



Commercial Harbor Craft Emissions in California

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Commercial Harbor Craft Workshop

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Background

- Proposed CHC regulation to Board in 09/2007
- Update inventory to support regulation
 - Develop a consistent statewide methodology
 - Improve on previous estimates
 - Reflect the most current harbor craft fleet
 - Provide flexibility for regulatory development



Outline

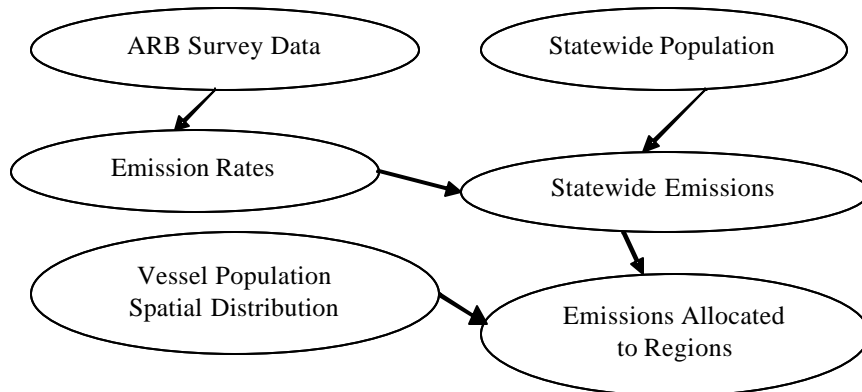
- Overview of Methodology
- Model Inputs
- Emissions Inventory
- Next Steps

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Overview of Methodology



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Overview of Methodology (Cont.)

- Assume ARB survey engine data are representative
 - ~ 410 auxiliary & ~1,031 main sample engines
 - ~ 16% (Aux.) & 18% (main) of the statewide engine population
- Estimate average emission rates using survey data
- Scale up to statewide population
- Allocate emissions to counties, districts, air basins based on hailing ports & where activities occur
- Project future emissions based on growth, engine turnover & proposed regulation

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Model Inputs

- Vessel & engine population
- Emission factors
- Activity
- Regulation

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Vessel Population

- Data sources
 - U.S. Coast Guard registration data
 - California Fish & Game registration data
 - ARB 2002 Commercial Harbor Craft Survey
 - Port of LA emission inventory
- Nine vessel types
 - Charter Fishing, Commercial Fishing, Crew & Supply, Ferries/Excursion Vessels, Pilot Vessels, Tow Boats, Tug Boats, Work Boats, Others
- ~ 4,185 vessels in 2004
- Reality check by contacting ports & marinas

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Vessel Population in 2004

Air District	Charter Fishing	Commercial Fishing	Crew & Supply	Ferries /Excursion	Pilot Vessels	Tow Boats	Tug Boats	Work Boats	Others	Total by District
Bay Area	164	972	9	140	4	23	57	34	64	1468
El Dorado County	6	0	0	3	0	0	0	0	0	9
Mendocino County	5	158	0	3	0	0	0	1	1	169
Monterey Bay Unified	18	336	0	17	0	0	1	0	7	379
North Coast Unified	6	285	2	0	0	0	2	2	1	299
Northern Sonoma County	9	132	0	4	0	0	0	0	0	145
Placer County	5	0	0	4	0	0	0	0	0	9
San Diego County	84	106	0	76	0	8	16	2	15	307
San Joaquin Valley Unified	9	23	1	5	1	0	1	1	1	43
San Luis Obispo County	8	131	1	3	0	0	2	1	0	145
Santa Barbara County	31	119	23	11	0	0	1	3	4	193
South Coast	191	274	15	134	21	1	38	33	37	745
Ventura County	16	148	12	11	1	0	3	0	4	194
Yolo/Solano	11	43	0	3	0	3	8	11	2	81
Total by Vessel Type	563	2727	64	416	27	35	128	89	136	4185

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Average Number of Engines per Vessel

