Floating Smokestacks

A CALL FOR ACTION TO CLEAN UP
MARINE SHIPPING POLLUTION

ENVIRONMENTAL DEFENSE FUND
finding the ways that work

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AUTHORS

Janea Scott

Hilary Sinnamon

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Our mission
Environmental Defense Fund is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

Cover photo: EDF

The complete report is available online at www.edf.org

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Executive summary

Ocean-going ships like cruise ships, container ships and tankers travel all over the world transporting people and cargo from one destination to another. These ships, also known as Category 3 ships, travel primarily on the open ocean but also up deeper rivers and inlets as well as on the Great Lakes. These ships are very large. For example, some of the biggest cruise ships range between 800–1100 feet in length—the length of more than three football fields. Not surprisingly, it takes very large engines to power such large ships. And while shipping is one of the most efficient ways to move people and goods from place to place, the ships themselves are huge polluters delivering staggering amounts of smog-forming oxides of nitrogen, small sooty particles, and the pollution that contributes to acid rain and global warming, in addition to their cargo. These ships are also poorly controlled and the adoption of clean air standards for these high-emitting engines has lagged far behind other major sources in the transportation sector.

A call to action

The International Maritime Organization (IMO), the body responsible for regulating international air pollution standards for ocean-going ships, is poised to adopt more protective emission standards in October 2008. This report examines why deep reductions in ship pollution are so important in our nation's quest to achieve cleaner, healthier air and protect the environment. Many ports, communities, cities and states across the United States are working hard to protect human health from the air pollution associated with ports, and the U.S. Environmental Protection Agency (EPA) has recently issued strong clean-up standards for smaller ships, like ferries and tugs. To ensure that meaningful clean-up standards are put in place for ocean-going ships, Environmental Defense Fund calls on the United States and the international community to finalize the stronger standards that will be on the table at the October 2008 IMO meeting. Working together, from the local level to the international level, we will be able to achieve cleaner, healthier air by reducing ship and port-related pollution.


Cruise ships ply routes worldwide, carrying thousands of passengers and extending over a thousand feet in length.

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Fuel tanker unloading at port.

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Big ocean-going ships are big polluters

The exhaust emitted from the large diesel engines on ocean-going vessels is among the most dangerous and pervasive sources of air pollution. Its constituents include particulate matter (PM or $PM_{2.5}$), implicated in a host of respiratory problems and thousands of premature deaths every year; smog-forming oxides of nitrogen (NO_x); sulfur dioxide (SO_2), which forms harmful fine particles and falls back to earth as acid rain; and a noxious brew of toxic chemicals that together pose a cancer risk greater than that of any other air pollutant. EPA estimated that in 2001, ocean-going ships emitted:

- more than 54,000 tons of fine particulate matter, which is equivalent to the pollution from 117 coal-fired power plants,
- approximately 745,000 tons of smog-forming NO_x pollution—comparable to the NO_x emissions from over *800 million* of today's new cars, and
- about 450,000 tons of SO_2, which is more than 40% of the total SO_2 from the mobile source sector.[1]

Furthermore EPA estimates that in 2006, ocean-going ships emitted about 55.6 million metric tons of carbon dioxide (CO_2).[2] Shipping-related PM emissions contribute to approximately 60,000 global deaths annually, with impacts concentrated in coastal regions on major trade routes.[3]

Despite the high levels of air pollution associated with these large ships, they are currently subject only to weak international emissions standards by the International Maritime Organization, which are enforced by EPA. These out-of-date standards are not based on advances in emissions control technology or improvements in fuel quality. Instead current international and national regulations simply codify emissions rates already being met by most international ships. The United States has the opportunity to collaborate with nations from around the world to secure the adoption of comprehensive and rigorous new clean-up standards for large ocean-going ships at the IMO's upcoming meeting in October 2008.

Pollution from ocean-going ships impacts local air quality

As ocean-going ships travel along our coastlines and dock at our nation's ports, their emissions threaten the health of the communities they float past. Many of these communities are not meeting the basic public health standards for fine particulates, ozone or both. Reducing pollution from ships is one of the essential tools needed to help restore healthy air in these communities. All across the country, ships deliver pollution in addition to goods and people. Table 1 below provides a sampling of ship pollution in various areas across the United States.

TABLE 1

Smog-forming oxides of nitrogen from ocean-going vessels in 6 busy port areas and comparable number of today's new automobiles

Port/coastal area	2002 NO_x emissions (metric tons)[4]	Comparable # of today's cars[5]
Seattle/Tacoma ports	12,400	13,300,000
Los Angeles/Long Beach ports	10,200	11,000,000
Houston/Galveston ports	5,600	6,000,000
Lower Mississippi ports[a]	16,800	18,100,000
Great Lakes ports[b]	550	590,000
New York/New Jersey ports	7,300	7,800,000

[a] Includes ports of Baton Rouge, South Louisiana, New Orleans, Plaquemine and Lake Charles

[b] Includes top 28 Great Lakes ports

Solutions exist

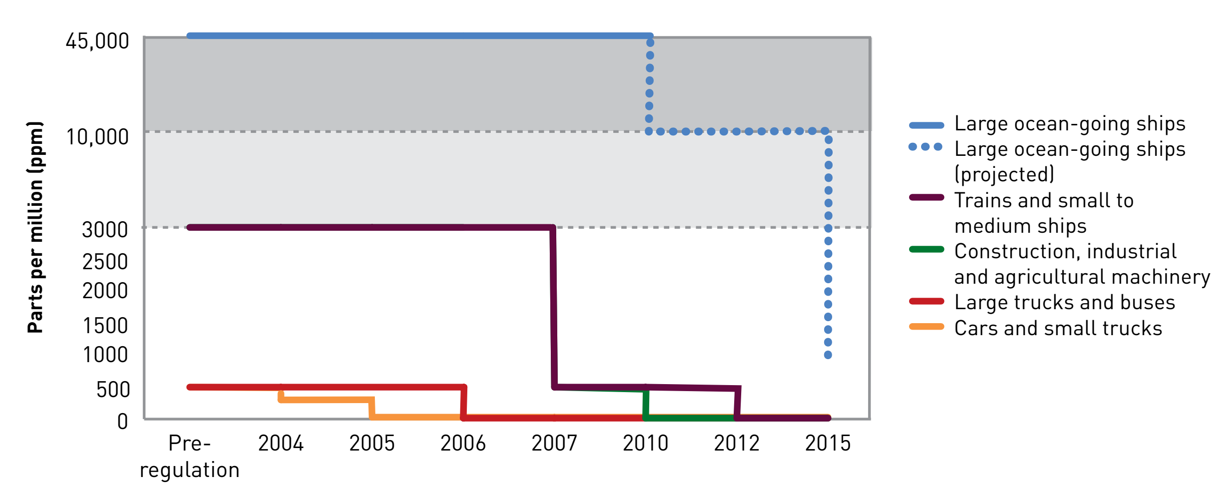
LOW SULFUR FUELS

Ships currently run on residual fuels that have extraordinarily high levels of sulfur. Residual fuel is the tar-like product left behind after the lighter petroleum products have been refined and is so viscous that it requires heating before it can be used for fuel in the ship. Depending on the sulfur content of the crude oil, residual fuel sulfur levels can be as high as 45,000 parts per million (ppm)—an astonishing 4.5% sulfur.[6] EPA reports that the worldwide *average* sulfur content of residual fuel is 27,000 ppm, or a remarkable 1,800 times the 15ppm required for nearly all other diesel engines already, or in the near future.[7] Using cleaner fuels can have a significant impact on the amount of pollution emitted, nearly eliminating harmful SO_2 emissions and significantly reducing toxic fine particle, or PM, emissions.

EMISSIONS-REDUCING TECHNOLOGIES

Numerous pollution control technology options are available to reduce pollution from ships. Many can be applied to existing ships as well as to new ships. For example, engine optimization and hull and propeller modifications can be made to reduce CO_2 emissions by 5–20%, while seawater scrubbers can reduce SO_2 emissions by up to 99%. Other technologies like slide valve fuel injectors and selective catalytic reduction (SCR) can significantly reduce smog-forming NO_x emissions.

FIGURE 1
Regulated fuel sulfur levels for mobile source engines[8]



Recommendations

Through leadership and collaboration, the opportunity to secure deep reductions in ship pollution is here. The IMO is poised to adopt a comprehensive and rigorous program in October 2008. EPA and IMO must reject the delays of the past and step forward in October to help restore cleaner, healthier air to our communities by cleaning up pollution from these large ocean-going ships. Therefore, Environmental Defense Fund respectfully recommends the following policy actions to protect human health and the environment from shipping pollution:

1. Immediately set rigorous, protective standards to clean up pollution from all ships in U.S. waters

Neither EPA nor the IMO have updated the standards that apply to ocean-going ships in several years. During this period of time, shipping has increased dramatically, clean-up technologies have advanced by leaps and bounds, and other diesel-fueled engines in the United States are being required to make 80–90% reductions in their pollution. The IMO must secure protective standards at their upcoming meeting in October or the EPA must set an example for the world by establishing protective standards at home. The U.S. proposal to the IMO includes well-designed clean air standards that:

- Reduce PM and SO_2 from new and existing Category 3 engines by at least 90% percent no later than 2011
- Make interim reductions in NO_x from new engines by at least 15–25% from current levels no later than 2011
- Require deeper NO_x reductions from new engines of at least 80% of the interim standards no later than 2016
- Require existing ships to reduce NO_x by at least 20% beginning no later than 2012

2. Establish an Emission Control Area along North American coastlines

Stronger international air pollution standards are enforced in Emission Control Areas (ECAs), established by the IMO, to protect areas particularly sensitive to shipping emissions. To protect communities and ecosystems in America, the U.S. EPA should apply to the IMO to establish an ECA for the entire United States coastline. The ECA must extend at least 200 nautical miles off the coast, the same distance as our economic zone, in order to be more fully protective. In addition, the United States should coordinate its efforts with the governments of Canada and Mexico to establish a North American ECA as many of our coastlines are impacted by ships traveling to and from Canadian and Mexican ports and many ships travel on routes that take them to ports in both countries as they unload their cargo from foreign destinations.

3. Address greenhouse gas emissions from ocean-going ships

Ocean-going ships are responsible for about 3% of *global* CO_2 emissions. Only the United States, China, Russia, India and Japan emit more carbon dioxide than the global marine shipping fleet. And in 2006, in U.S. waters alone, they released about 55.6 million metric tons of CO_2. To address global climate change, every sector must do its share. As an initial step, it is important to complete greenhouse gas inventories and establish fleet baselines. Environmental Defense Fund strongly encourages policymakers and legislators to adopt greenhouse gas emissions standards for ships, encourage innovative and creative solutions like container light weighting, and increase use of "anti-idling" measures, like shore side power. Additionally, Environmental Defense Fund strongly recommends addressing non-CO_2 greenhouse gases, like black carbon, from ships.

