APPENDIX A

PORT LAND-USE EFFICIENCY METHODOLOGY

THE EARTH'S BEST DEFENSE

HARBORING POLLUTION

Strategies to Clean Up U.S. Ports

August 2004

We examined the land-use efficiency of ten of the largest U.S. container ports and compared them to the Port of Singapore, an international port known for efficient land use. The standard measure of container throughput, twenty-foot equivalents units (TEUs)—roughly equal to half of a regular size container—was compared on a per-container-terminal-acres per-year basis.

METHODS

Data on 2001 container throughput (measured in TEUs) was collected from each port's web site. When possible, terminal acreage was also taken from these web sites. This acreage included only the size of terminals completely or predominantly dedicated to handling containers, not the total acreage of the port, since TEUs measure only container movement.

For the ports that separate container terminals from terminals that handle other cargo, container terminal acreage was taken directly from port web sites. These ports include Long Beach, Los Angeles, Seattle, and Oakland.[1] The acreage of Los Angeles' vacant container terminal was not included.

The container terminal acreage of New York/New Jersey was taken from the New York & New Jersey Harbor Navigation Study, which includes its own estimates of acreage and efficiency.[2] Charleston's estimates come from the South Carolina port's web site, which has a discussion of efficiency, and is verified with the "Draft Environmental Impact Statement (DEIS) for the Proposed Daniel Island Marine Cargo Terminal," which provides the container processing and storage acreage for the three terminals that handle containers: Columbus Street, North Charleston, and Wando Welch.[3] A DEIS for Miami does not give a precise number for container terminal acreage; however, it specifies that cargo-related operations use 372.5 acres and maintain that "the port handles primarily containerized cargo."[4] Houston acreage comes from Houston's own 2003 efficiency study entitled "U.S. Container Terminal Throughput Density."[5]

In the cases of both Hampton Roads and Savannah, no numbers detailing the exact proportion of the terminals that are dedicated to containers, or any efficiency studies produced by the ports themselves could be found.[6] Therefore, estimates were calculated based on available data. Hampton Roads published total area as well as container open storage area for its Newport News Marine Terminal. The area of this terminal for containers was estimated to be the open storage area plus the proportion of pier feet dedicated to containers times the remaining area, to account for facilities used in container processing that may be outside of the storage area. The calculation amounted to 43 acres + [27%*(140.64–43)].

The container area of the Norfolk International Terminals, for which no open storage area could be found, was taken to be 55 percent of the total area of the terminal minus the area of the piers devoted to other cargo. Fifty-five percent is the proportion of berth linear feet for containers. The final calculation was then 55%*[811–(9+9+14)] acres. For Portsmouth Marine Terminal, there are 46.8 acres of open storage area. This was added to one-third of the remaining terminal acreage, since all berths are used for container, break-bulk, and Ro/Ro cargo.

For Savannah, open storage acreage was added to 46 percent of remaining terminal acreage—since 92 percent of berth linear feet is container and Ro/Ro berths. This percentage was then divided in half to get only containers.

The acreages for Savannah and Hampton Roads are intended only as estimates, based on the given data.

RESULTS

The Port of Singapore exemplifies the gold standard in land-use efficiency at its four container terminals: Tanjong Pagar, Keppel, Brani, and Pasir Panjang.[7] Among U.S. ports, although Long Beach and Houston have the highest efficiencies (4,825 and 4,417 TEUs/acre/year, respectively), they are still about four times less efficient than the Port of Singapore. The average of the top ten U.S. ports, 2,996 TEUs/acre/year, shows that the United States still has a long way to go to reach the efficiency already in practice at some major ports abroad.

APPENDIX B

Additional Technical Information for Mitigation Measures

HARBORING POLLUTION

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DIESEL PARTICULATE FILTERS

Diesel particulate filters (DPFs) can achieve an 85 percent or betetr reduction in PM.[8] They are widely used in Europe and are available throughout the United States for 1994 model year or newer engines that are 4 four-stroke, turbocharged, and that can meet a 0.10 grams per brake horsepower-hour (g/bhp-hr) PM emission standard.[9] DPFs are sensitive to sulfur levels in fuel and typically require fuel with sulfur content as low as 15 parts per million. Regular on-road diesel sold today typically has sulfur levels ranging from 50 to 500 parts per million and can destroy the filters.

More than 100,000 retrofits with diesel particulate filters (DPFs) have been done worldwide.[10] Currently at least four different manufacturers have verified DPFs in California, and three have been verified through the U.S. EPA. All of these are "passive" DPFs that rely on high engine exhaust temperatures boosted by a catalyst and/or extra fuel to regenerate the particulate trap. Regeneration is necessary to remove soot buildup within the filters. These traps require high temperatures, of around 300 to 500 degrees Celsius to regenerate. Without regeneration, accumulated soot would either suddenly catch on fire, potentially damaging the filter, or it would block too much air flow, causing excessive pressure buildups in the engine and damaging or shutting the engine down.

"Active" DPFs are available in Europe, but have not yet been verified in the United States. These DPFs use electrical heaters or fuel burners to elevate temperatures for filter regeneration. Active DPFs are currently undergoing demonstration projects on both on- and off-road applications in the United States. In addition to those applications, they are used on some locomotives in Europe.

Effects of Fuel Sulfur Levels on DPF Systems

Use of low sulfur diesel will improve the ability of traps to reduce particulate matter (PM) emissions. With certain DPF systems, levels of 50 parts per million (ppm) or lower are necessary to achieve reductions. Verification of DPF systems, however, requires the use of low sulfur diesel fuel at 15 ppm or lower. Each DPF technology has a somewhat different response to sulfur levels in diesel fuel, depending on the catalyst used, but all manufacturers agree that the sulfur levels below 15 ppm ensure optimum emission control and DPF durability. Low sulfur diesel fuel costs up to 5 cents more per gallon than current California Air Resources Board (CARB) diesel, depending on fleet location.[11] Because many refineries are located near shipping ports, we also expect the incremental price for low sulfur diesel at these locations to be low.

Factors Affecting DPF Durability

Manufacturers claim that the useful life of the technology can be as high as 8,000 to 12,000 service hours, if traps are properly maintained. However, the useful life may be reduced when a DPF system is installed on a poorly maintained engine with leaking fuel injectors, a dirty intake air cleaner, excessive oil consumption and/or lubricating oil in the exhaust. In addition, particulate matter can build up on a DPF system when an engine does not achieve the proper regeneration temperature in a required duration of time (i.e., soot overloading). With this buildup, if the DPF subsequently begins to regenerate, the collected particulate can oxidize uncontrollably and ultimately destroy the DPF system.[12]

Installation of a DPF takes between 2.5 and 5 hours, and costs from $160 to $1,200 for labor. An engine back pressure monitor, necessary with the installation of any trap, costs between $1,000 and $1,200.[13]

Alternative Fuel Particulate Filters (APF)

Currently, no verified APF system can be applied to a dedicated alternative fuel heavy-duty diesel vehicle. The South Coast Air Quality Management District (AQMD) is currently contracting with West Virginia University to develop a DPF system that can operate on a dedicated alternative fuel vehicles, but the demonstration project is not expected to be complete until 2004 or later. Dual-fuel systems that pilot-inject diesel but operate mostly on natural gas do, however, have an APF system verified by CARB to reduce PM levels by 85 percent or more. Alternative fuels, like natural gas, do not contain sulfur, so sulfur is not an issue for these applications.

FLOW THROUGH FILTERS

Flow, through filters (FTFs) are an advanced emission-control technology that reduce PM emissions by 30 to 60 percent. This passive metal filter has a vast inner surface area that forces contact with the catalyzed surface, but does not trap soot. The technology is not currently commercially available, although it is expected to make it to the market soon. FTFs are not extremely sensitive to sulfur, continuing to function with fuel that has as much as 500 parts per million sulfur; however the filters may not be able to handle the amount of soot generated by very old, dirty engines.[14]

DIESEL OXIDATION CATALYSTS

Diesel oxidation catalysts (DOCs) can reduce total PM by 25 to 50 percent, depending on the composition of the PM emitted.[15] They, too, are not as sensitive to sulfur as

HEAVY-DUTY DIESEL ENGINE STANDARDS

TABLE B-1
U.S. EPA Emission Standards for Heavy-Duty Diesel Trucks, g/bhp·hr

Year	NMHC	NMHC + NO_x	CO	NO_x	PM
1974		16	40		
1979	1.5	5 or			
10	25				
1984	1.3 (T), or 0.5 (ss)		15.5	10.7 (T) or 9.0 (ss)	
1988					0.60
1990				6.0	
1991				5.0	0.25
1994				5.0	0.10
1998				4.0	0.10
2004	0.5	2.4 or 2.5			
2007	0.14			0.20	0.01

Sources: http://www.epa.gov/otaq/retrofit/overoh-all.htm

T = Over the Transient Test Cycle
ss = Over the Steady-state Test Cycle, NMHC=Non-methane hydrocarbons (similar to VOCs), CO=carbon monoxide, NO_x=nitrgen oxides, PM=particulate matter

