Appendix D

Emissions Estimation Methodology for Ocean-Going Vessels

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Emissions Estimation Methodology for Ocean-Going Vessels

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California Air Resources Board
Planning and Technical Support Division

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Ocean-Going Vessel Emission Estimation Methodology

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I. EXECUTIVE SUMMARY

Air Resources Board (ARB) staff have revised the methodology to calculate emissions from ocean-going vessels in California. This revised inventory will be used to support regulatory analysis of statewide regulations to reduce emissions from ocean-going vessels. Other goals in undertaking this emissions inventory update were to:

- Update the inventory to reflect recent (2006) activity data
- Include ship and port call specific data
- Align the inventory to reflect recent port inventories
- Revise growth assumptions and methods
- Incorporate existing control strategies into methodology
- Assess benefits of regulations

This inventory is a revision of an inventory developed by staff in 2005 in support of a number of programs, including the auxiliary engine regulation, the goods movement program, the Ozone State Implementation Plan (SIP), the sulfur emission control area designation, and others.

The proposed inventory increases the specificity of the earlier inventory by including vessel specific characteristics and port call specific activity data, including port call specific hotelling times for individual vessel visits; vessel-specific power and speed ratings, and a more accurate shipping lane network. It is also based on more recent activity data: the earlier inventory used a 2004 base year; the new inventory uses a 2006 base year. The growth factors have been updated with additional years of trend data, a port and vessel type specificity, and a more robust growth surrogate. Finally, existing control strategy emission reductions are built into the inventory model, rather than being applied from the forecasting database.

Emissions are calculated by estimating ship emissions on a ship by ship and a port call by port call basis, using actual ship engine power estimates, speeds, and actual ship hotelling times where possible. Base year emissions were forecasted using a set of growth factors specific to each port and each ship type.

Emissions were calculated within two distinct zones; the 24 nautical mile zone used for the 2005 auxiliary engine regulation and the goods movement program, and a 100 nautical mile zone that is used for ARB's emissions inventory system.

In the main body of this report, emissions are presented from the 24 nautical mile zone. Emissions from both zones are presented in Attachment A.

Using the proposed methodology, we estimate 2006 statewide emissions from ocean going vessels in the 24 nautical mile regulatory zone were over 14 tons per day of diesel PM, over 155 tons per day of oxides of nitrogen (NOx), and over 7,400 tons per day of carbon dioxide (CO2). Detailed emission estimates are presented in Table ES-1.

Table ES-1 summarizes the emissions by vessel type for the 24 nautical mile regulatory zone. Container ships account for almost 50% of the vessel calls, but about 60% of the NOx and PM10 emissions,

Table ES-1: Ship Emissions in 2006 (tons/day) in the 24 nm Zone

Vessel Type	Vessels	Port Calls	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Auto	234	1006	0.0	0.6	288.2	7.2	0.6	0.6	0.3	4.6
Bulk	475	983	0.0	0.6	322.6	7.9	0.7	0.7	0.3	5.1
Container	593	5038	0.5	7.7	3818.1	94.2	8.4	8.1	3.7	60.1
Cruise	52	770	0.1	0.9	615.9	12.0	1.2	1.1	0.4	9.0
General	147	371	0.0	0.3	133.2	3.3	0.3	0.3	0.1	2.1
Reefer	68	315	0.0	0.2	111.1	2.2	0.2	0.2	0.1	1.7
Ro-ro	28	112	0.0	0.1	30.8	0.7	0.1	0.1	0.0	0.5
Tanker	458	2391	0.2	2.4	2081.8	29.5	3.2	3.1	1.2	34.1
Total	**2055**	**10986**	**0.8**	**12.7**	**7401.6**	**157.1**	**14.6**	**14.3**	**6.1**	**117.2**

Table ES-2 summarizes the emissions by district for the 24 nautical mile regulatory zone. In 2006, emissions were almost evenly split between Southern and Northern California.

Table ES-2: Ship Emissions by District (tons/day) in the 24 nm Zone

District	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Bay Area AQMD	0.2	3.0	1958.9	37.7	3.6	3.5	1.5	31.4
Mendocino County AQMD	0.0	0.5	253.8	6.8	0.6	0.6	0.3	4.2
Monterey Bay Unified APCD	0.1	1.6	740.3	20.1	1.7	1.7	0.8	12.3
North Coast Unified APCD	0.0	0.4	203.5	5.5	0.5	0.5	0.2	3.4
Northern Sonoma County APCD	0.0	0.3	144.5	3.9	0.3	0.3	0.1	2.4
San Diego County APCD	0.0	0.5	271.8	5.9	0.6	0.5	0.2	4.2
San Joaquin Valley Unified APCD	0.0	0.0	30.6	0.3	0.0	0.0	0.0	0.5
San Luis Obispo County APCD	0.0	0.2	101.7	2.8	0.2	0.2	0.1	1.7
Santa Barbara County APCD	0.1	1.7	804.5	22.0	1.9	1.9	0.9	13.4
South Coast AQMD	0.2	3.8	2589.8	44.9	4.5	4.4	1.7	39.0
Ventura County APCD	0.0	0.6	296.3	7.3	0.6	0.6	0.3	4.8
Yolo/Solano AQMD	0.0	0.0	5.9	0.1	0.0	0.0	0.0	0.1
Total	**0.8**	**12.7**	**7401.6**	**157.1**	**14.6**	**14.3**	**6.1**	**117.2**

The following section provides background on the ship emissions inventory, the purpose and goals in preparing this emissions inventory, and a general overview of the methodology used to estimate emissions.

A. Background

For the purposes of this inventory, an ocean-going vessel (OGV) is a commercial vessel greater than or equal to 400 feet in length or 10,000 gross tons; or propelled by a marine compression ignition engine with a displacement of greater than or equal to 30 liters per cylinder.

Two different zones are used to tabulate ship emissions in California. A zone that follows within 24 nautical miles of California's mainland coastline is used for regulatory purposes, including the 2005 auxiliary engine regulation and the goods movement program. This zone can be seen in Figure 1. The ARB California Emissions Inventory Data and Reporting System (CEIDARS) includes all OGV emissions occurring within 100 nautical miles of the California coastline. This zone is also used for State Implementation Plan (SIP) purposes and can also be seen in Figure 1.

OGV emissions occur during three distinct operating modes: transit (emissions from vessel operations between ports), maneuvering (slow speed vessel operations while in-port areas), and hotelling (also known as berthing; in-port emissions while moored to a dock).

Two types of engines are found on OGVs, main engines and auxiliary engines. The main engine is a very large diesel engine used mainly to propel the vessel at sea. Main engines are used during the transit and maneuvering modes. Auxiliary engines on OGVs provide power for uses other than propulsion (except for diesel-electric vessels). Typically, an OGV will have a single, large main engine used for propulsion, and several smaller auxiliary "generator-set" engines. Auxiliary engines are used during all three operating modes. An exception to this configuration is diesel-electric vessels where diesel engine generator sets provide power for both propulsion and auxiliary power needs.

In addition to the engines, most ships have auxiliary boilers to provide steam heat for a variety of uses, including fuel heating and hot water. Some crude oil tankers also use boilers for moving crude oil product on and off the ship. Boilers are used during slow speed vessel operations or in port; at cruise speed, most vessels are equipped with an "economizer" at cruise speeds which uses exhaust gas to provide heat. Below certain engine loads, however, there is not sufficient waste heat available from the exhaust, and boilers are activated. For the purposes of this inventory, it is assumed that boilers are operated during maneuvering, hotelling, and during anchorage.

There are a number of types of ocean-going vessels including: auto carriers, bulk cargo carriers, container vessels, general cargo carriers and other miscellaneous vessels, passenger vessels, reefers (refrigerated vessels), roll-on-roll-off vessels (also known as a Ro-Ro: vessels in which vehicles can be driven on or off the vessel). A list of the different types of ocean-going vessel and a brief description of the goods transported by them presented in Table I-1.

Table I-1: Categories of Ocean-Going Vessels Included in the Emissions Inventory

Vessel Type	Description
Auto	Vessels designed to carry autos and trucks
Bulk Cargo	Bulk carriers are vessels used to transport bulk items such as mineral ore, fertilizer, wood chips, or grain.
Container	Container vessels are cargo vessels that carry standardized truck-sized containers.
General Cargo	Vessels designed to carry non-contaminated cargo such as steal, palletized goods, and heavy machinery.
Passenger	Passenger cruise vessels are passenger vessels used for pleasure voyages.
Reefers	Vessels used to transport perishable commodities which require temperature-controlled transportation, mostly fruits, meat, fish, vegetables, dairy products, and other foods.
Ro-Ro	A vessel designed to carry large wheeled cargo such as large off-road equipment, trailers or railway carriages. RORO is an acronym for “roll on/roll off”.
Tankers	Vessels designed to transport liquids in bulk.

B. Purpose and Overview

The ARB is revising the emission inventory for ocean-going vessels to reflect new information and improved methodologies. The new information includes updated activity data, additional sources of ship hotelling and anchorage information and ship-specific engine and speed data. Additionally, the growth assumptions to updated with additional years of trend data and also include the benefits of recent regulations. This document describes the inventory methodology and data inputs that were developed in support of the shore power regulation and the proposed main engine regulation.

The most recent year with activity data, 2006, was chosen as the base year. Base year emissions were forecasted by assessing trends in the growth of vessel net registered tonnage for the years 1994-2005. Net registered tonnage (NRT) is a measure of the volume of a ship’s cargo capacity; the growth in NRT is directly proportional to the growth in installed power of a vessel’s main propulsion engine. Controlled future year emissions for 2010 and 2020 were forecasted using the above methodology by including the benefits of the 2007 shore power regulation and the 2005 auxiliary engine regulation.

C. Public Process

Allowing stakeholders and the general public to review and comment on a product associated with a rulemaking process is a critical element of that rulemaking process. The following steps were taken to ensure interested parties could provide input.

Multiple public workshops or workgroups were held in 2007 that provided the stakeholders and the general public the opportunity to review and comment on the inventory. A number of teleconferences were conducted with port representatives and port consultants as well. We provided local air districts the opportunity to review, comment on the methodology and the inventory by conducting meetings and teleconferences. Comments obtained through these meetings, teleconferences and workshops were used to assess and modify the inventory.

II. EMISSION ESTIMATION METHODOLOGY

Ship emissions were calculated, to the extent possible, on a vessel and port call specific basis. Where possible, vessel specific power data was used, and port call specific hotelling times were used to calculate emissions.

A. Emission Inventory Inputs

Data needed for estimating ship emissions include:

- Base year vessel population
- Operating Mode specific activity hours
- Main engine, auxiliary engine, & auxiliary boiler power
- Vessel type and mode specific engine load
- Emission factors
- Vessel type and port growth rate
- Control measures

1. Base Year Vessel Population

There were several sources of activity data that were used for the inventory. First, vessel port calls were obtained from a database maintained by the California Lands Commission. This database includes vessel identification, port of arrival, previous port, next port, and date and time of arrival. The Lands Commission compiles this database from information obtained from marine exchanges and port authorities statewide. 2006 was chosen as the base year for this inventory, since it is the most recent data available. Second, vessel specific hotelling times and berth locations were obtained from port officials responsible for ship docking, or Wharfingers, in Los Angeles, Long Beach, Oakland, San Diego, San Francisco and Hueneme. Data was obtained for 2004 through 2006, but only 2006 data was used for this inventory. These data were reconciled to the extent possible with the port call data from the Lands Commission; for all ports, approximately 94-98% of the port calls were reconciled between the two databases. The remaining port calls in the Lands Commission database which could not be reconciled were assigned the port average hotelling times by vessel type.

Table II-1 summarizes the number of port calls by ship type and by port.

Table II-1: 2006 Port Calls in California

PortName	Auto	Bulk	Container	Cruise	General	Reefer	Ro-ro	Tanker	**Total**
Avalon/Catalina				114				1	**115**
Carquinez	207	90	1		14		4	478	**794**
El Segundo					1			267	**268**
Hueneme	232	2	1		1	167	6	8	**417**
Humboldt		5			10				**15**
Long Beach	247	290	1445	133	142	28	52	536	**2873**
Los Angeles	67	210	1671	260	69	31	2	311	**2621**
Monterey				2					**2**
Oakland	1	33	1890		30		1		**1955**
Pacific Lightering Zone								186	**186**
Redwood City		53			2				**55**
Richmond	63	38	25		6		22	444	**598**
Sacramento		22			14			6	**42**
San Diego	189	33	2	181	29	89	25	2	**550**
San Francisco		75	3	80	36			112	**306**
Stockton		132			17			40	**189**
All Ports	**1006**	**983**	**5038**	**770**	**371**	**315**	**112**	**2391**	**10986**

2. Operating Mode Specific Activity Hours

Three operating modes are used to characterize OGV activity: transit (emissions from vessel operations between ports), maneuvering (slow speed vessel operations while in-ports), and hotelling (also known as berthing; in-port emissions while moored to a dock or at anchor). For regulatory purposes, hotelling emissions in this inventory will be termed “hotelling” for ships moored at dock, and “anchorage” for ship activity at anchor at or near a port, but not moored to a dock. Main engine emissions occur during transit and maneuvering modes. Auxiliary engine emissions occur during all modes. Auxiliary boilers are operated during maneuvering, hotelling, and anchorage. Separate emission factors have been developed for main engines in the transit and maneuvering modes. Main engines do not operate during hotelling except for the generator sets on diesel-electric vessels. For the purposes of this emissions inventory, all diesel-electric vessel emissions are reported as auxiliary engine emissions.

a. Transit Mode

Operating hours in transit mode is calculated as distance traveled divided by vessel speed. Distance traveled is determined by evaluating the route taken between ports by the vessel; speed is a function of both the speed of which a vessel is capable of and of any speed limitations in effect.