4. Reduce or eliminate in-port emissions from ships.

In-port emissions from ocean-going ships are of special concern for public health because ships travel near land and in ports, emitting pollution close to people. The exhaust from these ships is among the most dangerous and pervasive sources of air pollution. To reduce exposure to this pollution, Environmental Defense Fund recommends policymakers carry out available solutions today including:

• Fuel switching from dirty, high sulfur fuels to cleaner grades of diesel fuel.

• Putting in place pollution control technologies, like shore power.

• Operational changes, like vessel speed reduction, which can significantly reduce fuel use.

• • •

Environmental Defense Fund calls on the United States to lead the way nationally and internationally by encouraging the IMO to adopt rigorous international standards for NO_x, PM, and SO_2 no later than October 2008. In the mean time, EPA must not delay in preparing protective national standards for all ships entering U.S. waters. Additionally, Environmental Defense Fund calls for standards to reduce global warming pollution from these ships to be in place no later than fall 2009.

CHAPTER 1

Ocean-going ships transport international cargo and passengers

Seaports across the world bustle with people, ships and cargo. Passengers begin and end grand adventures on gigantic cruise ships, while cranes load and unload cargo from container ships and tanker ships deliver oil, fuels and chemicals. Containers are loaded with materials ranging from electronics to textiles to foodstuffs[9] and are measured in a unit known as the TEU: twenty-foot equivalent units. Most standard shipping containers, however, are approximately 40 feet in length, equal to two TEUs.[10] Unpackaged goods, meaning goods that are not stored in a container, like fuels, sugar or cooking oils are also transported on ocean-going ships.[11,12] Ocean-going ships are powered by some of the largest diesel engines in the world. And just as their sheer size dominates port seascapes, the pollution from these floating smokestacks dominates the emissions inventory at many ports across our country.

Ocean-going vessels, like container ships and cruise ships, are powered by Category 3 engines. The Environmental Protection Agency divides ship engines into three groups. Category 1 and 2 engines power smaller vessels like recreation boats, tugboats, and ferries, which travel mostly between U.S. ports and in U.S. inland waterways. Category 3 engines power ocean-going vessels that travel primarily on the open ocean along U.S. coastlines and between U.S. and international ports, sometimes traveling up rivers and inlets and on the Great Lakes.

In May 2008, EPA finalized a three-part rule to significantly reduce the air pollution from Category 1 and 2 ships. These marine vessels will be subject to stringent, protective standards that will ultimately reduce pollution from each engine by at least 80%.[13] Unlike their smaller counterparts, Category 3 ships lack rigorous clean-up standards and will continue to be a significant and growing contributor to national and international air pollution problems until protective pollution limits are put in place.

Category 3 ships utilize both propulsion and auxiliary engines for their operation. Propulsion engines, also referred to as main engines, are large marine diesel engines which move or provide direction for ocean-going vessels.[14] Auxiliary engines range in size from small portable generators to locomotive-size engines,[15] and work as

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Left: A container ship being loaded with hundreds of containers. Containers this size are equivalent to 2 TEUs. Right: A truck pulling one container (equivalent to 2 TEUs). Hundreds of trucks are needed to distribute the containers delivered by one ship.

independent generators for auxiliary electrical power on Category 3 ships.[16] While there are separate EPA and IMO regulations governing the emissions for propulsion and auxiliary engines, EPA records the emissions from main and auxiliary engines when calculating the air emissions inventory for Category 3 ships.[17]

Ocean-going ships are similar to other modes of transportation because they move people and cargo. However, unlike trains and trucks, these large ships travel all over the world, making international shipping a significant factor in U.S. port traffic and emissions. In fact, only about 400 of the world's more than 88,000 non-military ocean-going ships are registered in the United States, or "U.S.-flag" ships.[18] Ships not registered in the U.S. are referred to as "foreign-flag" ships. Despite the small number of vessels flagged in the United States, our ports and coastlines are subject to a significant amount of traffic–most of it international. Approximately 90% of the ocean ships that call on U.S. ports are foreign-flag ships.[19] Since so many of the ships that travel to U.S. ports or along U.S. coastlines are foreign-flag ships, it is essential that all ships (both U.S.-flagged and foreign-flagged) in U.S. waters be held to the same rigorous pollution control standards.

Addressing shipping pollution is particularly critical because marine shipping is growing at such a rapid pace, and because the United States in particular receives such a large share of shipping trade. In 2005, world seaborne trade totaled 6.8 billion metric tons, an increase of nearly 50% over the previous decade.[20] The United States is second only to China in international marine container traffic: globally, one container in every nine is bound for, or comes from, the United States. Maritime container entries into U.S. ports increased from 6 million units in 2000 to 11.4 million units in 2005—nearly doubling in just five years.[21]

In this report, we look at the important role of marine shipping in the world economy and the contribution of large ships to local and U.S. emissions inventories. We review the serious health and environmental impacts posed by diesel exhaust. We also evaluate the health effects from shipping pollution on particular cities and ports across the nation; evaluate available solutions for reducing marine pollution; and finally, we provide concrete recommendations for ensuring the near-term reduction in shipping pollution that is impacting the health of our nation's communities.

CHAPTER 2

Floating smokestacks: ocean-going ships contribute to air pollution nationwide

Ships contribute to national emissions

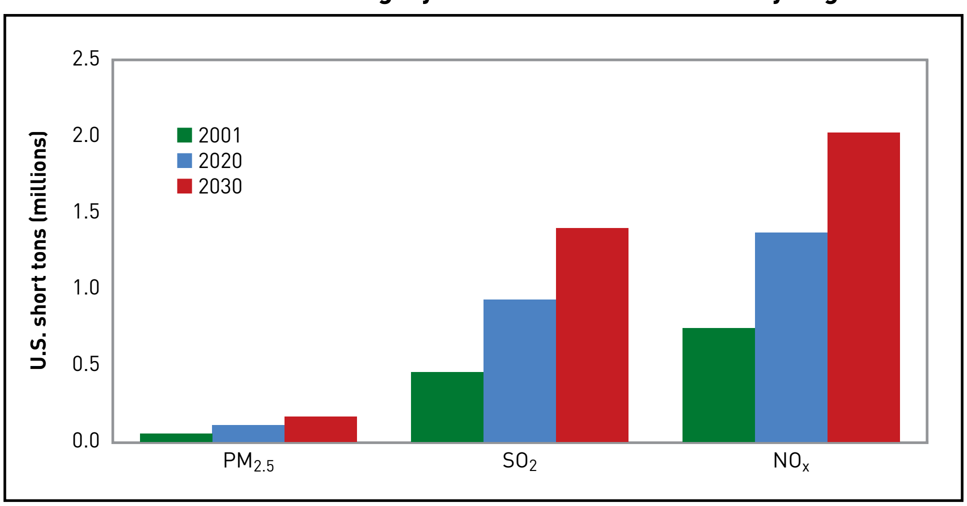
The large ocean-going ships that travel along U.S. coastlines and dock at our nation's ports contribute significantly to the national transportation emissions inventory. And much of the pollution from these large vessels is concentrated in ports and the densely populated metropolitan areas near ports that, in almost every instance, already suffer from unhealthy air.

In 2001, Category 3 ships in U.S. waters emitted more than 54,000 tons of fine particulate matter—comparable to the emissions from approximately 117 coal-fired power plants. These large ships were also responsible for about 745,000 tons of NO_x pollution, which is comparable to the emissions from roughly 94 coal-fired power plants.[22] Ocean-going ships emitted more than 450,000 tons of SO_2 in 2001, representing over 40% of all mobile source SO_2 emissions.[23] Further, worldwide, ocean-going ships are responsible for about 3% of the global greenhouse gas inventory.[24]

Figure 2 illustrates the increase in $PM_{2.5}$, NO_x, and SO_2 pollution expected from Category 3 ships over the next 25 years in the absence of strong emission standards. In 2001, Category 3 engines were responsible for approximately 745,000 short tons of smog-forming oxides of nitrogen and their contribution is expected to increase to a staggering *2 million* short tons in 2030. Those additional NO_x emissions would be equivalent to building 5 coal-fired power plants each year for the next 25 years.[25]

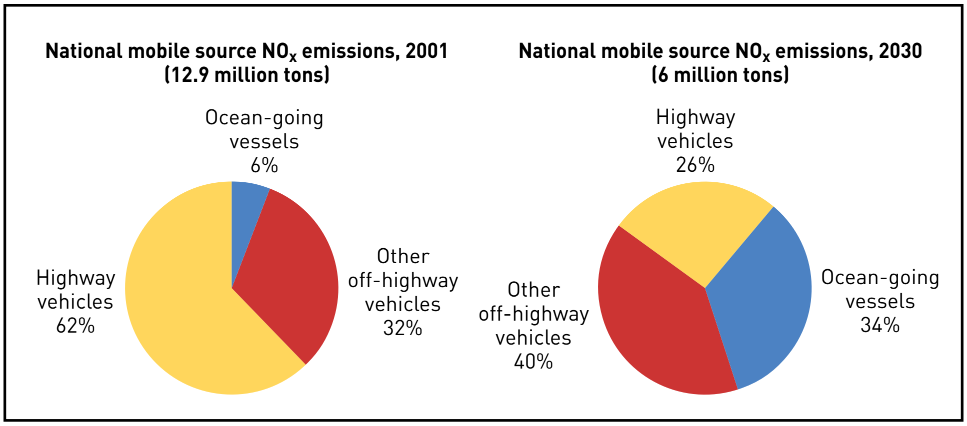
At the same time these large ships pollute at staggeringly high levels, EPA has finalized rigorous standards for every other significant diesel mobile source. Just this year (2008), EPA finalized standards for Category 1 and 2 ships (smaller ships, like ferries and tug boats) and locomotives that will ultimately require NO_x reductions of 80% and PM reductions of 90% from each engine. In 2004, EPA finalized similarly protective standards for land based nonroad engines, like construction, mining and

FIGURE 2
National emissions from Category 3 vessel main and auxiliary engines



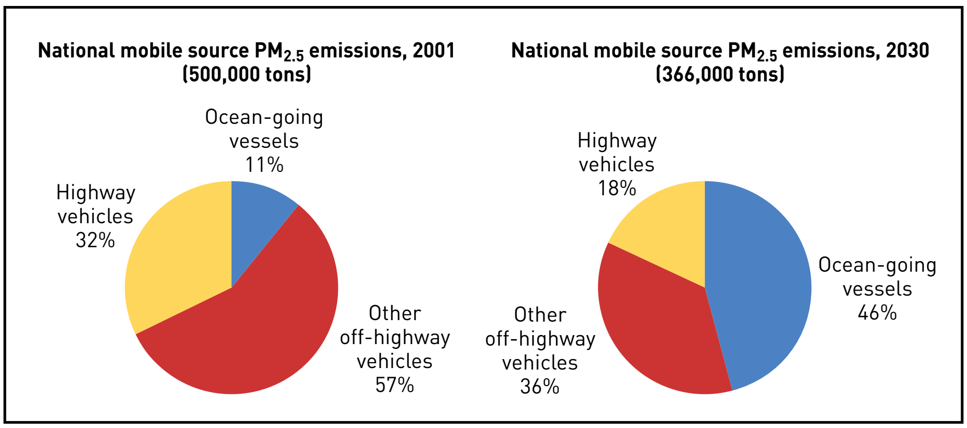
Source: Emission Inventories for Ocean-Going Vessels Using Category 3 Propulsion Engines In or Near the United States. Draft Technical Support Document. EPA 2007.

