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Marine Security of Hazardous Chemical Cargo

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Summary

Since the terror attacks of September 11, 2001, the nation has been working to improve the security of hazardous chemicals transportation. Marine shipments of hazardous chemical cargo may be attractive terrorist targets because of their large volume and inherent toxicity or flammability. Anecdotal evidence and international events suggest that terrorists may have both the desire and capability to attack such shipments in U.S. waters. Building on existing legislation, Congress is analyzing the security of hazardous chemical marine shipments and deciding whether to strengthen related federal security efforts. H.R. 2651, for example, would increase penalties for criminal or terrorist activities around ports and marine vessels. S. 1052 includes provisions to increase general port security, including foreign port security.

Drawing on marine commerce data from the Army Corps of Engineers (ACE), CRS has analyzed marine shipments of acutely toxic or combustible chemicals as defined under Environmental Protection Agency (EPA) regulations. According to this analysis, over 100,000 marine shipments (54 million tons) of chemicals potentially capable of causing mass casualties (injuries or deaths) among the general public passed through U.S. waters in 2003. These chemical shipments accounted for 2% of U.S. marine cargo tonnage and were shipped through 113 U.S. ports. The top 30 ports handled 95% of this hazardous chemical tonnage. Most marine shipments of hazardous chemicals are much larger than such shipments on land; they would be of sufficient volume, on average, to require an off-site risk management plan under EPA rules if the same quantity of chemical was stored at a chemical plant.

The Maritime Transportation Security Act (MTSA, P.L. 107-295) and the *International Ship and Port Facility Security Code* give the Coast Guard far-ranging authority over the security of hazardous marine shipping. The agency has developed port security plans addressing how to deploy federal, state, and local resources to prevent terrorist attacks. Under the MTSA, the Coast Guard has assessed the overall vulnerability of marine vessels, their potential to transport terrorists or terror materials, and their use as potential weapons. The Coast Guard has employed these assessments to augment marine assets security and develop new maritime security standards.

As federal oversight of hazardous chemical marine security continues to evolve, Congress may raise questions concerning terrorism risk uncertainty and efforts by federal agencies and the private sector to rigorously evaluate that risk. Congress may assess whether responsible federal agencies and private sector entities have in place sufficient resources and effective measures to secure hazardous chemical marine cargo from terrorist attack. Congress may also evaluate the emergency response capabilities of coastal communities exposed to chemical shipping hazards. Determining how hazardous chemical marine security fits together with other homeland security priorities to achieve common security goals could be an oversight challenge for the 109th Congress.

This report will be updated as events warrant.

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Introduction

The federal government has statutory obligations to regulate interstate commerce and secure the United States against terrorism. Therefore, Congress has a strong interest in federal regulations and programs related to hazardous chemicals security. Since September 11, 2001, legislators, government agencies, and industry have been working to prevent terrorist attacks involving hazardous chemicals. Their goal is to ensure the continued availability of such chemicals for commercial use while reducing the risk of their exploitation by terrorists.

Large quantities of hazardous chemicals are found in commercial facilities, marine transportation, rail transportation, and highway trucking.[1] To date, Congressional attention has focused largely on the security of hazardous chemicals transported by rail or tanker trucks, or stored at commercial facilities near populated areas. As the nation's rail, truck, and chemical facility policies mature, Congress is reviewing federal policies related to marine transportation of hazardous chemical cargo.[2] In the 109th Congress, for example, H.R. 2651 would establish or increase penalties for criminal or terrorist activities around ports and marine vessels. S. 1052 includes provisions to increase general port security, including ports in foreign countries. In response to the overall security environment, Congress is likely to seek a broader understanding of hazardous chemical marine shipments and efforts to secure them.

This report provides an overview of hazardous chemicals marine transportation in the United States. The report discusses the general risks from such marine transportation in the homeland security context. It focuses on many of the hazardous chemicals with the greatest potential to affect the public in a terrorist attack and the marine vessels that carry such chemicals. It summarizes federal statistics on the hazardous chemical marine shipments in U.S. waters, including shipment volumes by type of chemical and port location. It provides a brief overview of relevant U.S. maritime security regulation. It raises security policy issues associated with these shipments, including risk uncertainties, security resources, and security effectiveness. The report concludes with a discussion of marine chemicals security as part of the nation's overall chemical security strategy.

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[1] Certain hazardous chemicals (e.g., methane) are also transported by pipelines. For pipeline security information see CRS Report RL31990, *Pipeline Security: An Overview of Federal Activities and Current Policy Issues*, by (name redacted).

[2] Marine cargo transportation includes shipping on any commercially navigable waters: oceans, rivers, lakes, canals, or other waterways.

Scope and Limitations

This report addresses marine shipments of a limited set of acutely hazardous chemical cargoes that, if released, could potentially pose a catastrophic hazard to the general public. (The specific cargoes are defined in subsequent sections). The report does not examine other potential maritime security hazards such as petroleum products, biological agents, or container bombs, which may also be of interest to policymakers.[3] It focuses on threats to the general public from chemical release during marine transport. It does not address marine attacks targeting economic activity or the environment. Due to the sensitive nature of the topic and legal limitations on the publication of certain proprietary shipping data, the report does not provide detailed statistics for the specific hazardous chemicals or ports of interest.

Maritime Terrorism and Hazardous Chemical Cargo

Marine shipments of hazardous chemical cargo are potentially attractive terrorist targets because these chemicals are acutely toxic or highly combustible, and are shipped in large volumes. They may represent a serious threat to human life and physical infrastructure if intentionally released near populated areas. Hazardous chemical marine vessels are also part of two "critical infrastructures" identified by the Bush Administration—the chemicals and transportation sectors.[4] For these reasons, the protection of hazardous chemical shipments passing through U.S. waterways and ports is an important component of U.S. homeland security strategy.

Although security experts widely acknowledge that marine shipments of hazardous chemicals may be attractive terrorist targets, no marine vessel carrying hazardous chemicals has been used by terrorists in an attack on civilians. Nonetheless, marine accidents involving such shipments in the U.S. and abroad have demonstrated their potential to impact nearby communities. Foreign terrorists also have successfully attacked other types of marine vessels overseas. As discussed later in the report, intelligence suggests that terrorists may have both the interest and capability to execute hazardous chemical shipping attacks in the United States.

Hazardous Marine Cargo Accidents

Major accidents involving the marine transportation of hazardous chemicals are uncommon.[5] However, those that have occurred include some of the deadliest

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[3] For information and analysis of these other maritime security hazards, see CRS Report RL31733, *Port and Maritime Security: Background and Issues for Congress,* by (nam e redacted); CRS Report RS21293, *Terrorist Nuclear Attacks on Seaports: Threat and Response,* by Jonathan Medalia; and CRS Report RS21997, *Port and Maritime Security: Potential for Terrorist Nuclear Attack Using Oil Tankers,* by Jonathan Medalia.

[4] Office of the President. *The National Strategy for the Physical Protection of Critical Infrastructure and Key Assets.* Feb. 2003.

[5] Bureau of Transportation Statistics. Marine Casualty and Pollution Database. Data (continued...)

industrial accidents ever recorded. In 1917, for example, the explosion of the *Mont-Blanc*, carrying a cargo of explosives in the port of Halifax, killed over 1,900 people and seriously injured over 4,000 others.[6] The 1947 explosion of two cargo ships carrying ammonium nitrate and sulfur in Texas City, Texas destroyed the port, killing nearly 600 people and injuring another 3,500.[7]

Due to improved safety practices and vessel construction, a marine accident as destructive as the Texas City disaster has not occurred in the ensuing 60 years. However, serious incidents involving chemical marine shipments have forced the evacuation of threatened coastal populations. These incidents include a 1985 fire aboard the *Ariadne* carrying 100 containers of toxic chemicals in the port of Mogadishu, Somalia [8]; a 1987 accident aboard the *Cason* carrying 1,200 tons of flammable, toxic, and corrosive chemicals near Cape Finisterre, Spain [9]; and a 1999 fire aboard the *Multitank Ascania* carrying a cargo of vinyl acetate off the coast of Scotland.[10] These incidents did not result in serious casualties among neighboring communities, but emergency responders had a high degree of concern for public safety as indicated by the associated evacuations.

Likelihood of Terrorist Attacks on Ships

Although terrorists have never used a marine cargo vessel to launch a chemical attack on the general public, both international combatants and domestic terrorists tried to use explosives to release chemicals from land based manufacturing and storage facilities during the 1990s. Most of these attempts were in foreign war zones such as Croatia. They included attacks on a plant producing fertilizer, carbon black, and light fraction petroleum products; other plants producing pesticides; and a pharmaceutical factory using ammonia, chlorine, and other hazardous chemicals. All of these facilities were close to population centers. In the United States, there were at least two instances during the late 1990s when criminals attempted to release chemicals from similar facilities. One incident involved a large propane storage facility in California, and the other a gas refinery in Texas.[11]

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[5] (...continued)
available through 2001. Access at [http://transtats.bts.gov/Fields.asp?Table_ID=1148].

[6] Maritime Museum of the Atlantic. "The Halifax Explosion." Web page. Halifax, NS. July 7, 2005. [http://museum.gov.ns.ca/mma/AtoZ/HalExpl.html].

[7] Olafson, S. "'Texas City Just Blew Up.'" *Houston Chronicle*. April 16. 1997.

[8] Helsinki Commission (HELCOM). *HELCOM Manual on Co-operation in Response to Marine Pollution within the Framework of the Convention on the Protection of the Marine Environment of the Baltic Sea Area*. Vol. 2, Annex 3. Dec. 1 2002. pA3-4.

[9] Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE). "Cason." Web page. Brest, France. July, 2003. [http://www.le-cedre.fr/index_gb.html]

[10] United Kingdom, Dept. for Transport. "Report on Incidents Involving the Carriage of Hazardous and Noxious Substances (HNS) by Sea." Draft report. London. Aug. 21, 2002.

[11] Dept. of Justice. *Assessment of the Increased Risk of Terrorist or Other Criminal*
(continued...)

Terrorists have directly targeted marine vessels, mainly to destroy the vessel or cargo. In June 2002, Moroccan authorities foiled an Al-Qaeda plot to attack U.S. and British warships, and possibly commercial vessels, in the Straits of Gibraltar.[12] In October 2002, the oil tanker *Limburg* was successfully attacked off the Yemeni coast by a bomb-laden fishing boat.[13] Foreign governments have reportedly expressed concerns about terrorist groups commandeering a hazardous chemical vessel and "crashing it into a port."[14]

In the United States, the Department of Homeland Security (DHS) has been consistently concerned about the security of chemicals infrastructure, including chemical tanker ships.[15] The Homeland Security Council included terrorist attacks on ships carrying flammable and toxic chemical cargoes in a U.S. port among the hazard scenarios it developed as the basis for U.S. homeland security national preparedness standards.[16] The President's *National Strategy* states that "much of the port system represents a significant protection challenge, particularly in the case of high consequence cargo."[17]

One type of hazardous marine cargo—liquefied natural gas (LNG)—has received particular public attention. The DHS reportedly included LNG tankers among a list of potential terrorist targets in a security alert late in 2003.[18] The DHS also stated that "the risks associated with LNG shipments are real, and they can never be entirely eliminated."[19] A 2004 report by Sandia National Laboratories considered potential terrorist attacks on LNG tankers "credible and possible."[20] The Sandia report identified LNG tankers as vulnerable to ramming, pre-placed explosives,

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[11] (...continued)
Activity Associated with Posting Off-Site Consequence Analysis Information on the Internet. April 18, 2000. pp23-24.

[12] Sawer, P. "Terror Plot to Blow Up Navy Warships is Foiled." *The Evening Standard*. London. June 11, 2002. p4.

[13] "Ships as Terrorist Targets." *American Shipper*. November, 2002. p59.

[14] Stanley, B. "Seaports Eye Terror Threat." Associated Press. Jan. 5, 2004.

[15] Stephan, R. Acting Under Secretary for Information Analysis and Infrastructure Protection, Dept. of Homeland Security. Statement before the Senate Homeland Security and Governmental Affairs Committee. June 15, 2005.

[16] Homeland Security Council. *Planning Scenarios: Executive Summaries*. July 2004. p 6-1.

[17] Office of the President. *The National Strategy for the Physical Protection of Critical Infrastructure and Key Assets.* February, 2003. p60.