Distance Traveled: Vessel Traffic Lanes

The lanes used to estimate ship activity at sea were a composite of three sources. First, near-port vessel lanes were extracted from the Army Corps of Engineers (ACE) National Waterway Network. The portions of this network that reflect the vessel traffic patterns defined in navigational charts were used; other parts of the ACE network that

did not reflect actual ship traffic patterns were not used. The vessel traffic separation scheme used in the Santa Barbara Channel, in which vessels traveling south travel further west than those going north, is an example of the ACE data that was used for the model. For vessel traffic further out at sea, the Ship Traffic, Energy and Environment Model (STEEM) developed by Dr. Chengfeng Wang and Dr. James Corbett (2007) was used to define traffic lanes. Third, automated instrumentation system (AIS) telemetry data collected during 2007 was used to define the traffic lanes that connect these two networks.

Figures 1 shows the vessel traffic lane network used for the inventory. Figures 2 and 3 show a close-up of the Northern California and Southern California portions of the network.

Vessel routing between ports was defined using ArcGIS Network Analyst, which assumes that vessels take the shortest route between the point of origin and the destination. One-way restrictions in certain areas were enforced, such as Santa Barbara Channel as noted above, and in the approach to the San Francisco Bay Area.

Vessel traffic lane locations with respect to the main coastline of California were identified and cataloged to identify how far off the coastline ship activity occurred.

Figure 1: Vessel Traffic Lanes

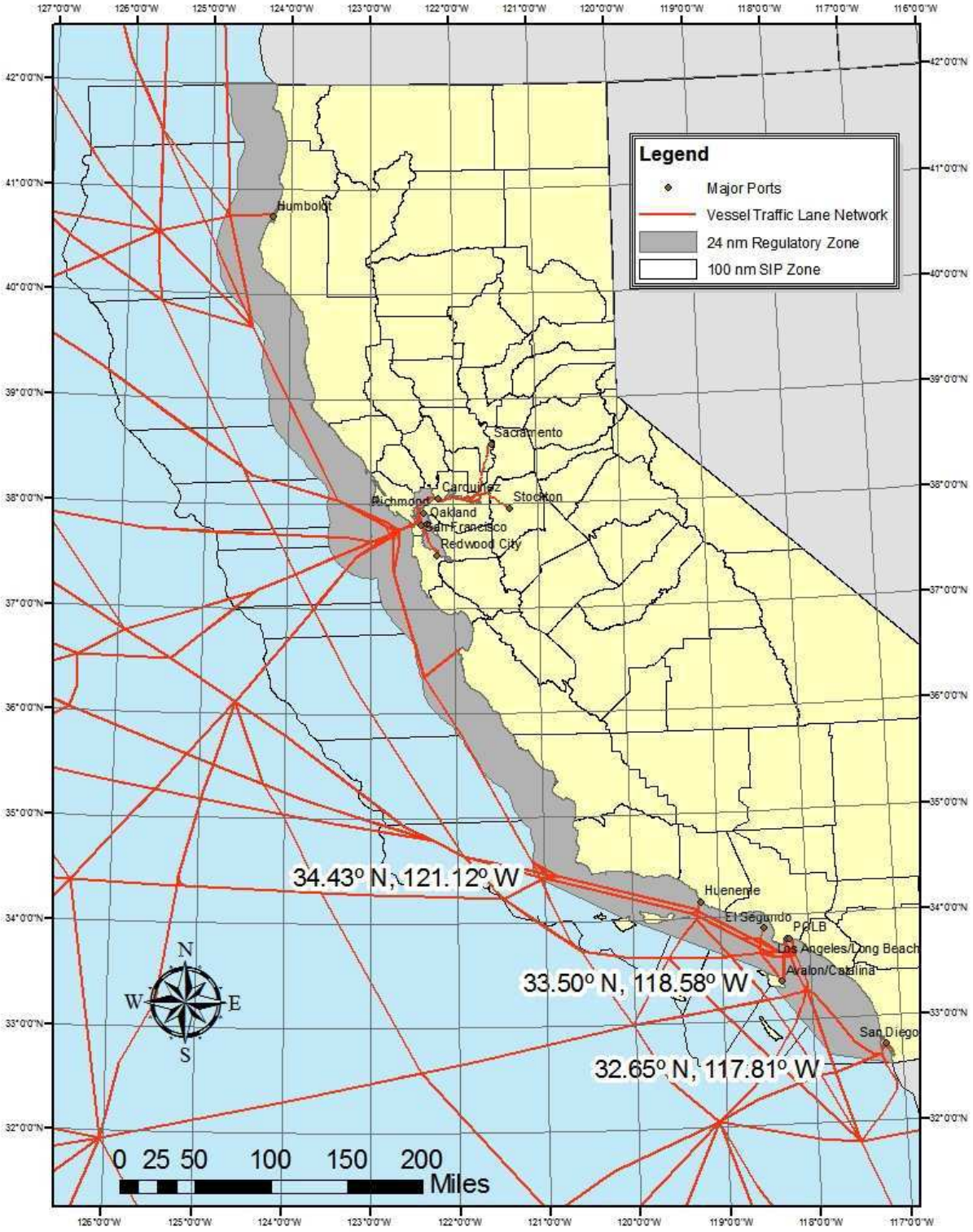


Figure 2: Vessel Traffic Lanes – Northern California

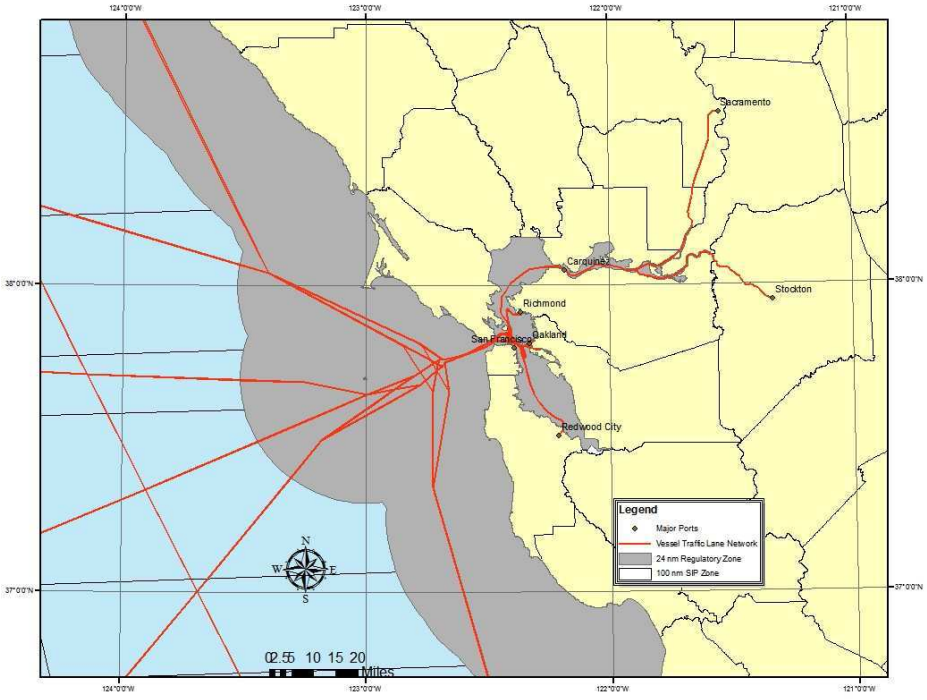
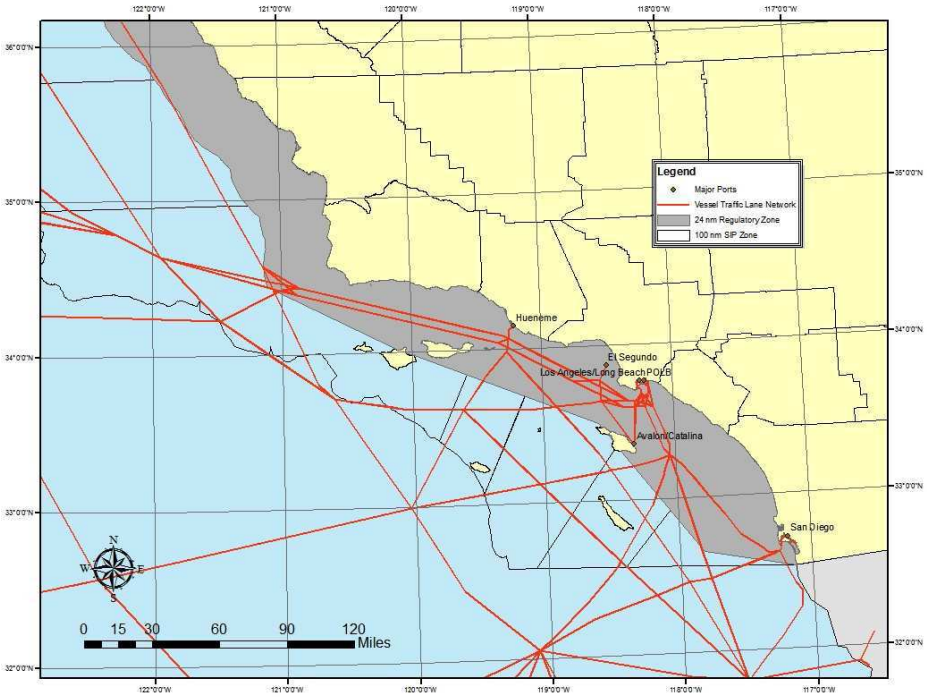


Figure 3: Vessel Traffic Lanes – Southern California



Vessel Speed

The maximum vessel speed was obtained from the 2007 version of Lloyds-Fairplay PC Register. The cruise speed was estimated to be 0.937 times the maximum speed, which results in a load factor of 0.823 during cruise mode. These figures were obtained from a survey performed for the Port of Los Angeles emission inventory (Starcrest, 2005 and 2007). It was assumed that vessels traveled at cruise speed in areas without specific speed restrictions.

Vessel speed restrictions for traffic lanes in various areas were determined from nautical charts. One such example is the precautionary zone in Los Angeles and Long Beach harbor, in which speed is restricted to either 11 or 9 knots depending on the type of ship. Vessel speeds within the Southern California voluntary vessel speed reduction zone were obtained from the Southern California Marine Exchange (MXSOCAL).

b. Maneuvering

Maneuvering time was calculated as the distance traveled during maneuvering divided by speed, plus 15 minutes for docking or undocking. For coastal ports, maneuvering was assumed to begin at the point where the pilot boarded the vessel and ended at the berth. For ports within the San Francisco Bay Area, maneuvering distances were estimated based upon either the Environ (2007) Port of Oakland inventory, based on AIS data, or discussions with port officials. It was assumed that fast ships (container ships, cruise ships, reefers) maneuvered inbound at 7 knots and slow ships (all other types) at 5 knots; all outbound ships were assumed to maneuver at 8 knots.

c. Hotelling

Hotelling time can be defined as beginning when a ship ties up at a berth, and ends when it leaves that berth. Likewise, anchorage is defined as beginning when a ship drops anchor and ends when the anchor is raised and the ship begins moving again. During hotelling and anchorage, vessels use at least one of their auxiliary engines to generate electric power for the ship. Auxiliary boilers are also used. Some ships will shift berths during a given port call for various reasons; for the purpose of this inventory, the hotelling time used for calculations combines the total hotelling time for all berths visited during a given port call.

Hotelling times used for the inventory obtained were specific to individual port calls and were obtained from port Wharfingers. Port calls that could not be identified in Wharfinger data were assigned average hotelling times by port and by vessel type from the Wharfinger data that was available. Table II-2 summarizes the average hotelling times by vessel type for 2006.

