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PROCEEDINGS

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Preserving Our Oceans for Future Generations

IMO

MARPOL AT 50

OUR COMMITMENT GOES ON

As MARPOL turns 50, there is no doubt it has had a positive impact on the environment, from reducing oil spills at sea and greenhouse gases released by shipping to combatting the microplastics in our oceans. However, as this image shows, there is still much work to do. Photo by SrikanthMannepuri | Ocean Image Bank

PROCEEDINGS

Fall 2023 Vol. 80, Number 2

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On Deck

On the Cover: ***As the maritime community marks 50 years of the International Convention for the Prevention of Pollution from Ships, or MARPOL, it has vowed to continue pushing for even greater success in protecting our oceans for future generations. Since MAROPOL's adoption, strides have been made in protecting our oceans, beaches, and marine life from pollution from ships. Current efforts include***

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Assistant Commandant's Perspective

by Rear Admiral Wayne R. Arguin
Assistant Commandant for Prevention Policy
U.S. Coast Guard

In recognition of the 50th anniversary of the International Convention for the Prevention of Pollution from Ships, or MARPOL, the International Maritime Organization (IMO) has declared MARPOL at 50 – Our commitment goes on as its 2023 World Maritime theme. In honor of this momentous milestone, I am pleased to present this edition of Proceedings highlighting the international and domestic standards that have shaped environmental improvements across the maritime industry. In this issue, we have teamed with industry and academic leaders, as well as government subject matter experts, to navigate us through the past, present, and future of MARPOL and U.S. regulations that have evolved to reduce shipping impact on the environment.

As the most efficient means to transport goods, maritime shipping has never been more in demand. To keep pace,

Champion's Point of View

by Captain Jerry Butwid
Chief of Operating and Environmental Standards
U.S. Coast Guard

In March 1989, I was a Seaman aboard the Coast Guard Cutter *Bear*. One morning on the mess deck, the crew was following the news of the *Exxon Valdez's* grounding. As we were watching the news, I overheard a seasoned Chief Warrant Officer say this incident would forever change how the Coast Guard regulates and how the industry will prepare for pollution prevention.

That moment is forever ingrained in my memory.

This year, the International Maritime Organization celebrates the 50th anniversary of the adoption of the International Convention for the Prevention of Pollution by Ships, or MARPOL.

I am excited to champion this issue of Proceedings which walks us through the past, present, and future of MARPOL and

the marine transportation system must expand, driving orderbooks for larger ships and deeper channels. With this increased demand comes significant public pressure for sustainability and environmental stewardship. Delivering greater capacity while also reducing shipping's carbon footprint will drive the use of emerging technologies and operating concepts. This pressure will also place strains on an already stressed workforce. Further development of alternative fueled vessels, and the associated infrastructure needed to support global shipping, will drive innovation and investment.

The United States Coast Guard has a rich history leading efforts at the IMO's Marine Environment Protection Committee (MEPC). MEPC addresses environmental issues under IMO's authority to control and prevent ship-source pollution like greenhouse gas emissions, plastics at sea, ballast water management, and the carriage of oil and chemicals in bulk. In this role, the service works with other IMO member states evaluating novel technologies to encourage the global fleet to make changes to better the environment. These efforts will become even more important as shipping pivots to more sustainable operations.

Domestically, the Coast Guard remains committed to protecting the environment. Under the Act to Prevent Pollution from Ships, the Coast Guard develops regulations to align domestic laws with the international standards, which gives the Coast Guard authority to conduct examinations aboard ships to enforce requirements established under MARPOL. The Oil Pollution Act of 1990 expanded pollution prevention equipment requirements and modified ship design standards. Further, the Vessel Incidental Discharge Act (VIDA), which became law in 2018, established a framework to regulate discharges incidental to the normal operation of a vessel. VIDA establishes standards to the incidental discharges, such as ballast water and graywater, to streamline various federal, state, and local requirements aimed at environmental stewardship.

While global trade has never been more important to national economic security and prosperity, we must continue the imperative work necessary to proactively reduce shipping's impact on the environment. The next generation is counting on it.

other significant laws that changed as nations became stronger advocates for environmental stewardship. The articles highlight the U.S. government's commitment, as well as that of the maritime industry, to taking actions that prevent pollution. They also provide an opportunity for readers to become familiar with the how laws and international conventions have evolved to meet changing needs.

VIDA, or the Vessel Incidental Discharge Act, is one example of how the United States is working to address an environmental challenge perpetuated by shipping. Congress passed VIDA, which amends the Clean Water Act requiring the development of national standards, in 2018. The goal of these standards is to reduce environmental impact of discharges incidental to the normal operation of commercial vessels and to streamline the various federal, state, and local requirements from the commercial vessel community.

I would like to thank all of the authors who shared their time and perspective for their professionalism in improving the protection of the natural environment. I invite everyone to enjoy these articles and get engaged in the process Collaboration between the public, the maritime industry, the Environmental Protection Agency, and the Coast Guard is vital to ensure we take the necessary steps to enhance environmental stewardship.

MARPOL's Origin, Fate, and Effect

How MARPOL has evolved domestically and internationally over the last 50 years

by LCDR Jeremy Maginot
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by LT Maria McElhaney
Executive Officer
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"Fate and effect" is a recurring mantra of the practice, profession, and, in general, field of oil spill prevention and response. Responders generally use this expression to calculate the trajectory of a real or potential threat to the marine environment. The concept can also be applied to the origins of the international conventions, treaties, laws, regulations, and policies that have evolved in response to managing the risk and consequence associated with a wide variety of pollutants being used and/or carried in the maritime domain. This article will discuss the origins and associated fate and effect of The International Convention for the Prevention of Pollution from Ships, commonly referred to as "MARPOL 73/78" or MARPOL, which stands for marine pollution. Additionally, it will look at how the convention shaped the world's view of and approach to threats presented to the marine environment by ships, as well as operational and accidental sources.

