

# MEMO

Project name: **2020 Seaport Emissions Inventory: Update of Commercial Harbor Craft Emissions**

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## 1 Introduction

Ramboll completed calculation of commercial harbor craft (CHC) emissions for the Port of Oakland 2020 Seaport Emission Inventory (SEI) in early 2021 (Port of Oakland, 2021) using the California Air Resources Board (CARB) emissions methodology for CHC available at that time (CARB, 2011) which was based on emission factors published in 2007. CARB has since updated their CHC emissions methodology (CARB, 2021) with updated load factors (LFs) and emission factors (EFs). In several cases, these revisions result in significantly lower emission estimates. Deterioration, useful life, and fuel correction factors were also updated by CARB. Given the substantial changes to CARB's methodology, the Port directed Ramboll to recalculate CHC emissions reported in the Port's 2020 Seaport emissions inventory using the new CARB methodology.

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## 2 Updates to CHC Emissions Methodology

Revised CHC engine EFs for model year (MY) 2004 – 2015 are substantially lower for particulate matter (PM) and marginally lower for nitrogen oxides (NOx). Nearly all tugs included in the 2020 SEI fell in this MY range. In contrast, revised EFs for both older and newer MY engines are roughly similar to the 2007 EFs.

CARB also updated engine LFs which further contribute to changes in emission estimates. Table 1 compares engine LFs used in the 2020 SEI with CARB's new LFs. Note that assist tug emissions in the 2020 SEI were based on load factors used in the 2005 and later Port of Los Angeles (POLA) emission inventories<sup>1</sup> as shown in Table 1 rather than the CARB 2007 load factors which were higher. Tugs of all sorts have revised main engine LFs that are substantially (about 50%) lower than those in previous inventories. Auxiliary engine LFs are not substantially lower, but those engines represent a small fraction of emissions (less than 10%).

<sup>1</sup> The Port of Los Angeles Inventory of Air Emissions for Calendar Year 2005 (through at least the 2017 calendar year and possible up to the 2020 calendar year inventory), <https://www.portoflosangeles.org/environment/air-quality/air-emissions-inventory> ; other reference: ICF Consulting. 2006. "Current Methodologies and Best Practices in Preparing Port Emission Inventories," Prepared for U.S. Environmental Protection Agency. April 4, 2006.

Updates to other emission input factors (deterioration rate, assumed useful life, fuel correction factors) included in CARB’s 2021 revised methodology contribute to both increases and decreases in estimated emissions.

CARB’s 2021 CHC inventory methodology also revised the vessel classification system to be more inclusive of different vessel (engine) types. For example, the revised methodology includes bunker barge pumps and barge-mounted dredge equipment whereas emissions from these engines in the 2020 SEI were estimated using offroad equipment emission factors from CARB’s EMFAC emissions model (EMFAC2021, v1.01<sup>2</sup>) and ATB tugs are now different vessel types from push tugs (push tugs are more commonly used in the Bay).

**Table 1. Comparison of previous (2007) and updated (2021) CHC engine load factors (highlighted rows indicate vessel types included in the 2020 SEI).**

Engine	Vessel Type	2021 Load Factor	2007 Load Factor
Main	Commercial Fishing	0.27	0.27
Main	Commercial Passenger Fishing	0.288	0.52
Main	Crew/Supply	0.26	0.45
Main	Dredge	0.436	0.51
Aux.	Dredge	0.567	0.42 crane 0.31 hoist winch
Main	Excursion	0.268	0.42
Main	Ferry-Catamaran	0.314	0.42
Main	Ferry-Monohull	0.314	0.42
Main	Ferry-Short Run	0.314	0.42
Main	Pilot Boat	0.333	0.51
Main	Research Boat	0.323	N/A
Main	Tugboat-Escort/Ship Assist	0.163	0.31 based on POLA inventory <sup>a</sup>
Aux.	Tugboat-Escort/Ship Assist	0.338	0.43
Main	Tugboat-Push/Tow	0.334	0.68
Aux.	Tugboat-Push/Tow	0.37	0.43
Main	Tugboat-ATB	0.50	0.68
Aux.	Tugboat-ATB	0.50	0.43
Main	Work Boat	0.333	0.45
Aux.	Work Boat	0.322	0.43

<sup>a</sup> - Original 2007 ARB estimate was a load factor of 0.50 for assist tugs; the 0.31 value was used in the 2020 SEI.

The Port of Oakland harbor craft emission inventory includes Tugboat-Escort/Ship Assist, Tugboat-Push/Tow (used to move dredge spoils disposal and bunkering barges), Tugboat-ATB (layover calls in

<sup>2</sup> <http://www.arb.ca.gov/emfac>

2020), Dredge, and Work Boats (used to support dredges also called tenders) highlighted in orange in Table 1.

### 3 Results

Revised emissions are summarized in Tables 2, 3, and 4 below. Table 2 provides the original 2020 SEI CHC emissions estimates for purposes of comparison. Revised estimates based on the new CARB methodology are shown in Table 3. Table 4 presents ratios of revised to original estimates expressed as percentages.