Table II-2: 2006 Hotelling Time Averages (hours per visit)

Port Name	Auto	Bulk	Container	Cruise	General	Reefer	Ro-ro	Tanker	**All Types**
Avalon/Catalina				11.7				35.5	**11.9**
Carquinez	19.2	75.5	34.3		39.9		19.7	34.9	**35.4**
El Segundo					46.8			34.9	**35.0**
Humboldt		55.3			47.8				**50.3**
Monterey				11.7					**11.7**
Pacific Lightering Zone								35.5	**35.5**
POak	18.2	13.2	20.1		13.4		13.4		**19.9**
POH	17.3	67.9	34.3		46.8	59.6	18.3	34.9	**34.9**
POLA	20.0	70.7	48.5	11.4	60.1	40.7	61.6	37.2	**44.7**
POLB	17.7	55.9	49.5	11.0	44.4	24.4	34.5	34.5	**42.1**
POSD	16.7	86.1	24.6	12.6	28.5	42.7	17.7	13.8	**24.4**
POSF		76.0	33.6	11.6	66.5			35.5	**42.8**
Redwood		74.3			46.8				**73.3**
Richmond	19.6	71.1	34.1		40.2		33.6	34.9	**35.6**
Sacramento		58.7			57.8			34.9	**55.0**
Stockton		69.3			60.4			34.9	**61.2**

Although the number of port calls by container ships to Oakland is roughly equivalent to the number of port calls at either Los Angeles or Long Beach, the hotelling time of these ships in Oakland is much shorter. Often, container ships will call on both Oakland and either Los Angeles or Long Beach; presumably, fewer containers are loaded or unloaded in Oakland than in southern California.

d. Anchorage

Anchorage data (ship identification, hours anchored, and anchorage location) was obtained from MXSOCAL in Southern California and the US Coast Guard Vessel Traffic Service (VTS) in the San Francisco Bay Area. Table II-3 summarizes anchorage times. It was assumed that ship operations during anchorage were the same as during

hotelling; that is, auxiliary engines and boilers operated at hotelling loads, and the main engine was not in operation.

Table II-3: 2006 Average Anchorage Times (hours per visit)

Port	Auto	Bulk	Container	Cruise	General	Reefer	Ro-ro	Tanker
Carquinez	14	39			32			25
Los Angeles-Long Beach	12	62	11	1	52	27	14	106
Oakland		9	8		30			
San Francisco		66	36	11	165			63
Redwood		169						
Richmond	26	25			34			23
Sacramento		8			25			7
Stockton		57			10			9

* Sacramento and Stockton bound ships anchor in the San Francisco Bay.

3. Main Engine, Auxiliary Engine, & Auxiliary Boiler Power

The main source of engine power was the PC-Register commercial ship database obtained from Lloyds-Fairplay (2007). Information from this database that was used in the inventory included main engine power, main engine speed, vessel type, date of build, cruise speed, and flag of vessel. Current and former vessel names were also used to identify vessels in activity records that were lacking IMO (International Maritime Organization) ID numbers. Vessel averages by vessel type were used if data were missing; if main engine speed data were missing it was assumed that they were slow speed engines. The Lloyds-Fairplay PC Register database did not contain information on the number, power and type of auxiliary engines or boilers, so data were obtained from alternate sources. Ships visiting the Port of Oakland were assigned auxiliary engine power estimates developed by Environ (2007) using auxiliary engine generation capacity data obtained from a different Lloyds-Fairplay database. Ships visiting the Ports of Los Angeles, Long Beach and San Diego were assigned auxiliary engine power estimates developed by Starcrest (2005 and 2007) from both the ARB 2005 OGV survey, the vessel boarding program performed as part of the POLA and POLB inventories, and a limited number of power ratings taken from another version of data from Lloyds-Fairplay (Environ, 2007). All other ships were assigned average auxiliary engine power ratings obtained from the ARB 2005 OGV survey. Ship auxiliary boiler power ratings were assigned averages developed by Starcrest (2007) from the vessel boarding program.

Table II-4: Average Vessel Characteristics

Vessel Type	Speed	Main Power	Auxiliary Power	Boiler Power
	(knots)	(kilowatts)		
Auto	19	11593	2999	278
Bulk	15	7803	2459	82
Container	23	37265	8156	380
Cruise	21	0	44042	750
General	15	7580	1799	99
Reefer	20	11091	3605	348
Ro-ro	18	12181	2605	82
Tanker	15	13034	2339	1593

Table II-4 summarizes the average vessel speed and main engine, auxiliary engine, and boiler power by vessel type. For boilers, fuel use rates were converted to equivalent kilowatts.

4. Load Factor

a. Main Engines

At cruise speed, the main engine load is 82.5%; as has been previously described, this estimate was based on a vessel boarding program and survey done by Starcrest as part of the POLA and POLB inventories (2005 and 2007). At higher loads, fuel consumption and engine maintenance costs go up dramatically, so vessel operators tend to operate at this level. At slower speeds, main engine load was calculated using the propeller law, which states that propulsion load varies by the cube of the vessel speed. Main engine load was calculated by divided the vessel speed by the maximum vessel speed and cubing the result.

b. Auxiliary Engines

The auxiliary engine load factor represents the actual engine power used divided by the total installed auxiliary engine power. Table II-5 shows the load factors, in percent, by vessel type.

The primary source of data on auxiliary engine load was the 2005 and 2007 ARB OGV surveys and the vessel boarding program done by Starcrest for the Port of Los Angeles and the Port of Long Beach emission inventories (2005 and 2007).

Table II-5: OGV Auxiliary Engine Load Characteristics (percent load)

Vessel Type	Load Factor (%)		
	Hotelling	Maneuvering	Transit
Auto Carrier/Ro-Ro	26%	45%	15%
Bulk Carrier/General Cargo	10%	45%	17%
Container Ship	18%	50%	13%
Passenger	16%	64%	80%
Reefer	32%	45%	15%
Tanker	26%	33%	24%

5. Emission Factors

Emission factors for OGVs vary by pollutant, operating mode (transit, maneuvering, or hotelling), engine type (main engine/slow speed, main engine/medium speed, or auxiliary/medium speed), and fuel type (heavy fuel oil- HFO or marine distillate). Emission factors for diesel particulate matter (PM), oxides of nitrogen (NOx), sulfur dioxide (SO2), hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide (CO2) were compiled. Emission factors for main and auxiliary engines of ocean-going vessels are expressed as grams of pollutant emitted per kilowatt-hour of energy (g/kW-h). Although emission factors for auxiliary boilers are usually expressed in terms of grams of pollutant emitted by metric tonne of fuel burned, they were converted to g/kW-h using a methodology defined by Starcrest (2007).

Tables II-6, II-7, and II-8 below present the emission factors used in the development of the ocean-going vessel emissions inventory. Table II-6 presents the emission factors for main engines during transit or high load operation while at sea. If data on main engine speed for a given vessel was not known, it was assumed the engine was slow speed.

Table II-6: Main Engine Emission Factors – Transit Mode (g/kW-hr)

Engine Speed	Fuel	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Slow	Marine Distillate (0.1% S)	0.07	1.10	588	17.0	0.25	0.35	0.78	0.36
Slow	Marine Distillate (0.5% S)	0.07	1.10	588	17.0	0.38	0.35	0.78	1.90
Slow	Heavy Fuel Oil	0.08	1.38	620	18.1	1.50	1.46	0.69	10.50
Medium	Marine Distillate (0.1% S)	0.08	1.10	645	13.2	0.25	0.35	0.65	0.40
Medium	Marine Distillate (0.5% S)	0.08	1.10	645	13.2	0.38	0.35	0.65	2.08
Medium	Heavy Fuel Oil	0.09	1.10	677	14.0	1.50	1.46	0.57	11.50
High	Marine Distillate (0.1% S)	0.08	1.10	645	12.1	0.25	0.35	0.65	0.40
High	Marine Distillate (0.5% S)	0.08	1.10	645	12.1	0.38	0.35	0.65	2.08
High	Heavy Fuel Oil	0.09	1.10	645	12.7	1.50	1.46	0.23	11.50

Table II-7 presents the emission factors for main engines during maneuvering or low load operation near ports.

Table II-7: Main Engine Emission Factors – Maneuvering Mode (g/kW-hr)

Engine Speed	Fuel	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Slow	Marine Distillate (0.1% S)	0.07	1.10	588	17.0	0.25	0.35	0.78	0.36
Slow	Marine Distillate (0.5% S)	0.07	1.10	588	17.0	0.38	0.35	0.78	1.90
Slow	Heavy Fuel Oil	0.08	1.38	620	18.1	1.50	1.46	0.69	10.50
Medium	Marine Distillate (0.1% S)	0.08	1.10	645	13.2	0.25	0.35	0.65	0.40
Medium	Marine Distillate (0.5% S)	0.08	1.10	645	13.2	0.38	0.35	0.65	2.08
Medium	Heavy Fuel Oil	0.09	1.10	677	14.0	1.50	1.46	0.57	11.50
High	Marine Distillate (0.1% S)	0.08	1.10	645	12.1	0.25	0.35	0.65	0.40
High	Marine Distillate (0.5% S)	0.08	1.10	645	12.1	0.38	0.35	0.65	2.08
High	Heavy Fuel Oil	0.09	1.10	645	12.7	1.50	1.46	0.23	11.50

Table II-8 presents the emission factors for auxiliary engines, including diesel-electric vessels. As shown in the table, the emission factors for auxiliary engine vary depending on the type of fuel used.

Table II-8: Auxiliary Engine Emission Factors – Transit, Maneuvering, and Hotelling (g/kW-hr)

Engine Speed	Fuel	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Medium	Marine Distillate (0.1% S)	0.09	1.10	690	13.9	0.25	0.35	0.52	0.40
Medium	Marine Distillate (0.5% S)	0.09	1.10	690	13.9	0.38	0.35	0.52	2.10
Medium	Heavy Fuel Oil	0.09	1.10	722	14.7	1.50	1.46	0.46	11.10

Table II-9 presents the emission factors for auxiliary boilers, which use heavy fuel oil. These emission factors were converted to grams per kilowatt hour from grams per tonne of fuel using methodology developed by Starcrest (2007).

Table II-9: Auxiliary Boiler Emission Factors (g/kW-hr)

Fuel	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Marine Distillate (0.1% S)	0.03	0.20	970	2.0	0.13	0.12	0.11	0.57
Marine Distillate (0.5% S)	0.03	0.20	970	2.0	0.20	0.19	0.11	2.99
Heavy Fuel Oil	0.03	0.20	970	2.1	0.80	0.78	0.11	16.50

The emission factors for main engines, auxiliary engines and auxiliary boilers used by ARB staff are generally consistent with the emission factors used by Starcrest in developing the 2005 Port of Los Angeles emissions inventory and the updates done in 2007. The Starcrest emission factors were based on work done by Entec (2002). The Entec emission factors were developed using Lloyd's of London and IVL Swedish Environmental Institute data that related emissions to engine speed and the type of fuel used. The Entec emission factors also relied on earlier work done by Arcadis in 1999.

ARB staff developed an alternate particulate matter emission factor for engines burning heavy fuel oil based upon an extensive review of emission tests described in scientific literature. This emission factor, set at 1.5 grams/kilowatt-hour, is based upon the use of HFO fuel with 2.5% sulfur content. The basis of this emission factor is fully described in a white paper written by ARB staff in 2007, which is available on the ARB web site.

For CO emissions from the main engines during transit, staff elected to use a U.S. EPA emission factor published in the Environ report (2007). This emission factor is consistent with the CO emission factors used by Starcrest for the Port of Los Angeles emission inventory.

6. Fuel Consumption

It was assumed that all main engines and auxiliary boilers burned heavy fuel oil. The main engine assumption was based on the 2005 ARB OGV survey; the auxiliary boiler assumption was based on communications with boiler manufacturers. For auxiliary engines, it was assumed that 92% of cruise ships burned heavy fuel oil and 8% distillate. For all other ships, it was assumed that 71% use heavy fuel oil and 29% use distillate in their auxiliary engines. These data were obtained from the 2005 ARB OGV survey.

Table II-10: Fuel Consumption Rates (g/kW-hr)

Engine	Engine Speed	Mode	Fuel	Fuel Use Rate
Auxiliary	All	All	Marine Distillate	217
	All	All	Residual	227
Boiler	N. A.	All	Residual	305
Main	High	Transit	Residual	213
	Medium	Transit	Marine Distillate	203
	Slow	Transit	Marine Distillate	185
	Medium	Transit	Residual	213
	Slow	Transit	Residual	195
	High	Maneuvering	Residual	213
	Medium	Maneuvering	Marine Distillate	203
	Slow	Maneuvering	Marine Distillate	185
	Medium	Maneuvering	Residual	213
	Slow	Maneuvering	Residual	195

Fuel consumption rates were obtained from Entec (2002) and vary by engine, engine speed, and mode of operation. Fuel use rates are expressed in the same units as emission factors; in grams per kilowatt hour. Table II-10 summarizes the fuel consumption rates used.

7. Growth Rate

Growth rates were estimated by vessel type and by port. These growth rates were based upon an analysis of US Army Corps of Engineers vessel call data between the years 1994-2005. The total net registered tonnage (NRT), a measure of the volume of cargo a ship can carry, was determined by vessel type and by port. Previous ARB OGV growth rates were based on total installed main engine power determined from vessel call data between the years 1997 and 2003. Growth in NRT is directly proportional to growth in installed power. NRT was used to estimate growth because it was not possible to determine main engine power for many of the records; in contrast, NRT data was available for almost 99% of the records analyzed. The growth rates selected are the midpoint between the best fit compounded annual growth rate in NRT between 1994 through 2005 and the best fit linear (arithmetic) growth rate in NRT for the same time period. The sum of growth of all California ports was set to equal to the statewide growth with the assumption that the ports will grow proportionally to their historical NRT growth between the years 1994-2005.