The International Maritime Organization, a specialized agency of the United Nations, is headquartered in London.

Governments have recognized that responding to and recovering from an environmental catastrophe, like an oil spill, may take years, and the associated restorative efforts may span decades. As a result, they have a vested interest in ensuring their respective coastal states, as well as vessels flying their flag or operating in their waters, are adequately prepared to mitigate the likelihood of a spill or release of hazardous substances into their navigable waters or tributaries. Throughout recorded history, marine oil spills have been among the world's most damaging environmental disasters and the field of oil spill preparedness and response has consistently evolved to meet new threats and adapt to emerging technologies. It is understood that much of the international and domestic policy framework that governs this field derives from lesson learned and policy implications from previous environmental catastrophes. By examining the events and latent unsafe conditions that contributed to a discharge or release into the marine environment, policymakers can identify, analyze, formulate, and implement measures to mitigate the risk and consequence of a future occurrence. This process of policymaking based on lessons learned led to the creation and implementation of MARPOL.

Why is it called MARPOL 73/78 and What is the MEPC?

MARPOL 73/78 specifically refers to the International Convention for the Prevention of Pollution from Ships of 1973, which was modified by the Protocol of 1978, meaning it was formed following the combination of two treaties that were adopted in 1973 and 1978. The MARPOL 73/78 convention became effective on October 2, 1983, and its six annexes and associated requirements were implemented over a defined and negotiated timeline. Further, the Convention and its annexes are routinely updated by the Marine Environment Protection Committee (MEPC), an International Maritime Organization-affiliated delegation that administers and addresses environmental issues under IMO's responsibility. MEPC, an IMO subcouncil, helps shape and adopt policy, administrative and mechanical measures designed to prevent and mitigate the environmental impact of shipping activities, specifically the release or spill of oil and chemicals carried in bulk, sewage, garbage, and emissions from vessels. Further, it covers ballast water management, antifouling systems, ship recycling, pollution preparedness and response, and the identification of special sea areas. To accomplish this, the MEPC comprises representatives from IMO member states, as well as observers from nonmember states, and intergovernmental and nonprofit organizations who meet periodically and publish resolutions in a final report of the committee for which the resolution was adopted. For permanence, these resolutions are memorialized with a specific naming convention that may be incorporated by reference throughout the maritime industry. For example, in 2022, a recent resolution of the MEPC was named MEPC.368(79) and refers to the MEPC Resolution number 368 that was adopted during the 79th session of the committee. In this case MEPC.368(79) concerned amendments to the 2014 Standard Specification for Shipboard Incinerators MEPC.244(66).

The tanker *Torrey Canyon* broke apart in pounding seas after running aground on Seven Stones Reef off Land's End, Cornwall, United Kingdom, on March 18, 1967. Highlighting the limitations of OILPOL, the incident caused the release of 860,000 barrels of crude oil into the sea over the next 12 days.

Historical Events Leading to MARPOL 73/78

MARPOL was not the first convention of its kind. There was a precursor known as the International Convention for the Prevention of Pollution of the Sea by Oil, or OILPOL, that took effect shortly after the establishment of the Inter-Governmental Maritime Consultive Organization, which was created in 1948 and served as the predecessor to the IMO. As detailed in the Parties to the Convention section of the consolidated MARPOL, the framers specifically recognized OILPOL's role as the "first multilateral instrument to be concluded with the prime objective of protecting the environment and appreciating the significant contribution which that Convention has made in preserving the seas and coastal environment from pollution."

The International Maritime Organization is a specialized agency of the United Nations for regulating shipping worldwide.

As mentioned above, laws and regulations are often reactive and the product of one or more incidents. Environmental protection regulations and the MARPOL 73/78 convention specifically are no exception

OILPOL

In 1954, the United Kingdom organized an oil pollution conference attended by 32 nations that led to the adoption of the International Convention for the Prevention of Pollution of the Sea by Oil. OILPOL was the result of growing concerns regarding the increasing amount of oil being transported by sea and the potential environmental and economic impacts of oil discharges by ships. The convention served as the first international instrument and primary framework for the prevention of pollution by ships until the implementation of MARPOL, by establishing requirements for ship design and operation, limitations for the discharge of oil, and setting forth processes to compensate for environmental damage. However, in the decades that followed the creation of OILPOL, there would be a series of environmental disasters that would expose its shortcomings.

Torrey Canyon

It was the grounding of the Torrey Canyon that revealed the limitations of OILPOL and brought the need for effective pollution prevention regulations to the forefront of the international community. On March 18, 1967, the supertanker ran aground and struck the Seven Stones Reef in international waters off the coast of Cornwall, United Kingdom. Over the next 12 days, the ship discharged approximately 860,000 barrels of crude oil into the sea. As a result of the challenges associated with salvage efforts, the Royal Navy bombed the ship with the intent of igniting the remaining cargo on board. While the additional cargo was released, the oil failed to ignite. The environmental impacts were immediate and long-lasting, affecting coastal regions of the United Kingdom and France and highlighting the need for advanced changes.

Amoco Cadiz

In 1978, the maritime community and its stakeholders were becoming more aware of the risks and threats inherent to the transportation of oil by ships and responded by implementing regulatory changes. One of the largest environmental incidents and worst spills in history was also about to take place. On March 16, 1978, the oil tanker *Amoco Cadiz* was en route from the Persian Gulf to Rotterdam, the Netherlands, when a steering failure during a heavy storm left the vessel drifting towards the French coast. Despite attempts to change the course of the ship, the vessel ran aground approximately one mile off the port of Portsall, France. The ongoing heavy weather caused significant damage to the ship's hull, which broke into three sections and released nearly 69 million gallons of oil into the sea. The incident triggered severe environmental and economic consequences, including loss of marine life, damage to fisheries, and significant cleanup costs. It also became a catalyst for the implementation of MARPOL and other international mechanisms for cooperation and coordination in the response to environmental incidents.

