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Attached is the draft "Air Resources Board Emission Estimation Methodology for Commercial Harbor Craft Operating in California." This document provides a description of the methodology developed to estimate emissions from commercial harbor craft and the estimated emissions for harbor craft.

This draft is being released so comments can be made on the methodology. Please do not cite or quote from this draft document, as it is possible that the methodology and the estimated emissions may change based on the comments we receive.

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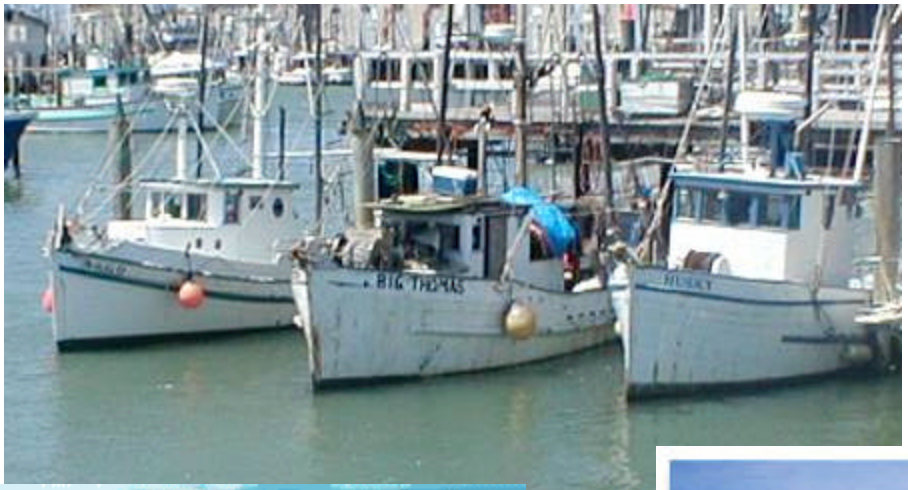
Emission Estimation Methodology for Commercial Harbor Craft Operating in California



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[to be added]

EXECUTIVE SUMMARY

The California Air Resources Board (ARB) staff developed a new statewide emission estimation methodology for commercial harbor craft. This effort was undertaken to improve the current emissions estimates for commercial harbor craft and to support the development of a statewide emission control strategy addressing emissions from commercial harbor craft. Elements of the updated statewide methodology included an updated population of commercial harbor craft statewide by vessel type, improved activity profiles by vessel type, and the development of updated emission factors. Emissions estimates were developed for nine vessel types including commercial fishing vessels, charter fishing vessels (including "party boats"), ferries, crew and supply vessels, pilot vessels, tugboats, towboats, workboats, and "others."

Based on the methodology, the ARB staff estimates that in 2003, commercial harbor craft diesel-fueled engines in California emitted 3.7 tons per day of diesel PM. In addition, those engines are estimated to have emitted 69.7 tons per day of oxides of nitrogen (NOx), 5.5 tons per day of hydrocarbons, and 14.6 tons per day of carbon monoxide (CO). As shown in Table ES-1, commercial fishing vessels, ferries and excursion vessels, and tug boats are the responsible for approximately 75 percent of the emissions for all pollutants.

Table ES-1
Estimated Statewide 2003 Commercial Harbor Craft Emissions

Vessel Category	Numbers of Vessels	2003 Pollutant Emissions, Tons/Day			
		NOx	HC	CO	PM
Commercial Fishing	**2,669**	22.3	1.5	4.1	0.9
Charter Fishing	**536**	10.8	0.9	2.4	0.6
Crew and Supply	**71**	1.1	0.1	0.3	0.1
Ferries/ Excursion	**405**	20.6	1.7	4.5	1.0
Pilot	**32**	0.7	0.1	0.1	0
Tug	**128**	10.5	0.9	2.4	0.5
Tow	**35**	2.0	0.2	0.4	0.1
Workboats	**90**	0.5	0	0.1	0
Other	**135**	1.2	0.1	0.3	0.1
Totals	**4,101**	69.7	5.5	14.6	3.7

Emissions were also allocated to the districts based on the hailing or home port information provided by the principle sources of vessel population information. A summary of the five districts responsible for approximately 80% of the statewide emissions from commercial harborcraft is presented in Table ES-2. As is shown, the top 5 districts were all located on the Pacific Ocean coastline of California. [1]

Table ES-2
Estimated 2003 Commercial Harbor Craft Emissions for Selected Districts

District	Vessel Population	2003 Pollutant Emissions, Tons/Day			
		NOx	HC	CO	PM
Bay Area	**1,183**	21.6	1.7	4.6	1.0
SCAQMD	**848**	18.3	1.5	4.1	0.9
San Diego	**339**	8.5	0.7	1.9	0.4
Monterey Bay Unified	**395**	3.3	0.3	0.7	0.2
North Coast Unified	**417**	3.1	0.3	0.7	0.2
Totals	**3,182**	54.9	4.5	12.1	2.7

[1] In some cases, the district-specific estimates may not agree with current district estimates.

I. INTRODUCTION

In this chapter, ARB staff provides background on the harbor craft emissions inventory, our purpose and goals in preparing an emissions inventory update, and a general overview of the methodology developed to estimate the emissions from commercial harbor craft.

A. Background

Commercial harbor craft are vessels used for commercial purposes or to support public services. There are several types of harbor craft including crew and supply boats, charter fishing vessels, commercial fishing vessels, ferry or excursion vessels, pilot vessels, towboat or push boats, tug boats and work boats. These vessels generally operate within California coastal waters and inland waterways[2] and have a home port located in California although some vessels may reside for a period of time outside of California. For the purposes of this inventory, commercial harbor craft do not include recreational vessels used for personal pleasure or the larger ocean-going vessels generally used to transport cargo.