Growth rates developed using this methodology were checked and verified against other studies, including the Port of Los Angeles and Port of Long Beach emission inventory updates done in 2007 by Starcrest, the Port of San Diego emission inventory, and the Port of Oakland emission inventory done by Environ. The growth rates container ships in 2020 in Los Angeles and Long Beach were very close to those developed by Starcrest in 2007; however, the intervening years were different, so these growth rates were set to those developed by Starcrest in this case.

Table II-11: Growth Rates by Port and Vessel Type

Port	Auto	Bulk	Container	Cruise	General	Reefer	Roro	Tanker
Avalon/Catalina				3.9%				1.0%
Carquinez	-4.0%	-0.7%	-4.0%		0.3%		-4.0%	-0.9%
El Segundo								5.4%
Hueneme	5.9%	-27.0%	8.3%	7.3%	8.3%	1.4%	5.9%	5.0%
Humboldt		-13.4%		0.0%	-0.7%			
Los Angeles-Long Beach	1.4%	-2.3%	6.8%	3.9%	1.0%	-8.0%	1.4%	1.0%
Monterey				0.0%	0.0%			
Oakland		-3.8%	4.4%		4.4%		4.4%	
Pacific Lightering Zone								5.4%
Redwood		5.2%			5.2%			
Richmond	-1.4%	-3.8%	-5.4%		-5.4%		-1.4%	0.0%
Sacramento		-5.4%			-1.9%		-1.9%	-2.1%
San Diego	4.0%	1.5%	6.8%	8.7%	2.7%	7.0%	4.0%	5.0%
San Francisco	-0.9%	3.4%	-0.9%	5.3%	-0.9%	0.0%	0.0%	0.0%
Stockton		3.4%			1.9%	1.9%		5.3%

Table II-11 summarizes the growth rates by port and by vessel type.

8. Control Measures

There are several control measures built into the ship inventory:

- 1997 MARPOL Annex VI Emission Standards
- 2004 Los Angeles/Long Beach Voluntary Speed Reduction Zone
- 2005 US EPA Category 3 Engine Standards (MARPOL Annex VI)
- 2005 Auxiliary Engine Regulation (not currently enforced)
- 2007 Shore Power Regulation

The 1997 MARPOL standards were established by the International Maritime Organization (IMO) at the International Convention on the Prevention of Pollution from Ships", known as MARPOL. It provides for limits on NOx emissions from ships, depending on engine speed. For slow speed engines, NOx is limited for ships built after 1999 to 17 gms/kw-hr, which is a six percent reduction.

The Los Angeles/Long Beach Voluntary Speed Reduction (VSR) Zone was established by the Southern California Marine Exchange (MXSOCAL) in 2004. This is a voluntary control measure which requests that ships not exceed a speed of 12 knots within 20 nautical miles of Point Fermin. This inventory calculates the benefits of this control by the inclusion of ship and port call specific speed data obtained from the Southern California Marine Exchange.

The 2005 US EPA category 3 standards are an implementation of international standards agreed to by 136 countries; the agreement is commonly known as MARPOL Annex VI (MARPOL stands for Marine Pollution). Ships built on or after 2000 are required to emit approximately 6-12% less NOx, depending on engine speed. There is

also a limit for sulfur in heavy fuel oil of 4.5% (average California fuel sulfur content of HFO is 2.5%).

In 2005, the ARB approved a regulation which requires ship auxiliary engines to use 0.5% sulfur fuel on or after 2007, and 0.1% sulfur after 2010. The final rule was approved by the Office of Administrative Law in October, 2007. Enforcement of the regulation has been temporarily suspended due to a legal challenge. Accordingly, the benefits of this measure are not included in 2010 nor 2020 emissions estimates. It is anticipated that the regulation will be back in force upon the approval of a waiver by the US EPA.

In 2007, the ARB approved a regulation which requires container ships, cruise ships, and reefer ships visiting five California ports to use shore power. Fleets with less than 25 visits per year are exempt; ships are permitted 3 hours of auxiliary engine use per visit after the regulation goes into effect. By 2014, fleets are required to use shore power for 50% of visits; by 2020, they are required to use shore power for 80% of visits.

B. Methodology

The basic equation used for estimating emissions from ocean-going vessels is:

$$E_{y,t,om,e} = \Sigma\, Pop_t * EF_{e,om,f} * Hrs_{om,t} * VP_{om,t} * \%Load_{om,t}$$

where

E = pollutant specific emissions (tons per year of NOx, HC, CO2, SO2, and diesel PM)
Pop = population of ocean-going vessels by vessel type
EF = emission factor by engine type, operating mode, and fuel (units of glkw-hr)
Hrs = average annual use in hours by operating mode and vessel type
VP = average power by operating mode and vessel type
% Load = average engine load by operating mode and vessel type
y = inventory year
om = operating mode (transit, maneuvering, hotelling)
t = vessel type (auto, container, bulk cargo, etc.)
f = fuel (HFO or MGO/MDO)
e = engine type

Each of these elements, and how they were incorporated into the ocean-going vessel emission estimates, are discussed below. The base year for the ocean-going vessel emissions inventory is 2006.

III. RESULTS

A. Fuel Consumption

Fuel consumption in both the 24 nautical mile zone and the 100 nautical mile zone was estimated using the same methodology as emissions except substituting emission factors with the fuel consumption rates discussed above. Table III-1 summarizes these results.

Table III-1: Fuel Consumption (tons/day)

24 nm Zone (tons/day)															
Engine	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Auxiliary	610	638	668	699	699	696	691	683	672	686	700	713	726	738	749
Boiler	457	467	478	490	502	515	528	543	558	575	592	611	630	651	673
Main	1260	1307	1356	1408	1463	1522	1583	1648	1717	1790	1867	1949	2035	2125	2222
Total	**2328**	**2412**	**2502**	**2597**	**2664**	**2732**	**2803**	**2874**	**2948**	**3051**	**3159**	**3272**	**3391**	**3514**	**3644**
100 nm Zone (tons/day)															
Engine	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Auxiliary	682	713	746	781	784	785	784	781	775	794	813	832	851	869	887
Boiler	457	467	478	490	502	515	528	543	558	575	592	611	630	651	673
Main	2052	2134	2221	2313	2411	2514	2624	2740	2863	2994	3132	3278	3433	3597	3771
Total	**3190**	**3314**	**3445**	**3583**	**3697**	**3814**	**3937**	**4064**	**4197**	**4362**	**4537**	**4720**	**4914**	**5117**	**5331**

B. Emissions in the 24 nautical mile regulatory zone

Ship emissions presented here include all emissions within the 24 nautical mile regulatory zone used for the 2005 auxiliary engine regulation and the goods movement program. Emissions are presented for the years 2006, 2010, and 2020. The effects of the all existing regulations as described above are included in these estimates. Tables III-2 through III-4 summarize ship emissions by source (auxiliary engine, auxiliary boiler, and main engine) and vessel type for the years 2006, 2010, and 2020. Table III-5 presents the totaled emissions for these three sources. Container ships account for over half of the ship emissions for the year 2006; tankers account for nearly one quarter of ship emissions.

Tables III-6 through III-8 summarize ship emissions by source and by district; table III-9 summarizes the totaled emissions by district. It is important to note here that the assignment of emissions to districts is for comparison purposes only. The ARB California Emissions Inventory Data and Reporting System (CEIDARS) emission inventory database requires emissions occurring in the Outer Continental Shelf (OCS) Air Basin to be assigned to specific counties and specific air pollution control districts. It is important to note that meteorology defines how OCS emissions impact land; assignment of specific OCS areas to counties and districts is done for database reasons and for comparison, and not to indicate that a specific county or district is either responsible or impacted by a specific OCS area. There exists no official federal or state governmental assignment of OCS waters to specific counties, districts or air basins.

It should also be noted that auxiliary boilers operate only during hotelling, anchorage, and maneuvering, so they occur only in areas with ports, and not in areas such as San Luis Obispo which does not have a port suitable for these ships.

C. Emissions in the 100 nautical mile CEIDARS zone

Ship emissions presented here include all emissions within the 100 nautical mile zone used for the CEIDARS database system and for State Implementation Plan (SIP) purposes. Emissions are presented for the years 2006, 2010, and 2020. The effects of all existing regulations are included in these estimates. Tables III-10 through III-12 summarize ship emissions by source (auxiliary engine, auxiliary boiler, and main engine) and vessel type for the years 2006, 2010, and 2020. Table III-13 summarizes emissions by vessel type totaled for the three sources. Container ships account for over half of the ship emissions for the year 2006; tankers account for nearly one quarter of ship emissions.

Tables III-14 through III-16 summarize ship emissions by source and by district; table III-17 totals these sources by district. As described above, it is important to note here that the assignment of emissions to districts is for comparison purposes only. Table III-18 shows the total emissions by engine type in the Regulated California Waters.

Table III-2: Auxiliary Engine Emissions by Vessel Type in 24 nm Regulatory Zone

2006 Auxiliary Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Vessel Type	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Auto	0.0	0.1	52.1	1.1	0.1	0.1	0.0	0.6
Bulk	0.0	0.1	71.8	1.5	0.1	0.1	0.0	0.9
Container	0.1	1.4	907.6	18.4	1.5	1.5	0.6	10.8
Cruise	0.1	0.9	586.5	11.9	1.1	1.1	0.4	8.5
General	0.0	0.0	26.3	0.5	0.0	0.0	0.0	0.3
Reefer	0.0	0.1	44.3	0.9	0.1	0.1	0.0	0.5
Ro-ro	0.0	0.0	6.6	0.1	0.0	0.0	0.0	0.1
Tanker	0.0	0.4	245.4	5.0	0.4	0.4	0.2	2.9
Total	**0.2**	**3.0**	**1940.7**	**39.4**	**3.4**	**3.3**	**1.3**	**24.6**
2010 Auxiliary Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.1	55.2	1.1	0.1	0.1	0.0	0.7
Bulk	0.0	0.1	71.0	1.4	0.1	0.1	0.0	0.8
Container	0.1	1.6	1065.1	21.6	1.8	1.7	0.7	12.7
Cruise	0.1	1.1	697.5	14.2	1.4	1.3	0.5	10.1
General	0.0	0.0	27.2	0.6	0.0	0.0	0.0	0.3
Reefer	0.0	0.1	43.1	0.9	0.1	0.1	0.0	0.5
Ro-ro	0.0	0.0	7.0	0.1	0.0	0.0	0.0	0.1
Tanker	0.0	0.4	255.7	5.2	0.4	0.4	0.2	3.0
Total	**0.3**	**3.4**	**2221.9**	**45.1**	**3.9**	**3.8**	**1.5**	**28.2**
2020 Auxiliary Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.1	68.4	1.4	0.1	0.1	0.0	0.8
Bulk	0.0	0.1	73.8	1.5	0.1	0.1	0.0	0.9
Container	0.1	1.4	879.1	17.8	1.4	1.4	0.6	10.5
Cruise	0.1	1.5	1006.2	20.5	2.0	1.9	0.7	14.5
General	0.0	0.0	30.0	0.6	0.0	0.0	0.0	0.4
Reefer	0.0	0.0	27.1	0.6	0.0	0.0	0.0	0.3
Ro-ro	0.0	0.0	8.2	0.2	0.0	0.0	0.0	0.1
Tanker	0.0	0.4	290.7	5.9	0.5	0.5	0.2	3.5
Total	**0.3**	**3.7**	**2383.5**	**48.4**	**4.2**	**4.1**	**1.6**	**30.9**

Table III-3: Auxiliary Boiler Emissions by Vessel Type in 24 nm Regulatory Zone

2006 Auxiliary Boiler Emissions (tons/day) in 24 nm. Regulatory Zone								
Vessel Type	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Auto	0.0	0.0	22.2	0.0	0.0	0.0	0.0	0.4
Bulk	0.0	0.0	31.2	0.1	0.0	0.0	0.0	0.5
Container	0.0	0.1	316.1	0.7	0.3	0.3	0.0	5.4
Cruise	0.0	0.0	29.3	0.1	0.0	0.0	0.0	0.5
General	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.1
Reefer	0.0	0.0	22.4	0.0	0.0	0.0	0.0	0.4
Ro-ro	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Tanker	0.0	0.2	1023.8	2.2	0.8	0.8	0.1	17.4
Total	**0.0**	**0.3**	**1454.1**	**3.1**	**1.2**	**1.2**	**0.2**	**24.7**
2010 Auxiliary Boiler Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.0	23.7	0.1	0.0	0.0	0.0	0.4
Bulk	0.0	0.0	30.7	0.1	0.0	0.0	0.0	0.5
Container	0.0	0.1	403.9	0.9	0.3	0.3	0.0	6.9
Cruise	0.0	0.0	36.1	0.1	0.0	0.0	0.0	0.6
General	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.1
Reefer	0.0	0.0	24.0	0.1	0.0	0.0	0.0	0.4
Ro-ro	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
Tanker	0.0	0.2	1067.9	2.3	0.9	0.9	0.1	18.2
Total	**0.1**	**0.3**	**1595.7**	**3.5**	**1.3**	**1.3**	**0.2**	**27.1**
2020 Auxiliary Boiler Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.0	30.2	0.1	0.0	0.0	0.0	0.5
Bulk	0.0	0.0	31.8	0.1	0.0	0.0	0.0	0.5
Container	0.0	0.2	750.0	1.6	0.6	0.6	0.1	12.8
Cruise	0.0	0.0	62.3	0.1	0.1	0.1	0.0	1.1
General	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.2
Reefer	0.0	0.0	31.6	0.1	0.0	0.0	0.0	0.5
Ro-ro	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Tanker	0.0	0.3	1224.3	2.7	1.0	1.0	0.1	20.8
Total	**0.1**	**0.4**	**2140.5**	**4.6**	**1.8**	**1.7**	**0.2**	**36.4**