[18] Office of Congressman Edward J. Markey. Personal communication. Jan. 5, 2004.

[19] Turner, P.J., Assistant Secretary for Legislative Affairs, Department of Homeland Security (DHS). Letter to U.S. Representative Edward Markey. April 15, 2004. p1.

[20] Sandia National Laboratories (SNL). *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*. SAND2004-6258. Albuquerque, NM. Dec. 2004. pp49-50.

insider takeover, hijacking, or external terrorist actions (such as a *Limburg*-type attack, a missile attack, or an airplane attack).[21]

What is "Hazardous" Chemical Cargo?

Homeland Security Presidential Directive 7 (HSPD-7) directs federal homeland security activities to focus on terrorist attacks that could cause "catastrophic health effects or mass casualties comparable to those from the use of a weapon of mass destruction."[22] For purposes of this report, hazardous chemical cargo is chemicals carried aboard a commercial marine vessel that, if accidentally released or combusted, could, under certain circumstances, pose a catastrophic hazard to the general public. Typically, such hazards could include poisoning, asphyxiation, chemical burns, or thermal burns. In some cases, a single chemical could present a combination of these hazards. Numerous federal standards identify potentially hazardous chemicals. With respect to public security, relevant standards are promulgated by the Department of Transportation (DOT), the Coast Guard, and the Environmental Protection Agency (EPA).

DOT Hazardous Materials

The DOT regulates the transportation of all hazardous materials under the Hazardous Materials Transportation Act of 1975 (P.L. 93-633) and subsequent amendments. The act empowers the Secretary of Transportation to designate as "hazardous" any particular quantity or form of material that "may pose an unreasonable risk to health, safety and property when transported in commerce." The DOT defines and classifies hazardous materials in 49 C.F.R. § 172.101. The DOT's list includes thousands of materials—including toxic, radioactive, corrosive, explosive, and flammable materials—which could potentially be shipped. The DOT groups individual materials by type of hazard (e.g., inhalation poisoning) but not necessarily by relative degree of hazard. The DOT does provide a ranking of relative hazard by general class or division in 49 C.F.R. § 173.2a. This ranking is summarized in **Appendix 1**.

In addition to its general hazardous material safety regulations, the DOT requires shippers of certain "highly hazardous" cargo to develop security plans in 49 C.F.R. § 172.8.[23] Under these provisions (subject to various conditions), the DOT defines highly hazardous cargo to include:

- radioactive material (Class 7);

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[21] SNL. Dec. 2004. pp61-62. For more information on LNG Security see CRS Report RL32073, *Liquefied Natural Gas (LNG) Infrastructure Security*, by (name redacted).

[22] Exec. Office of the President. "Critical Infrastructure Identification, Prioritization, and Protection." Homeland Security Presidential Directive 7. Dec. 17, 2003.

[23] The DOT's security plan requirements under 49 C.F.R. § 172.8 extend to marine vessels. However, to avoid redundancy, DOT's accepts security plans required by other agencies (e.g., Coast Guard) if they are consistent with DOT's requirements.

- over 55 pounds of explosives (Division 1.1, 1.2, or 1.3);
- over 1.06 quarts per package of material poisonous by inhalation;
- 3,500 gallons or more of bulk hazardous liquids or gases;
- 468 cubic feet or more of bulk hazardous solids;
- 5,000 pounds or more of packaged hazardous material;
- agents regulated by the Centers for Disease Control and Prevention;
- certain hazardous materials that require placarding under other provisions in 49 C.F.R. § 172.

Note that the DOT's definition of "highly hazardous" materials extends to most of the materials in 49 C.F.R. § 172.101 when they are present above the prescribed quantities.

Coast Guard Hazardous Cargoes

The Coast Guard regulates the safety and security of marine vessels and is responsible for enforcing all applicable federal hazardous material laws in U.S. waters. Coast Guard regulations identify hazardous cargo in several sections of the federal code. Under the Port and Waterways Safety Act of 1972 (P.L. 92-340), the Coast Guard defines "certain dangerous cargoes" in 33 C.F.R. § 160.204. The definition of "certain dangerous cargoes" refers to the DOT list mentioned above, and specifically names certain liquefied gas and bulk liquid cargoes. In 46 C.F.R., the Coast Guard prescribes special requirements for vessels carrying certain hazardous materials, identified as follows:

- Bulk solid hazardous materials (46 C.F.R. § 148).
- Bulk liquid hazardous materials carried in barges (46 C.F.R. § 151).
- Bulk liquid, liquified gas, or compressed gas hazardous materials carried by ship (46 C.F.R. § 153).
- Incompatible chemicals where multiple chemicals may be carried together in parcel tankers or on container ships (46 C.F.R. § 150).

The Coast Guard also identifies hazardous marine cargoes through regulation of waterfront facilities handling these cargoes in 33 C.F.R. Parts 126, 127, and 154. Collectively, hundreds of different hazardous materials are included on the Coast Guard's lists. While Coast Guard regulations identify particular hazardous materials potentially carried in marine vessels, they do not necessarily identify the relative degree of hazard among these materials.

EPA Hazardous Substances

The EPA regulates stationary facilities handling potentially hazardous substances under the Clean Air Act (CAA), Section 112(r)(7). In 1990, Congress passed P.L. 101-549, which amended the CAA, Section 112, to require facilities possessing more than specified threshold quantities of certain hazardous substances to file risk management plans (RMPs). These RMPs summarize the potential threat from sudden, large releases of those substances. These plans must also include the results of *off-site* consequence analysis for a worst-case accident and plans to prevent releases and mitigate any damage.

The Clean Air Act Amendments defined "hazardous substances" to include 14 listed substances (including chlorine and ammonia) and at least 100 additional chemicals to be designated by the EPA. The amendments directed EPA to designate chemicals posing the greatest risks to human health or to the environment, based on three criteria: the severity of potential acute adverse health effects, the likelihood of accidental releases, and the potential magnitude of human exposure. The EPA promulgated a list of 77 acutely toxic substances, 63 flammable gases and volatile flammable liquids, and "high explosive substances" (found in 40 C.F.R. § 68). As a result of a legal settlement, the EPA deleted high explosives from the list in 1998. The list was further amended in 2000 to exclude flammable substances when used as a fuel, or held for sale as a fuel at a retail facility. The current EPA/RMP list is shown in **Appendix 2**.[24]

The vast majority of hazardous materials on the DOT lists do not likely represent a "catastrophic" health hazard to the general public, because the materials involved are not shipped or stored in sufficient quantity, or because their physical properties limit their potential off-site impacts. Likewise, most of the hazardous materials listed by the Coast Guard in 33 C.F.R. and 46 C.F.R. do not represent catastrophic health hazards. Accordingly, the EPA list may more appropriately identify those chemicals considered to have the greatest potential consequences to the general public. Since the chemicals in EPA's list are considered among the most hazardous on land, it follows that many of them may be similarly hazardous if transported on water.

This report uses the EPA/RMP chemicals as the basis for marine cargo hazard analysis. Nearly all of the EPA's listed hazardous substances under the CAA Section 112(r) are found in the DOT and Coast Guard hazardous materials lists, so the findings in this report should be applicable to the DOT or Coast Guards lists as well. (The EPA/RMP chemicals are cross-referenced to the DOT categories in **Appendix 2**.) Two notable classes of hazardous material identified by DOT not on the EPA/RMP list are radioactive materials and explosives. Army Corps of Engineers marine commerce statistics for 2003 (discussed later in this report) show that explosives and radioactive materials would account for less than 0.3% of U.S. hazardous marine cargo if added to the EPA/RMP hazardous materials list.[25] Excluding these two classes is unlikely to affect the policy conclusions in this report.

Health Effects of Hazardous Chemicals

As noted above, the EPA/RMP chemicals are broadly classified as acutely toxic or flammable (or both). The degree of toxicity or flammability of specific chemicals within the EPA/RMP list varies with their chemical properties. The following example chemicals illustrate such variations:

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[24] The list may be viewed electronically at the following link, visited May 9, 2003. [http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr68_00.html].

[25] See page nine for a discussion of the source of this statistic.

Ammonia. Ammonia is an acutely toxic, potentially explosive, liquefied gas primarily used in the manufacture of fertilizers and as a fertilizer itself. It has many other uses as well; for example, as a chemical production component, as source of protein in livestock feeds, and in metal treatment operations.[26] Ammonia can reach harmful concentrations in the air very quickly on loss of containment. It can causing severe skin irritation, and if inhaled, can cause respiratory irritation, eye corrosion, and fatal fluid buildup in the lungs.[27]

Methane. Methane (natural gas) is used as a heating fuel and industrial feedstock for a range of chemical processes. Methane is not inherently toxic, although high vapor concentrations may cause asphyxiation by displacing breathable air. Cryogenic methane (liquefied natural gas, or LNG) may freeze body parts with which it comes into contact. Methane is extremely flammable when mixed with air and may be explosive when such mixtures are in confined spaces.[28]

Methyloxirane. Methyloxirane is used to manufacture polyurethane foam (for furniture and cars), solvents (in paints, cleaners, and waxes), polyster resins, and other industrial products. Methyloxirane is a toxic liquid and a fire hazard. Human exposure may irritate the eyes, skin, and respiratory tract. Methyloxirane vapor is extremely flammable when mixed with air and reacts explosively with chlorine, ammonia, strong oxidants, and acids.[29]

As the examples above demonstrate, an uncontrolled release of a specific chemical on the EPA/RMP list could have varying effects on an exposed population. Evaluating the particular effects of such releases material by material is beyond the scope of this report, nor is it necessary for a general discussion of hazardous marine cargo policy. The important point is that the EPA considers all the RMP chemicals, when present above their individual threshold quantities, to be sufficiently hazardous to the general public to warrant special regulatory treatment (i.e., off-site consequence analysis). Recognizing that certain shipments of specific cargoes may be more hazardous than others, this report assume that they are all hazardous enough to warrant public concern as potential terrorist targets.

Hazardous Chemical Releases Over Water

The EPA/RMP list of hazardous chemicals was developed for facilities on land. Due to their chemical properties, the health hazard associated with these chemicals

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[26] R.M. Technologies. "Uses of Ammonia." Company website. Mt. Laurel, N.J. Aug. 15, 2005. [http://www.rmtech.net/uses_of_ammonia.htm].

[27] International Programme on Chemical Safety. "International Chemical Safety Cards: Ammonia." ICSC 0414. Geneva, Switzerland. Oct. 1991.

[28] International Programme on Chemical Safety. "International Chemical Safety Cards: Methane." ICSC 0291. Geneva, Switzerland. Oct. 2000. Although methane is on the EPA/RMP chemicals list, LNG is exempted from the EPA's RMP requirements because it is used as a fuel. The analysis in this report includes LNG.

[29] International Programme on Chemical Safety. "International Chemical Safety Cards: Propylene Oxide." ICSC 0192. Geneva, Switzerland. March 17, 1995.

may be significantly different if released over water. Certain EPA/RMP chemicals dissolve in water (e.g, propylene oxide) or sink in water (e.g., tetramethyllead), potentially reducing the hazard they pose to the general public in a marine incident. Other chemicals (e.g., ammonia) dissolve in water, but evaporate quickly as well. Still others (e.g., cryogenic methane) float and evaporate faster on water than on land, creating a larger hazard zone more quickly in a marine release than a land release for the same quantity of chemical.[30] Because land release and water release characteristics of specific EPA/RMP chemicals may differ, only limited conclusions may be drawn from a study of EPA/RMP hazards in marine shipments. Further research and analysis are required for a better understanding of the relative marine hazards of specific chemicals.

Hazardous Marine Cargo Statistics

The Army Corps of Engineers (ACE) maintains statistics of marine commerce in U.S. waters. These statistics may be used to estimate the marine shipping volumes of EPA/RMP chemicals. (See **Appendix 3** for a description of the ACE database and its limitations.) According to the ACE statistics, a subset of the EPA/RMP chemicals are transported through U.S. waters in significant quantities. **Table 1** summarizes the total U.S. waterborne shipments of these chemicals by the DOT's general hazard category. As the table shows, over 48 million tons of EPA/RMP chemicals passed through U.S. waters in 2003, the most recent year for which data are available. These hazardous chemicals accounted for 2% of total U.S. waterborne cargo tonnage.