With respect to commercial harbor craft emission inventories, the local air pollution control districts have historically been responsible for the development of emission estimates and the submittal of updates to the California Emission Inventory Development and Reporting System (CEIDARS). California's air pollution control districts (APCD) and air quality management districts (AQMD) use a variety of approaches to develop district-specific harbor craft emission inventories. For example, the Monterey Bay Unified APCD uses statewide diesel fuel usage estimates; the North Coast Unified AQMD uses the U.S. Environmental Protection Agency's compilation of emission factors (AP-42); the Bay Area AQMD uses the 1991 Booz, Allen, and Hamilton methodology for estimating emissions from marine vessels; and the San Diego County APCD, the Santa Barbara County APCD, the South Coast AQMD, and the Ventura County APCD all follow the methodology developed in 1999 by Acurex.

According to the 2004 California Almanac of Emissions and Air Quality, commercial harbor craft diesel-fueled compression ignition engines operating in California waters emitted 1.14 tons per day of diesel PM. In addition, those engines are estimated to have emitted 20.67 tons per day of oxides of nitrogen (NOx), 2.13 tons per day of hydrocarbons, and 5.57 tons per day of carbon monoxide (CO).

[2] California Coastal Waters were defined in the ARB document, "Report to the Legislature on Air Pollutant Emissions From Marine Vessels," June 1984 and are defined, using meteorological data, as the area offshore of California within which pollutants are likely to be transported ashore and affect air quality in California's coastal air basins.

B. Purpose and Overview

Our goals in undertaking this emissions inventory update were to:

- Develop a consistent methodology that could be used statewide to estimate emissions from commercial harbor craft,
- Establish a structure that would allow allocation of the statewide emissions to individual counties and air pollution control districts,
- Integrate the updated commercial harbor craft inventory into the ARB's OFFROAD model,
- Update the inventory to reflect the most current harbor craft fleet;
- Accurately reflect adopted regulations and other regulatory programs in the baseline inventory and in any forecasts

The emission estimation methodology estimates the statewide population and emissions for compression ignition diesel-fueled engines associated with commercial harbor craft. These engines include the propulsion and auxiliary engines. For most commercial harbor craft, the propulsion engines are the primary engines and move the vessel through the water. The auxiliary engines generally provide power to the vessels electrical systems and can also provide additional power to unique, essential vessel equipment (i.e. refrigeration units) during the normal day-to-day operation of the vessel.

Emission estimates were developed for 9 categories of commercial harbor craft vessels. The nine categories are described in Table I-1. Estimates for oxides of nitrogen (NOx), hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM) were made.

Table I-1
Categories of Commercial Marine Harbor Craft Included in the Emissions Inventory

Vessel Type	Description
Commercial Fishing	Vessels used in the search and collection of fish for the purpose of sale at market
Commercial Charter Fishing	Vessels available for hire by the general public and used for the search and collection of fish for the purpose of personal consumption
Crew and Supply	Vessels used for carrying personnel and supplies to and from off-shore and in-harbor locations
Ferry/Excursion	Vessels used for public use in the transportation of persons or property
Pilot	Vessels used to guide ocean-going vessels into and out of a port or harbor
Towboat/Pushboat	Vessels used to tow/push barges and pontoons. The hull of these vessels is usually rectangular in plan and has little freeboard.
Tug Boats	Vessels used for the towing and pushing of ships or other floating structures such as barges
Work boat	Vessels used to perform duties such as fire/rescue, law enforcement, hydrographic surveys, spill/response research, training, and construction
Other	Vessels used in various commercial operations that do not fit into any other category such as vessels used to dispose of cremated remains.

C. Public Process

[to be added]

II. EMISSIONS CALCULATION METHODOLOGY

In this chapter we provide a discussion on the methodology followed to generate the emissions inventory and the assumptions and data inputs used.

Briefly, the approach used to develop the harbor craft emissions inventory estimates entailed determining the average daily emissions per engine for the nine categories of vessels using the individual profiles developed using the ARB Survey. This was accomplished using the ARB's HARBOR model to estimate annual, or daily, emissions per engine for each engine reported in the ARB Survey. The HARBOR model is discussed in detail in Chapter III of this document. This data was then used to estimate average emissions for each vessel category by engine use. To estimate total statewide emissions, the populations of vessels and engines was estimated for each district and then multiplied by the average daily emissions per engine.

Below, we provide a more detailed discussion of the methodology used to estimate the commercial harbor craft emission inventory, including the assumptions and data inputs used.

A. Methodology

As a starting point, the basic equation for the emissions estimate ARB staff developed is:

$$P_{t,i,y} = S\,Pop_{t,i,v} * Eng_{t,i} * HP * \%Load * EF_{i,v} * Hrs_{i,v}$$

where

P = pollutant (HC, CO, NO_x, PM, and CO_2)[3]
Pop = vessel population
Eng = average number of engines
HP = engine rated brake horsepower
% Load = average engine load
EF = emission factor
Hrs = annual use (actual hours)
y = inventory year
t = vessel type (fishing, tug, etc)
i = engine type (auxiliary or propulsion)
v = engine age (based on model year)

We will discuss each of these basic elements and how they were incorporated into the commercial harbor craft emission estimates. The base year for the

[3] SO_2 will be estimated using the percent sulfur found in the different types of diesel fuel used statewide.

commercial harbor craft inventory is 2003. A flow chart depicting the development of the commercial harbor craft emission inventory is presented in Appendix A and discussed below.