Vessel Type	Main Engine	Auxiliary Engine
Commercial Fishing	1.12	0.46
Charter Fishing	1.77	0.75
Ferries	2.01	1.23
Crew and Supply	2.5	1.1
Pilot Vessels	1.7	0.14
Tug Boats	1.92	1.59
Tow Boats	2.1	1.17
Work Boats	1.46	0.32
Others	1.11	0.46

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Fleet Growth

- Adopted air districts' fleet growth rates
- Adjustments
 - Tug growth is flat since tugs are generally over powered & able to handle larger vessels
 - Commercial fishing growth adjusted to reflect 6% decline per year in fish landings over last decade
 - Assume 6% per year decline until 2009
 - From 2010, the growth is flat

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Engine Turnover

- Attrition Curve (ARB's OFFROAD Attrition Curve & EPA's OFFROAD Scrappage Curve)
- Redefined engine useful life
 - Age distribution asymmetric
 - Total life when 90% of engines retire
 - Useful life as half of total life
- New engines added with growth & engine turnover
 - New engines are cleaner
 - Emissions decrease with fleet turnover

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OFFROAD Attrition Curve



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Engine Useful Life (years)

Vessel Type	Main Engine	Auxiliary Engine
Commercial Fishing	21	15
Charter Fishing	16	15
Ferries	20	20
Crew and Supply	22	22
Pilot Vessels	19	25
Tug Boats	21	22.5
Tow Boats	26	25
Work Boats	17	23
Others	23	22

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Emission Factor Sources

- Power-based emission factors
- Data evaluated
 - ARB OFFROAD Model emission factors
 - U.S. EPA (AP-42)
 - Lloyd's Register of Ships
 - U.S. EPA Category 1 marine engine emission factors
 - U.S. EPA Marine Engine Certification data
 - Actual emission testing results
- Based on ARB OFFROAD tier 0 emission factors
 - Harbor craft engines are marinized OFFROAD engines
 - OFFROAD emission factors table is the most complete

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Deterioration Factors

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

Notes: Adopted from ARB's OFFROAD model; deterioration factor represents % increase of emission factors over one useful life (half of total life); useful life derived from survey data which is different from OFFROAD's useful life.

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Emission Factor Adjustments

- Adjusted to "E3" marine cycle for main engines
 - 1.18 for NOx, no adjustment for HC, 0.73 for CO, 0.95 for PM
- Adjusted to "D2" marine cycle for auxiliary engines
 - No adjustment for NOx, 1.19 for HC, 1.03 for CO, 0.84 for PM
- Adjusted to MARPOL & EPA Standards if they are lower

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Engine Load Factors

Vessel Type	Propulsion Engine	Auxiliary Engine
Commercial Fishing	0.27	0.43
Charter Fishing	0.52	0.43
Ferries	0.76*	0.43
Crew and Supply	0.45	0.43
Pilot Vessels	0.51	0.43
Tug Boats	0.50	0.31
Tow Boats	0.68	0.43
Work Boats	0.45	0.43
Others	0.52	0.43

* Subject to change.

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Emission Estimation

- Estimate emissions based on population, zero hour emission factors, engine deterioration, load factor, hours of operation
- Scale survey emissions to statewide population
- Estimate emissions under different control scenarios

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Regulation Scenarios

- Engine repower based on compliance schedule
- Identify sample engines reaching compliance year in each calendar year
- Replace these engines with new engines

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Spatial Allocation

- Allocate emissions to regions based on Goods Movement Plan & adjusted to 100 nautical miles
- Allocate between land-based air basin & Outer Continental Shelf based on survey
 - Adjust using engineering judgment
 - Agree well with districts' allocation

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Spatial Allocation by Distance from Shore

Vessel Type	<=3 nm	>3 and <=24 nm	>24 nm
Commercial Fishing	12%	30%	58%
Charter Fishing	15%	32%	52%
Ferry & Excursion *	59%	31%	10%
Tow Boats	44%	17%	38%
Tug Boats	37%	12%	51%
Pilot Vessels	41%	23%	36%
Work Boats	42%	25%	33%
Crew & Supply	33%	22%	45%
Others	36%	24%	40%

*We assign 100% of ferry and excursion emissions in the Bay Area district to 0-3 nm.