Table 1: 2003 U.S. Waterborne Tonnage of EPA/RMP Hazardous Cargo

DOT Category	Description	Total Volumes (1,000 short tons)
Division 2.3	Poisonous gases	9,597
Division 2.1	Flammable gases	27,134
Class 3 Class 8 Division 6.1	Flammable liquids Corrosive materials Poisonous liquids/solids	6,779 2,835 2,238
Total		**48,583**

Sources: 49 C.F.R. § 173.2a; Army Corps of Engineers; EPA; CRS analysis. Note that DOT Divisions are subcategories within a Class.

Hazardous Cargo Shipment Frequency and Volumes

It may be appropriate to consider both size and number of shipments in an analysis of marine cargo terrorism hazards. The hazardous materials on the EPA/RMP list are included primarily because their chemical properties make them

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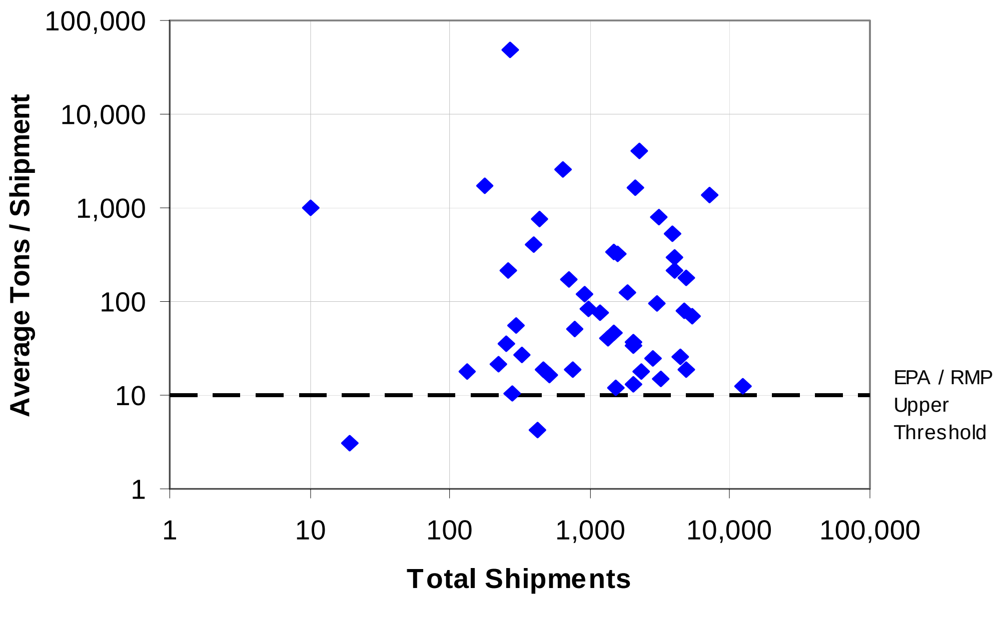
[30] HELCOM. Vol. 2, Annex 4. Dec. 1 2002. pA4-4.

hazardous to human health. To be a potentially catastrophic threat to the general public, however, these materials must be present in large enough volumes to impact nearby populations in the event of a maritime release. Accordingly, the overall volume of a hazardous material in a marine shipment becomes an important consideration when evaluating potential public impacts of terrorist attack. Additionally, a larger number of shipments could potentially equate to a larger overall terrorist risk because terrorists could have more opportunities for a successful attack, among other reasons.

Over 100,000 marine shipments of EPA/RMP hazardous cargo passed through U.S. waterways in 2003. **Figure 1** summarizes the total number of shipments and average cargo tons per shipment in 2003 for the EPA/RMP hazardous chemicals as estimated by the ACE.[31] Because cargo vessels may load or unload partial cargoes at multiple locations over the course of a single shipment, the tonnage of cargo actually carried aboard a vessel at any time may vary. Note that the data in **Figure 1** are plotted on a logarithmic scale for clarity of presentation.

Figure 1: 2003 Marine Shipments of EPA/RMP Hazardous Chemicals



Sources: 49 C.F.R. § 173.2a; Army Corps of Engineers; EPA; CRS analysis.

The EPA regulations specify minimum threshold quantities for risk planning between 500 and 20,000 pounds for the EPA/RMP chemicals. The dashed line in **Figure 1** represents the 20,000 pound (10 ton) upper threshold above which off-site consequence plans are required for facilities on land. According to the ACE data, the average shipment volume for the hazardous chemicals in **Figure 1** generally exceed the EPA/RMP 20,000 pound threshold.[32] Based on these statistics, the average waterborne shipment of most of the EPA/RMP hazardous chemicals would be of

[31] One low-volume chemical is excluded because its shipments data are not available.

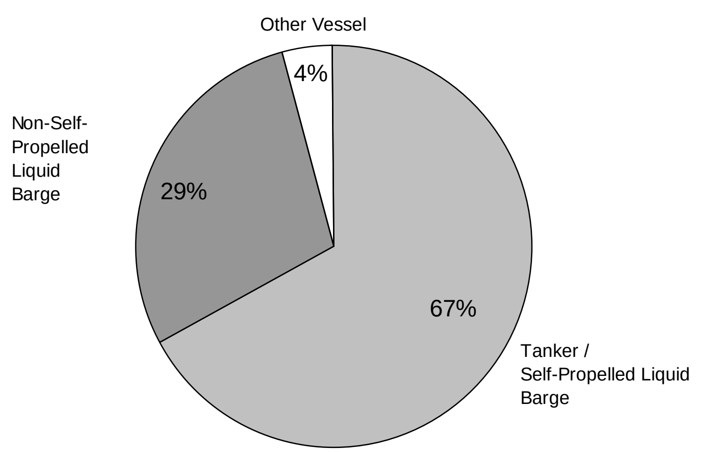
[32] ACE tons represent short tons (2,000 pounds).

sufficient volume to require an off-site risk management plan under the EPA's rules if the same quantity of chemical was stored on land. It is also interesting to note that each category of chemicals in **Figure 1** was typically shipped between several hundred and several thousand times in 2003. "Low frequency" and "high frequency" hazardous cargoes are not easily distinguished.

Hazardous Cargo Vessel Characteristics

Many types of marine vessels may transport hazardous cargo in bulk. These vessels have distinct construction and operating characteristics depending upon the quantities and physical properties of the cargoes they are designed to carry. Cargo vessel characteristics are an important security consideration. They determine, in part, the physical vulnerability of such vessels to accident or deliberate attack, as well as the potential consequences of an accident or attack. As **Figure 2** shows, over 67% of EPA/RMP hazardous marine cargo in 2003 was shipped in tankers (liquefied gas or chemical parcel), or self-propelled liquid chemical barges. An additional 29% was shipped in non-self-propelled liquid chemical barges. Container ships, dry cargo barges, and other vessels carried 4% of such cargo. This section will review the characteristics of each of these vessel categories.

Figure 2: Marine Shipments of EPA/RMP Chemicals by Vessel Type



Sources: 49 C.F.R. § 173.2a; Army Corps of Engineers; EPA; CRS analysis.

Liquefied Gas Tankers

Liquefied gas tankers are oceangoing ships designed to carry one or more types of liquefied gas cargo—gas which has been cooled, pressurized, or both, below its boiling point so it can be shipped as a liquid. Such liquefied gas cargoes include butane and propane (both referred to as liquefied petroleum gases, or LPG), liquefied natural gas (LNG), butadiene, propylene, ethylene, vinyl chloride, methyl chloride, ammonia and propylene oxide. These are all chemicals on the EPA/RMP list.

Liquefied gas tankers consist of several large and separate onboard tanks which may be pressurized, refrigerated, and insulated to accommodate different cargo needs (**Figure 3**). International shipping codes impose extensive standards for the construction and operation of these vessels.[33] Their cargo tanks must be built to withstand high pressures or low temperatures, as necessary. Therefore, these tanks are robust and resistant to impact damage, or flexible and able to distort without failure. The vessels are also "double-hulled," with cargo tanks located above a double bottom and inboard of the outer hull, independent of the tankers' outer hull structures. Consequently, liquefied gas tankers possess a level of structural integrity greater than that found in most other classes of ship, which makes them highly resistant to grounding and collision damage.[34] LNG tankers carry only LNG. Other liquefied gas tankers may simultaneously carry a combination of different cargoes, such as butane and propylene, in different storage tanks.[35] Such combination cargoes create potentially unique multi-chemical hazards.

Figure 3: Typical Liquefied Natural Gas Tanker

Source: Yuasa, K., Uwatok, K., and Ishimaru, J. "Key Technologies of Mitsubishi LNG Carriers: Present and Future." *Mitsubishi Heavy Industries, Ltd. Technical Review*. Vol.38 No.2. June. 2001.

Liquefied gas carriers vary greatly in capacity. Fully pressurized ships may carry up to 4,300 m^3 of cargo, although most can carry no more than 2,500 m^3 of cargo.[36] LNG tankers, on the other hand, have capacities of 25,000 m^3 to 147,000 m^3, with ships of 200,000 m^3 capacity planned for new construction.[37] (A cargo capacity of 200,000 m^3, is equivalent to approximately 82,000 tons of LNG.) At the upper end of this range, LNG tankers are among the largest cargo vessels in the world.

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[33] International Maritime Organization (IMO). *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)*. IMO-104E. 1993.

[34] Society of International Gas Tanker & Terminal Operators, Ltd. (SIGTTO). *Safe Havens for Disabled Gas Carriers*. 3rd Ed. Feb. 2003. p2.

[35] Japan Ship Exporters' Assoc. "MHI Completes 35,000m^3 Multi-Purpose LPG Carrier, *Berlian Ekuator*." *SEA-Japan*. Newsletter. No. 304. April - May 2004. p 3.

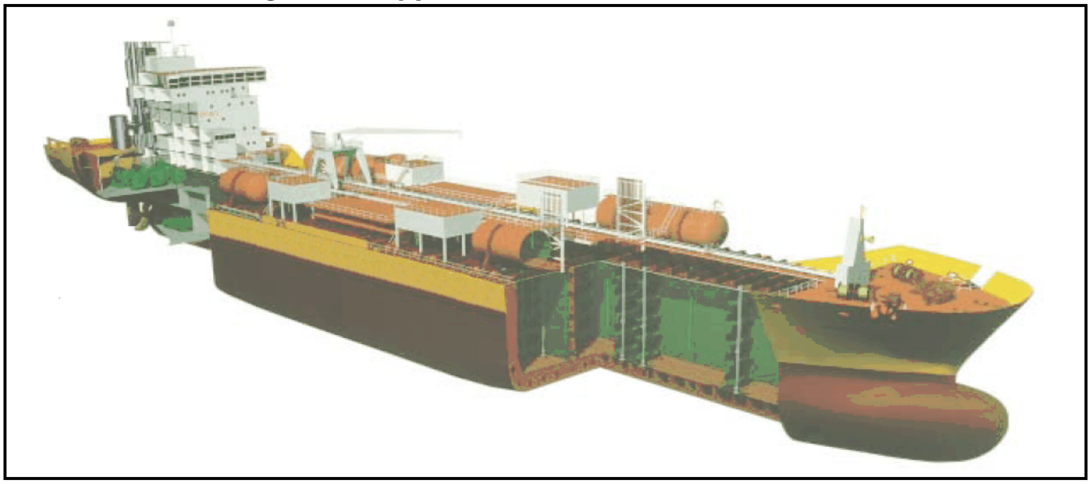
[36] SIGGTO. 2003. p.8.

[37] "Qatar Orders LNG Ships." *International Oil Daily*. June 30, 2005.

Chemical Parcel Tankers

Chemical parcel tankers are versatile vessels designed to carry a wide range of liquid and chemical cargoes, including EPA/RMP hazardous chemicals. Externally, they appear similar to petroleum product tankers, but typically can carry 10 to 60 separate cargo tanks to simultaneously accommodate multiple cargoes or "parcels." They range in total cargo capacity from approximately 3,000 to 50,000 tons, although most are well under 50,000 tons.[38] **Figure 4** is an illustration of a chemical parcel tanker with a cutaway view showing individual cargo tanks.

Figure 4: Typical Chemical Parcel Tanker



Source: Intl. Assoc. of Independent Tanker Owners. "Features of a Modern Chemical Parcel Tanker." *The Tanker Newsletter*. Oslo, Norway. Issue No. 4. April 2000.

