



**What is the emissions inventory?**

The Puget Sound Maritime Air Emissions Inventory (PSEI) is an accounting of air emissions from maritime-related equipment operating in the greater Puget Sound region. The inventory was conducted voluntarily to provide a strong technical foundation for future environmental programs, initiatives, and policy decisions. The baseline inventory was conducted in 2005 with updates being performed every five years (2011 and 2016) to track emission reductions over time and ensure that emission estimates remain current. Results showed that air pollutant emissions decreased by up to 97 percent, depending on the type, including 69 percent for fine particles, which pose a significant threat to human health.

**Who developed the emissions inventory?**

The inventory was commissioned by the Puget Sound Maritime Air Forum, an association of private and public maritime organizations, ports, air agencies, environmental groups and other parties with regulatory responsibilities associated with the maritime industry. The 2016 inventory update was funded by contributions from the Air Forum partner organizations. Starcrest Consulting Group was selected to develop the inventory.

**Why was the inventory developed?**

The purpose of the emissions inventory is to provide scientifically defensible estimates of the nature, location and magnitude of air pollutant emissions from maritime-related activities in the greater Puget Sound region. The data will be used to prioritize pollution prevention investments as well as to inform air quality policy.

**What is measured by the inventory?**



The PSEI estimates emissions from maritime-related activities in tons per year within the U.S. portion of the Puget Sound/Georgia Basin International Airshed. This area spans from the U.S./Canadian border through the Strait of Juan de Fuca to just south of Olympia (~140 miles) north to south and from the Cascade Mountains to the Olympic Mountains and the mouth of the Strait of Juan de Fuca from east to west (~160 miles).

Emissions are estimated for relevant criteria air pollutants and precursors (carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic compounds and particulate matter) as designated by the U.S. Environmental Protection Agency (EPA), greenhouse gases (carbon dioxide, methane and nitrous oxide), diesel particulate matter and black carbon (soot).

Data were gathered for six major maritime-related source categories: ocean-going vessels (cargo, cruise and tanker ships), harbor vessels (tugs, ferries and recreational vessels), cargo-handling equipment (cranes, forklifts, straddle carriers and yard tractors), on-road heavy-duty vehicles (semi-trucks), terminal operator fleet vehicles (passenger cars and trucks) and rail operations. Military operations and equipment were not included.

### Why are maritime-related air emissions important?

Marine diesel engines, like all diesel engines are significant sources of criteria air pollutants and their relevant precursors (NO<sub>x</sub>, SO<sub>2</sub>, CO, VOC and particulate matter), toxic air pollutants and greenhouse gases. Exposure to these pollutants can cause both acute and chronic health effects, such as decreased lung function, aggravation of respiratory and cardiac disease, increased risk of cancer, increased risk of chronic respiratory and cardiovascular disease, and other health effects. These emissions also contribute to climate change, the formation of ground-level ozone, impaired visibility and acid deposition. Given the public health and environmental risks associated with maritime air pollution, minimizing these emissions is a top priority of the Puget Sound Air Forum. Understanding the magnitude, location and health risks associated with each source of pollution helps to identify where pollution prevention programs can have the largest public benefit.

### Technical Approach

Data summarizing maritime operations and equipment use were collected from ports, individuals, agencies and companies that own, operate, maintain and/or charter vessels and equipment. The data collected summarized the numbers of equipment operating, equipment ages and subtypes, the mode/method of operation and hours of operation. These data provided what is called the “activity level,” or the type, duration and intensity of equipment operation. Emissions were estimated from the activity levels by applying emission factors, which quantify the amount of emissions per unit of activity.

### What are the inventory findings and how do they compare with the 2005 baseline?

Maritime-related emissions decreased in nearly every sector between 2005 and 2016. The emission reductions resulted from voluntary investments by the maritime industry and government agencies in cleaner engines, fuels and operational efficiency, as well as regulations that stipulated more stringent emission standards for new engines and cleaner fuels. The few areas where emissions went up were typically driven by an increase in activity. In other words, the fleet got bigger and the decrease in emissions from individual engines did not cancel out the increase in fleet size.