TABLE B-2
U.S. EPA Tier 1-3 Nonroad Diesel Engine Emission Standards (g/bhp·hr)

Engine Power	Tier	Year	CO	VOCs	NMHC+NO_x	NO_x	PM
hp < 11	Tier 1	2000	6.0	—	7.8	—	0.75
	Tier 2	2005	6.0	—	5.6	—	0.60
11 ≤ hp < 25	Tier 1	2000	4.9	—	7.1	—	0.60
	Tier 2	2005	4.9	—	5.6	—	0.60
25 ≤ hp < 50	Tier 1	1999	4.1	—	7.1	—	0.60
	Tier 2	2004	4.1	—	5.6	—	0.45
50 ≤ hp < 100	Tier 1	1998	—	—	—	6.9	—
	Tier 2	2004	3.7	—	5.6	—	0.30
	Tier 3	2008	3.7	—	3.5	—	-†
100 ≤ hp < 175	Tier 1	1997	—	—	—	6.9	—
	Tier 2	2003	3.7	—	4.9	—	0.22
	Tier 3	2007	3.7	—	3.0	—	—†
175 ≤ hp < 300	Tier 1	1996	8.5	1.0	—	6.9	0.40
	Tier 2	2003	2.6	—	4.9	—	0.15
	Tier 3	2006	2.6	—	3.0	—	—†
300 ≤ hp < 600	Tier 1	1996	8.5	1.0	—	6.9	0.40
	Tier 2	2001	2.6	—	4.8	—	0.15
	Tier 3	2006	2.6	—	3.0	—	—†
600 ≤ hp < 750	Tier 1	1996	8.5	1.0	—	6.9	0.40
	Tier 2	2002	2.6	—	4.8	—	0.15
	Tier 3	2006	2.6	—	3.0	—	—†
hp ≥ 750	Tier 1	2000	8.5	1.0	—	6.9	0.40
	Tier 2	2006	2.6	—	4.8	—	0.15

† Not adopted, engines must meet Tier 2 PM standard.
See Table 3-1 for Tier 4 standards.

DPFs, functioning with fuel that has as much as 500 parts per million sulfur. That said, reductions of pollutants are higher with the use of lower sulfur fuels. In fact, DOCs actually increase PM emissions when used with EPA off-road grade diesel, which has roughly 3,000 parts per million sulfur.

The installation of a DOC system is relatively straightforward and can be as simple as installing a muffler replacement on a heavy truck. Nearly 20,000 DOCs have been installed on urban buses and trucks in the United States and Europe. The earliest trucks and buses retrofitted have accumulated more than 93,000 miles and have been virtually maintenance free. DOCs are also used in other parts of the world. In Mexico, for example, more than 8,000 heavy trucks have been retrofitted. Hong Kong recently embarked on a large retrofit program that involves 2,000 urban buses and more than 40,000 medium-duty diesel vehicles. Hundreds of thousands of retrofits have been completed throughout the world.[16]

NO_X CONTROL STRATEGIES

While most advanced NO_x reduction strategies are still under research and development, several others are already on the market for purchase. Exhaust Gas Recirculation (EGR) can reduce NO_x by as much as 40 percent. Hundreds of buses have been retrofitted with EGR in Europe, and many demonstrations are under way in the United States.[17] EGR can increase PM emissions, and therefore should not be used without a DPF or other PM control. LNCs require low sulfur diesel to achieve modest NO_x reductions of 10 to 20 percent. A limited number of vehicles in the United States have been retrofitted with this still improving technology.

COMBINED TECHNOLOGIES

Various diesel emission control strategies can be integrated into a single system. One integrated strategy uses a DOC in combination with emulsified diesel fuel, a cleaner diesel fuel described in detail below. Several terminal operators at the ports of Long Beach and Los Angeles have adopted this strategy for reducing diesel emissions because it can quickly be integrated into existing operations with relatively low upfront costs.

Another system that combines technologies uses a passive DPF in combination with a lean NO_x catalyst (LNC). This retrofit system allows diesel units to simultaneously achieve significant NO_x, PM, CO, and ROG emission reductions. Prior to retrofitting the equipment, data logging of temperature profiles is necessary to ensure that the duty cycle will result in exhaust temperatures that are high enough for the DPF to operate without clogging. The California Air Resources Board recently verified that one product that bundles a DPF with an LNC eliminates at least 85 percent of diesel PM and 25 percent of NO_x. Demonstrations of this control technology on construction equipment in Sacramento, California, have also proved successful.[18] LNCs are also available in combination with DOCs, achieving 25 percent reductions of both PM and NO_x.

TABLE B-3
Estimated Emissions From Idling

Average Truck's Idle Pollutants	CO[a]	CO_2[b]	VOCs[a]	No_x[b]	PM_{10}[a]
Grams/hour	94	8,224	12.5	144	2.57
Total tons per year	316	27,651	42	484	8.64
Reductions per year (tons)	263	23,043	35	403	6.7

a American Trucking Association Green Truck web site, www.truckline.com/air_emissions/1420.html as quoted in Frank Stodolsky, Linda Gaines, and Anant Vyas, "Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks," Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, Argonne, IL, June 2000, p. 31.

b U.S. EPA's "Study of Exhaust Emissions from Idling Heavy Duty Diesel Trucks and Commercially Available Idle-Reducing Devices," Certification and Compliance Division, Office of Transportation and Air Quality, Author: Han Lim, EPA420-R-02-025, October 2002, p. 9.

REDUCED TRUCK IDLING

It is difficult to estimate the exact benefits of idling reductions from trucks because emissions and practices vary substantially with the size, location, and practices at specific ports. Benefits are estimated in this report using emissions data and the associated sources in Table B-3, and statistics from the Port of Los Angeles regarding the number of containers that move through the port every day. In 2002, more than 6.1 million TEUs moved in and out of the Port of Los Angeles. The port averages 272 work days per year (52 five-day work weeks plus twelve weekend days during the late summer "peak" season). Therefore, an average working day sees the movement of 11,224 containers (approximately two TEUs equate to a "container") in and out of the port. Truckers typically report spending one or more hours of idling time while running loads to and from the Port of Los Angeles. Assuming every truck that carried one of these containers idled for one hour, the estimated emissions would be as calculated in Table B-3. The proposed idle-reduction measure would decrease idle time from one hour in each instance to only 10 minutes.

The approximate emission reductions from this measure can be found in the last row of Table B-3. Nitrogen oxide (NO_x) emissions from idling trucks at the Port of Los Angeles would be reduced an average of nearly 1.5 tons a day, toxic PM would be reduced by 53 pounds per day, and emissions of the primary greenhouse gas, carbon dioxide, would be reduced by nearly 85 tons per day.

In addition, the EPA estimates that the average truck wastes 0.8 to 1 gallon of fuel per hour of idling. Using the same assumptions used to calculate emission reductions above, we estimate that more than 9,200 gallons of fuel are wasted every day at the Port of Los Angeles, which accumulates to more than 2.5 million gallons of fuel wasted from unnecessary idling every year. This measure would save most of that wasted fuel, totaling more than 2 million gallons every year at the Port of Los Angeles.

TECHNICAL INFORMATION ON TUGBOAT RE-POWERS

A number of tugboats have been repowered in California in recent years. The Port of Los Angeles, the Port of Oakland, and the Carl Moyer Program have all subsidized tugboat repower projects. But based on a recent technical report that has not yet been published, we believe that the potential benefits of repowering tugs have been generally underestimated.[19]

This report contains data on existing engines and operations of ferry, tour boat and tugboat operators in the San Francisco Bay area. The report also includes data on engine models, age, type of service, annual operating hours, and fuel consumption. Emission rates for each engine were identified by contacting engine manufacturers. While NO_x emission rates were available for nearly all engines, emission factors for PM and other criteria emissions were scarce. Most existing marine engines can be tuned for higher fuel economy (with higher NO_x emissions) or low NO_x emissions (with loss of fuel economy). It was assumed that current tug engines were tuned for high fuel economy. While data was acquired for both propulsion and auxiliary engines, the analysis is focused on the much larger and higher emitting propulsion engines. Analysis is also focused on tugs with 1,500 horsepower or larger propulsion engines, which are typically involved in cargo vessel escort and assist operations.

Data on operating hours was limited, and in some cases confidential, making it necessary to estimate hours of operation for some tugs based on their type of service and similar data provided by the San Francisco Marine Exchange. Seaworthy Systems, Inc. estimated the potential benefits of repowering by identifying potential replacement engines for each tug based on their experience with marine engines and tug operations. The emission rates of replacement engines were compared to the emission rates of currently installed engines. An estimate of emissions avoided was calculated by assuming that each tug's annual operating hours would remain constant after repowering.

Table B-4 below summarizes the emissions avoided by repowering various tugboats, based on the data in the San Francisco Bay Area report.

Assuming the data collected are reasonably representative of tugs and their operation in other areas, tug engine repowering is a very cost-effective mitigation measure for ports working to substantially reduce NO_x emissions.