Exxon Valdez

Perhaps the environmental disaster best known for shaping maritime environmental policy is the *Exxon Valdez* oil spill. On March 24, 1989, the oil tanker ran aground on a reef while transiting in Prince William Sound, Alaska. The incident led to the discharge of 11 million gallons of crude oil into the water. The incident had devastating consequences to the ecosystem, including a severe impact to birds and marine life. Domestically, the *Exxon Valdez* disaster prompted the creation of the Oil Pollution Act of 1990, aimed to prevent and mitigate environmental impacts associated with oil pollution. Internationally, while this incident occurred after MARPOL's initial entry

The *Exxon Valdez* grounded on Bligh Reef in Prince William Sound, Alaska, on March 24, 1989, spilling 11 million gallons of crude oil, which resulted in the largest oil spill in U.S. history at the time. Coast Guard photo

Workers steam blast rocks soaked in crude oil from the leaking tanker *Exxon Valdez*. The tanker ran aground on Bligh Reef in Prince William Sound, Alaska, on March 24, 1989. Coast Guard photo

into force, it led to IMO's implementation of the double-bottom and double-side standards—or alternative IMO-approved or alternative IMO-approved designs. The new standards were required to be met by new oil tankers 5,000 deadweight tons and above, delivered after July 6, 1996, and double sides or double bottoms for oil tankers 600 deadweight tons and above carrying heavy oil as cargo in international voyages.

The Creation and Adoption of MARPOL

The cumulative effect of these casualties resulted in the creation and adoption of the MARPOL convention, which was intended to expand upon the successes of OILPOL and incorporate best practices and lessons learned from recent response efforts. MARPOL ambitiously set out to fundamentally change the way nations mitigate maritime environmental disasters by mandating aggressive preventative measures and prescriptive requirements that are enforced at the international and federal levels, rather than left to maritime operators and businesses.

MARPOL's Annexes

The MARPOL convention includes six technical annexes covering various sources of ship-related pollution. Currently, the adoption and implementation of Annex I, Regulations for the Prevention of Pollution by Oil; and Annex II, Regulations for the Control of Pollution by Noxious Liquid Substances (NLS) in Bulk is required for all signatory nations, while Annexes III, IV, V, and VI received sufficient ratifications to enter into effect but remained optional for signatory nations.

Annex I, Regulations for the Prevention of Pollution by Oil, was one of the first annexes to enter into force on October 2, 1983, and addresses oil pollution generated from operational measures and accidental discharges. Amended in 1992, 2001, and 2003, Annex I prescribed revolutionary pollution prevention standards such as double-hull requirements for oil tankers and regulations addressing oil monitoring and control systems for discharges of oily water from bilge and cargo tanks.

Annex II, Regulations for the Control of Pollution NLS in Bulk, entered into force on October 2, 1983. The annex provided control measures for specific noxious substances cited in the annex and carried in bulk, and prescribed that certain vessels must carry a Shipboard Marine Pollution Emergency Plan approved by its administration. It similarly set forth discharge criteria to include maximum allowable discharge limits to adequate reception facilities and prescribed compliance with the International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk, or IBC Code.

Annex III, Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form, entered into force on July 1, 1992. This annex establishes requirements for the packing, marking, labeling, documentation, and stowage of harmful substances to prevent pollution during their handling and transport. Further, this annex governs substances identified as marine pollutants and harmful substances as identified in the International Maritime Dangerous Goods Code.

Annex IV, Regulations for the Prevention of Pollution by Sewage from Ships, became effective on September 27, 2003, and was revised in 2005. This annex established requirements for the treatment and discharge of sewage from ships to prevent the release of harmful substances

into the marine environment. It prescribed guidelines for the installation and operation of sewage treatment plants on board ships, defined special areas, and outlined specific discharge requirements in such areas.

Annex V, Regulations for the Prevention of Pollution by Garbage from Ships, entered into force on December 31, 1988. This annex created requirements to prevent and minimize pollution caused by garbage discharge into the sea from ships. Its most sweeping feature is its applicability to all ships. Annex V prohibits the discharge of all garbage into the sea, including plastics, food waste, and paper, except under specific conditions outlined by its regulations. It also requires that all garbage be properly stored, sorted, and disposed of at designated port reception facilities.

Annex VI, Regulations for the Prevention of Air Pollution from Ships entered into force on May 19, 2005. This annex prescribes regulations for the reduction of e missions of ozone-depleting substances like sulfur oxides, nitrogen oxides, and other harmful substances from ships. It also implemented the use of fuels with low sulfur content and prompted compliance with more stringent emission limits in emission control areas.

How was MARPOL Implemented in the United States

Once IMO enacted MARPOL, it was referred to the individual member states for ratification. The Constitution of the United States gives the Senate unique ability to advise and consent, as well as the sole authority to approve or ratify treaties negotiated by the executive branch. MARPOL was no different.

On January 19, 1979, the President Jimmy Carter transmitted Treaty Document 96-3, also known as The International Convention for the Prevention of Pollution from Ships, agreed upon in London on November 2, 1973, together with the convention's Annexes I and II, and two related protocols to the Senate. On January 23, 1979, it was referred to the Committee on Foreign Relations where, on June 25, 1980, it was reported out of the committee without reservation. Finally, on July 2, 1980, following general debate it was approved by the Senate by a 90-0 vote.

