a rating of the vehicle's total carrying capacity. Therefore, the emission estimates do not distinguish among the different configurations.

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

Figure 7.1: Truck with Container

Figure 7.2: Bobtail Truck

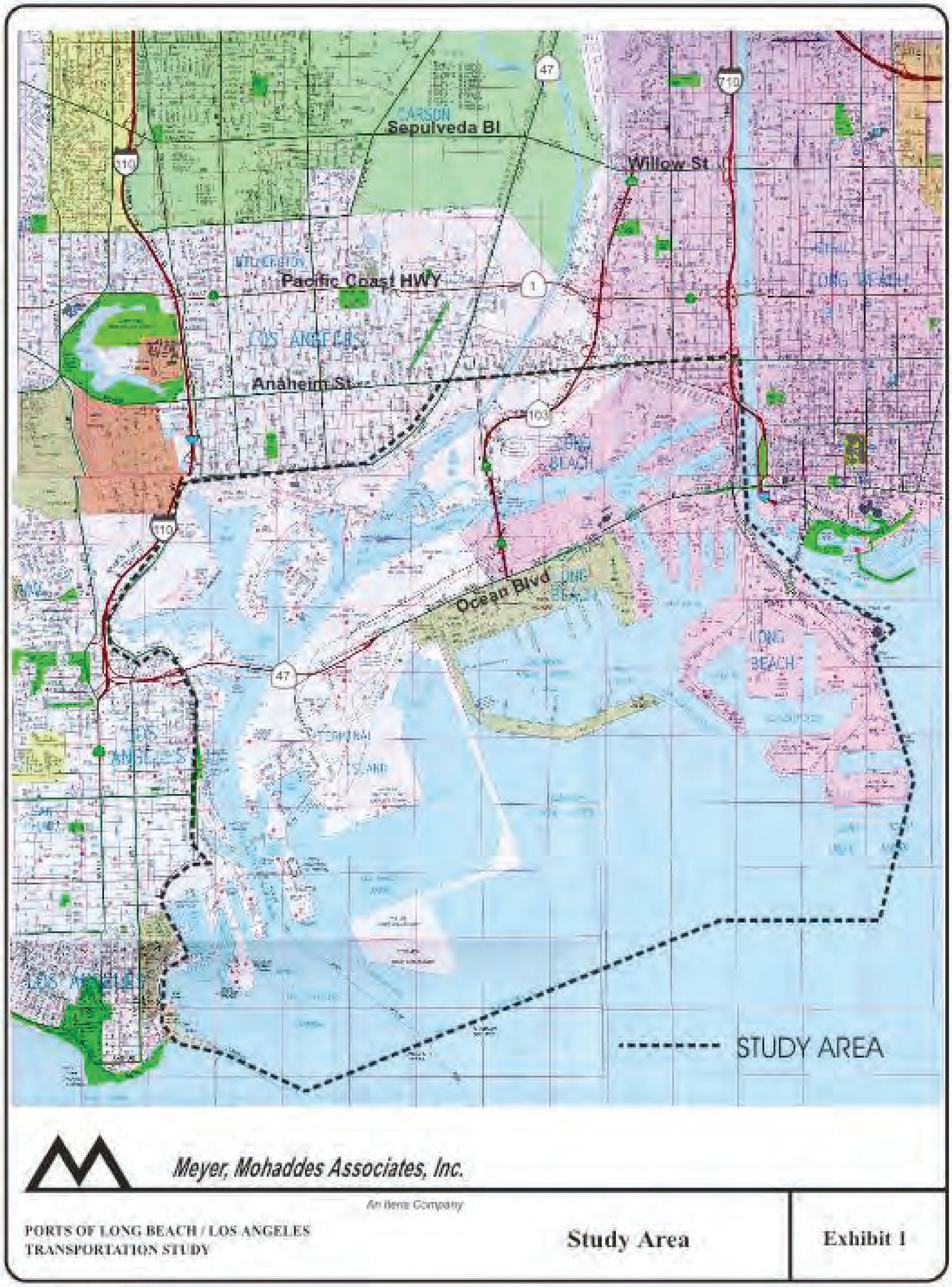
7.2 Geographical Delineation

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

- On-terminal operations, which include waiting for terminal entry, transiting the terminal to drop off and/or pick up cargo, and departing the terminals.
- Off-terminal operations, consisting of travel on public roads outside the Port boundaries but within SoCAB. This includes travel within the boundaries of the adjacent Port of Long Beach, because the routes many trucks take run through both ports on the way to and from Port terminals.

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

Figure 7.3: Port and Near-Port Roadways



7.3 Data and Information Acquisition

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

7.3.1 On-Terminal

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

7.3.2 On-Road

The Port retained a consultant (Iteris, previously known as Meyer Mohaddes Associates) to develop estimates of on-road truck activity inside and outside the Port. To do this, the consultant used trip generation and travel demand models they have used in previous Port transportation studies[45] to estimate the volumes (number of trucks) and average speeds on roadway segments between defined intersections.

The trip generation model was derived from a computer model designed to forecast truck volumes that was developed by Moffatt & Nichol Engineers (M&N), who were team members on the *2001 Port Transportation Study*. The Port's consultant developed and validated the trip generation model using terminal gate traffic count data. They reported in their traffic study report that the model validation confirmed that the model was able to predict truck movements to within two to 10 percent of actual truck counts for all the container terminals combined, and to within 15 percent or better for the majority of individual terminals (MMA 2001). These were considered to be excellent validation results considering the variability of operating conditions and actual gate counts on any given day. The main input to the trip generation model for this study consisted of the average daily container throughput in 2007.

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

The results of the trip generation model were used as input to a Port-area travel demand model also developed by Iteris. This model was based on the regional model used for transportation planning by the Southern California Association of Governments (SCAG), the federally designated Metropolitan Planning Organization for the SoCAB area. Iteris incorporated port-specific truck travel information from the trip generation model, as well as the results of an origin/destination survey of approximately 3,300 Port-area truck drivers, into the Port-area travel demand model.

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

The roadway volumes of truck traffic outside the Port area were estimated by Iteris using a regional analysis that modeled Port-related trucks bi-directionally on highways and major thoroughfares within the greater Los Angeles area until the trucks leave the highways and enter city streets. The intent was to model Port-related trucks on their way from the Port until they make their first stop, whether for delivery of a container to a customer or to a transloading facility, or reach the boundary of the South Coast Air Basin. Transloading is the process of unloading freight from its overseas shipping container and re-packing it for overland shipment to its destination.

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

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

7.4 Operational Profiles

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

7.4.1 On-Terminal

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

Table 7.2: Summary of Reported Container Terminal Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	17.5	1.5	na	0.17	0.37	0.10
Minimum	10	0.9	na	0.00	0.08	0.00
Average	13	1.2	na	0.10	0.26	0.03
Total			**4,486,223**			

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

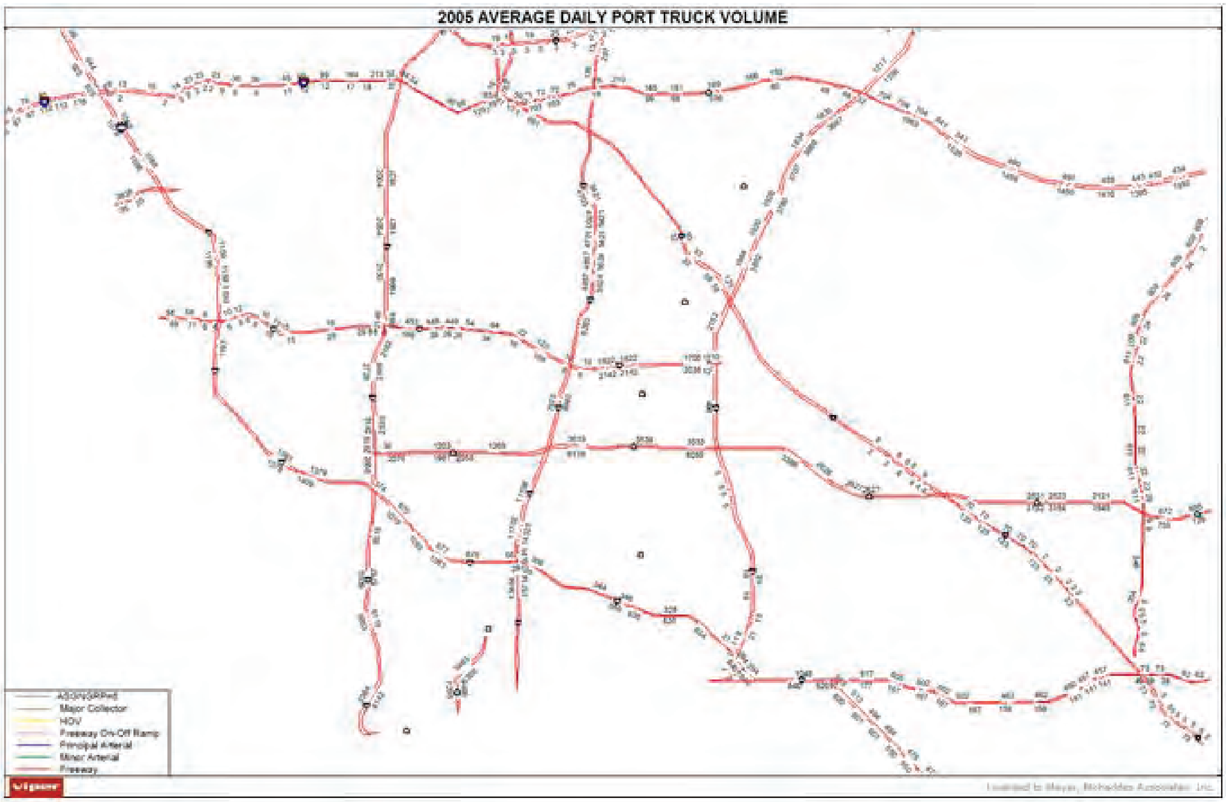
Table 7.3: Summary of Reported Non-Container Facility Operating Characteristics

	Speed (mph)	Distance (miles)	No. Trips (per year)	Gate In (hours)	Unload/ Load (hours)	Gate Out (hours)
Maximum	20.0	1.3	na	0.17	0.45	0.10
Minimum	2	0.0	na	0.00	0.00	0.00
Average	8	0.5	na	0.05	0.12	0.03
Total			**1,762,562**			

7.4.2 On-Road

Figure 7.4 provides a graphical example of the regional analysis, a map of area roadways listing the number of trucks on each segment of road, in each direction of travel. The information on these maps was incorporated into the same calculations used for the in-port on-road estimates described above. The daily traffic estimates are based on average week-day activity during a peak month. They have been annualized for the emission estimates presented in this inventory by adjusting for peak to average conditions on the basis of 255 weekdays of terminal operation per year, and assuming that weekend activity accounts for 15% of total annual activity. These adjustments are empirically derived factors used by the Port in their planning processes requiring annualization of daily activity measures.

Figure 7.4: Regional Traffic Volume Map



7.5 Methodology

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

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

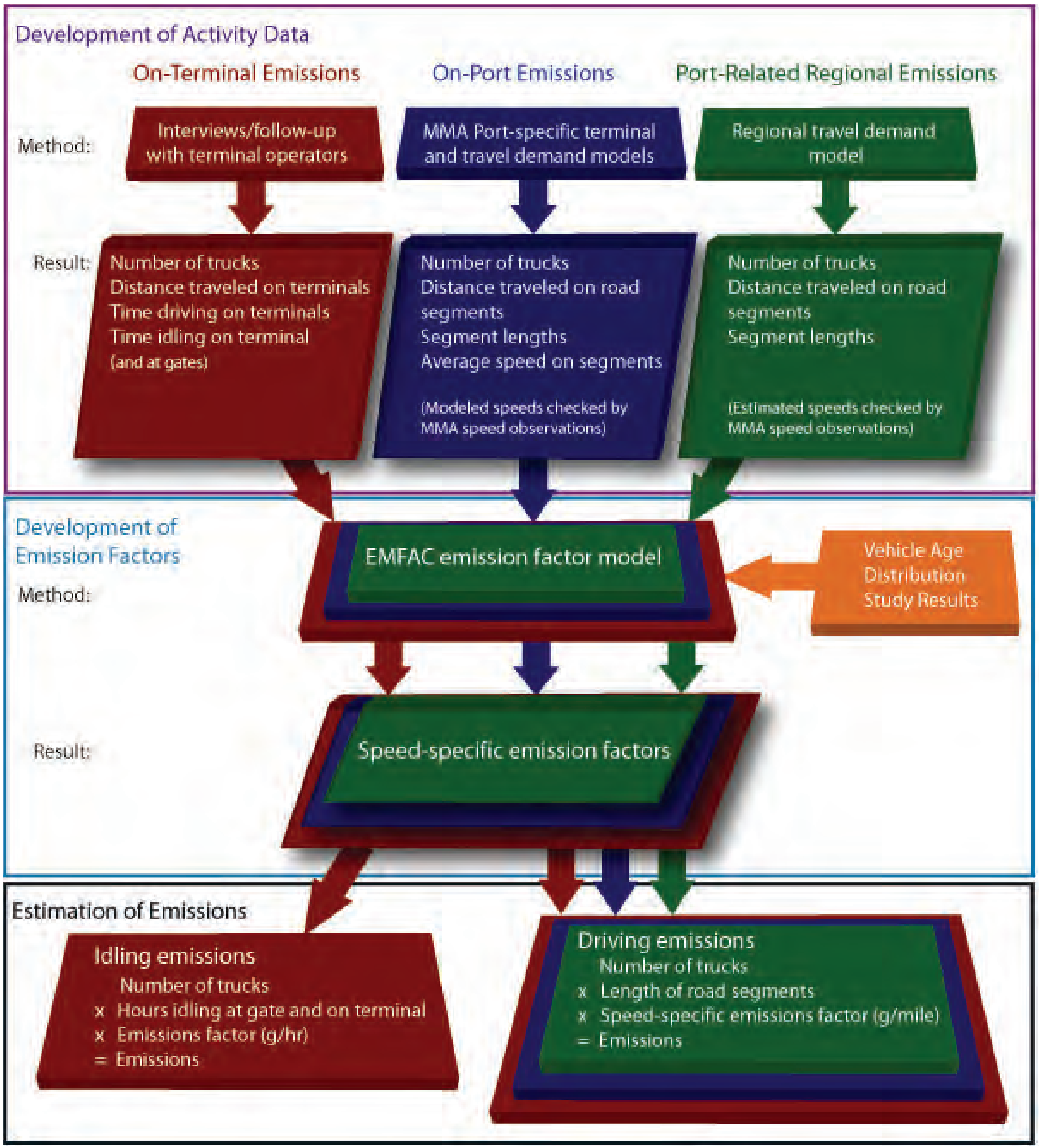
Equation 7.1

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

Where:

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

Figure 7.5: HDV Emission Estimating Process



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

Equation 7.2

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

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

7.5.1 The EMFAC model

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

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

7.5.2 Basic Emission Rates

The basic emission rates of heavy duty-diesel trucks included in EMFAC are derived from tests of vehicles randomly selected from the in-use fleet. Because CARB has imposed progressively more stringent standards for the allowable emissions from trucks over many years, different model years of trucks have been certified to specific standards and, therefore, are assumed to emit at different rates. Table 7.4 lists the emission factors used to estimate the emission of trucks visiting the Port.