Chemical parcel tankers, like gas carriers, are governed by international construction standards.[39] They may have cargo tanks lined with stainless steel or specialized coatings, such as epoxy, zinc silicate, or polyurethane, to ensure compatibility with a range of chemicals. The tankers have double bottoms or hulls, and maintain spaces between tank walls to prevent incompatible cargoes from coming into contact with each other.[40] Like LPG tankers, chemical parcel tankers may carry multiple chemical cargoes of different hazardous chemicals at one time.

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[38] "Vessel Types of Southampton, Portsmouth, and The Solent." June 2005.

[http://www.solentwaters.co.uk/Ships%20and%20Ports/Vessel%20Types%202/page10.html].

[39] International Maritime Organization (IMO). *International Code for the Construction of Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)*. 1IMO-100E. 1998.

[40] United Nations Foundation. "Chemical Tankers." *UN Atlas of the Oceans*. June 2005. [http://www.oceansatlas.com/unatlas/uses/transportation_telecomm/maritime_trans/shipworld/tanker_pas/chem/chem.htm].

Liquid Chemical Barges

Liquid chemical barges are shallow draft vessels designed to carry bulk liquid chemicals, primarily in coastal regions and through inland waterways. Liquid chemical barges are similar to parcel tankers in that they may contain multiple separate cargo tanks lined with stainless steel or other special coatings. Such barges range in size from 700 tons to 3,500 tons of total cargo capacity.[41] Larger barges transporting hazardous chemicals are typically double-hulled and self-propelled (**Figure 5**), although smaller chemical barges may be unpowered, relying upon tugboats or towboats for movement. Unpowered chemical barges on inland waterways are approximately 52 to 54 feet wide and up to 300 feet long.[42] Inland barges usually travel river systems in groups of two to eight barges per towboat, although "linehaul" tows may consist of more than 20 barges, picking up and dropping off barges at various points along a given route.[43] Such inland barges may be refrigerated, employing two insulated cargo tanks, each approximately 18 feet in diameter and up to 240 feet long, and each capable of carrying 1,250 to 1,500 tons of ammonia, propylene, or other refrigerated chemical product.[44] Pressurized cargo tanks are also available for pressurized liquid cargoes.

Figure 5: Typical Self-Propelled Liquid Chemical Barge

Source: Royal Vopak. "Photo Gallery: Barging." Internet page. Rotterdam, Netherlands. July 20, 2005. [http://photoshop.vopak.com/pictureGallery/page_showPictures.php?category=barging]

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[41] Royal Vopak. "Business Activities: Barging." Company website. Rotterdam, The Netherlands. June 20, 2005. [http://www.vopak.com/business_segments/barging/142_214.php]

[42] Army Corps of Engineers (ACE). "Barge Impact Analysis for Rigid Walls." ETL 1110-2-563. Sept. 30, 2004. pB-7.

[43] Kirby Corp. "Kirby Inland Marine: Our Services." Company website. Houston, TX. June 20, 2005. [http://www.kmtc.com/inland/services.cfm.]

[44] Technicold Services, Inc. "Barge Characteristics." Company website. San Antonio, TX. June 20, 2005. [http://www.gcbtechnicold.biz/marine.htm]

Other Marine Vessels

Hazardous chemicals may be transported on conventional container ships in multi-modal tank containers, drums, portable tanks, or other cargo consignments. Roll-on/roll-off vessels may carry such chemicals in tanker trucks or in conventional tractor-trailers with internally packaged cargo.[45] Given the size of modern container ships, large quantities of a variety of hazardous chemicals may be present in a container ship at any time. The *Jolly Rubino*, for example, was reported to be carrying 3 containers of vinyl acetate, an EPA/RMP chemical, and 18 containers of other DOT toxic chemicals when it caught fire off South Africa in 2002.[46] Hazardous chemicals must be shipped in designated cargo areas aboard these vessels. In addition to container ships, hazardous chemicals may also be shipped aboard general cargo ships, container barges, ferries (in road vehicles), and other vessels.

Comparing Marine and Land Volumes

The public hazards associated with EPA/RMP hazardous cargo in a given setting are proportional to volume. Accordingly, it is informative to compare the volumes of hazardous chemicals present on marine vessels to volumes of the same chemicals in other modes of transportation and in stationary storage facilities on land.

Land Transportation Volumes

Marine vessels, rail tank cars, and highway tanker trucks are all bulk transportation modes for EPA/RMP hazardous chemicals. In many cases, a given shipment of hazardous cargo may be moved sequentially by all three modes to its final destination. The maximum range in cargo capacity of rail tank cars is approximately 50 to 90 tons, depending upon the chemicals carried.[47] Containerized tanks carried on flatbed railcars may carry up to 70 tons per tank.[48] Note that rail shipments may carry multiple tank cars and hazardous cargoes simultaneously. Highway tanker trucks also carry many EPA/RMP hazardous cargoes, such as anhydrous ammonia, chlorine, and LPG. Standard cargo capacity for these tanker trucks ranges from approximately 15 to 30 tons, depending upon the type of cargo.[49]

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[45] Rickaby, S. "The OPRC-HNS Protocol and its Practical Implications." Presentation to the Petroleum Assoc. of Japan Oil Spill Symposium. Tokyo. Feb. 24-25, 2005. p3.

[46] South African Ministry of Environmental Affairs and Tourism. "Jolly Rubino Containers Wash Up Along Eastern Cape Coast." Press release. Pretoria, South Africa. Sept. 24, 2002.

[47] Union Tank Car Co. "Products and Services." Internet page. Chicago, IL. June 28, 2005. [http://www.utlx.com/Products_and_Services/basicdesign/index.asp].

[48] "ISO Tank Containers Replace Drums As Specialty Chemical Storage Vessels." *Modern Bulk Transporter*. PRIMEDIA Business Magazines & Media, Inc. July 1, 1998.

[49] Mississippi Tank Co. "New Trailers." Internet page. Hattiesburg, MS. June 28, 2005. [http://www.mstank.com/ntrailer.htm].

Table 2: Cargo Tank Capacity for EPA/RMP Transport Modes

Transportation Type	Typical Tank Capacity (Tons)
Liquefied gas tanker	500 – 13,700
Chemical parcel tanker	300 – 2,600
Liquid cargo barge	350 – 1,500
Rail tank car	55 – 90
Highway tanker truck	15 – 30

Source: CRS

Table 2 summarizes the typical range of cargo tank capacity for the principal marine, rail, and highway tankers that transport EPA/RMP chemicals as discussed above. Note that multiple tanks are usually found on liquefied gas tankers, chemical parcel tankers, and liquid cargo barges. As the table shows, marine cargo tank capacity generally exceeds the capacity of a single rail or highway tanker truck by one or more orders of magnitude. (This is generally true for other types of cargo as well.) Because marine tankers often carry partial cargoes, and because barge and rail shipments may involve multiple barges or rail tank cars, comparing actual volumes shipped across these modes is more difficult than comparing tank capacity. Based on the average marine shipment volumes reported in **Figure 1** and the rail and highway tank capacities in **Table 2**, it appears that many marine shipments of EPA/RMP hazardous material are larger than an individual shipment of the same material on land.

Chemical Facility Volumes

The EPA maintains a database of on-site chemical storage volumes for all facilities required to file risk management plans under the Clean Air Act, Section 112(r). Under the act, these facilities must report the amount of chemical held on hand as well as the amount held in a single process. These filings may be used to estimate the maximum and average quantity of a given EPA/RMP chemical across all facilities required to file risk management plans (with off-site consequence analysis data). Note that these facilities are the subset of all chemical facilities with the highest on-site quantities of the EPA/RMP chemicals in a single storage location.

CRS compared average and maximum marine shipping volumes from the ACE database to average and maximum land storage volumes from the EPA database for nine EPA/RMP chemicals: acrylonitrile, anhydrous ammonia, chlorine, ethylene, methyloxirane, oxirane, propene, sulfur dioxide, and vinyl chloride.[50] These chemicals represent high, medium, and low volume shipments of both toxic and

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[50] ACE data are for calendar year 2003. EPA chemical plant data are from the May 2005 update of the EPA RMP*National Database.

flammable chemicals. The results of this comparison are summarized in **Table 3**. (Because detailed shipping and storage information for specific chemicals is proprietary, the table does not name the chemicals; they are not presented in alphabetical order.)

Table 3: Marine and Chemical Facility Volumes of Nine EPA/RMP Chemicals

Chemical	Avg. Volume (Tons)		Max. Volume (Tons)	
	Marine	Land	Marine	Land
#1	1,487	1,162	8,096	31,836
#2	3,978	608	41,698	400,000
#3	2,546	1,527	39,643	29,700
#4	1,728	3,449	4,629	32,007
#5	174	72	1,200	21,500
#6	218	6,804	6,963	83,000
#7	996	8,539	5,955	75,000
#8	10	398	533	6,000
#9	3	72	19	1,418

Sources: Army Corps of Engineers, EPA, CRS analysis.

As the table shows, for the chemicals shipped in higher volumes (#1- #4), the average marine shipments were generally larger than the average volumes stored at EPA/RMP chemical plants. This finding is consistent with the practice of shipping higher volume cargo in larger vessels. The table also shows that the largest marine shipments were substantially smaller than the largest volumes stored at chemical plants, except for chemical #3.

Hazardous Chemical Shipments through U.S. Ports

Marine shipments of EPA/RMP hazardous chemicals either originate or terminate in U.S. ports. In some cases, port facilities serve as transportation hubs for temporary storage and transfer of hazardous cargo to rail tank cars or truck tankers. In other cases, port facilities may be industrial plants that receive hazardous marine cargo directly for use in industrial processes, such as petrochemical refining, water treatment, and fertilizer production. Some port facilities produce hazardous cargo. Transportation and industrial facilities are more prevalent in some ports than others, so total marine shipments of EPA/RMP chemicals may vary significantly from port to port. Likewise, shipments of specific EPA/RMP chemicals vary across ports. Because security hazards may be related to both the volume and specific type of EPA/RMP cargo moving through a given port, it may be helpful to examine the relative concentration of EPA/RMP hazardous marine shipments through U.S. ports.

Hazardous Chemical Cargo Ports

There are more than 360 commercial ports in the United States containing approximately 3,200 cargo and passenger handling facilities.[51] According to ACE statistics, EPA/RMP hazardous chemicals were shipped through 113 of these ports in 2003. Of these 113 ports, the top 30 handled approximately 95% of EPA/RMP hazardous cargo tonnage. For purposes of policy discussion, these 30 ports are listed in **Table 4** in alphabetical order, along with the two categories of hazardous marine cargo shipped in greatest tonnage through each port. Note that additional EPA/RMP hazardous cargoes not listed in **Table 4** may also be shipped in large volumes through a given port. For example, 22 EPA/RMP chemicals were shipped through the port of Baton Rouge in quantities exceeding 2,500 tons in 2003. Furthermore, volumes of a given type of cargo (e.g., LPG) in one port bear no relation to volumes of the same type of cargo in any other port. Marine shipments of EPA/RMP hazardous chemicals in the remaining 83 ports that handle such cargo may be no less a security concern than shipments in the top 30 ports. An attack on a single hazardous cargo vessel may have serious public consequences independent of other shipments through a given port.

As **Table 4** shows, the top 30 hazardous chemical ports are found in 15 states. Over half of these ports are in the Gulf of Mexico—in Texas (9 ports), Louisiana (5 ports), Alabama (1 port), Florida (1 port), and Mississippi (1 port). All of the top 30 ports in **Table 4** are classified by the ACE as coastal, except for Huntington, WV, which is located on the Ohio River.[52] No Great Lakes ports are on the list. The mix of principal EPA/RMP hazardous chemicals varies considerably from port to port. The chemicals listed most frequently among the top two hazardous cargoes shipped through these ports are LPG (13 ports) and ammonia (12 ports). LPG (typically propane) is an extremely flammable and potentially explosive gas, heavier than air, and shipped under pressure in liquefied form.[53] The characteristics of ammonia, a toxic gas, were summarized earlier in this report (page 8).

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[51] American Association of Port Authorities. "U.S. Public Port Facts." Internet page. Alexandria, VA. July 5, 2005. [http://www.aapa-ports.org/industryinfo/portfact.htm]

[52] Some ACE "coastal" ports may be geographically inland (e.g., Stockton,CA), but accessible to oceangoing vessels.