FIGURE 3
Growing contribution of shipping emissions to national NO_x mobile source inventory, 2001–2030



Source: 72 Fed. Reg. 69,522 (December 7, 2007) "Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule," at 69,546..

FIGURE 4
Growing contribution of shipping emissions to national $PM_{2.5}$ mobile source inventory, 2001–2030



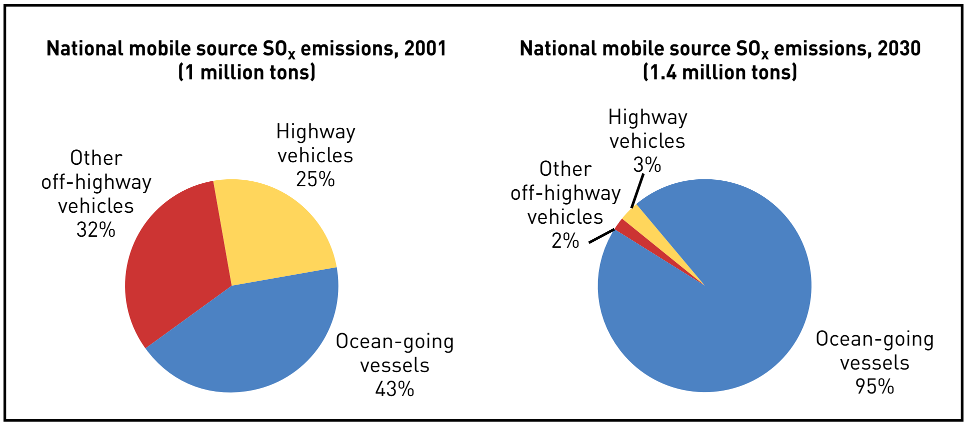
Source: 72 Fed. Reg. 69,522 (December 7, 2007) "Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule," at 69,546.

agricultural equipment. These rules were based on similar standards established in 2001 for heavy-duty trucks and buses.[26] Thus, while the levels of pollution from these other diesel engines are expected to dramatically decrease over the next few decades, actual emissions from Category 3 ships will continue to rise.

Further, pollution from large ocean-going ships will also become an increasingly significant portion of the total emissions from the mobile source sector. Even in the least dramatic example, see Figure 3, NO_x pollution from ocean-going ships becomes a strikingly large piece of the pie–growing from 6% in 2001 to 34% over the next two decades. In fact, by 2030, if allowed to grow unchecked, ocean-going ships will be responsible for about 16% of NO_x emissions from *all* sources.[27]

Figure 4 shows how fine particulate matter will increase from 11% in 2001 to 46% in 2030, and most notably, Figure 5 illustrates that by 2030 national mobile source

FIGURE 5
Growing contribution of shipping emissions to national SO2 mobile source inventory, 2001–2030



Source: 72 Fed. Reg. 69,522 (December 7, 2007) "Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule," at 69,546.

SO_2 emissions will be made up almost entirely from ocean-going ship emissions in 2030. Indeed, by 2030, large ships will account for 14% of the SO_2 emissions from *all* sources.[28] These figures represent national averages so these percentages would likely vary port city by port city.

As these figures show, ocean-going ships contribute significantly to national mobile source emissions inventories and the pollution from these large ships will continue to grow without a rigorous abatement program. Further, similar to other diesel engines, large ships stay in service for decades. The transition from older dirty engines to the newer cleaner engines can be very slow. It is imperative for meaningful new standards to be established without delay so the transition to cleaner engines can begin as soon as possible. It is also important to put in place programs to reduce pollution from the ships that are currently operating.

Marine shipping contributes to global warming

Ocean-going vessels also contribute to national and international greenhouse gas emissions inventories. In 2006, in U.S. waters alone, these vessels emitted about 55.6 million metric tons of CO_2.[29] And worldwide, marine shipping is responsible for an estimated 912 million metric tons of CO_2, or 3% of the global greenhouse gas inventory.[30] The global shipping industry as a whole is responsible for more annual greenhouse gas emissions than almost any individual nation in the world. As Table 2 shows, only the United States, China, Russia, India and Japan emit more carbon dioxide than the global marine shipping fleet.[31]

While marine shipping is one of the most efficient modes of cargo transport on a per ton per mile basis—one ship can move one ton of cargo up to 500 miles on one gallon of fuel[32]—the fuel used to power these ships is extremely dirty, the engines are high-emitting, and there is vast room for improvement in cleaner, more efficient design and operation. Including military vessels, there are just over 100,000 vessels in the world's cargo fleet, yet their CO_2 emissions are comparable to 12-21% of the total

TABLE 2
Only 5 nations emit more CO_2 than the global marine shipping fleet

Ranking	Country	2004 emissions (billion metric tons CO_2)
1	United States	6.05
2	China[a]	5.01
3	Russia	1.52
4	India	1.34
5	Japan	1.25
6	Global shipping fleet	0.91[b]
7	Germany	0.80

[a] Recent data suggests that China has overtaken the U.S. as the top emitter of CO_2
[b] 2001 emissions

Sources: United Nations Millennium Development Goals Indicators: Carbon Dioxide emissions (CO2), thousand metric tons of CO2 (CDIAC) at: http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=749

Corbett, J.J. et. al., Updated Emissions from Ocean Shipping. Journal of Geophysical Research, 2003.

greenhouse gases emitted by the worldwide onroad transportation sector.[33] Consequently, significant emissions reductions could be achieved by controlling a relatively small number of sources.

Ocean-going ships contribute to global warming pollution beyond CO_2 emissions. As described above, these ships emit extraordinary levels of NO_x emissions, which contribute to the formation of ozone. The International Panel on Climate Change has identified ground-level ozone as the third largest contributor to global warming of all air pollution caused by humans.[34]

Additionally, ocean-going ships contribute significant levels of black carbon to the atmosphere every year—another potent global warming pollutant.[35] Black carbon refers to the solar-absorbing component of soot, which is released during the combustion process. Scientists now believe that soot and other forms of black carbon could have as much as 60% of the current global warming effect of carbon dioxide, more than that of any greenhouse gas besides CO_2.[36] In addition to impacting climate change, black carbon contributes to adverse health effects, including premature mortality.[37]

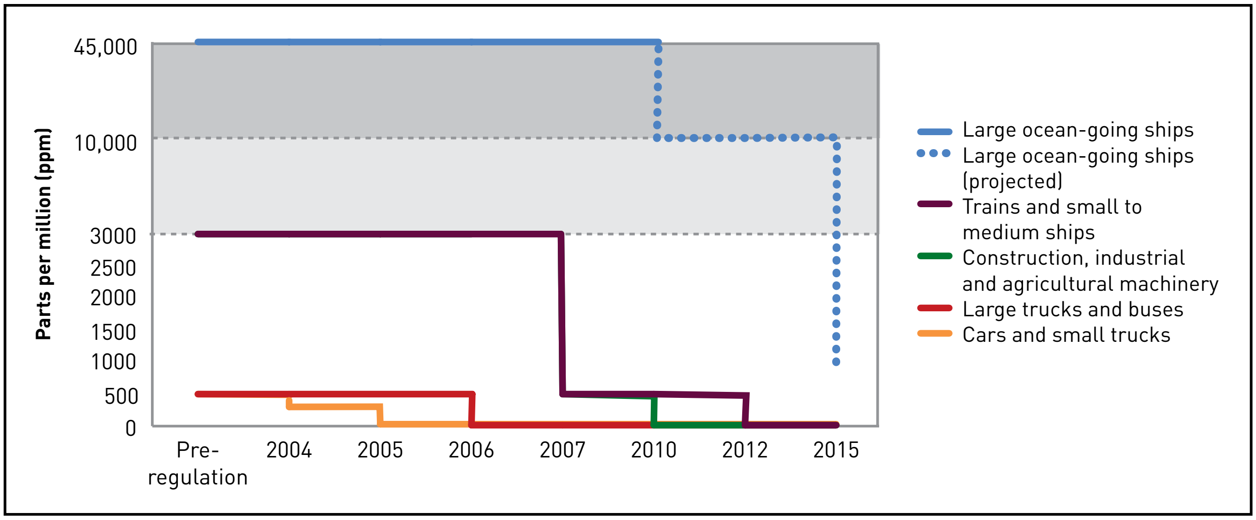
Commercial shipping is responsible for 1.7% of global black carbon emissions. Black carbon from shipping also has disproportionate effects on air quality near port areas because of the intensity of shipping in these areas.[38] Black carbon is also often transported over long distances. This may be particularly deleterious for the Artic sea ice where black carbon darkens snow and ice surfaces, contributing to melting.[39]

Weak regulations and dirty fuel make shipping one of the dirtiest modes of transport

Despite the high overall levels of air pollution associated with ocean-going ships, they are currently only subject to weak international emissions standards set by the

FIGURE 6

Regulated fuel sulfur levels for mobile source engines[40]



IMO, under the purview of the United Nations and by EPA. This situation must be rectified. These out-of-date standards do not reflect the latest advances in emission control technologies or improvements in fuel quality. Instead current international and national regulations simply codify emissions rates already being met by most international ships. This is one reason why pollution levels from these large ships are so high.