Table 7.4: Emission Factors in EMFAC 2007 (ZMR in g/mi – DR in g/mi/10,000mi)

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

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

Table 7.5: Idle Emission Rates in EMFAC 2007 (g/hr)

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

A more in-depth explanation of CARB's heavy-duty diesel inventory estimation methodology can be found in their document "*Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors*"[46] 3 April 2006.

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

While most emissions from heavy-heavy duty diesel trucks are estimated on a per-mile or per-hour basis, the inventory SO_x was calculated based upon an estimate of the amount of fuel consumed. The following equation was used to derive the SO_x inventory.

Equation 7.3

$$SO_x \text{ emissions (tpd)} = \frac{(X \text{ g S}/1{,}000{,}000 \text{ g fuel}) \times (3{,}311.21 \text{ g/gallon}) \times (2 \text{ g } SO_x/\text{g S}) \times (Y\text{miles/day})}{(5.273 \text{ miles/gallon}) \times (453.59 \text{ g/lb} \times 2{,}000 \text{ lbs/ton})}$$

In this equation, g is grams, S is sulfur, and lb is pounds. The emission calculations have been based on the introduction of 15 ppm ULSD as commercially available on-road diesel fuel at the beginning of September 2006. The weight of a gallon of diesel fuel is assumed to be 7.3 pounds or 3,311.21 grams (7.3 lbs x 453.59 g/lb). Based on the EMFAC model, the fleet average fuel economy of the heavy-heavy duty diesel fleet is assumed to be 5.273 miles per gallon. The estimates of daily vehicle miles of travel were from the Iteris trip generation and travel demand modeling for in-Port and regional on-road travel, and were derived through tenant surveys for the on-terminal estimates.

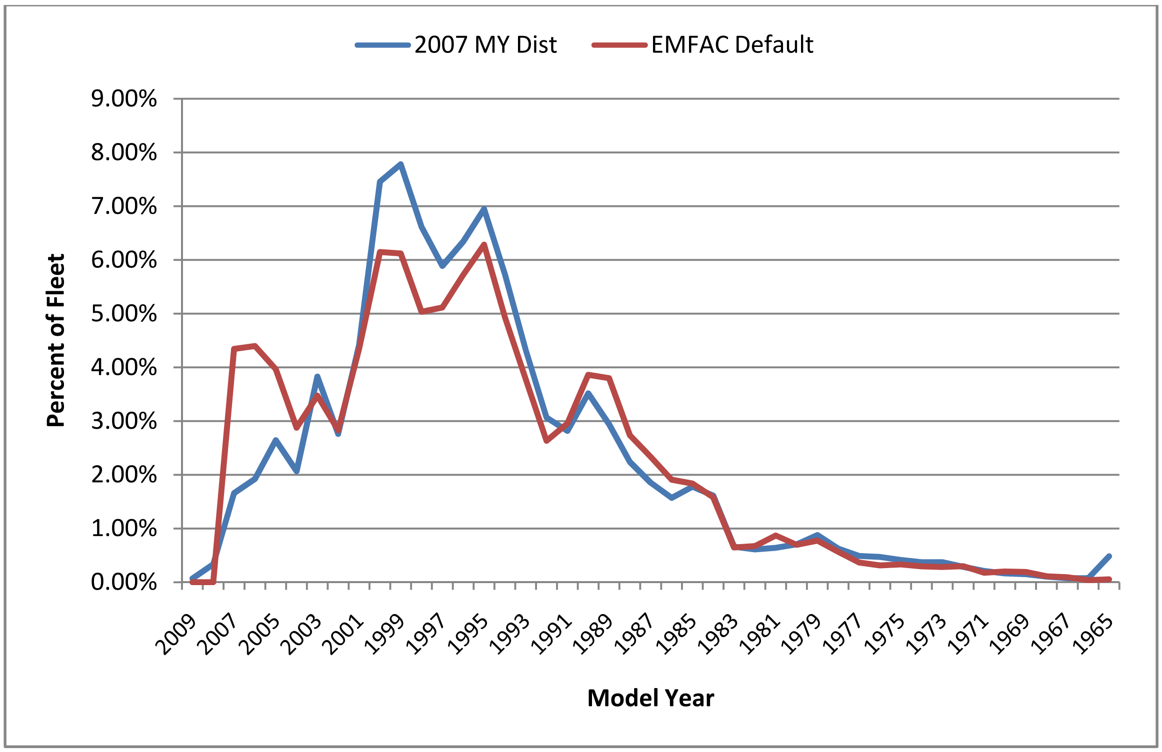
7.5.3 Age Distribution

The age distribution (count of vehicles by model year) of trucks calling upon the Port was determined through evaluation of license plate numbers provided by several container terminals. This is an on-going project of the two ports and the age distribution will be updated periodically as new data is received and evaluated.

For the calendar year 2007, over 4,000,000 records were received from the terminals obtained primarily by means of optical character recognition systems (OCR) automatically capturing and digitally storing the license plate information as trucks enter or leave the terminal. These 4,000,000 records yielded about 218,000 unique license plate numbers. Registration information was requested from the California Department of Motor Vehicles and 54,493 records were returned containing model year and registration information for both California base-plated and out of state trucks. These 54,493 vehicles accounted for over 3,000,000 of the Port related truck trips taken in 2007. A majority of the truck trips (>80%) were attributable to the relatively small portion of the fleet that frequent the port more than once every other day (12.2%).

The distribution of the truck population by age is presented in Figure 6.6 below. The average age of the Port-related fleet was determined to be 12.2 years, which is in reasonable agreement with the EMFAC estimate of heavy-duty diesel trucks in operation within the South Coast Air Basin of 11.6 years. While the average age is similar, the EMFAC distribution includes a greater proportion of trucks in the newest age range (up to six years old) and correspondingly fewer trucks in the eight to 13-year age range.

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



EMFAC carries an estimate of 45 model years of population within each calendar year ranging from the newest, for which the model year is the same as the current calendar year, to the oldest where the model year is the current calendar year minus 45. Therefore, EMFAC does not allow the model year to be greater than the current calendar year. For purposes of this analysis, 2008 and 2009 model year trucks that were in the sample of license plates provided by the terminals were assumed to have the same activity as 2007 model year trucks.

7.5.4 Mileage Accrual Rates/Cumulative Mileage

Since no data were available to estimate the actual mileage of each truck visiting the Port, the mileage accrual rates from EMFAC were used. The mileage accrual rates are the estimates of the miles traveled each year by vehicles of a specific age and type of vehicle. When vehicles are new, the mileage accrual rates are assumed to be at their highest. The miles per year tend to decline as the truck ages.

CARB has also modified the mileage accrual rates used in EMFAC as discussed in their document entitled "*Redistribution of Heavy-Heavy Duty Diesel Truck Vehicle Miles Traveled in California*" 13 September 2006[47]. The mileage accrual rates included in the EMFAC 2007 update and used in this analysis are shown in Table 7.6.

Table 7.6: Mileage Accrual Rates Heavy-Heavy Duty Diesel Trucks in EMFAC 2007 (mi/yr)

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

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

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

In keeping with our example of a three year old truck, the basic emission rate for NO_x would be calculated as follows:

Equation 7.4

12.5 g/mi (ZMR) + 0.052 g/mi/10K miles (DR) x 252,317 miles (Cumulative Mileage) = 13.81 g/mi

A population weighted basic emission rate for each pollutant was derived performing the calculation above for each model year; the results were then weighted by the population fraction in each model year. These fleet weighted emission rates are presented in Table 7.7.

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

Pollutant	Emission Rate (g/mile)
HC	1.67
CO	8.57
NO_x	21.88
PM	1.36

7.5.5 Correction Factors

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

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

Table 7.8: CARB Diesel Fuel Correction Factors

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

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

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

In the current version of EMFAC, at least two pollutant specific speed correction factors are needed to properly characterize the emissions of the heavy-duty truck fleet. The equation and coefficients needed to derive the speed correction factors included in EMFAC 2007 are described in CARB documentation[48].

Equation 7.5

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

Table 7.9 lists the speed correction factor coefficients.

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

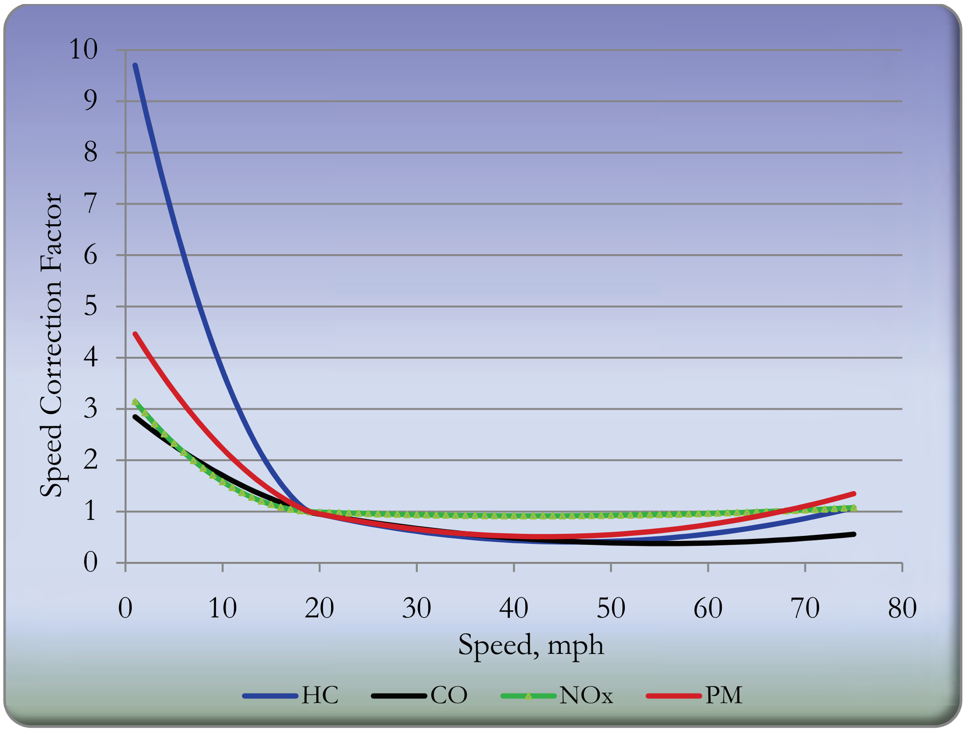
Table 7.9: CARB Speed Correction Factor Coefficients

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

These speed correction factors were used to derive speed specific emission factors for each pollutant at 5 mile per hour increments for use in this analysis. This was accomplished by deriving the model year and pollutant specific speed correction factors and then weighting each factor by the population of Port trucks in each model year group. Figure 7.7 shows the fleet weighted speed correction factors for each pollutant.

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

Figure 7.7: Fleet Weighted Speed Correction Factors



7.6 Emission Estimates

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

Idling emissions were estimated separately for the on-terminal estimates, since the off-terminal traffic modeling analysis reported only volumes, distances, and average speeds, which were used to estimate VMT. This is a valid approach because the average speeds include estimates of normal traffic idling times and the emission factors are designed to take this into account. Since annual activity was used for the on-terminal analysis, emissions have been calculated as tons per year, with idling and transit activities estimated separately. Table 7.10 summarizes the two modes of on-terminal operation by terminal.

Table 7.10: 2007 On-Terminal VMT and Idling Hours by Terminal Type

Terminal Type	Total Miles Traveled	Total Hours Idling (all trips)
Container	875,600	466,987
Container	1,506,750	385,058
Container	675,000	120,000
Container	509,521	212,300
Container	1,192,787	329,436
Container	827,117	220,564
Other	188,369	28,635
Other	273,991	41,651
Other	67,600	8,543
Other	3,809	1,904
Dry Bulk	1,250	375
Break Bulk	700	1,027
Auto	1,823	1,218
Liquid	70	140
Break Bulk	58,500	25,350
Liquid	18	0
Dry Bulk	13,520	2,055
Other	26,750	16,942
Other	520	922
Other	64	527
Other	10,140	1,408
Other	991,340	449,407
Liquid	7,612	17,659
Liquid	2,951	2,460
Total	**7,235,800**	**2,334,568**

Emission estimates for HDV activity associated with Port terminals and other facilities are presented in the following tables. Tables 7.11 and 7.12 summarize emissions from HDVs associated with all Port terminals.

