ATTACHMENT G

DEVELOPMENT OF 2011 STATEWIDE TOXICS AND ACTUAL ANNUAL AND OZONE SEASON WEEKDAY EMISSIONS INVENTORIES FOR COMMERCIAL MARINE VESSELS

DEVELOPMENT OF 2011 STATEWIDE TOXICS AND ACTUAL ANNUAL AND OZONE SEASON WEEKDAY EMISSIONS INVENTORIES FOR COMMERCIAL MARINE VESSELS

This attachment provides the detailed documentation of methods and procedures used in developing the commercial marine vessel emissions inventory.

DEVELOPMENT OF 2011 STATEWIDE TOXICS AND ACTUAL ANNUAL AND OZONE SEASON WEEKDAY EMISSIONS INVENTORIES FOR COMMERCIAL MARINE VESSELS

FINAL REPORT

Prepared for:

Texas Commission on Environmental Quality
Air Quality Division

Prepared by:

Eastern Research Group, Inc.

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Development of 2011 Statewide Toxics and Actual Annual and Ozone Season Weekday Emissions Inventories for Commercial Marine Vessels

FINAL REPORT

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1.0 Executive Summary

The purpose of this project was to develop statewide criteria pollutant and toxics annual and ozone season weekday emissions inventories for locomotives and commercial marine vessels (CMVs) for the calendar year 2011. This inventory was a deliverable under Work Order No. 582-11-99776-FY12-10 for Contract Agreement 582-11-99776.

The pollutants for which estimates were developed included nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOC), sulfur dioxide (SO_2), ammonia (NH_3), particulate matter less than or equal to 10 micrometers (PM_{10}), particulate matter less than or equal to 2.5 micrometers ($PM_{2.5}$) and regulated hazardous air pollutants (HAPs). Marine vessels do not emit all regulated HAPs; emissions of these pollutants were developed where emission factors were available.

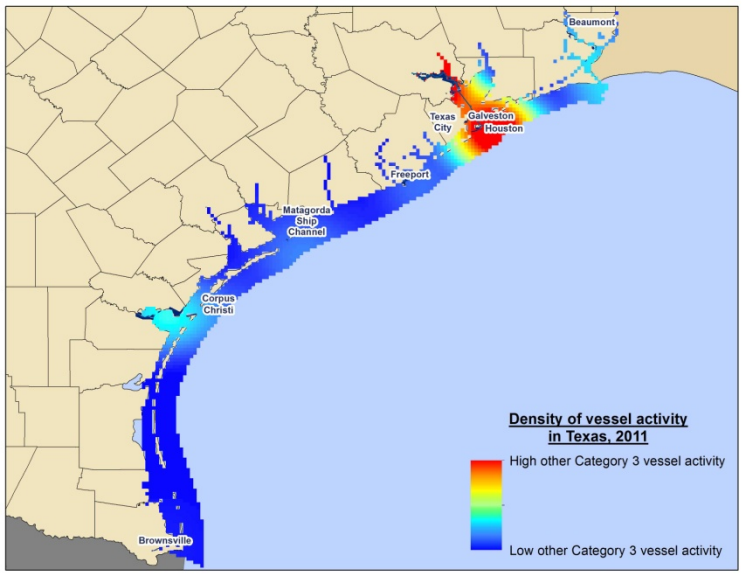
This inventory was developed for the following Source Classification Codes (SCC):

- 2280002100 Vessel equipped with Category 1 and 2 propulsion engines operating in port areas
- 2280002200 Vessel equipped with Category 1 and 2 propulsion engines operating underway
- 2280003100 Vessel equipped with Category 3 propulsion engines operating in port areas
- 2280003200 Vessel equipped with Category 3 propulsion engines operating underway

This inventory was developed within a framework based on methods consistent with the pertinent United States Environmental Protection Agency (EPA) requirements and guidance on development of actual emissions inventories.

Most of the emissions are associated with three geographic areas as noted in Figure 1-1: Houston-Galveston, Port Arthur-Beaumont, and Corpus Christi. The Houston-Galveston area also includes Texas City and shows the highest level of activity in Texas state waters.

Figure 1-1. Category 3 Vessel Traffic Patterns



Overall, activity and associated emissions within Texas state waters showed a moderate increase of approximately 10 percent between 2008 and 2011. While the annual growth rates for most areas and most vessel types were estimated at around 1 percent, these activity numbers reflect in part the recovery from the economic downturn that impacted 2008's activity. Category 3 underway activities comprised the largest portion of the state waters activity, amounting to 51 percent of the total activity and 39percent of NO_x emissions. Category 3 in-port activity comprised another 23 percent of the activity and 26 percent of NO_x emissions. Category 1 and 2 port and underway activity is better captured in this inventory than in previous inventory efforts; however, combined, they represent only about one quarter of the area's activity and just over one third of the NO_x emissions. The Houston-Galveston area, including Texas City, Freeport, and portions of the Intracoastal Waterway, represent the majority of emissions in state waters. Brazoria, Chambers, Galveston, and Harris counties combined represent 61 percent of the state's total NO_x emissions. Spatially, this area is a hotspot of activity, combining not only 3 major ports but also a significant portion of the Intracoastal Waterway.

2.0 INTRODUCTION

2.1 Purpose and Objectives

The overall purpose of this project is to develop statewide criteria and toxics annual and ozone season weekday emission inventories for locomotives and commercial marine vessels (CMVs) for the calendar year 2011. These inventories were developed within a framework based on methods consistent with the pertinent EPA requirements and guidance on development of actual emissions inventories.

The project objectives include the following:

- Compile 2011 activity data for CMV.
- Calculate emissions using the latest EPA emission factors.
- Spatially allocate emissions to Geographic Information System (GIS) shapefiles used by the EPA's Emission Inventory System.
- Summarize activity and emissions data by SCC and County.
- Format activity and emissions data into Extensible Markup Language (XML).
- Provide documentation of the procedures used to estimate and spatially allocate emissions.

This Texas 2011 inventory for CMVs was developed based on the following most recent studies and datasets:

- TCEQ, Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling prepared by Environ International, August 31, 2010
- Automatic Identification System (AIS), Gulf of Mexico data file, 2012
- EPA/Office of Transportation and Air Quality Emission Factors Dataset, 2010
- U.S. Army Corps of Engineers Dredging Activity database 2012
- National Marine Fisheries Service (NMFS), 2012, Total Commercial Fishery Landings at an individual U.S. Port
- Texas Parks and Wildlife, 2012, Values of Commercial Fish Landings
- US Coast Guard 2012 Data

To ensure that local port data were used where ever possible, ERG started with data from the TCEQ study Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling. For the remaining ports ERG used the United State's Department of Transportation Maritime Administration (MARAD) data for Texas ports to quantify vessel calls.

For this inventory, ERG also compiled AIS data to quantify vessel traffic patterns in the Gulf of Mexico. Though the data were very useful in mapping vessel movements for each

vessel type included in this study, it was not possible to use the raw data to accurately estimate operating hours and link that data up to vessel characteristics needed to estimate emissions within the project schedule.

2.2 Report Organization

Section 2 of this report documents the emissions estimating procedures used, including sources of the data, available emission factors, assumptions made, and spatial allocation procedures used. Summary emissions tables are provided on a statewide and county level basis for the criteria and toxic pollutants in Section 3. A complete list of references is provided in Section 5.

The criteria and hazardous air pollutant emissions associated with CMV activities are included in the access database submitted with this report.

2.3 Background

This report covers CMV activity as a nonpoint source. The CMV source category includes all marine vessels in Texas waters. CMVs tend to emit significant amounts of NO_x, CO, SO_2, PM, and VOC.

In order to submit marine vessel data as staging tables in an Emission Inventory System format, only EPA defined SCCs can be used. For marine vessels, the acceptable codes are limited to the following:

- 2280002100 Vessel equipped with Category 1 and 2 propulsion engines operating in port areas
- 2280002200 Vessel equipped with Category 1 and 2 propulsion engines operating underway
- 2280003100 Vessel equipped with Category 3 propulsion engines operating in port areas
- 2280003200 Vessel equipped with Category 3 propulsion engines operating underway

Category 1 and 2 vessels typically have diesel engines that use marine distillate fuels and operate near a port or local waterway and would include:

- Tugboats (assist, fleeting, and line-haul)
- Offshore support vessels
- Pilot boats
- Local DOT ferries

Category 3 vessels include ocean-going ships that are fueled with residual/distillate blends and tend to be larger vessels that are able to operating in deeper waters and include:

- Auto Carriers
- Container Ship
- Cruise ships
- Roll-on/Roll-off vessel
- Refrigeration vessels
- Tankers
- Bulk carriers
- General Cargo Ships
- LNG tankers
- Ocean-going tugs

Table 2-1 shows typical SCC assignments for different vessel types operating in Texas state waters. Note that actual operations may vary. For example, some larger vessels store and use both residual and marine distillate diesel fuel depending upon the air quality requirements at the port. Also, some smaller vessels operate in port at a loads appropriate for underway activities, spend little time maneuvering, and then shut down engines while dockside such that port emissions would be minimal.

Table 2-1. Example SCC Assignments by Vessel Types

	SCC			
	Category 1 & 2 Marine Distillate Fuels		Category 3 Residual Blend Fuels	
	Port	Underway	Port	Underway
Vessel Type	2280002100	2280002200	2280003100	2280003200
Tugboats (assist, fleeting, and line-haul)	✓	✓		
Offshore support vessels	✓	✓		
Pilot boats	✓	✓		
Local DOT ferries	✓	✓		
Commercial fishing	✓	✓		
Dredging	✓	✓	✓	✓
Coast Guard	✓	✓	✓	✓
Auto Carriers			✓	✓
Container Ship			✓	✓
Cruise ships	✓	✓	✓	✓
Roll-on/Roll-off vessel			✓	✓
Refrigeration vessels			✓	✓
Tankers			✓	✓
Bulk carriers			✓	✓
General Cargo Ships			✓	✓
LNG tankers			✓	✓

Vessel Type	SCC			
	Category 1 & 2 Marine Distillate Fuels		Category 3 Residual Blend Fuels	
	Port	Underway	Port	Underway
	2280002100	2280002200	2280003100	2280003200
Ocean going tugs	✓	✓	✓	✓

In order to get the accurate estimates different data and emission estimation methodologies were used to develop the 2011 emissions inventory for CMVs including the following:

- CMVs that call upon the Port of Houston
- CMVs traveling in Texas state waters, excluding the Houston-Galveston nonattainment area
- Military vessel operations
- Dredging activities
- Fishing vessels

As mentioned earlier, ERG started with the TCEQ study Implement Port of Houston's Current Inventory and Harmonize the Remaining 8-county Shipping Inventory for TCEQ Modeling, as it was the most recent and complete emission inventory of CMV emissions for the port of Houston and surrounding nonattainment counties. For the remaining ports ERG used MARAD vessel call data. Fishing boat, dredging operations, and military vessels are addressed separately because their activity data were compiled using different procedures than those used for the CMVs.

The methodologies used to estimate emissions for this inventory project comply with the latest EPA guidance on estimating emissions from marine vessels. These procedures apply compiled vessel activity data in terms of kilowatt hours to recent emission factors developed in support of new marine vessel engine exhaust emissions standards, emission control area standards, and new marine fuel sulfur content standards. The EPA compiled a dataset of marine vessel emission factors for category 1 and 2 and category 3 vessels for the period from 2002 to 2050 which account for fleet turnover and compliance with appropriate regulations. ERG used the EPA's emission factor data for 2011 in this inventory.

For this inventory, ERG also compiled 2011 AIS data to quantify vessel traffic patterns in the Gulf of Mexico. Though the data were very useful in mapping vessel movements for each vessel type included in this study, unfortunately it was not possible to use the raw data to accurately estimate operating hours and link that data up to vessel characteristics needed to estimate emissions within the project schedule.

For this inventory, ERG compiled 2011 AIS data to quantify vessel traffic patterns in the Gulf of Mexico. These data were very useful in mapping vessel movements for each vessel type included in this study, though it was not possible to use the raw data accurately to estimate operating hours and link that data up to vessel characteristics needed to estimate emissions within the project schedule.

Gulf wide vessel traffic data were reviewed to attempt to quantify monthly traffic patterns in order to adjust the annual emission estimates to accurately reflect average ozone season daily emissions. Though the data did indicate slight differences in activity from month to month for 2011 for different vessel types, in aggregate vessel traffic was consistent throughout the year.

Detailed emissions and activity data are provided in the Microsoft Access database provided with this memorandum. Estimates and activity data by county for Texas areas of interest are provided in the Appendix of this report.