TABLE B-4
Emission Reductions From Tugboat Re-powers

Engine Size (HP)	Number of Tugs in Sample	Average Annual Operating Hours	Average NO_x Emissions (lbs/hr)	Average NO_x Emissions (tons/yr)	Average NO_x from Replacement Engines (tons/yr)	Reduction	Cost per ton of NO_x Avoided[a]
1500-1999	8	2,688	96	129	67	48%	$589
2000-2499	10	2,915	137	196	102	48%	$447
2500+	5	5,180	170	446	252	43%	$223

a The estimate includes the capital cost of purchasing two new replacement engines per tug, but does not include the cost of installation or the opportunity cost of taking the boat out of service. It does not include the cost or benefits of replacing auxiliary engines.

FUEL CELLS (FOR SHORESIDE POWER)[20]

Fuel cell technology in marine applications offers many significant enhancements over existing diesel generators. These include very low exhaust emissions, inherently low vibration and sound levels, and improved thermal efficiency (particularly at low load levels). The U.S. Navy and many foreign navies are considering the use of integrated electric plants that employ fuel cells in future ship designs.

While ongoing studies are examining the use of fuel cells for ship propulsion, applications for fuel cells today may be limited to onshore power supply during ship hoteling, offshore platform auxiliary power, remote navigation, radar, and oceanographic data acquisition and transmission systems. Fuel cells for propulsion of tugboats, supply vessels, and commercial ships is technically feasible and has the capability of maintaining high efficiency over a broad range of load requirements, but it is not yet commercially available. Issues such as availability of fuels and various physical and operating constraints must be considered for each application. Another consideration is how well fuel cells will perform relative to such competing systems as diesel power plants. In the near term, fuel cells are likely to be competitive with larger engines for tankers, container ships, and bulk carriers, where operation is at constant speeds and current high-efficiency, low-rpm diesel engines are used. Accordingly, fuel cells used for ship propulsion in the near future will likely be for those applications where quiet operations are useful and where power settings are not constantly changing.

Fuel cells are also available for auxiliary power. Auxiliary power units can provide electricity to all systems aboard, including hotel services (lighting, plumbing, and pumps for water); bilge and ballast pumps; fuel transfer systems, cargo-handling systems; and navigation systems. At this time, less capital investment and less risk would be required for these systems than it would be for ship propulsion systems based on fuel cells.

Fuel cells offer several other benefits for marine applications. For propulsion applications, fuel cells have the advantage of modular design, which enables flexibility in the arrangement of plant components, which could, in turn, lead to a more cost-effective layout of power and cargo spaces, and even of basic ship structure. As with other electrical power plants, fuel cells might help mitigate the maneuvering problems of ships and tugs by enabling electrical power to be quickly switched to different locations—to reverse main propellers or to activate side thrust propellers or water jets, for example.

Total efficiency improvements in the neighborhood of 10 to 20 percent above low-speed diesel powered engines will be realized for fuel cells. Typical efficiencies for low-speed diesel power plants are in the neighborhood of 40 percent, while fuel cells such as the molten carbonate fuel cell (MCFC), which operates at higher temperatures than the phosphoric acid fuel cell (PAFC), have efficiencies of up to 55 percent. The solid oxide fuel cell (SOFC) is not currently available on the commercial market, but can achieve even higher efficiencies.

Significant progress has been made in the use of fuel cells for the power industry. At the present time, two technologies have been successfully employed in the

TABLE B-5
Fuel Cell Technologies

	PEMFC	PAFC	MCFC	SOFC
Electrolyte	Ion Exchange Membrane	Immobilized Liquid Phosphoric Acid	Immobilized Liquid Molten Carbonate	Ceramic
Operating Temperature	80°C	200°C	650°C	1,000°C
Electrical Efficiency	30–35%	36–38%	45–55%	45–50%
Overall Efficiency (Electrical + Thermal)	50–60%	75–80%	75–80%	75–80%

commercial market: the PAFC manufactured by United Technologies Company and the MCFC manufactured by Fuel Cell Energy, Inc. A comparison of fuel cell technologies is shown in Table B-5.

The current cost of fuel cells is estimated to be in the range of $4,000 per kW.[21] While this cost is relatively high compared to the more conventional diesel technology on the order of $300 to $500 per kW, the costs for fuel cells are projected to be in the range of $1,500 to $2,000 per kW in the next three to five years. With those costs in mind, several incentive programs have been adopted to assist in the commercialization of fuel cells. For example, the California Public Utilities Commission will provide up to $2,500 per kW or 40 percent of the project cost for fuel cells operating on nonrenewable fuels such as natural gas. This would reduce the cost per kW to $2,400 per kW. In addition to capital costs, operation and maintenance costs will run in the neighborhood of an additional $200 per kW.[22]

CLEANER MARINE FUELS

Marine fuels used for international trips, including marine diesel oil (MDO) and marine gas oil (MGO), are required to meet a minimum 60° Celsius flashpoint specification. The "flashpoint" specifications of non-marine lower sulfur fuels may fall below the 60° Celsius specification. In fact, non-road and on-road diesel fuel in the United States have a minimum 52° Celsius flashpoint, and the sulfur content ranges from 0.0015 percent (15 ppm) to 0.5 percent (5,000 ppm). However, in reality, the on-road and off-road fuel being sold by major U.S. suppliers has a much higher flashpoint. The 1996 average flashpoint was 73° Celsius for all blends of diesel sold in the United States.[23]

Vessel operators have argued that the lower specification for these fuels presents an unacceptable risk, given the large quantities of fuel carried by large marine vessels, and would not comply with international treaties on ocean safety.[24] In order to accommodate the flashpoint requirements, British Petroleum has altered its fuel specifications for ECD-1 (15 ppm sulfur content) to meet the 60° Celsius flashpoint.[25] Other fuel providers in California are following suit.

Lower sulfur distillates may also need different types of lube oil. This could be overcome by installing an extra cylinder oil tank. Entec recently surveyed shipbuilders to determine the costs associated with accommodating additional fuel

MARINE DIESEL STANDARDS

TABLE B-6
EPA Commercial Marine Vessel Standards

Category	Displacement (D) dm³ per cylinder or Engine Speed (n, rpm)	CO g/HP-hr	NO_x+THC g/HP-hr	PM g/HP-hr	Date
1	Power ≥ 50 HPD < 0.9	6.7	10.1	0.54	2005
	0.9 ≤ D < 1.2	6.7	9.6	0.40	2004
	1.2 ≤ D < 2.5	6.7	9.6	0.27	2004
	2.5 ≤ D < 5.0	6.7	9.6	0.27	2007[a]
2	5.0 ≤ D < 15	6.7	10.5	0.36	2007[a]
	15 ≤ D < 20 Power < 4400 HP	6.7	11.7	0.67	2007[a]
	15 ≤ D < 20 Power ≥ 4400 HP	6.7	13.1	0.67	2007[a]
	20 ≤ D < 25	6.7	13.1	0.67	2007[a]
	25 ≤ D < 30	6.7	14.7	0.67	2007[a]
3	< 130 rpm		22.8		2004
	130 rpm–2000 rpm		$60\ (\text{rpm})^{-0.2}$		2004
	≥ 2000 rpm		13.1		2004

Source: DieselNet; www.dieselnet.com/standards/us/marine.html.
EPA, Regulatory Announcement, Emission Standards Adopted for New Marine Diesel Engines, Office of Transportation and Air Quality, EPA 420-F-03-001, January 2003.

Category 1 and 2 vessels (700 to 11,000 HP) are used to provide propulsion power to vessels such as tugboats, pushboats, supply vessels, fishing vessels, and other commercial ships. They are also used as stand-alone generators for auxiliary electrical power on many types of (larger) vessels.

Category 3 vessels (3,000 to 100,000 HP) use very large marine diesel engines for propulsion of oceangoing vessels, such as container ships, oil tankers, bulk carriers, and cruise ships.

EPA Category 3 standards are equivalent to the MARPOL Annex VI NO_x limits.

LOCOMOTIVE EMISSIONS STANDARDS

TABLE B-7
Emission Standards for Locomotives Built During Specified Timeframe, g/bhp·hr

Duty Cycle	VOCs	CO	NO_x	PM
Tier 0 (1973–2001)				
Line-haul	1.0	5.0	9.5	0.60
Switch	2.1	8.0	14.0	0.72
Tier 1 (2002–2004)				
Line-haul	0.55	2.2	7.4	0.45
Switch	1.2	2.5	11.0	0.54
Tier 2 (2005 and later)				
Line-haul	0.3	1.5	5.5	0.20
Switch	0.6	2.4	8.1	0.24
Estimated Locomotive Emission Rates in 1997				
Line-haul	0.5	1.5	13.5	0.34
Switch	1.1	2.4	19.8	0.41

Source: DieselNet; http://www.dieselnet.com/standards/us/loco.html

Note that the VOC standard is in the form of total hydrocarbons (THCs) for diesel engines.

storage. The available options are to install additional tank(s) or to split existing tank(s). So long as space is available, the cost for installing an additional tank (including all ancillary components) ranges from $30,000 to $95,000, depending on the size of the ship.[26] That price excludes the cost for lost cargo space and increased fuel consumption due to the larger size of the vessel.