Table III-4: Main Engine Emissions by Vessel Type in 24 nm Regulatory Zone

2006 Main Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Vessel Type	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Auto	0.0	0.5	213.9	6.1	0.5	0.5	0.2	3.6
Bulk	0.0	0.5	219.6	6.3	0.5	0.5	0.2	3.7
Container	0.3	6.3	2594.5	75.1	6.6	6.4	3.1	43.9
Cruise	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General	0.0	0.2	98.9	2.8	0.2	0.2	0.1	1.7
Reefer	0.0	0.1	44.3	1.3	0.1	0.1	0.1	0.8
Ro-ro	0.0	0.0	23.0	0.6	0.1	0.1	0.0	0.4
Tanker	0.1	1.8	812.6	22.3	2.0	1.9	0.9	13.8
Total	**0.5**	**9.4**	**4006.8**	**114.6**	**10.1**	**9.8**	**4.6**	**67.9**
2010 Main Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.5	224.9	6.5	0.6	0.5	0.3	3.8
Bulk	0.0	0.5	218.8	6.3	0.5	0.5	0.2	3.7
Container	0.4	7.7	3186.9	92.4	8.1	7.9	3.8	54.0
Cruise	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
General	0.0	0.2	103.7	2.9	0.3	0.2	0.1	1.8
Reefer	0.0	0.1	53.5	1.6	0.1	0.1	0.1	0.9
Ro-ro	0.0	0.1	24.1	0.6	0.1	0.1	0.0	0.4
Tanker	0.1	1.9	840.5	23.1	2.0	2.0	0.9	14.2
Total	**0.6**	**11.0**	**4652.3**	**133.3**	**11.7**	**11.4**	**5.4**	**78.8**
2020 Main Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.6	273.9	7.9	0.7	0.7	0.3	4.6
Bulk	0.0	0.5	233.2	6.7	0.6	0.6	0.3	4.0
Container	0.7	13.1	5377.8	156.2	13.8	13.4	6.4	91.1
Cruise	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
General	0.0	0.3	118.9	3.3	0.3	0.3	0.1	2.0
Reefer	0.0	0.2	94.1	2.8	0.2	0.2	0.1	1.6
Ro-ro	0.0	0.1	27.9	0.7	0.1	0.1	0.0	0.5
Tanker	0.1	2.1	937.3	25.8	2.3	2.2	1.0	15.9
Total	**0.9**	**16.9**	**7063.2**	**203.4**	**17.9**	**17.5**	**8.3**	**119.6**

Table III-5: Total Emissions by Vessel Type in 24 nm Regulatory Zone

Total for Ships in 24 nm. Regulatory Zone								
2006 Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.6	288.2	7.2	0.6	0.6	0.3	4.6
Bulk	0.0	0.6	322.6	7.9	0.7	0.7	0.3	5.1
Container	0.5	7.7	3818.1	94.2	8.4	8.1	3.7	60.1
Cruise	0.1	0.9	615.9	12.0	1.2	1.1	0.4	9.0
General	0.0	0.3	133.2	3.3	0.3	0.3	0.1	2.1
Reefer	0.0	0.2	111.1	2.2	0.2	0.2	0.1	1.7
Ro-ro	0.0	0.1	30.8	0.7	0.1	0.1	0.0	0.5
Tanker	0.2	2.4	2081.8	29.5	3.2	3.1	1.2	34.1
Total	**0.8**	**12.7**	**7401.6**	**157.1**	**14.6**	**14.3**	**6.1**	**117.2**
2010 Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.6	303.8	7.6	0.7	0.6	0.3	4.9
Bulk	0.0	0.6	320.5	7.8	0.7	0.7	0.3	5.1
Container	0.5	9.5	4655.9	114.9	10.2	10.0	4.5	73.5
Cruise	0.1	1.1	733.7	14.3	1.4	1.4	0.5	10.7
General	0.0	0.3	139.0	3.5	0.3	0.3	0.1	2.2
Reefer	0.0	0.2	120.5	2.5	0.2	0.2	0.1	1.8
Ro-ro	0.0	0.1	32.4	0.8	0.1	0.1	0.0	0.5
Tanker	0.2	2.5	2164.1	30.6	3.3	3.3	1.2	35.5
Total	**0.9**	**14.8**	**8469.9**	**181.9**	**16.9**	**16.5**	**7.0**	**134.2**
2020 Emissions (tons/day) in 24 nm. Regulatory Zone								
Auto	0.0	0.7	372.5	9.3	0.8	0.8	0.4	6.0
Bulk	0.0	0.7	338.8	8.3	0.7	0.7	0.3	5.4
Container	0.8	14.6	7007.0	175.7	15.8	15.4	7.0	114.3
Cruise	0.1	1.6	1068.6	20.6	2.0	2.0	0.7	15.6
General	0.0	0.3	157.7	3.9	0.3	0.3	0.2	2.5
Reefer	0.0	0.3	152.8	3.4	0.3	0.3	0.1	2.5
Ro-ro	0.0	0.1	37.5	0.9	0.1	0.1	0.0	0.6
Tanker	0.2	2.8	2452.3	34.3	3.8	3.7	1.4	40.2
Total	**1.3**	**21.0**	**11587.2**	**256.4**	**23.9**	**23.3**	**10.1**	**187.0**

Table III-6: Auxiliary Engine Emissions by District in 24 nm Regulatory Zone

2006 Auxiliary Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.0	0.6	387.1	7.9	0.7	0.6	0.3	4.8
Mendocino County AQMD	0.0	0.0	30.4	0.6	0.1	0.1	0.0	0.4
Monterey Bay Unified APCD	0.0	0.1	75.4	1.5	0.1	0.1	0.0	1.0
North Coast Unified APCD	0.0	0.0	25.0	0.5	0.0	0.0	0.0	0.3
Northern Sonoma County APCD	0.0	0.0	17.3	0.4	0.0	0.0	0.0	0.2
San Diego County APCD	0.0	0.2	159.3	3.2	0.3	0.3	0.1	2.2
San Joaquin Valley Unified APCD	0.0	0.0	10.1	0.2	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.0	0.0	10.2	0.2	0.0	0.0	0.0	0.1
Santa Barbara County APCD	0.0	0.1	68.6	1.4	0.1	0.1	0.0	0.9
South Coast AQMD	0.1	1.7	1099.9	22.3	1.9	1.8	0.7	13.7
Ventura County APCD	0.0	0.1	55.7	1.1	0.1	0.1	0.0	0.7
Yolo/Solano AQMD	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Total	**0.2**	**3.0**	**1940.7**	**39.4**	**3.4**	**3.3**	**1.3**	**24.6**
2010 Auxiliary Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Bay Area AQMD	0.1	0.6	420.2	8.5	0.7	0.7	0.3	5.2
Mendocino County AQMD	0.0	0.1	35.9	0.7	0.1	0.1	0.0	0.5
Monterey Bay Unified APCD	0.0	0.1	89.0	1.8	0.2	0.2	0.1	1.2
North Coast Unified APCD	0.0	0.0	29.4	0.6	0.1	0.1	0.0	0.4
Northern Sonoma County APCD	0.0	0.0	20.4	0.4	0.0	0.0	0.0	0.3
San Diego County APCD	0.0	0.3	195.9	4.0	0.4	0.4	0.1	2.8
San Joaquin Valley Unified APCD	0.0	0.0	11.6	0.2	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.0	0.0	12.0	0.2	0.0	0.0	0.0	0.2
Santa Barbara County APCD	0.0	0.1	81.1	1.6	0.1	0.1	0.1	1.1
South Coast AQMD	0.2	1.9	1265.0	25.7	2.2	2.1	0.8	15.8
Ventura County APCD	0.0	0.1	59.7	1.2	0.1	0.1	0.0	0.7
Yolo/Solano AQMD	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0
Total	**0.3**	**3.4**	**2221.9**	**45.1**	**3.9**	**3.8**	**1.5**	**28.2**
2020 Auxiliary Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Bay Area AQMD	0.1	0.7	429.1	8.7	0.7	0.7	0.3	5.4
Mendocino County AQMD	0.0	0.1	56.5	1.1	0.1	0.1	0.0	0.8
Monterey Bay Unified APCD	0.0	0.2	138.7	2.8	0.3	0.2	0.1	1.9
North Coast Unified APCD	0.0	0.1	46.0	0.9	0.1	0.1	0.0	0.6
Northern Sonoma County APCD	0.0	0.0	32.1	0.7	0.1	0.1	0.0	0.4
San Diego County APCD	0.0	0.5	297.9	6.1	0.6	0.6	0.2	4.2
San Joaquin Valley Unified APCD	0.0	0.0	16.6	0.3	0.0	0.0	0.0	0.2
San Luis Obispo County APCD	0.0	0.0	18.9	0.4	0.0	0.0	0.0	0.3
Santa Barbara County APCD	0.0	0.2	127.2	2.6	0.2	0.2	0.1	1.7
South Coast AQMD	0.1	1.8	1157.2	23.5	2.0	2.0	0.8	14.7
Ventura County APCD	0.0	0.1	62.1	1.3	0.1	0.1	0.0	0.8
Yolo/Solano AQMD	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Total	**0.3**	**3.7**	**2383.5**	**48.4**	**4.2**	**4.1**	**1.6**	**30.9**

Table III-7: Auxiliary Boiler Emissions by District in 24 nm Regulatory Zone

2006 Auxiliary Boiler Emissions (tons/day) in 24 nm. Regulatory Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.0	0.1	570.1	1.2	0.5	0.5	0.1	9.7
Monterey Bay Unified APCD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
North Coast Unified APCD	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
San Diego County APCD	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0.3
San Joaquin Valley Unified APCD	0.0	0.0	20.1	0.0	0.0	0.0	0.0	0.3
South Coast AQMD	0.0	0.2	820.5	1.8	0.7	0.7	0.1	14.0
Ventura County APCD	0.0	0.0	21.1	0.0	0.0	0.0	0.0	0.4
Yolo/Solano AQMD	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.1
Total	**0.0**	**0.3**	**1454.1**	**3.1**	**1.2**	**1.2**	**0.2**	**24.7**
2010 Auxiliary Boiler Emissions (tons/day) in 24 nm. Regulatory Zone*								
Bay Area AQMD	0.0	0.1	574.1	1.2	0.5	0.5	0.1	9.8
Monterey Bay Unified APCD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
North Coast Unified APCD	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
San Diego County APCD	0.0	0.0	23.7	0.1	0.0	0.0	0.0	0.4
San Joaquin Valley Unified APCD	0.0	0.0	24.3	0.1	0.0	0.0	0.0	0.4
South Coast AQMD	0.0	0.2	946.3	2.0	0.8	0.8	0.1	16.1
Ventura County APCD	0.0	0.0	23.6	0.1	0.0	0.0	0.0	0.4
Yolo/Solano AQMD	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.1
Total	**0.1**	**0.3**	**1595.7**	**3.5**	**1.3**	**1.3**	**0.2**	**27.1**
2020 Auxiliary Boiler Emissions (tons/day) in 24 nm. Regulatory Zone*								
Bay Area AQMD	0.0	0.1	598.3	1.3	0.5	0.5	0.1	10.2
Monterey Bay Unified APCD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
North Coast Unified APCD	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
San Diego County APCD	0.0	0.0	46.6	0.1	0.0	0.0	0.0	0.8
San Joaquin Valley Unified APCD	0.0	0.0	39.1	0.1	0.0	0.0	0.0	0.7
South Coast AQMD	0.0	0.3	1421.5	3.1	1.2	1.1	0.2	24.2
Ventura County APCD	0.0	0.0	32.2	0.1	0.0	0.0	0.0	0.5
Yolo/Solano AQMD	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0
Total	**0.1**	**0.4**	**2140.5**	**4.6**	**1.8**	**1.7**	**0.2**	**36.4**