Table 7.11: Summary of HDV Emissions, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	7,235,800	31	28	31	480	0.2	233	90
On-Road	269,918,953	339	312	339	6,863	6	2,296	356
Total	**277,154,753**	**370**	**340**	**370**	**7,343**	**6**	**2,529**	**445**

Table 7.12: Summary of HDV GHG Emissions, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	7,235,800	35,903	1	5
On-Road	269,918,953	575,745	16	21
Total	**277,154,753**	**611,648**	**17**	**26**

Tables 7.13 and 7.14 show emissions associated with container terminal activity separately from emissions associated with other Port terminals and facilities.

Table 7.13: Summary of HDV Emissions Associated with Container Terminals, tpy

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	5,586,774	24	22	24	364	0.1	179	68
On-Road	243,266,375	306	281	306	6,185	5	2,070	321
Total	**248,853,149**	**329**	**303**	**329**	**6,549**	**5**	**2,249**	**389**

Table 7.14: Summary of HDV GHG Emissions Associated with Container Terminals, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	5,586,774	27,487	1	4
On-Road	243,266,375	518,895	15	19
Total	**248,853,149**	**546,382**	**15**	**23**

Tables 7.15 and 7.16 show emissions associated with other Port terminals and facilities separately.

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

Activity Location	VMT	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
On-Terminal	1,649,026	7	6	7	116	0	54	21
On-Road	26,652,579	33	31	33	678	1	227	35
Total	**28,301,604**	**40**	**37**	**40**	**794**	**1**	**280**	**56**

Table 7.16: Summary of HDV GHG Emissions Associated with Other Port Terminals, tpy

Activity Location	VMT	CO_2	N_2O	CH_4
On-Terminal	1,649,026	8,416	0	1
On-Road	26,652,579	56,850	2	2
Total	**28,301,604**	**65,266**	**2**	**3**

SECTION 8 SUMMARY OF 2007 EMISSION RESULTS

The emission results for the Port of Los Angeles 2007 Inventory of Air Emissions are presented in this section. Tables 8.1 and 8.2 summarize the 2007 total Port-related emissions in the South Coast Air Basin by category in tons per year.

Table 8.1: 2007 Port-related Emissions by Category, tpy

Category	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
Ocean-going vessels	416	333	333	6,142	3,718	587	267
Harbor craft	53	49	53	1,281	1	348	85
Cargo handling equipment	46	43	45	1,662	2	919	81
Rail locomotives	60	54	60	1,675	55	268	94
Heavy-duty vehicles	370	340	370	7,343	6	2,529	445
Total	**944**	**817**	**860**	**18,102**	**3,781**	**4,652**	**973**

DB ID457

Table 8.2: 2007 Port-related GHG Emissions by Category, tpy

Category	CO_2	N_2O	CH_4
Ocean-going vessels	361,038	21	5
Harbor craft	89,130	3	2
Cargo handling equipment	255,180	5	6
Rail locomotives	98,059	3	8
Heavy-duty vehicles	611,648	17	26
Total	**1,415,055**	**48**	**47**

The greenhouse gas emissions summarized in Table 8.3 are in metric tons per year (2,200 lbs/ton) instead of the short tons per year (2,000 lbs/ton) used throughout the report. Table 8.3 includes the CO_2 equivalent which is derived by multiplying the GHG emissions estimates by the following global warming potential (GWP)[49] values and then adding them together:

- CO_2 – 1
- CH_4 – 21
- N_2O – 310

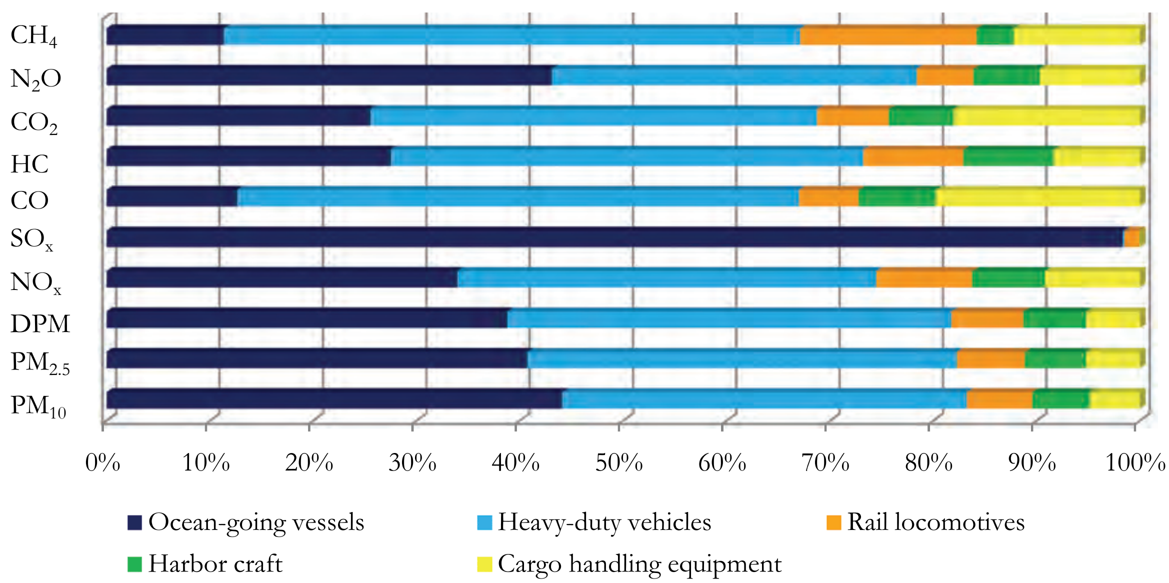
[49] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006*, 15 April 2008.

Table 8.3: 2007 Port-related GHG Emissions by Category, MT/yr

Category	CO_2 Equivalent	CO_2	N_2O	CH_4
Ocean-going vessels	334,121	328,217	19	5
Harbor craft	81,928	81,027	3	2
Cargo handling equipment	233,397	231,982	4	5
Rail locomotives	90,036	89,144	2	7
Heavy-duty vehicles	561,303	556,044	15	24
Total	**1,300,785**	**1,286,414**	**43**	**43**

Figure 8.1 shows the distribution of the 2007 total port-related emissions for each pollutant and category.

Figure 8.1: 2007 Port-related Emissions by Category, %



In order to put the Port-related emissions into context, the following figures and tables compare the Port's contributions to the other sources in the South Coast Air Basin. The 2007 SoCAB emissions used for this comparison were interpolated from the 2005 and 2008 emissions listed in the 2007 AQMP Appendix III[50].

[50] SCAQMD, *Final 2007 AQMP Appendix III Table A-2 and A-3, Base & Future Year Emissions Inventories*, June 2007.

Figure 8.2: 2007 DPM Emissions in the South Coast Air Basin, %

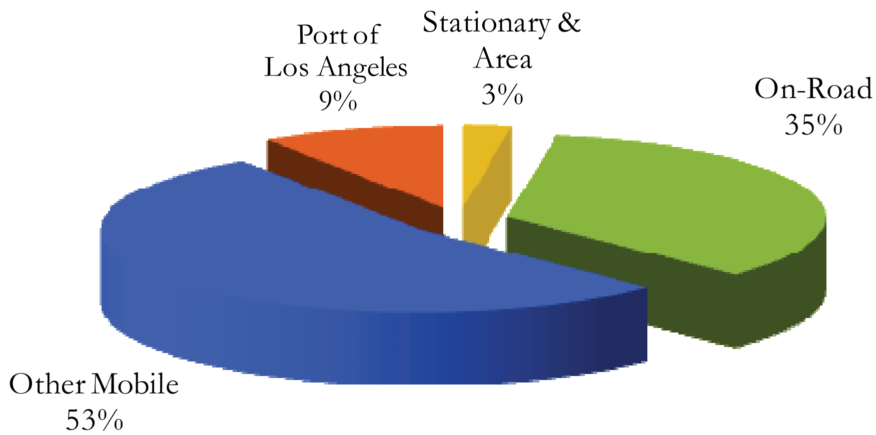


Figure 8.3: 2007 NO_x Emissions in the South Coast Air Basin, %

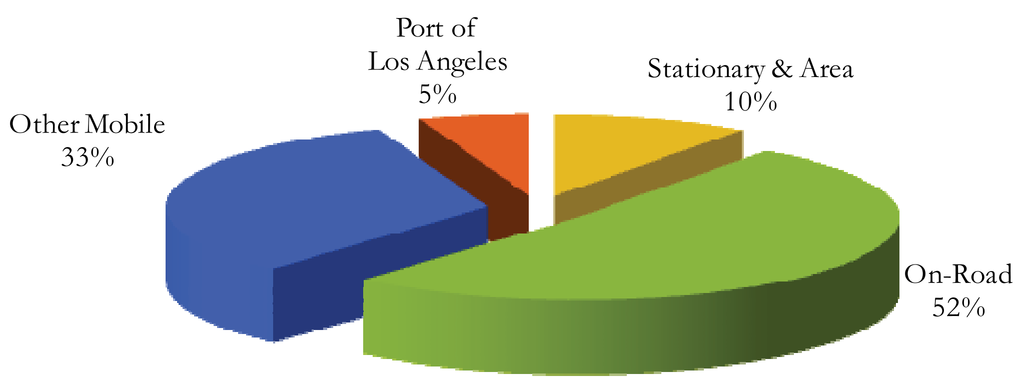
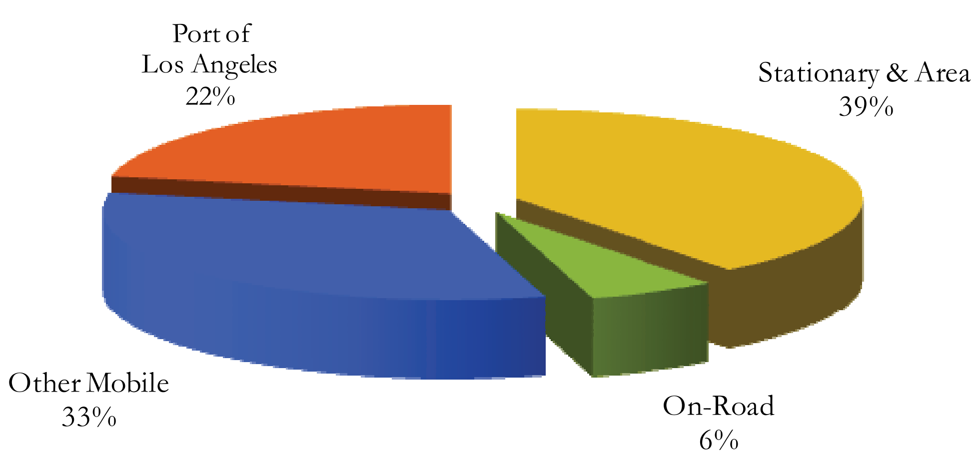


Figure 8.4: 2007 SO_x Emissions in the South Coast Air Basin, %



Tables 8.4 through 8.6 show by source subcategory, the percent emissions as it relates to the source category, the total Port-related emissions, and the South Coast Air Basin emissions. For example, containership DPM emissions are 77% of the OGV emissions, 30% of the Port emissions and 3% of the South Coast Air Basin emissions.

Table 8.4: 2007 DPM Emissions Percentage Comparison, tpy and %

Category	Subcategory	DPM Emissions	Percent DPM Emissions of Total Category	Port	SoCAB AQMP
CHE	RTG crane, crane	6	13%	1%	0%
CHE	Forklift	2	5%	0%	0%
CHE	Top handler, side pick	8	19%	1%	0%
CHE	Other	6	14%	1%	0%
CHE	Yard tractor	22	50%	3%	0%
CHE	**Subtotal**	**45**	**100%**	**5%**	**0%**
OGV	Auto carrier	5	1%	1%	0%
OGV	Bulk vessel	11	3%	1%	0%
OGV	Containership	257	77%	30%	3%
OGV	Cruise	22	7%	3%	0%
OGV	General cargo	7	2%	1%	0%
OGV	Ocean tugboat	1	0%	0%	0%
OGV	Miscellaneous	0	0%	0%	0%
OGV	Reefer	4	1%	0%	0%
OGV	RoRo	0	0%	0%	0%
OGV	Tanker	26	8%	3%	0%
OGV	**Subtotal**	**333**	**100%**	**39%**	**4%**
Harbor Craft	Assist tug	18	35%	2%	0%
Harbor Craft	Harbor tug	6	11%	1%	0%
Harbor Craft	Commercial fishing	6	12%	1%	0%
Harbor Craft	Ferry	7	13%	1%	0%
Harbor Craft	Line haul tug	2	4%	0%	0%
Harbor Craft	Government	2	3%	0%	0%
Harbor Craft	Excursion	7	13%	1%	0%
Harbor Craft	Crewboat	4	8%	0%	0%
Harbor Craft	Work boat	1	2%	0%	0%
Harbor Craft	**Subtotal**	**53**	**100%**	**6%**	**1%**
HDV	On-Terminal	31	8%	4%	0%
HDV	On-Road	339	92%	39%	4%
HDV	**Subtotal**	**370**	**100%**	**43%**	**4%**
Rail	Switching	7	11%	1%	0%
Rail	Line haul	53	89%	6%	1%
Rail	**Subtotal**	**60**	**100%**	**7%**	**1%**
Port	**Total**	**860**		**100%**	**9%**
SoCAB AQMP	**Total**	**9,198**			