Furthermore, using appropriate lube oil in conjunction with the lower sulfur fuel will alleviate corrosion.

APPENDIX C

MODEL AQUATIC RESOURCES PROTECTION PROGRAM FOR MARINE PORTS

NRDC
THE EARTH'S BEST DEFENSE

HARBORING POLLUTION

Strategies to Clean Up U.S. Ports

August 2004

This appendix contains the detailed Best Management Practices (BMPs) of the model aquatic resources protection program for ports ("The Model Program") described in Chapter 3. The Model Program is organized in checklist form, since the stormwater issues are comprehensively covered by the Stormwater National Pollutant Discharge Elimination System (NPDES) Permit under the Clean Water Act and the Stormwater Pollution Prevention Plans (SWPPPs) prepared under the permit. Shorelines, in-water, and overwater construction and maintenance permit issues are covered by Army Corps of Engineers Section 404 and Section 10 permits, Section 401 Water Quality Certification, state environmental and fish and wildlife agencies, local land-use jurisdictions (cities and counties), and Native American tribes, as applicable.

REFERENCES TO DETAILED BMP GUIDANCE

A number of sources contain guidance for applying BMPs within the stormwater element, usually in a general industrial context. At the outset of the stormwater NPDES program, the EPA outlined many practices in its publication *Storm Water Management for Industrial Activities.*[27] A number of state environmental agencies have followed the EPA's general pattern within comprehensive stormwater management guidance handbooks. Two of the most up to date were issued within the last few years by the states of California and Washington.

BMPs within the shoreside and harbor element are less extensively catalogued. However, the American Association of Port Authorities (AAPA) published an Environmental Management Handbook that covers a number of these areas, as well as a few stormwater topics and BMPs for construction, with convenient guidance sheets.[28]

The Model Program described here specifically cites the AAPA's Environmental Management Practices (EMPs) in these cases. Environment Canada covered some of these elements with BMP guidance in "Best Management Practices (BMPs) for Ship and Boat Building and Repair in British Columbia."[29] The Model Program also cites these practices. Finally, the Code of Federal Register (CFR) has specified regulations pertaining to fluid transfers to and from ships, which are cited under the appropriate topics.

MODEL AQUATIC RESOURCES PROTECTION PROGRAM ELEMENT 1: STORMWATER

A. Documentation and Analysis (Responsibility: port authority, tenants if co-permittees)

1. Mapping and associated descriptive information should be assembled for the following features:
   a. Facility boundaries and adjacent properties
   b. Topography
   c. Surface waters
   d. Discharge points
   e. Conveyance and discharge structures, such as storm drains and spouts
   f. Drainage catchments and pathways where the runoff flows
   g. Buildings on the terminal site from which runoff may flow
   h. Locations of potential contact between pollutants and rain or runoff associated with the port's industrial and commercial operations such as
      ▸ loading, unloading, handling, and storage areas for materials (raw materials, finished products, etc.);
      ▸ loading, unloading, handling, and storage areas for wastes (hazardous and nonhazardous);
      ▸ tanks and drums for storage of oils and other liquids; and
      ▸ outdoor manufacturing areas, areas subject to deposition of dusts or particulate air emissions
   i. Vehicle and equipment service areas (e.g., fueling, washing, steam cleaning, repairing)
   j. Transit, parking, loading, and unloading areas for truck and rail transport
   k. General parking areas, access roads, other paved areas
   l. Cargo loading and unloading and transfer areas using stationary (e.g., cranes) and mobile (e.g., forklifts) equipment
   m. Areas of existing or potential erosion and/or dissolution of pollutants from stockpiles and bare soil
   n. Port operations and maintenance activities, such as
      ▸ road maintenance;
      ▸ sewage system operation and maintenance;
      ▸ storm drain system operation and maintenance; and
      ▸ general facilities and equipment maintenance (e.g., docks, piers, landscaping, utilities, fencing, buildings, mechanical facilities, warehouses, service vehicles)
   o. Existing pollution control structures (for example, an oil/water separator or other control device)
   p. Subsurface injection wells

2. A thorough, systematic, and well-documented process of analysis is necessary to identify existing and potential problems and to assess possible solutions. The analysis should assess:
   a. The types and extent of pollution risks posed by features described above (1h–n) in the preceding list
   b. Recorded incidents of pollutant spills and leaks in the outdoor environment
   c. Monitoring data showing the existence or lack of water pollution and ecological problems
   d. Alternatives for preventing identified problems or treating runoff to the extent problems cannot be entirely prevented (refer to section B, Practice Specification).
   e. Selected alternatives and justification (BMPs chosen from the analysis under 2d should be matched to the problems identified in steps 2a-c)

B. Practice Specification (Responsibility: port authority, tenants if co-permittees except as noted) Note: BMPs are indicated in italics.

1. **Operational Practices.** The following facility-wide practices should be implemented to prevent the development of stormwater pollution problems to the maximum extent possible:
   a. *Pollution prevention personnel.* Specific personnel should be assigned responsibility for each aspect of the stormwater management program.
   b. *Preventive maintenance.* There should be a formal program of preventive maintenance for the purpose of avoiding equipment deterioration and failure that causes spills and leaks of pollutants.
   c. *Good housekeeping.* There should be a policy for maintaining an orderly, clean facility and instruments to implement it (e.g., incentives, publicity, signs, drain inlet stenciling, regular sweeping).
   d. *Spill response.* There should be a clear, comprehensive, organized program to respond properly if a spill occurs, including: (1) whom to notify, (2) who is in charge, (3) specific instructions for different materials that could be spilled, (4) spill containment procedures, (5) easy-to-find-and-use spill clean-up kits, (6) how a spill will be prevented from getting into a drainage system (e.g., valving, diversion, absorption), (7) a disposal plan, and (8) a worker training program.
   e. *Illicit connection (IC) and illegal discharge (ID) control.* There should be documentation of a program to review the storm drain system to find and remove connections that would introduce unallowable non-stormwater discharges (IC control). There should be an ongoing program to avoid IC reconnections and dumping of liquid or solid wastes into or where they could enter the storm drain system (ID control).
   f. *Improved materials and waste management.* The potential for materials used and wastes produced in the port can be reduced by such management strategies as substitution of less polluting products for more contaminating ones and decreasing waste through recycling and reuse of materials.
   g. *Inspection.* The inspection program should be organized on three levels:

(1) annual comprehensive site compliance evaluation (site walk by supervisory experienced inspector, documentation review, completion of comprehensive checklists, follow-up actions); (2) regular and ongoing program to find potential problems before they occur (e.g., deteriorating equipment that may leak or spill, BMPs needing maintenance); (3) record keeping. There should be a comprehensive system for recording and accessing information gathered from carrying out all aspects of the stormwater management program.

h. *Employee training.* There should be a formal, documented training program for all aspects of the stormwater management program and for all personnel who perform or supervise any function that could affect runoff water quality appropriate to the level and responsibilities of the employees. For example, outdoor workers may get "tailgate training" in why it is important and in how to prevent polluting releases in their work. Supervisors may get classroom training in assigning maintenance tasks for a treatment BMP.

2. **Source Control Practices.** These practices in some way prevent pollutants from coming into contact with rainfall or runoff. They should be used to the maximum extent that is appropriate to the port's facilities and activities. The documentation and analysis should assess the applicability of appropriate practices on this list for the features posing pollutant risks, and the SWPPP should specify their locations and parameters. (Responsibility: port authority, tenants if co-permittees, contractors to port authority or tenants)

   a. Preferred source control practices applying to the port's industrial and commercial operations are:
      - *Alter polluting activity* (e.g., substitute nonpolluting for polluting material)
      - *Cover activity* (for example, stockpiles of petroleum coke or other potentially polluting substances or materials)
      - *Contain activity* (e.g., secondary containment vessel to catch leak or spill of contents of stored liquid; prevent runoff from draining out of contained area, with later evaporation or removal, treatment, and proper disposal. Note that throughout The Model Program, secondary containment means providing a volume at least equal to 110 percent of the volume of the largest stored container or 10 percent of the total stored volume, whichever is higher.)
      - *Segregate activity* (e.g., slope so that water running on the surface cannot pass over an area that may be contaminated)

Note: AAPA's EMPs Nos. O-11 and O-12 cover vehicle and equipment maintenance and vehicle washing, respectively, from a port perspective.

   b. Additional source control practices applying to the port's industrial and commercial operations that should be used only if no preferred practice can be implemented:
      - *Discharge stormwater to process wastewater treatment* (with assurance that stormwater discharge will not compromise treatment)

▶ *Discharge stormwater to sanitary sewer* (with appropriate permits)
▶ *Discharge stormwater to dead-end "sump" or collecting basin* (with later evaporation or removal, treatment, and proper disposal)

c. Source control practices applying to areas subject to erosion:
▶ *Cover stockpiles*
▶ *Erosion control for bare soils* (for example, planting drought resistant vegetation to hold soil in place)

d. Source control practices applying to port operations and maintenance activities (Responsibility: port authority, contractors for these activities):
▶ Road maintenance BMPs such as sweeping (to remove dirt and potential pollutants from runoff stream) and saw-cutting activities management (to avoid deposition of potentially polluting particles into runoff); paving activities management; concrete activities management
▶ Sewage system operation and maintenance BMPs such as reporting and repairing blockages, leaks, ruptures, etc. and containment and clean up of spills, leaks, and overflows
▶ Storm drain system operation and maintenance BMPs such as cleaning of catch basins, drain inlets, conveyances, pump station forebays and catch basin stenciling and signage
▶ General facilities and equipment maintenance BMPs. The preferred BMPs applying to the port's industrial and commercial operations also apply, as appropriate, to general facilities and equipment maintenance. AAPA's EMP No. O-2 covers buildings and grounds maintenance.