[53] International Programme on Chemical Safety. "International Chemical Safety Cards: Propane." ICSC 0319. Geneva, Switzerland. Nov. 27, 2003.

Table 4: Top 30 Ports Handling EPA/RMP Hazardous Cargo in 2003

(in Alphabetical Order)

Port Name	Principal Hazardous Chemical Cargoes	DHS List?
Baltimore, MD	LNG, cyclic hydrocarbons	Yes
Baton Rouge, LA	Ammonia, sulfuric acid	Yes
Beaumont, TX	Ammonia, butylenes/butadienes	Yes
Boston, MA	LNG, hydrochloric acid	Yes
Corpus Christi, TX	Hydrochloric acid, butylenes/butadienes	Yes
Freeport, TX	Ammonia, sulfuric acid	Yes
Houston, TX	LPG, butylenes/butadienes	Yes
Huntington, WV	Propylene oxide, LPG	Yes
Lake Charles, LA	LNG, butylenes/butadienes	Yes
Long Beach, CA	Ether, LPG	Yes
Los Angeles, CA	LPG, toluene diisocyanate	Yes
Marcus Hook, PA	LPG, ethers	No
Matagorda, TX	Ammonia, acrylonitrile	No
Mobile, AL	LPG, boron trichloride/titanium tetrachloride	Yes
New Orleans, LA	Ammonia, propylene	Yes
New York, NY & NJ	Ethers, boron trichloride/titanium tetrachloride	Yes
Nikishka, AK	LNG, ammonia	No
Orange, TX	Cyanogen/nitriles, LPG	No
Pascagoula, MS	LPG, ammonia	Yes
Paulsboro, NJ	Ethers, LPG	No
Philadelphia, PA	Cyclopropane/1,3-pentadiene, ethers	Yes
Plaquemines, LA	LPG, acrylonitrile	Yes
Port Arthur, TX	LPG, cyclopropane/1,3-pentadiene	Yes
Portsmouth, NH	LPG	Yes
Savannah, GA	LNG, ammonia	Yes
South Louisiana, LA	Ammonia, LPG	Yes
Stockton, CA	Ammonia, furan	No
Tampa, FL	Ammonia, sulfuric acid	Yes
Texas City, TX	Vinyl acetate/acetylaldehyde, ammonia	Yes
Victoria, TX	Cyanogen/nitriles, butylenes/butadienes	Yes

Sources: Army Corps of Engineers, EPA, CRS analysis.

The list of ports in **Table 4** is derived solely from estimates of EPA/RMP hazardous cargo volumes, which are only one of many factors that may affect the terrorism risk in U.S. ports. Other key factors include:

- DOT hazardous cargo shipments (e.g., gasoline, explosives);
- non-chemical cargo shipping hazards (e.g., dirty bombs);
- marine passenger traffic (e.g., ferries, cruise ships);
- hazardous materials sites or critical infrastructure on land;

- proximity to populations on land;
- physical configuration of the ports;
- threat intelligence and vulnerability assessments.

The Department of Homeland Security (DHS) does consider these other factors in its Port Security Grant Program, which provides competitive security enhancement grants to U.S. ports under the DHS Appropriations Act of 2005 (P.L.108-334). For the FY2005 program, DHS evaluated the 129 largest U.S. ports using its risk-based formula to identify 66 ports eligible to apply for the grants.[54] **Table 4** shows that 24 of the top 30 hazardous material ports are among the 66 ports eligible to apply for DHS port security grants.

Coast Guard Efforts to Secure Hazardous Cargo

The Coast Guard is the lead federal agency assigned to promote U.S. maritime security, including vessel and port security. Among other duties, the Coast Guard tracks, boards, and inspects commercial ships approaching U.S. waters. A senior Coast Guard officer in each port oversees the security and safety of vessels, waterways, and many shore facilities in the geographic area.

In pursuit of its mission to protect life, property, and the marine environment, the Coast Guard has a history of special concern for ships and barges carrying hazardous cargo. Coast Guard safety and environmental protection regulations have long specified how vessels carrying such cargo must be constructed and operated, how hazardous cargo should be transferred at waterfront facilities, and what procedures should be used to respond to accidental cargo releases.[55] Compliance with these safety regulations could help mitigate the damage from a terrorist attack, for instance, by minimizing the amount of cargo released, and might also help deter an attack. Prior to 9/11, however, the Coast Guard had only limited regulations directed specifically at terrorism; existing marine anti-terrorism law was primarily concerned with cruise ships.[56] The Coast Guard's maritime security regulation has since been expanded.

New Maritime Security Regulation

Since the 9/11 attacks, the Coast Guard has begun to distinguish more clearly between safety measures designed to prevent accidents and security measures designed to prevent sabotage or subversive acts. The Coast Guard's area maritime security committees, which are led by local captains of the port, and include chemical sector representatives, have assessed specific port vulnerabilities and created plans

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[54] Dept. of Homeland Security. "FY2005 Port Security Grant Program." May 13, 2005.

[55] Coast Guard hazardous cargo regulations are found throughout 33 CFR and 46 CFR.

[56] Anti-terrorism measures were intended to prevent another *Achille Lauro* incident, in which Palestinian terrorists hijacked an Italian cruise ship, killing a passenger, in 1985.

to address those vulnerabilities.[57] These plans evaluate the overall susceptibility of marine targets, their use to transport terrorists or terror materials, and their use as potential weapons. The plans also address how federal, state, and local resources will be deployed to prevent terrorist attacks. While the vulnerability assessments focus on vessels and facilities under Coast Guard jurisdiction, some scenarios involve other vital port infrastructure like bridges, channels, and tunnels.[58] The Coast Guard has used these assessments in augmenting security of key marine assets and in developing the agency's new maritime security standards under the Maritime Transportation Security Act of 2002 (MTSA, P.L. 107-295).[59]

The Coast Guard also has led in the creation of the *International Ship and Port Facility Security Code* (ISPS Code) promulgated by the International Maritime Organization, a United Nations organization that establishes standards for the safe and secure operation of ships and ports.[60] The ISPS Code, which went into effect on July 1, 2004, largely parallels the MTSA requirements. The ISPS Code requires that every ship and certain port facilities around the world draw up a security plan to be approved by their national government. These security plans must indicate the operational and physical security measures to be taken under three tiered threat levels (normal, medium, and high). Every ship and port must also designate a security officer to ensure that the ISPS Code is implemented; must deploy required security equipment (e.g., vessel tracking devices); must monitor and control access of people and cargo at the port and aboard the vessel; and must ensure that security communications are readily available. According to the Coast Guard, by July 1, 2004, the service reviewed and approved the security plans of over 9,000 vessels under the provisions of the MTSA and ISPS Code. The Coast Guard also completed on-site inspections of thousands of these vessels six months thereafter to ensure the plans were being implemented as approved. In addition to these vessel inspections, the Coast Guard has completed security assessments of the nation's 55 "most economically and militarily strategic" ports.[61]

Hazardous Cargo Vessel Regulations

In addition to enforcing MTSA regulations and the ISPS Code, the Coast Guard has taken specific measures to help prevent a terrorist attack against hazardous chemicals vessels and other high consequence shipping. The Coast Guard has

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[57] Admiral Craig Bone, U.S. Coast Guard. Testimony before the Senate Homeland Security and Governmental Affairs Committee. "Chemical Facility Security: What Is the Appropriate Federal Role?" July 27, 2005.

[58] 68 F.R 126. July 1, 2003. p39246.

[59] Coast Guard security regulations are promulgated at 33 C.F.R. 101.100 *et cet.*

[60] International Maritime Organization (IMO). *International Convention for the Safety of Life at Sea (SOLAS), 1974*. Chap. XI-2 " Special Measures to Enhance Maritime Security." July 7, 2005. [http://www.imo.org/Conventions/contents.asp?topic_id=257&doc_id=647#xi2]

[61] Wrightson, M., Director, Homeland Security and Justice, Government Accountability Office (GAO). Testimony before the Senate Commerce, Science and Transportation Committee hearing on Port Security. Washington, DC. May 17, 2005.

evaluated the vulnerability of marine tankers to several different types of attack, such as “a boat loaded with explosives” or “being commandeered and intentionally damaged.”[62] The agency is also conducting a special assessment of inland barges carrying certain dangerous cargoes to evaluate their vulnerabilities and analyze potential blast consequences.[63] The Coast Guard requires all U.S. bound vessels and inland barges carrying hazardous chemicals to report information about the vessel, crew, cargo, and voyage four days prior to the ship’s arrival or departure. Based on this information and other intelligence, the Coast Guard determines the potential security risk that a vessel may pose, whether it may enter U.S. waters, and what actions the agency will take to ensure secure transit. The Coast Guard may board a vessel before or during entrance to a harbor and may post armed sea-marshals on the bridge or at the engine room to prevent unauthorized access during harbor transit. Ships carrying hazardous cargo may be escorted by Coast Guard patrol boats that enforce a moving security zone around the vessel while it transits a harbor (**Figure 6**) and while moored at a waterfront terminal.[64] While moored, vessels carrying hazardous cargo may be required to provide their own roving patrols on deck and at the terminal. During periods of high threat levels, or in certain sensitive areas of a harbor, non-commercial traffic may be banned. The Coast Guard also maintains 13 Maritime Safety and Security Teams nationwide which can perform security operations at any given port area(s) when needed.

Maritime Domain Awareness

The Coast Guard is trying to better distinguish suspicious from legitimate harbor activity in an effort the service refers to as “maritime domain awareness.” Consistent with the ISPS Code and MTSA, cargo and passenger vessels calling at U.S. ports are required to be outfitted with Automatic Identification System (AIS) transponders which allow shore-side facilities and other ships to track vessel movement. (Smaller craft, such as fishing and recreational boats, are not required to install AIS transponders).[65] The Coast Guard has installed AIS receivers at ten port areas to date, and plans to install receivers at all remaining U.S. ports. The Coast Guard is also developing “joint harbor operations centers” (JHOCs) in U.S. harbors in a model simialr to air traffic control towers at airports. JHOCs would have various equipment to track and monitor vessel traffic in a harbor, such as AIS, radar, voice communications with ships via radio, closed-circuit television, and personnel with binoculars. They would also have access to intelligence databases and be staffed with other federal security agencies and local law enforcement in order to better coordinate a response should a threat materialize. Through its “Waterways Watch” program, the Coast Guard is enlisting the eyes and ears of the recreational boating public on how to identify and report suspicious activity. The Coast Guard is

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[62] 68 F.R. 126. July 1, 2003. p39244

[63] Admiral Craig Bone, U.S. Coast Guard. Testimony before the Senate Homeland Security and Governmental Affairs Committee. “Chemical Facility Security: What Is the Appropriate Federal Role?” July 27, 2005.

[64] These security zones are specified for each port or waterway and for particular types of ships or barges calling at these ports beginning at 33 C.F.R. 165.30.

[65] 33 C.F.R. 164.46 identifies which vessels need to be equipped with AIS.

working with the Transportation Security Administration to develop a more secure merchant mariner credential and a credentialing card for landside workers, such as longshoremen and truck drivers.[66]

Figure 6: Coast Guard Patrol Boats Escorting a Chemicals Barge

Source: U.S. Coast Guard, 8th Dist. "Photography: Marine Safety." Internet page. Feb 14, 2005. [http://www.piersystem.com/external/index.cfm?cid=425&fuseaction=EXTERNAL.press&doctypeID=4758].

NOAA Hazardous Materials Response

The National Oceanic and Atmospheric Administration (NOAA) maintains hazardous material emergency response-related capabilities which may be used by the Coast Guard and other agencies to plan for, or quickly respond to, an accident or attack on a hazardous chemical vessel. These capabilities include the CAMEO program, an integrated set of chemical dispersion software models jointly developed by NOAA and EPA for first responders and emergency planners. The CAMEO program includes a database with response recommendations for over 6,000 chemicals, an electronic mapping program, and a model that predicts the movement of chemical gases in the atmosphere.[67] NOAA has also linked its three operational air dispersion models to improve its support to emergency planners and first responders. According the agency, NOAA partnered in 2002 with the Coast Guard and the Office of Naval Intelligence "in conducting risk assessments on 50 of the most hazardous chemicals stored at or shipped in bulk through U.S. ports."[68] CRS is not aware of any publicly available information related to these risk assessments. NOAA, along with the DHS, is also currently helping to coordinate federal chemicals emergency response through the Interagency Modeling and Atmospheric

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[66] The credentialing card for landside workers is know as the Transportation Workers Identification Credential (TWIC).