Table 8.5: 2007 NO_x Emissions Percentage Comparison, tpy and %

Category	Subcategory	NO_x Emissions	Percent NO_x Emissions of Total Category	Port	SoCAB AQMP
CHE	RTG crane	209	13%	1%	0%
CHE	Forklift	146	9%	1%	0%
CHE	Top handler, side pick	313	19%	2%	0%
CHE	Other	151	9%	1%	0%
CHE	Yard tractor	843	51%	5%	0%
CHE	**Subtotal**	**1,662**	**100%**	**9%**	**1%**
OGV	Auto carrier	73	1%	0%	0%
OGV	Bulk vessel	202	3%	1%	0%
OGV	Containership	4,174	68%	23%	1%
OGV	Cruise	832	14%	5%	0%
OGV	General cargo	113	2%	1%	0%
OGV	Ocean tugboat	60	1%	0%	0%
OGV	Miscellaneous	2	0%	0%	0%
OGV	Reefer	83	1%	0%	0%
OGV	RoRo	3	0%	0%	0%
OGV	Tanker	599	10%	3%	0%
OGV	**Subtotal**	**6,142**	**100%**	**34%**	**2%**
Harbor Craft	Assist tug	457	36%	3%	0%
Harbor Craft	Harbor tug	130	10%	1%	0%
Harbor Craft	Commercial fishing	165	13%	1%	0%
Harbor Craft	Ferry	152	12%	1%	0%
Harbor Craft	Line haul tug	54	4%	0%	0%
Harbor Craft	Government	39	3%	0%	0%
Harbor Craft	Excursion	158	12%	1%	0%
Harbor Craft	Crewboat	102	8%	1%	0%
Harbor Craft	Work boat	24	2%	0%	0%
Harbor Craft	**Subtotal**	**1,281**	**100%**	**7%**	**0%**
HDV	On-Terminal	480	7%	3%	0%
HDV	On-Road	6,863	93%	38%	2%
HDV	**Subtotal**	**7,343**	**100%**	**41%**	**2%**
Rail	Switching	283	17%	2%	0%
Rail	Line haul	1,392	83%	8%	0%
Rail	**Subtotal**	**1,675**	**100%**	**9%**	**1%**
Port	**Total**	**18,102**		**100%**	**5.5%**
SoCAB AQMP	**Total**	**327,040**			

Table 8.6: 2007 SO_x Emissions Percentage Comparison, tpy and %

Category	Subcategory	SO_x Emissions	Percent SO_x Emissions of Total Category	Port	SoCAB AQMP
CHE	RTG crane	0	14%	0%	0%
CHE	Forklift	0	2%	0%	0%
CHE	Top handler, side pick	0	17%	0%	0%
CHE	Other	0	5%	0%	0%
CHE	Yard tractor	1	62%	0%	0%
CHE	**Subtotal**	**2**	**100%**	**0%**	**0%**
OGV	Auto carrier	39	1%	1%	0%
OGV	Bulk vessel	112	3%	3%	1%
OGV	Containership	2,262	61%	60%	13%
OGV	Cruise	215	6%	6%	1%
OGV	General cargo	72	2%	2%	0%
OGV	Ocean tugboat	5	0%	0%	0%
OGV	Miscellaneous	1	0%	0%	0%
OGV	Reefer	33	1%	1%	0%
OGV	RoRo	1	0%	0%	0%
OGV	Tanker	978	26%	26%	6%
OGV	**Subtotal**	**3,718**	**100%**	**98%**	**22%**
Harbor Craft	Assist tug	0.2	32%	0%	0%
Harbor Craft	Harbor tug	0.1	10%	0%	0%
Harbor Craft	Commercial fishing	0.1	14%	0%	0%
Harbor Craft	Ferry	0.1	15%	0%	0%
Harbor Craft	Line haul tug	0.0	3%	0%	0%
Harbor Craft	Government	0.0	3%	0%	0%
Harbor Craft	Excursion	0.1	14%	0%	0%
Harbor Craft	Crewboat	0.0	6%	0%	0%
Harbor Craft	Work boat	0.0	2%	0%	0%
Harbor Craft	**Subtotal**	**1**	**100%**	**0%**	**0%**
HDV	On-Terminal	0	3%	0%	0%
HDV	On-Road	6	97%	0%	0%
HDV	**Subtotal**	**6**	**100%**	**0%**	**0%**
Rail	Switching	0	0%	0%	0%
Rail	Line haul	55	100%	1%	0%
Rail	**Subtotal**	**55**	**100%**	**1%**	**0%**
Port	**Total**	**3,781**		**100%**	**22%**
SoCAB AQMP	**Total**	**17,046**			

SECTION 9 COMPARISON OF 2007, 2006, 2005 AND 2001 FINDINGS AND EMISSION ESTIMATES

The emissions for 2007, 2006, 2005 and 2001 calendar year activity are compared in this section. Each subsection contains the emissions table and chart comparisons, states how the emissions estimates were derived and compares findings for that source category. For each specific source category, if there was a methodological change in 2007, then the previous years' emissions were recalculated using that previous year activity with the new 2007 methodology to provide a valid basis for comparison. If there was no change in methodology, then the emissions included in the 2006 inventory report were used for the comparison.

Methodological differences for 2007 vs. previous 2006 Inventory of Air Emissions:

OGV

- The methodology used in 2007 to estimate ocean-going vessel emissions is the same as what was used in 2006 Inventory of Air Emissions, but some factors were updated. Fuel correction factors (FCF) used for 2007 EI are based on CARB's marine auxiliary engine rule. Due to the change, the previous years' emissions were recalculated for OGV.

Harbor Craft

- The methodology used in 2007 to estimate harbor craft emissions is the same as what was used in 2006 Inventory of Air Emissions.

CHE

- The methodology used in 2007 to estimate cargo handling equipment emissions is the same as what was used in 2006 Inventory of Air Emissions.

Rail

- The methodology used in 2007 to estimate rail emissions is the same as what was used in 2006 Inventory of Air Emissions.

HDV

- The methodology used in 2007 to estimate HDV emissions is the same as what was used in 2006 Inventory of Air Emissions, with the exception of N_2O EF change. The N_2O EF used for 2007 uses a gram per gallon N_2O emission rate for distillate fuels consistent with CARB's methodology.

Table 9.1 and Figure 9.1 illustrate the differences in vessel calls and container cargo throughputs between 2001, 2005, 2006, and 2007.

Table 9.1: TEUs and Vessel Call Comparison, %

EI Year	All Calls	Containership Calls	TEUs	Average TEUs/Call
2007	2,538	1,575	8,355,038	5,305
2006	2,708	1,626	8,469,853	5,209
2005	2,341	1,423	7,484,625	5,260
2001	2,717	1,584	5,183,520	3,272
2007-2006	**-6%**	**-3%**	**-1%**	**2%**
2007-2005	**8%**	**11%**	**12%**	**1%**
2007-2001	**-7%**	**-1%**	**61%**	**62%**

Figure 9.1: TEUs and Vessel Call Comparison, %

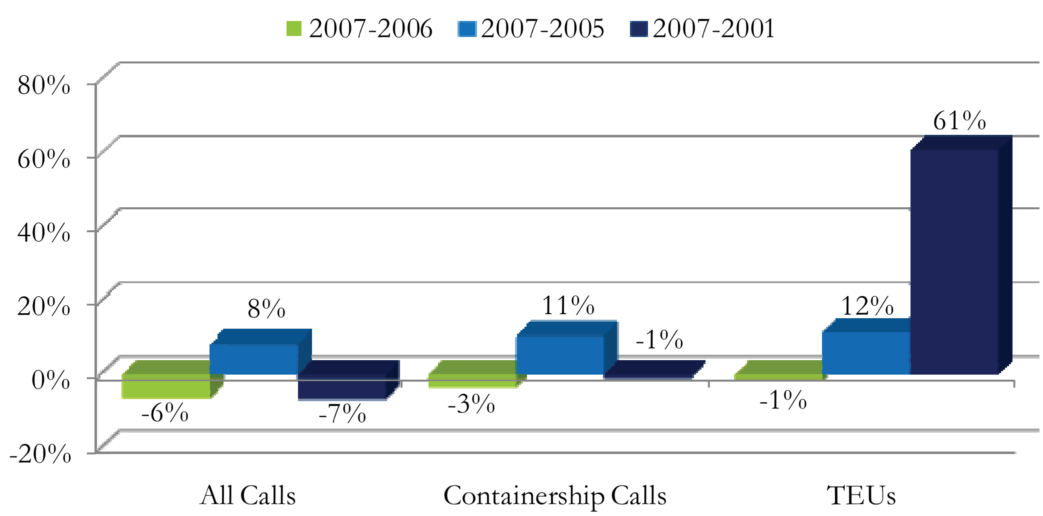


Table 9.2 presents the total net change in emissions for all source categories in 2007 as compared to 2006, 2005 and 2001. Despite increased throughput activity since 2001, the 2007 port-wide emissions were lower than 2006 and 2005, except for CO in 2005 which increased. When compared to 2001 emissions, the 2007 emissions were lower for PM and SO_x, but NO_x, CO and hydrocarbon emissions increased. Most of the emission reduction programs have been aimed to reduce particulate matter, thus the 14% to 20% PM emission reduction. The diesel engines are currently burning diesel fuel with lower sulfur content, including the fuel switching for ocean-going vessels for their auxiliary engines, and this has a direct impact on the SO_x emissions which have been reduced over 34%. The CO and hydrocarbon increases are due to increase in activity; the new engine standards which have higher CO and HC emission rates; and the increase in propane engines in the inventory which have higher CO emissions than diesel engines.

Table 9.2: Port-wide Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	944	817	860	18,102	3,781	4,652	973
2006	1,177	1,011	1,080	19,962	5,729	4,969	1,100
2005	1,135	969	1,052	18,324	5,767	4,350	1,025
2001	1,089	917	na	16,119	6,330	3,451	837
2007-2006	**-20%**	**-19%**	**-20%**	**-9%**	**-34%**	**-6%**	**-12%**
2007-2005	**-17%**	**-16%**	**-18%**	**-1%**	**-34%**	**7%**	**-5%**
2007-2001	**-13%**	**-11%**	**na**	**12%**	**-40%**	**35%**	**16%**

Figure 9.2 presents the percent change in emissions between 2007 and 2006. From 2006 to 2007, the port-wide emissions decreased for all pollutants. There was a slight 1% decrease in TEU throughput also, but the emissions decrease was greater than the throughput decrease because of the emission reduction strategies in place in 2007. The main reason for the decrease in emissions in 2007 is due to OGV emissions decrease as a result of the CARB auxiliary engine rule which was in place for 2007. The fuel switch to cleaner fuels by OGV auxiliary engines helped reduce the 2007 emissions as compared to 2006.

Figure 9.2: Port-wide Emissions Comparison, 2007-2006, % Change

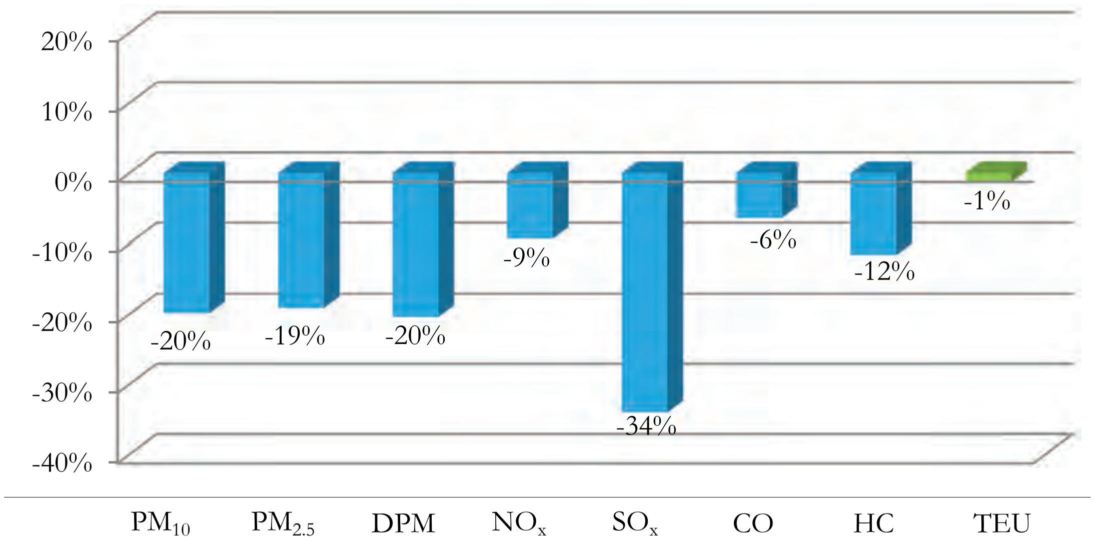


Figure 9.3 presents the percent change in emissions between 2007 and 2005. From 2005 to 2007, despite a 12% increase in throughput, port-wide emissions decreased for all pollutants except for CO. The main reason for the decrease in emissions in 2007 is due to OGV emissions decrease as a result of the CARB auxiliary engine rule which was in place for 2007. The fuel switch to cleaner fuels by OGV auxiliary engines helped reduce the 2007 emissions as compared to 2006. The CO increase is due to the new engine standards and more propane equipment seen in the inventory.