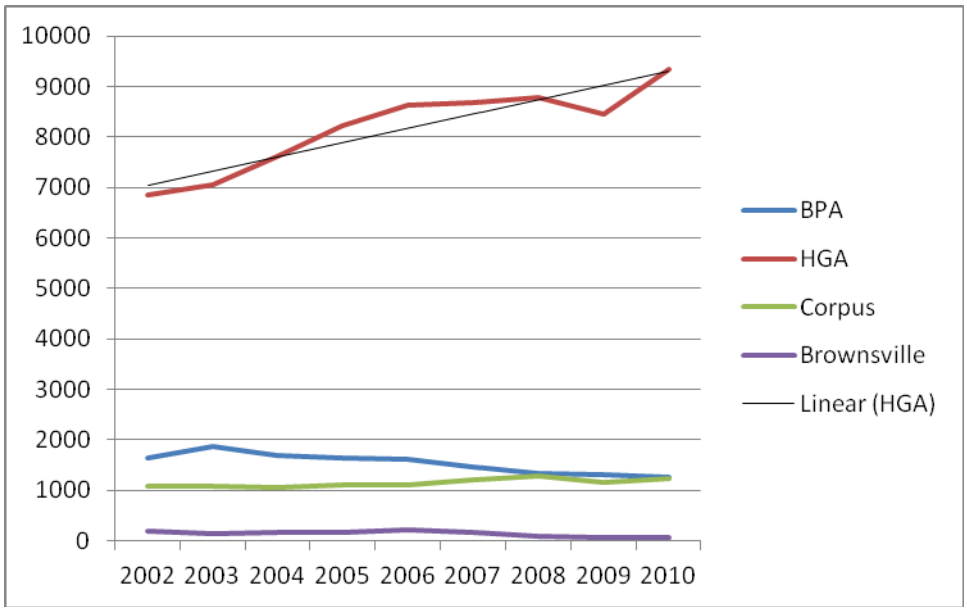
3.0 EMISSION ESTIMATES

3.1 Port of Houston

For this inventory, emission estimates were obtained from the latest inventory for the Port of Houston developed for TCEQ. The 2007 port authority's inventory provided estimates for all criteria pollutants for ocean-going vessels, (e.g. containerships, bulk cargo ships, tankers) and harbor vessels (e.g., assist tugs and tugboats push or tow barges). An earlier port inventory only focused on emissions that occur directly from the port, the new study includes marine vessel emissions from the other counties associated with the Houston-Galveston nonattainment area.

Unfortunately the port inventories were not developed to represent activities in 2011. In order for data from the 2007 port inventory to be used in this 2011 inventory, ERG obtained historical MARAD vessel call data from the United States Army Corps of Engineers to quantify changes in the number of calls for Texas ports and vessel type. Figure 3-1 is a graph of the number of calls between 2002 and 2010 at the four major port areas in Texas including a linear interpolation for the Houston-Galveston area.

Figure 3-1. Category 3 Vessel Traffic Patterns



The MARAD data was only available through 2010. ERG used the linear projection of Houston and Galveston traffic to account for the increased traffic to 2011. It should also be noted that the other ports have remained flat over the last three years. Table 3-1 shows the actual number of port call for each of the four port areas in Texas for the period from 2007 to 2010.

Table 3-1. Summary of Port calls from 2007 to 2010 for Texas Ports

Region	2007	2008	2009	2010
BPA	1464	1346	1321	1247
HGA	8687	8772	8448	9341
Corpus	1217	1279	1165	1230
Brownsville	178	102	56	74
Total	11546	11499	10990	11892

Vessel call data were available from MARAD for tankers, containerships, and bulk and general cargo vessels. Information concerning towboats calls were obtained from the U.S. Army Corps of Engineers' Waterbourne Commerce data. Table 3-2 shows the number of calls at individual ports in Houston area each year between 2007 and 2010 for tanker traffic, containerships, bulk and general cargo vessels, and tug boats, respectively.

Table 3-2. Houston Area Vessel Calls by Port 2007-2010

Port	2007	2008	2009	2010
Tanker Traffic				
Freeport	604	609	561	537
Galveston	154	188	160	248
Houston	3757	4038	3905	4236
Texas City	1160	931	971	1135
Container Ship Traffic				
Freeport	99	90	106	100
Galveston	2	11	3	0
Houston	818	854	931	1012
Texas City	0	1	0	0
Bulk and General Cargo Traffic				
Freeport	103	92	73	140
Galveston	330	361	381	451
Houston	1620	1553	1317	1450
Texas City	40	44	40	32

Table 3-2. Houston Area Vessel Calls by Port 2007-2010 (Continued)

Port	2007	2008	2009	2010
Towboat Traffic				
Freeport	2747	2427	1634	1446
Galveston	2163	1775	1890	1780
Houston	39162	36286	30429	30843
Texas City	4376	3690	4205	3529

The 2007 Houston port activity data were adjusted using the above data to approximate 2011 activity levels. Data for tankers, container ships, and bulk and general cargo vessels

were used to develop Category 3 growth rates, and Category1 and Category 2 activity was adjusted using the tug and towboat data presented in Table 2-5.

For the Port of Houston inventory, emissions were estimated as a function of vessel power demand multiplied by an emission factor, where the emission factor is expressed in terms of grams per kilowatt hour (g/kW-hr). Emission factors and propulsion engine load were then applied to the activity data to estimate emissions. The following represent the basic equation used to estimating port emissions:

$$E = MCR \times LF \times A \times EF$$

Where:

E	=	Emissions from the engine(s) usually calculated as grams of emissions per year,
MCR	=	maximum continuous rated engine power, kW
LF	=	Load Factor
A	=	activity, hours
EF	=	Emission factor (g/kw-hr)

Note, because the Houston ship channel is a reduced speed zone the load factor of 30 percent was assumed for underway emissions. It is understood that in the upper reaches of the ship channel loads may be as low as 6 percent and that towboat operations may be as high as 65 percent.

ERG used the EPA's updated emission factors for the year 2011 to account for vessel turnover and compliance with marine vessels air quality regulations. The emission factors were applied to the 2011 activity values to calculate 2011 emissions in tons.

Example Calculation:

10,000 kw rated vessel operates underway 106.2 hours per year in state waters with a load factor of 0.80. The NO_x emission factor is 19.54 g/kW-hr.

$$E = MCR \times LF \times A \times EF$$

$$AE = 10{,}000 \text{ kw} \times 106.2 \text{ hrs} \times 0.8 \times 19.54 \text{ g } NO_x\text{/kW-hr}$$

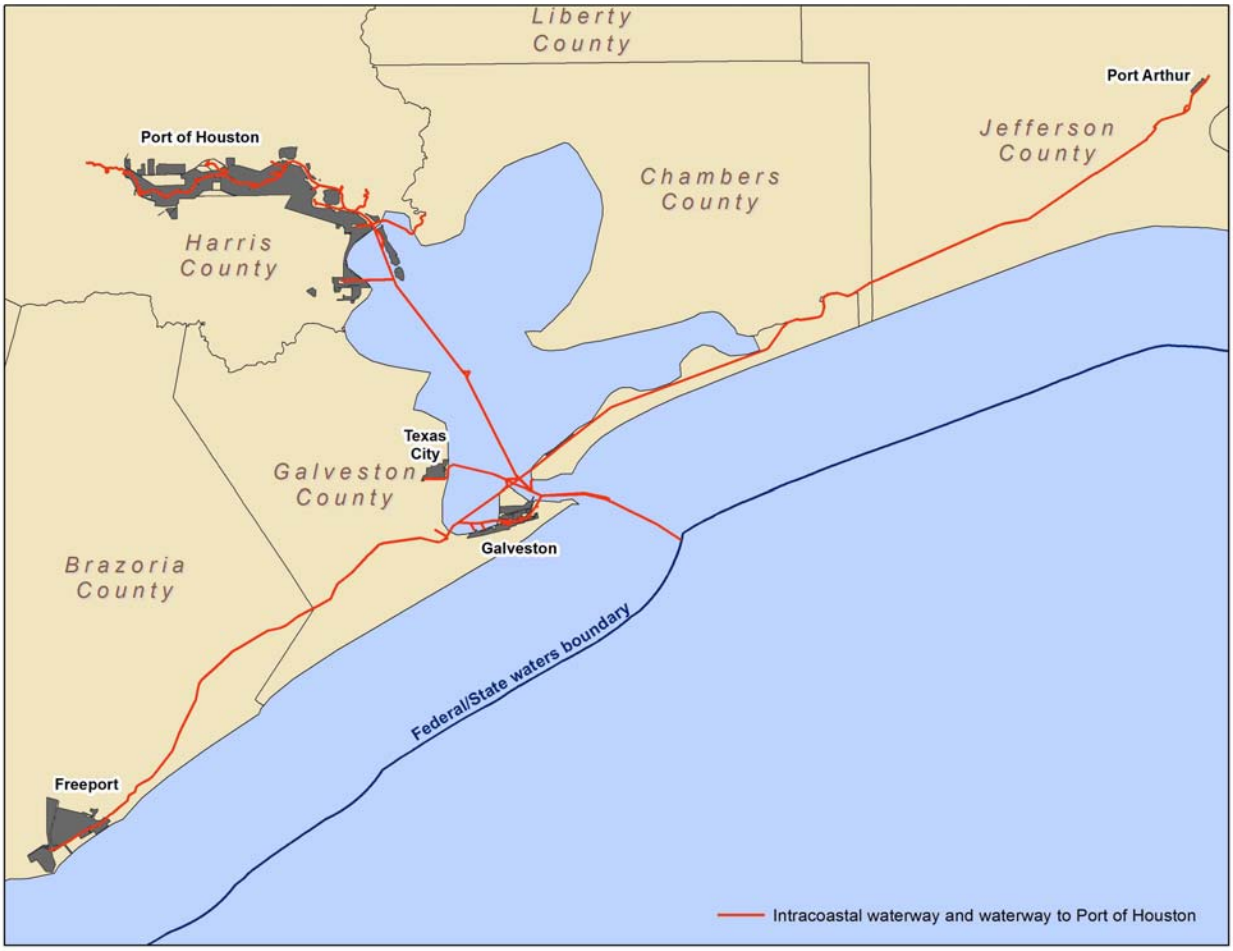
$$AE = 16{,}601 \text{ kg of } NO_x \text{ per year}$$

This approach is recommended by the EPA in their *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories - Final Report*. Note that the calculations presented in all other sections of this report also follow the same

procedures, allowing for the development of consistent and comparable emission estimates.

The port activity and emission estimates were assigned to Houston, Freeport, Galveston/Texas City and the Intracoastal Waterway based on the number of calls to each. This approach could underestimate emissions at Texas City and Galveston as it would not account for ship movements in these areas as most of these movements would be associated with ship calls at the port of Houston. To correct for this, ERG assigned emissions to the following areas as noted in Figure 3-2; Ocean Going Vessels (OGV) Harris county based on the length of the shipping lane in the county (northern portion of the ship channel), OGV Galveston base on the length of shipping lane in the county (southern portion of the ship channel out to sea), Intracoastal Waterway Galveston, Intracoastal Waterway Chambers also based on the length of Intracoastal Waterway in the county, and Freeport out to sea.

Figure 3-2. Shipping Lane Segments for the Houston Ship Channel and Intracoastal Waterway



3.2 Other Texas State Waters

The Houston-Galveston area ports dominate marine vessel traffic, but to ensure completeness ERG used 2002-2010 MARAD vessel call data to develop kw-hrs based on typical vessel propulsion engines and average trip times. An annual growth rate based on the historical data was calculated and applied to the 2010 data to represent 2011 activity levels. Table 3-3 summarizes the MARAD data and estimated underway travel times and the calculated kilowatt hours for the vessel types included in the MARAD data set for each port that reported traffic. Underway emissions can sometimes be larger than port calls as estimates developed here include vessels that transit the area without stopping to call at a port.