3. **Treatment Practices.** Each area or activity for which operational and source control BMPs cannot fully prevent contact between pollutants and rainfall or runoff should be served by a treatment BMP. The documentation and analysis should assess the need for and applicability of appropriate practices on this list, and the SWPPP should specify their locations and parameters. In both groups 3.a and 3.b, BMPs are listed roughly in the order of their effectiveness in reducing the concentrations and mass loadings of pollutants, assuming proper selection, design, and operation. However, performance varies for different pollutants. BMPs should always be selected according to treatment objectives to prevent the discharge from causing or contributing to a violation of water quality standards.

a. **Practices most suitable for relatively highly developed port areas**
Much of the land in port areas is usually densely developed and provides little land for the types of treatment BMPs that typically serve residential and other less developed areas. The BMPs in this group require little or no surface space, and the space can be used for more than one purpose.
▶ *Confined-space infiltration.* Capable of infiltrating all of the runoff for the design rainfall condition; infiltration represents the only treatment BMP that can be 100 percent effective in reducing pollutants to surface water for the design condition; must be carefully sited, designed, constructed, and operated to avoid infiltration failure or groundwater contamination. Types: Infiltration

trench with below-ground introduction of runoff via a pipe and subsurface infiltration gallery.

▶ *Porous pavement.* Allows infiltration of runoff into the pavement, and from there into the underlying soil; can be as effective as other types of infiltration. Types include: *porous concrete, porous asphalt*, which has coarse aggregate producing substantial pore space, is subject to clogging by soil and other particles and should generally be avoided in areas where they tend to be generated. Another type is *open grid and modular pavements* or blocks with openings filled with gravel or soil and sometimes vegetation. Open grid and modular pavements are best for areas with light vehicle loading and therefore probably have limited applicability in port areas.

▶ *Sand filter.* Box with presettling chamber followed by sand bed; relatively effective, especially for solids and oils.

▶ *Multi-chamber treatment train.* Filtration with enhanced capability to settle solids and remove certain organic contaminants; intended especially for areas that tend to generate relatively toxic pollutants.

▶ *Wet vault.* Underground equivalent of surface pond; lack of light, vegetation, and associated biological activity reduces effectiveness for most pollutants relative to surface pond.

▶ *Extended-detention vault.* Underground equivalent of surface extended detention pond; similar in effectiveness to surface pond (moderate) because biological activity not important in short residence time available.

▶ *Oil/water separator.* Targeted at a single category of pollutants, unlike other BMPs listed; stormwater runoff often has lower oil concentrations than device is capable of treating; therefore, only useful in areas that generate relatively high concentrations.

▶ *Commercially marketed filtering devices (e.g., StormFilter® by Stormwater Management, Inc.).* Has used various filtering media in modular canister arrangement; unless oversized, contact time is too short for highest levels of pollutant removal.

▶ *Commercially marketed hydrodynamic devices (e.g., Aqua Swirl Concentrator™ by Aqua Shield, Inc.; Continuous Deflective Separation (CDS) unit by CDS Technology, Ltd.; Downstream Defender' by HIL Technology, Inc.; Stormceptor® by Rinker Materials, Inc.; Vortechs System by Vortechnics, Inc.).* Uses forces produced by the velocity of water in circular motion as well as gravity to separate particulate and floatable pollutants; capable of removing only trash and the largest particles typically present in stormwater, along with some oil and floatables; should be used only for these purposes, sometimes as a pretreatment to remove the largest materials prior to additional treatment.

▶ *Commercially marketed gravity settlement devices (e.g., BaySaver by BaySaver Stormwater Treatment Systems, Inc.).* Similar purpose and limitations as hydrodynamic devices but rely on gravity and density differences of materials without forces produced by velocity.

- *Commercially marketed multi-facet treatment systems (e.g., AquaFilter by Aqua Shield, Inc.; StormTreat™ by StormTreat Systems, Inc.).* Combine processes (hydrodynamic and filtering for AquaFilter and gravity settling and wetland plant treatment for StormTreat™) to get added effectiveness; logistic limitations in enlarging limit to treating relatively small flows as a practical matter.
- *Commercially marketed drain inlet inserts (many manufacturers).* Generally have some type of filtering medium in a container that is suspended within a drop inlet to contact runoff as it falls; some filters catch only solids and then just trash the largest particles; others with special media can remove such pollutants as metals and oil, but contact time is so limited that efficiencies are low; inserts require frequent maintenance, therefore, they should be used only for purposes consistent with their abilities in short-term service or in situations where the necessary maintenance attention can be assured.

b. **Practices most suitable for less-developed port areas**

Ports often have land outside of the location of their most intense operations that could be used for treatment BMPs requiring more space. Whether or not the port can and chooses to place treatment BMPs there depends on the characteristics of the location, if stormwater can be collected and conveyed to the site, and the competition for space for future development and setting aside land to preserve or restore natural resources.

- *Open-space infiltration.* See note on confined-space infiltration above. Types include an infiltration trench with surface introduction of runoff in sheet flow and an infiltration basin.
- *Constructed wetland.* Wetland built outside of jurisdictional waters and operated for the primary purpose of treating stormwater and/or wastewater; relatively effective.
- *Wet pond.* Pond with a permanent or semipermanent pool giving a long hydraulic residence time for treatment processes to occur; relatively effective.
- *Extended-detention pond.* Holds water for 48 to72 hours; reduced hydraulic residence time relative to wet pond lowers efficiency to moderate level.
- *Biofiltration.* Vegetated with dense, fine plants (usually grasses); can be relatively effective with significant infiltration; efficiency varies depending on pollutant with little infiltration. Removal of solids and oils are relatively high, while removal of nutrients and dissolved pollutants are relatively low. Types include biofiltration swale channels, generally with flow at measurable depth, and biofiltration strips, which have a broad surface with thin sheet flow.

4. **Non-Stormwater Discharges.** (Responsibility: port authority, tenants if co-permittees)
Non-stormwater discharges are introductions of any liquid other than rainfall runoff into a storm drain system, including water from other sources. The discharge can be via a permanent or semipermanent connection, direct dumping into a storm drain inlet, or dumping in a location that eventually drains to the stormwater system. The subject of non-stormwater discharge is a special facet of

illicit connection and illegal discharge control. Regulations under the Clean Water Act recognize some allowed non-stormwater discharges that are not expected to pollute (e.g., air conditioner condensate) or are emergencies (e.g., water used to fight a fire). Otherwise, stormwater NPDES permit users are required to certify elimination of non-stormwater discharges based on a specific program of observations and/or testing (e.g., dye testing). A model program for non-stormwater discharges would have certification, including:

a. Identification of potential non-stormwater discharges
b. Description of test results and evaluation of the presence of any non-stormwater discharge
c. Evaluation criteria or test method used
d. Date of testing or evaluation
e. Drainage points observed during the testing or evaluation
f. Maintenance program for hose connections and valves to prevent non-stormwater generation through leakage

5. **Monitoring** (Responsibility: port authority or other public agency under cooperative agreement with port authority)
Monitoring required by the stormwater NPDES permit is infrequent and very basic. Performed at that level, it would likely fail to diagnose many problems. The basic program involves only quarterly observations of visible signs of pollution and a grab sample of stormwater runoff. Some ports perform their own monitoring, while external agencies conduct it at others. A model monitoring program would encompass:

a. Flow-proportional composite sampling and analysis of stormwater runoff discharges representative of the overall facility for a selection of storms during the year. (What is representative depends on the climatic characteristics of the location. The storm selection should represent storms following relatively extended dry periods, relatively large rainfall quantities, and events with relatively high rainfall intensities. Generally, at least 12 storms should be sampled each year, but in semiarid climates with a limited number of events it is difficult to achieve this number. In these cases, the target should be at least one-third of the annual rain storms.)
b. Sampling and analysis of receiving water quality
c. Sampling and analysis of the receiving water's sediments
d. Monitoring of biota inhabiting the receiving water to determine trends in key populations
e. Selected monitoring of best management practices (e.g., to trace problems, establish effectiveness of new technologies)
f. Special monitoring for projects like dredging and filling

The monitoring programs should be fully documented in terms of:

a. Monitoring objectives
b. Sampling program design (locations, times, and methods of sampling)

c. Field and laboratory analyses performed on samples and the methods used (analyses should be related to the potential pollutants)
d. Quality assurance/quality control program
e. Data analysis methods
f. Available results and comparison to applicable regulatory criteria
g. Interpretations of results and conclusions reached to date

MODEL AQUATIC RESOURCES PROTECTION PROGRAM ELEMENT 2: SHORESIDE AND HARBOR

Many activities in a port are conducted adjacent to, over, and in the water. Avoiding or minimizing water pollution from these activities depends largely on preventive source controls. The lists in sections A and B represent practices employed somewhere in the shipping industry, although the practices are not yet universal or even necessarily widespread, and are not applicable to every situation.