Table III-8: Main Engine Emissions by District in 24 nm Regulatory Zone

2006 Main Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.1	2.3	1001.8	28.6	2.5	2.4	1.2	17.0
Mendocino County AQMD	0.0	0.5	223.4	6.2	0.5	0.5	0.2	3.8
Monterey Bay Unified APCD	0.1	1.5	664.8	18.6	1.6	1.6	0.7	11.3
North Coast Unified APCD	0.0	0.4	178.1	5.0	0.4	0.4	0.2	3.0
Northern Sonoma County APCD	0.0	0.3	127.3	3.5	0.3	0.3	0.1	2.2
San Diego County APCD	0.0	0.2	94.3	2.6	0.2	0.2	0.1	1.6
San Joaquin Valley Unified APCD	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
San Luis Obispo County APCD	0.0	0.2	91.5	2.6	0.2	0.2	0.1	1.6
Santa Barbara County APCD	0.1	1.6	736.0	20.6	1.8	1.7	0.8	12.5
South Coast AQMD	0.1	2.0	669.4	20.8	1.9	1.9	0.9	11.3
Ventura County APCD	0.0	0.5	219.6	6.2	0.5	0.5	0.2	3.7
Yolo/Solano AQMD	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Total	**0.5**	**9.4**	**4006.8**	**114.6**	**10.1**	**9.8**	**4.6**	**67.9**
2010 Main Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Bay Area AQMD	0.1	2.7	1141.4	32.6	2.8	2.8	1.3	19.3
Mendocino County AQMD	0.0	0.5	250.9	7.0	0.6	0.6	0.3	4.3
Monterey Bay Unified APCD	0.1	1.7	772.1	21.6	1.9	1.8	0.8	13.1
North Coast Unified APCD	0.0	0.4	200.7	5.6	0.5	0.5	0.2	3.4
	0.0	0.3	142.8	4.0	0.3	0.3	0.2	2.4
San Diego County APCD	0.0	0.3	111.8	3.1	0.3	0.3	0.1	1.9
San Joaquin Valley Unified APCD	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
San Luis Obispo County APCD	0.0	0.2	106.3	3.0	0.3	0.3	0.1	1.8
Santa Barbara County APCD	0.1	1.9	861.7	24.1	2.1	2.0	0.9	14.6
South Coast AQMD	0.1	2.4	806.8	25.1	2.3	2.3	1.1	13.7
Ventura County APCD	0.0	0.6	257.0	7.2	0.6	0.6	0.3	4.4
Yolo/Solano AQMD	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Total	**0.6**	**11.0**	**4652.3**	**133.3**	**11.7**	**11.4**	**5.4**	**78.8**
2020 Main Engine Emissions (tons/day) in 24 nm. Regulatory Zone								
Bay Area AQMD	0.2	3.8	1648.3	47.1	4.1	4.0	1.9	27.9
Mendocino County AQMD	0.0	0.8	358.6	10.0	0.9	0.8	0.4	6.1
Monterey Bay Unified APCD	0.1	2.6	1163.5	32.6	2.8	2.7	1.3	19.7
North Coast Unified APCD	0.0	0.6	289.7	8.1	0.7	0.7	0.3	4.9
	0.0	0.4	203.4	5.7	0.5	0.5	0.2	3.4
San Diego County APCD	0.0	0.4	181.5	5.1	0.4	0.4	0.2	3.1
San Joaquin Valley Unified APCD	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
San Luis Obispo County APCD	0.0	0.4	160.1	4.5	0.4	0.4	0.2	2.7
Santa Barbara County APCD	0.2	2.9	1320.3	37.0	3.2	3.1	1.5	22.4
South Coast AQMD	0.2	4.1	1343.5	42.2	3.9	3.9	1.8	22.8
Ventura County APCD	0.0	0.9	393.3	11.1	1.0	0.9	0.4	6.7
Yolo/Solano AQMD	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Total	**0.9**	**16.9**	**7063.2**	**203.4**	**17.9**	**17.5**	**8.3**	**119.6**

Table III-9: Total Emissions by District in 24 nm Regulatory Zone

2006 Emissions (tons/day) in 24 nm. Regulatory Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.2	3.0	1958.9	37.7	3.6	3.5	1.5	31.4
Mendocino County AQMD	0.0	0.5	253.8	6.8	0.6	0.6	0.3	4.2
Monterey Bay Unified APCD	0.1	1.6	740.3	20.1	1.7	1.7	0.8	12.3
North Coast Unified APCD	0.0	0.4	203.5	5.5	0.5	0.5	0.2	3.4
Northern Sonoma County APCD	0.0	0.3	144.5	3.9	0.3	0.3	0.1	2.4
San Diego County APCD	0.0	0.5	271.8	5.9	0.6	0.5	0.2	4.2
San Joaquin Valley Unified APCD	0.0	0.0	30.6	0.3	0.0	0.0	0.0	0.5
San Luis Obispo County APCD	0.0	0.2	101.7	2.8	0.2	0.2	0.1	1.7
Santa Barbara County APCD	0.1	1.7	804.5	22.0	1.9	1.9	0.9	13.4
South Coast AQMD	0.2	3.8	2589.8	44.9	4.5	4.4	1.7	39.0
Ventura County APCD	0.0	0.6	296.3	7.3	0.6	0.6	0.3	4.8
Yolo/Solano AQMD	0.0	0.0	5.9	0.1	0.0	0.0	0.0	0.1
Total	**0.8**	**12.7**	**7401.6**	**157.1**	**14.6**	**14.3**	**6.1**	**117.2**
2010 Emissions (tons/day) in 24 nm. Regulatory Zone								
Bay Area AQMD	0.2	3.4	2135.7	42.4	4.0	3.9	1.7	34.3
Mendocino County AQMD	0.0	0.6	286.8	7.7	0.7	0.7	0.3	4.7
Monterey Bay Unified APCD	0.1	1.8	861.2	23.4	2.0	2.0	0.9	14.3
North Coast Unified APCD	0.0	0.5	230.4	6.2	0.5	0.5	0.2	3.8
Northern Sonoma County APCD	0.0	0.3	163.2	4.4	0.4	0.4	0.2	2.7
San Diego County APCD	0.0	0.6	331.4	7.2	0.7	0.7	0.3	5.1
San Joaquin Valley Unified APCD	0.0	0.0	36.3	0.3	0.0	0.0	0.0	0.6
San Luis Obispo County APCD	0.0	0.3	118.3	3.2	0.3	0.3	0.1	2.0
Santa Barbara County APCD	0.1	2.0	942.8	25.7	2.2	2.2	1.0	15.7
South Coast AQMD	0.3	4.5	3018.1	52.9	5.3	5.2	2.0	45.5
Ventura County APCD	0.0	0.7	340.2	8.5	0.7	0.7	0.3	5.5
Yolo/Solano AQMD	0.0	0.0	5.3	0.1	0.0	0.0	0.0	0.1
Total	**0.9**	**14.8**	**8469.9**	**181.9**	**16.9**	**16.5**	**7.0**	**134.2**
2020 Emissions (tons/day) in 24 nm. Regulatory Zone								
Bay Area AQMD	0.3	4.6	2675.7	57.1	5.3	5.2	2.3	43.5
Mendocino County AQMD	0.1	0.9	415.1	11.2	1.0	0.9	0.4	6.8
Monterey Bay Unified APCD	0.2	2.8	1302.3	35.4	3.1	3.0	1.4	21.6
North Coast Unified APCD	0.0	0.7	335.9	9.0	0.8	0.8	0.3	5.5
Northern Sonoma County APCD	0.0	0.5	235.5	6.3	0.5	0.5	0.2	3.9
San Diego County APCD	0.1	0.9	526.0	11.2	1.1	1.0	0.4	8.1
San Joaquin Valley Unified APCD	0.0	0.0	56.3	0.5	0.1	0.1	0.0	0.9
San Luis Obispo County APCD	0.0	0.4	179.0	4.9	0.4	0.4	0.2	3.0
Santa Barbara County APCD	0.2	3.1	1447.6	39.6	3.4	3.3	1.5	24.1
South Coast AQMD	0.4	6.1	3922.2	68.8	7.1	7.0	2.8	61.6
Ventura County APCD	0.1	1.0	487.5	12.4	1.1	1.1	0.5	8.0
Yolo/Solano AQMD	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.1
Total	**1.3**	**21.0**	**11587.2**	**256.4**	**23.9**	**23.3**	**10.1**	**187.0**

Table III-10: Auxiliary Engine Emissions by Vessel Type in 100 nm Regulatory Zone

2006 Auxiliary Engine Emissions (tons/day) in 100 nm. SIP Zone								
Vessel Type	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Auto	0.0	0.1	58.1	1.2	0.1	0.1	0.0	0.7
Bulk	0.0	0.1	80.9	1.6	0.1	0.1	0.1	1.0
Container	0.1	1.5	982.4	19.9	1.6	1.6	0.7	11.7
Cruise	0.1	1.1	698.0	14.2	1.4	1.3	0.5	10.1
General	0.0	0.0	28.7	0.6	0.0	0.0	0.0	0.3
Reefer	0.0	0.1	46.0	0.9	0.1	0.1	0.0	0.5
Roro	0.0	0.0	7.2	0.1	0.0	0.0	0.0	0.1
Tanker	0.0	0.4	266.4	5.4	0.4	0.4	0.2	3.2
Total	**0.3**	**3.3**	**2167.6**	**44.0**	**3.8**	**3.7**	**1.4**	**27.6**
2010 Auxiliary Engine Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.0	0.1	61.7	1.3	0.1	0.1	0.0	0.7
Bulk	0.0	0.1	80.1	1.6	0.1	0.1	0.1	1.0
Container	0.1	1.8	1158.9	23.5	1.9	1.9	0.8	13.8
Cruise	0.1	1.3	833.1	16.9	1.6	1.6	0.5	12.0
General	0.0	0.0	29.7	0.6	0.0	0.0	0.0	0.4
Reefer	0.0	0.1	45.0	0.9	0.1	0.1	0.0	0.5
Roro	0.0	0.0	7.6	0.2	0.0	0.0	0.0	0.1
Tanker	0.0	0.4	277.1	5.6	0.5	0.4	0.2	3.3
Total	**0.3**	**3.8**	**2493.2**	**50.6**	**4.4**	**4.2**	**1.7**	**31.8**
2020 Auxiliary Engine Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.0	0.1	76.5	1.6	0.1	0.1	0.1	0.9
Bulk	0.0	0.1	83.5	1.7	0.1	0.1	0.1	1.0
Container	0.1	1.6	1046.0	21.2	1.7	1.7	0.7	12.5
Cruise	0.2	1.9	1229.9	25.0	2.4	2.3	0.8	17.7
General	0.0	0.1	32.7	0.7	0.1	0.1	0.0	0.4
Reefer	0.0	0.0	30.1	0.6	0.0	0.0	0.0	0.4
Roro	0.0	0.0	8.9	0.2	0.0	0.0	0.0	0.1
Tanker	0.0	0.5	313.8	6.4	0.5	0.5	0.2	3.7
Total	**0.4**	**4.3**	**2821.5**	**57.3**	**5.0**	**4.9**	**1.9**	**36.7**

Table III-11: Auxiliary Boiler Emissions by Vessel Type in 100 nm Regulatory Zone

2006 Auxiliary Boiler Emissions (tons/day) in 100 nm. SIP Zone								
Vessel Type	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Auto	0.0	0.0	22.2	0.0	0.0	0.0	0.0	0.4
Bulk	0.0	0.0	31.2	0.1	0.0	0.0	0.0	0.5
Container	0.0	0.1	316.1	0.7	0.3	0.3	0.0	5.4
Cruise	0.0	0.0	29.3	0.1	0.0	0.0	0.0	0.5
General	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.1
Reefer	0.0	0.0	22.4	0.0	0.0	0.0	0.0	0.4
Roro	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Tanker	0.0	0.2	1023.8	2.2	0.8	0.8	0.1	17.4
Total	**0.0**	**0.3**	**1454.1**	**3.1**	**1.2**	**1.2**	**0.2**	**24.7**
2010 Auxiliary Boiler Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.0	0.0	23.7	0.1	0.0	0.0	0.0	0.4
Bulk	0.0	0.0	30.7	0.1	0.0	0.0	0.0	0.5
Container	0.0	0.1	403.9	0.9	0.3	0.3	0.0	6.9
Cruise	0.0	0.0	36.1	0.1	0.0	0.0	0.0	0.6
General	0.0	0.0	8.1	0.0	0.0	0.0	0.0	0.1
Reefer	0.0	0.0	24.0	0.1	0.0	0.0	0.0	0.4
Roro	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
Tanker	0.0	0.2	1067.9	2.3	0.9	0.9	0.1	18.2
Total	**0.1**	**0.3**	**1595.7**	**3.5**	**1.3**	**1.3**	**0.2**	**27.1**
2020 Auxiliary Boiler Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.0	0.0	30.2	0.1	0.0	0.0	0.0	0.5
Bulk	0.0	0.0	31.8	0.1	0.0	0.0	0.0	0.5
Container	0.0	0.2	750.0	1.6	0.6	0.6	0.1	12.8
Cruise	0.0	0.0	62.3	0.1	0.1	0.1	0.0	1.1
General	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.2
Reefer	0.0	0.0	31.6	0.1	0.0	0.0	0.0	0.5
Roro	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Tanker	0.0	0.3	1224.3	2.7	1.0	1.0	0.1	20.8
Total	**0.1**	**0.4**	**2140.5**	**4.6**	**1.8**	**1.7**	**0.2**	**36.4**