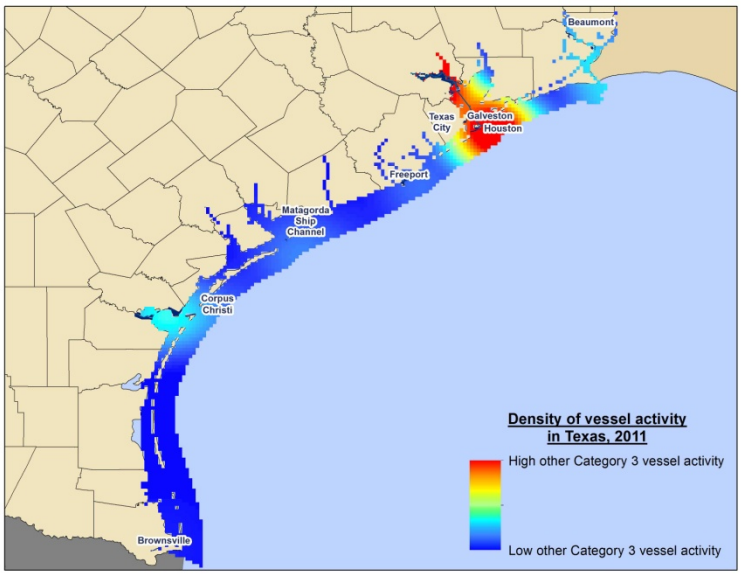
Table 3-3. 2011 Vessel Traffic

Port	Vessel Calls	Underway Kw-hrs	Port kW-hrs
Tanker Traffic			
Beaumont	42	1,461,604	87,284
Brownsville	33	10,315,253	616,005
Corpus Christi	805	31,580,599	1,885,927
Ingleside	143	28,275,845	1,688,574
Port Arthur	739	25,914,959	1,547,586
Container Ship Traffic			
Beaumont	0	1,094	0
Brownsville	0	0	0
Corpus Christi	1	0	0
Ingleside	0	0	0
Port Arthur	0	21,687	0
Bulk and General Cargo Traffic			
Beaumont	17	86,239	9,458
Brownsville	36	836,428	104,675
Corpus Christi	237	8,011,911	976,889
Ingleside	103	5,123,071	633,839
Port Arthur	439	2,220,661	243,556
Other Category 3 Traffic			
Beaumont	58	1,422,807	869,980
Brownsville	68	2,238,755	1,368,894
Corpus Christi	1,040	41,013,430	25,077,789
Ingleside	239	19,254,530	11,773,242
Port Arthur	1,157	25,369,956	15,425,174
Towboat Traffic and other Category 1 and 2 Traffic			
Beaumont	11,254	13,060,216	9,723,831
Brownsville	931	840,235	1,123,842
Corpus Christi	5,720	10,403,623	14,097,232
Ingleside	0	4,416,151	5,612,415
Port Arthur	7,210	8,366,625	6,229,272

Kilowatt hours were adjusted for a load factor of 80 percent for underway operations and 10 percent for dockside load. As with the Port of Houston component of this study, EPA emission factors that account for vessel turnover and compliance with federal marine vessel emission regulations in 2011 were applied to the adjusted kilowatt hours to estimate emissions.

ERG also used highly refined AIS data to accurately quantify vessel movements within and between ports. These AIS data track vessel movements using GPS transmitters continuously reporting locations and vessel identification information. The AIS data include ship identification codes, current ship location, direction, speed, destination, and time stamp to match individual vessels to their characteristics is a very time consuming process and the project budget and schedule limited the use of AIS data to general spatial allocations of vessel traffic as represented in Figure 3-3. To develop vessel type spatial allocations, over one million vessel locations from the 2011 AIS data were evaluated to determine vessel type. The location data were split by vessel type and mapped in a GIS, then a density analysis was conducted to derive a solid surface representation of vessel activity throughout Texas state waters. Since the final inventory needed to meet the National Emission Inventory's (NEI) Emission Inventory System (EIS) input requirements, the NEI shapes representing marine vessel activity were overlaid on top of the activity grids, and activity within each shape was summed. Note that activity and emissions for the Houston-Galveston area were provided in a grid format which was converted into traffic density grids that agreed with the AIS vessel traffic patterns.

Figure 3-3. Density of Category 3 Vessel Activity in Texas State Waters in 2011



The port and underway data were also summed up to the county level in order to be incorporated into the Texas Air Emissions Reporting system.

3.3 Military Vessels

Estimating activity and emissions for military vessels is a challenge, due to homeland security issues. In the Gulf of Mexico, military vessel activity is implemented by the U.S. Navy and the U.S. Coast Guard. ERG assumed that Navy vessel activities in Texas state waters were relatively small, since the last Navy base located in Texas was closed around 2006 and most military vessel exercises occur in Federal waters.

ERG obtained information about Coast Guard vessels operating in Texas waters using fleet profiles obtained from their Web sites and from direct communication with Coast Guard staff as summarized in Table 3-4. The U.S. Coast Guard is currently updating their fleet to include new vessels and upgrade older vessels. As of 2011, none of the patrol boats have been replaced, however, the Coast Guard did take delivery of 65 foot special purpose craft, (SPC-LE 33). These are fast gas powered outboard motorboats equipped with three 275 HP engines on each boat. ERG was not able to get any indication from the Coast Guard how many of these vessels went sent to Texas Coast Guard stations. These boats tend to be used at coastal rescue stations, so actual hours of operation may be relatively small and their impact on coastal air quality will be limited.

The Coast Guard's Eighth District is responsible for safety and security of the full length of the Mississippi, as well as the Gulf of Mexico. In Texas, the District operates 48 large vessels (greater than 40 feet) and an estimated 46 smaller boats from eight ports. These ports include the following:

- Corpus Christi
- Freeport
- Galveston
- Ingleside
- Sabine
- San Padre Island
- Port Aransas
- Port O'Connor

Table 3-4. Coast Guard Vessel Characteristics and Associated Ports

County	Port	Vessel Name	Vessel Type	Number of Vessels	Number of Engines	Horsepower per Engine	Operating Hours per Vessel	Percentage of Time in State Waters	Total Engine Operating Hours in State Waters	Total Hp-Hrs
Brazoria 48039	Freeport	Manta	87 ft Coastal Patrol Boat	1	2	1,475	1,800	20	720	1,062,000
		NA	41 ft Utility Boat	3	1	265	1,800	100	1,800	477,000
		NA	47 ft Motor Life Boat	1	2	435	1,800	100	3,600	1,566,000
		NA	55 ft Aids to Navigation Boat	3	2	660	1,700	80	2,720	1,795,200
TOTAL – Brazoria County				8	7	--	--	--	8,840	4,900,200
Calhoun 48057	Port O'Connor	NA	41 ft Utility Boat	3	1	265	1,800	100	1,800	477,000
		NA	47 ft Motor Life Boat	1	2	435	1,800	100	3,600	1,566,000
		NA	55 ft Aids to Navigation Boat	1	2	660	1,700	80	2,720	1,795,200
TOTAL – Calhoun County				5	5				8,120	3,838,200
Cameron 48061	San Padre Island	Amberjack	87 ft Coastal Patrol Boat	1	2	1,475	1,800	20	720	1,062,000
		NA	41 ft Utility Boat	3	1	265	1,800	100	1,800	477,000
		NA	47 ft Motor Life Boat	1	2	435	1,800	100	3,600	1,566,000
		NA	55 ft Aids to Navigation Boat	1	2	660	1,700	80	2,720	1,795,200
TOTAL – Cameron County				6	7				8,840	4,900,200
Galveston 48167	Galveston	Harry Claiborne	175 ft Coastal Buoy Tender	1	2	1,700	1,200	20	480	816,000
		Dauntless	210 Medium Endurance Cutter	1	2	2,550	1,200	20	480	1,224,000
		Clamp / Hatchet	75 ft Inland Construction Tender	2	2	660	1,700	100	3,400	2,244,000
		Manowar / Skipjack	87 ft Coastal Patrol Boat	2	2	1,475	1,800	20	720	1,062,000
		NA	41 ft Utility Boat	3	1	265	1,800	100	1,800	477,000
		NA	47 ft Motor Life Boat	1	2	435	1,800	100	3,600	1,566,000
TOTAL – Galveston County				10	11				10,480	7,389,000

Table 3-4. Coast Guard Vessel Characteristics and Associated Ports (Continued)

Jefferson 48245	Sabine	Heron	87 ft Coastal Patrol Boat	1	2	1,475	1,800	20	720	1,062,000
		NA	41 ft Utility Boat	3	1	265	1,800	100	1,800	477,000
		NA	47 ft Motor Life Boat	1	2	435	1,800	100	3,600	1,566,000
		NA	55 ft Aids to Navigation Boat	3	2	660	1,700	80	2,720	1,795,200
TOTAL – Jefferson County				**8**	**7**				**8,840**	**4,900,200**
Nueces 48355	Port Aransas	NA	41 ft Utility Boat	3	1	265	1,800	100	1,800	477,000
		NA	47 ft Motor Life Boat	1	2	435	1,800	100	3,600	1,566,000
	Corpus Christi	Mallet	75 ft Inland Construction Tender	1	2	660	1,700	100	3,400	2,244,000
		Brant	87 ft Coastal Patrol Boat	1	2	1,475	1,800	20	720	1,062,000
		Steelhead	87 ft Coastal Patrol Boat	1	2	1,475	1,800	20	720	1,062,000
		NA	64 ft Aide to Navigation Boat	1	2	660	1,700	80	2,720	1,795,200
		NA	55 ft Aids to Navigation Boat	2	2	660	1,700	80	2,720	1,795,200
TOTAL – Nueces County				**10**	**13**				**15,680**	**10,001,400**
San Patricio 48409	Ingleside	Manatee	87 ft Coastal Patrol Boat	1	2	1,475	1,800	20	720	1,062,000
TOTAL – San Patricio				**1**	**2**				**720**	**1,062,000**

Table 2-4 notes the home port of each Coast Guard vessel, the number, and horsepower rating of the propulsion engines, annual hours of operation and an estimate of the number of hours these vessels operate in state waters. The table also calculates total annual horse power hours in state waters. The Coast Guard provided an estimate of the annual hours of operation and the percent time the vessel operated within state waters. ERG used these data to estimate the horsepower hours of operation within state waters using the following equation:

$$\text{Hp-Hrs} = \text{Vn} \times \text{Hp} \times \text{En} \times \text{Ao} \times \text{SWf}$$

Where:

Hp-Hrs = Horsepower hours
Vn = Number vessels
Hp = Horsepower rating of the Coast Guard vessel's propulsion engines
En = Number of propulsion engines the Coast Guard vessel is equipped with
Ao = Annual operating hours
SWf = Fraction of time that the vessel spends in Texas State waters

Example: Military Vessel Activity Calculation

The 87-foot coastal patrol boat, Steelhead, operates out of Corpus Christie; it is equipped with two 1,475 horsepower engines. The vessel operates 1,800 hours per year, 20 percent of operations are in Texas State waters.

$$\text{Hp-Hrs} = \text{Vn} \times \text{Hp} \times \text{En} \times \text{Ao} \times \text{SWf}$$

$$\text{Hp-Hrs} = 1 \times 1{,}475 \text{ Hp} \times 2 \times 1{,}800 \text{ hrs} \times 20/100$$
$$\text{Hp-Hrs} = 1{,}062{,}000$$

ERG developed emission estimates for NO_x, CO, non-methane volatile organic compounds (NMVOC), SO_2, ammonia (NH_3), PM_{10}, and $PM_{2.5}$ using the following equation:

$$AE = AH \times CF_1 \times LF \times EF \times CF_2$$

Where:

AE = Annual Emissions (tons per year)
AH = Annual activity (Hp-Hr)

CF_1 = Conversion factor (0.741 kW/Hp)
LF = Engine load factor
EF = Emissions factor (g/kW-Hr)
CF_2 = Conversion factor (1.10231 E-6 ton/g)

Example: Military Vessel Emission Calculation

The 87-foot coastal patrol boat, Steelhead, has annual Hp-Hrs of 1,062,000, which it operates at a load factor or 0.80. Estimate the NO_x emissions using a NO_x emission factor of 13.2 g/kW-Hr

$$AE = AH \times CF_1 \times LF \times EF \times CF_2$$

$$AE = 1{,}062{,}000 \text{ Hp-hrs per year} \times 0.741 \text{ kW/Hp} \times 0.80 \times 13.2 \text{ g/kW-Hr} \times 1.10231 \text{ E-6 ton/g}$$

$$AE = 8.38 \text{ tons per year}$$

ERG assumed that the underway load factor for propulsion engines of Coast Guard vessels was 80 percent. To estimate emissions, ERG used emission factors from the EPA developed in support of recent marine vessel rule making. ERG spatially allocated Coast Guard activity and emissions based on the district associated with each base and assigned to appropriate counties based on the GIS shape files. Coast Guard Emission estimates are presented in Table 3-5 for annual emissions and Table 3-6 for ozone season day emissions. Each table includes emission estimates for each vessel along with vessel characteristics such as home port, vessel name and type, and calculated hours of operation in state waters.

