



**Public Workgroup Meeting to
Discuss Commercial Harbor
Craft Regulatory Issues**

**Draft Emission Estimation
Methodology for Commercial Harbor
Craft in California**

August 5, 2004

California Environmental Protection Agency



Air Resources Board

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**Goals for the Commercial Harbor
Craft Inventory Update**

- Build into ARB OFFROAD model
- Develop consistent methodology
- Generate improved emission estimates for NO_x, PM, CO, HC, and SO_x
- Accurately reflect adopted regulations and other regulatory programs in the baseline inventory and forecasts

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Emission Estimation Methodology

- “Bottom up” methodology based on survey of California’s ports, harbors, and marinas and harbor craft operations
- Emissions allocated to districts based on location of ports, harbors, and marinas
- Most core information used to develop the emission estimates comes from ARB’s Commercial Harbor Craft Survey

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Emission Estimation Details

- Base year = 2002
- Emissions estimated based on power use emission factors (g/bhp-hr)
- Engine profiles developed for nine vessel types
- Estimates emissions for propulsion and auxiliary engines
- Overwater emission inventory boundary includes California Coastal Waters

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Emission Estimation Details (cont.)

- Vessel Types
 - ▶ Commercial fishing vessels
 - ▶ Charter fishing vessels
 - ▶ Ferries
 - ▶ Crew and supply boats
 - ▶ Pilot vessels
 - ▶ Tugs
 - ▶ Tow boats
 - ▶ Work boats
 - ▶ Others

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Basic Methodology for Estimating Emissions for Harbor Craft

- Estimate populations of the nine vessel types for each district
- Use ARB Survey data to:
 - ▶ provide vessel-specific engine data (including engine age, horsepower, and annual hourly activity)
 - ▶ estimate ave. number of engines per vessel type
 - ▶ estimate ave. emissions per engine per vessel type
- **Estimate Emissions =**
(vessel pop.) x
(ave. # of engines per vessel) x
(ave. ems per engine)

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Keys Assumptions

- **ARB's Survey is representative of statewide commercial harbor craft fleets**
- **Estimated emissions occur in California Coastal Waters**
- **Estimated emissions are associated solely with diesel-fueled engines**

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Sources of Population Data

- U.S. Coast Guard Documentation information
- CA. Department of Fish and Game Commercial Boat Registration information
- Port of Los Angeles Emission Inventory
- ARB Survey (2002)
- ARB 2003 Port/Harbor/ Marina Survey

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Approach Use to Estimate Vessel Populations

- Segregated data into 4 groups - fishing, ferry/excursion, work and other
- Matched vessel-by-vessel by vessel name and owner/operator address, deleted duplicates
- Allocated to district/county by location of “home port” or “port of call”
- Used district-specific vessel type ratios based on ARB’s Survey to allocate to the nine vessel types

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Proposed Statewide Vessel Populations

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

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Average Numbers of Engines Per Vessel Type

Vessel Type	Auxiliary	Propulsion
Charter Fishing	0.75	1.75
Commercial Fishing	0.46	1.11
Crew and Supply	1.11	2.5
Ferry	1.23	2
Pilot	0.14	1.71
Towboats	1.17	2
Tugboats	1.59	1.92
Work Boats	0.32	1.45
Others	0.46	1.12

Source: ARB Survey

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Approach Used to Estimate Average Emissions Per Engine by Vessel Type

$$\text{Ave. emissions per engine type} = \frac{\sum (\text{emfac}) \times (\text{load}) \times (\text{annual activity}) \times (\text{hp})}{\text{total \# of engines per vessel type}}$$

per vessel type

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Emission Factors

- **Power-based emission factors**
- **Potential sources of emission factors - AP-42, manufacturer's certification data, actual in-use test results, ARB's OFFROAD Model**
- **Recommended ARB's OFFROAD Model (with adjustments)**