Figure 9.3: Port-wide Emissions Comparison, 2007-2005, % Change

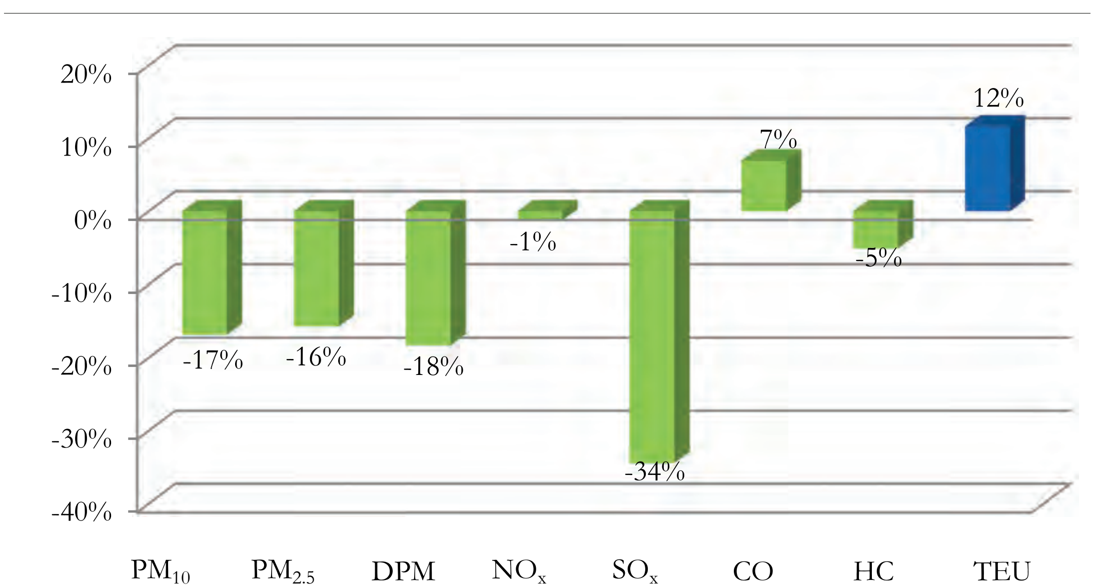
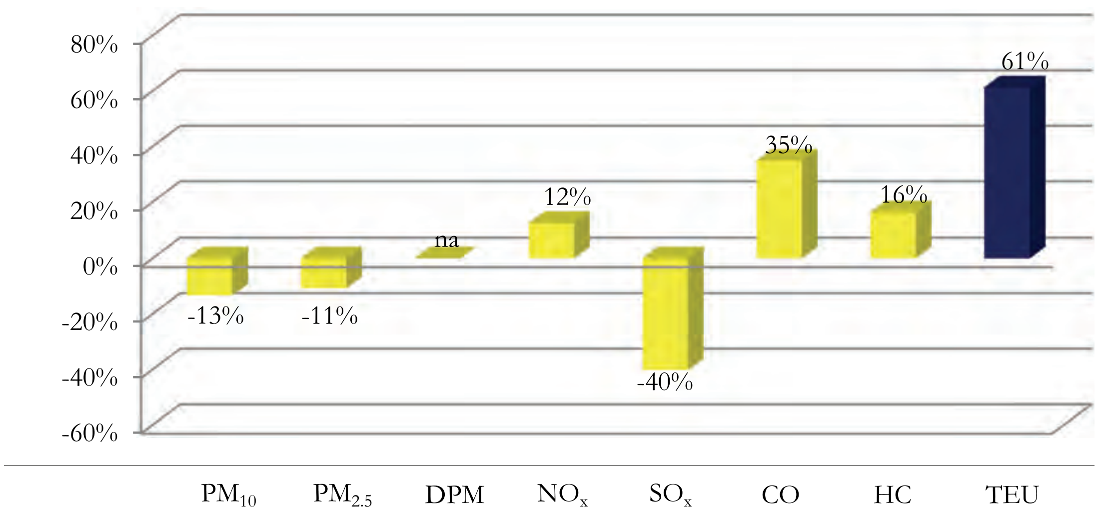


Figure 9.4 presents the percent change in emissions from between 2007 and 2001. From 2001 to 2007, despite a 61% increase in throughput, emissions decreased for PM and SO_x. The emissions increases for NO_x, CO and hydrocarbons are due mainly to an increase in activity, the new emissions standards (with increased CO values) and more propane engines which have higher CO emissions compared to diesel engines. The OGV, CHE and harbor craft emissions decreased in 2007 as compared to 2001.

Figure 9.4: Port-wide Emissions Comparison, 2007-2001, % Change



In summary, the 2007 emissions for all pollutants were reduced port-wide as compared to 2005 and 2006, except for CO. Also, despite a 62% increase in TEU throughput from 2001 to 2007, the PM and SO_x emissions decreased in 2007. Similar to the port-wide emissions, the emissions per container handled continued to decline in 2007 compared to 2006, 2005, and 2001 for all pollutants.

Table 9.3 compares the port-wide greenhouse gas emissions for 2007 and 2006 showing an 11% decrease in the CO_2 equivalent.

Table 9.3: Port-wide GHG Emissions Comparison, 2007-2006, MT/yr

Year	CO_2 Equivalent	CO_2	N_2O	CH_4
2007	1,300,785	1,286,414	43	43
2006	1,455,986	1,441,014	48	47
Change (%)	**-11%**	**-11%**	**-10%**	**-8%**

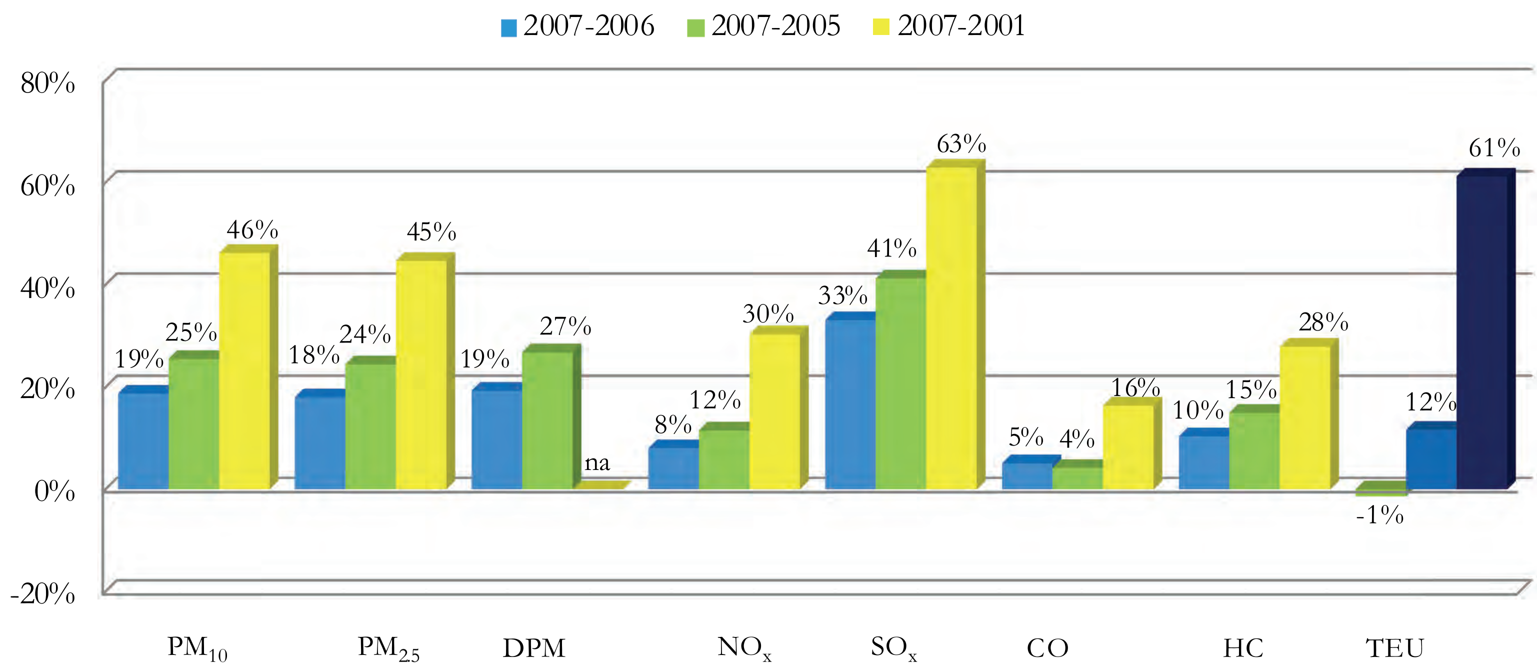
Table 9.4 and Figure 9.5 compare emissions efficiency changes for the various years which show that emissions per TEU continue to improve over the years. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.4: Port-wide Emissions Efficiency, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	1.1	1.0	1.0	21.7	4.5	5.6	1.2
2006	1.4	1.2	1.3	23.6	6.8	5.9	1.3
2005	1.5	1.3	1.4	24.5	7.7	5.8	1.4
2001	2.1	1.8	na	31.1	12.2	6.7	1.6
2007-2006	**19%**	**18%**	**19%**	**8%**	**33%**	**5%**	**10%**
2007-2005	**25%**	**24%**	**27%**	**12%**	**41%**	**4%**	**15%**
2007-2001	**46%**	**45%**	**na**	**30%**	**63%**	**16%**	**28%**

The olive green column to the right represents TEU change from 2007 to 2006 (-1%), the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU changed from 2001 to 2007 (61%). A positive percent for the emissions efficiency comparison means an improvement in efficiency.

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



9.1 Ocean-going Vessels

The various emission reduction strategies for ocean-going vessels are listed in Table 9.5 by percent of all calls.

Table 9.5: OGV Emission Reduction Strategies, % of All Calls

	Percent (%) of All Calls					
Year	**Slide Valve**	**IMO Compliant**	**Shore Power**	**Fuel Switch Aux Eng**	**Fuel Switch Main Eng**	**VSR**
2007	15%	45%	3%	100%	26%	84%
2006	7%	44%	2%	39%	10%	74%
2005	4%	32%	1%	27%	3%	64%
2001	0%	0%	0%	0%	0%	58%

Engine activity is measured as a product of the engine kilowatts and the annual activity in hours. Table 9.6 compares the overall engine activity (in terms of kW-hrs) in 2001, 2005, 2006 and 2007. The engine activity has a direct impact on emissions.

Table 9.6: OGV Power Comparison, kW-hr

Year	Total All Engines Total kW-hr	Main Eng Total kW-hr	Aux Eng Total kW-hr	Boiler Total kW-hr
2007	450,813,391	167,239,441	193,511,090	90,062,860
2006	489,973,405	179,297,185	206,770,806	103,905,415
2005	455,470,216	167,174,105	197,769,140	90,526,971
2001	467,138,476	212,359,344	167,454,248	87,324,885
2007-2006	**-8%**	**-7%**	**-6%**	**-13%**
2007-2005	**-1%**	**0%**	**-2%**	**-1%**
2007-2001	**-3%**	**-21%**	**16%**	**3%**

The methodology used in 2007 to estimate OGV emissions was similar to what was used in 2006, but the fuel correction factors (FCF) were updated to reflect CARB's fuel correction factors used in CARB's auxiliary engine fuel regulation in place in 2007. Thus, the various years' activity was used to re-estimate the various years' emissions using the 2007 OGV emissions methodology including the new FCF. Therefore, the 2006, 2005 and 2001 OGV emissions listed in Table 9.7 do not match emissions listed in previous EI reports. Table 9.6 shows the emissions estimate comparisons for calendar year 2007, 2006, 2005 and 2001 for OGV in tons per year and as a percent change, respectively.

Table 9.7: OGV Emissions Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC	TEU
2007	416	333	333	6,142	3,718	587	267	8,355,038
2006	623	498	526	6,728	5,687	613	273	8,469,853
2005	630	504	548	6,285	5,609	550	242	7,484,625
2001	702	561	617	7,170	6,212	585	251	5,183,520
2007-2006	**-33%**	**-33%**	**-37%**	**-9%**	**-35%**	**-4%**	**-2%**	**-1%**
2007-2005	**-34%**	**-34%**	**-39%**	**-2%**	**-34%**	**7%**	**11%**	**12%**
2007-2001	**-41%**	**-41%**	**na**	**-14%**	**-40%**	**0%**	**7%**	**61%**

The PM and SO_x emissions were reduced by roughly 30% due to the fuel switching that occurred in 2007 for 100% of the auxiliary engines and the voluntary fuel switching of some companies for the main engines. The newer vessels with IMO-compliant engines and fuel efficient slide valves also contributed to the PM and NO_x emission reductions.

Figure 9.6 shows the OGV percent emissions changes over time. The olive green column to the right represents TEU change from 2007 to 2006 (-1%), the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU changed from 2001 to 2007 (61%).