Another reason Category 3 engines are such significant polluters is the fuel burned to power these large ships is some of the dirtiest fuel on the market. Residual fuel, also known as bunker fuel, heavy fuel oil (HFO) or intermediate fuel oil (IFO), is the tar-like product left behind after all the lighter petroleum fractions are refined from crude oil. In fact, the fuel is so viscous that it requires heating before it can be burned. Residual fuel has high content of ash, metals, nitrogen, and sulfur that result in incredibly high SO_2 and PM emissions. Depending on the sulfur content of the crude oil, residual fuel sulfur levels can be as high as 45,000 parts per million (ppm)–an astonishing 4.5% sulfur.[41] EPA reports that the worldwide average sulfur content of residual fuel is 27,000 ppm.[42] This is 1,800 times the 15 ppm level required in heavy-duty diesel trucks and buses and soon to be required for locomotives and Category 1 and 2 ships.

As stated earlier, by 2030 ocean-going ships in U.S. waters will grow to be 95% of the SO_2 emissions from the mobile source sector and 14% of the total from all sources if allowed to grow unchecked. To address the growing pollution from these large ships, it is essential that steps are taken, both internationally and nationally, to clean up the fuel they burn.

CHAPTER 3

Air pollution from ocean-going ships is harmful to human health and the environment

The exhaust emitted from the large diesel engines on ocean-going vessels is among the most dangerous and pervasive sources of air pollution. All diesel emissions include particulate matter, implicated in a host of respiratory problems and thousands of premature deaths every year; smog-forming oxides of nitrogen; sulfur dioxide, which forms harmful fine particles and falls back to earth as acid rain; and a noxious brew of toxic chemicals that together pose a cancer risk greater than that of any other air pollutant. As noted in chapter 2, ocean-going ships are significant contributors to the levels of $PM_{2.5}$, NO_x and SO_2 around the United States.

While there are no direct studies of the health effects from diesel emissions of ocean-going vessels, the health effects of the constituents of diesel emissions are well known. Diesel air pollution adds to cancer risk all around the United States. In many counties across the country, diesel emissions are the hazardous air pollutant with the highest contribution to cancer risk. Additionally, because diesel air pollution is a complex mixture of chemicals, exposure to common consituents in diesel exhaust is considered to contribute to a wide range of non-cancer health effects, including pulmonary disease, cardiovascular effects, neurotoxicity, low birth weight in infants, premature births, congenital abnormalities, and elevated infant mortality rates.[43]

Particulate matter

Particulate matter (PM) can aggravate respiratory conditions such as asthma and chronic bronchitis and has been associated with cardiac arrhythmias (heartbeat irregularities), heart attacks and premature deaths. People with heart or lung disease, the elderly and children are among those at highest risk from exposure to particulate pollution.[44]

In 2006, EPA strengthened the nation's health-based national ambient air quality standards in response to extensive scientific research documenting adverse effects at lower concentrations. A recent study by Corbett and Winebrake estimated mortality

Ocean-going vessels deliver staggering amounts of harmful air pollution to communities near ports and along shipping routes.

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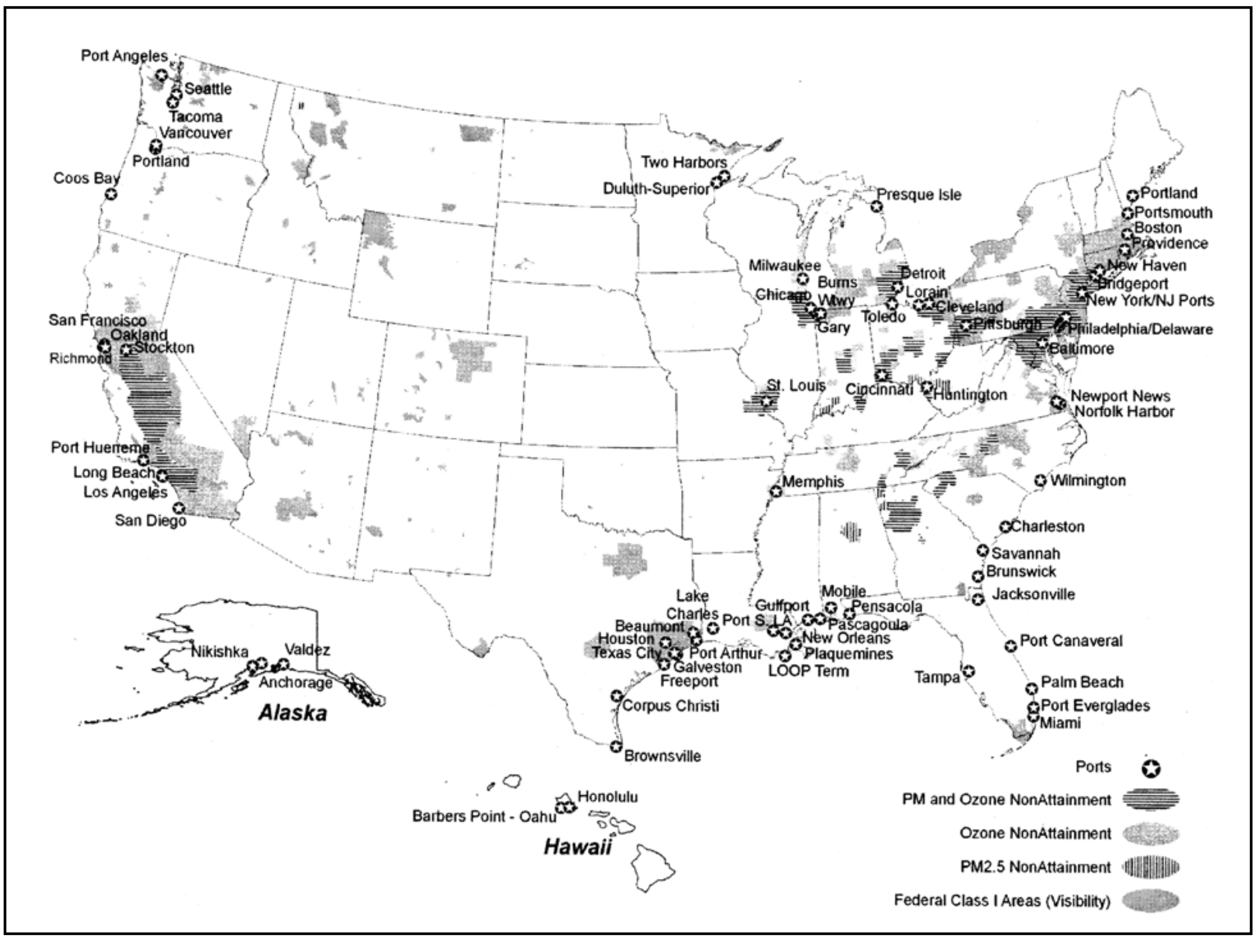
associated with shipping-related PM emissions. The study calculated that worldwide, shipping emissions contribute to approximately 60,000 deaths annually, with impacts concentrated in coastal regions on major trade routes.[45] The study also predicts that under current regulation and with the expected growth in shipping activity, annual mortalities could increase by 40%, or another 24,000 deaths, by 2012.[46]

NO_x and ozone

Oxides of nitrogen (NO_x) combine with volatile organic compounds in the presence of sunlight to form smog, or ground-level ozone. High ozone levels cause acute respiratory problems, aggravated asthma, decreased lung function, inflammation of lung tissue, an increase in hospital admissions and emergency room visits for respiratory causes, and crop damage. Children with asthma are most at risk. Ozone is also associated with premature death.[47] In 2008, EPA strengthened the national health-based standard for ozone in response to scientific research showing harmful effects at lower levels.[48]

FIGURE 7
Air quality problems are widespread especially in U.S. port areas



Source: Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule (December 7, 2007). 72 Fed. Reg. 69522, page 69528.

Reductions in PM and NO_x are needed to meet National Ambient Air Quality Standards

National Ambient Air Quality Standards (NAAQS) are standards established by the EPA that apply to air quality across the United States. Primary standards are designed to protect human health with an adequate margin of safety, including sensitive populations. Secondary standards are designed to protect the environment from any known or anticipated adverse effects of a pollutant. Across the country, there are approximately 88 million people in 208 counties that either do not meet the 1997 $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) or contribute to violations in other counties, and 149 million people in 391 counties designated as out of compliance with the 1997 8-hour ozone NAAQS.[49] These standards have recently been strengthened so the number of people breathing unhealthy air across the United States is likely to increase. Ocean-going ships are a major source of harmful fine particles and their emissions also contribute to harmful smog levels. In Figure 7, EPA identifies 40 ports that are currently located in these non-attainment areas. This map, however, is not based on recent updates strengthening the public health-based standards for fine particulate matter and ozone, so air quality problems in United States port areas are likely to be more widespread than this map indicates.

The International Maritime Organization allows deeper reductions in the areas that are most impacted by ship pollution

In 2005, the IMO adopted rules allowing party nations to establish special Sulfur Emission Control Areas (SECAs) with more stringent control on sulfur emissions. SECAs were designed especially to help communities around the world hit hard by acid rain as a result of significant SO_2 emissions, specifically from shipping. In these specially designated areas, the sulfur content of fuel oil used on board ships must not exceed 1.5% or 15,000 parts per million. Alternatively, ships must fit an exhaust gas cleaning system or use any other technological method to limit SO_2 emissions. Both the North Sea and Baltic Sea have established SECAs to address their significant acid rain problems.[50]

The story does not end here, however. The same SO_2 and NO_x emissions that can transform into acid rain can also transform into particulate matter that harms public health and obscures scenic vistas. Indeed millions of people across the United States are breathing unhealthy air. Fortunately, the IMO is considering expanding the protections afforded by a SECA. In October the world will vote on whether to broaden *Sulfur* Emission Control Areas to *Emission* Control Areas (ECA). An ECA would aggressively address PM and NO_x emissions in addition to SO_2 emissions in sensitive areas of the world.[51]

Environmental Defense Fund strongly supports expanding these protective zones to strengthen protection of human health. We urge the world to vote "yes" to changing SECAs into ECAs at the October 2008 IMO meeting. We also encourage the EPA to establish an Emission Control Area, extending 200 nautical miles off the coast, for the entire coastline of the U.S. to help protect communities and ecosystems impacted by the high level of harmful emissions from ocean-going ships.