B. Vessel Population and Vessel Profiles

The commercial harbor craft vessel populations were developed based on data available from the U.S. Coast Guard, the California Department of Fish and Game, the ARB Commercial Harbor Craft Survey, and information from recent emission inventory estimates generated for the Port of Los Angeles. Each of these sources of commercial harbor craft information is described in greater depth below. In addition, the specific steps taken to develop estimates of numbers of specific vessel types and spatially allocate those populations is also described below.[4]

The principle sources of the state-wide harbor craft population estimates include:

United States Coast Guard Vessel Data:

The United States Coast Guard (USCG) administers a vessel documentation program. The USCG vessel documentation program is a national form of registration. The ARB purchased the U.S. Coast Guard documentation data through the National Technical Information Service.

Types of vessels that are documented vessels include:

- those that measure at least five net tons (a measure of the vessel's volume, most vessels more than 25 feet in length will measure five net tons or more)
- wholly owned by a citizen of the United States (with the exception of certain oil spill response vessels)
- vessels of five net tons or more used in fishing activities on navigable waters of the United States or in the Exclusive Economic Zone (EEZ)
- vessels used in coastwise trade (transportation of merchandize or passengers between points in the United States)
- towboats operating between points and dredges operating in United States or the EEZ must be documented.

[4] In early 2004, ARB staff contacted approximately 60 of California's harbormasters and port and marina administrators. Using a brief two-page survey, ARB staff collected estimates of the current commercial harbor craft populations for the nine vessel types described earlier in this document. ARB staff was able to obtain numbers of commercial harbor craft at all but one of the harbors, ports, and marinas contacted. This information was used as a reality check of the estimates using the four population data sources listed above.

The information provided represents nation-wide vessel documentation information for the years 1985 through June 2001. ARB staff sorted the data by state and removed all non-California documented vessels. The majority of the vessels that are California documented vessels fall into one of five categories of vessels. Those categories are commercial, fishing, offshore supply, passenger, tow/tugboats, and unclassified.

The advantages of using the USCG vessel documentation database are:

1) It was generated by a registration program administered by a branch of the United States government.
2) It is one of the few available databases with such comprehensive information about U.S.-based merchant vessels.
3) It contains information about a wide variety of vessels.
4) It contains names and addresses of the owner/operators.

The disadvantages of using the USCG vessel documentation database are:

1) It is dated, the registrations of many of the listed vessels have expired.
2) Vessels may not operate out of their registered port.
3) It's possible that not all vessels operating in California ports are registered.
4) For fishing vessels, it's impossible to differentiate between commercial vessels and charter vessels.

California Department of Fish and Game Data:

The California Department of Fish and Game (DFG) registers all commercial fisherpersons, fishing vessels, passenger fishing boats, and fish businesses in California. The Department of Fish and Game provided us with their file of the commercial fishing permits registrations issued for 2004. That information was used to evaluate the commercial and charter fishing categories of commercial harbor craft.

Port of Los Angeles Fishing Vessel Data:

During the course of the development of a port-wide emission inventory, the Port of Los Angeles (the Port) collected information about the commercial fishing vessels that operate out of the Port. The Port provided the ARB with vessel names and owner/operator contact information for approximately 250 commercial fishing vessels.

ARB's Commercial Harbor Craft Survey (March 2004):

The ARB conducted a survey of commercial harbor craft owner/operators in an effort to collect information about where the different types of harbor craft in the State operate, vessel activity, and engine-specific information (ARB's Statewide

Commercial Harbor Craft Survey, or ARB Survey). Owners/operators of commercial fishing vessels, tugs, ferries and excursion vessels, work and tow boats, and crew and supply boats were sent a copy of the ARB's survey in late 2002. The survey requested information about the home port, the type of vessel, if the vessel was used for commercial fishing, the type of fishery targeted, annual fuel use, information about where the vessel generally operated, and engine information (make and model of the engine, is it a propulsion or auxiliary engine, horsepower, was it a repower, annual hours of use, etc.).

The survey was sent to more than 5,000 owner/operators statewide and the ARB received more than 700 responses were submitted representing approximately 850 vessels. For the purposes of developing a estimate of emissions from commercial harbor craft, the ARB staff consider the results of the Survey to be representative of the population of commercial harbor craft statewide. A copy of the Survey is provided in Appendix B.

Estimating the Vessel Populations:

To establish a data base from which to estimate the statewide commercial harbor craft vessel populations, the information from the USCG, the California Department of Fish and Game (DFG), the Port of Los Angeles (POLA), and the ARB commercial harbor craft survey were each segregated into four major groups: ferries/excursions, fishing, other, and work. These four groupings were selected for commercial harbor craft population estimate development because those are the four primary groups the USGC uses to classify commercial harbor craft. The information from the DFG, the POLA and the USCG fishing were grouped with the information from the ARB's commercial harbor craft survey for commercial fishing and charter vessel data to develop the statewide population estimates for commercial fishing vessels. Ferry, crew and supply, and pilot vessel information from the ARB commercial harbor craft survey were grouped with the USCG ferries/excursion vessel data to develop statewide population estimates for ferries/excursion vessels. The ARB commercial harbor craft survey data for tugs, tow boats and work boats were added to the USCG work group data to develop statewide population estimates for work boats. The others data from the ARB commercial harbor craft survey were added to the USCG's other group data to develop statewide population estimates for other types of commercial harbor craft.

Duplicates within a group were removed.[5] After that process was completed, it appeared as though there were an unusually high number of ferry/excursion vessels. That group was then combined with the fishing group and the removal

[5] Duplicates were removed by matching vessel names and owner/operator names and addresses. If there was no match between the vessel name and the owner/operator address, both (or, however many vessels had the same name and different owner/operator address information) were included in our evaluation of statewide commercial vessel populations.

of duplicates process repeated. Any vessels that overlapped between these two groups were removed from the ferry/excursion group.