Once the Senate completed its constitutional duties, the matter was referred to the legislature where it was to begin statutory rule makings to implement MARPOL's requirements. On February 28, 1980, House Resolution 6665 of the 96th Congress was introduced in the House of Representatives. After resolving differences between the House and Senate, it was presented to President Carter on October 10, 1980, and signed into law 11 days later, becoming Public Law No. 96-478. While the Treaty did become law upon the president's signature, Annexes I and III did not enter into effect until October 2, 1983.

The oily water separator aboard the motor vessel *Tennei Maru* has a sensor that detects how much oil is in the water that is set to be discharged. If the oil-to-water ratio is 15 parts per million or more, it sounds an alarm and stops the discharge. Coast Guard photo by Petty Officer 2nd Class Prentice Danner

Future of MARPOL

The MARPOL Convention has been ratified by more than 150 countries, representing more than 95 percent of the world's shipping tonnage. It is enforced around the world by port state control authorities, which means that ships entering ports of MARPOL signatories must comply with its requirements. Noncompliance with the Convention, and its associated implementing statutes can result in a wide array of corrective actions including warnings, fines, vessel detention, and even imprisonment. The IMO will continue to evaluate and amend MARPOL through MEPC Resolutions to ensure it remains relevant and best suited to protect the marine environment from discharges and releases.

About the author:

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Preventing Pollution in Our Nation's Waters

An ongoing endeavor

by Liesl C. Olson
Prevention Operations and Planning
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If asked to describe what members of the Coast Guard do daily, the average American would likely reference search and rescue activities frequently broadcast on the news, or possibly oil spill cleanup efforts. While those are undeniably important missions, it is the tireless efforts of individuals working in the background that help avert such disasters from occurring in the first place. Working under the statutory mission of marine safety, a segment of the Coast Guard performs less glamorous, but nonetheless critical, missions to ensure the safe movement and storage of oil and hazardous materials on the United States' navigable waters. Working in what is known internally as the Prevention Department, these teams inspect vessels, containers, and facilities to ensure compliance with applicable federal regulations, with the ultimate goal of preventing pollution in America's waterways.

Several of these regulations are historic regarding preventing pollution in domestic waters and have important nexuses to ensuring pollutants do not enter the water. They include:

- Limitation of Liability Act of 1851
- Rivers and Harbors Appropriation Act of 1899
- Oil Pollution Act of 1924
- Federal Water Pollution Control Act of 1948 and the extensive 1990 update
- Clean Water Act (CWA) of 1972
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980
- Oil Pollution Act of 1990 (OPA 90)

Oily waste on the Seawitch container ship. Courtesy photo

The goal of the Clean Water Act of 1972 was to restore the nation's waters to a fishable and swimmable standard by 1983. Coast Guard Photo by Petty Officer 3rd Class Aidan Cooney

A History of Relevant Regulations

Limitation of Liability Act of 1851

Prior to the passage of this act, vessel owners operating in the U.S. were liable for the entire value of their ship and its cargo. This put them at a disadvantage to their foreign competitors who were only held liable for the value of the vessel at the end of the voyage plus "pending freight." Thus, foreign vessel owners were protected from being held liable for damages incurred due to unforeseeable storms or pirate attacks.[1] Passing this act leveled the playing field and encouraged owners of U.S.-flagged ships to keep operating.[2] This law inadvertently had negative implications for water pollution as the limitation of liability also applied to oil spill cleanups. Its shortcomings became obvious in the aftermath of the massive 1967 Torrey Canyon oil spill. The supertanker struck a reef off the coast of the United Kingdom after the captain opted to take a shortcut. The tanker spilled approximately 119,000 tons of oil in what was, at the time, the "costliest shipping disaster ever."[3,4] Though cleanup efforts were extensive and involved multiple nations, the responsible party only paid $50 towards these efforts—the value of its one remaining lifeboat.[5]

Rivers and Harbors Appropriation Act of 1899

The very first environmental law in the United States was the Rivers and Harbors Appropriation Act of 1899, which included a provision—the Refuse Act—that prohibited discharging refuse into navigable waters without a permit.6 The intent of this act was not pollution prevention per se, but rather to mitigate hazards to navigation. Nevertheless, it helped pave the way for future regulations protecting the environment, as it was subsequently interpreted to include discharges of oil in the late 1960s.7

Oil Pollution Act of 1924

In 1924, the Oil Pollution Act (OPA), was introduced. The first U.S. law to specifically address oil pollution in its navigable waters, the Act's original purpose was to place limitations on the deliberate discharge of oil into navigable waters and to establish civil and criminal penalties for violations.[8] Penalties included a fine of up to $10,000, which constituted a maritime lien on the vessel and could be used to withhold clearance from American ports until paid.[9]

The Oil Pollution Act was necessary because ships cleaned out their ballast tanks to remove accumulated

oily water before entering port, and at the time, the tanks' contents were emptied directly into the ocean. Since oil floats on the water, it coats sea birds' feathers making it harder for them to fly. As observed by ornithologist William Dawson in 1923, eventually they make their way to shore to preen but are unable.[10,11]

OPA was expanded in 1961 to help prevent the discharge of oil during the necessary cleaning of holding tanks. This expansion required ships to install certain equipment like oily water separators, which separate oil out of the bilge water that accumulates in engine spaces as a result of normal ship operations, ensuring less oil escapes into the ocean when water is discharged.[12] Today, this equipment must limit the oil content to a maximum of 15 parts per million before water is discharged. This is a meaningful reduction from the typical concentration of 100 ppm - 400 ppm of oil and hydrocarbons found in vessel bilge water prior to separation.[13] To help ensure this standard is maintained, alarms and automatic closure devices that halt discharge if the ratio is in excess of 15 ppm are required on vessels greater than 400 gross tons.[14] Beginning with its 1961 expansion, the Act also required ships to keep records of all operations which might result in the discharge of oil.[15] Despite the mandatory nature of these requirements, engineers still face pressures to dispose of the massive amounts of oily bilge water that accumulate through normal ship operations.[16] In the interest of time and efficiency, some make illegal modifications to their oily water separators, commonly known as "magic pipes," allowing them to pump waste directly overboard.[17]