3.4 Dredging Operations

ERG obtained information concerning dredging operations occurring in Texas State waters for 2011 from the U.S. Army Corps of Engineers Dredging Activity Database USACE 2012a). The 14 dredging projects that were identified were implemented by private contractors. The Army Corps of Engineers private company data set included information on the following:

- The name of the dredging site
- The type of dredging activities (new vs. maintenance)
- The type of dredging equipment used
- The dates when dredging was initiated and completed
- The amount of material dredged and the disposal method
- Information about the company that was awarded the work, including the address of the company.

Table 3-5. 2011 Annual Coast Guard Vessel Emission Estimates (tons per year)

County	Port	Vessel Name	Vessel Type	Total Hp-Hrs	NO_X	CO	NMVOC	SO_X	NH_3	PM_{10}	$PM_{2.5}$	NH_4
Brazoria	Freeport	Manta	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
	Freeport	NA	41 ft Utility Boat	477,000	3.76	0.35	0.06	0.5	0	0.06	0.06	0.0009
	Freeport	NA	47 ft Motor Life Boat	1,566,000	12.36	1.13	0.21	1.65	0	0.21	0.21	0.00315
	Freeport	NA	55 ft Aids to Navigation Boat	1,795,200	14.17	1.3	0.24	1.89	0	0.24	0.24	0.0036
TOTAL - Brazoria County				4,900,200	38.67	3.55	0.65	5.16	0.00	0.65	0.65	0.0098
Calhoun	Port O'Connor	NA	41 ft Utility Boat	477,000	3.76	0.35	0.06	0.5	0	0.06	0.06	0.0009
	Port O'Connor	NA	47 ft Motor Life Boat	1,566,000	12.36	1.13	0.21	1.65	0	0.21	0.21	0.00315
	Port O'Connor	NA	55 ft Aids to Navigation Boat	1,795,200	14.17	1.3	0.24	1.89	0	0.24	0.24	0.0036
TOTAL - Calhoun County				3,838,200	30.29	2.78	0.51	4.04	0	0.51	0.51	0.00765
Cameron	San Padre Island	Amberjack	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
	San Padre Island	NA	41 ft Utility Boat	477,000	3.76	0.35	0.06	0.5	0	0.06	0.06	0.0009
	San Padre Island	NA	47 ft Motor Life Boat	1,566,000	12.36	1.13	0.21	1.65	0	0.21	0.21	0.00315
	San Padre Island	NA	55 ft Aids to Navigation Boat	1,795,200	14.17	1.3	0.24	1.89	0	0.24	0.24	0.0036
TOTAL - Cameron County				4,900,200	38.67	3.55	0.65	5.16	0	0.65	0.65	0.00975
	Galveston	Harry Claiborne	175 ft Coastal Buoy Tender	816,000	6.44	0.59	0.11	0.86	0	0.11	0.11	0.00165
	Galveston	Dauntless	210 Medium Endurance Cutter	1,224,000	9.66	0.89	0.16	1.29	0	0.16	0.16	0.0024
	Galveston	Clamp / Hatchet	75 ft Inland Construction Tender	2,244,000	17.71	1.62	0.3	2.36	0	0.3	0.3	0.0045
	Galveston	Manowar / Skipjack	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
	Galveston	NA	41 ft Utility Boat	477,000	3.76	0.35	0.06	0.5	0	0.06	0.06	0.0009
	Galveston	NA	47 ft Motor Life Boat	1,566,000	12.36	1.13	0.21	1.65	0	0.21	0.21	0.00315
TOTAL - Galveston County				7,389,000	58.31	5.35	0.98	7.78	0.00	0.98	0.98	0.0147

Table 3-5. 2011 Annual Coast Guard Vessel Emission Estimates (tons per year) (Continued)

County	Port	Vessel Name	Vessel Type	Total Hp-Hrs	NOX	CO	NMVOC	SOX	NH3	PM10	PM2.5	NH4
Jefferson	Sabine	Heron	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
	Sabine	NA	41 ft Utility Boat	477,000	3.76	0.35	0.06	0.5	0	0.06	0.06	0.0009
	Sabine	NA	47 ft Motor Life Boat	1,566,000	12.36	1.13	0.21	1.65	0	0.21	0.21	0.00315
	Sabine	NA	55 ft Aids to Navigation Boat	1,795,200	14.17	1.3	0.24	1.89	0	0.24	0.24	0.0036
TOTAL – Jefferson County				4,900,200	38.67	3.55	0.65	5.16	0	0.65	0.65	0.00975
Nueces	Port Aransas	NA	41 ft Utility Boat	477,000	3.76	0.35	0.06	0.5	0	0.06	0.06	0.0009
	Port Aransas	NA	47 ft Motor Life Boat	1,566,000	12.36	1.13	0.21	1.65	0	0.21	0.21	0.00315
	Corpus Christi	Mallet	75 ft Inland Construction Tender	2,244,000	17.71	1.62	0.3	2.36	0	0.3	0.3	0.0045
	Corpus Christi	Brant	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
	Corpus Christi	Steelhead	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
	Corpus Christi	NA	64 ft Aide to Navigation Boat	1,795,200	14.17	1.3	0.24	1.89	0	0.24	0.24	0.0036
	Corpus Christi	NA	55 ft Aids to Navigation Boat	1795200	14.17	1.3	0.24	1.89	0	0.24	0.24	0.0036
TOTAL – Nueces County				10,001,400	78.93	7.24	1.33	10.53	0.00	1.33	1.33	0.0200
San Patricio	Ingleside	Manatee	87 ft Coastal Patrol Boat	1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021
TOTAL - San Patricio				1,062,000	8.38	0.77	0.14	1.12	0	0.14	0.14	0.0021

Table 3-6. 2011 Ozone Season Day Coast Guard Vessel Emission Estimates (tons per day)

County	Port	Vessel Name	Vessel Type	Total Hp-Hrs	NOX	CO	NMVOC	SOX	NH3	PM10	PM2.5	NH4
Brazoria	Freeport	Manta	87 ft Coastal Patrol Boat	2,910	0.0230	0.0021	3.84E-04	0.0031	0	3.84E-04	3.84E-04	5.75E-06
Brazoria	Freeport	NA	41 ft Utility Boat	1,307	0.0103	0.0010	1.64E-04	0.0014	0	1.64E-04	1.64E-04	2.47E-06
Brazoria	Freeport	NA	47 ft Motor Life Boat	4,290	0.0339	0.0031	5.75E-04	0.0045	0	5.75E-04	5.75E-04	8.63E-06
Brazoria	Freeport	NA	55 ft Aids to Navigation Boat	4,918	0.0388	0.0036	6.58E-04	0.0052	0	6.58E-04	6.58E-04	9.86E-06
TOTAL – Brazoria County				13,425	0.1059	0.0097	0.0018	0.0141	0	0.0018	0.0018	2.67E-05
Calhoun	Port O'Connor	NA	41 ft Utility Boat	1,307	0.0103	9.59E-04	1.64E-04	0.0013699	0	1.64E-04	1.64E-04	2.47E-06
Calhoun	Port O'Connor	NA	47 ft Motor Life Boat	4,290	0.0339	3.10E-03	5.75E-04	0.0045205	1	5.75E-04	5.75E-04	8.63E-06
Calhoun	Port O'Connor	NA	55 ft Aids to Navigation Boat	4,918	0.0388	3.56E-03	6.58E-04	0.0051781	2	6.58E-04	6.58E-04	9.86E-06
TOTAL – Calhoun County				10,516	0.0830	0.0076	0.0014	0.0111	3	0.0014	0.0014	2.10E-05
Cameron	San Padre Island	Amberjack	87 ft Coastal Patrol Boat	2,910	0.0230	2.11E-03	3.84E-04	0.0030685	4	3.84E-04	3.84E-04	5.75E-06
Cameron	San Padre Island	NA	41 ft Utility Boat	1,307	0.0103	9.59E-04	1.64E-04	0.0013699	5	1.64E-04	1.64E-04	2.47E-06
Cameron	San Padre Island	NA	47 ft Motor Life Boat	4,290	0.0339	3.10E-03	5.75E-04	0.0045205	6	5.75E-04	5.75E-04	8.63E-06
Cameron	San Padre Island	NA	55 ft Aids to Navigation Boat	4,918	0.0388	3.56E-03	6.58E-04	0.0051781	7	6.58E-04	6.58E-04	9.86E-06
TOTAL – Cameron County				13,425	0.1059	0.0097	0.0018	0.0141	22	0.0018	0.0018	2.67E-05
Galveston	Galveston	Harry Claiborne	175 ft Coastal Buoy Tender	2,236	0.0176	1.62E-03	3.01E-04	0.0023562	9	3.01E-04	3.01E-04	4.52E-06
Galveston	Galveston	Dauntless	210 Medium Endurance Cutter	3,353	0.0265	2.44E-03	4.38E-04	0.0035342	10	4.38E-04	4.38E-04	6.58E-06
Galveston	Galveston	Clamp / Hatchet	75 ft Inland Construction Tender	6,148	0.0485	4.44E-03	8.22E-04	0.0064658	11	8.22E-04	8.22E-04	1.23E-05
Galveston	Galveston	Manowar / Skipjack	87 ft Coastal Patrol Boat	2,910	0.0230	2.11E-03	3.84E-04	0.0030685	12	3.84E-04	3.84E-04	5.75E-06
Galveston	Galveston	NA	41 ft Utility Boat	1,307	0.0103	9.59E-04	1.64E-04	0.0013699	13	1.64E-04	1.64E-04	2.47E-06
Galveston	Galveston	NA	47 ft Motor Life Boat	4,290	0.0339	3.10E-03	5.75E-04	0.0045205	14	5.75E-04	5.75E-04	8.63E-06
TOTAL – Galveston County				20,244	0.1598	0.0147	0.0027	0.0213	69	0.0027	0.0027	4.03E-05
Jefferson	Sabine	Heron	87 ft Coastal Patrol Boat	2,910	0.0230	2.11E-03	3.84E-04	0.0030685	16	3.84E-04	3.84E-04	5.75E-06
Jefferson	Sabine	NA	41 ft Utility Boat	1,307	0.0103	9.59E-04	1.64E-04	0.0013699	17	1.64E-04	1.64E-04	2.47E-06
Jefferson	Sabine	NA	47 ft Motor Life Boat	4,290	0.0339	3.10E-03	5.75E-04	0.0045205	18	5.75E-04	5.75E-04	8.63E-06
Jefferson	Sabine	NA	55 ft Aids to Navigation Boat	4,918	0.0388	3.56E-03	6.58E-04	0.0051781	19	6.58E-04	6.58E-04	9.86E-06

Table 3-6. 2011 Ozone Season Day Coast Guard Vessel Emission Estimates (tons per day) (Continued)

County	Port	Vessel Name	Vessel Type	Total Hp-Hrs	NOX	CO	NMVOC	SOX	NH3	PM10	PM2.5	NH4
TOTAL - Jefferson County				13,425	0.1059	0.0097	0.0018	0.0141	70	0.0018	0.0018	2.67E-05
Nueces	Port Aransas	NA	41 ft Utility Boat	1,307	0.0103	9.59E-04	1.64E-04	0.0013699	21	1.64E-04	1.64E-04	2.47E-06
Nueces	Port Aransas	NA	47 ft Motor Life Boat	4,290	0.0339	3.10E-03	5.75E-04	0.0045205	22	5.75E-04	5.75E-04	8.63E-06
Nueces	Corpus Christi	Mallet	75 ft Inland Construction Tender	6,148	0.0485	4.44E-03	8.22E-04	0.0064658	23	8.22E-04	8.22E-04	1.23E-05
Nueces	Corpus Christi	Brant	87 ft Coastal Patrol Boat	2,910	0.0230	2.11E-03	3.84E-04	0.0030685	24	3.84E-04	3.84E-04	5.75E-06
Nueces	Corpus Christi	Steelhead	87 ft Coastal Patrol Boat	2,910	0.0230	2.11E-03	3.84E-04	0.0030685	25	3.84E-04	3.84E-04	5.75E-06
Nueces	Corpus Christi	NA	64 ft Aide to Navigation Boat	4,918	0.0388	3.56E-03	6.58E-04	0.0051781	26	6.58E-04	6.58E-04	9.86E-06
Nueces	Corpus Christi	NA	55 ft Aids to Navigation Boat	4,918	0.0388	3.56E-03	6.58E-04	0.0051781	27	6.58E-04	6.58E-04	9.86E-06
TOTAL - Nueces County				27,401	0.2162	0.0198	0.0036	0.0288	168	0.0036	0.0036	5.47E-05
San Patricio	Ingleside	Manatee	87 ft Coastal Patrol Boat	2,910	0.0230	2.11E-03	3.84E-04	0.0030685	29	3.84E-04	3.84E-04	5.75E-06
TOTAL - San Patricio				2,910	0.0230	2.11E-03	3.84E-04	0.0030685	29	3.84E-04	3.84E-04	5.75E-06

ERG used the dredging start and completion date to estimate the total hours of operation for the dredging equipment. In some cases, the start or completion date or both were not documented in the database, in which case ERG used the estimated start and completion dates in the proposal to define the period of activity.