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Proposed Emission Factors

- **Use ARB OFFROAD**
 - for 1996 - 2003 model years, use Tier 0
 - for 2004 and newer, use U.S EPA emission standards
 - adjust OFFROAD Model emission factors to reflect E3 test cycle
- **Deterioration rates specific to harbor craft based on useful life and OFFROAD deterioration factors**

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Harbor Craft-based Deterioration Emission Factors

- Engine useful life estimated from harbor craft median age and average annual activity
Useful life (hrs) = median age x average annual activity
- Use OFFROAD Model deterioration factors applied to harbor craft useful life and zero hour emission factors

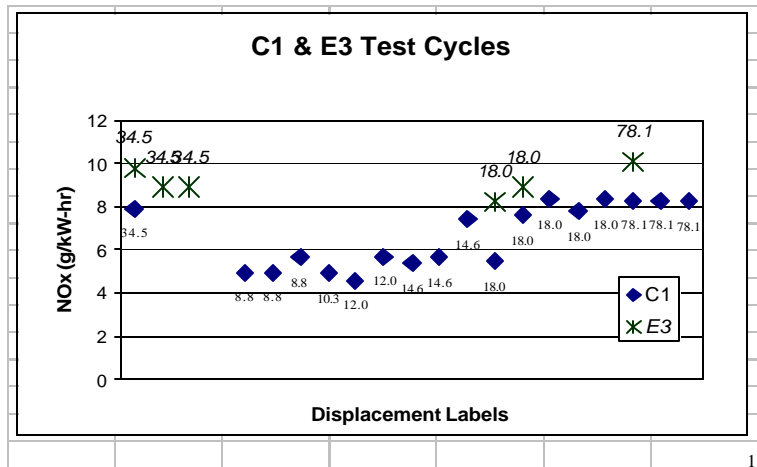
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Adjust OFFROAD Model Emission Factors to E3 Test Cycle

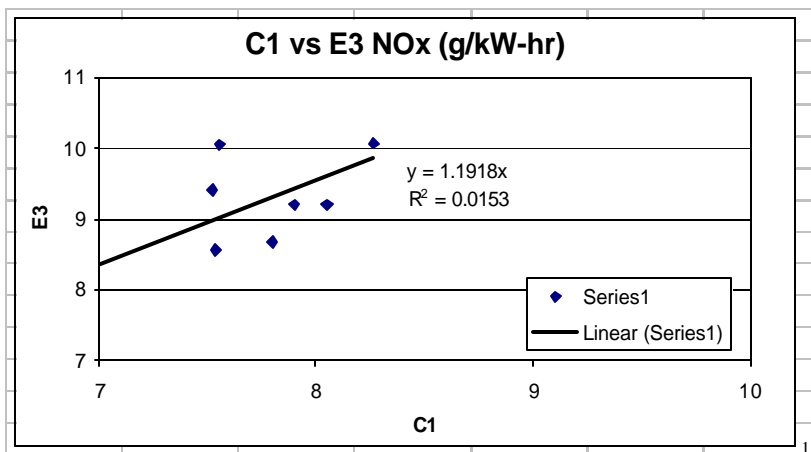
- OFFROAD Model emission factors based on “C1” engine test cycle
- Adjust OFFROAD Model emission factors to reflect “E3” test cycle
 - compare source test data for similar engines tested in “C1” and “E3” test cycles
 - developed adjustment factors
- Adjustment factors: NO_x (1.18)
PM (0.94)
CO (0.73)
HC (none)

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Adjust OFFROAD Model Emission Factors to E3 Test Cycle (cont.)



Adjust OFFROAD Model Emission Factors to E3 Test Cycle (cont.)