Act to Prevent Pollution from Ships

Enacted in 1980, the Act to Prevent Pollution from Ships (APPS) added incentives for whistleblowers who expose deliberate bypass of the oily water separation system. This includes a reward of up to half of any fine paid for APPS violations, which has led to multiple reports and prosecutions.[18,19]

Federal Water Pollution Control Act

The first major U.S. law to address water pollution on a broader scale was the Federal Water Pollution Control Act, enacted in 1948.[20] After several minor updates in the intervening years, it was overhauled in 1972 and updated in 1977. After its reorganization and expansion, it commonly became known as the Clean Water Act.[21] Beyond controlling the introduction of pollutants into the nation's water, this Act established goals of restoring the purity of the protected waters to a level deemed "fishable" and "swimmable" by 1983.[22,23] The goal date passed unmet, but efforts to achieve this level of purity continue.

The CWA delineated zones relevant to the application of various discharge standards associated with vessels. These three zones are waters extending out to 3 miles, the territorial sea; 12 miles, the contiguous zone; and past 12 miles, the ocean. It also specified that it is unlawful to discharge any pollutant from a point source, a discrete conveyance, such as a pipe, ditch, or vessel, into navigable waters without a National Pollutant Discharge Elimination System (NPDES) permit.[24] The Vessel Incidental Discharge Act, an amendment introduced in 2018, establishes uniform national standards for discharges incidental to the normal operation of commercial vessels into navigable waters. [25]

While the CWA focuses primarily on preventing pollution, separate laws govern what to do with existing pollution. In 1980, the Comprehensive Environmental Response, Compensation, and Liability Act was enacted and established a fund, informally known as the Superfund, designated for the investigation and cleanup of hazardous material, or hazmat, and toxic waste sites. The intention of Superfund cleanups is to prevent the release of hazardous substances into the surrounding environment and mitigate the risk of any remaining toxic materials through remedial actions.[26] As originally written, the act included provisions for both oil spills as well as hazmat cleanup, but petroleum products were specifically excluded to avoid pressure from lobbyists[27] and to ensure its enactment.[28]

Petty Officer 3rd Class Derek Shank, a machinery technician, stands inside the oily water separator aboard Coast Guard Cutter Sherman in 2015. The machine's job is to separate oil from bilge water before it is discharged from the ship to keep as much of the pollution out of the oceans as possible. Coast Guard photo by Petty Officer 3rd Class Melissa E. McKenzie