Each population was then assigned to a county and a district based on their reported home port.[6] The distribution of vessels into the nine inventory categories was determined based on district-specific vessel distribution ratios developed using information from the ARB commercial harbor craft survey. As shown in Table II-1, fishing vessels account for the largest percentage of vessels at 77 percent of the total commercial harbor craft population. A summary of the district commercial harbor craft vessel population allocations is provided in Table II-2.

Based on this approach, we estimate that there are approximately 4,100 harbor craft vessels statewide.

Table II-1
Estimated Statewide Harbor Craft Vessel Population

Vessel Use	Estimated 2003 Population
Commercial Fishing Vessels	2,669
Charter Fishing Vessels	536
Ferries/Excursion Vessels	71
Crew and Supply Vessels	405
Pilot Vessels	32
Tug Boats	128
Tow Boats	35
Work Boats	90
Others	135
Total	4,101

[6] Those vessels that did not have a "home port" listed (11 percent of the vessels) were assigned one based on the address of the owner/operator. Those vessels that reported a "home port" out side of California (4 percent of the vessels) were assigned to counties and districts based on general consensus by ARB staff.

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Table II-2
District - By - District Vessel Type Counts

District	Vessel Type/Population									Totals
	Comm. Fishing	Charter Fishing	Ferries	Crew and Supply	Pilot Vessels	Tug Boats	Tow Boats	Work Boats	Other	
Amador	0	0	0	0	0	0	0	0	0	0
Antelope Valley	0	0	0	0	0	0	0	0	0	0
Bay Area	757	113	137	19	0	53	23	29	53	1183
Butte	2	1	0	0	0	0	0	1	1	5
Calaveras	0	0	0	0	0	0	0	0	0	0
Colusa	0	0	0	0	0	0	0	0	0	0
El Dorado	16	4	3	1	0	0	0	0	0	24
Feather River	0	0	0	0	0	0	0	0	1	1
Glenn	0	0	0	0	0	0	0	0	0	0
Great Basin	1	0	0	0	0	0	0	0	0	1
Imperial	0	0	0	0	0	0	0	0	0	0
Kern	0	0	0	0	0	0	0	0	0	0
Lake	1	0	0	0	0	0	0	0	0	1
Lassen	0	0	0	0	0	0	0	0	1	1
Mariposa	0	0	0	0	0	0	0	0	0	0
Mendocino	204	6	3	0	0	0	0	1	1	215
Modoc	0	0	0	0	0	0	0	0	0	0
Mojave	0	0	0	0	0	0	0	0	0	0
Monterey Bay	356	19	13	0	0	0	0	0	7	395
North Coast	397	8	0	6	0	3	0	2	1	417
Northern Sierra	0	0	0	0	0	0	0	0	1	1
Northern Sonoma	149	11	4	1	0	0	0	0	1	166
Placer	14	3	4	1	0	0	0	0	2	24
Sacramento	19	4	2	0	0	5	3	8	2	43
San Diego	122	100	75	0	0	17	8	2	15	339
San Joaquin	18	6	5	1	1	1	0	1	1	34
San Luis Obispo	147	9	3	3	0	2	0	1	0	165
Santa Barbara	68	18	7	6	0	1	0	4	4	108
Shasta	0	0	0	0	0	0	0	0	0	0
Siskiyou	0	0	0	0	0	0	0	0	0	0
South Coast	304	220	141	32	30	41	1	39	39	848
Tehama	2	1	0	0	0	0	0	0	1	4
Tuolumne	0	0	0	0	0	0	0	0	0	0
Ventura	77	9	7	1	1	3	0	0	4	102
Yolo-Solano	15	4	1	0	0	2	0	2	0	24

Engine Profiles

The detailed data collected in the ARB's Statewide Commercial Harbor Craft Survey was used to develop individual engine profiles for each of the engines reported as a part of the Survey. As described previously, the Survey collected information about the various commercial harbor craft operating in California's coastal waters and inland waterways, harbors, and ports during 2002. The information collected included detailed vessel information including the vessel's home port, the vessel use, age, and annual fuel use, percent of hours operated at various distances off the California coast. In addition, the Survey collected information about the engines powering those vessels. That information included the number of engines, the engine make and model, the engine age, the engine's horsepower, and the engine's annual hours of operation.

Based on the Survey, individual engine profiles were developed by combining specific information about an engine. That information includes the engine use, the type of vessel the engine is associated with, the model year of the engine, the engine horsepower, the annual hours of operation, the typical engine load, the stroke of the engine (2 or 4), the engine manufacturer, the engine model, whether the exhaust from the engine is "wet" or "dry," whether the engine has been repowered or not, and a number of engine-specific and pollutant-specific emission factor elements. A list of engine-specific information used and the individual engine profiles are provided in Appendix H (the HARBOR model raw data output).

Military Vessels

In most of the recent commercial harbor craft emission inventories developed, emission estimates for U.S. Navy and/or U.S. Coast Guard (USCG) vessels have been included as a component of the commercial harbor craft population of vessels. As a result of the limited information currently available about the numbers of military vessels, vessel characteristics, and vessel activity, the ARB propose to including only historical estimates of emissions from those vessel types. [That information has yet to be incorporated into the emission estimates.]

C. Vessel Activity

Two of the key inputs mentioned in the engine profiles include an engine's annual hours of operation and the typical engine load.

The ARB Survey provided engine-specific annual use values. It was assumed that all of an engine's hours of operation occurred within the California Coastal Waters. The annual use values were used to estimate an engine's cumulative use. Cumulative use is estimated by multiplying the annual use by the age of the engine. This estimate of cumulative engine use was the basis for estimating the impacts of engine deterioration on individual engines. An in-depth discussion of

the how emission factor deterioration rates were developed and applied is found in Appendix F.