Environmental impacts

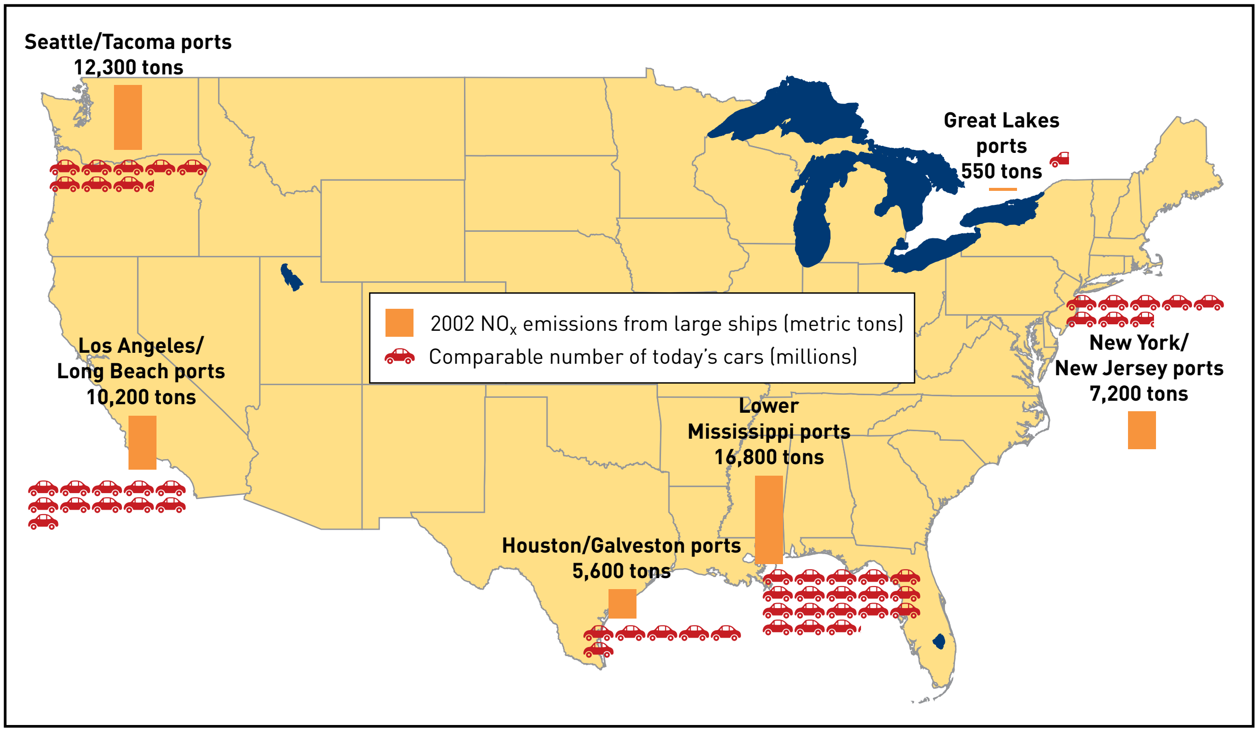
In addition to severely impacting public health, the pollution from diesel engines on ocean-going ships impacts our environment. For example, this pollution impairs visibility. The same fine particles that have adverse health effects cause the haze that pollutes scenic vistas in national parks and wilderness areas and creates "brown clouds" in our urban centers.

Diesel air pollution threatens ecosystems across the country. The constituents of diesel exhaust contribute to the acid rain that continues to harm sensitive ecosystems across the United States. Acid rain occurs when pollutants like SO_2 and NO_x react with water, oxygen, and other chemicals in the atmosphere to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid.[52] When this acid falls back to the earth, it harms our nation's revered ecosystems–causing acidification of lakes and streams and contributing to the damage of trees, like red spruce trees, at high elevations and many sensitive forest soils.[53] Studies indicate that despite progress made under the Clean Air Act, acid rain continues to be a problem in the northeast.[54] Acid rain impacts ecosystems all around the world.

Ocean-going ships impact communities across the nation

FIGURE 8

A sampling of communities impacted by the pollution from ocean-going ships and a comparison of that pollution to today's new cars



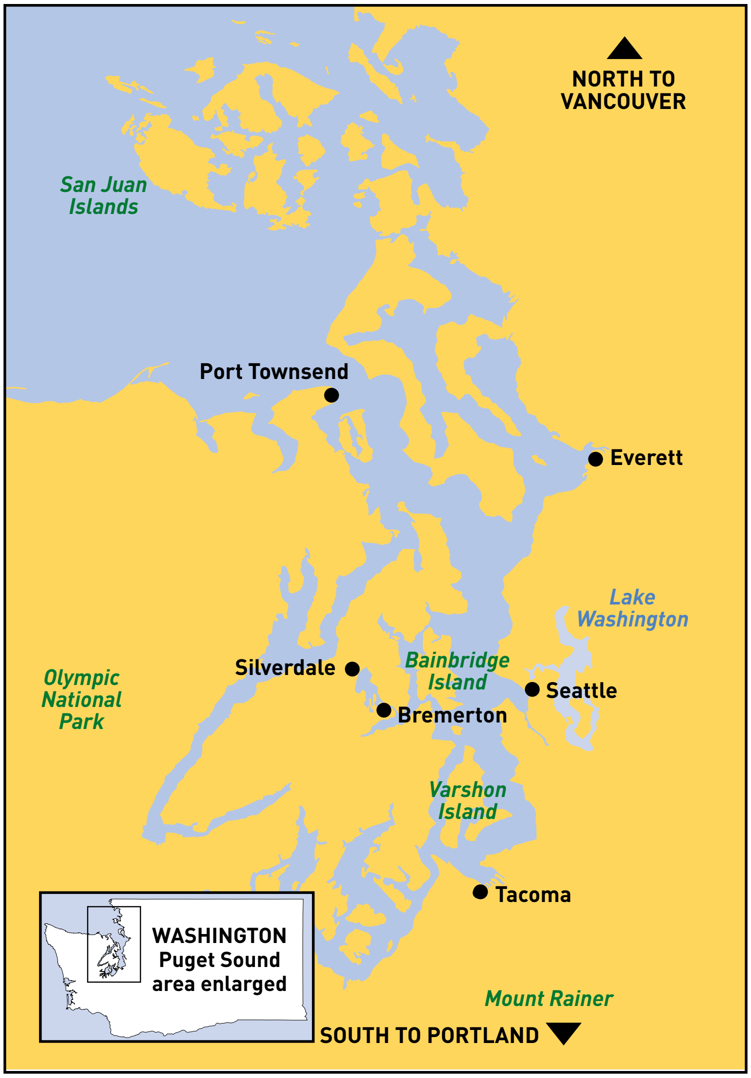
Source: EPA, "Emission Inventories for Ocean-Going Vessels Using Category 3 Propulsion Engines In or Near the United States; Draft Technical Support Document," EPA420-D-07-007; December 2007. Table 3-16 and 3-34.

Communities adjacent to ports are often densely populated and significantly impacted by shipping emissions as ships enter and exit the ports and idle while docked. In addition, toxic diesel emissions from these ships also impact air quality in communities along coastlines adjacent to shipping lanes.[55] Many ports and localities are taking important actions to clean up port-related pollution. But, ocean-going ships are often the dominant source of pollution at ports, and they are also the polluter that ports, local communities and states have not historically regulated. This chapter examines some of the areas across the nation that are hardest hit by shipping emissions to highlight how essential it is to put in place strong national and international clean-up standards as well as local measures to protect human health from these high-emitting engines.

Puget Sound region

Puget Sound is in the northwestern corner of Washington State and both small and large ports are located along its shores. The Sound is about 70 nautical miles, measured from its ocean entrance to its southern most point around the Port of Olympia. From 2003 to 2007, the annual number of ships calling on the Port of

FIGURE 9
Map of Puget Sound region



Source: http://www.globalsecurity.org/military/facility/images/seattle-map.gif

Everett increased from 28 to 124.[56] In 2007 more than 1,200 vessels, including about 750 container ships and 190 cruise ships, called on the Port of Seattle[57] and more than 1,100 vessels called on the Port of Tacoma.[58] According to EPA estimates, in 2002, the Ports of Tacoma and Seattle together emitted approximately 12,300 metric tons of NO_x, 940 metric tons of $PM_{2.5}$, and 7,000 metric tons of SO_2.[59] The NO_x emissions from ships in those two ports alone are comparable to the pollution from over 13 million of today's cars.[60] To put that in perspective, there are just over 3 million cars registered in the entire state of Washington.[61] And that does not include the thousands of tons of NO_x emissions from the other ports in the Sound.[62]

However, an inventory conducted by the Puget Sound Clean Air Agency in 2005 estimated that ocean-going ships calling on all ports along Puget Sound were responsible for some 3,700 tons of NO_x; 220 tons of $PM_{2.5}$; 3,400 tons of SO_2; and 219,000 equivalent tons of CO_2.[63] While the entire state of Washington is currently listed as meeting its clean air standards for both ozone and fine particulate matter, recent updates show that the Puget Sound region will soon be designated as not meeting these health standards. Cleaning up the ships in and around Puget Sound will be an important part of the strategy to achieve public-health based air quality goals, address pollution hot-spots, reduce global warming pollution and maintain clean, healthy air.

Los Angeles/Long Beach

According to the World Shipping Council's container cargo rankings of U.S. ports, the ports of Los Angeles and Long Beach together accounted for more than 36% of all U.S. containerized imports and exports in 2003; together with Oakland, California ports handle nearly half of all U.S. waterborne containerized cargoes.[64]

The Port of Los Angeles recently released an emissions inventory for 2006. In 2006, approximately 2,700 ships called on the port, including about 1,600 container ships, delivering nearly 8.5 million TEUs of cargo. A TEU is a "twenty-foot equivalent unit" and is used to describe how much a ship can carry. A standard container is two TEUs.[65]

EPA estimates that in 2002, ships in the Port of LA also delivered roughly 4,850 metric tons of NO_x, 320 metric tons of $PM_{2.5}$, and 2,800 metric tons of SO_2. The NO_x emissions alone from these ships are comparable to the emissions from over 5 million of today's cars.[66] A more recent inventory conducted by the Port of LA in 2006 found that ships in the Port emitted approximately 6,600 tons of smog-forming NO_x, 515 tons of $PM_{2.5}$, 5,700 tons of SO_2 and 406,000 tons of CO_2.[67]

As the second-busiest seaport in the United States and the 15th busiest cargo port in the world, the Port of Long Beach is a key portal between the U.S. and Asia and a powerful economic engine whose trade generates nearly 1.4 million domestic jobs and accounts for 13% of all containerized cargo moving through the country.[68] In 2006, the Port of Long Beach registered nearly 7.3 million TEUs of cargo and was called upon by 2,792 ocean-going vessels, nearly half of which were container ships.[69] In 2002, EPA estimates that ships in the Port emitted around 5,300 metric tons of NO_x, 350 metric tons of $PM_{2.5}$, and 3,100 metric tons of SO_2. However, a more recent emissions inventory conducted by the Port in 2006 found that ships emitted a combined total of approximately 7,200 tons of NO_x, 600 tons of $PM_{2.5}$, 6,800 tons of SO_x, and 437,000 tons of CO_2.[70]

Houston

The Port of Houston is comprised of the Port of Houston Authority and more than 150 private industrial companies stationed along the 25-mile-long Houston Ship Channel, making it the largest petrochemical complex in the country. A total of 6,348 ship calls were made to the Houston Ship Channel in 2006.[71] These vessels moved over 220 million tons of total cargo, and helped position Houston as the largest port in the United States with respect to foreign tonnage and second in total tonnage.[72]

Container shipping terminal at the Port of Houston.