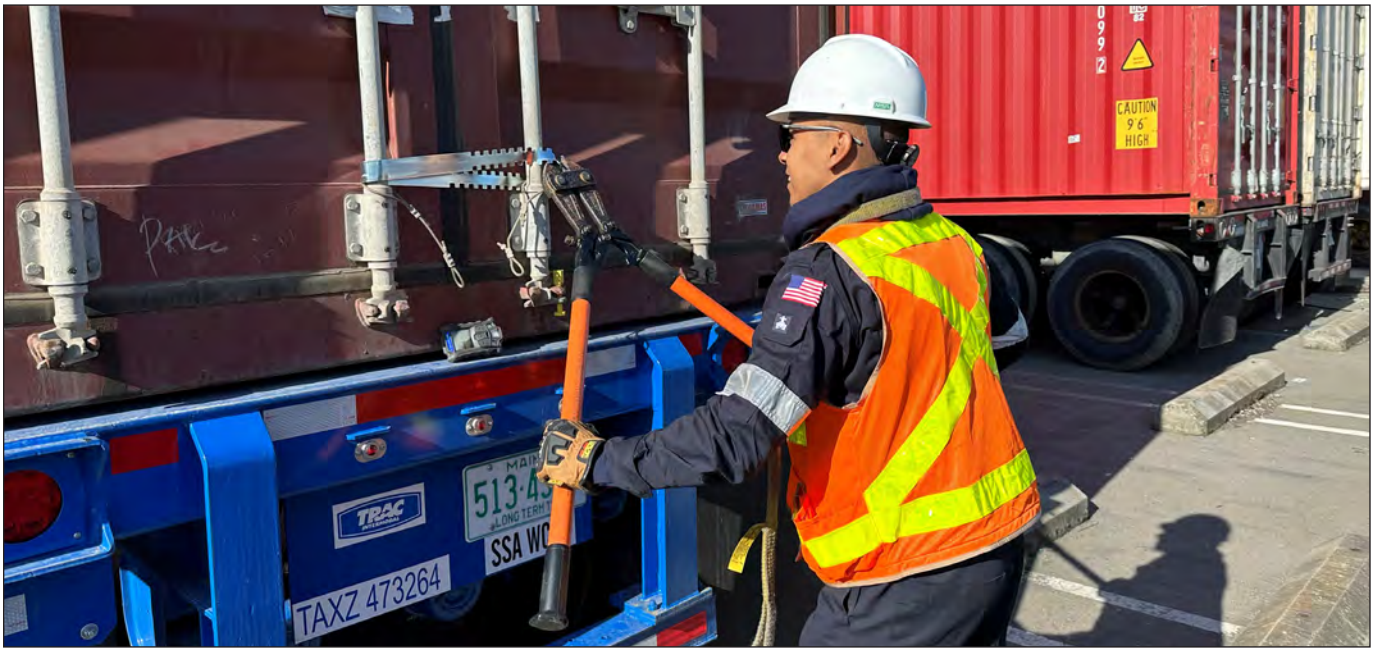
Oil Pollution Act of 1990

In 1989, the supertanker *Exxon Valdez* ran aground in Prince William Sound, Alaska, spilling nearly 11 million gallons of oil. In contrast to the *Torrey Canyon* spill where the captain deliberately took a shortcut, the *Exxon Valdez* incident occurred because the watchstander stood an overlong watch in violation of company policy and subsequently failed to safely maneuver the vessel. This event caused widespread public outrage and galvanized the American people to call for stricter regulations on the oil industry. Partially in response to those calls for action, the CWA was amended in 1990 and became known as the Oil Pollution Act of 1990, or simply, OPA 90. The Act was established, to provide "a comprehensive approach to oil spill prevention, response, liability, and compensation."[29] It established the liability of the "responsible party" unless it could be proven that the discharge was due solely to an act of God, war, or a third party.[30] It also established higher liability limits for oil spills and broadened the scope of damages for which polluters are liable. Additionally, it authorized payments of up to $1 billion per incident from the Oil Spill Liability Trust Fund for expeditious oil removal from spill areas.[31]

Liability was only one of many changes included in this 1990 update. Also introduced was a mandate aimed at improving the construction of oil tankers operating within the nation's territorial seas—12 nautical miles from shore—and the Exclusive Economic Zone, which generally extends 200 nautical miles beyond the territorial sea boundary. This mandate requires that all new ships intended for oil transportation within U.S. waters be built with double hulls to increase the likelihood of containment following a collision.[32] Single-hulled tankers were phased out gradually due to the difficulty of converting them to the double-hull design, and the delayed rollout reduced the impact on the shipping industry.[33] Previously constructed single-hull tankers were allowed to continue operating until January 1, 2015, the date determined to be the end of their operational lives. In addition to the double-hull requirement, OPA 90 also requires owners and operators of tank vessels and facilities to submit individual response plans, such as Spill Prevention Control and Countermeasure plans or Facility Response Plans.[34]

The enactment of these new requirements resulted in a marked decline in the number of spills, which dropped from an average of 79 annually in the 1970s to 6 per year by the 2010s—a whopping 90 percent decrease.[35] A recent report concludes that "regulatory changes, advances in science and technology, and, for the most part, attention

Petty Officer 2nd Class Peter Blunk fills out a checklist while conducting a fuel transfer monitor operation. Coast Guard photo by PA3 Katelyn Tyson



Petty Officer 3rd Class Alejandro Benites opens a container identified for inspection in the Port of Oakland. April 2023. Coast Guard photo by LT Liesl Olson

to safety have helped to reduce the amount of oil pollution in North American waters."[36] The regulatory process can be slow and imperfect, but the long-term impacts are remarkable.

Coast Guard Prevention Teams: Accountability at Sea Level

Enacting environmental regulations is an important step in preventing pollution, but implementing and enforcing these regulations is equally vital. America's appetite for fuel is formidable. From heating houses and fueling road trips to moving goods across the country, the United States is dependent on petroleum products as well as hazardous materials, which include fertilizers to grow food and lithium batteries that power electric cars and gadgets. In 2022 alone, almost 360 million barrels of crude oil and petroleum products were moved via our waterways through ports aboard large tanker ships and barges[37] and 3.3 billion tons of hazardous materials were shipped in the United States.[38]

While the shipment and storage of these substances is controlled by regulations, safety is improved only as much as people comply, and compliance is directly related to the anticipation of being held accountable. To this end, Coast Guard teams annually inspect commercial vessels including fishing, towing, passenger, research vessels, and tankers, facilities, and containers for compliance with regulations related to safety and security.

Domestic vessel inspections are critical for identifying potential spill hazards. One particular device inspectors are on the lookout for is the previously-mentioned "magic pipe." This pipe or hose, often detachable—and concealable—can be used to bypass the oily water separator and deliberately pump oily water directly overboard. The Act to Prevent Pollution from Ships added significant rewards for whistleblowers who disclose magic pipe use, yet the practice continues. In 2019, a whistleblower from the M/T *Zao Galaxy* surreptitiously passed a note reading "magic pipe" and "damage marine environment" to a Coast Guard inspector during an inspection, initiating an investigation into the ship's use of this device. Additional evidence was provided by another crew member who had cell phone video of various illegal oily waste discharges, one of which was just 3 nautical miles from the Golden Gate Bridge.[39] Vessel inspectors clearly play a crucial role in ensuring compliance with pollution-preventing measures on ships.

On the shore side, annual facility inspections begin with reviewing documentation such as plans for responding to spills, records of staff training, and records of equipment maintenance to ensure safe normal operations and preparation for worst case scenarios. The teams also walk through the facility at scheduled intervals. These walk-throughs allow inspectors to check hose conditions and markings, etc. and confirm no safety threats exist to humans or the environment, and visually verify that equipment in use is not actively leaking or operating in an unsafe condition.

In addition to holding companies accountable for adequate oil spill prevention measures, these inspections also offer a chance to engage with industry professionals. The conversations that arise offer valuable insight into current trends while fostering a good working

relationship with a representative of the Captain of the Port. It is easier to bring up an issue or question when there is an established relationship than to slog through what might seem like a bureaucratic jungle to find the right person to contact, especially during an emergency. Routine inspections are, therefore, invaluable as proactive prevention and an opportunity to establish a relationship to allow for quick, effective communication should a spill occur.

Coast Guard teams also inspect large numbers of shipping containers each year. Inspectors check the structural integrity of the container, ensure chemicals are properly packaged and marked, and compare the contents of the container with what is declared on the corresponding paperwork. The goal is to facilitate the movement of goods while diligently making sure that any risk of water pollution en route is minimized.