Overall, the revised methodology results in a 68% reduction for DPM (i.e., revised DPM emissions are 32% of the original reported emissions) and a 38% reduction for NOx (62% of the original reported emissions). The bulk of the reductions come from assist tugs and similar tugs used for the dredge spoils removal and bunker barge movements. These reductions are predominantly attributable to both lower load factors (as evidenced by the lower CO2 emissions) and lower emission factors, in particular for PM.

**Table 2. Port of Oakland 2020 commercial harbor craft emissions: originally published estimate (Port of Oakland, 2021)**

Harbor Craft	Criteria Air Pollutants							Greenhouse Gas CO <sub>2</sub> e = GWP-weighted sum of CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O			
	ROG	CO	NOx	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	SO <sub>x</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> e
O&M Dredging	5.27	25.16	50.86	1.66	1.57	1.66	0.06	6,397	0.47	0.08	6,433
Assist Tug	15.33	74.91	103.52	3.63	3.52	3.63	0.11	12,928	1.38	0.39	13,077
Tug & Barge	0.25	1.45	1.63	0.057	0.056	0.057	0.002	259	0.02	0.01	262
<b>Subtotal</b>	<b>20.85</b>	<b>101.52</b>	<b>156.01</b>	<b>5.35</b>	<b>5.15</b>	<b>5.35</b>	<b>0.17</b>	<b>19,583</b>	<b>1.88</b>	<b>0.48</b>	<b>19,772</b>
Bunkering Barges	2.47	7.42	22.52	1.15	1.11	1.15	0.02	2,056	0.23	0.05	2,077
<b>Total</b>	<b>23.32</b>	<b>108.94</b>	<b>178.53</b>	<b>6.49</b>	<b>6.25</b>	<b>6.49</b>	<b>0.18</b>	<b>21,639</b>	<b>2.11</b>	<b>0.53</b>	<b>21,850</b>

**Table 3. Port of Oakland 2020 commercial harbor craft emissions: revised estimate using updated methodology (CARB, 2021)**

Harbor Craft	Criteria Air Pollutants							Greenhouse Gas CO <sub>2</sub> e = GWP-weighted sum of CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O			
	ROG	CO	NOx	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	SO <sub>x</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> e
O&M Dredging	1.56	6.99	53.44	1.01	0.98	1.01	0.05	4,818	0.14	0.18	4,879
Assist Tug	1.74	7.80	45.88	0.82	0.79	0.82	0.06	5,402	0.16	0.21	5,472
Tug & Barge	0.04	0.15	0.78	0.020	0.019	0.020	0.001	113	0.00	0.00	115
<b>Subtotal</b>	<b>3.33</b>	<b>14.93</b>	<b>100.10</b>	<b>1.84</b>	<b>1.79</b>	<b>1.84</b>	<b>0.11</b>	<b>10,334</b>	<b>0.30</b>	<b>0.39</b>	<b>10,465</b>
Bunkering Barges	0.31	1.39	11.25	0.25	0.24	0.25	0.01	908	0.03	0.03	920
<b>Total</b>	<b>3.64</b>	<b>16.32</b>	<b>111.35</b>	<b>2.09</b>	<b>2.03</b>	<b>2.09</b>	<b>0.12</b>	<b>11,242</b>	<b>0.33</b>	<b>0.42</b>	<b>11,385</b>

**Table 3. Ratios of revised (Table 3) to original (Table 2) emissions**

Harbor Craft	Criteria Air Pollutants							Greenhouse Gas CO <sub>2</sub> e = GWP-weighted sum of CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O			
	ROG	CO	NO <sub>x</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	SO <sub>x</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	CO <sub>2</sub> e
O&M Dredging	30%	28%	105%	61%	62%	61%	83%	75%	30%	226%	76%
Assist Tug	11%	10%	44%	22%	22%	22%	52%	42%	11%	53%	42%
Tug & Barge	15%	10%	48%	35%	35%	35%	60%	44%	17%	44%	44%
<b>Subtotal</b>	<b>16%</b>	<b>15%</b>	<b>64%</b>	<b>34%</b>	<b>35%</b>	<b>34%</b>	<b>63%</b>	<b>53%</b>	<b>16%</b>	<b>81%</b>	<b>53%</b>
Bunkering Barges	12%	19%	50%	22%	22%	22%	47%	44%	12%	68%	44%
<b>Total</b>	<b>16%</b>	<b>15%</b>	<b>62%</b>	<b>32%</b>	<b>32%</b>	<b>32%</b>	<b>65%</b>	<b>52%</b>	<b>16%</b>	<b>80%</b>	<b>52%</b>

## 4 References

CARB, 2011. "California Air Resources Board Harbor Craft (CHC) Emissions Inventory," October 2011. <https://www.arb.ca.gov/msei/ordiesel.htm>

CARB, 2021. "Appendix H: 2021 Update to the Emission Inventory for Commercial Harbor Craft: Methodology and Results," September 21 2021. <https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road>

Port of Oakland, 2021. 2020 Seaport Emissions Inventory, Final Report. November. <https://www.portofoakland.com/community/environmental-stewardship/seaport-air-emissions-inventory-2005/>