PORT OF HOUSTON

Collaborating to protect human health from all sources of port pollution

Many ports, communities, cities and states are taking action to clean up port-related pollution from all sources, including ships. For example, in 2006, the **Ports of Los Angeles and Long Beach** developed the San Pedro Bay Ports Clean Air Action Plan, which commits to reducing particulate pollution by 45% over five years by addressing all port-related emissions sources—ships, trucks, trains, equipment and harbor craft. In order to reach their goal, the ports are already in the process of providing shore-side power to container ships and cruise ships; requiring vessel speed reduction incentives and cleaner fuel; phasing out all "dirty" diesel trucks; and many other strategies.[73]

The **Ports of Seattle and Tacoma** along with **Port Metro Vancouver** developed the Northwest Ports Clean Air Strategy in 2007, which commits the ports to emission reductions from ships, cargo-handling equipment and drayage trucks and sets benchmarks for each.[74] The Port of Seattle also provides shore-side power to container and cruise ships. Seattle City Lights, the local utility, gets a significant portion of its power from hydro plants and other renewable sources, making the shore-side power a much cleaner alternative to idling the ships' diesel engines.[75] The Port is also partnering with Holland America Line and Krystallon, a company that makes seawater scrubbers, to test the emissions reducing technology on a cruise ship that calls on Seattle's port.[76]

Additionally, the **Port of New York** has taken action to reduce emissions—retrofitting Staten Island ferries and electrifying many of the port cranes and gates. The Port saw a 30% decline in cargo-handling equipment emissions from 2002 to 2004 as a result of phasing out some of the dirtiest equipment for cleaner electric ones.[77]

Many other ports and communities around the nation are taking similar steps to address local air pollution problems by reducing marine shipping emissions and they are an important part of the national and global solution to cleaner shipping. Ports and municipalities can help mold national and international regulations by driving technology development and encouraging the private sector to make reductions. They also signal to federal and national agencies that the pollution impacting local communities needs to be addressed now. This collaboration between private partners, local, state and federal governments and the IMO will help make marine shipping a cleaner transportation option.

As population in the Houston-Baytown-Sugar Land metropolitan statistical area is projected to rise to 6.4 million by 2020, port traffic, and in particular container traffic, is expected to increase commensurately.[78] Current estimates project a growth rate of 7% per year that extends through 2020 for containers handled by the port.[79] In tandem with the expected increase in pollution from the growth in container traffic is an increase in pollution from emission sources of other types of ocean-going ships, including tankers and cruise ships that operate in and around the Houston ship channel. EPA estimates that marine vessels in the Houston-Galveston ports emitted about 5,600 metric tons of NO_x, 590 metric tons of $PM_{2.5}$, and 5,000 metric tons of SO_2 in 2002.[80] Those NO_x emissions are comparable to the pollution from over 6 million of today's new cars.[81]

The Houston metropolitan area has continually failed to meet the health-based federal air quality standards for ozone and must look for ways to make significant reductions. Ocean-going ships provide this opportunity as they are not only a significant contributor to the area's pollution problems, but cost-effective reduction strategies are readily available today.

Reducing emissions from Category 3 engines will help facilitate the Houston area's ability to attain federal ambient air quality standards and to decrease health impacts associated with poor air quality. This will improve the quality of life for populations and ecosystems located around the Port of Houston.

Lower Mississippi

From Baton Rouge to the mouth of the Mississippi, along 254 miles of river, five deep water ports handle cargo coming down the Mississippi River and up from the Gulf of Mexico: Baton Rouge, South Louisiana, New Orleans, Plaquemine and Lake Charles ports. Together, these ports handle more cargo volume than any port complex in the world, including more than 258 million short tons of cargo in 2007. Export traffic consists mainly of grain grown in the American heartland, transported by barge down the inland waterways of the Mississippi, Missouri and Ohio River systems, and loaded onto ocean-going freighters bound for ports around the world. The largest of the lower Mississippi ports, the Port of South Louisiana, alone accounts for 15% of total U.S. exports. In fact, over 4,000 ocean-going vessels and 55,000 barges call at the Port of South Louisiana each year, making it the top ranked port in the country for export tonnage and total tonnage.[82]

EPA estimates that in 2002, ocean-going ships were responsible for approximately 16,800 metric tons of NO_x, 1,290 metric tons of $PM_{2.5}$, and 10,700 metric tons of SO_2 in the five ports of the Lower Mississippi.[83] The NO_x emissions alone are comparable to the pollution from over 18 million of today's new cars.[84] Notably, this accounting of ship emissions represents some of the highest levels of marine pollution anywhere in the country. Like other metropolitan areas struggling to bring healthier air to their people, communities surrounding the Lower Mississippi would benefit immensely from significant reductions in marine shipping pollution.

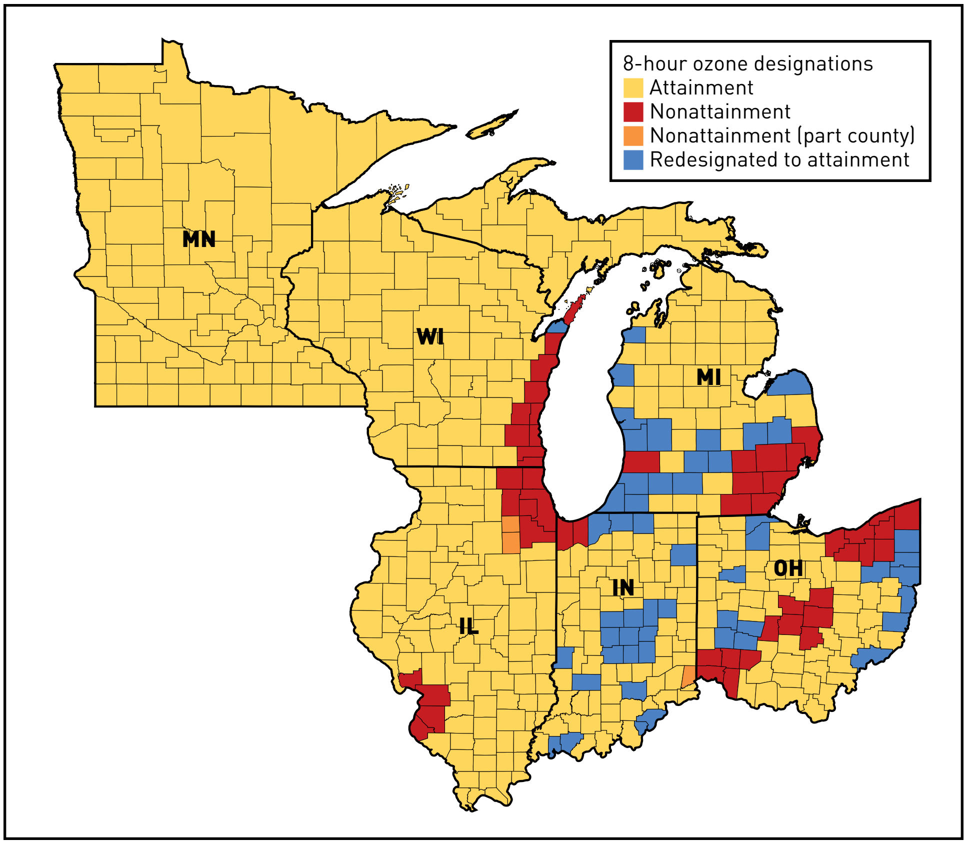
The Great Lakes Region

More than 65 ports, including 15 major international ports and more than 50 smaller ports are located along the Great Lakes-St. Lawrence Seaway system. The Great Lakes and St. Lawrence River form the world's longest deep-draft inland waterway, extending from Duluth, Minnesota on Lake Superior, to the Gulf of St. Lawrence on the Atlantic Ocean. The system covers a distance of more than 2,340 miles. From Milwaukee, Wisconsin to Oswego New York, the Great Lakes ports process about 192 million tons of cargo per year.[85]

About 74% of the tonnage brought in by ocean-going vessels, known colloquially as "Salties," because they enter the Great Lakes from the Atlantic Ocean, consists of imported steel and exported grain. This is about 12.3 million metric tons annually, or 6.8% of the total Seaway tonnage.[86]

FIGURE 10

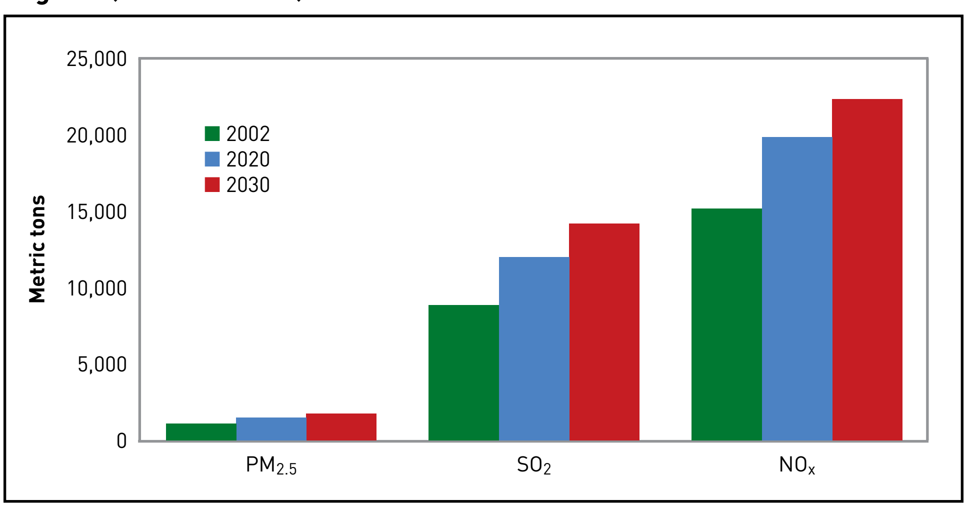
Designations for the 1997 8-hour ozone standard in the Great Lakes region (as of September 2, 2008)



Source: http://www.epa.gov/ozonedesignations/regions/region5desig.htm

FIGURE 11

Regional Great Lakes emissions from Category 3 vessel main and auxiliary engines (in metric tons)



Source: Emission Inventories for Ocean-Going Vessels Using Category 3 Propulsion Engines In or Near the United States, Draft Technical Support Document, EPA. Tables 3-58, 4-16 and 4-17.