Though this equipment operates 24 hours per day, seven days per week, ERG assumed that dredging engines operate 90 percent of the time, to account for vessel positioning, minor maintenance, and refueling activities.

Two different dredging types were used in state waters: cutter suction and hopper vessels. Cutter suction dredges use a rotating drill to bring sediment up. Hopper vessels use a vacuum device that transports sediments from the ocean floor into the vessel's hold. ERG assumed that cutter suction dredges are equipped with engines rated from 5,000 to 15,000 horsepower (for this project ERG used a value of 9,600 horsepower (7,161 kW) based on data provided by dredging services that implemented similar dredging activities). Hopper dredges have a horsepower rating of 7,500 to 12,000 horsepower (5,593 to 8,951 kW), based on data provided by dredging companies that implemented identified dredging activities an average value of 9,814 horsepower (7272 kW) as used for hopper dredges.

Details concerning the dredging vessels were obtained from Web sites of the companies implementing the dredging contracts; however, few details were readily available. The information that was available was compiled in the project database.

The U.S. Army Corps of Engineers' dredging database included the estimated project arrival and departure dates (based on the proposal for the dredging project) and actual project arrival and departure dates. For this inventory, hours of operation were estimated based on the actual arrival and departure dates.

Total kilowatt hours were estimated by using the following equation:

$$TKW = THP \times 0.741\ KW/HP \times (DP\text{-}AR) \times 24\ hrs/day \times 0.90$$

Where:

TKW	=	Total Kilowatt Hours (kW-hr)
THP	=	Total maximum horsepower rating of the engine (HP)
0.741	=	Conversion of HP to kW
DP	=	Departure date
AR	=	Arrival date
24	=	Hours per day

0.90 = Total fraction of time operating (considering ongoing maintenance activities and refueling)

Example: Dredging Activity Calculation

A hopper vessel equipped with a 9814 Hp engine, arrived at site on January 1, 2011 and departed on January 11, 2007:

kW-Hr = THP × 0.741KW/HP × (DP-AR) × 24 hrs/day × 0.90
kW-Hr = 9,814 Hp × 0.741 KW/HP× (1/1/07 – 1/11/07) × 24 × 0.90
kW-Hr = 1,570,790 kW-Hr

The total operating kilowatt hours were calculated based on the hours of operation applied to the vessel and horse power rating. The total kilowatt hours are noted in Table 3-7 along with the name of the dredging job, the county where the operation occurred the type of dredger used, hours of operation (assuming 90 percent of the time that the vessel is at the site it is operating), the kilowatt rating of the engines, the assumed load factor.

Table 3-7. Summary of 2011 Dredging Activities in Texas State Waters

Job Name	County	Type	Days	Hours (90percent)	kW **	LoadFactor	Kw-Hrs
BIH-Brownsville Jetty Ch.	Cameron	Cutter Suction	31	669.6	7161	0.8	3,836,004
CCSC-LaQuinta Ch Extension	Brazoria	Cutter Suction	578	12484.8	7161	0.8	71,522,922
CSC-Inner Basin-Main TB	Nueces	Cutter Suction	110	2376	7161	0.8	13,611,629
Channel to Harlingen	Cameron	Cutter Suction	204	4406.4	7161	0.8	25,243,384
Channel to Port Mansfield	Willacy	Cutter Suction	18	388.8	7161	0.8	2,227,357
Freeport Entrance Channel	Brazoria	Hopper	45	972	7272	0.8	5,654,707
GIWW-CC to Port Isabel	Cameron	Cutter Suction	254	5486.4	7161	0.8	31,430,488
GIWW-Freeport-Brazos R Xing	Brazoria	Cutter Suction	131	2829.6	7161	0.8	16,210,212
GIWW-Turnstake Is.-Live Oak	Calhoun	Cutter Suction	107	2311.2	7161	0.8	13,240,403
Galv. Ent-Inner/Outer Bar Ch	Galveston	Hopper	204	4406.4	7272	0.8	25,634,673
HSC-Exxon - Carpenters Bayou	Galveston	Cutter Suction	156	3369.6	7161	0.8	19,303,764
MSC-Matagorda to Pt Comfort	Matagorda	Cutter Suction	178	3844.8	7161	0.8	22,026,090
SNWW-Sabine Neches Canal	Jefferson	Cutter Suction	72	1555.2	7161	0.8	8,909,430
SNWW-Sabine Pass.	Jefferson	Cutter Suction	79	1706.4	7161	0.8	9,775,624

Emission estimates were developed for NO_x, CO, NMVOC, SO_2, NH_3, PM_{10}, and $PM_{2.5}$ using the following equation:

$$AE = AH \times EF \times CF$$

Where:

AE = Annual Emissions (tons per year)
AH = Annual activity (kW-Hr)
EF = Emissions factor (g/kW-Hr)
CF = Conversion factor (1.10231 E-6 ton/g)

Example: Dredging Emission Calculation

Estimate the NO_x emissions of a dredging vessel with annual operations of 829,487 kW-hr. The NO_x emission factor is 19.54 g/kw-hr.

$$AE = AH \times CF_1 \times LF \times EF \times CF_2$$

$$AE = 829{,}487\text{kW-hrs} \times 19.54 \text{ g/kW-Hr} \times 1.10231 \text{ E-6 ton/g}$$

$$AE = 17.9 \text{ tons of } NO_x \text{ per year}$$

ERG assumed the load factor for dredging propulsion engines to be 80 percent. The emission factors used in estimating the emissions are from dredging were obtained from the EPA (EPA 2010), Criteria emission estimates for dredging vessels by county are provided in Table 3-8 and Table 3-9 for annual and daily ozone emissions.

Table 3-8. 2011 Dredging Vessel Emission Estimates (tons per Year)

County Name	FIPS	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Brazoria	48039	51.16	251.67	9.23	8.95	3.09	5.76	0.18
Calhoun	48057	111.30	547.52	20.07	19.47	6.73	12.53	0.40
Cameron	48061	190.96	939.44	34.44	33.40	11.54	21.49	0.69
Galveston	48167	98.74	485.78	17.81	17.27	5.97	11.11	0.36
Harris	48201	60.92	299.70	10.99	10.66	3.68	6.86	0.22
Jefferson	48245	30.85	151.77	5.56	5.40	1.87	3.47	0.11
Nueces	48355	42.96	211.33	7.75	7.51	2.60	4.83	0.15
Orange	48361	28.12	138.32	5.07	4.92	1.70	3.16	0.10
San Patricio	48409	225.72	1,110.42	40.70	39.48	13.65	25.40	0.81
Willacy	48489	7.03	34.58	1.27	1.23	0.42	0.79	0.03
Total		847.74	4,170.52	152.88	148.29	51.25	95.41	3.06

Table 3-9. 2011 Ozone Season Day Dredging Vessel Emission Estimates (tons per day)

County Name	FIPS	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Brazoria	48039	0.1402	0.6895	0.0253	0.0245	0.0085	0.0158	0.0005
Calhoun	48057	0.3049	1.5001	0.0550	0.0533	0.0184	0.0343	0.0011
Cameron	48061	0.5232	2.5738	0.0943	0.0915	0.0316	0.0589	0.0019
Galveston	48167	0.2705	1.3309	0.0488	0.0473	0.0164	0.0304	0.0010
Harris	48201	0.1669	0.8211	0.0301	0.0292	0.0101	0.0188	0.0006
Jefferson	48245	0.0845	0.4158	0.0152	0.0148	0.0051	0.0095	0.0003
Nueces	48355	0.1177	0.5790	0.0212	0.0206	0.0071	0.0132	0.0004
Orange	48361	0.0770	0.3790	0.0139	0.0135	0.0047	0.0087	0.0003
San Patricio	48409	0.6184	3.0422	0.1115	0.1082	0.0374	0.0696	0.0022
Willacy	48489	0.0193	0.0947	0.0035	0.0034	0.0012	0.0022	0.0001
Total		2.3226	11.4261	0.4188	0.4063	0.1404	0.2614	0.0084

Commercial Fishing

Commercial fishing activity was based on a variety of data for commercial fishing in Texas. Fishing vessel ship calls were estimated as a function of vessel purpose and its type of fishery. Table 3-10 provides a summary of vessel operating characteristics for the four main types of fishing operations, specifically information about the number of vessel, port calls per year, distance traveled in state waters per call, vessel speed, kilowatt rating of the engine, calculated hours of operation in state waters, and calculated kilowatt hours. To estimate annual kilowatt-hours of operation per vessel the number of calls were multiplied by the vessel's kilowatt rating, the hours per call and a load factor of 80 percent. Fishing vessel kilowatt hours were calculated using the following equation:

$$Actf = Kw \times Dt / Sp \times Cf \times Lf$$

Where:

Actf = Annual activity per vessel in terms of adjusted kilowatt hours
Kw = Typical Kilowatt rating of fishing boats propulsion engines by type of fishing vessel operation
Dt = Distance traveled in state waters per trip (nautical miles)
Sp = Vessel speed (nautical miles per hour)
Cf = Number of calls per year
Lf =Load factor (percent/100)

Most fishing vessels have a governor and "trolling gear" to lower engine loads to 68 percent optimizing diesel fuel consumption. For this component of the TCEQ emission inventory the load factor was assumed to be 68 percent.

Example: Fishing Vessel Activity Calculation

A vessel involved in fishing operations for snappers is equipped with a 224 kW propulsion engines, has 40 calls per year, where they transit 20 nautical miles per call and operate at a speed of 7.5 nautical miles per hour, to calculate the total horsepower hours of operation the following equation was used:

$$Actf = Kw \times Dt / Sp \times Cf \times Lf$$

$$Actf = 224\ kw \times 20\ NM/7.5\ NM/hr \times 40 \times 68/100$$
$$Hp\text{-}Hrs = 16{,}247$$

Table 3-10. Vessel Operating Characteristics by Fishing Operation Type

Fishery Operation	Vessels	Calls/Yr	Distance	Speed	Hours	kW	kW/ Vessel - Yr
Snapper	47	40	20	7.5	2.7	224	16,247
Shrimp	809	20	20	7.5	2.7	522	18,931
Oyster	154	100	40	7.5	5.3	224	81,133
Other	202	50	30	7.5	4.0	186	25,354
Total	1,212						141,646

*travel distance in state waters per vessel call.

The fleet of Gulf of Mexico fishing vessels involved in pelagic fishing (e.g., red snapper and other ground fish), long-line tuna and swordfish, and shrimping operations, actually operate most of the time in federal waters. Many of these fishing boats go out into the Gulf and stay out for a week to three months. When returning to Texas ports each vessel only operates for 3 to 5 hours within Texas waters.

Fishing operations within state waters are dominated by the oyster fishery in the upper Texas Coast with most vessels operating in the Galveston area. These vessels rarely leave the bays or Texas waters and can include bait shrimping, black drum, bluecrabs, flounder, and other inshore fisheries. These boats spend 100percent of the time within Texas waters and are basically regulated by the fishing season, permits, and the Texas Parks & Wildlife Department. Table 3-11 shows the distinction between these types of fisheries using the dominant fishery to represent its class. The state total poundage of fish caught was obtained from the Texas Parks and Wildlife (TPWD 2012). To estimate the number of vessels associated with each type of fishing operations, the fraction of poundage shown in Table 3-11 was applied to the state total fishing vessel population as provided by the National Transportation Safety Board for 2010 (NTSB 2010), after adjusting for the fraction of the fishing vessel fleet that is equipped with diesel engines (65percent), over gasoline powered outboard engines. Table 2-11 also noted the primary fishing area (i.e., state or federal waters).

Table 3-11. Types of Texas Fisheries by Activity Class

Fishery Operation	Poundage (X 1,000)	Percent	Vessels*	Primary Fishing area
Snapper	1,600	3.86	47	Federal waters
Shrimp	27,659	66.76	809	Federal waters
Oyster	5,265	12.71	154	State waters
Other	6,908	16.67	202	State waters
	41,432	100.00	1212	

The four main fishery ports in Texas are Brownville, Galveston, Placios, and Port Arthur. 2010 fish landing for each port were obtained from the National Marine Fisheries Service (NMFS 2012) and are presented in Table 3-12. Each ports percentage

of the total were calculated in Table 3-12, both as total catch and by fishery operations (e.g., snapper, shrimp, oyster and other).