[67] National Oceanic and Atmospheric Administration (NOAA). "CAMEO." Internet page. Aug. 6, 2005. [http://response.restoration.noaa.gov/cameo/cameo.html]

[68] National Oceanic and Atmospheric Administration (NOAA). "NOAA Contributions to Homeland Security Since Sept. 11, 2001." *NOAA Magazine*. Sept. 17, 2002.

Assessment Center, which provides custom products and a single point of contact for all-hazards dispersion modeling predictions and assessments.[69]

Private Industry Initiatives

Industry groups also have taken steps to promote the security of hazardous marine cargo. When evaluating hazardous materials regulations, the Coast Guard receives input from the Chemical Transportation Advisory Committee (CTAC). CTAC is an advisory group made up of members selected from the following sectors associated with marine transportation of hazardous materials: chemical manufacturing, vessel design and construction, occupational safety and health, marine environmental protection, and the marine transportation of chemicals. In October 2002, CTAC formed a Subcommittee on Hazardous Cargo Transportation Security for the purpose of assessing vulnerability, promoting industry security awareness, and consequence management. The American Waterways Operators (AWO), a trade association of barge operators, in consultation with the Coast Guard and Army Corps of Engineers, created a model vessel security plan to thwart potential terrorist attacks on the inland waterway system. The plan includes an appendix which lists cargoes AWO has deemed "high consequence."[70] The Chemical Distribution Institute (CDI) is a non-profit organization financed by the chemical industry which serves as an industry "self-policing" mechanism. CDI inspects and issues audit reports on the world's fleet of chemical and LPG tankers, tank storage terminals, and container ships carrying hazardous cargo.[71] Separately, the American Chemistry Council has also issued transportation security guidelines for the chemical industry.[72]

Policy Issues

Securing hazardous chemicals against terrorist attack is a priority in U.S. homeland security policy. Given the large quantities of such chemicals found aboard marine vessels on U.S. waterways and in U.S. ports, it is apparent that maritime security of chemical cargo is necessarily included in this priority. Although Congress and the Coast Guard have put in place new maritime security measures since 9/11, several policy issues related to hazardous marine cargo may warrant further Congressional attention. The most significant concerns are risk uncertainty, resource availability, and security effectiveness, although other issues have also emerged in recent policy discussions.

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[69] National Oceanic and Atmospheric Administration (NOAA). "NOAA's Homeland Security Capabilities Continue to Strengthen and Expand." *NOAA Magazine*. Nov. 10, 2002.

[70] American Waterways Operators. "AWO Develops Model Vessel Security Plan." Press release. Arlington, VA. May 3, 2002.

[71] For further information on the chemical industry's security activities, see CRS Report RL31530, *Chemical Facility Security*, by (name redacted).

[72] *Transportation Security Guidelines for the U.S. Chemical Industry*, American Chemistry Council, 2001.

Terrorism Risk Uncertainties

Terrorism risk is generally defined as the product of threat, vulnerability, and consequence. Significant uncertainties exist across all three of these factors as they relate to hazardous marine cargo. The potential threat posed by terrorists targeting ships in U.S. waters, for example, has been the subject of debate since 9/11. Although experts acknowledge the general threat information put forth by government agencies, some believe that public concern about specific threats to hazardous chemicals shipping is overstated and should not impede maritime trade.[73] Others assert that terrorists have demonstrated both the desire and capability to attack such shipping with the intention of harming the general population.[74] The basis of such conclusions is open to question, however, due to the inherent uncertainty of threat intelligence and the shifting goals and methods of potential attackers. As the Federal Energy Regulatory Commission has remarked, "unlike accidental causes, historical experience provides little guidance in estimating the probability of a terrorist attack."[75]

Vulnerability and consequence analysis of marine chemical hazards also may face important uncertainties. The Coast Guard reports having approved mandatory security vulnerability assessments and security plans for thousands of vessels as required under the MTSA and ISPS codes. NOAA reports having established a partnership with the Coast Guard to conduct hazardous chemical risk assessments at U.S. ports. Notwithstanding these Coast Guard activities, some analysts suggest that the potential vulnerabilities and consequences of a terrorist attack on (or with) a hazardous marine cargo vessel are not well understood. Recent public controversy about terrorist risks to LNG shipping, for example, has been largely driven by conflicting vulnerability and consequence studies from a variety of government and private sector groups.[76] The security sensitivity of such assessments and plans complicates efforts to evaluate them. Little public information is available, for example, on the physical vulnerabilities of different types of marine vessels to terrorist attacks with weapons or improvised explosives, although the *Cole* and *Limburg* attacks suggest that such vulnerabilities exist. Furthermore, while there is a body of public marine research related to *accidental* release of hazardous chemicals, little appears directly related to *intentional* release, which may have substantially different characteristics. Vessel vulnerability assessments and security plans are central to U.S. maritime security strategy, but their value and effectiveness for hazardous chemicals carriers may be limited if operators lack a full understanding of vulnerability and consequence, especially for attacks affecting the general public.

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[73] "Ship Risk Overblown, Says Expert." *Geelong Advertiser*. July 1, 2004. p 19.

[74] Clarke, R.A., et al. *LNG Facilities in Urban Areas*. Good Harbor Consulting, LLC. Prepared for the Rhode Island Office of Attorney General. GHC-RI-0505A. May 2005.

[75] Federal Energy Regulatory Commission (FERC). FERC/EIS-0176D. Dec. 2004. p4-162.

[76] CRS Report RL32205. *Liquefied Natural Gas (LNG) Import Terminals: Siting, Safety, and Regulation* by Paul Parfomak and Aaron Flynn. p 17; McLaughlin, J. "LNG is Nowhere Near as Dangerous as People Are Making it Out to Be." *Lloyd's List*. Feb. 8, 2005. p5.

It may be impossible for federal officials to determine with precision the risk of terror attacks on hazardous marine cargoes. Nonetheless, any reduction in risk uncertainty would aid in prioritizing maritime security activities. For example, the Coast Guard may be able to focus its port security efforts through ensuring timely reception of the most relevant intelligence information from federal intelligence agencies. Security experts may further reduce risk uncertainty through research and analysis of vessel vulnerabilities and chemical attack consequences. Such analyses may benefit from the use of standard models and methodologies, such as those maintained by NOAA, those used by EPA for chemical plant releases on land, or the model developed for LNG tankers in conjunction with recent marine terminal siting applications.[77] A federal role may be important when performing such security analysis to help ensure methodological consistency across chemicals, vessel types, locations, and agencies.

Maritime Security Resources

The costs associated with hazardous marine cargo security and the potential diversion of Coast Guard and other government agency resources from other activities have been a concern to policy makers.[78] According to Coast Guard officials, the service's maritime security expenditures are not all incremental, since they are part of the Coast Guard's general mission to protect the nation's waters and coasts. Nonetheless, Coast Guard staff have acknowledged that resources dedicated to securing marine shipments of hazardous cargo might be otherwise deployed for boating safety, search and rescue, drug interdiction, or other missions.[79] A recent Government Accountability Office (GAO) study reported that security activities grew from 4 percent to 34 percent of the Coast Guard's total annual resource hours in the two years following 9/11.[80]

President Bush requested $8.1 billion for the Coast Guard in FY2006. Of this total, the President requested $2.2 billion for port, waterway, and coastal security, which is a 6% increase over the FY2005 enacted amount. Hazardous marine cargo security is funded from the Coast Guard's general maritime security budget, so it is not a line item in the FY2006 DHS budget request. However, the Coast Guard's FY2006 budget does seek an additional $11 million in general maritime security funding over FY2005 levels. These resources are for new small response boats and

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[77] Sandia National Laboratories (SNL). *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*. SAND2004-6258. Albuquerque, NM. Dec. 2004.

[78] See, for example: Government Accountability Office (GAO). *COAST GUARD: Station Readiness Improving, but Resource Challenges and Management Concerns Remain*. GAO-05-161. Jan. 2005; U.S. Senator Jack Reed at the Senate Energy and Natural Resources Committee, Subcommittee on Energy Hearing on Liquified Natural Gas. Feb 15, 2005.

[79] U.S. Coast Guard, Port Security Directorate. Personal communication. Aug. 12, 2003.

[80] Government Accountability Office (GAO). *Maritime Security: Enhancements Made, But Implementation and Sustainability Remain Key Challenges*. GAO-05-448T. May 17, 2005. p12.

associated crew to increase the Coast Guard's operational presence and response posture, enforce security zones, and escort high interest vessels.[81] The budget also includes $5.7 million to implement a nationwide vessel monitoring system and $87.4 million to increase surveillance of vessels by aircraft.

State and local agencies are also seeking more funding to offset the costs of hazardous marine cargo security. These funding concerns are most clearly illustrated in the case of LNG tankers, which may cost the public up to $80,000 to secure each time they deliver a shipment.[82] State and local police and emergency services agencies pay a significant share of these costs. They believe LNG security costs may force them to divert limited local resources from other important public services.[83] Acknowledging such concerns, federal officials have recommended that new LNG terminal operators pay the costs of any additional maritime security or safety needed for their facilities.[84] The Energy Policy Act of 2005 requires private and public sector cost-sharing for LNG tanker security (Sec. 311d). Nonetheless, because the accounting of security costs is ambiguous and tied to uncertain sources of federal funding, such as DHS port security grants, some government officials continue to voice concern over LNG security costs.[85] Furthermore, some LNG companies have resisted suggestions that they pay more for public security, reasoning that the federal, state, and local taxes they pay should cover public law enforcement and emergency services.[86] Others have expressed a willingness to pay for "excess" security only if it exceeds the level of security service ordinarily commensurate with corporate tax payments.[87]

The security costs associated with LNG shipments may not be indicative of the costs to secure other EPA/RMP hazardous marine cargo. New security technology, more specific threat intelligence, and changing threat assessments may all help to lower hazardous marine cargo security costs in the future. Nonetheless, the costs to public agencies to secure hazardous marine cargo from terrorist attack appears significant and may warrant a review of associated cost-sharing mechanisms.

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[81] Dept. of Homeland Security (DHS). *Budget-in-Brief, Fiscal Year 2006*.

[82] CRS Report RL32073. *Liquefied Natural Gas (LNG) Infrastructure Security: Issues for Congress* by (name redacted). March 16, 2005. p 20.

[83] McElhenny, J. "State Says LNG Tanker Security Cost $20,500." Associated Press. Nov. 2, 2001. p1.

[84] Baldor, L.C. "Federal Agency, R.I. Officials Meet over LNG Terminal." *Associated Press*. March 17, 2005.

[85] U.S. Sen. Jack Reed. Remarks at the Senate Energy and Natural Resources Committee, Energy Subcommittee hearing on Liquefied Natural Gas. Feb. 15, 2005.

[86] McElhenny, J. Nov. 2, 2001. p1.

[87] Dominion Resources, Corporate Security. Personal communication. Richmond, VA. Aug. 19, 2003.

Effectiveness of Security Measures

As this report notes, the Coast Guard has in place a range of security measures to protect hazardous chemicals shipping. Nonetheless, the effectiveness of these measures is regarded as an open issue. Given the current understanding of general marine threats, some question whether the Coast Guard efficiently deploys the security resources it has.[88] Others question whether adequate measures are in place to evaluate the Coast Guard's security activities. For example, the GAO has concluded:

> Although there is widespread agreement that actions taken so far have led to a heightened awareness of the need for [maritime] security and an enhanced ability to identify and respond to many security threats, assessing the degree of progress in making the nation more secure is difficult. Thus far, seaport security actions ... lack performance measures to define what these activities are intended to achieve and measure progress toward these goals.[89]

Addressing hazardous cargo, some specifically question whether Coast Guard security activities adequately address relative terrorism risks within and across ports based on quantitative risk analysis. Within a given port, for example, there may be a greater or lesser risk from terrorist attacks on ammonia tankers than from dirty bombs hidden aboard container ships. The Coast Guard states that its internal maritime security plan identifies "high risk cargos" and conducts operations to address those risks.[90] Nonetheless, given the terrorism risk uncertainties associated with hazardous chemical vessels and the competing demands for Coast Guard resources, some question whether the level of Coast Guard security for hazardous chemicals vessels appropriately reflects their relative risk.[91] Because Coast Guard port captains have considerable discretion in the deployment of security resources within their ports, some observers also question whether similar chemical shipments posing similar terrorism hazards receive different levels of protection from one port to another. While differences in protection may be appropriate in some instances, such a situation could lead to excessive security of hazardous marine cargoes in some ports and inadequate security in others. In its oversight of the Coast Guard's security activities, Congress may take steps to assess the effectiveness of the agency's hazardous marine cargo activities in the context of its larger maritime security responsibilities.