Proposed Engine Activity Inputs - Load

- **U.S. EPA Non-Road Model**
 - **assume 43% load for all vessel types except tug boats**
- **POLA Inventory Development**
 - **assume 31% load for tug boats**

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Proposed Engine Activity Inputs - Horsepower and Annual Activity

- **Use individual vessel data from ARB Survey (1,900 engines)**
 - **horsepower**
 - **annual hours of operation**
- **Use statewide averages to fill data gaps**

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ARB's HARBOR Model

- Fortran-based program
- Developed such that it can be included in the ARB's OFFROAD Model
- Processes the engine activity information and the deteriorated emission factors and develops emission estimates on a per engine basis (tpy)
- Post-process data output to estimate statewide emissions

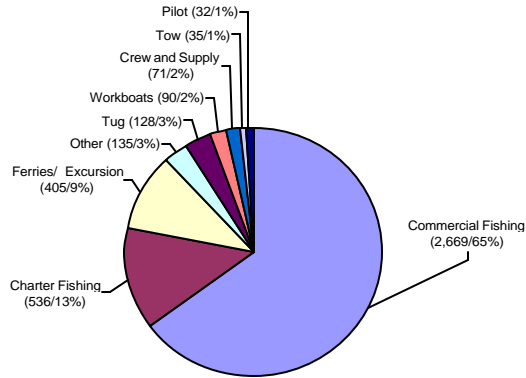
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Draft 2002 Commercial Harbor Craft Emissions (tpd)

Vessel Category	Numbers of Vessels	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
Pilot	32	0.7	0.1	0.1	0
Tug	128	10.5	0.9	2.4	0.5
Tow	35	2	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

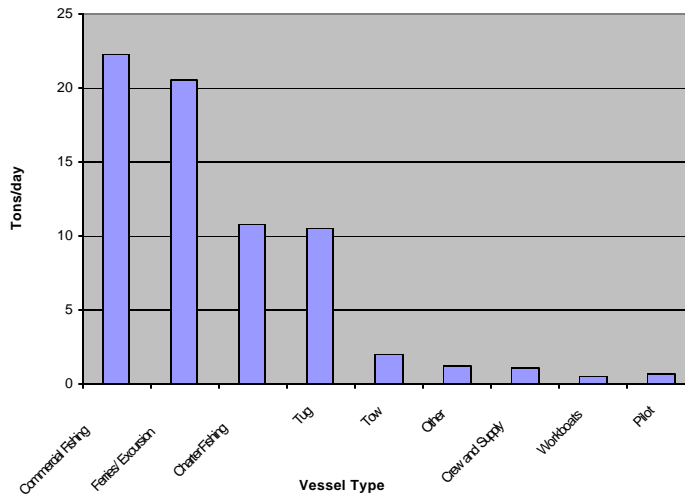
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Draft Commercial Harbor Craft Statewide Vessel Population



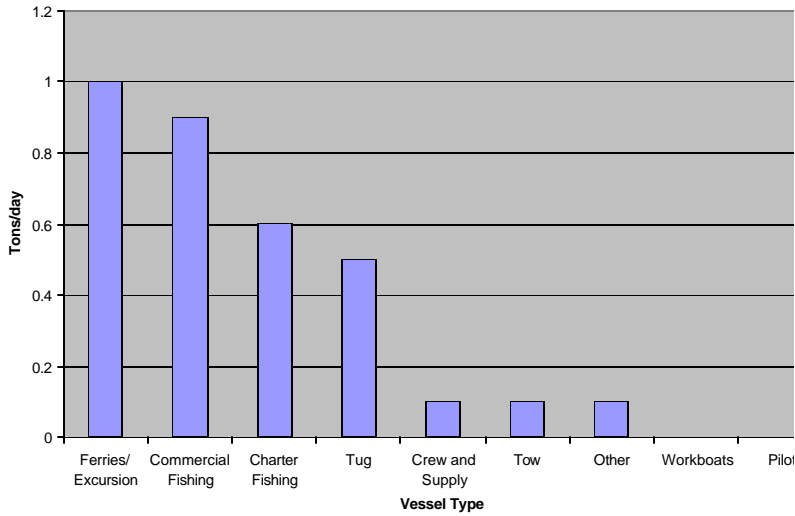
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Draft Commercial Harbor Craft Estimated 2002 Statewide NOx Emissions by Vessel Type