Table 3-12. Port Landings 2010 for Port Allocations

Port	County	M-Pounds	Percent	Snapper Percent	Shrimp Percent	Oyster Percent	Other Percent
Brownsville	Cameron	22.7	32.61	10	30	0	20
Galveston	Galveston	13.4	19.25	40	25	70	30
Palacios	Matagorda	13.9	19.97	40	25	20	40
Port Arthur	Jefferson	19.6	28.16	10	20	10	10
Total		69.6	100.00	100	100	100	100

NMFS (2012)

The fractions in Table 3-12 were used to estimate what portion of the Texas fleet for each fisheries operation is associated with each fishery port as summarized in Table 3-13.

Table 3-13. Texas Fishing Vessel Fleet by Port and Fishing Operation

Port	Snapper	Shrimp	Oyster	Other	Totals
Brownsville	5	243	0	40	288
Galveston	19	202	108	61	389
Palacios	19	202	31	81	333
Port Arthur	5	162	15	20	202
Total	47	809	154	202	1,212

The vessel fleet data presented in Table 3-13 were applied to the adjusted annual kW-hrs data presented in Table 3-10 to estimate the kW-hrs associated with fishing operations and port as presented in Table 3-14.

Table 3-14. Kilowatt hours for Texas Fishing Vessel Fleet by Port and Fishing Operation

Port	County	Snapper	Shrimp	Oyster	Other	Totals
Brownsville	Cameron	75,923	4,593,651	0	1,024,368	5,693,942
Galveston	Galveston	303,692	3,828,043	8,744,196	1,536,551	14,412,482
Palacios	Matagorda	303,692	3,828,043	2,498,342	2,048,735	8,678,812
Port Arthur	Jefferson	75,923	3,062,434	1,249,171	512,184	4,899,712
Total		759,230	15,312,170	12,491,709	5,121,838	33,684,947

These kilowatt hours were applied to the EPA's emission factors to estimate criteria and HAP emissions using the following equation:

$$AEf = Actf \times EF \times CF$$

Where:

AEf = Annual Emissions associated with fishing vessels (tons per year)

Actf = Annual activity (kW-Hr)

EF = Emissions factor (g/kW-Hr)
CF = Conversion factor (1.10231 E-6 ton/g)

Example: Fishing Vessel Emission Calculation

For snapper fishing vessels account for 75,923 kW-hrs. These data can be applied to the following equation:

$$AE = Actf \times EF \times CF$$

AEf = 75,923 kW-hr × 14.08 g/kw-hr × 1.10231E-6 ton/gr 1.2 tons of NO_x per year

Criteria emission estimates for commercial fishing are presented in Table 3-15 for annual and Table 3-16 for ozone season daily emissions by port and pollutant.

Table 3-15. Annual Commercial Fishing Emissions (tons per year)

County Name	FIPS	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Cameron	48061	17.97	88.40	3.24	3.14	1.09	2.02	0.06
Galveston	48167	45.48	223.76	8.20	7.96	2.75	5.12	0.16
Jefferson	48245	15.46	76.07	2.79	2.70	0.93	1.74	0.06
Matagorda	48321	27.39	134.74	4.94	4.79	1.66	3.08	0.10
Total		106.30	522.97	19.17	18.60	6.43	11.96	0.38

Table 3-16. Ozone Season Daily Commercial Fishing Emissions (tons per day)

County Name	FIPS	CO	NOx	PM10	PM2.5	SO2	VOC	NH3
Cameron	48061	0.0492	0.2422	0.0089	0.0086	0.0030	0.0055	0.0002
Galveston	48167	0.1246	0.6130	0.0225	0.0218	0.0075	0.0140	0.0004
Jefferson	48245	0.0424	0.2084	0.0076	0.0074	0.0026	0.0048	0.0002
Matagorda	48321	0.0750	0.3692	0.0135	0.0131	0.0045	0.0084	0.0003
Total		0.2912	1.4328	0.0525	0.0509	0.0176	0.0328	0.0011

4.0 Summary of Results

Table 4-1 present the total CMV activity in terms of kilowatt hours and emissions (tons per year) for each pollutant and SCC by counties. Table 4-2 present the total activity in terms of kilowatt hours and emissions (pounds per ozone season day) for each pollutant and SCC by counties.

Table 4-1. Summary of 2011 Commercial Marine Vessel Emissions

				2011 Annual Emissions (TPY)						
County	**SCC**	**SCC Description**	**Activity (kW-hrs)**	**CO**	**NH3**	**NOx**	**PM10**	**PM2.5**	**SO2**	**VOC**
Aransas	2280002100	Diesel - Port	5,612,415	1.771	0.003	8.713	0.319	0.310	0.107	0.199
Aransas	2280002200	Diesel - Underway	4,416,151	11.149	0.040	54.850	2.011	1.950	0.674	1.255
Aransas	2280003100	Residual - Port	14,095,654	2.744	0.003	30.363	1.157	1.057	9.162	1.208
Aransas	2280003200	Residual - Underway	52,653,445	82.001	0.165	907.347	34.566	31.596	273.806	36.085
Total Aransas Emissions				**97.67**	**0.21**	**1,001.27**	**38.05**	**34.91**	**283.75**	**38.75**
Brazoria	2280002100	Diesel - Port	13,823	0.044	0.000	0.215	0.008	0.008	0.003	0.005
Brazoria	2280002200	Diesel - Underway	40,666,742	126.032	0.455	620.019	22.728	22.046	7.619	14.184
Brazoria	2280003100	Residual - Port	33,788,153	65.776	0.066	727.815	27.727	25.344	219.630	28.945
Brazoria	2280003200	Residual - Underway	2,882,312	5.611	0.011	62.087	2.365	2.162	18.736	2.469
Total Brazoria Emissions				**197.46**	**0.53**	**1,410.13**	**52.83**	**49.56**	**245.99**	**45.60**
Calhoun	2280002100	Diesel - Port	4,748,248	1.498	0.003	7.372	0.270	0.262	0.091	0.169
Calhoun	2280002200	Diesel - Underway	41,619,764	127.336	0.459	626.434	22.963	22.274	7.698	14.331
Calhoun	2280003100	Residual - port	13,228,902	2.575	0.003	28.496	1.086	0.992	8.599	1.133
Calhoun	2280003200	Residual - Underway	32,618,996	50.800	0.102	562.105	21.414	19.574	169.624	22.355
Total Calhoun Emissions				**182.209**	**0.567**	**1,224.406**	**45.733**	**43.103**	**186.012**	**37.987**
Cameron	2280002100	Diesel - Port	1,123,842	0.355	0.001	1.745	0.064	0.062	0.021	0.040
Cameron	2280002200	Diesel - Underway	70,698,182	220.276	0.794	1,083.658	39.723	38.532	13.317	24.790

Table 4-1. Summary of 2011 Commercial Marine Vessel Emissions (Continued)

				2011 Annual Emissions (TPY)						
County	**SCC**	**SCC Description**	**Activity (kW-hrs)**	**CO**	**NH3**	**NOx**	**PM10**	**PM2.5**	**SO2**	**VOC**
Cameron	2280003100	Residual - Port	2,089,574	0.407	0.000	4.501	0.171	0.157	1.358	0.179
Cameron	2280003200	Residual - Underway	13,390,436	20.854	0.042	230.750	8.791	8.035	69.632	9.177
Total Cameron Emissions				**241.891**	**0.837**	**1,320.654**	**48.749**	**46.786**	**84.329**	**34.186**
Chambers	2280002100	Diesel - Port	0	0.000		0.000	0.000	0.000	0.000	0.000
Chambers	2280002200	Diesel - Underway	951,160	3.002	0.011	14.767	0.541	0.525	0.181	0.338
Chambers	2280003200	Residual - Underway	1,607,737	3.130	0.006	34.632	1.319	1.206	10.451	1.377
Total Chambers Emissions				**6.132**	**0.017**	**49.399**	**1.861**	**1.731**	**10.632**	**1.715**
Galveston	2280002100	Diesel - Port	623,097	1.966	0.004	9.674	0.355	0.344	0.119	0.221
Galveston	2280002200	Diesel - Underway	94,330,837	294.216	1.061	1,447.409	53.057	51.466	17.786	33.112
Galveston	2280003100	Residual - port	74,383,578	144.803	0.145	1,602.262	61.039	55.795	483.508	63.721
Galveston	2280003200	Residual - Underway	40,617,503	79.070	0.159	874.923	33.331	30.467	264.022	34.795
Total Galveston Emissions				**520.055**	**1.369**	**3,934.268**	**147.782**	**138.072**	**765.436**	**131.849**
Harris	2280002100	Diesel - Port	460,131	1.452	0.003	7.144	0.262	0.254	0.088	0.163
Harris	2280002200	Diesel - Underway	49,554,545	156.386	0.564	769.351	28.202	27.356	9.454	17.600
Harris	2280003100	Residual - port	277,682,625	540.566	0.542	5,981.432	227.867	208.290	1,804.994	237.878
Harris	2280003200	Residual - Underway	58,358,017	113.606	0.228	1,257.063	47.889	43.774	379.339	49.993
Total Harris Emissions				**812.010**	**1.337**	**8,014.990**	**304.219**	**279.674**	**2,193.874**	**305.635**
Jackson	2280002100	Diesel - Port	66,354	0.021	0.000	0.103	0.004	0.004	0.001	0.002

Table 4-1. Summary of 2011 Commercial Marine Vessel Emissions (Continued)

				2011 Annual Emissions (TPY)						
County	**SCC**	**SCC Description**	**Activity (kW-hrs)**	**CO**	**NH3**	**NOx**	**PM10**	**PM2.5**	**SO2**	**VOC**
Jackson	2280002200	Diesel - Underway	46,906	0.118	0.000	0.583	0.021	0.021	0.007	0.013
Jackson	2280003100	Residual - port	121,613	0.024	0.000	0.262	0.010	0.009	0.079	0.010
Jackson	2280003200	Residual - Underway	309,188	0.482	0.001	5.328	0.203	0.186	1.608	0.212
Total Jackson Emissions				**0.645**	**0.001**	**6.276**	**0.238**	**0.219**	**1.695**	**0.238**
Jefferson	2280002100	Diesel - Port	21,426,841	6.762	0.012	33.266	1.219	1.183	0.409	0.761
Jefferson	2280002200	Diesel - Underway	35,047,792	98.230	0.354	483.247	17.714	17.183	5.938	11.055
Jefferson	2280003100	Residual - port	18,531,939	3.608	0.004	39.919	1.521	1.390	12.046	1.588
Jefferson	2280003200	Residual - Underway	58,841,401	91.637	0.184	1,013.980	38.628	35.310	305.985	40.325
Total Jefferson Emissions				**200.237**	**0.554**	**1,570.412**	**59.083**	**55.065**	**324.378**	**53.729**
Kenedy	2280002100	Diesel - Port	197,942	0.062	0.000	0.307	0.011	0.011	0.004	0.007
Kenedy	2280002200	Diesel - Underway	133,644	0.337	0.001	1.660	0.061	0.059	0.020	0.038
Kenedy	2280003100	Residual - port	1,824	0.000	0.000	0.004	0.000	0.000	0.001	0.000
Kenedy	2280003200	Residual - Underway	27,954	0.044	0.000	0.482	0.018	0.017	0.145	0.019
Total Kenedy Emissions				**0.444**	**0.001**	**2.453**	**0.091**	**0.087**	**0.171**	**0.064**

Table 4-1. Summary of 2011 Commercial Marine Vessel Emissions (Continued)