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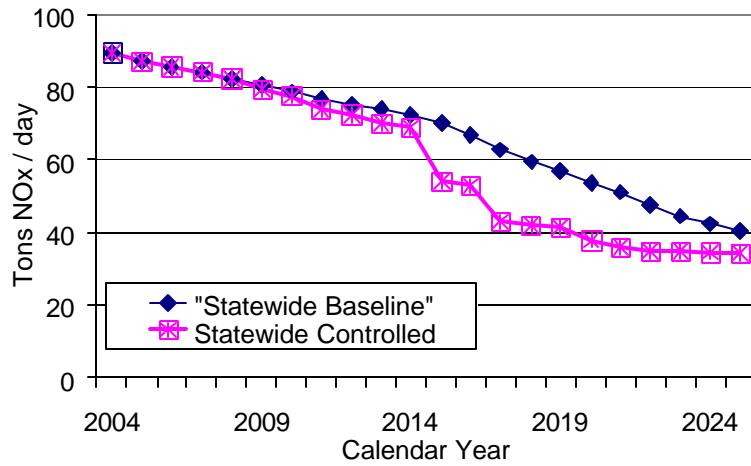
Emissions by Vessel Type in 2004 (tpd)

Vessel Type	NOx	% of Total	PM	% of Total
Charter Fishing	12.70	14%	0.60	15%
Commercial Fishing	17.42	19%	0.80	20%
Crew and Supply	1.45	2%	0.07	2%
Ferries & Excursion	37.38	42%	1.59	40%
Others	1.46	2%	0.07	2%
Pilot Vessels	0.43	0%	0.02	1%
Tow Boats	2.97	3%	0.13	3%
Tug Boats	15.30	17%	0.65	16%
Work Boats	0.50	1%	0.02	1%
Total	89.63	100%	3.95	100%

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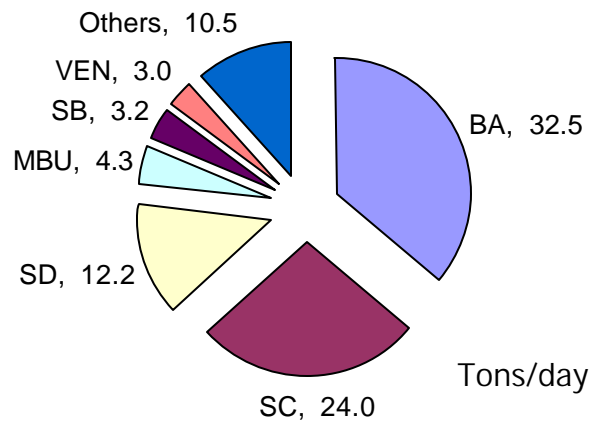
NOx Emission Inventory