Figure 9.6: OGV Emissions Comparison, %

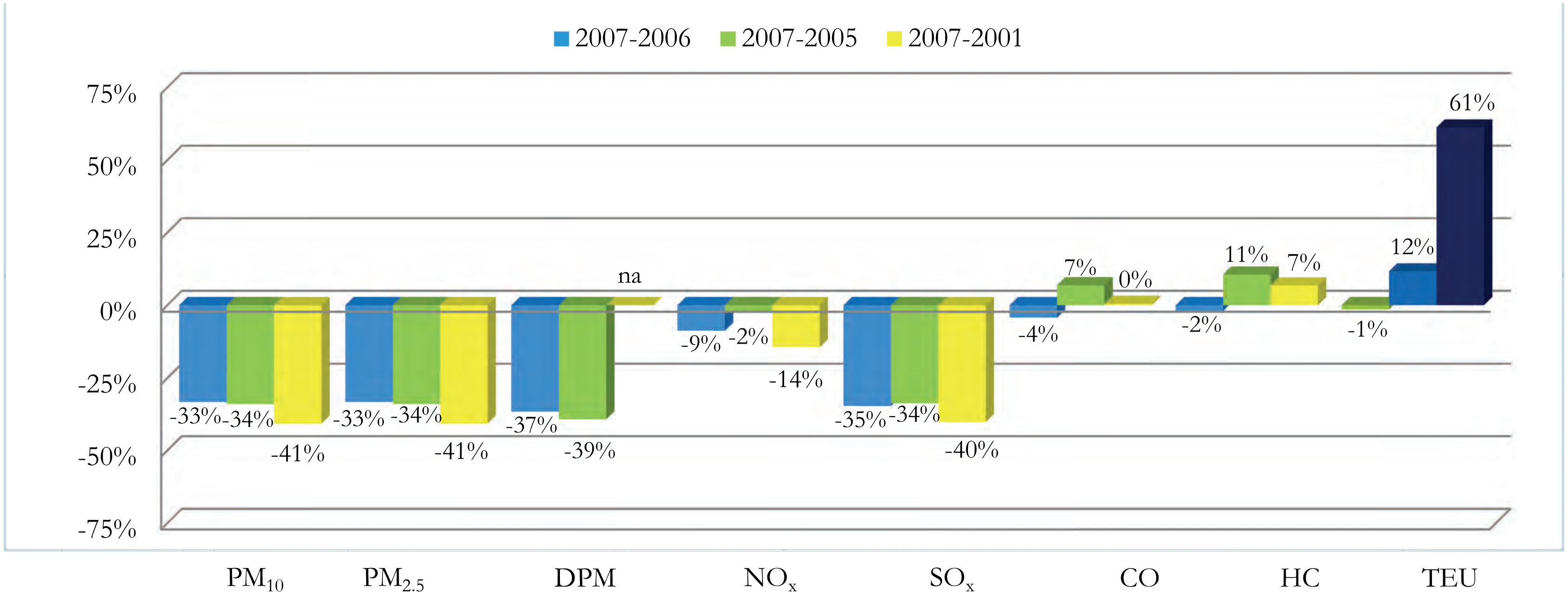


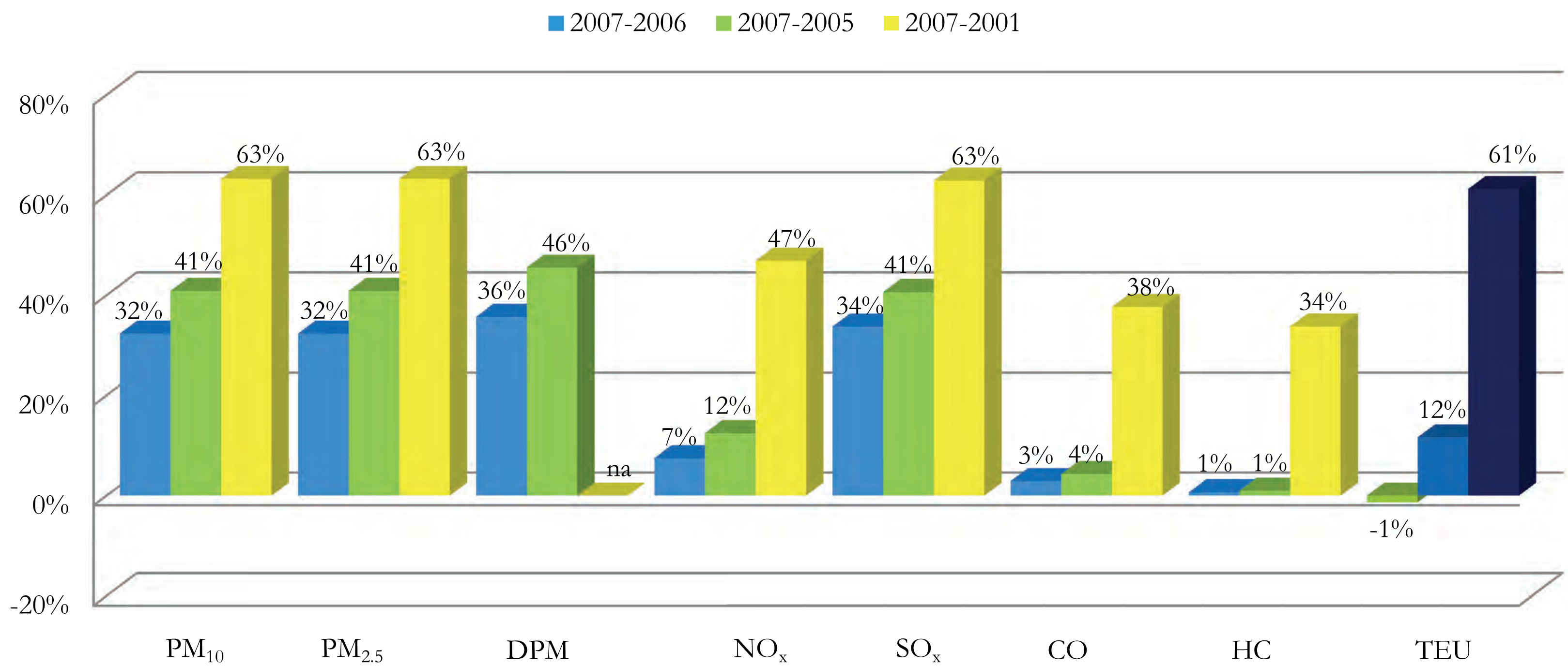
Table 9.8 and Figure 9.6 show the emissions efficiency changes for 2007-2005 and 2007-2005, and 2007-2001. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.8: OGV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	0.5	0.4	0.4	7.4	4.4	0.7	0.3
2006	0.7	0.6	0.6	7.9	6.7	0.7	0.3
2005	0.8	0.7	0.7	8.4	7.5	0.7	0.3
2001	1.4	1.1	na	13.8	12.0	1.1	0.5
2007-2006	**32%**	**32%**	**36%**	**7%**	**34%**	**3%**	**1%**
2007-2005	**41%**	**41%**	**46%**	**12%**	**41%**	**4%**	**1%**
2007-2001	**63%**	**63%**	**na**	**47%**	**63%**	**38%**	**34%**

Figure 9.7 shows the OGV emissions efficiency comparison. The olive green column to the right represents TEU change from 2007 to 2006 (-1%), the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU changed from 2001 to 2007 (61%).

Figure 9.7: OGV Emissions Efficiency Comparison, %



9.2 Harbor Craft

Table 9.9 summarizes the number of harbor craft inventoried for 2007, 2006, 2005 and 2001. Overall, there was a 10% increase in the total vessel count between 2007 - 2006 and 2007 - 2005. There was a 29% decrease in vessel count between 2007 - 2001. Assist tugs vessel count have stayed the same for the last three years. Commercial fishing vessels decreased significantly from 2001, but their count did go up slightly in 2007 when compared to 2006 which may be due to the seasonal variances of commercial fishing. Crew boat vessel count was down in 2005, but bounced back in 2006 and 2007. In 2001, the ocean tugs and line haul tugboats were not inventoried on a vessel by vessel basis, so the count is not included in the 2001 vessel count column.

Table 9.9: Harbor Craft Count Comparison

Harbor Vessel Type	2007 Count	2006 Count	2005 Count	2001 Count	2007-2006 % Change	2007-2005 % Change	2007-2001 % Change
Assist tug	16	16	16	18	0%	0%	-11%
Commercial fishing	138	120	130	260	15%	6%	-47%
Crew boat	22	19	9	17	16%	144%	29%
Excursion	24	24	24	27	0%	0%	-11%
Ferry	9	9	9	9	0%	0%	0%
Government	27	26	27	24	4%	0%	13%
Ocean tug	7	7	7	na	0%	0%	na
Tugboat	23	20	19	24	15%	21%	-4%
Work boat	15	15	14	17	0%	7%	-12%
Total	**281**	**256**	**255**	**396**	**10%**	**10%**	**-29%**

Table 9.10 summarizes the percent distribution of engines based on engine standards. For this comparison, the following model years fall into the Tier 0, Tier 1 and Tier 2:

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

In 2001, model year was not known for all engines, but it can be assumed that close to 100% of the harbor craft had engines in the Tier 0 range since the engine model year was probably 1999 or older.

Between 2001 and 2005, many engines were replaced as a result of the Carl Moyer Program and Port-funded projects to reduce emissions in the harbor. In 2005, 64% of the engines were Tier 0 engines; 30% had Tier 1 engines and 7% had Tier 2 engines. In 2006, the percentage of Tier 0 engines was further reduced to 61% and the Tier 2 percentage increased to 10%. In 2007, the percentage of Tier 0 engines increased to 64%, while the percentage of Tier 1 and 2 engines decreased to 27% and 9%, respectively.

Table 9.10: Harbor Craft Engine Standards Comparison by Tier

Year	Tier 0	Tier 1	Tier 2
2007	64%	27%	9%
2006	61%	29%	10%
2005	64%	30%	7%
2001	100%	0%	0%

Table 9.11 compares the engines (main and auxiliary engines combined) by vessel type and Tier for 2005, 2006 and 2007. Although many vessels have been repowered, there are still many Tier 0 engines at the Port. This is due to the high cost of replacing engines and the time it requires the vessel to be out of service which is lost revenue for the harbor craft owners.

Table 9.11: Harbor Craft Engine Standards Comparison by Vessel Type

Harbor Vessel Type	2007 Tier 0	2007 Tier 1	2007 Tier 2	2006 Tier 0	2006 Tier 1	2006 Tier 2	2005 Tier 0	2005 Tier 1	2005 Tier 2
Assist tug	32	20	12	31	20	12	35	24	4
Commercial fishing	130	32	6	108	34	6	149	42	6
Crew boat	42	18	9	30	18	9	14	18	9
Excursion	45	23	2	45	23	2	45	23	2
Ferry	4	18	10	4	18	10	8	14	10
Government	36	12	0	34	12	0	34	12	0
Ocean tug	20	8	0	20	8	0	20	8	0
Tugboat	40	22	14	32	21	14	32	23	8
Work boat	35	7	0	35	7	0	31	7	0
Total Engines	**384**	**160**	**53**	**339**	**161**	**53**	**368**	**171**	**39**

As can be seen in Table 9.12, there was a 10% increase in vessel count in 2007 from 2006 and 2005. The activity (as measured by horsepower-hours) increased only 1% in 2007 from 2006. The activity hours does not change at same rate as the vessel count. For example, in 2007, the assist tugs and tugboats' activity dropped slightly from 2006. This could be due to slight decrease in vessel calls which has an impact on assist tug activity.

Table 9.12: Harbor Craft Engine Comparison

Year	Vessel Count	Engine Count	Total HP-hr
2007	281	597	117,501,429
2006	256	553	115,940,879
2005	255	578	115,692,693
2001	396	748	122,879,494
2007-2006	**10%**	**8%**	**1%**
2007-2005	**10%**	**3%**	**2%**
2007-2001	**-29%**	**-20%**	**-4%**

In order to be consistent with CARB, the Port's 2006 and 2007 harbor craft emissions calculation methodology followed CARB's recent harbor craft emissions calculations methodology. CARB's deterioration rates, useful life, and zero hour emission factors for commercial harbor craft were used. Because this was a change from the methodology used for the 2005 and 2001 emission estimates, the 2005 and 2001 emissions were re-calculated using the 2006/2007 emissions methodology in order to make a meaningful comparison. Some of the significant changes in harbor craft methodology from 2005 and 2001 to 2006/2007 include:

- Emission factors changed (used EPA's EF in 2005 and 2001, used CARB's EF in 2006 and 2007)
- In the 2005 and 2001 Port EIs, deterioration rates were not included in the calculations, but the 2006/2007 methodology includes deterioration rates
- The load factor for excursion vessels and ferries changed from 0.76 in 2005 to 0.42 in 2006 and 2007

The resulting 2006, 2005 and 2001 harbor craft emissions based on 2006/2007 methodology included in the 2006 Inventory of Air Emissions are used to compare to the 2007 emissions below. Table 9.13 shows the emissions estimate comparisons for calendar year 2007, 2006, 2005 and 2001 for harbor craft.

The 1 to 2% increase in emissions from 2006 is directly related to the 1% increase in activity in 2007. Since ULSD was used by vessels in 2006 and 2007, there is no reduction in SO_x emissions as seen for the other years. Comparing 2007 emissions to 2005, the reductions are mainly due to the use of ULSD for all vessels. The reductions in 2007 when compared to 2001 are due to vessel repower, decrease in vessel count, and use of ULSD in 2007.

Table 9.13: Harbor Craft Emission Comparison, tpy and % Change

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	53	49	53	1,281	1	348	85
2006	52	48	52	1,265	1	345	84
2005	56	52	56	1,336	6	369	89
2001	82	75	na	1,777	18	443	145
2007-2006	**2%**	**2%**	**2%**	**1%**	**1%**	**1%**	**2%**
2007-2005	**-6%**	**-6%**	**-6%**	**-4%**	**-90%**	**-6%**	**-4%**
2007-2001	**-36%**	**-36%**	**na**	**-28%**	**-96%**	**-21%**	**-41%**