Ports are taking some initiative in protecting and improving or restoring the aquatic natural resources under their jurisdictions. These areas are subject to oversight by a multitude of agencies administering a wide variety of laws and regulations. Section C presents some measures that ports can take in this regard, as appropriate to their specific setting and circumstances.

Note: BMPs are indicated in italics.

A. Ship Servicing Source Controls (Responsibility: port authority or its contractor, except as noted; quite often these functions are the responsibility of the shipping line or the terminal operator or their contracted providers)

1. Ship fueling—refer to 33 CFR 154 (Responsibility: fuel barge operator, shipping line, or fueling facility operator)
   a. Prohibition of waterside fueling, where spill and fire risks are high.
   b. *Special care in waterside fueling by barge.* (Note: Barge fueling can offer the advantage of requiring only one fuel hose connection and disconnection, when many spills occur, compared to fueling with many tanker trucks. Special care involves increased presence of fire department personnel inspecting the operation and ready provisions to localize any potential spill by containment.)
   c. *Automatic shutoff nozzles and fuel/air separation.*
   d. *Other specific practices.* Refer to AAPA EMP No. O-6.

2. Liquid product loading and liquid waste unloading—refer to 33 CFR 154, 155, and 158 and Environment Canada BMPs Nos. 3.1-3.9 and 4.1–4.3
   a. *Stop valve for each connection.*
   b. Sanitary sewer connection or pump-out facilities and trucks to transport for treatment off-site.
   c. *Bulk storage and handling—liquid practices.* Refer to AAPA EMP No. O-4.
   d. *Chemical storage and handling—non-bulk.* Refer to AAPA EMP No. O-5.

3. Solid product loading and solid waste unloading (Responsibility: shipping line, terminal operator, or port authority)
   a. *Ship and shore solid waste handling.* Refer to AAPA EMP No. O-8.
   b. *Bulk storage and handling—dry.* Refer to AAPA EMP No. O-3.
   c. *Automobile storage and transport.* Refer to AAPA EMP No. O-1.

4. Ballast water (Responsibility: shipping line, terminal operator, or port authority)
   a. Discharge prohibition (normally, now implemented by requiring *deep-water ballast exchange* before reaching port).
   b. Collect, treat onshore, and recycle or discharge.
   c. *On-board antibiotic measures* (e.g., filtration; extermination by agitation or salinity alteration; chemical, thermal, ultrasound, or ultraviolet light treatment).

5. Bilge water (Responsibility: shipping line, terminal operator, or port authority)
   a. *Discharge prohibition* (if oily or if any solvents, detergents, emulsifying agents, or dispersants added).
   b. *Collect, treat (to ≤10 miligrams/liter effluent oil and grease), on-site, and recycle or discharge.*
   c. *Collect and treat off-site.*

6. General ship maintenance (Responsibility: shipping line, terminal operator, or port authority)
   a. *Vessel repair and maintenance BMPs.* Refer to AAPA EMP No. O-13.

7. Routine ship cleaning (Responsibility: shipping line, terminal operator)
   a. *Block scuppers; collect wash water and discharge to approved onshore facility with treatment.* Note: A scupper is a hole on the side of a boat that allows water, such as that from large waves splashing on board, to drain from decks.

8. Hull washing operations (in preparation for maintenance; usually, high pressure and sometimes ultra-high pressure)
   a. *Prohibit on tide grids unless there is a collection sump with pump out for treatment.*
   b. *Restrict to areas where wash water can be contained (clean up area prior to washing operation).*
   c. *Contain, collect, and treat wash water* [Note: Practices vary with different configurations (e.g., dry dock, marine railway, various lifts) and water volume and solids content; refer to Environment Canada BMP No. 1.1.].

9. Abrasive blasting operations
   a. Prohibit on tide grids.
   b. *Shrouding for complete vessels or major portions thereof* (Note: Practices vary with different configurations [e.g., dry dock, marine railway, various lifts], but all require support frames and secure fastening to contain grit and dust; refer to Environment Canada BMP 1.2.).

   c. *Permanent or temporary shelter with dust control and venting for components or parts.*
   d. Convert to alternative.
      - *Ultra-high pressure wash*—Refer to hull washing operations for BMP)
      - *Wetted grit chemically treated to bind heavy metals.*
   e. *Store clean blast material in covered, contained area away from water.*
   f. *Dry methods for spent blast material clean up.*
   g. *Prevention of spent blast material tracking by vehicles.*
   h. *Store spent blast material in covered, contained area away from water*—Refer to Environment Canada BMP Nos. 1.3-1.6.
   i. *Recycle spent blast material* (e.g., raw material for cement manufacture).

10. Other surface preparation (sanding, scraping, stripping)—Refer to Environment Canada BMP Nos. 1.7-1.9
   a. *Dustless sander.*
   b. *Tarp under blocked vessel.*

11. Coating operations (e.g., painting)
   a. *Alternative, nontoxic antifouling compounds* (formulations preventing marine organism attachment, instead of containing heavy metal toxins that kill organisms; non-solvent paints).
   b. *Shrouding for complete vessels or major portions thereof* (Note: Practices vary with different configurations [e.g., dry dock, marine railway, various lifts].
      - *Tarp under blocked vessel.*
      - Unless shrouded, use only rollers or brushes.
      - Use covered, contained mixing shelter away from water.
   c. *Other specific practices*—Refer to AAPA EMP No. O-7 and Environment Canada BMP Nos. 2.1-2.10.

12. Ship dismantling or demolition
   a. *Ship breaking BMPs*—Refer to AAPA EMP No. O-15.

13. *Port and contractor employee education*

14. *Ship personnel education*

B. Harbor Operations Source Controls (Responsibility: port authority or its contractor)

1. Pilings
   a. *Replacement of creosote-coated wood with concrete or steel.*
   b. *Use of nontoxic hydraulic fluid for pile driving.*

2. Dredging
   a. *Timed to minimize ecological impacts.*

b. *Silt curtain* (impermeable barrier; most effective in reducing turbidity in still, nontidal waters).
c. *Gunderboom* (barrier to solids, but permeable to water; most effective in reducing turbidity when not operated in tidal flow).
d. *Clamshell or specially designed dredge, operated with limitations on ascending velocity, multiple bites, and bottom stock piling* (most effective in reducing turbidity with relatively soft sediments of uniform consistency).
e. *Onshore confined disposal facility providing treatment for water.*
f. *Other specific practices*—Refer to AAPA EMP No. O-16.

3. Tug and other harbor craft operations
   a. *Replacement of two-stroke with four-stroke engines*
   b. *Protection of marine mammals and sensitive aquatic habitats*—Refer to AAPA EMP No. O-9

4. *Port and contractor employee education*

C. Aquatic Natural Resources Stewardship (Responsibility: port authority)

Note: These practices represent broad themes and are not detailed in any way because of their site-specific nature.

1. *Removing barriers to migrating fish*
2. *Nearshore habitat rehabilitation*
3. *Estuarine wetlands rehabilitation*
4. *Freshwater wetlands rehabilitation*
5. *Contaminated marine sediment removal*
6. *Contaminated onshore soil removal*

APPENDIX D

International Rules and Treaties

The following summarizes the primary international laws, treaties, conventions, and annexes regulating the marine environment: the Law of the Sea Convention, the IMO MARPOL Convention of 1973 & 1978, the International Convention on the Control of Harmful AntiFouling Systems on Ships 2001 (known as the AFS Convention), several European Union Directives, the European Union Sustainability Policy on Transportation, and the "ECOPORTS" Project.

LAW OF THE SEA CONVENTION[30]

The Law of the Sea Convention (LOSC), first created in 1958, is generally regarded as the central international law governing most aspects of navigation and the protection of the marine environment. The United States is not a party to the LOSC. However, the United States respects *de facto* portions of the LOSC, including the definitions of Exclusive Economic Zones.

The LOSC contains a "no harm" policy obligating members to apply preventive measures "to protect and preserve the marine environment" (LOSC Article 192) and to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or to areas beyond the limits of national jurisdiction (LOSC Article 194(2)). The LOSC deals with all sources of pollution, including air pollution, that affect the marine environment. But it is not geared toward protecting the terrestrial environment from pollution from ships.