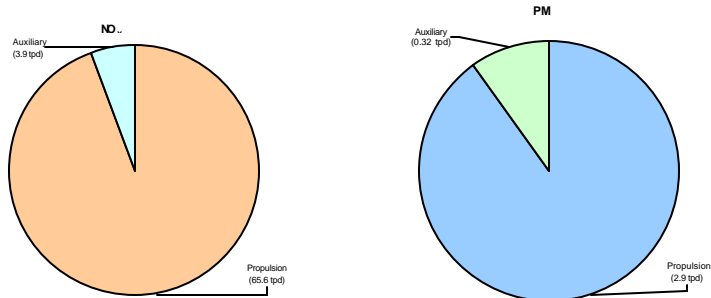
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Draft Commercial Harbor Craft Estimated 2002 Statewide PM Emissions by Vessel Type



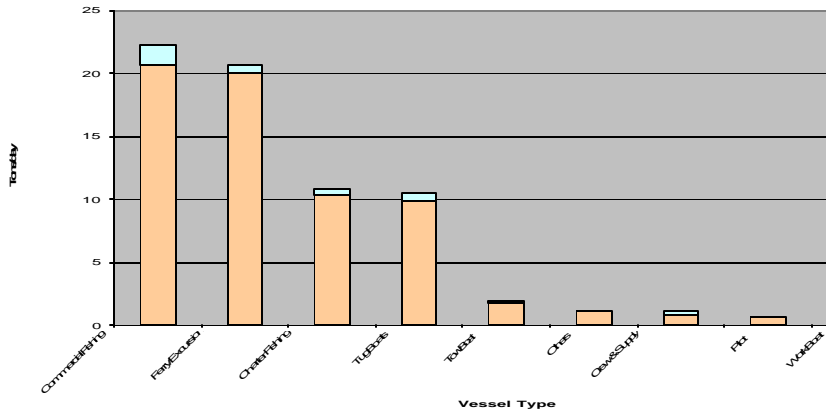
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Statewide CHC NOx and PM Estimated 2002 Emissions from Propulsion and Auxiliary Engines



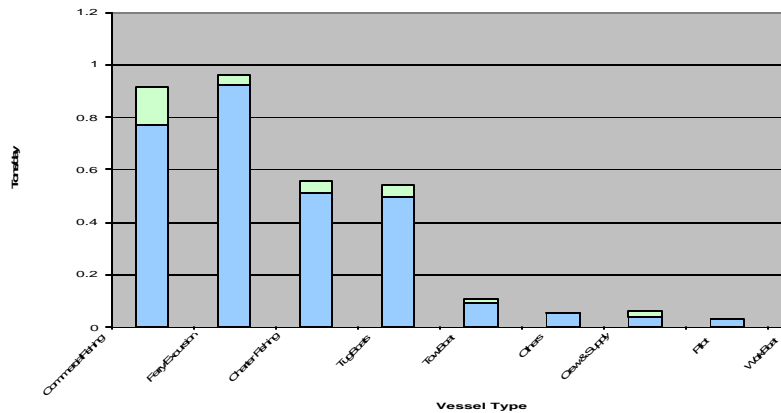
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Draft CHC Estimated 2002 Propulsion and Auxiliary Engine NOx Emissions by Vessel Type



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Draft CHC Estimated 2002 Propulsion and Auxiliary Engine PM Emissions by Vessel Type



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Future Methodology Efforts

- **Impacts of Carl Moyer and district repower programs**
- **Estimate emissions of SO₂ using fuel usage data**
- **Include emission estimates for military vessels**
- **Determine if all emissions actually occur in California Coastal Waters**
- **Finalize methodology**

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ARB Commercial Harbor Craft Emission Inventory Update Contacts

- **Kirk Rosenkranz**
 - e-mail: **krosenkr@arb.ca.gov**
 - phone: **916.327.7843**
- **Archana Agrawal**
 - e-mail: **aagrawal@arb.ca.gov**
 - phone: **626.450.6136**

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