Load: The engine load under normal operating conditions is the second activity input. Information about the operating loads for commercial harbor craft engines is limited. The primary source of marine engine load factors was the U.S. EPA's Non-road Model. Using this model, a load value of 43% was assigned to all harbor craft vessel and engine types with the except of tugboat engines. A load value of 31% for assist tugs is based on the "Harbor Craft" element of the Port of Los Angeles' emission inventory report and was developed by the Starcrest Consulting Group, LLC.

D. Emission Factors

The proposed emission estimation methodology relies on power-based emission factors (g/bhp-hr). There are several sources of data currently available which provide information on emission factors for marine engines. These include the U.S. EPA's Compilation of Air Pollutant Emission Factors (AP-42), Lloyd's Register of Ships, U.S. EPA Category 1 marine engine emission factors, U.S. EPA Marine Engine Certification data, ARB OFFROAD Model, and actual emission testing results from a variety of vessels.

After evaluation of the available data (see Appendix D), we propose to use the emission factors for non-road engines set forth in the ARB OFFROAD Model with the following adjustment:

- for 1996 through 2003 model year engines, use the Tier Zero (1996) emission factors;
- for 2004 and beyond model year engines, use the U.S. EPA emission standards for marine engines (as applicable), and
- adjust the OFFROAD Model emission factors to reflect an "E3" test cycle for marine engines.[7]

No changes were made to the OFFROAD emission factors to differentiate between "wet" and "dry" exhaust from marine engines. This decision was made based on a lack of information definitively supporting any difference between the characteristics of the two methods of exhausting marine engine combustion gases.

[Note: ARB is continuing to evaluate available emission factors to determine if there are more representative emission factors for marine engines. If more

[7] Because the OFFROAD Model emission factors are based on a "C1" engine test cycle, ARB staff compared emission results from similar engines testing for both the "C1" and "E3" test cycles. Based on this evaluation, we recommended that the OFFROAD Model emission factors be adjusted to better reflect the "E3" test cycle. The adjustment factors are 1.19 for NOx, 0.72 for CO, and 0.94 for PM. A detailed discussion of the evaluation is provided in Appendix E.

appropriate emission factors are found, they will be incorporated into the final emission estimates.]

Developing an Estimate of Commercial Harbor Craft Engine Useful Life and the Development of Emission Factor Deterioration Curves

As an engine ages, the pollutant-specific emission factors slowly increase with age. This phenomenon is described as "deterioration." Deterioration occurs at different rates for each pollutant. When developing emission estimates, it is essential that deterioration be taken into account and factored in the emission estimation methodology. One of the critical elements of trying to typify deterioration is establishing the appropriate useful life for the source engines. Appendix F of this document describes the procedure used by ARB staff to establish the useful life of commercial harbor craft engines as well as the pollutant-specific emission factor deterioration curves.

E. Additional Issues to Be Addressed

[Note: There are a several assumptions of the proposed emission inventory where there was limited data and we would appreciate any input you may have regarding them. These include:

- *All of the hours a vessel operates occur in California Coastal Waters.*
- *Emission factors are the same for "wet" and "dry" exhaust engines.*
- *All commercial harbor craft engines are powered by diesel fuel.*
- *The Statewide Average Vessel Profile adequately represents the individual district vessel profiles.]*

III. EMISSION INVENTORY MODEL STRUCTURE

In this chapter, the computer program developed to estimate commercial harbor craft emissions is described. To aid in the discussion, we have called this model "HARBOR" to distinguish it from the ARB's OFFROAD Model at this time. Our goal is to incorporate HARBOR into the OFFROAD Model in the future.

A. Program Structure

HARBOR Structure

The HARBOR is designed to estimate the emissions for PM, HC, NOx, and CO from the harbor craft engines. The program provides an overall structure to incorporate the emission factor, deterioration rate, annual operation hour, engine age, horsepower, load factor, engine mode (2 or 4 stroke), operation mode (dry or wet), and Carol Moyer information (repower/non-repower). Unlike the OFFROAD or NONROAD, the program does not need to allocate engine/vessel population to each geographic region; rather it is designed to calculate the emissions for each harbor craft engine. District-by-district estimates of emissions are made based on this engine-specific information. The engine-specific, vessel-specific tons per day emission estimates generated using the HARBOR output are found in Appendix H.

The HARBOR model develops engine-specific emission data using a data file developed from the information provided by the ARB's commercial harbor craft survey (the Survey). The data file contains engine-specific information for each engine reported in the Survey. The HARBOR model needs several key fields populated in order for it to develop engine-specific emission estimates. Those fields include the engine horsepower, the engine age, and the annual hours of operation of the engine. Not all of these data fields were reported for all engines. The ARB staff used the Survey data to develop vessel-specific, engine use-specific, horsepower range-specific average values for those three data points. Staff then used that information to fill in the blank data fields that the HARBOR model works from. The vessel profiles used to fill in the blanks are found in Appendix C.

The overall structure is illustrated in Figure III-1. The program consists of four main modules: activity, emissions, adjustment, and outputs. The activity module contains such information as engine's annual operation hours, engine age, and load factor, which is a function of the vessel type. The emission module includes the zero-hour emission factors and deterioration factors for PM, HC, NOx, and CO. The adjustment module involves in three adjustment factors: fuel, wet/dry, and repower/non-repower. The outputs include two files: (1) emission and activity for each engine, which includes engine type, vessel type, vessel group, engine model year, annual operation hours, engine horsepower, load factor, cumulative hours, zero-hour emission factor, deterioration rate, annual

emissions, engine mode, operation mode, Carl Moyer information, engine/vessel maker, and engine model, and (2) total emissions for each pollutant sorted and summed by engine type, vessel type, vessel group, horsepower range, engine mode, operation mode, repower/non-repower, and location (distance zones from the shore). The definition for engine type, vessel type, vessel group, and horsepower range is listed in Table III-1.