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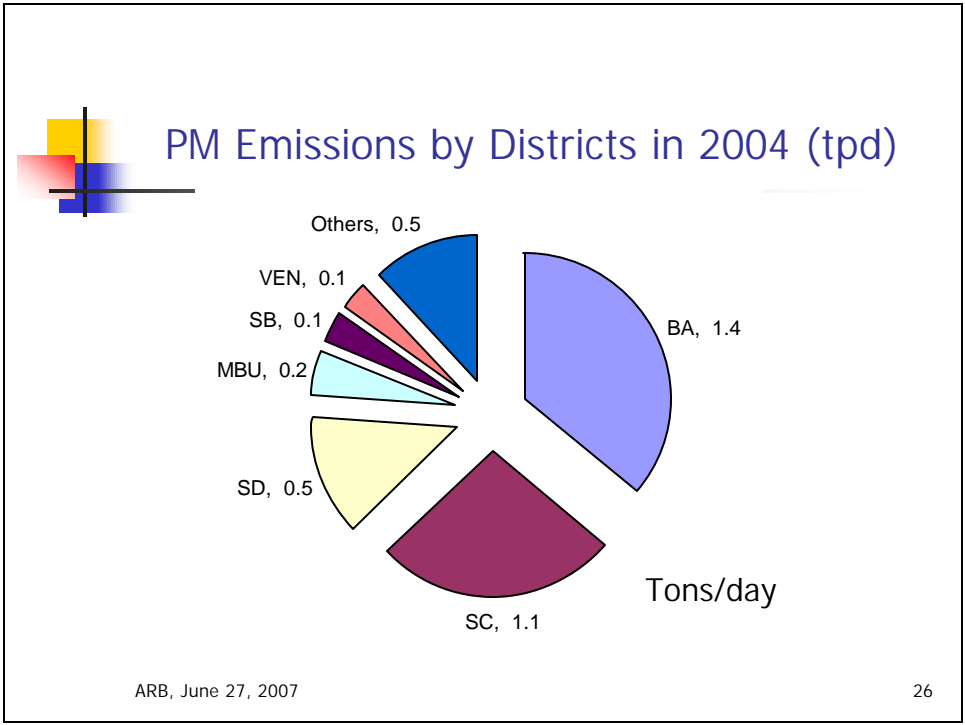
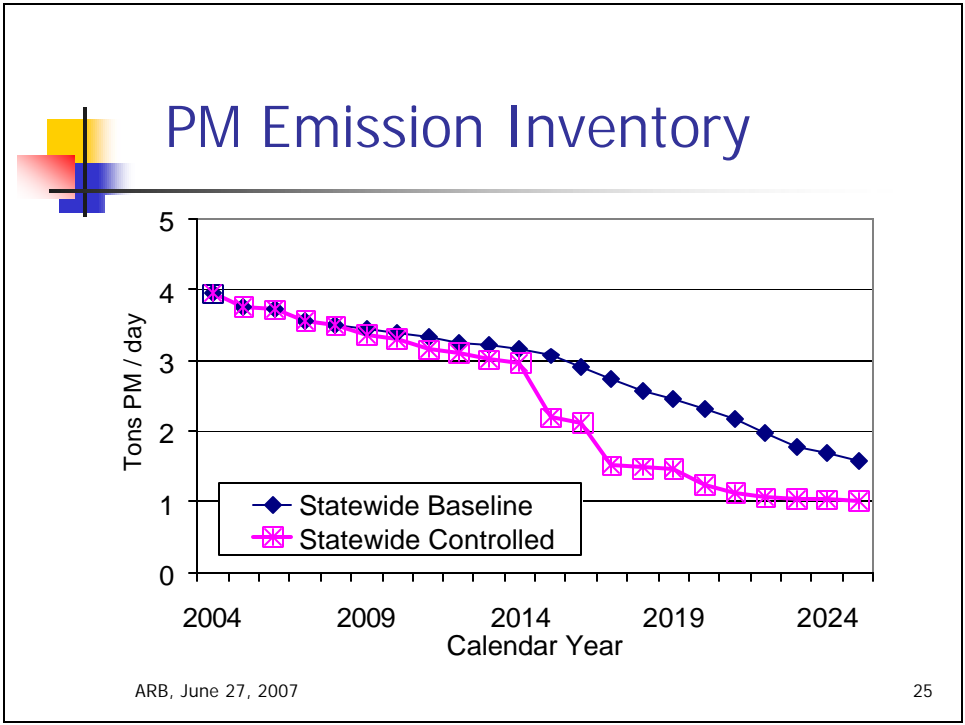
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NOx Emissions by Districts in 2004 (tpd)



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Next Steps

- Address comments
- Finalize emissions inventory
- Finalize methodology documentation
- Update with population & activity data from record keeping requirements

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Previous presentations on Commercial Harbor Craft Regulation can be found at :
<http://www.arb.ca.gov/msprog/offroad/marinevess/harborcraft.htm>