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[88] See, for example: Dresser, M. and Barrett, G. "Port Security Gaps Pose Threat." *The Baltimore Sun*. July, 10, 2005. p1A; Government Accountability Office (GAO). *MARITIME SECURITY: Better Planning Needed to Help Ensure an Effective Port Security Assessment Program.* GAO-04-1062. September, 2004.

[89] GAO. May 17, 2005. p3.

[90] Admiral Craig Bone, U.S. Coast Guard. Testimony before the Senate Homeland Security and Governmental Affairs Committee. "Chemical Facility Security: What Is the Appropriate Federal Role?" July 27, 2005.

[91] McLaughlin, J. Feb. 8, 2005. p5.

Emergency Response

Emergency response to marine chemical attacks is another concern among security analysts. The Homeland Security Council's national planing scenario involving chemical cargo ships assumes 350 deaths and 1,000 hospitalizations resulting from an attack.[92] Others have suggested higher casualties for specific types of chemical tanker attacks in shipping channels near densely populated areas. If a terrorist attack succeeded in injuring or killing such large numbers of people, it might overwhelm federal and local emergency agencies and medical facilities. An attack involving one or more toxic chemicals might further complicate emergency response by imposing special demands on emergency response teams and requiring specialized medical treatment for poisoning and burns. Salvage of a vessel damaged or sunk in such an attack could be an additional problem, due to the chemical hazard and other limitations among U.S. marine salvage companies.[93]

Because of the hazardous cargo terrorism risk, it may be judged to be prudent for emergency and medical authorities near potentially affected waterways to develop specific prospective measures to deal releases of chemical cargoes most relevant to their region. Federal or private sector assistance in the form of funding or expertise might be utilized to support such efforts, especially for communities with insufficient capabilities to develop emergency response plans. The DOT's Hazardous Materials Emergency Preparedness Fund (created in the Transportation Equity Act of 2005, Sec. 7114d), and the DHS's Homeland Security Grant Program are two potential source of funding for marine chemicals emergency response plans, but Congress may opt to consider others.[94] The emergency response plan and cost-sharing provisions for coastal LNG terminals and tankers in The Energy Policy Act of 2005 (Sec. 311d) may be an alternative legislative model for such planning.

Conclusions

This report shows that marine shipments of EPA/RMP hazardous chemicals are comparable in volume to quantities stored at large chemical plants, and are typically many times larger than shipments in individual rail or highway tankers. Marine vessels carrying hazardous chemicals often pass near populated areas along U.S. waterways and through the largest and most commercially important U.S. ports. Available studies and anecdotal evidence suggest that these shipments may be attractive terrorist targets and, if successfully attacked or used as a weapon, could cause catastrophic injuries among the general public.

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[92] Homeland Security Council. *Planning Scenarios: Executive Summaries*. July 2004. p 6-1. The scenario includes casualties from a simultaneous attack on nearby petroleum refineries.

[93] Transportation Research Board of the National Academies. *Marine Salvage Capabilities: Responding to Terrorist Attacks in U.S. Ports – Actions to Improve Readiness*. Washington, DC. 2004.

[94] For more information on DHS Grants, see CRS Report RL32696, *Fiscal Year 2005 Homeland Security Grant Program: State Allocations and Issues for Congressional Oversigh*t by (name redacted).

Both government and industry have taken numerous steps to try to improve maritime security of hazardous chemical cargo. The MTSA gives the Coast Guard clear and far-ranging authority over the security of hazardous marine shipping. In its efforts to fulfill this legislative mandate, the Coast Guard is continuing to evolve its security activities. As oversight of the federal role in marine chemicals security continues, Congress may raise questions concerning terrorism risk uncertainty and efforts by federal agencies and the private sector to rigorously evaluate that risk. Congressional policy makers may also analyze whether the Coast Guard, other government agencies, and the private sector have sufficient resources to secure hazardous chemical cargo commensurate with that risk and whether current security measures will be effective against a terrorist attack. Since a marine attack is possible even under tight security, evaluating the emergency response capabilities of coastal communities exposed to chemical shipping hazards may be of interest as well.

In addition to these specific issues, Congress may assess how the various elements of U.S. hazardous chemicals marine security fit together in the nation's overall strategy to protect the public from hazardous chemicals and cargo. Bulk quantities of hazardous chemicals are found in marine vessels, in rail and highway tankers, and in chemical facilities on land. As noted earlier in this report, the same physical shipment of a chemical may pass sequentially through all these sectors. Balancing the nation's chemicals security resources across these sectors is a policy challenge because marine transportation, land transportation, and chemical facilities fall under different homeland security authorities and regulations. Limited vulnerability and consequence information, especially for marine transportation, complicates this problem by making it difficult to compare terrorism risk scenarios across sectors, even for the same chemical hazard. Without such a comprehensive perspective on hazardous chemical risks, security analysts may have difficulty identifying which chemicals assets to protect and how well to protect them with the limited security resources available. Likewise, diverting marine resources away from safety to enhance security might further reduce terror risk, but increase overall risk, if safety programs become less effective as a result. Reviewing how these security priorities and activities fit together to achieve common goals could be an oversight challenge for Congress.

Appendix 1: DOT Hazardous Cargo Ranking

Rank	Category	Description	Example Material
1	Class 7	Radioactive materials	Uranium hexafluoride
2	Division 2.3	Poisonous gases	Chlorine
3	Division 2.1	Flammable gases	Propane
4	Division 2.2	Nonflammable gases	Compressed nitrogen
5	Division 6.1	Poisonous liquids (by inhalation)	Liquid pesticide
6	Division 4.2	Spont. combustible (pyrophoric)	Barium alloys
7	Division 4.1	Flammable solids (self-reactive)	Naphthalene
8	Class 3 Class 8 Division 4.1 Division 4.2 Division 4.3 Division 5.1 Division 6.1	Flammable liquids Corrosive materials Flammable solids Spont. combustible (non-pyrpohoric) Dangerous when wet Oxidizers Poisonous liquids/solids (not inhalation)	Crude oil Sulfuric acid Coal Charcoal Lithium compounds Ammonium nitrate Halogen salts
9	Unspecified	Combustible liquids	Non-specific
10	Class 9	Misc. hazardous materials	Asbestos

Source: 49 C.F.R. § 173.2a. Note that DOT Divisions are subcategories within a Class.

Appendix 2: EPA Hazardous Chemicals Requiring Clean Air Act Off-site Risk Management Plans

Chemical Name	CAS Number	Threshold Quantity (pounds)	Hazard Type	DOT Category
1,1-Dimethylhydrazine [Hydrazine, 1,1-dimethyl-]	57-14-7	15,000	Toxic	6.1
1,3-Butadiene	106-99-0	10,000	Fire	2.1
1,3-Pentadiene	504-60-9	10,000	Fire	3
1-Butene	106-98-9	10,000	Fire	2.1
1-Chloropropylene [1-Propene, 1-chloro-]	590-21-6	10,000	Fire	2.1
1-Pentene	109-67-1	10,000	Fire	3
2,2-Dimethylpropane [Propane, 2,2-dimethyl-]	463-82-1	10,000	Fire	2.1
2-Butene	107-01-7	10,000	Fire	2.1
2-Butene-cis	590-18-1	10,000	Fire	2.1
2-Butene-trans [2-Butene, (E)]	624-64-6	10,000	Fire	2.1
2-Chloropropylene [1-Propene, 2-chloro-]	557-98-2	10,000	Fire	2.1
2-Methyl-1-butene	563-46-2	10,000	Fire	3
2-Methylpropene [1-Propene, 2-methyl-]	115-11-7	10,000	Fire	2.1
2-Pentene, (E)-	646-04-8	10,000	Fire	3
2-Pentene, (Z)-	627-20-3	10,000	Fire	3
3-Methyl-1-butene	563-45-1	10,000	Fire	3
Acetaldehyde	75-07-0	10,000	Fire	3
Acetylene [Ethyne]	74-86-2	10,000	Fire	2.1
Acrolein [2-Propenal]	107-02-8	5,000	Toxic	6.1
Acrylonitrile [2-Propenenitrile]	107-13-1	20,000	Toxic	3
Acrylyl chloride [2-Propenoyl chloride]	814-68-6	5,000	Toxic	3
Allyl alcohol [2-Propen-1-ol]	107-18-6	15,000	Toxic	6.1
Allylamine [2-Propen-1-amine]	107-11-9	10,000	Toxic	6.1
Ammonia (anhydrous)	7664-41-7	10,000	Toxic	2.3
Ammonia (conc 20% or greater)	7664-41-7	20,000	Toxic	8
Arsenous trichloride	7784-34-1	15,000	Toxic	6.1
Arsine	7784-42-1	1,000	Toxic	2.3
Boron trichloride [Borane, trichloro-]	10294-34-5	5,000	Toxic	2.3
Boron trifluoride [Borane, trifluoro-]	7637-07-2	5,000	Toxic	2.3
Boron trifluoride compound with methyl ether (1:1)	353-42-4	15,000	Toxic	4.3
Bromine	7726-95-6	10,000	Toxic	8
Bromotrifluorethylene [Ethene, bromotrifluoro-]	598-73-2	10,000	Fire	2.1
Butane	106-97-8	10,000	Fire	2.1
Butene	25167-67-3	10,000	Fire	2.1
Carbon disulfide	75-15-0	20,000	Toxic	3
Carbon oxysulfide [Carbon oxide sulfide (COS)]	463-58-1	10,000	Fire	2.3
Chlorine	7782-50-5	2,500	Toxic	2.3
Chlorine dioxide [Chlorine oxide (ClO2)]	10049-04-4	1,000	Toxic	5.1
Chlorine monoxide [Chlorine oxide]	7791-21-1	10,000	Fire	n/a
Chloroform [Methane, trichloro-]	67-66-3	20,000	Toxic	6.1
Chloromethyl ether [Methane, oxybis[chloro-]	542-88-1	1,000	Toxic	3
Chloromethyl methyl ether [Methane, chloromethoxy-]	107-30-2	5,000	Toxic	6.1
Crotonaldehyde [2-Butenal]	4170-30-3	20,000	Toxic	6.1
Crotonaldehyde, (E)- [2-Butenal, (E)-]	123-73-9	20,000	Toxic	6.1
Cyanogen [Ethanedinitrile]	460-19-5	10,000	Fire	2.3