The program is executed by:

(1) Reading a record for an engine, which includes engine type, vessel type, engine model year, horsepower, annual operation hours, load factor, engine mode (2/4 stroke), operation mode (dry/wet), Carol Moyer information (repower/non-repower), engine maker, and engine model;
(2) Sorting the record by the order: engine type, vessel type, horsepower range, and engine mode (2/4 stroke);
(3) Calculating emission factor and deterioration factor for each pollutant. The zero-hour emission factors and deterioration rates are a function of engine type, vessel type, and horsepower range. The deterioration factor is calculated by the deterioration rate (expressed in g/bhp-hr^2) multiplied by the cumulative hours, which is the product of the engine age and the average annual operation hours for specific engine type, vessel type, and horsepower range. The final emission factors used to calculate emissions are the sum of the zero-hour emission factor and the deterioration factor;
(4) Calculating the annual emissions for each engine and each pollutant. The adjustment factors for fuel, operation mode (wet/dry), and repower will be applied; and,
(5) Sorting and summing the emissions for each pollutant by engine type, vessel type, vessel group, horsepower range, engine mode (2/4 stroke), operation mode (dry/wet), repower/non-repower, and location (distance zones from the shore).

The HARBOR output file is presented in its entirety in Appendix G.

Table III-1
Engine Types, Vessel Groups, Vessel Types, and Horsepower Ranges used in the HARBOR Program

Engine Type	Vessel Group	Vessel Type	Horsepower Range
Propulsion	Fishing	Commercial Fishing	0-50, 50-120, 120-175, 175-250, 250-500, 500-750, 750-1000, 1000-1500, 1500-2000, 2000-3000, 3000+
		Charter Fishing	
	Transport	Ferry	
		Crew and Supply	
		Pilot	
	Working	Tugboats	
		Towboats	
		Workboats	
		Others	
Auxiliary	Fishing	Commercial Fishing	0-50, 50-120, 120-175, 175-250, 250-500, 500+
		Charter Fishing	
	Transport	Ferry	
		Crew and Supply	
		Pilot	
	Working	Tugboats	
		Towboats	
		Workboats	
		Others	

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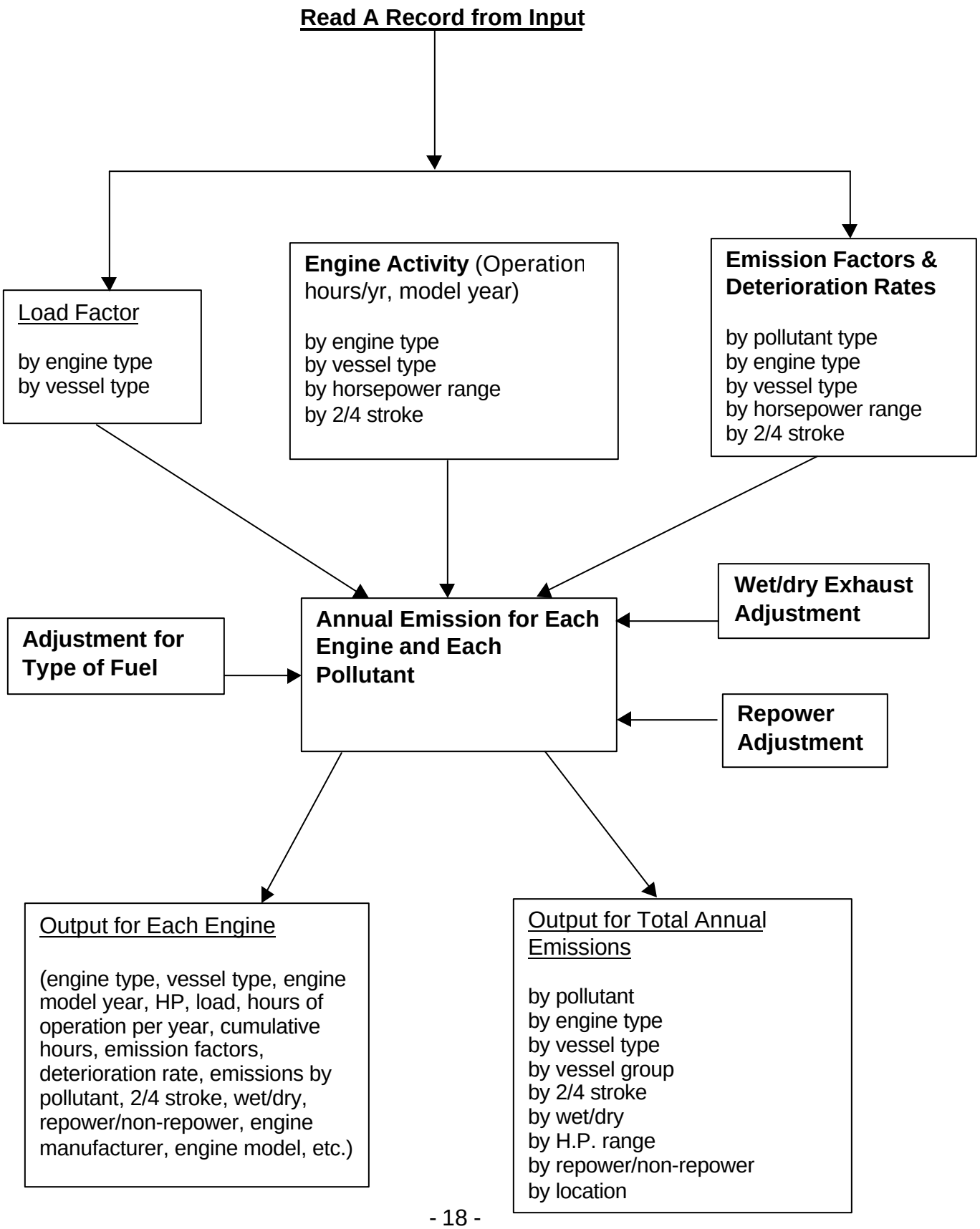
Figure III-1
Flowchart of Overall Program Structure of HABOR



It should be noted that there are a number of modules built into the HARBOR model that have not yet come into use. The "Adjustment for Fuel type," "Wet/dry Exhaust Adjustment," and "Repower Adjustment" modules have not been populated, but are available for use in future iterations of the HARBOR model.