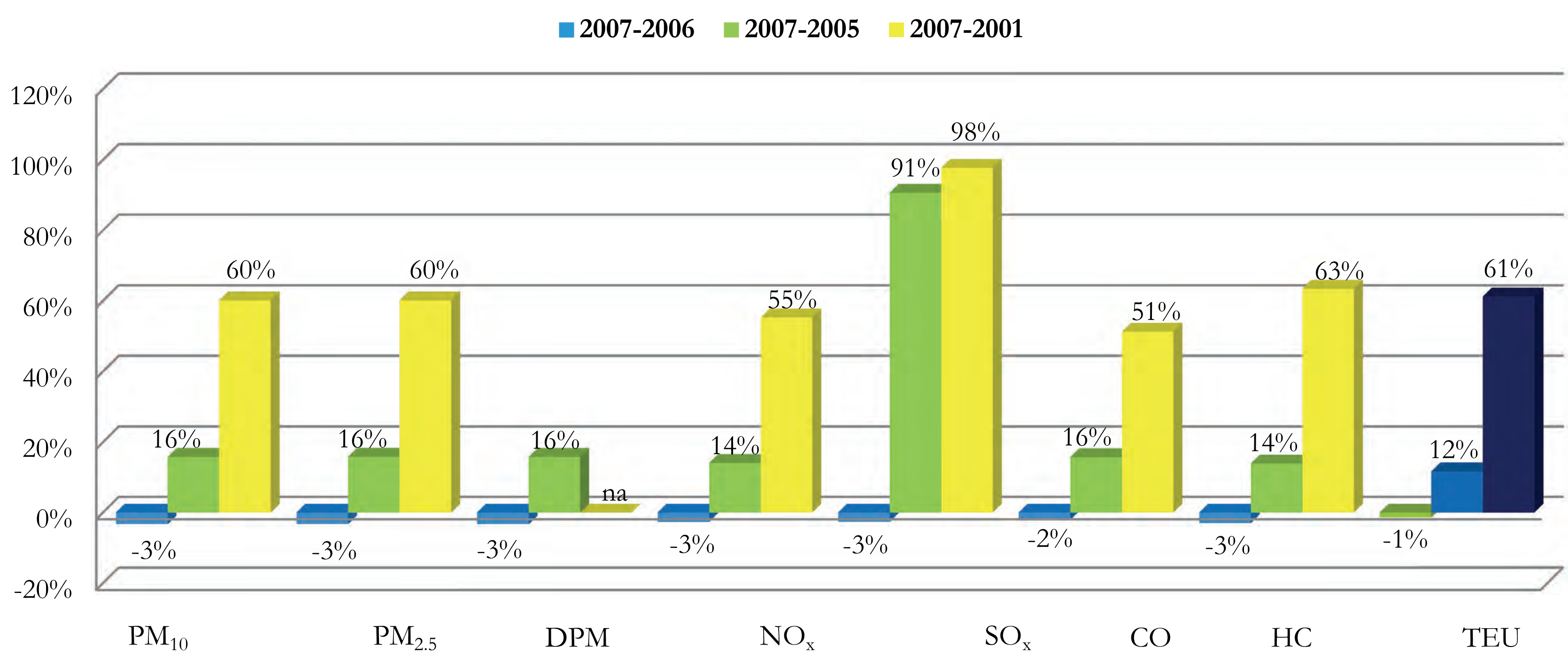
Table 9.14 shows the emissions efficiency changes for 2007-2006, 2007-2005 and 2007-2001. It should be noted that the total emissions for harbor craft was used for efficiency comparison, which includes emissions from harbor craft (e.g. commercial fishing vessels) that are not relevant to container throughput. From 2006 to 2007, there is a 1% decrease in TEU throughput and a 2% to 3% loss in emissions efficiency. From 2005 to 2007, there was a 12% increase in TEU throughput and emissions efficiency improved 14% to 91%. From 2001 to 2007, despite a 61% increase in TEU throughput, emissions efficiency improved for all pollutants from 51% to 98%. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.14: Harbor Craft Emissions Efficiency Comparison, tons/10,000 TEU & %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	0.06	0.06	0.06	1.53	0.00	0.42	0.10
2006	0.06	0.06	0.06	1.49	0.00	0.41	0.10
2005	0.07	0.07	0.07	1.78	0.01	0.49	0.12
2001	0.16	0.15	na	3.43	0.03	0.85	0.28
2007-2006	**-3%**	**-3%**	**-3%**	**-3%**	**-3%**	**-2%**	**-3%**
2007-2005	**16%**	**16%**	**16%**	**14%**	**91%**	**16%**	**14%**
2007-2001	**60%**	**60%**	**na**	**55%**	**98%**	**51%**	**63%**

In Figure 9.8, the last 3 bars to the right, the olive column represents TEU change from 2006 to 2007 (-1%), the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU change from 2001 to 2007 (61%).

Figure 9.8: Harbor Craft Emissions Efficiency Comparison, %



9.3 Cargo Handling Equipment

Table 9.15 shows a 6% decrease between 2006 and 2007 in equipment activity (measured as a product of horsepower, annual activity and load factor) despite a 5% increase in total number of equipment. The increase in equipment count is due to the tenants buying new equipment in 2007 to conform to the CARB CHE rule. The decrease in activity is possibly due to equipment not used as much due to a decrease in throughput between 2006 and 2007 and the new equipment may not have been used if it arrived at end of the calendar year. Between 2005 and 2007, equipment activity increased by 24% and the equipment count increased by 18%. Between 2001 and 2007, equipment activity increased by 92% and the equipment count increased by 80%.

Table 9.15: CHE Count and Activity Comparison

	Total Population	Total Hp-hr-LF
2007	2,014	298,475,254
2006	1,926	318,299,748
2005	1,702	241,366,009
2001	1,121	155,825,843
2007-2006	**5%**	**-6%**
2007-2005	**18%**	**24%**
2007-2001	**80%**	**92%**

Table 9.16 summarizes the various engine power types for CHE, which include electric, liquefied natural gas (LNG), propane, gasoline, and diesel. Electric powered equipment has doubled and propane powered equipment has more than tripled at the port since 2001.

Table 9.16: CHE Engine Power Matrix

Equipment	Electric	LNG	Propane	Gasoline	Diesel
2007					
Forklifts	1	0	350	8	175
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	107
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	138
Yard tractors	0	2	58	0	947
Sweepers	0	0	0	2	9
Other	19	0	0	1	85
Total	**89**	**2**	**408**	**11**	**1,504**
2006					
Forklifts	0	0	355	8	191
Wharf gantry cranes	69	0	0	0	0
RTG cranes	0	0	0	0	103
Side handlers	0	0	0	0	43
Top handlers	0	0	0	0	134
Yard tractors	0	2	58	0	897
Sweepers	0	0	0	2	10
Other	19	0	0	0	104
Total	**88**	**2**	**413**	**10**	**1,482**
2005					
Forklifts	0	0	263	8	151
Wharf gantry cranes	67	0	0	0	0
RTG cranes	0	0	0	0	98
Side handlers	0	0	0	0	41
Top handlers	0	0	0	0	127
Yard tractors	0	0	53	0	848
Sweepers	0	0	0	3	8
Other	12	0	0	0	103
Total	**79**	**0**	**316**	**11**	**1,376**
2001					
Forklifts	0	0	116	4	80
Wharf gantry cranes	44	0	0	0	0
RTG cranes	0	0	0	0	34
Side handlers	0	0	0	0	37
Top handlers	0	0	0	0	74
Yard tractors	0	0	0	0	590
Sweepers	0	0	0	1	3
Other	0	0	0	0	70
Total	**44**	**0**	**116**	**5**	**888**

Table 9.17 summarizes the various emissions controls for diesel powered CHE by equipment counts and by percent total diesel equipment (found in the total equipment count column). It should be noted that emission controls can be used in combination with each other, therefore they cannot be added across to come up with total equipment count (control equipment counts are greater than total equipment counts).

Table 9.17: CHE Diesel Power Equipment Emissions Control Matrix

						Total	% of Diesel Powered Equipment				
Equipment	DOC Installed	On-Road Engines	DPF Installed	USLD Fuel	Emulsified Fuel	Diesel-Powered Equipment	DOC Installed	On-Road Engines	DPF Installed	USLD Fuel	Emulsified Fuel
2007											
Forklifts	4	4	0	175	0	175	2%	2%	0%	100%	0%
RTG cranes	10	0	0	107	0	107	9%	0%	0%	100%	0%
Side handlers	13	0	0	43	0	43	30%	0%	0%	100%	0%
Top handlers	54	0	0	138	0	138	39%	0%	0%	100%	0%
Yard tractors	508	273	58	947	0	947	54%	29%	6%	100%	0%
Sweepers	0	1	0	9	0	9	0%	11%	0%	100%	0%
Other	0	3	0	85	0	85	0%	4%	0%	100%	0%
Total	**589**	**281**	**58**	**1,504**	**0**	**1,504**	**39%**	**19%**	**4%**	**100%**	**0%**
2006											
Forklifts	4	4	0	191	15	191	2%	2%	0%	100%	8%
RTG cranes	10	0	0	103	28	103	10%	0%	0%	100%	27%
Side handlers	13	0	0	43	10	43	30%	0%	0%	100%	23%
Top handlers	54	0	0	134	42	134	40%	0%	0%	100%	31%
Yard tractors	531	216	0	897	128	897	59%	24%	0%	100%	14%
Sweepers	0	1	0	10	0	10	0%	10%	0%	100%	0%
Other	0	5	0	104	0	104	0%	5%	0%	100%	0%
Total	**612**	**226**	**0**	**1,482**	**223**	**1,482**	**41%**	**15%**	**0%**	**100%**	**15%**
2005											
Forklifts	3	0	0	27	15	151	2%	0%	0%	18%	10%
RTG cranes	0	0	0	36	28	98	0%	0%	0%	37%	29%
Side handlers	14	0	0	16	10	41	34%	0%	0%	39%	24%
Top handlers	48	0	0	79	36	127	38%	0%	0%	62%	28%
Yard tractors	520	164	0	483	129	848	61%	19%	0%	57%	15%
Sweepers	0	0	0	0	0	8	0%	0%	0%	0%	0%
Other	0	1	0	65	0	103	0%	1%	0%	63%	0%
Total	**585**	**165**	**0**	**706**	**218**	**1,376**	**43%**	**12%**	**0%**	**51%**	**16%**
2001											
Forklifts	0	0	0	0	0	80	0%	0%	0%	0%	0%
RTG cranes	0	0	0	0	0	34	0%	0%	0%	0%	0%
Side handlers	0	0	0	0	0	37	0%	0%	0%	0%	0%
Top handlers	0	0	0	0	0	74	0%	0%	0%	0%	0%
Yard tractors	0	0	0	0	0	590	0%	0%	0%	0%	0%
Sweepers	0	0	0	0	0	3	0%	0%	0%	0%	0%
Other	0	0	0	0	0	70	0%	0%	0%	0%	0%
Total	**0**	**0**	**0**	**0**	**0**	**888**	**0%**	**0%**	**0%**	**0%**	**0%**

Emulsified fuel was not used in 2007 since supply was not available. ULSD was used in 2006 and 2007 by all diesel equipment.

The cargo handling equipment emission estimating methodology used in 2007 stayed the same as the 2006 methodology, therefore emissions included in the 2006 EI were used to compare to the 2007 emissions. Table 9.18 shows the emissions estimate comparisons for calendar year 2007, 2006, 2005 and 2001 for cargo handling equipment in tons per year and as a percent change. Between 2006 and 2007, the emissions for all pollutants decreased between 6% and 14%. For both 2006 and 2007 ULSD was used by all the equipment. The activity decreased from 2006 to 2007 by 6%.

Comparing 2007 to 2005 and 2001, the emissions decreased for PM and SO_x while emissions increased for NO_x and CO. The decrease in SO_x emissions is due to the use of ULSD in 2007, while the increase in NO_x emissions is due to increase in activity and increase in CO emissions is due to newer engines and propane engines which have higher CO emission standards.

Table 9.18: CHE Emissions Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	46	43	45	1,662	2	919	81
2006	52	49	51	1,853	2	977	95
2005	47	43	46	1,520	9	765	80
2001	48	44	47	1,258	8	647	97
2007-2006	**-12%**	**-12%**	**-12%**	**-10%**	**-8%**	**-6%**	**-14%**
2007-2005	**-2%**	**-2%**	**-3%**	**9%**	**-80%**	**20%**	**1%**
2007-2001	**-4%**	**-3%**	**-5%**	**32%**	**-76%**	**42%**	**-16%**

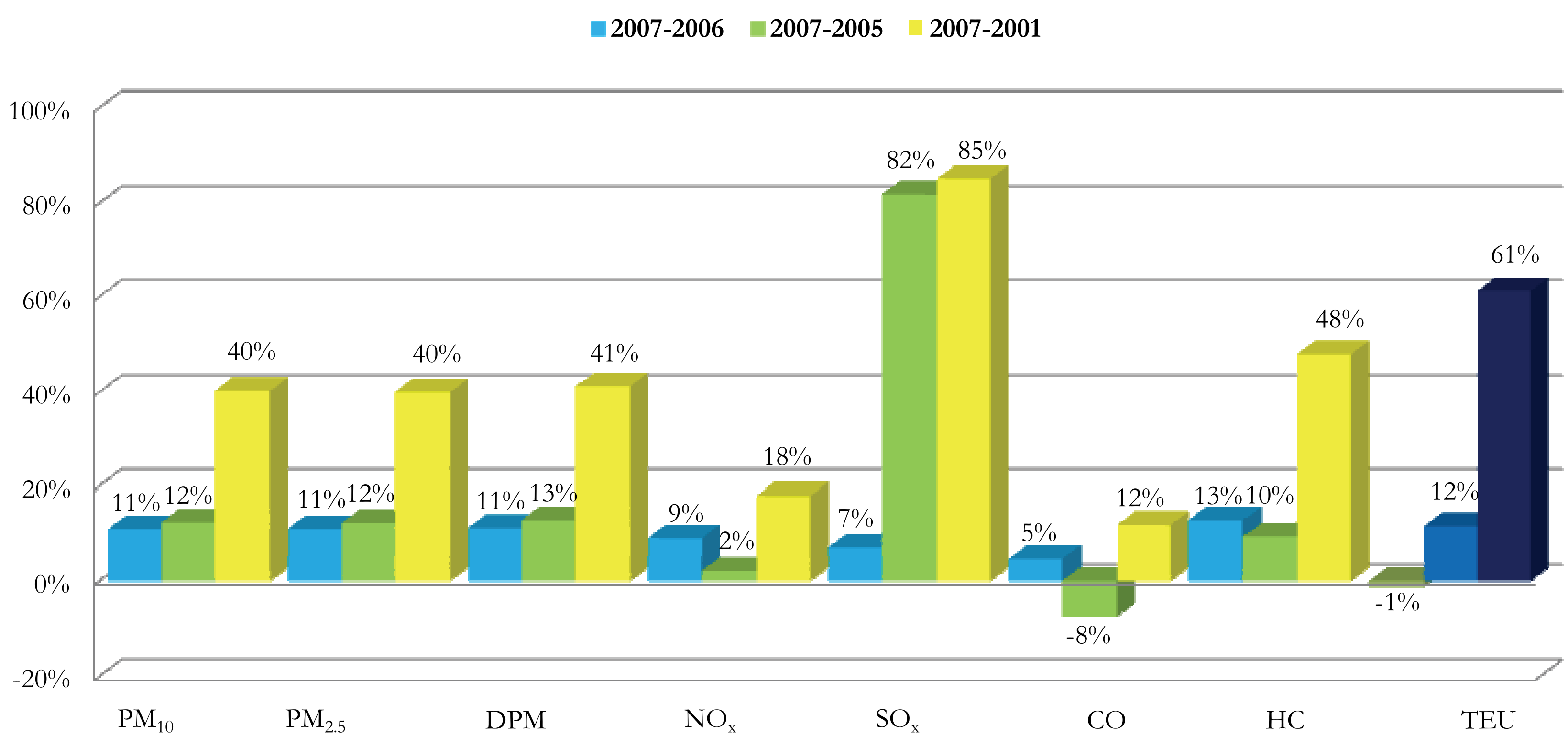
Table 9.19 shows the emissions efficiency changes for 2007-2006, 2007-2005 and 2007-2001. From 2006 to 2007, there was a 1% decrease in TEU throughput, and a 5% to 13% improvement in emissions efficiency for all pollutants. From 2005 to 2007, there was a 12% increase in TEU throughput, but emissions efficiency improved 2% to 82% for pollutants, with the exception of CO. From 2001 to 2007, despite a 61% increase in TEU throughput, emissions efficiency improved from 12% to 85% for all pollutants. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.19: CHE Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	0.05	0.05	0.05	1.99	0.00	1.10	0.10
2006	0.06	0.06	0.06	2.19	0.00	1.15	0.11
2005	0.06	0.06	0.06	2.03	0.01	1.02	0.11
2001	0.09	0.08	0.09	2.43	0.01	1.25	0.19
2007-2006	**11%**	**11%**	**11%**	**9%**	**7%**	**5%**	**13%**
2007-2005	**12%**	**12%**	**13%**	**2%**	**82%**	**-8%**	**10%**
2007-2001	**40%**	**40%**	**41%**	**18%**	**85%**	**12%**	**48%**

In the figure below, the olive column represents TEU change from 2006 to 2007, the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU changed from 2001 to 2007 (61%).