Conclusion

Federal regulations are introduced in response to problems and updated as needed to reflect a changing environment and evolving resource needs. Meticulously following these regulations across the maritime community has led to dramatic improvements in environmental health and cleanliness.

The Coast Guard plays an important role in holding waterway users accountable. By maintaining professional ties with the maritime industry through regular inspections, the Coast Guard also identifies trends and concerns and can act to forestall or prevent future marine pollution. As we look to the future, perhaps by vigilantly updating regulations to reflect current conditions and holding waterway users accountable for their actions we can hope to, one day, achieve that goal set 51 years ago: Make all of the nation's waters fishable and swimmable.

About the author:

LT Liesl Olson has served in the U.S. Coast Guard for 13 years across many disciplines, including cutters, sectors, training centers, port security units, and most recently, Pacific Area. The diversity of her career offers a greater perspective of the breadth of capabilities with which the Coast Guard serves the citizens of the United States.

Endnotes

1 Arnold & Itkin. May 6, 2021. "The Limitation of Liability Act of 1851: Avoiding Responsibility for the Worst Maritime Disasters." GCaptain. The Limitation of Liability Act of 1851: Avoiding Responsibility for the Worst Maritime Disasters.

2 "Maritime Limitations of Liability: A Study in Conflict of Laws." Spring, 1962. Duke Law Journal: Vol. 1962:259. Maritime Limitations of Liability: A Study in Conflict of Laws.

3 Seeberg-Elverfeldt, Niels J. (1980) "The Limitation of Liability Statute and its Applicability to Oil Pollution Damage Resulting from Offshore Drilling." NYLS Journal of International and Comparative Law: Vol. 2: Iss. 1, Article 4. Limitation of Liability Statute and its Applicability to Oil Pollution Damage Resulting from Offshore Drilling

4 33 U.S. Code § 407

5 Meiklejohn, Douglas. July 6, 1970. "Liability for Oil Pollution Cleanup and the Water Quality Improvement Act of 1970." Cornell Law Review: Volume 55: Iss. 6, Article 5. http://scholarship.law.cornell.edu

6 Shigenaka, Gary. "The Oil Pollution Act of 1990: A History of Spills and Legislation." August 17, 2020. NOAA's Office of Response and Restoration Blog. The Oil Pollution Act of 1990: A History of Spills and Legislation

7 Meiklejohn, Douglas. July 6, 1970. "Liability for Oil Pollution Cleanup and the Water Quality Improvement Act of 1970." Cornell Law Review: Volume 55: Iss. 6, Article 5. http://scholarship.law.cornell.edu

8 Dawson, William L. The Birds of California: Volume 3. Page 1506. 1923. South Moulton Company, San Diego.

9 Shigenaka, Gary. "The Oil Pollution Act of 1990: A History of Spills and Legislation." August 17, 2020. NOAA's Office of Response and Restoration Blog. The Oil Pollution Act of 1990: A History of Spills and Legislation

10 Anish. "Oily Water Separator: Construction and Working. February 22, 2019. Marine Insight. Oily Water Separator: Construction and Working

1 46 U.S. Code § 162.050

12 Shigenaka, Gary. "The Oil Pollution Act of 1990: A History of Spills and Legislation." August 17, 2020. NOAA's Office of Response and Restoration Blog. The Oil Pollution Act of 1990: A History of Spills and Legislation

13 Anish. "Oily Water Separator: Construction and Working. February 22, 2019. Marine Insight. Oily Water Separator: Construction and Working

14 33 U.S. Code § 1008 (1964)

15 46 U.S. Code § 162.050

16 33 U.S. Code § 1008 (1964)

17 Legal News Network. "Engineers Allegedly Ordered Crew Members to Use "Magic Pipe" to Bypass Pollution Control Equipment." December 13, 2006. Lawfuel. Engineers Allegedly Ordered Crew Members to Use "Magic Pipe"

18 Ibid

19 Letourneau, Keith. "The Years of Magic(al) Pipe Thinking." June 21, 2022. Texas Lawyer. The Years of Magic(al) Pipe Thinking

20 ""Magic Pipe" MARPOL Violations Can Be Spotted from Space." April 8, 2019. Maritime Executive. "Magic Pipe" MARPOL Violations Can Be Spotted from Space.

21 "History of the Clean Water Act." Updated July 6, 2022. United States Environmental Protection Agency. History of the Clean Water Act | US EPA

22 "Summary of the Clean Water Act." Updated July 6, 2022. United States Environmental Protection Agency. Summary of the Clean Water Act | US EPA

23 Copeland, Claudia. "Clean Water Act: A Summary of the Law." October 18, 2016. Clean Water Act: A Summary of the Law

24 "Federal Water Pollution Control Act Amendments of 1972." Public Law 92-500 Sec.101(a)(2). Retrieved from: Clean Water Act

25 "Summary of the Clean Water Act." Updated July 6, 2022. United States Environmental Protection Agency

26 The Vessel Incidental Discharge Act (VIDA)." Updated December 14, 2022. The Vessel Incidental Discharge Act (VIDA) | US EPA

27 Superfund: CERCLA Overview. Updated January 24, 2023. Superfund: CERCLA Overview | US EPA

28 Kelly, Erin. "CERCLA and the Exemption of the Oil and Gas Industry." July 6, 2021. Kleinman Center for Energy Policy. CERCLA and the Exemption of the Oil and Gas Industry

29 Donaldson, Michael P. "The Oil Pollution Act of 1990: Reaction and Response." Villanova Environmental Law Journal, Vol. 3, Iss. 2, Art. 2. 1992. The Oil Pollution Act of 1990: Reaction and Response