[Note: the "by location" element of the "Output for Total Annual Emissions" module has not been incorporated in the first draft of the commercial harbor craft emission estimate, but ARB staff is in the process of incorporating that element in future iterations of the emission estimates]

IV. ESTIMATED EMISSIONS

A. Statewide Estimate

Using the proposed methodology, the ARB staff estimates that the statewide emissions from commercial harbor craft diesel-fueled engines in 2003 were 3.7 tons per day of diesel PM. In addition, those engines were estimated to have emitted 69.7 tons per day of oxides of nitrogen (NOx), 5.5 tons per day of hydrocarbons, and 14.6 tons per day of carbon monoxide (CO)2003 (in tons per day). The details of emission estimates for commercial harbor craft by vessel type are presented in Table IV-1.

Table IV-1
Estimated Statewide 2003 Commercial Harbor Craft Emissions

Vessel Category	Numbers of Vessels	2003 Pollutant Emissions, Tons/Day			
		NOx	HC	CO	PM
Commercial Fishing	**2,669**	22.3	1.5	4.1	0.9
Charter Fishing	**536**	10.8	0.9	2.4	0.6
Crew and Supply	**71**	1.1	0.1	0.3	0.1
Ferries/ Excursion	**405**	20.6	1.7	4.5	1.0
Pilot	**32**	0.7	0.1	0.1	0
Tug	**128**	10.5	0.9	2.4	0.5
Tow	**35**	2.0	0.2	0.4	0.1
Workboats	**90**	0.5	0	0.1	0
Other	**135**	1.2	0.1	0.3	0.1
Totals	**4,101**	69.7	5.5	14.6	3.7

In addition, also shown in Table IV-1, commercial fishing vessels, ferries and excursion vessels, and tug boats are the responsible for approximately 75 percent of the emissions for all pollutants.

There are any number of ways the commercial harbor craft emission estimates can be sorted and presented. Table IV-2 provides estimates of the tons per day of NOx by engine type by vessel type. Table IV-2 shows that propulsion engines account for 94 percent of NOx emissions from commercial harbor craft and commercial fishing and ferry/excursion vessels account for more than 60 percent of the NOx emissions associated with those types of engines.

Table IV-2
Estimated Statewide 2003 NOx Emissions By Engine Type Vessel Type

	Propulsion		Auxiliary	
Vessel Type	NOx (tpd)	%	NOx (tpd)	%
Commercial Fishing	20.58	31.4	1.71	43.8
Charter Fishing	10.31	15.7	0.47	12.1
Ferry/Excursion	20.08	30.6	0.53	13.6
Crew & Supply	0.82	1.2	0.26	6.6
Pilot	0.66	1.0	0.00	0.049
Tug Boats	9.82	15.0	0.64	16.3
Tow Boat	1.77	2.7	0.18	4.7
Work Boat	0.44	0.7	0.08	2.1
Others	1.15	1.7	0.03	0.8
Total	65.6		3.9	

B. District-by-District Estimates

Estimates of emissions from commercial harbor craft were made on a district-by-district basis using the numbers of specific vessel types located in each district. A summary of district-specific emissions for NOx, HC, CO, and PM is provided in Table IV-5. These estimates were made using the following equation:

$$P_{t,i} = S\,Pop_{t,i} * \#\ of\ Engines_{t,i} * Ems_{t,i}$$

where

P = pollutant (HC, CO, NO_x, and PM)
Pop = district-specific vessel population
# of Engines = average numbers of engines
Ems = annual average emissions (tpd) (from HARBOR model)
t = vessel type (fishing, tug, etc)
i = engine type (auxiliary or propulsion)

The numbers of propulsion and auxiliary engines associated with each fleet in each district has been estimated by multiplying the numbers of vessels of a specific type by the average numbers of engines per vessel type. The average numbers of engines by engine type and vessel type are estimated using the ARB Survey. An estimate of the average annual emissions of a specific pollutant from a specific type of vessel's engine were estimated using the baseline information generated by HARBOR. Those values were then multiplied by the numbers of engines per district to estimate the average annual emissions for a specific

district. The details of this step of the emission estimation process is presented in Appendix H.

Emissions were also allocated to the districts based on the hailing or home port information provided by the principle sources of vessel population information .A summary of the five districts responsible for approximately 80% of the statewide emissions from commercial harbor craft is presented in Table IV-3. As shown below, the top 5 districts were all located on the Pacific Ocean coastline in California.[8] Emissions data for all California districts is provided in Table IV-4.

Table IV-3
Estimated 2003 Commercial Harbor Craft Emissions for Selected Districts

District	Vessel Population	2003 Pollutant Emissions, Tons/Day			
		NOx	HC	CO	PM
Bay Area	**1,183**	21.6	1.7	4.6	1.0
SCAQMD	**848**	18.3	1.5	4.1	0.9
San Diego	**339**	8.5	0.7	1.9	0.4
Monterey Bay Unified	**395**	3.3	0.3	0.7	0.2
North Coast Unified	**417**	3.1	0.3	0.7	0.2
Totals	**3,182**	54.9	4.5	12.1	2.7

[8] In some cases, the district-specific estimates may not agree with current district estimates.