Table III-12: Main Engine Emissions by Vessel Type in 100 nm Regulatory Zone

2006 Main Engine Emissions (tons/day) in 100 nm. SIP Zone								
Vessel Type	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Auto	0.0	0.7	323.0	9.2	0.8	0.8	0.4	5.5
Bulk	0.0	0.8	333.5	9.6	0.8	0.8	0.4	5.6
Container	0.6	10.4	4468.5	127.7	11.1	10.9	5.1	75.7
Cruise	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
General	0.0	0.3	138.6	3.9	0.3	0.3	0.2	2.3
Reefer	0.0	0.2	72.9	2.1	0.2	0.2	0.1	1.2
Roro	0.0	0.1	36.0	1.0	0.1	0.1	0.0	0.6
Tanker	0.1	2.5	1149.6	31.4	2.8	2.7	1.3	19.5
Total	**0.8**	**15.0**	**6522.3**	**185.0**	**16.1**	**15.7**	**7.4**	**110.5**
2010 Main Engine Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.0	0.8	341.0	9.8	0.8	0.8	0.4	5.8
Bulk	0.0	0.8	331.8	9.6	0.8	0.8	0.4	5.6
Container	0.7	12.9	5535.8	158.3	13.8	13.5	6.4	93.8
Cruise	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
General	0.0	0.3	145.0	4.0	0.4	0.3	0.2	2.5
Reefer	0.0	0.2	87.5	2.6	0.2	0.2	0.1	1.5
Roro	0.0	0.1	37.7	1.0	0.1	0.1	0.0	0.6
Tanker	0.1	2.6	1185.6	32.4	2.9	2.8	1.3	20.1
Total	**1.0**	**17.7**	**7664.7**	**217.6**	**19.0**	**18.5**	**8.7**	**129.8**
2020 Main Engine Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.1	1.0	418.3	12.0	1.0	1.0	0.5	7.1
Bulk	0.0	0.8	352.7	10.2	0.9	0.8	0.4	6.0
Container	1.2	22.4	9547.7	273.2	23.8	23.3	11.0	161.7
Cruise	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
General	0.0	0.4	165.3	4.6	0.4	0.4	0.2	2.8
Reefer	0.0	0.3	150.1	4.4	0.4	0.4	0.2	2.5
Roro	0.0	0.1	43.2	1.1	0.1	0.1	0.0	0.7
Tanker	0.2	2.9	1310.8	35.9	3.2	3.1	1.4	22.2
Total	**1.5**	**27.8**	**11988.5**	**341.4**	**29.8**	**29.1**	**13.7**	**203.1**

Table III-13: Total Emissions by Vessel Type in 100 nm Regulatory Zone

2006 Emissions (tons/day) in 100 nm. SIP Zone								
Vessel Type	CH_4	CO	CO_2	NO_x	PM_{10}	$PM_{2.5}$	ROG	SO_x
Auto	0.0	0.8	403.3	10.5	0.9	0.9	0.4	6.5
Bulk	0.1	0.9	445.6	11.3	1.0	1.0	0.4	7.1
Container	0.7	12.0	5767.0	148.4	13.0	12.7	5.8	92.8
Cruise	0.1	1.1	727.4	14.3	1.4	1.4	0.5	10.6
General	0.0	0.4	175.2	4.5	0.4	0.4	0.2	2.8
Reefer	0.0	0.2	141.3	3.1	0.3	0.3	0.1	2.2
Roro	0.0	0.1	44.5	1.1	0.1	0.1	0.0	0.7
Tanker	0.2	3.1	2439.7	39.1	4.1	4.0	1.6	40.1
Total	**1.1**	**18.6**	**10144.0**	**232.1**	**21.1**	**20.6**	**9.0**	**162.8**
2010 Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.1	0.9	426.4	11.1	1.0	0.9	0.4	6.9
Bulk	0.1	0.9	442.6	11.2	1.0	0.9	0.4	7.1
Container	0.9	14.8	7098.6	182.7	16.0	15.6	7.2	114.4
Cruise	0.1	1.3	869.3	17.0	1.7	1.6	0.5	12.6
General	0.0	0.4	182.8	4.6	0.4	0.4	0.2	2.9
Reefer	0.0	0.3	156.5	3.5	0.3	0.3	0.1	2.4
Roro	0.0	0.1	46.6	1.2	0.1	0.1	0.0	0.8
Tanker	0.2	3.2	2530.7	40.4	4.2	4.1	1.6	41.6
Total	**1.3**	**21.8**	**11753.5**	**271.7**	**24.7**	**24.1**	**10.5**	**188.8**
2020 Emissions (tons/day) in 100 nm. SIP Zone								
Auto	0.1	1.1	525.0	13.6	1.2	1.1	0.5	8.5
Bulk	0.1	0.9	467.9	11.9	1.0	1.0	0.5	7.5
Container	1.4	24.2	11343.7	296.1	26.2	25.5	11.8	186.9
Cruise	0.2	1.9	1292.6	25.2	2.5	2.4	0.8	18.8
General	0.0	0.4	206.9	5.3	0.5	0.5	0.2	3.3
Reefer	0.0	0.4	211.8	5.1	0.4	0.4	0.2	3.4
Roro	0.0	0.1	53.6	1.3	0.1	0.1	0.0	0.9
Tanker	0.2	3.6	2848.9	44.9	4.7	4.6	1.8	46.8
Total	**1.9**	**32.6**	**16950.5**	**403.3**	**36.6**	**35.7**	**15.8**	**276.2**

Table III-14: Auxiliary Engine Emissions by District in 100 nm Regulatory Zone

2006 Auxiliary Engine Emissions (tons/day) in 100 nm. SIP Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.1	0.6	407.5	8.3	0.7	0.7	0.3	5.0
Mendocino County AQMD	0.0	0.1	40.4	0.8	0.1	0.1	0.0	0.5
Monterey Bay Unified APCD	0.0	0.1	80.7	1.6	0.1	0.1	0.1	1.1
North Coast Unified APCD	0.0	0.1	59.8	1.2	0.1	0.1	0.0	0.8
Northern Sonoma County APCD	0.0	0.0	17.3	0.4	0.0	0.0	0.0	0.2
San Diego County APCD	0.0	0.3	180.0	3.7	0.3	0.3	0.1	2.5
San Joaquin Valley Unified APCD	0.0	0.0	10.5	0.2	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.0	0.1	51.2	1.0	0.1	0.1	0.0	0.7
Santa Barbara County APCD	0.0	0.2	123.5	2.5	0.2	0.2	0.1	1.6
South Coast AQMD	0.1	1.7	1117.1	22.7	1.9	1.9	0.7	13.9
Ventura County APCD	0.0	0.1	77.6	1.6	0.1	0.1	0.1	1.0
Yolo/Solano AQMD	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Total	**0.3**	**3.3**	**2167.6**	**44.0**	**3.8**	**3.7**	**1.4**	**27.6**
2010 Auxiliary Engine Emissions (tons/day) in 100 nm. SIP Zone								
Bay Area AQMD	0.1	0.7	443.7	9.0	0.8	0.7	0.3	5.5
Mendocino County AQMD	0.0	0.1	47.7	1.0	0.1	0.1	0.0	0.6
Monterey Bay Unified APCD	0.0	0.1	95.3	1.9	0.2	0.2	0.1	1.3
North Coast Unified APCD	0.0	0.1	70.3	1.4	0.1	0.1	0.0	1.0
Northern Sonoma County APCD	0.0	0.0	20.5	0.4	0.0	0.0	0.0	0.3
San Diego County APCD	0.0	0.3	220.1	4.5	0.4	0.4	0.1	3.1
San Joaquin Valley Unified APCD	0.0	0.0	12.1	0.2	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.0	0.1	60.6	1.2	0.1	0.1	0.0	0.8
Santa Barbara County APCD	0.0	0.2	148.0	3.0	0.3	0.3	0.1	1.9
South Coast AQMD	0.2	2.0	1286.8	26.1	2.2	2.1	0.9	16.1
Ventura County APCD	0.0	0.1	86.3	1.8	0.1	0.1	0.1	1.1
Yolo/Solano AQMD	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Total	**0.3**	**3.8**	**2493.2**	**50.6**	**4.4**	**4.2**	**1.7**	**31.8**
2020 Auxiliary Engine Emissions (tons/day) in 100 nm. SIP Zone								
Bay Area AQMD	0.1	0.7	463.7	9.4	0.8	0.8	0.3	5.8
Mendocino County AQMD	0.0	0.1	75.0	1.5	0.1	0.1	0.0	1.0
Monterey Bay Unified APCD	0.0	0.2	148.5	3.0	0.3	0.3	0.1	2.0
North Coast Unified APCD	0.0	0.2	109.9	2.2	0.2	0.2	0.1	1.5
Northern Sonoma County APCD	0.0	0.0	32.2	0.7	0.1	0.1	0.0	0.4
San Diego County APCD	0.0	0.5	333.6	6.8	0.6	0.6	0.2	4.7
San Joaquin Valley Unified APCD	0.0	0.0	17.3	0.4	0.0	0.0	0.0	0.2
San Luis Obispo County APCD	0.0	0.1	95.0	1.9	0.2	0.2	0.1	1.3
Santa Barbara County APCD	0.0	0.4	239.9	4.9	0.4	0.4	0.2	3.1
South Coast AQMD	0.2	1.8	1198.2	24.3	2.1	2.0	0.8	15.2
Ventura County APCD	0.0	0.2	106.8	2.2	0.2	0.2	0.1	1.4
Yolo/Solano AQMD	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
Total	**0.4**	**4.3**	**2821.5**	**57.3**	**5.0**	**4.9**	**1.9**	**36.7**

Table III-15: Auxiliary Boiler Emissions by District in 100 nm Regulatory Zone

2006 Auxiliary Boiler Emissions (tons/day) in 100 nm. SIP Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.0	0.1	570.1	1.2	0.5	0.5	0.1	9.7
Monterey Bay Unified APCD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
North Coast Unified APCD	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
San Diego County APCD	0.0	0.0	18.3	0.0	0.0	0.0	0.0	0.3
San Joaquin Valley Unified APCD	0.0	0.0	20.1	0.0	0.0	0.0	0.0	0.3
South Coast AQMD	0.0	0.2	820.5	1.8	0.7	0.7	0.1	14.0
Ventura County APCD	0.0	0.0	21.1	0.0	0.0	0.0	0.0	0.4
Yolo/Solano AQMD	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.1
Total	**0.0**	**0.3**	**1454.1**	**3.1**	**1.2**	**1.2**	**0.2**	**24.7**
2010 Auxiliary Boiler Emissions (tons/day) in 100 nm. SIP Zone								
Bay Area AQMD	0.0	0.1	574.1	1.2	0.5	0.5	0.1	9.8
Monterey Bay Unified APCD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
North Coast Unified APCD	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
San Diego County APCD	0.0	0.0	23.7	0.1	0.0	0.0	0.0	0.4
San Joaquin Valley Unified APCD	0.0	0.0	24.3	0.1	0.0	0.0	0.0	0.4
South Coast AQMD	0.0	0.2	946.3	2.0	0.8	0.8	0.1	16.1
Ventura County APCD	0.0	0.0	23.6	0.1	0.0	0.0	0.0	0.4
Yolo/Solano AQMD	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.1
Total	**0.1**	**0.3**	**1595.7**	**3.5**	**1.3**	**1.3**	**0.2**	**27.1**
2020 Auxiliary Boiler Emissions (tons/day) in 100 nm. SIP Zone								
Bay Area AQMD	0.0	0.1	598.3	1.3	0.5	0.5	0.1	10.2
Monterey Bay Unified APCD	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
North Coast Unified APCD	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
San Diego County APCD	0.0	0.0	46.6	0.1	0.0	0.0	0.0	0.8
San Joaquin Valley Unified APCD	0.0	0.0	39.1	0.1	0.0	0.0	0.0	0.7
South Coast AQMD	0.0	0.3	1421.5	3.1	1.2	1.1	0.2	24.2
Ventura County APCD	0.0	0.0	32.2	0.1	0.0	0.0	0.0	0.5
Yolo/Solano AQMD	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0
Total	**0.1**	**0.4**	**2140.5**	**4.6**	**1.8**	**1.7**	**0.2**	**36.4**