IMO MARPOL CONVENTION OF 1973 & 1978

The Protocol of 1978, commonly known as MARPOL and originally known as the 1973 International Convention for the Prevention of Pollution From Ships, is the main international convention covering pollution prevention of the marine environment by ships from operational or accidental causes. Updated by additional amendments since its inception, MARPOL comprises six "annexes." In its original form, MARPOL addressed only oil pollution issues, but expanded its coverage to tanker safety and pollution prevention in 1978 following a spate of tanker accidents. Table D-1 outlines MARPOL's annexes. The United States is party to only four. MARPOL's 162 member states are required to accept Annexes I and II, while the remaining Annexes are voluntary.

TABLE D-1
MARPOL Annexes, Dates of Entry into Force and U.S. Participation

	Measure	Date of Entry into Force	U.S. Participation
Annex I	Prevention of Oil Pollution	1983	Yes
Annex II	Control of Pollution From Noxious Liquid Substances in Bulk	1987	Yes
Annex III	Pollution Prevention for Harmful Substances Carried in Packaged Form	1992	Yes
Annex IV	Prevention of Sewage Pollution From Ships	September 2003	No
Annex V	Pollution Prevention for Garbage From Ships	1988	Yes
Annex VI	Prevention of Air Pollution From Ships	May 2005	No

Annex I: Prevention of Oil Pollution

Oil pollution of the seas was recognized as a problem in the first half of the 20th century, and various countries introduced national regulations to control oil discharges within territorial waters. In 1954, the International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL) sought to address pollution resulting from the two major causes of oil pollution-routine tanker operations and the discharge of oily wastes from machinery operations. OILPOL took force in 1958, establishing "prohibited zones" extending at least 50 miles from the nearest land, in which the discharge of oil or oily mixtures was forbidden. It also required "contracting parties" to move to provide facilities to receive oily water and residues. OILPOL was expanded and further strengthened with amendments in 1962, 1969, and 1971, and was eventually incorporated into MARPOL as Annex I.

Annex I went into force in 1983, making oil discharges illegal in all but extremely limited circumstances. It designated "special areas" where oil discharges are completely prohibited.[31] These areas deemed highly vulnerable to oil pollution, include the Mediterranean, Black, Baltic, and Red seas, and the "Gulfs area" (the Persian Gulf and Gulf of Aden). Under Annex I, all oil-carrying ships are required to be capable of retaining oily wastes on board. In 1978, Annex I was strengthened to require segregated ballast tanks (SBTs) on all new midsize tankers (20,000 to 70,000 dead weight tons).[32] SBTs also were required to be positioned so that they would help protect cargo tanks in the event of a collision or grounding. Finally, 1992 amendments to Annex I mandated double hulls on new oil tankers and established a double-hull retrofit phase-in schedule for existing tankers.

Annex II: Control of Bulk Liquid Substances Other Than Oil

Annex II details the discharge criteria and measures for the control of pollution by "noxious liquid substances" (i.e., chemicals) carried in bulk. Approximately 250 chemicals and other liquids, including wine for example, are covered by this measure, which came into force in 1987. The discharge of their residues is allowed only to reception facilities unless certain concentrations and conditions, which vary with the category of substances, are met. Residues containing noxious substances cannot be discharged within 12 miles of any coastline. More stringent discharge restrictions apply to the Baltic and Black sea areas.

Annex III: Prevention of Pollution from Harmful Substances in Packaged Form

Annex III went into force in 1992 and was the first of several voluntary measures. Member states ratifying MARPOL must adopt Annexes I and II but can choose not to accept the remaining four annexes even if the annexes have met the minimum requirements for "entry into force.". As a result, member states have taken much longer to adopt Annexes III through VI. Annex III establishes requirements for certain standards on packing, marking, labeling, documentation, stowage, quantity limitations, exceptions, and notifications for preventing pollution from harmful substances. Under its terms, all incidents involving the discharge of harmful substances in packaged form into the sea must be reported. The United States is a party to this annex.

Annex IV: Prevention of Sewage Pollution From Ships

Annex IV went into force in September 2003. It imposes requirements for controlling sewage discharge into the sea. Ships are prohibited under its terms from discharging sewage within four miles of land, unless they have one of three specified onboard advanced treatment plants. Sewage must be fully ground up and disinfected before discharge within four to twelve miles offshore. The annex applies to most new large ships, while existing large ships have five years to comply. While the United States is not a party to this annex, the federal Clean Water Act regulates ship sewage in U.S. territorial waters.[33]

Annex V: Prevention of Dumping Garbage From Ships

Annex V went into force in 1988. It prohibits the disposal of garbage from ships in coastal waters and "special areas," and restricts the manner in which garbage may be disposed of in general. The annex requires that log books of incineration and discharge be kept. The requirements are much stricter in a number of "special areas," including the Baltic, Black, Mediterranean, Red, and North seas; the Persian Gulf and Gulf of Aden; and the Caribbean and Antarctic areas. Most important, the annex completely bans dumping all forms of plastic into the sea. Plastics can take as long as 450 years to biodegrade in seawater.[34] Unfortunately, the dumping of garbage into the sea is still a common practice; recent surveys carried out in the United States have found up to 10 tons of garbage per mile of coastline. The United States is a party to this annex.

Annex VI: Prevention of Air Pollution From Ships

Originally adopted in 1997, in May 2004, Annex VI garnered the requisite number of international signatories to lead to its "entry into force" starting in May 2005. This annex establishes limits on several air pollutants generated by ships, although it does not cover several of the most harmful, including particulate matter, volatile organic compounds, and carbon monoxide. The EPA passed similar standards for large U.S. marine vessels in January 2003. In May 2003, Annex VI was sent to Congress for U.S.

ratification; however, at the time of this writing, the U.S. had not yet ratified.[35] Once in effect, Annex VI will:

▸ Set limits on sulfur oxide (SO_x) and nitrogen oxide (NO_x) emissions from ship exhausts;[36]
▸ Prohibit deliberate emissions of ozone depleting substances;
▸ Institute a global cap of 4.5 percent (45,000 parts per million) on the sulfur content of fuel oil and require the IMO to monitor the worldwide average sulfur content of fuel;
▸ Allow for the creation of special "SO_x Emission Control Areas," where more stringent controls on sulfur emissions will be imposed; and
▸ Prohibit the onboard incineration of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs).

In the SO_x Emission Control Areas, such as the Baltic Sea, ships have two choices. They may either use fuel oil with a sulfur content that does not exceed 1.5 percent (15,000 parts per million), or they may control their SO_x emissions with an exhaust-gas cleaning system or with other technologies.

Prohibited ozone depleting substances include halons and chlorofluorocarbons (CFCs). New installations containing ozone depleting substances are prohibited on all ships, but hydro-chlorofluorocarbons (HCFCs) remain permissible until 2020. These requirements are in accordance with the Montreal Protocol of 1987, an international environmental treaty, under which nations agreed to cut CFC consumption and production in order to protect the stratospheric ozone layer.[37]

Enforcement

Violations of MARPOL are punishable either under the laws of a nation party to the convention, or under the law of the nation associated with the offending vessel. With the exception of very small vessels, ships on international voyages must carry valid international certificates to present at foreign ports as evidence that they comply with MARPOL. If inspecting authorities find evidence of an inaccurate, fraudulent, or missing certificate, they may detain the ship until they are satisfied that the ship can proceed to sea without presenting an unreasonable threat to the marine environment.

INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTIFOULING SYSTEMS ON SHIPS IN 2001

The International Convention on the control of harmful antifouling systems on ships (the AFS Convention), adopted by the IMO in 2001 and signed by the United States in 2002 (but not yet ratified by Congress), will prohibit the use of harmful "organotins" in anti-fouling paints used on ships and will establish a mechanism to prevent the future use of other harmful substances in antifouling systems.[38] Under the terms of the new AFS Convention, participating nations are required to prohibit and/or restrict the use of harmful antifouling systems on ships flying their flag or otherwise operating under their authority, as well as on ships that enter a port, shipyard, or offshore terminal of a participating nation.

Since January 2003, the application of organotin-based systems has been banned, fulfilling one of the tasks (Chapter 17 of Agenda 21) developed by the 1992 Rio Conference on Environment and Development. The harmful environmental effects of organotin compounds were first recognized by the IMO in 1989. One year later, the IMO Marine Environment Protection Committee (MEPC) adopted a resolution that recommended that governments adopt measures to eliminate the use of antifouling paint containing tributyltin (TBT), one of the main organotins on nonaluminum hulled vessels of less than 25 meters in length, and eliminate the use of antifouling paints with a leaching rate of more than four micrograms of TBT per day. For information on non-toxic alternatives to TBT, see Chapter 1.

Under the AFS Convention, these restrictions will tighten in January 2008, and ships will be required either to be free of external paints with TBT on their hulls, external parts, or surfaces, or to apply a coating that forms a barrier to such compounds leaching from the underlying noncompliant antifouling systems.

The AFS Convention applies to all ships, including fixed and floating platforms, floating storage units (FSUs), and Floating Production Storage and Offtake units.