	Emission Changes 2005 - 2016								
	NO <sub>x</sub>	VOCs	CO	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	DPM	BC	CO <sub>2e</sub>
Ocean-going vessels	-27%	-36%	-20%	-97%	-87%	-85%	-87%	-69%	-29%
Harbor vessels	8%	26%	104%	-99%	-15%	-15%	-16%	-16%	21%
Recreational vessels	35%	-32%	-22%	-91%	-31%	-31%	-17%	-9%	23%
Locomotives	-55%	-49%	-33%	-99%	-52%	-52%	-52%	-51%	-27%
Cargo-handling equipment	-56%	-67%	-88%	-99%	-65%	-65%	-65%	-67%	-36%
Heavy-duty vehicles	-48%	-54%	-50%	-88%	-46%	-45%	-46%	-75%	16%
Fleet vehicles	-77%	-67%	-71%	-91%	-84%	-85%	-89%	-88%	-70%
<b>Total</b>	<b>-23%</b>	<b>-29%</b>	<b>-21%</b>	<b>-97%</b>	<b>-72%</b>	<b>-69%</b>	<b>-72%</b>	<b>-41%</b>	<b>-10%</b>

<b>2016 (Emissions in tons per year)</b>									
	<b>NO<sub>x</sub></b>	<b>VOCs</b>	<b>CO</b>	<b>SO<sub>2</sub></b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>DPM</b>	<b>BC</b>	<b>CO<sub>2e</sub></b>
Ocean-going vessels	11,516	346	964	374	192	181	178	11	587,994
Harbor vessels	6,590	478	2,332	4	235	216	230	163	443,948
Recreational vessels	989	1,774	12,416	2	38	35	5	10	139,381
Locomotives	1,099	63	206	1	32	29	32	23	77,366
Cargo-handling equipment	332	32	182	0	17	17	17	12	49,838
Heavy-duty vehicles	1,297	66	320	2	61	57	61	19	238,805
Fleet vehicles	3	1	12	0.02	0.07	0.06	0.04	0.03	1,037
<b>Total</b>	<b>21,824</b>	<b>2,760</b>	<b>16,432</b>	<b>384</b>	<b>575</b>	<b>535</b>	<b>524</b>	<b>238</b>	<b>1,538,368</b>

<b>2005 (Emissions in tons per year)</b>									
	<b>NO<sub>x</sub></b>	<b>VOCs</b>	<b>CO</b>	<b>SO<sub>2</sub></b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>DPM</b>	<b>BC</b>	<b>CO<sub>2e</sub></b>
Ocean-going vessels	15,836	542	1,202	12,789	1,514	12,12	1,336	36	827,705
Harbor vessels	6,122	380	1,144	405	277	255	274	194	368,087
Recreational vessels	734	2,590	15,966	23	55	51	6	11	113,354
Locomotives	2,460	123	308	193	67	61	67	47	106,058
Cargo-handling equipment	763	96	1,477	47	49	48	49	36	77,769
Heavy-duty vehicles	2,516	143	646	16	112	103	112	76	206,028
Fleet vehicles	13	3	42	0.23	0.44	0.4	0.36	0.26	3,474
<b>Total</b>	<b>28,445</b>	<b>3,877</b>	<b>20,786</b>	<b>13,473</b>	<b>2,073</b>	<b>1,730</b>	<b>1,843</b>	<b>401</b>	<b>1,702,475</b>

### **What's being done now to reduce maritime air pollution?**

In addition to participating in the emissions inventory, forum members are also working within their own organizations, and on local, national and international initiatives, to reduce emissions.

Forum partners are replacing old engines with cleaner ones, retrofitting engines with advanced pollution control devices, increasing operational efficiency to decrease emissions, using shore power instead of ship engines when cruise and cargo ships are in port, and rebuilding engines.

The voluntary emission reductions achieved to date by the maritime industry in the Puget Sound region and other West Coast ports are unprecedented among industrial sectors.

### **What's next?**

Results of the 2016 PSEI will help focus future efforts and investments to reduce air pollution from maritime activities. The inventory provides the most up-to-date assessment of maritime emissions in the Puget Sound region and thereby supports evaluation of past, present and future emission control strategies. Review and assessment of these data will enable the maritime community to better design and implement fact-based, cost-effective air pollution control strategies to help minimize public health risks, maintain attainment of national air quality standards and protect the environment.

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