Table IV- 4
Estimated Statewide 2003 Commercial Harbor Craft Emissions (tpd)

District	NOx	HC	CO	PM
Amador	0.00	0.00	0.00	0.00
Antelope Valley	0.00	0.00	0.00	0.00
Bay Area	21.64	1.69	4.59	1.03
Butte	0.51	0.40	0.11	0.02
Calaveras	0.01	0.00	0.00	0.00
Colusa	0.00	0.00	0.00	0.00
El Dorado	0.38	0.03	0.08	0.02
Feather River	0.00	0.00	0.00	0.00
Glenn	0.01	0.00	0.00	0.00
Great Basin	0.01	0.20	0.72	0.13
Imperial	0.00	0.00	0.00	0.00
Kern	0.00	0.00	0.00	0.00
Lake	0.01	0.20	0.72	0.13
Lassen	0.00	0.00	0.00	0.00
Mariposa	0.01	0.00	0.00	0.00
Mendocino	1.98	0.14	0.37	0.09
Modoc	0.01	0.00	0.00	0.00
Mojave	0.00	0.00	0.00	0.00
Monterey Bay	4.02	0.28	0.77	0.17
North Coast	3.87	0.27	0.73	0.17
Northern Sierra	0.01	0.00	0.00	0.00
Northern Sonoma	1.69	0.12	0.33	0.07
Placer	0.41	0.03	0.09	0.02
Sacramento	0.98	0.08	0.22	0.05
San Diego	8.71	0.70	1.90	0.43
San Joaquin	0.78	0.06	0.17	0.04
San Luis Obispo	1.78	0.13	0.35	0.08
Santa Barbara	1.48	0.11	0.31	0.07
Shasta	0.04	0.00	0.01	0.00
Siskiyou	0.00	0.00	0.00	0.00
South Coast	18.87	1.52	4.13	0.92
Tehama	0.38	0.03	0.08	0.02
Tuolumne	0.01	0.00	0.00	0.00
Ventura	1.46	0.11	0.30	0.07
Yolo-Solano	0.47	0.04	0.10	0.02
Statewide Emissions	69.5	6.1	16.1	3.6

C. Comparison with Previous Emission Estimates

[Note: A summary table comparing the emission estimates made using this methodology with the estimates of emissions for commercial harbor craft currently residing in the ARB's CEIDARS data base.]

Table IV- 5
Comparison of the Emission Estimates Developed Using the Proposed Commercial Harbor Craft Emission Estimation Methodology and the Commercial Vessel Emission Estimates Currently In CEIDARS

District	NOx (Proposed)	NOx (CEIDARS)	HC (Proposed)	HC (CEIDARS)	CO (Proposed)	CO (CEIDARS)	PM (Proposed)	PM (CEIDARS)
Amador	0.00		0.00		0.00		0.00	
Antelope Valley	0.00		0.00		0.00		0.00	
Bay Area	21.64	5.51	1.69	0.55	4.59	1.85	1.03	0.32
Butte	0.51		0.04		0.11		0.02	
Calaveras	0.01		0.00		0.00		0.00	
Colusa	0.00		0.00		0.00		0.00	
El Dorado	0.38		0.03		0.08		0.02	
Feather River	0.00		0.00		0.00		0.00	
Glenn	0.01		0.00		0.00		0.00	
Great Basin	0.01		0.00		0.00		0.00	
Imperial	0.00		0.00		0.00		0.00	
Kern	0.00		0.00		0.00		0.00	
Lake	0.01		0.00		0.00		0.00	
Lassen	0.00		0.00		0.00		0.00	
Mariposa	0.01		0.00		0.00		0.00	
Mendocino	1.98	0.74	0.14	0.14	0.37	0.30	0.09	0.08
Modoc	0.01		0.00		0.00		0.00	
Mojave	0.00		0.00		0.00		0.00	
Monterey Bay	4.02		0.28		0.77		0.17	
North Coast	3.89	1.76	0.27	0.33	0.74	0.72	0.17	0.19
Northern Sierra	0.01		0.00		0.00		0.00	
Northern Sonoma	1.69	0.03	0.12	0.01	0.33	0.01	0.07	0.00
Placer	0.40		0.03		0.09		0.02	

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District	NOx (Proposed)	NOx (CEIDARS)	HC (Proposed)	HC (CEIDARS)	CO (Proposed)	CO (CEIDARS)	PM (Proposed)	PM (CEIDARS)
Sacramento	0.98	0.12	0.08	0.02	0.22	0.04	0.05	0.01
San Diego	8.71	2.10	0.70	0.39	1.90	0.86	0.43	0.23
San Joaquin	0.78	0.19	0.06	0.04	0.17	0.08	0.04	0.02
San Luis Obispo	1.79	0.19	0.13	0.04	0.35	0.08	0.08	0.02
Santa Barbara	1.48	0.82	0.11	0.13	0.31	0.32	0.07	0.10
Shasta	0.03		0.00		0.01		0.00	
Siskiyou	0.00		0.00		0.00		0.00	
South Coast	18.87	8.00	1.52	0.40	4.13	1.10	0.92	0.10
Tehama	0.38		0.03		0.08		0.02	
Tuolumne	0.01		0.00		0.00		0.00	
Ventura	1.46	0.28	0.11	0.07	0.30	0.14	0.07	0.04
Yolo-Solano	0.47	0.10	0.04	0.02	0.10	0.04	0.02	0.01
Total	69.54	19.84	5.39	2.14	14.65	5.54	3.29	1.12

V. FUTURE EFFORTS

[To Be Added –

- *Projections of Future Emissions from Commercial Harbor Craft*
- *Impacts of the Carl Moyer and district repower programs on emissions from commercial harbor craft]*