				2011Annual Emissions (TPY)						
County	**SCC**	**SCC Description**	**Activity (kW-Hr)**	**CO**	**NH3**	**NOx**	**PM10**	**PM2.5**	**SO2**	**VOC**
Kleberg	2280002100	Diesel - Port	1,632,796	0.515	0.001	2.535	0.093	0.090	0.031	0.058
Kleberg	2280002200	Diesel - Underway	1,175,945	2.969	0.011	14.606	0.535	0.519	0.179	0.334
Kleberg	2280003100	Residual - port	2,351,692	0.458	0.000	5.066	0.193	0.176	1.529	0.201
Kleberg	2280003200	Residual - Underway	6,303,160	9.816	0.020	108.619	4.138	3.782	32.777	4.320
Total Kleberg Emissions				**13.758**	**0.032**	**130.825**	**4.959**	**4.568**	**34.517**	**4.913**
Liberty	2280002100	Diesel - Port	1,138	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Liberty	2280002200	Diesel - Underway	2,543	0.006	0.000	0.032	0.001	0.001	0.000	0.001
Total Liberty Emissions				**0.007**	**0.000**	**0.033**	**0.001**	**0.001**	**0.000**	**0.001**
Matagorda	2280002100	Diesel - Port	6,544,257	2.065	0.004	10.160	0.372	0.361	0.125	0.232
Matagorda	2280002200	Diesel - Underway	13,436,430	39.400	0.142	193.832	7.105	6.892	2.382	4.434
Matagorda	2280003100	Residual - port	16,087,675	3.132	0.003	34.654	1.320	1.207	10.457	1.378
Matagorda	2280003200	Residual - Underway	33,920,090	52.826	0.106	584.526	22.268	20.355	176.390	23.246
Total Matagorda Emissions				**97.423**	**0.255**	**823.172**	**31.066**	**28.815**	**189.354**	**29.291**
Nueces	2280002100	Diesel - Port	11,173,739	3.526	0.006	17.348	0.636	0.617	0.213	0.397
Nueces	2280002200	Diesel - Underway	29,360,404	82.717	0.298	406.929	14.917	14.469	5.001	9.309
Nueces	2280003100	Residual - port	22,556,495	4.391	0.004	48.588	1.851	1.692	14.662	1.932
Nueces	2280003200	Residual - Underway	66,026,209	102.827	0.207	1,137.792	43.345	39.621	343.347	45.249
Total Nueces Emissions				**193.461**	**0.516**	**1,610.657**	**60.749**	**56.399**	**363.223**	**56.888**
Orange	2280002100	Diesel - Port	2,029,788	0.641	0.001	3.151	0.116	0.112	0.039	0.072
Orange	2280002200	Diesel - Underway	10,334,468	31.715	0.114	156.021	5.719	5.548	1.917	3.569
Orange	2280003100	Residual - port	815,383	0.159	0.000	1.756	0.067	0.061	0.530	0.070
Orange	2280003200	Residual - Underway	2,418,393	3.766	0.008	41.675	1.588	1.451	12.576	1.657
Total Orange Emissions				**36.280**	**0.123**	**202.604**	**7.489**	**7.172**	**15.062**	**5.369**

Table 4-1. Summary of 2011 Commercial Marine Vessel Emission (Continued)

				2011 Annual Emissions (TPY)						
County	**SCC**	**SCC Description**	**Activity (KW-Hr)**	**CO**	**NH3**	**NOx**	**PM10**	**PM2.5**	**SO2**	**VOC**
Refugio	2280002100	Diesel - Port	103,913	0.033	0.000	0.161	0.006	0.006	0.002	0.004
Refugio	2280002200	Diesel - Underway	72,061	0.182	0.001	0.895	0.033	0.032	0.011	0.020
Refugio	2280003100	Residual - port	66,526	0.013	0.000	0.143	0.005	0.005	0.043	0.006
Refugio	2280003200	Residual - Underway	185,299	0.289	0.001	3.193	0.122	0.111	0.964	0.127
				0.516	**0.001**	**4.393**	**0.166**	**0.154**	**1.020**	**0.157**
San Patricio	2280002100	Diesel - Port	2,923,493	0.923	0.002	4.539	0.166	0.161	0.056	0.104
San Patricio	2280002200	Diesel - Underway	74,427,857	233.049	0.841	1,146.498	42.027	40.766	14.089	26.228
San Patricio	2280003100	Residual - port	5,384,110	1.048	0.001	11.598	0.442	0.404	3.500	0.461
San Patricio	2280003200	Residual - Underway	14,579,731	22.706	0.046	251.244	9.571	8.749	75.817	9.992
Total San Patricio Emissions				**257.726**	**0.889**	**1,413.878**	**52.206**	**50.080**	**93.461**	**36.785**
Victoria	2280002100	Diesel - Port	0	0.000		0.000	0.000	0.000	0.000	0.000
Victoria	2280002200	Diesel - Underway	0	0.000		0.000	0.000	0.000	0.000	0.000
Victoria	2280003100	Residual - port	4,137	0.001	0.000	0.009	0.000	0.000	0.003	0.000
Victoria	2280003200	Residual - Underway	56,619	0.088	0.000	0.976	0.037	0.034	0.294	0.039
Total Victoria Emissions				**0.089**	**0.000**	**0.985**	**0.038**	**0.034**	**0.297**	**0.039**
Willacy	2280002100	Diesel - Port	41,760	0.013	0.000	0.065	0.002	0.002	0.001	0.001
Willacy	2280002200	Diesel - Underway	2,256,335	7.102	0.026	34.940	1.281	1.242	0.429	0.799
Willacy	2280003100	Residual - port	52,122	0.010	0.000	0.112	0.004	0.004	0.034	0.004
Willacy	2280003200	Residual - Underway	370,303	0.577	0.001	6.381	0.243	0.222	1.926	0.254
Total Willacy Emissions				**7.702**	**0.027**	**41.499**	**1.531**	**1.471**	**2.390**	**1.059**
Total				**2,866**	**7**	**22,762**	**857**	**798**	**4,796**	**784**

Table 4-2. Summary of 2011 Commercial Marine Vessel Emission

2011 Ozone Season Day Emissions (TPD)

FIPS	County Name	Source Classification Code		Sum of Activity Value	CO	NH3	NOx	PM10-PRI	PM25-PRI	SO2	VOC
48007	Aransas	2280002100	Diesel - Port	15,376	0.0049	0.0000	0.0239	0.0009	0.0008	0.0003	0.0005
48007	Aransas	2280002200	Diesel - Underway	12,099	0.0305	0.0001	0.1503	0.0055	0.0053	0.0018	0.0034
48007	Aransas	2280003100	Residual - port	38,618	0.0075	0.0000	0.0832	0.0032	0.0029	0.0251	0.0033
48007	Aransas	2280003200	Residual - Underway	144,256	0.2247	0.0005	2.4859	0.0947	0.0866	0.7502	0.0989
Total County-level OSD Emissions				210,350	0.27	0.00	2.74	0.10	0.10	0.78	0.11
48039	Brazoria	2280002100	Diesel - Port	38	0.0001	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
48039	Brazoria	2280002200	Diesel - Underway	111,416	0.3453	0.0012	1.6987	0.0623	0.0604	0.0209	0.0389
48039	Brazoria	2280003100	Residual - port	92,570	0.1802	0.0002	1.9940	0.0760	0.0694	0.6017	0.0793
48039	Brazoria	2280003200	Residual - Underway	7,897	0.0154	0.0000	0.1701	0.0065	0.0059	0.0513	0.0068
Total County-level OSD Emissions				211,921	0.54	0.00	3.86	0.14	0.14	0.67	0.12
48057	Calhoun	2280002100	Diesel - Port	13,009	0.0041	0.0000	0.0202	0.0007	0.0007	0.0002	0.0005
48057	Calhoun	2280002200	Diesel - Underway	114,027	0.3489	0.0013	1.7163	0.0629	0.0610	0.0211	0.0393
48057	Calhoun	2280003100	Residual - port	36,244	0.0071	0.0000	0.0781	0.0030	0.0027	0.0236	0.0031
48057	Calhoun	2280003200	Residual - Underway	89,367	0.1392	0.0003	1.5400	0.0587	0.0536	0.4647	0.0612
Total County-level OSD Emissions					0.499	0.002	3.355	0.125	0.118	0.510	0.104
48061	Cameron	2280002100	Diesel - Port	3,079	0.0010	0.0000	0.0048	0.0002	0.0002	0.0001	0.0001
48061	Cameron	2280002200	Diesel - Underway	193,694	0.6035	0.0022	2.9689	0.1088	0.1056	0.0365	0.0679
48061	Cameron	2280003100	Residual - port	5,725	0.0011	0.0000	0.0123	0.0005	0.0004	0.0037	0.0005
48061	Cameron	2280003200	Residual - Underway	36,686	0.0571	0.0001	0.6322	0.0241	0.0220	0.1908	0.0251
Total County-level OSD Emissions					0.663	0.002	3.618	0.134	0.128	0.231	0.094

Table 4-2. Summary of 2011 Commercial Marine Vessel Emission (Continued)

2011 Ozone Season Day Emissions (TPD)

FIPS	County Name	Source Classification Code		Sum of Activity Value	CO	NH3	NOx	PM10-PRI	PM25-PRI	SO2	VOC
48071	Chambers	2280002100	Diesel - Port	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48071	Chambers	2280002200	Diesel - Underway	2,606	0.0082	0.0000	0.0405	0.0015	0.0014	0.0005	0.0009
48071	Chambers	2280003200	Residual - Underway	4,405	0.0086	0.0000	0.0949	0.0036	0.0033	0.0286	0.0038
Total County-level OSD Emissions					0.017	0.000	0.135	0.005	0.005	0.029	0.005
48167	Galveston	2280002100	Diesel - Port	1,707	0.0054	0.0000	0.0265	0.0010	0.0009	0.0003	0.0006
48167	Galveston	2280002200	Diesel - Underway	258,441	0.8061	0.0029	3.9655	0.1454	0.1410	0.0487	0.0907
48167	Galveston	2280003100	Residual - port	203,791	0.3967	0.0004	4.3898	0.1672	0.1529	1.3247	0.1746
48167	Galveston	2280003200	Residual - Underway	111,281	0.2166	0.0004	2.3970	0.0913	0.0835	0.7233	0.0953
Total County-level OSD Emissions					1.425	0.004	10.779	0.405	0.378	2.097	0.361
48201	Harris	2280002100	Diesel - Port	1,261	0.0040	0.0000	0.0196	0.0007	0.0007	0.0002	0.0004
48201	Harris	2280002200	Diesel - Underway	135,766	0.4285	0.0015	2.1078	0.0773	0.0749	0.0259	0.0482
48201	Harris	2280003100	Residual - port	760,774	1.4810	0.0015	16.3875	0.6243	0.5707	4.9452	0.6517
48201	Harris	2280003200	Residual - Underway	159,885	0.3112	0.0006	3.4440	0.1312	0.1199	1.0393	0.1370
Total County-level OSD Emissions					2.225	0.004	21.959	0.833	0.766	6.011	0.837
48239	Jackson	2280002100	Diesel - Port	182	0.0001	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000
48239	Jackson	2280002200	Diesel - Underway	129	0.0003	0.0000	0.0016	0.0001	0.0001	0.0000	0.0000
48239	Jackson	2280003100	Residual - port	333	0.0001	0.0000	0.0007	0.0000	0.0000	0.0002	0.0000
48239	Jackson	2280003200	Residual - Underway	847	0.0013	0.0000	0.0146	0.0006	0.0005	0.0044	0.0006
Total County-level OSD Emissions					0.002	0.000	0.017	0.001	0.001	0.005	0.001

Table 4-2. Summary of 2011 Commercial Marine Vessel Emission (Continued)

2011 Ozone Season Day Emissions (TPD)

FIPS	County Name	Source Classification Code		Sum of Activity Value	CO	NH3	NOx	PM10-PRI	PM25-PRI	SO2	VOC
48245	Jefferson	2280002100	Diesel - Port	58,704	0.0185	0.0000	0.0911	0.0033	0.0032	0.0011	0.0021
48245	Jefferson	2280002200	Diesel - Underway	96,021	0.2691	0.0010	1.3240	0.0485	0.0471	0.0163	0.0303
48245	Jefferson	2280003100	Residual - port	50,772	0.0099	0.0000	0.1094	0.0042	0.0038	0.0330	0.0043
48245	Jefferson	2280003200	Residual - Underway	161,209	0.2511	0.0005	2.7780	0.1058	0.0967	0.8383	0.1105
Total County-level OSD Emissions					0.549	0.002	4.302	0.162	0.151	0.889	0.147
48261	Kenedy	2280002100	Diesel - Port	542	0.0002	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000
48261	Kenedy	2280002200	Diesel - Underway	366	0.0009	0.0000	0.0045	0.0002	0.0002	0.0001	0.0001
48261	Kenedy	2280003100	Residual - port	5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48261	Kenedy	2280003200	Residual - Underway	77	0.0001	0.0000	0.0013	0.0001	0.0000	0.0004	0.0001
Total County-level OSD Emissions					0.001	0.000	0.007	0.000	0.000	0.000	0.000
48273	Kleberg	2280002100	Diesel - Port	4,473	0.0014	0.0000	0.0069	0.0003	0.0002	0.0001	0.0002
48273	Kleberg	2280002200	Diesel - Underway	3,222	0.0081	0.0000	0.0400	0.0015	0.0014	0.0005	0.0009
48273	Kleberg	2280003100	Residual - port	6,443	0.0013	0.0000	0.0139	0.0005	0.0005	0.0042	0.0006
48273	Kleberg	2280003200	Residual - Underway	17,269	0.0269	0.0001	0.2976	0.0113	0.0104	0.0898	0.0118
Total County-level OSD Emissions					0.038	0.000	0.358	0.014	0.013	0.095	0.013
48291	Liberty	2280002100	Diesel - Port	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48291	Liberty	2280002200	Diesel - Underway	7	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
Total County-level OSD Emissions					0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4-2. Summary of 2011 Commercial Marine Vessel Emission (Continued)