EUROPEAN UNION DIRECTIVES AND INITIATIVES

The European Union has issued several directives affecting the shipping and port operations of its member nations.

Waste Reception

The Waste Reception Facilities at Ports (Directive 2000/59/EC) EU Directive requires all member states to ensure that ports are equipped with reception facilities that can adequately handle all wastes from ships that normally call at those ports.[39] The facilities are to be designed to minimize delay for vessels and to meet the needs of ships of all sizes calling at the port. The port authorities are also required to have a waste reception and handling plan.

This EU directive adopts a "polluter pays" principle, passing the cost of reception and waste management onto shippers. To prevent dumping of wastes as a way to avoid paying fees at reception facilities, every vessel is required to contribute to the cost of facilities and treatment, whether or not it discharges waste.[40] While this approach does not reward vessels that minimize waste, vessels may be charged a lower fee if they demonstrate that they have implemented management practices or onboard technologies that reduce the amount of waste generated.

Vessel Monitoring

The EU's Vessel Monitoring Directive (2002/59/EC) establishes a monitoring system to prevent accidents and pollution at sea, and to minimize shipping-related harm to the marine and coastal environment.[41] Under its terms, ships must provide information on hazardous and dangerous goods they transport. Ports and national authorities are also granted more authority to deny entry or exit from a port due to bad weather circumstances, and they are encouraged to provide adequate resources for emergency response, including places of refuge and procedures for accident and pollution response.

Cleaner Marine Fuels

Research has demonstrated that the sulfur content of marine fuel contributes significantly to acid rain, which poses a serious problem in Northern Europe.[42] In November 2002, the EU introduced a revised Cleaner Marine Fuels Directive (COM(2002) 595 final, amendment of Directive 1999/32/EC), amending a 1999 directive, to further strengthen sulfur limits in marine fuels.[43] The revised directive will bring EU nations far beyond compliance with the terms of Annex VI of MARPOL. However, in June 2004, the EU Environment Council loosened the 2002 language slightly to accommodate several Mediterranean EU members.[44]

The newly agreed to directive language contains three provisions:

- A 1.5 percent (15,000 parts per million) limit on sulfur for all vessels, regardless of their flag, that travel in the North Sea, English Channel, and the Baltic Sea, beginning in May 2006. These are the same sulfur limits and areas that were established as Sulfur Emission Control Areas under MARPOL Annex VI.
- A requirement that all passenger vessels on regular service to or from any port in the European Union use fuel with a sulfur limit of 1.5 percent.
- A 0.1 percent (1,000 parts per million) sulfur limit on all inland water vessels and on all ships while they are berthed in ports inside the European Union, beginning in January 2010.[45] (The November 2002 language originally required an intermediate fuel sulfur limit of 0.2% earlier than the 0.1% requirement. The new 0.1% requirement has a later implementation time and allows an extra two years for compliance of certain vessels serving the Greek Islands.) This proposal will now go back to the European Parliament for a second reading before a final agreement is made.

The current average sulfur content of marine fuels is approximately 2.7 percent, according to studies conducted for the European Union. Since ships will only be required to use 0.1 percent sulfur fuels while berthed in an EU port, they can take on the required fuel in the port of call. Thus the in-port requirement will apply to all vessels, regardless of their flag state and regardless of their last port of call.[46]

Sustainable Transportation

The EU is exploring strategies for sustainable development of European transportation networks.[47] The "Presidency Conclusion" serves as a framework for this effort:

> *A sustainable transport policy should tackle rising volumes of traffic and levels of congestion, noise, and pollution, and encourage the use of environment-friendly modes of transport as well as the full internalisation of social and environmental costs. Action is needed to bring about a significant*

> *decoupling of transport growth and GDP growth, in particular by a shift from road to rail, water, and public passenger transport.*[48]

With a priority on reducing greenhouse gas emissions, in 2001 the European Commission adopted its White Paper: European Transport Policy for 2010.[49] This policy guideline calls for the revitalization of rail transport and the development of short sea shipping and inland waterway transportation as a means of reducing pollution and congestion, while increasing the safety of cargo transport.

The goal is to shift cargo from road transport to rail and waterway transport because rail and water are more energy-efficient, cleaner, and safer modes.[50] However, the White Paper acknowledges the additional need to further reduce emissions from ships, in particular sulfur and particulate matter, and to improve labor and safety standards of marine transportation.[51]

ECOPORTS

The EU's "ECOPORTS" project is a three-year European cooperative study formally begun June 1, 2002, at an estimated cost of $5 million.[52] ECOPORTS focuses on the development and implementation of an online environmental management and information system. More than 50 ports have committed to be members of the project, with a goal of adding an additional 100 members in Europe, including seaports, inland ports, industries located in ports, and other parties in the logistics chain. Key to the project will be the expertise gleaned from a series of studies that will determine the best approach to address the need for the port sector and the European Union to further develop and implement environmental practices.

These studies are based on seven work packages covering the technical development of environmental tools, testing and validating those tools, creating new projects to use the tools, analyzing the impacts of those projects, sharing information on successful projects, and developing a "ports and environment" network.

ENDNOTES

1 Port of Long Beach, www.polb.com; Port of Los Angeles, www.portoflosangeles.org; Port of Seattle, http://www.portseattle.org/harbor/default.htm; Port of Oakland, www.portofoakland.com.

2 US Army Corps of Engineers, New York & New Jersey Harbor Navigation Study, Chapter 4: Without-Project Condition, September 1999.

3 www.port-of-charleston.com/WhatsNew/press_room/pressroom.asp?PressRelease=23; US Army Corps of Engineers, Draft Environmental Impact Statement (DEIS) for the Proposed Daniel Island Marine Cargo Terminal, August 1999.

4 Miami Harbor General Reevaluation Report Study, Draft Environmental Impact Statement, February 2003.

5 JWD under contract to Port of Houston Authority, U.S. Container Terminal Throughout Density, February 2003.

6 Georgia Port Authority, www.gaports.com; Virginia Port Authority, www.vaports.com

7 TEUs found at Port of Singapore Authority, http://www.mpa.gov.sg/index.html

8 The average fuel cost per hour for diesel units was $2.38 per hour. During the same time period and under comparable operating conditions, the LPG units averaged $1.96 per hour. This is based on a fuel economy of 2.3 gph for LPG and 1.7 gph for the diesel units. The operational savings was realized from the differential fuel cost of $1.42 for diesel and $0.92 for LPG.

9 Ibid.

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12 CARB, Diesel Risk Reduction Plan, Appendix IX: Diesel PM Control Technologies, p. 29., October 2000.

13 ARB, Staff Report, Solid Waste Collection Vehicles, F-6, 2003.

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22 Cost represents average cost obtained in personal conversations between Ron Friesen and representatives of Fuel Cell Energy, Inc and United Technologies Corp Fuel Cells.

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31 With minor and well-defined exceptions.

32 SBTs were already required on new tankers of 70,000 dwt and above.

33 http://www.epa.gov/owow/oceans/regulatory/vessel_sewage/

34 Hellenic Marine Environment Protection Association (HELMEPA) as cited on www.imo.org.

35 http://www.marinelog.com/DOCS/NEWSMMIII/MMIIIMay16c.html

36 NO_x limits range from 9.8 to 17 g/kW-hr depending on the engine's maximum operating speed.

37 The stratospheric ozone layer is a UV protective layer miles above the earth's surface. This beneficial ozone layer should not be confused with tropospheric or ground level ozone, commonly known as smog, which is known to cause respiratory illnesses among other health problems.

38 IMO, International Convention on the Control of Harmful Anti-Fouling Systems on Ships 2001, in Adoption of the final act of the conference and any instruments, recommendations and resolutions resulting from the work of the conference, International Conference on the Control of Harmful Anti-Fouling Systems for Ships, Editor. 2001: IMO.

39 EC, Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues. 2000: Official Journal of the European Communities.

40 The "polluter pays" approach is common in EU policies, but is particularly controversial in this instance because of the potential economic benefit for ships that illegally dump wastes before calling on a port that does not require a minimum charge from each vessel. Many ports impose a clear flat-fee system that encourages the use of waste reception facilities. But circumstances at sea make monitoring and enforcement difficult. Furthermore, some ports that adopted a general waste reception fee for all vessels, regardless of the amount of delivered waste, may be overloaded with waste that shippers did not dispose of at ports that have reception fees scaled to the amount of waste. The Port of Hamburg discontinued its no-cost waste reception for that reason after EU Directive 2000/59/EC took effect.

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42 EC Study C.1/01/2002, DG Environment: Advice on impact of reduction in sulfur content of marine fuels marketed in the EU.

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50 For every horsepower that is capable to move 150 kg by road, 500 kg can be moved by rail and 4,000 kg by vessel according to the EU Directorate Energy and Transportation.

51 http://europa.eu.int/pol/trans/index_en.htm

52 www.ecoports.com; $5.04 million is roughly the equivalent of 4.1 million Euros as of July 2004. See http://www.xe.com/ucc/convert.cgi.