Figure 9.9: CHE Emissions Efficiency Comparison, %



9.4 Rail Locomotives

Tables 9.20 show the various throughput comparisons for rail locomotives for 2005, 2006 and 2007. From 2005 to 2007, there was an 11% increase in total on-dock rail and a 16% increase in near-dock rail.

Table 9.20: TEU Throughput Comparison

	2005	2006	2007	% Change 2005-2007	% Change 2006-2007
Total Port Throughput	7,484,615	8,469,980	8,355,038	12%	-1%
Total On-Dock Rail	1,891,198	2,466,759	2,098,398	11%	-15%
% On-Dock	25%	29%	25%		
Near-Dock Rail[(1)]	555,694	653,321	643,919	16%	-1%
% Near-Dock	7%	8%	8%		

The methodology used in 2007 to estimate rail locomotive emissions was the same as that used in 2006, therefore rail emissions included in the 2006 EI were used to compare to the 2007 emissions. Table 9.21 shows the emissions estimate comparisons for calendar year 2007, 2006, 2005, and 2001 for locomotive engines in tons per year and as a percent change.

Between 2006 and 2007, the emissions for all pollutants decreased between 16% and 58%. From 2005 to 2007, emissions increased for all pollutants except for NO_x and SO_x. From 2001 to 2007, the emissions increased for all pollutants except for SO_x. The emissions increases from 2005 and 2001 are directly due to the increased throughput in 2007 from those years. The SO_x emission reduction is due to the use of ULSD by switching locomotives for all of 2007 and the use of ULSD for part of the year by line-haul locomotives.

Table 9.21: Rail Emission Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	60	54	60	1,675	55	268	94
2006	72	65	72	2,081	131	320	115
2005	56	52	56	1,685	95	233	89
2001	34	31	na	1,413	55	145	57
2007-2006	**-17%**	**-17%**	**-17%**	**-20%**	**-58%**	**-16%**	**-18%**
2007-2005	**7%**	**3%**	**7%**	**-1%**	**-42%**	**15%**	**6%**
2007-2001	**76%**	**73%**	**na**	**19%**	**0%**	**85%**	**65%**

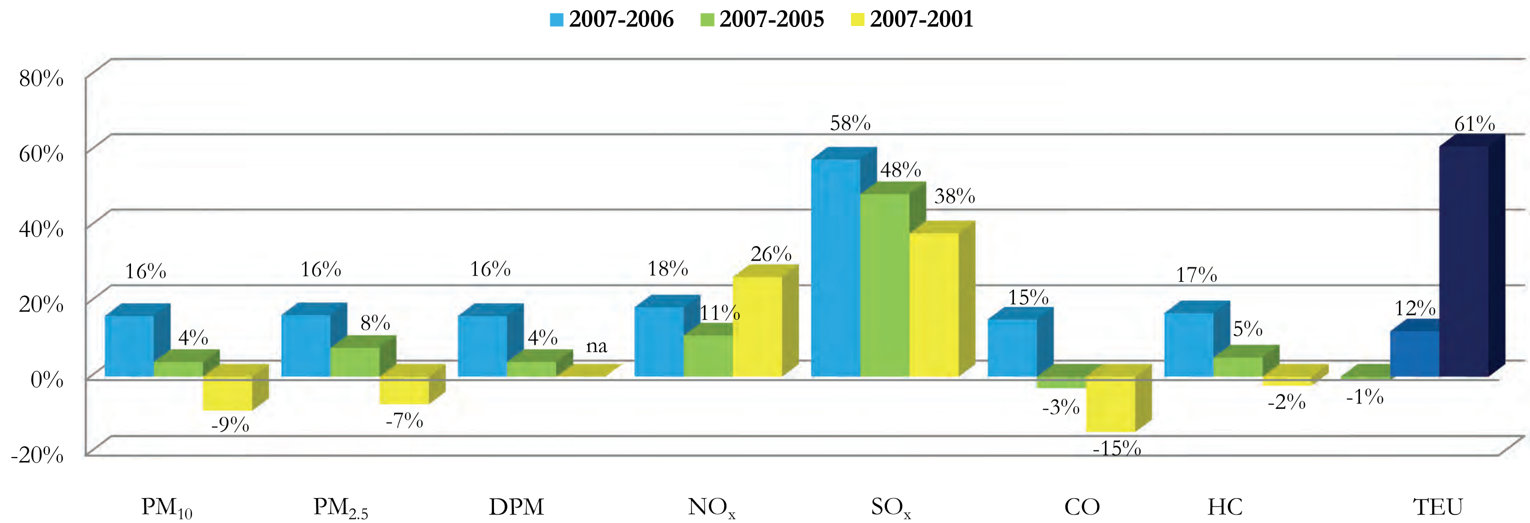
Table 9.22 and Figure 9.9 show the emissions efficiency changes for 2006-2005 and 2006-2001. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.22: Rail Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	0.07	0.06	0.07	2.01	0.07	0.32	0.11
2006	0.09	0.08	0.09	2.46	0.16	0.38	0.14
2005	0.07	0.07	0.07	2.25	0.13	0.31	0.12
2001	0.07	0.06	na	2.73	0.11	0.28	0.11
2007-2006	**16%**	**16%**	**16%**	**18%**	**58%**	**15%**	**17%**
2007-2005	**4%**	**8%**	**4%**	**11%**	**48%**	**-3%**	**5%**
2007-2001	**-9%**	**-7%**	**na**	**26%**	**38%**	**-15%**	**-2%**

In the figure below, the olive column represents TEU change from 2006 to 2007, the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU changed from 2001 to 2007 (61%).

Figure 9.10: Rail Emissions Efficiency Comparison, %



9.5 Heavy-Duty Vehicles

The average on-terminal total idling time at container terminals has improved by 5 minutes since 2006 and 10 minutes since 2005. Table 9.23 shows the decrease in total port-wide idling time which is due to mainly to three factors:

- The terminals modernized their gate system with optical character recognition (OCR) and added several queuing lines at the in and out gates which increased the efficiency at the gates and thus reduced idling time.
- Assembly Bill 2650 (known as the Lowenthal Bill), introduced in 2004, required that each marine terminal in California operate in a manner that does not cause the engines on trucks to idle or queue for more than 30 minutes while waiting to enter the gate into the marine terminal.
- Since July 2005, all marine terminals at the Ports of Long Beach and Los Angeles, offer off-peak shifts on nights and weekends. As part of the program, a Traffic Mitigation Fee is required for cargo movement through the ports during peak daytime hours.

Table 9.23: HDV Idling Time Comparison, hours

EI Year	Total Idling Hours
2007	2,334,568
2006	2,962,463
2005	3,017,252
2001	4,404,847
2007-2006	-21%
2007-2005	-23%
2007-2001	-47%

Comparing 2007 to 2006, the HDV emissions decreased for all pollutants. From 2005 to 2007, the PM and CO emissions increased while NO_x, SO_x, and HC emissions decreased. From 2001 to 2007, all emissions increased with the exception of SO_x and HC emissions. SO_x emissions were reduced significantly in 2007 due to the use of ULSD by all trucks for all of 2007.

Table 9.24: HDV Emissions Comparison, tpy and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	370	340	370	7,343	6	2,529	445
2006	404	372	404	8,579	40	2,808	599
2005	346	319	346	7,498	47	2,433	525
2001	280	257	na	6,104	43	2,226	469
2007-2006	**-9%**	**-9%**	**-9%**	**-14%**	**-85%**	**-10%**	**-26%**
2007-2005	**7%**	**7%**	**7%**	**-2%**	**-87%**	**4%**	**-15%**
2007-2001	**32%**	**32%**	**na**	**20%**	**-86%**	**14%**	**-5%**

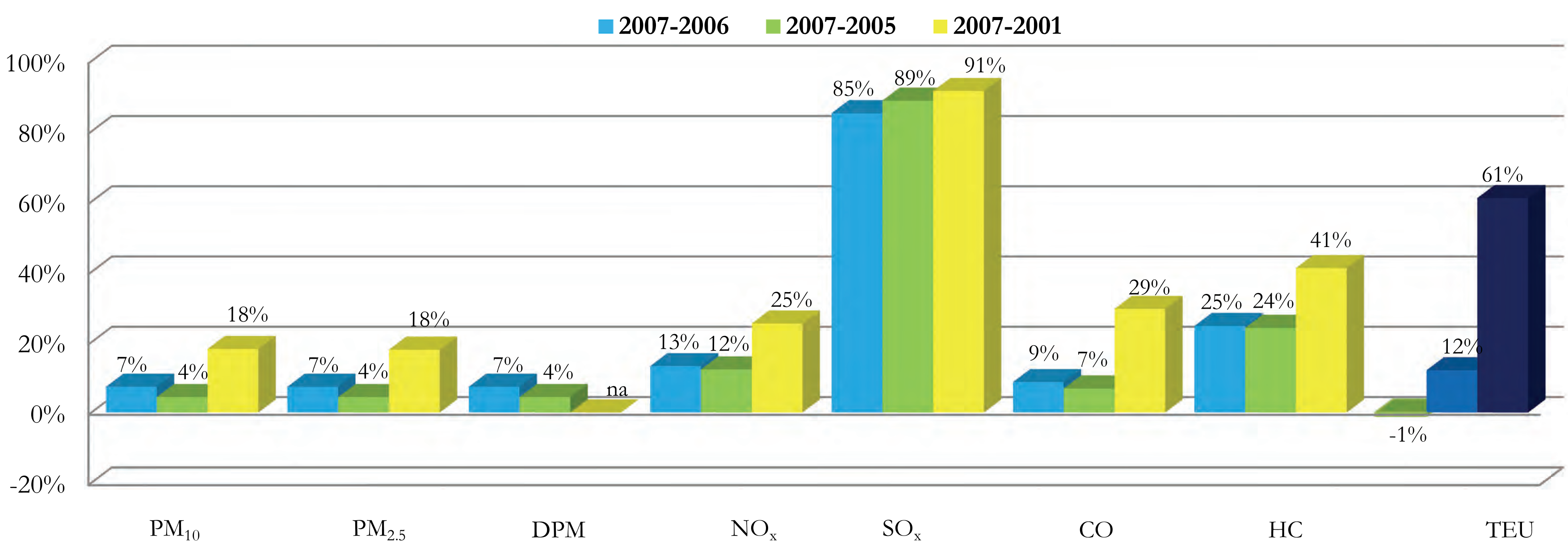
Table 9.25 and Figure 9.10 show the emissions efficiency changes for 2007-2006, 2007-2005 and 2007-2001. A positive percent for the emissions efficiency comparison means an improvement in efficiency.

Table 9.25: HDV Emissions Efficiency Comparison, tons/10,000 TEU and %

EI Year	PM_{10}	$PM_{2.5}$	DPM	NO_x	SO_x	CO	HC
2007	0.44	0.41	0.44	8.79	0.01	3.03	0.53
2006	0.48	0.44	0.48	10.13	0.05	3.32	0.71
2005	0.46	0.43	0.46	10.02	0.06	3.25	0.70
2001	0.54	0.50	na	11.78	0.08	4.29	0.90
2007-2006	**7%**	**7%**	**7%**	**13%**	**85%**	**9%**	**25%**
2007-2005	**4%**	**4%**	**4%**	**12%**	**89%**	**7%**	**24%**
2007-2001	**18%**	**18%**	**na**	**25%**	**91%**	**29%**	**41%**

In the figure below, the olive column represents TEU change from 2006 to 2007, the light blue column represents TEU change from 2005 to 2007 (12%) and the dark blue column represents TEU changed from 2001 to 2007 (61%).

Figure 9.11: HDV Emissions Efficiency Comparison, %



In summary, the 2007 emissions for all pollutants were reduced port-wide as compared to 2005 and 2006, except for CO. Also, despite a 61% increase in TEU throughput from 2001 to 2007, the PM and SO_x emissions decreased in 2007. Similar to the port-wide emissions, the emissions per container handled continued to decline (i.e., emissions efficiency increased) in 2007 compared to 2006, 2005, and 2001 for all pollutants. In 2007, emissions from ocean-going vessels decreased because operators voluntarily complied with CARB's marine auxiliary engine fuel regulation that was in place for 2007. The cargo handling equipment emissions decreased in 2007 due mainly to equipment turnover. Harbor craft was the only source category to see a slight 1-2% increase in emissions in 2007 from 2006. For harbor craft, there were emissions reductions in 2007 as compared to 2005 and 2001. Rail emissions decreased due to the replacement of old locomotives and the use of cleaner diesel fuels in 2007 from 2006. Heavy-duty truck emissions decreased in 2007 from the 2006 emission levels due to equipment turnover, decrease in activity and the use of cleaner fuels.