2011 Ozone Season Day Emissions (TPD)

FIPS	County Name	Source Classification Code		Sum of Activity Value	CO	NH3	NOx	PM10-PRI	PM25-PRI	SO2	VOC
48321	Matagorda	2280002100	Diesel - Port	17,929	0.0057	0.0000	0.0278	0.0010	0.0010	0.0003	0.0006
48321	Matagorda	2280002200	Diesel - Underway	36,812	0.1079	0.0004	0.5310	0.0195	0.0189	0.0065	0.0121
48321	Matagorda	2280003100	Residual - port	44,076	0.0086	0.0000	0.0949	0.0036	0.0033	0.0287	0.0038
48321	Matagorda	2280003200	Residual - Underway	92,932	0.1447	0.0003	1.6014	0.0610	0.0558	0.4833	0.0637
Total County-level OSD Emissions					0.267	0.001	2.255	0.085	0.079	0.519	0.080
48355	Nueces	2280002100	Diesel - Port	30,613	0.0097	0.0000	0.0475	0.0017	0.0017	0.0006	0.0011
48355	Nueces	2280002200	Diesel - Underway	80,439	0.2266	0.0008	1.1149	0.0409	0.0396	0.0137	0.0255
48355	Nueces	2280003100	Residual - port	61,799	0.0120	0.0000	0.1331	0.0051	0.0046	0.0402	0.0053
48355	Nueces	2280003200	Residual - Underway	180,894	0.2817	0.0006	3.1172	0.1188	0.1086	0.9407	0.1240
Total County-level OSD Emissions					0.530	0.001	4.413	0.166	0.155	0.995	0.156
48361	Orange	2280002100	Diesel - Port	5,561	0.0018	0.0000	0.0086	0.0003	0.0003	0.0001	0.0002
48361	Orange	2280002200	Diesel - Underway	28,314	0.0869	0.0003	0.4275	0.0157	0.0152	0.0053	0.0098
48361	Orange	2280003100	Residual - port	2,234	0.0004	0.0000	0.0048	0.0002	0.0002	0.0015	0.0002
48361	Orange	2280003200	Residual - Underway	6,626	0.0103	0.0000	0.1142	0.0043	0.0040	0.0345	0.0045
Total County-level OSD Emissions					0.099	0.000	0.555	0.021	0.020	0.041	0.015
48391	Refugio	2280002100	Diesel - Port	285	0.0001	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000
48391	Refugio	2280002200	Diesel - Underway	197	0.0005	0.0000	0.0025	0.0001	0.0001	0.0000	0.0001

Table 4-2. Summary of 2011 Commercial Marine Vessel Emission (Continued)

2011 Ozone Season Day Emissions (TPD)

FIPS	County Name	Source Classification Code		Sum of Activity Value	CO	NH3	NOx	PM10-PRI	PM25-PRI	SO2	VOC
48391	Refugio	2280003100	Residual - port	182	0.0000	0.0000	0.0004	0.0000	0.0000	0.0001	0.0000
48391	Refugio	2280003200	Residual - Underway	508	0.0008	0.0000	0.0087	0.0003	0.0003	0.0026	0.0003
Total County-level OSD Emissions					0.001	0.000	0.012	0.000	0.000	0.003	0.000
48409	San Patricio	2280002100	Diesel - Port	8,010	0.0025	0.0000	0.0124	0.0005	0.0004	0.0002	0.0003
48409	San Patricio	2280002200	Diesel - Underway	203,912	0.6385	0.0023	3.1411	0.1151	0.1117	0.0386	0.0719
48409	San Patricio	2280003100	Residual - port	14,751	0.0029	0.0000	0.0318	0.0012	0.0011	0.0096	0.0013
48409	San Patricio	2280003200	Residual - Underway	39,944	0.0622	0.0001	0.6883	0.0262	0.0240	0.2077	0.0274
Total County-level OSD Emissions					0.706	0.002	3.874	0.143	0.137	0.256	0.101
48469	Victoria	2280002100	Diesel - Port	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48469	Victoria	2280002200	Diesel - Underway	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48469	Victoria	2280003100	Residual - port	11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
48469	Victoria	2280003200	Residual - Underway	155	0.0002	0.0000	0.0027	0.0001	0.0001	0.0008	0.0001
Total County-level OSD Emissions					0.000	0.000	0.003	0.000	0.000	0.001	0.000
48489	Willacy	2280002100	Diesel - Port	114	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
48489	Willacy	2280002200	Diesel - Underway	6,182	0.0195	0.0001	0.0957	0.0035	0.0034	0.0012	0.0022
48489	Willacy	2280003100	Residual - port	143	0.0000	0.0000	0.0003	0.0000	0.0000	0.0001	0.0000
48489	Willacy	2280003200	Residual - Underway	1,015	0.0016	0.0000	0.0175	0.0007	0.0006	0.0053	0.0007
Total County-level OSD Emissions					0.021	0.000	0.114	0.004	0.004	0.007	0.003

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Appendix A
Commercial Marine Vessel Emission Factors

Table A-1. 2011 Criteria Emission Factors for Marine Vessels

	Emission Factors (g/kW-hr)					
	CO	NOx	PM10	PM2.5	SO2	VOC
Category 1 & 2	2.86	14.08	0.52	0.50	0.17	0.32
Category 3	1.77	19.54	0.74	0.68	5.90	0.78

Table A-2. Hazardous Air Pollutants for vessel equipped with Category 1 and 2 Propulsion Engines

Pollutant	Basis for Speciation	Speciation Profile	
		Port	Underway
2,2,4-trimethylpentane	VOC	3.00E-04	2.50E-04
Acenaphthene	$PM_{2.5}$	1.80E-05	1.50E-05
Acenaphthylene	$PM_{2.5}$	2.78E-05	2.31E-05
Acetaldehyde	VOC	5.57E-02	4.64E-02
Acrolein	VOC	2.63E-03	2.19E-03
Ammonia	PM_{10}	1.00E-02	2.00E-02
Anthracene	$PM_{2.5}$	2.78E-05	2.31E-05
Arsenic	PM_{10}	1.75E-05	3.00E-05
Benz[a]Anthracene	$PM_{2.5}$	3.00E-05	2.50E-05
Benzene	VOC	1.53E-02	1.27E-02
Benzo[a]Pyrene	PM_{10}	2.50E-06	5.00E-06
Benzo[b]Fluoranthene	PM_{10}	5.00E-06	1.00E-05
Benzo[g,h,I,]Perylene	$PM_{2.5}$	6.75E-06	5.63E-06
Benzo[k]Fluoranthene	PM_{10}	2.50E-06	5.00E-06
Cadmium	PM_{10}	2.83E-06	5.15E-06
Chromium III	PM_{10}	1.65E-05	3.30E-05
Chromium VI	PM_{10}	8.50E-06	1.70E-05
Chrysene	$PM_{2.5}$	5.25E-06	4.38E-06
Copper	PM_{10}	9.58E-04	1.75E-03
Dioxin	PM_{10}	2.50E-09	5.00E-09
Ethylbenzene	VOC	1.50E-03	1.25E-03
Fluoranthene	$PM_{2.5}$	1.65E-05	1.38E-05
Fluorene	$PM_{2.5}$	3.68E-05	3.06E-05
Formaldehyde	VOC	1.12E-01	9.35E-02
HCB	PM_{10}	2.00E-08	4.00E-08
Indeno[1,2,3-c,d]Pyrene	PM_{10}	5.00E-06	1.00E-05

Table A-2. Hazardous Air Pollutants for vessel equipped with Category 1 and 2 Propulsion Engines (Continued)

Pollutant	Basis for Speciation	Speciation Profile	
		Port	Underway
Lead	PM_{10}	7.50E-05	1.50E-04
Manganese	PM_{10}	1.53E-06	1.28E-06
Mercury	PM_{10}	2.50E-08	5.00E-08
Naphthalene	$PM_{2.5}$	1.05E-03	8.76E-04

Pollutant	Basis for Speciation	Speciation Profile	
		Port	Underway
n-Hexane	VOC	4.13E-03	3.44E-03
Nickel	PM_{10}	5.00E-04	1.00E-03
PCB	PM_{10}	2.50E-07	5.00E-07
Phenanthrene	$PM_{2.5}$	4.20E-05	3.50E-05
Propionaldehyde	VOC	4.58E-03	3.81E-03
Pyrene	$PM_{2.5}$	2.93E-05	2.44E-05
Selenium	PM_{10}	2.83E-08	5.15E-08
Styrene	VOC	1.58E-03	1.31E-03
Toluene	VOC	2.40E-03	2.00E-03
Xylene	VOC	3.60E-03	3.00E-03
Zinc	PM_{10}	5.00E-04	1.00E-03

Table A-3. Hazardous Air Pollutants for vessel equipped with Category 3 Propulsion Engines

Pollutant	Basis for Speciation	Speciation Profile	
		Port	Underway
Acenaphthene	$PM_{2.5}$	3.40E-07	3.40E-07
Acenaphthylene	$PM_{2.5}$	5.25E-07	5.25E-07
Acetaldehyde	VOC	2.29E-04	2.29E-04
Ammonia	PM_{10}	2.38E-03	4.77E-03
Anthracene	$PM_{2.5}$	5.25E-07	5.25E-07
Arsenic	PM_{10}	8.74E-05	1.75E-04
Benz[a]Anthracene	$PM_{2.5}$	5.67E-07	5.67E-07
Benzene	VOC	9.80E-06	9.80E-06
Benzo[a]Pyrene	PM_{10}	4.37E-07	8.74E-07
Benzo[b]Fluoranthene	PM_{10}	8.74E-07	1.75E-06
Benzo[g,h,I,]Perylene	$PM_{2.5}$	1.28E-07	1.28E-07
Benzo[k]Fluoranthene	PM_{10}	4.37E-07	8.74E-07
Beryllium	PM_{10}	5.46E-07	5.46E-07
Cadmium	PM_{10}	2.26E-05	2.26E-05
Chromium III	PM_{10}	1.27E-04	1.27E-04

Table A-3. Hazardous Air Pollutants for vessel equipped with Category 3 Propulsion Engines (Continued)

Pollutant	Basis for Speciation	Speciation Profile	
		Port	Underway
Chromium VI	PM_{10}	6.53E-05	6.53E-05
Chrysene	$PM_{2.5}$	9.93E-08	9.93E-08
Cobalt	PM_{10}	5.94E-05	1.54E-04
Copper	PM_{10}	1.91E-04	3.48E-04
Dibenzo[a,h]Anthracene	$PM_{2.5}$	0.00E+00	0.00E+00
Dioxin	PM_{10}	4.37E-10	8.74E-10
Fluoranthene	$PM_{2.5}$	3.12E-07	3.12E-07
Fluorene	$PM_{2.5}$	6.95E-07	6.95E-07

Pollutant	Basis for Speciation	Speciation Profile	
		Port	Underway
Formaldehyde	VOC	1.57E-03	1.57E-03
HCB	PM_{10}	3.50E-09	6.99E-09
Indeno[1,2,3-c,d]Pyrene	PM_{10}	8.74E-07	1.75E-06
Lead	PM_{10}	1.40E-05	2.62E-05
Manganese	PM_{10}	5.73E-05	5.73E-05
Mercury	PM_{10}	2.71E-07	5.24E-07
Naphthalene	$PM_{2.5}$	1.99E-05	1.99E-05
Nickel	PM_{10}	3.25E-03	5.89E-03
PCB	PM_{10}	4.37E-08	8.74E-08
Phenanthrene	$PM_{2.5}$	7.94E-07	7.94E-07
Phosphorus	PM_{10}	1.79E-03	5.73E-03
POM as 16-PAH	$PM_{2.5}$	2.49E-05	2.49E-05
POM as 7-PAH	PM_{10}	4.90E-07	4.90E-07
Pyrene	$PM_{2.5}$	5.53E-07	5.53E-07
Selenium	PM_{10}	1.91E-06	3.48E-06
Zinc	PM_{10}	1.31E-04	2.62E-04