Chemical Name	CAS Number	Threshold Quantity (pounds)	Hazard Type	DOT Category
Cyanogen chloride	506-77-4	10,000	Toxic	2.3
Cyclohexylamine [Cyclohexanamine]	108-91-8	15,000	Toxic	8
Cyclopropane	75-19-4	10,000	Fire	2.1
Diborane	19287-45-7	2,500	Toxic	2.3
Dichlorosilane [Silane, dichloro-]	4109-96-0	10,000	Fire	2.3
Difluoroethane [Ethane, 1,1-difluoro-]	75-37-6	10,000	Fire	2.1
Dimethylamine [Methanamine, N-methyl-]	124-40-3	10,000	Fire	2.1
Dimethyldichlorosilane [Silane, dichlorodimethyl-]	75-78-5	5,000	Toxic	3
Epichlorohydrin [Oxirane, (chloromethyl)-]	106-89-8	20,000	Toxic	6.1
Ethane	74-84-0	10,000	Fire	2.1
Ethyl acetylene [1-Butyne]	107-00-6	10,000	Fire	2.1
Ethyl chloride [Ethane, chloro-]	75-00-3	10,000	Fire	2.1
Ethyl ether [Ethane, 1,1'-oxybis-]	60-29-7	10,000	Fire	3
Ethyl mercaptan [Ethanethiol]	75-08-1	10,000	Fire	3
Ethyl nitrite [Nitrous acid, ethyl ester]	109-95-5	10,000	Fire	3
Ethylamine [Ethanamine]	75-04-7	10,000	Fire	2.1
Ethylene [Ethene]	74-85-1	10,000	Fire	2.1
Ethylene oxide [Oxirane]	75-21-8	10,000	Toxic	2.3
Ethylenediamine [1,2-Ethanediamine]	107-15-3	20,000	Toxic	8
Ethyleneimine [Aziridine]	151-56-4	10,000	Toxic	6.1
Fluorine	7782-41-4	1,000	Toxic	2.3
Formaldehyde (solution)	50-00-0	15,000	Toxic	8
Furan	110-00-9	5,000	Toxic	3
Hydrazine	302-01-2	15,000	Toxic	8
Hydrochloric acid (conc 30% or greater)	7647-01-0	15,000	Toxic	8
Hydrochloric acid (conc 37% or greater)	7647-01-0	15,000	Toxic	2.3
Hydrocyanic acid	74-90-8	2,500	Toxic	6.1
Hydrogen	1333-74-0	10,000	Fire	2.1
Hydrogen chloride (anhydrous) [Hydrochloric acid]	7647-01-0	5,000	Toxic	8
Hydrogen fluoride/Hydrofluoric acid (conc 40% or greater)	7664-39-3	1,000	Toxic	8
Hydrogen fluoride/Hydrofluoric acid (conc 50% or greater) [Hydrofluoric acid]	7664-39-3	1,000	Toxic	8
Hydrogen selenide	7/5/7783	500	Toxic	2.3
Hydrogen sulfide	6/4/7783	10,000	Toxic	2.3
Iron, pentacarbonyl- [Iron carbonyl (Fe(CO)5), (TB-5-11)-]	13463-40-6	2,500	Toxic	6.1
Isobutane [Propane, 2-methyl]	75-28-5	10,000	Fire	2.1
Isobutyronitrile [Propanenitrile, 2-methyl-]	78-82-0	20,000	Toxic	3
Isopentane [Butane, 2-methyl-]	78-78-4	10,000	Fire	3
Isoprene [1,3-Butadiene, 2-methyl-]	78-79-5	10,000	Fire	3
Isopropyl chloride [Propane, 2-chloro-]	75-29-6	10,000	Fire	3
Isopropyl chloroformate [Carbonochloridic acid, 1-methylethy ester]	108-23-6	15,000	Toxic	6.1
Isopropylamine [2-Propanamine]	75-31-0	10,000	Fire	3
Methacrylonitrile [2-Propenenitrile, 2-methyl-]	126-98-7	10,000	Toxic	3
Methane	74-82-8	10,000	Fire	2.1
Methyl chloride [Methane, chloro-]	74-87-3	10,000	Toxic	2.1
Methyl chloroformate [Carbonochloridic acid, methylester]	79-22-1	5,000	Toxic	6.1

Chemical Name	CAS Number	Threshold Quantity (pounds)	Hazard Type	DOT Category
Methyl ether [Methane, oxybis-]	115-10-6	10,000	Fire	2.1
Methyl formate [Formic acid, methyl ester]	107-31-3	10,000	Fire	3
Methyl hydrazine [Hydrazine, methyl-]	60-34-4	15,000	Toxic	6.1
Methyl isocyanate [Methane, isocyanato-]	624-83-9	10,000	Toxic	6.1
Methyl mercaptan [Methanethiol]	74-93-1	10,000	Toxic	2.3
Methyl thiocyanate [Thiocyanic acid, methyl ester]	556-64-9	20,000	Toxic	n/a
Methylamine [Methanamine]	74-89-5	10,000	Fire	2.1
Methyltrichlorosilane [Silane, trichloromethyl-]	75-79-6	5,000	Toxic	3
Nickel carbonyl	13463-39-3	1,000	Toxic	6.1
Nitric acid (conc 40% or greater)	7697-37-2	15,000	Toxic	8
Nitric acid (conc 80% or greater)	7697-37-2	15,000	Toxic	8
Nitric oxide [Nitrogen oxide (NO)]	10102-43-9	10,000	Toxic	2.3
Nitrogen Tetroxide	10544-72-6	250	Toxic	2.3
Oleum (Fuming Sulfuric acid) [Sulfuric acid, mixture with sulfur trioxide]	8014-95-7	10,000	Toxic	8
Pentane	109-66-0	10,000	Fire	3
Peracetic acid [Ethaneperoxoic acid]	79-21-0	10,000	Toxic	forbidden
Perchloromethylmercaptan [Methanesulfenyl chloride, trichloro-]	594-42-3	10,000	Toxic	6.1
Phosgene [Carbonic dichloride]	75-44-5	500	Toxic	2.3
Phosphine	7803-51-2	5,000	Toxic	2.3
Phosphorus oxychloride [Phosphoryl chloride]	10025-87-3	5,000	Toxic	8
Phosphorus trichloride [Phosphorous trichloride]	12/2/7719	15,000	Toxic	6.1
Piperidine	110-89-4	15,000	Toxic	8
Propadiene [1,2-Propadiene]	463-49-0	10,000	Fire	2.1
Propane	74-98-6	10,000	Fire	2.1
Propionitrile [Propanenitrile]	107-12-0	10,000	Toxic	3
Propyl chloroformate [Carbonochloridic acid, propylester]	109-61-5	15,000	Toxic	6.1
Propylene [1-Propene]	115-07-1	10,000	Fire	2.1
Propylene oxide [Oxirane, methyl-]	75-56-9	10,000	Toxic	3
Propyleneimine [Aziridine, 2-methyl-]	75-55-8	10,000	Toxic	3
Propyne [1-Propyne]	74-99-7	10,000	Fire	2.1
Silane	7803-62-5	10,000	Fire	2.1
Sulfur dioxide (anhydrous)	9/5/7446	5,000	Toxic	2.3
Sulfur tetrafluoride [Sulfur fluoride (SF4), (T-4)-]	7783-60-0	2,500	Toxic	2.3
Sulfur trioxide	11/9/7446	10,000	Toxic	8
Tetrafluoroethylene [Ethene, tetrafluoro-]	116-14-3	10,000	Fire	2.1
Tetramethyllead [Plumbane, tetramethyl-]	75-74-1	10,000	Toxic	6.1
Tetramethylsilane [Silane, tetramethyl-]	75-76-3	10,000	Fire	3
Tetranitromethane [Methane, tetranitro-]	509-14-8	10,000	Toxic	5.1
Titanium tetrachloride [Titanium chloride (TiCl4) (T-4)-]	7550-45-0	2,500	Toxic	8
Toluene 2,4-diisocyanate [Benzene, 2,4-diisocyanato-1-methyl-]	584-84-9	10,000	Toxic	6.1
Toluene 2,6-diisocyanate [Benzene, 1,3-diisocyanato-2-methyl-]	91-08-7	10,000	Toxic	6.1
Toluene diisocyanate (unspec. isomer) [Benzene, 1,3-diisocyanatomethyl-]	26471-62-5	10,000	Toxic	6.1
Trichlorosilane [Silane, trichloro-]	10025-78-2	10,000	Fireire	4.3
Trifluorochloroethylene [Ethene, chlorotrifluoro-]	79-38-9	10,000	Fire	2.3

Chemical Name	**CAS Number**	**Threshold Quantity** (pounds)	**Hazard Type**	**DOT Category**
Trimethylamine [Methanamine, N,N-dimethyl-]	75-50-3	10,000	Fire	2.1
Trimethylchlorosilane [Silane, chlorotrimethyl-]	75-77-4	10,000	Toxic	3
Vinyl acetate monomer [Acetic acid ethenyl ester]	108-05-4	15,000	Toxic	3
Vinyl acetylene [1-Buten-3-yne]	689-97-4	10,000	Fire	n/a
Vinyl chloride [Ethene, chloro-]	75-01-4	10,000	Fire	2.1
Vinyl ethyl ether [Ethene, ethoxy-]	109-92-2	10,000	Fire	3
Vinyl fluoride [Ethene, fluoro-]	75-02-5	10,000	Fire	2.1
Vinyl methyl ether [Ethene, methoxy-]	107-25-5	10,000	Fire	2.1
Vinylidene chloride [Ethene, 1,1-dichloro-]	75-35-4	10,000	Fire	3
Vinylidene fluoride [Ethene, 1,1-difluoro-]	75-38-7	10,000	Fire	2.1

Sources: 40 C.F.R. § 68, 49 C.F.R. § 173.2a

Appendix 3: Army Corps of Engineers Marine Commerce Data

The Army Corps of Engineers (ACE) collects, processes, and archives detailed marine commerce statistics through its Waterborne Commerce Statistics Center (WCSC). These statistics are used by the ACE primarily to plan new capital projects and manage existing projects. The ACE maintains separate domestic and foreign commerce databases. The domestic database records domestic and foreign vessel trips and tonnages by commodity for U.S. ports and waterways. The foreign database records waterborne commerce between the U.S. and foreign countries by U.S. port, foreign port, foreign country, commodity group, and tonnage. Vessel types include dry cargo ships and tankers; barges (loaded and empty); fishing vessels; towboats (with or without barges in tow); tugboats; crew boats and supply boats to offshore locations; and newly constructed vessels from the shipyards to the point of delivery. Vessels remaining idle during a monthly reporting period are also reported. Under federal law, vessel operators must report domestic waterborne commercial movements to the ACE.[95]

Limitations of the ACE Waterborne Commerce Data

The ACE waterborne commerce databases were not developed to support the type of chemical-specific analysis presented in this report. However, they may be used for that purpose subject to certain significant limitations and *caveats*. At the request of CRS, the ACE provided its best estimates of EPA/RMP cargo statistics derived from the available data. Based on a review of more limited shipping and hazardous chemicals data from other sources, CRS believes the ACE estimates are sufficiently accurate to warrant inclusion in this report. However, the values reported here should be viewed strictly as estimates, with the following key *caveats*.

Cargo Classification. The ACE databases identify cargos using two sets of standardized commodity codes—an internal WCSC code, and the United Nations (UN) international standard code. In some cases, these commodity codes do not consistently or uniquely correspond to the individual hazardous chemicals in the EPA/RMP list, which are identified by their Chemical Abstract Service (CAS) registry numbers as assigned by the American Chemical Society. Such inconsistencies arise either from commodity aggregation or differences in definition. CRS has attempted to identify and correct for these inconsistencies to the extent possible through comparison of WCSC and UN codes, and consultation with classification experts. For example, the WCSC system classifies LNG and LPG under the same 5-digit code (34000). Using LNG trade data from the Department of Energy, CRS was able to separate the LNG and LPG volumes for this report. Nonetheless, shipment estimates reported for a number of other EPA/RMP chemicals likely include some volume of other chemicals not on the EPA/RMP list.

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[95] Army Corps of Engineers (ACE). "Waterborne Commerce Statistics Center: Mission." Internet page. July 20, 2005. [http://www.iwr.usace.army.mil/ndc/wcsc/wcscmiss.htm].

Alternatively, shipments of certain EPA/RMP chemicals may be included in the shipment totals for a similar EPA/RMP chemical.[96]

Cargo Volumes. As noted earlier in this report, chemicals cargo vessels may load or unload partial cargoes at multiple locations over the course of a single shipment. The ACE data report the movement of cargo at each of these loading and unloading points, but cannot report the total tonnage of cargo actually carried aboard a vessel at any time.

Data Quality. The ACE waterborne commerce databases contain millions of records. Like any database of this size, errors in data classification, entry, and processing may appear in summary statistics. Furthermore, CRS's data request involved new and complex queries of the ACE databases. The ACE employs a rigorous internal review process for data analysis and reporting to minimize the infiltration of such errors into its analytic products. Nonetheless, CRS identified inconsistencies in the ACE estimates which the ACE was able to correct. It is possible, however, that additional, data quality-related errors have escaped both the notice of the ACE and CRS.

Legal Restrictions on ACE Commerce Data Release

The ACE waterborne commerce databases contain detailed commercial information about private companies. This report includes only summary estimates of chemicals shipping data and does not associate shipping data for any specific chemical with any named vessel or operating company. ACE data at the level of individual shipments, vessels, or operators is considered privileged information not for public release under 18 U.S.C. § 93.905. CRS products are not prepared for general public distribution.

[96] For a further discussion of these classification limitations and related issues, see Army Corps of Engineers (ACE). "U.S. Waterway Data." Internet page. August 6, 2005. [http://www.iwr.usace.army.mil/ndc/data/datahazr.htm]