More than 800 Salties, flagged in more than 60 countries, travel to or through the Great Lakes each year.[87] According to EPA's most recent inventory, these ships are responsible for significant amounts of pollution, including approximately 550 metric tons of NO_x, 45 metric tons of $PM_{2.5}$, and 390 metric tons of SO_2 in 2002.[88] NO_x is a key component in the formation of smog, or ground-level ozone. Figure 10 shows the area of the Great Lake states (except New York) that are not meeting the public health standard for ozone. Figure 11 illustrates how pollution from ships sailing past and docked in the Great Lakes region is expected to grow in absence of strong federal or international standards, demonstrating just how important rigorous clean-up standards for ocean-going ships are. Notably, region-wide emissions from ocean-going ships are significantly higher than the emissions from the ships at port.

New York/New Jersey

The Port of New York and New Jersey, operated by the bi-state Port Authority of New York and New Jersey, has the third highest shipping traffic of any U.S. port, handling 5,110 ship calls in 2006.[89] These ships moved over 157 million tons of total cargo, ranking second behind Houston in foreign tonnage and third in total tonnage—handling nearly double the cargo of the next closest port.[90]

The New York City metropolitan area has the largest population of any in the United States—estimated at 18.8 million in 2006 and projected to continue growing.[91] Port traffic will also climb, as the Port of New York and New Jersey is the primary terminal on the eastern seaboard. EPA estimates that in 2002, marine vessels in the ports produced about 7,200 metric tons of NO_x, 570 metric tons of $PM_{2.5}$, and 4,600 metric tons of SO_2.[92] As population and port traffic increase, this number will rise. Further, this does not include emissions associated with operating the port or with transporting the cargo once it arrives at the port. These NO_x emissions are comparable to that of more than 7.8 million of today's new cars.[93]

The American Lung Association reported in 2008 that New York City has the eighth worst ozone pollution of any U.S. city and the thirteenth worst short-term $PM_{2.5}$ pollution.[94] Reducing pollution from C3 engines is critical to help clean the air in New York City.

Santa Barbara

In addition to impacting air quality at our nation's ports and port cities, pollution from ships also occurs in "unexpected" areas. EPA has acknowledged that shipping emissions impact virtually all U.S. coastal areas, as ships travel between ports along shipping lanes close to coastlines.[95] Furthermore, according to Professors James Corbett and Paul Fischbeck, of the University of Delaware and Carnegie Mellon University, respectively, a large portion of ship emissions in U.S. waters occur outside of ports regions, either in near-shore shipping lanes or along inland waterway routes.[96]

In fact, in Santa Barbara County, about 100 miles up the West Coast from Los Angeles area ports but next to major shipping lanes, the 1999 emissions inventory indicates that ships emitted more than 10,500 tons of NO_x each year, more than the estimated 9,400 tons of NO_x from on-road motor vehicles in the county.[97] In fact, the NO_x emissions from ships are comparable those from about 11 million of today's new cars.[98] Shipping emissions are currently about 37% of the total NO_x in the Santa Barbara area. By 2015, ship emissions are expected to increase by 67%, making ships responsible for 61% of Santa Barbara's total NO_x emissions.[99]

The proximity of commonly used shipping lanes to coastlines has resulted in significant pollution to coastal areas. The California Air Resources Board has sponsored several studies that document this movement using non-toxic tracer gases.[100] Other studies by Eddington and colleagues demonstrate that offshore emissions can migrate 50–60 miles onshore to affect the coast.[101]

A case study on the impacts of shipping on air quality in the Santa Barbara area revealed that in 2000 alone over 6,000 ship transits occurred offshore of Santa Barbara county (an average of almost 18 transits every day of the year). And of the over 1,000 vessels making these transits, 44 of them were each responsible for more than 50 tons per year of NO_x.[102] To put that in perspective, *each* of those 44 ships emitted NO_x pollution comparable to 54,000 of today's new cars.[103]

These data indicate that shipping emissions concentrated in commercial ports and emitted along our coastlines are putting millions of people in hundreds of communities at risk of harmful diesel pollution.

• • •

This chapter includes a small sampling of ports, communities, and localities affected by pollution from ocean-going ships. Many of the areas highlighted in this chapter are working hard to clean up the port-related pollution they can address, including implementing solutions like vessel speed reduction, requiring switches to cleaner fuel, and alternative marine power. Environmental Defense Fund applauds these areas for their leadership and strongly encourages more widespread application of these solutions. In order to achieve the deepest emissions reductions, from each and every ship, in all U.S. waters, stringent national and international standards must also be implemented.

CHAPTER 5

Solutions exist for reducing pollution from ocean-going ships

Category 3 ships are incredibly high polluting–partly because currently they are subject only to very weak international emissions standards that do not reflect available control technology, but also because large oceangoing vessels burn some of the dirtiest fuel in the world. Because the quality of fuel burned in these ships heavily influences emissions, switching to lower sulfur fuel is one way to make significant reductions in SO_2 and PM emissions. In addition to cleaner fuels, existing pollution control technology can lead to considerable reductions in all major pollutants. And clean air solutions from ships and their engines must include measures to address heat-trapping greenhouse gases. When looking at the various options for reducing ship emissions, it is important to take a multi-pollutant approach, to protect human health and the environment from the full suite of airborne contaminants.

Low sulfur fuel

The extraordinarily high sulfur content of residual fuel makes shipping one of the biggest sources of SO_2 pollution on earth, despite the relatively small number of ocean-going ships in existence. High sulfur levels are also responsible for significant PM emissions from ships. However, because SO_2 emissions are directly related to the concentration of sulfur in the fuel, a reduction in the sulfur level of ocean-going marine fuels results in direct SO_2 emissions reductions.[104] For example, research conducted by leading scientists in the field found that reducing shipping fuel sulfur concentrations from 2.6% to 0.1%, or from 26,000 ppm to 1,000 ppm, resulted in a nearly 98% reduction in SO_2 emissions.[105] And the 0.1% sulfur level fuel used to achieve these significant reductions is still nearly 70 times higher than the fuel required for smaller commercial ships.[106]

Reducing sulfur levels can also result in significant reductions in both direct and indirect PM emissions by reducing the fraction of PM from sulfate formation and PM emissions from ash and metal. It is estimated that PM emissions can be reduced by over 70% through the use of low sulfur distillate fuel.[107]

When looking at the SO_2 and PM emissions reductions from cleaner fuel, it is also important to consider the impact on greenhouse gas emissions. In the same study referenced above, reducing the sulfur concentration from 2.6% to 0.1% resulted in a 1–2% increase in greenhouse gas emissions due to the additional energy required to further refine the fuel. This greenhouse gas tradeoff is much smaller than previously thought and can be eliminated through increased efficiencies on board the ship (see below) or increased efficiencies in the refining process to reduce the sulfur.[108]

Most ship engines that are designed to run on bunker fuel are also capable of burning the cleaner low sulfur distillate fuel. Some ships currently have multiple fuel tanks and burn different grades of fuel depending on whether they enter an area of the world that requires cleaner fuel. So no significant ship changes or upgrades are necessary to run cleaner, less polluting diesel fuel.[109]

In fact, the California Air Resources Board (CARB) analyzed the costs of reducing the sulfur in marine diesel fuel. Under a proposed rule in California, sulfur levels for diesel fuel in main and auxiliary boiler engines would be reduced to 1.5% sulfur beginning in 2009 and to 0.1% beginning in 2012.[110] CARB estimates that the entire regulation would cost about $1.5 billion (2008$) and the benefits would total over $15 billion (2008$) and avoid over 1,600 premature deaths in just 6 years.[111] That equates to an extremely high cost/benefit ratio of 1 to 10.

Emissions-reducing technology

In addition to cleaning up the fuel, there are numerous technology options available that can reduce ship emissions. These emissions-reducing technologies can be applied to both existing ship engines and built into new ones.

Reductions in NO_x can be made through engine upgrades that reduce the maximum combustion temperature, such as optimizing fuel injection, adding water to the combustion process or recirculating exhaust gas back through the combustion process. Combined, these strategies are capable of reducing NO_x emissions up to 80%.[112] NO_x reductions can also be obtained through the use of an exhaust after-treatment technology called selective catalytic reduction (SCR). SCR is a commonly used technology to reduce NO_x emissions in all varieties of diesel engines, and has been successfully installed in over 300 marine vessels. SCR systems are capable of reducing NO_x emissions in marine exhaust by more than 90%.[113] Indeed, an SCR system can remove over 1,700 tons of NO_x per year from *one* large marine vessel. And these systems are highly cost effective, ranging from under $300–$500/ton of NO_x removed.[114]

In addition to the immediate and sizeable SO_2 and PM emissions reductions attainable through the use of cleaner fuel, similar reductions can be achieved with the addition of a seawater scrubber, a type of exhaust after-treatment technology. Seawater scrubbers, which are similar to scrubbers used on power plants, utilize the seawater's ability to absorb SO_2, thereby reducing SO_2 emissions. They can be installed on new and existing ships and are capable of reducing SO_2 emissions on the order of 95-99% and direct sulfate PM emissions by as much as 80%.[115] In fact, a seawater scrubber can remove over 1,000 tons of SO_2 from just one large ship in a year.[116] Scrubbers are also cost-effective with costs of approximately $300/ton of SO_2 removed on a new ship and less than $500/ton of SO_2 removed on a retrofitted ship.[117]

Seawater scrubbers are estimated to have a greenhouse gas penalty of about 1–3%, but it can be offset through other operational improvements and efficiency measures on the ship (see below). It is important, however, that seawater scrubbers be developed in a fashion that protects water quality and properly disposes of sludge removed from the exhaust.