Table III-16: Main Engine Emissions by District in 100 nm Regulatory Zone

2006 Main Engine Emissions (tons/day) in 100 nm. SIP Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.2	3.2	1398.9	39.8	3.4	3.4	1.6	23.7
Mendocino County AQMD	0.0	0.7	298.6	8.3	0.7	0.7	0.3	5.1
Monterey Bay Unified APCD	0.1	1.6	724.6	20.3	1.7	1.7	0.8	12.3
North Coast Unified APCD	0.1	1.0	438.4	12.2	1.1	1.0	0.5	7.4
Northern Sonoma County APCD	0.0	0.3	128.1	3.6	0.3	0.3	0.1	2.2
San Diego County APCD	0.0	0.3	120.4	3.4	0.3	0.3	0.1	2.0
San Joaquin Valley Unified APCD	0.0	0.0	4.6	0.1	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.1	1.0	461.4	12.9	1.1	1.1	0.5	7.8
Santa Barbara County APCD	0.2	3.4	1524.4	42.6	3.7	3.6	1.7	25.8
South Coast AQMD	0.1	2.4	865.9	26.3	2.4	2.3	1.1	14.7
Ventura County APCD	0.1	1.2	555.4	15.6	1.3	1.3	0.6	9.4
Yolo/Solano AQMD	0.0	0.0	1.8	0.1	0.0	0.0	0.0	0.0
Total	**0.8**	**15.0**	**6522.3**	**185.0**	**16.1**	**15.7**	**7.4**	**110.5**
2010 Main Engine Emissions (tons/day) in 100 nm. SIP Zone								
Bay Area AQMD	0.2	3.7	1601.3	45.6	3.9	3.9	1.8	27.1
Mendocino County AQMD	0.0	0.7	335.0	9.3	0.8	0.8	0.4	5.7
Monterey Bay Unified APCD	0.1	1.9	842.1	23.6	2.0	2.0	0.9	14.3
North Coast Unified APCD	0.1	1.1	490.3	13.6	1.2	1.2	0.5	8.3
Northern Sonoma County APCD	0.0	0.3	143.8	4.0	0.3	0.3	0.2	2.4
San Diego County APCD	0.0	0.3	142.5	4.0	0.3	0.3	0.2	2.4
San Joaquin Valley Unified APCD	0.0	0.0	5.2	0.2	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.1	1.2	536.0	15.0	1.3	1.3	0.6	9.1
Santa Barbara County APCD	0.2	4.1	1836.4	51.4	4.4	4.3	2.0	31.1
South Coast AQMD	0.1	2.9	1051.0	32.0	2.9	2.9	1.4	17.8
Ventura County APCD	0.1	1.5	679.6	19.0	1.6	1.6	0.8	11.5
Yolo/Solano AQMD	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Total	**1.0**	**17.7**	**7664.7**	**217.6**	**19.0**	**18.5**	**8.7**	**129.8**
2020 Main Engine Emissions (tons/day) in 100 nm. SIP Zone								
Bay Area AQMD	0.3	5.4	2323.6	66.2	5.7	5.6	2.7	39.4
Mendocino County AQMD	0.1	1.0	477.2	13.3	1.1	1.1	0.5	8.1
Monterey Bay Unified APCD	0.2	2.8	1269.6	35.6	3.1	3.0	1.4	21.5
North Coast Unified APCD	0.1	1.5	694.1	19.3	1.7	1.6	0.8	11.8
Northern Sonoma County APCD	0.0	0.4	205.1	5.7	0.5	0.5	0.2	3.5
San Diego County APCD	0.0	0.5	230.7	6.4	0.6	0.5	0.3	3.9
San Joaquin Valley Unified APCD	0.0	0.0	7.3	0.2	0.0	0.0	0.0	0.1
San Luis Obispo County APCD	0.1	1.8	807.9	22.7	2.0	1.9	0.9	13.7
Santa Barbara County APCD	0.4	6.7	3030.4	84.9	7.3	7.1	3.3	51.3
South Coast AQMD	0.2	5.0	1777.0	54.3	5.0	4.9	2.3	30.1
Ventura County APCD	0.1	2.6	1164.5	32.6	2.8	2.8	1.3	19.7
Yolo/Solano AQMD	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0
Total	**1.5**	**27.8**	**11988.5**	**341.4**	**29.8**	**29.1**	**13.7**	**203.1**

Table III-17: Total Emissions by District in 100 nm Regulatory Zone

2006 Emissions (tons/day) in 100 nm. Regulatory Zone								
District	**CH_4**	**CO**	**CO_2**	**NO_x**	**PM_{10}**	**$PM_{2.5}$**	**ROG**	**SO_x**
Bay Area AQMD	0.2	4.0	2376.4	49.3	4.6	4.5	1.9	38.4
Mendocino County AQMD	0.0	0.7	339.0	9.1	0.8	0.8	0.4	5.6
Monterey Bay Unified APCD	0.1	1.7	805.4	21.9	1.9	1.8	0.8	13.4
North Coast Unified APCD	0.1	1.0	498.5	13.4	1.2	1.1	0.5	8.2
Northern Sonoma County APCD	0.0	0.3	145.4	3.9	0.3	0.3	0.2	2.4
San Diego County APCD	0.0	0.5	318.6	7.1	0.7	0.6	0.3	4.9
San Joaquin Valley Unified APCD	0.0	0.0	35.1	0.4	0.0	0.0	0.0	0.5
San Luis Obispo County APCD	0.1	1.1	512.6	13.9	1.2	1.2	0.5	8.5
Santa Barbara County APCD	0.2	3.6	1647.8	45.1	3.9	3.8	1.8	27.4
South Coast AQMD	0.3	4.3	2803.5	50.7	5.0	4.9	1.9	42.6
Ventura County APCD	0.1	1.4	654.0	17.2	1.5	1.5	0.7	10.7
Yolo/Solano AQMD	0.0	0.0	7.5	0.1	0.0	0.0	0.0	0.1
Total	**1.1**	**18.6**	**10144.0**	**232.1**	**21.1**	**20.6**	**9.0**	**162.8**
2010 Emissions (tons/day) in 100 nm. Regulatory Zone								
Bay Area AQMD	0.3	4.5	2619.2	55.8	5.2	5.1	2.2	42.4
Mendocino County AQMD	0.0	0.8	382.7	10.3	0.9	0.9	0.4	6.3
Monterey Bay Unified APCD	0.1	2.0	937.4	25.5	2.2	2.2	1.0	15.5
North Coast Unified APCD	0.1	1.2	560.9	15.0	1.3	1.3	0.6	9.3
Northern Sonoma County APCD	0.0	0.3	164.3	4.4	0.4	0.4	0.2	2.7
San Diego County APCD	0.0	0.7	386.3	8.5	0.8	0.8	0.3	5.9
San Joaquin Valley Unified APCD	0.0	0.0	41.5	0.5	0.1	0.1	0.0	0.6
San Luis Obispo County APCD	0.1	1.3	596.6	16.2	1.4	1.4	0.6	9.9
Santa Barbara County APCD	0.2	4.3	1984.4	54.4	4.7	4.6	2.1	33.0
South Coast AQMD	0.3	5.1	3284.2	60.2	5.9	5.8	2.3	50.0
Ventura County APCD	0.1	1.6	789.5	20.8	1.8	1.8	0.8	13.0
Yolo/Solano AQMD	0.0	0.0	6.6	0.1	0.0	0.0	0.0	0.1
Total	**1.3**	**21.8**	**11753.5**	**271.7**	**24.7**	**24.1**	**10.5**	**188.8**
2020 Emissions (tons/day) in 100 nm. Regulatory Zone								
Bay Area AQMD	0.4	6.2	3385.6	76.9	7.0	6.9	3.1	55.4
Mendocino County AQMD	0.1	1.2	552.2	14.8	1.3	1.3	0.6	9.1
Monterey Bay Unified APCD	0.2	3.0	1418.2	38.6	3.3	3.3	1.5	23.5
North Coast Unified APCD	0.1	1.7	804.3	21.6	1.9	1.8	0.8	13.3
Northern Sonoma County APCD	0.0	0.5	237.3	6.4	0.6	0.5	0.2	3.9
San Diego County APCD	0.1	1.0	610.9	13.3	1.2	1.2	0.5	9.4
San Joaquin Valley Unified APCD	0.0	0.1	63.6	0.7	0.1	0.1	0.0	1.0
San Luis Obispo County APCD	0.1	1.9	902.9	24.6	2.1	2.1	1.0	15.0
Santa Barbara County APCD	0.4	7.1	3270.4	89.8	7.8	7.6	3.5	54.5
South Coast AQMD	0.4	7.2	4396.7	81.8	8.3	8.0	3.3	69.5
Ventura County APCD	0.2	2.8	1303.5	34.9	3.0	3.0	1.4	21.6
Yolo/Solano AQMD	0.0	0.0	5.0	0.1	0.0	0.0	0.0	0.1
Total	**1.9**	**32.6**	**16950.5**	**403.3**	**36.6**	**35.7**	**15.8**	**276.2**

Table III-18: Total Emissions by Engine Type in 24 nm Regulatory Zone

Emissions in 24 nm Zone (tons/day)																	
Uncontrolled (With Shore Power)																	
Engine	**PollutantName**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2009-2020**
Auxiliary	CO2	1940.7	2029.4	2123.6	2223.6	2221.9	2213.5	2197.4	2172.7	2138.2	2182.4	2225.6	2267.7	2308.3	2347.1	2383.5	26882.0
Auxiliary	Fuel Used	610.2	638.1	667.7	699.2	698.6	696.0	690.9	683.1	672.3	686.2	699.8	713.0	725.8	738.0	749.4	8452.3
Auxiliary	NOx	39.4	41.2	43.1	45.2	45.1	45.0	44.6	44.1	43.4	44.3	45.2	46.1	46.9	47.7	48.4	546.1
Auxiliary	PM10	3.4	3.5	3.7	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.1	4.2	4.2	47.3
Auxiliary	SOx	24.6	25.7	26.9	28.2	28.2	28.2	28.0	27.8	27.4	28.0	28.6	29.2	29.8	30.4	30.9	344.8
Boiler	CO2	1454.1	1486.3	1520.6	1557.0	1595.7	1636.7	1680.3	1726.6	1775.7	1827.8	1883.1	1941.8	2004.1	2070.3	2140.5	21839.6
Boiler	Fuel Used	457.2	467.4	478.1	489.6	501.7	514.6	528.3	542.9	558.3	574.7	592.1	610.6	630.2	651.0	673.1	6867.1
Boiler	NOx	3.1	3.2	3.3	3.4	3.5	3.5	3.6	3.7	3.8	4.0	4.1	4.2	4.3	4.5	4.6	47.3
Boiler	PM10	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	18.0
Boiler	SOx	24.7	25.3	25.9	26.5	27.1	27.8	28.6	29.4	30.2	31.1	32.0	33.0	34.1	35.2	36.4	371.5
Main	CO2	4006.8	4154.8	4311.4	4477.1	4652.3	4837.6	5033.5	5240.7	5459.7	5691.2	5936.0	6194.7	6468.3	6757.4	7063.2	67811.7
Main	Fuel Used	1260.3	1306.9	1356.2	1408.3	1463.4	1521.7	1583.3	1648.4	1717.3	1790.1	1867.1	1948.5	2034.5	2125.5	2221.7	21329.8
Main	NOx	114.6	118.9	123.4	128.2	133.3	138.7	144.4	150.4	156.7	163.5	170.6	178.1	186.1	194.5	203.4	1947.8
Main	PM10	10.1	10.4	10.8	11.3	11.7	12.2	12.7	13.2	13.8	14.4	15.0	15.7	16.4	17.1	17.9	171.1
Main	SOx	67.9	70.4	73.0	75.8	78.8	81.9	85.3	88.8	92.5	96.4	100.5	104.9	109.6	114.5	119.6	1148.6
Controlled (Main Engine, Auxiliary Engine Beginning July, 2009 @ 0.5%, Jan. 2012 @ 0.1%)																	
Engine	**PollutantName**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2009-2020**
Auxiliary	CO2	1940.7	2029.4	2123.6	2182.8	2221.9	2213.5	2197.4	2172.7	2138.2	2182.4	2225.6	2267.7	2308.3	2347.1	2383.5	26841.2
Auxiliary	Fuel Used	610.2	638.1	667.7	686.3	671.3	668.7	663.7	656.2	645.6	658.9	671.9	684.6	696.7	708.3	719.3	8131.5
Auxiliary	NOx	39.4	41.2	43.1	44.3	43.4	43.2	42.9	42.4	41.7	42.6	43.4	44.2	45.0	45.8	46.5	525.3
Auxiliary	PM10	3.4	3.5	3.7	2.5	1.2	1.2	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8	11.9
Auxiliary	SOx	24.6	25.7	26.9	17.3	6.3	6.3	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	40.2
Boiler	CO2	1454.1	1486.3	1520.6	1479.2	1515.9	1554.9	1596.3	1640.2	1686.9	1736.4	1788.9	1844.7	1903.9	1966.8	2033.5	20747.6
Boiler	Fuel Used	457.2	467.4	478.1	478.1	476.6	488.9	501.9	515.7	530.4	546.0	562.5	580.0	598.7	618.4	639.4	6536.7
Boiler	NOx	3.1	3.2	3.3	3.3	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.3	4.4	45.0
Boiler	PM10	1.2	1.2	1.3	0.8	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	3.8
Boiler	SOx	24.7	25.3	25.9	15.7	4.9	5.0	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	52.0
Main	CO2	4006.8	4154.8	4311.4	4253.2	4419.7	4595.7	4781.9	4978.6	5186.7	5406.7	5639.2	5885.0	6144.8	6419.6	6710.0	64421.1
Main	Fuel Used	1260.3	1306.9	1356.2	1375.2	1390.2	1445.6	1504.1	1566.0	1631.5	1700.6	1773.8	1851.1	1932.8	2019.2	2110.6	20300.7
Main	NOx	114.6	118.9	123.4	125.0	125.2	130.2	135.6	141.2	147.2	153.5	160.2	167.3	174.8	182.7	191.0	1834.0
Main	PM10	10.1	10.4	10.8	7.0	2.9	3.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.9	3.0	35.7
Main	SOx	67.9	70.4	73.0	44.8	14.3	14.8	2.9	3.0	3.1	3.3	3.4	3.6	3.7	3.9	4.1	104.9

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