COURTESY OF MJ BRADLEY

One component of an SCR system

Another available technology, called the Advanced Maritime Emissions Control System, places a large bonnet over the exhaust stack of a ship, treating the air pollution as it exits, and removing up to 95% of NO_x, PM and SO_2. This technology does not require any modification to the ships and can capture and treat exhaust while ships are berthed or anchored waiting to be berthed.[118]

Greenhouse gas emissions can be reduced through operational changes like vessel speed reduction. Slowing a ship down reduces the amount of fuel burned. The IMO estimates that if the entire global shipping fleet reduced its speed by 10%, it would result in a 23% reduction in emissions.[119] There are also operational improvements that can help reduce CO_2 emissions from ships. It is estimated that CO_2 emissions can be reduced in new vessels by 5-20% through available technology, including hull and propeller modifications and engine optimization for efficiency over power.[120] Other potential solutions include making the ships and/or the containers they carry out of lighter materials. If a ship weighs less, then it does not require as much fuel to operate thus reducing fuel use and cutting the associated greenhouse gas emissions.[121]

Hotelling emissions

Ships also generate considerable emissions while docked at ports because they run their auxiliary and main engines for electricity and to cool or heat the ship and its fuel tanks. When ships are in port, essentially idling in the manner described above, it is called "hotelling". At deep-sea ports, auxiliary engines are responsible for roughly 47% of the NO_x and PM emissions from ships.[122] Table 3 shows hotelling emissions at various ports.

TABLE 3
Hotelling emissions by deep sea port in 2002 (metric tons)

	NO_x	$PM_{2.5}$	SO_2
Ports of Seattle and Tacoma	1,250	90	790
Los Angeles and Long Beach	4,130	250	2,600
Houston/Galveston	2,100	310	2,700
Lower Mississippi[123]	6,300	490	4,300
New York/New Jersey	2,700	210	1900
Great Lakes Ports	250	20	170

Source: Emission Inventories for Ocean-Going Vessels Using Category 3 Propulsion Engines In or Near the United States, Draft Technical Support Document, EPA420-D-07-007, Table 3-21 and 3-39.

Hotelling emissions can also be reduced through the use of low sulfur fuel or available technology. The most common technology already in practice in many of our nation's ports is called "cold ironing" and provides electric power to the docked ship from land-side generation sources. This strategy displaces emissions from the hotelling ship to the shore-side source, significantly reducing the overall emissions while the ship is "idling" at port. Additionally, if shore-side power is generated by clean, renewable sources of electricity then pollution is eliminated rather than shifted

PORT OF LOS ANGELES

PORT OF LOS ANGELES

Left: A crane lifts the electrical plugs of the shore-side power system to a ship at the Port of Los Angeles. Right: A close-up of a ship's electrical "plug-in" to shore-side power at the Port of Los Angeles.

from one place to another. For example, Seattle City Light, the local utility in Seattle, gets a significant amount of its power from hydroelectric plants and other renewable sources, making shore-side power at the port much cleaner than ships idling their dirty diesel engines.[124]

Many ports, including Los Angeles, Juneau, and Seattle, have already installed the necessary landside power delivery infrastructure and ship operators have retrofitted numerous vessels to connect to facilities at these ports. It is estimated that cold ironing can reduce NO_x, SO_2 and PM emissions by more than 90%.[125]

CHAPTER 6

Policy recommendations

This report describes the startlingly large amount of air pollution associated with ocean-going ships in U.S. waters and shows that pollution from these ships is far-reaching—extending well beyond the U.S. port cities where one might expect to see this pollution. Neither EPA nor the IMO have updated the standards that apply to ocean-going ships in several years. During this period of time, shipping has increased, clean-up technologies have advanced by leaps and bounds, and other diesel-fueled engines in the United States are being required to make 80–90% reductions in their pollution.

Ocean-going ships are significant polluters today and without strong standards their pollution will continue to grow. Nationally, in 2030, if pollution from C3 engines is allowed to grow unchecked, they will account for about 34% of mobile-source NO_x, 45% of mobile-source $PM_{2.5}$, and 94% of mobile-source SO_2. These percentages would likely vary port city by port city. At the same time, an extensive body of science documents that SO_2, NO_x, and $PM_{2.5}$ contribute to particulate and ozone concentrations that harm human health and the environment at lower concentrations than previously understood. In 2006 and 2008, EPA tightened the nation's health-based air quality standards for particulate pollution and ozone making the need for deep reductions in shipping pollution even more urgent.

Marine shipping presents an important opportunity to significantly reduce harmful NO_x, SO_2 and PM pollution to improve our nation's air quality, as well as global warming-causing pollutants like CO_2, which could make shipping one of the cleanest and most efficient modes of freight transport. Measured in BTUs per ton-mile, waterborne freight is currently 85% less energy intensive than trucking, but nearly twice as energy intensive as rail freight.[126] However, with available technology upgrades, combined with changes in shipping practices, like slower speeds, marine shipping has the potential to become even more efficient.

Without stringent clean-up standards, ships will continue to not only be the significant polluters that they are today, but will become a growing contributor to air quality problems across the United States. However, ships are an essential component to goods movement and one of the most efficient modes of freight transportation. It is of vital importance to require ocean-going ships in U.S. waters to be as clean as technologically feasible. Therefore Environmental Defense Fund recommends the following four steps to cut the harmful pollution from ships:

1. Rigorous, protective standards must be secured immediately

There are two policy options available to ensure that meaningful clean-up standards are put in place for both U.S. and foreign ships. The first option is updating international standards through the IMO. Indeed, the IMO is on track to adopt more rigorous emission standards for ships in October 2008. The proposed standards were put forth by the United States and, if adopted and implemented by the participating nations, will result in significant emissions reductions from all ocean-going ships. These updated emission standards would apply to all ships calling on U.S. ports and traveling through U.S. waters.

The second policy option is EPA moving forward with its own standards that apply to all ships calling on U.S. ports and traveling along our coastlines. EPA has authority to regulate both U.S. and foreign-flagged ships. EPA's leadership in carrying out the IMO standards and in pressing ahead with federal standards is critical to protect human health and the environment in the United States. Environmental Defense Fund respectfully recommends IMO adoption of the standards below, currently under consideration for amending Annex VI of the MARPOL treaty.[127]

- Reduce PM and SO_2 from new and existing Category 3 engines by at least 90% percent no later than 2011
- Make interim reductions in NO_x from new engines by at least 15-25% from current levels no later than 2011
- Require deeper NO_x reductions from new engines of at least 80% of the interim standards no later than 2016.
- Require existing ships to reduce NO_x by at least 20% beginning no later than 2012
- Establish Emission Control Areas to provide further reductions

The International Maritime Organization is meeting this October (2008) to consider amendments to Annex VI of the MARPOL treaty. These amendments would require substantial reductions in the pollution from C3 engines. In order to clean up the emissions from C3 engines, these standards must remain strong and protective. Therefore, to protect public health and the environment, Environmental Defense Fund encourages the parties to the MARPOL treaty to vote "yes" on the U.S.-proposal at the October meeting.

2. Establish an Emission Control Area along North American coastlines

Stronger international air pollution standards are enforced in Emission Control Areas, established by the IMO, to protect areas particularly sensitive to shipping emissions. In order to protect communities and ecosystems in America, EPA should apply to the IMO to establish an Emission Control Area for the entire coastline of the U.S. The ECA must include rigorous SO_2, NO_x and PM standards and extend at least 200 nautical miles off the coast, the same distance as our economic zone, in order to be fully protective. Further, the United States should coordinate its efforts with the governments of Canada and Mexico to establish a North American ECA as many of our coastlines are impacted by ships traveling to and from Canadian and Mexican ports and many ships travel on routes that take them to ports in both countries as they unload their cargo from foreign destinations.

3. Address greenhouse gas emissions from ocean-going ships

Our earth is warming and ocean-going ships are responsible for about 3% of global CO_2 emissions and about 55.6 million metric tons of CO_2 in U.S. waters. To solve global climate change, every sector must do its share. It is important to complete greenhouse gas inventories and establish fleet baselines. Environmental Defense

Fund strongly encourages policymakers and legislators to address the global warming pollution from these high-emitting ships through the following solutions:

- Establish greenhouse gas emission standards for ships
- Encourage more efficient shipping practices
- Increase use of "anti-idling" measures, like shore side power

Additionally, Environmental Defense Fund strongly recommends addressing non-CO_2 greenhouse gases from ships, including black carbon.

4. Reduce or eliminate in-port emissions from ships

In-port emissions from C3 ships are of great concern, because ships that are near land or in port are emitting harmful pollution close to people. The exhaust emitted from ocean-going vessels is among the most dangerous and pervasive sources of air pollution. Its constituents include particulate matter, implicated in a host of respiratory problems and thousands of premature deaths every year; smog-forming oxides of nitrogen; sulfur dioxide, which forms harmful fine particles and falls back to earth as acid rain; and a noxious brew of toxic chemicals that together pose a cancer risk greater than that of any other air pollutant. Furthermore, diesel air pollution adds to cancer risk all around the country. In many counties across the country, diesel emissions are the hazardous air pollutant with the highest contribution to cancer risk. To reduce exposure to this pollution, EDF recommends policymakers carry out available solutions today including:

- Fuel switching, from dirty, high sulfur fuels to cleaner grades of diesel fuel.
- Putting in place pollution control technologies, like alternative marine or shore side power.
- Operational changes like vessel speed reduction.

Notes

1 Control of Emissions From New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder; Proposed Rule (December 7, 2007). 72 Fed. Reg. 69522, page 69545-69546.

2 Regulating Greenhouse Gas Emissions Under the Clean Air Act; Proposed Rule (July 30, 2008) 73 Fed. Reg. 44354 at 44466

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NATIONAL HEADQUARTERS
257 Park Avenue South
New York, NY 10010
212-505-2100

AUSTIN, TX
44 East Avenue
Austin, TX 78701
512-478-5161

BOSTON, MA
18 Tremont Street
Boston, MA 02108
617-723-2996

BOULDER, CO
2334 North Broadway
Boulder, CO 80304
303-440-4901

LOS ANGELES, CA
633 West 5th Street
Los Angeles, CA 90071
213-223-2190

RALEIGH, NC
4000 Westchase Boulevard
Raleigh, NC 27607
919-881-2601

SACRAMENTO, CA
1107 9th Street
Sacramento, CA 95814
916-492-7070

SAN FRANCISCO, CA
123 Mission Street
San Francisco, CA 94105
415-293-6050

WASHINGTON, DC
1875 Connecticut Avenue, NW
Washington, DC 20009
202-387-3500

Project offices

BEIJING, CHINA
East C-501
No. 28 East Andingmen Street
Beijing 100007 China
+86 10 6409 7088

BENTONVILLE, AR
1116 South Walton Blvd.
Bentonville, AR 72712
479-845-3816