30 Ibid

31 USCG. "Oil Pollution Act of 1990"

32 Foley, Vincent. "After the Collision: Oil Spill Reporting, Cooperation, and Avoiding the Handcuffs." December 2006. Holland & Knight Law. After the Collision: Oil Spill Reporting, Cooperation and Avoiding the Handcuffs

33 NOAA. "A Final Farewell to Oil Tankers with Single Hulls." December 11, 2014.

34 Helton, Doug. "The Spills that Never Happened Thanks to Double Hulls." March 26, 2021. NOAA: Office of Response and Restoration. The Spills that Never Happened Thanks to Double Hulls

35 EPA. "Oil Pollution Act (OPA) and Federal Facilities." Updated January 4, 2023. Oil Pollution Act (OPA) and Federal Facilities

36 ITOPF (2022). "Oil Tanker Spill Statistics 2021." ITOPF Ltd, London, UK. Oil Tanker Spill Statistics 2021

37 National Academies of Sciences, Engineering, and Medicine. 2022. Oil in the Sea IV: Inputs, Fates, and Effects. Washington, DC: The National Academies Press. Oil in the Sea IV: Inputs, Fates, and Effects.

38 Crude Oil and Petroleum Products Movements by Tanker and Barge between PAD Districts. Source: eia.gov

39 PHMSA'S Quarterly Newsletter for Hazardous Material Safety, April-June 2022. PHMSA's Quarterly Hazmat Newsletter | PHMSA (dot.gov)

Past Efforts

Bilge Management on Ships

by Clifford "Sandy" Cameron
Chief Engineer
United States Merchant Marine

As a maritime academy cadet in 1982, I had the luck of sailing on a merchant ship that called on Port Everglades, Florida. After spending an afternoon at a local beach, I noticed my feet covered with spots of a black tar that had been hidden in the sand. Learning this tar was oily waste pumped overboard by some of the many vessels visible offshore, it made me uneasy to think my chosen profession might be the root cause of this contamination.

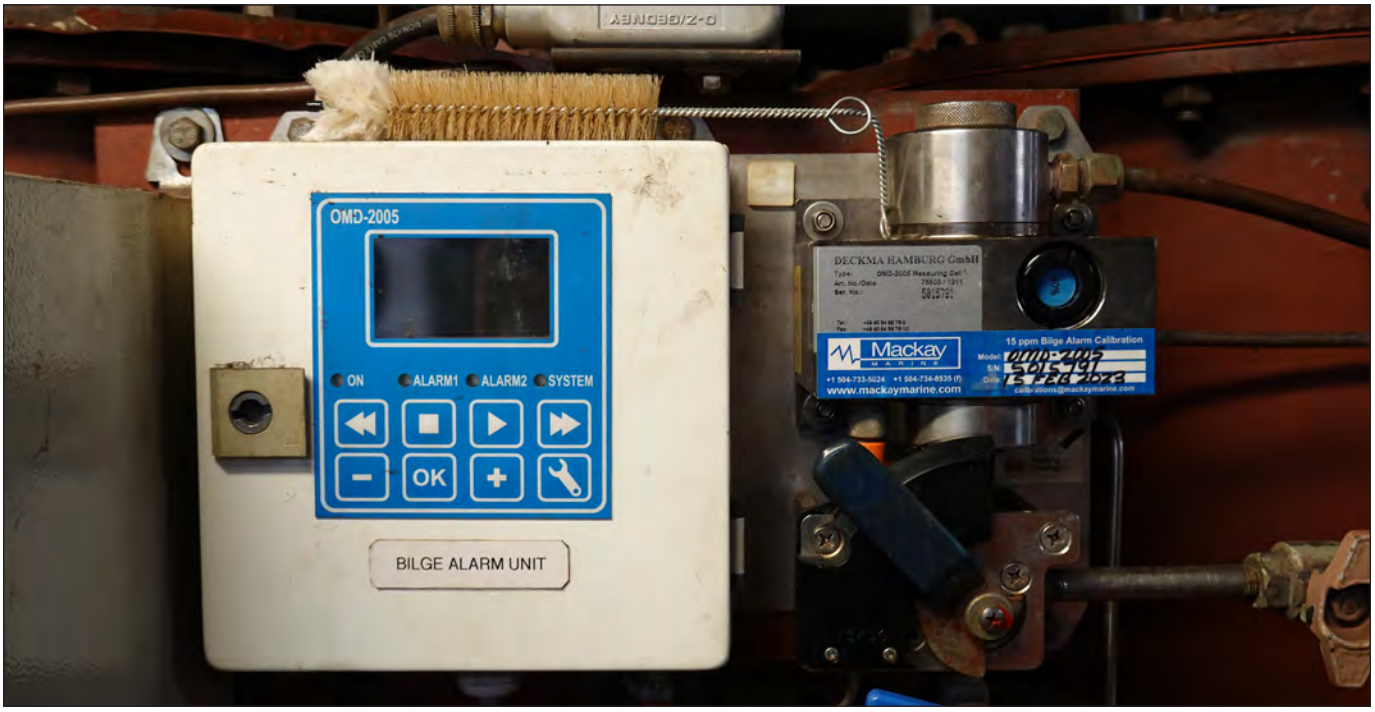
Shortly after this experience, modern deep-sea vessels became subject to International Law For The Prevention of Pollution at Sea, or MARPOL, Annex 1. This new law included requirements for special handling of waters collected in vessel machinery spaces or, as it is commonly called, "bilge water." New rules required vessels to minimize and adequately process these fluids so that only oil-free water was discharged overboard. Mandatory cleanliness meant that any bilge water discharged had to contain less than 15 parts of oil per million parts of water, the maximum allowable concentration that will not create a visible sheen on water.

These new regulations caused major changes to the practice of handling and pumping bilge water overboard from large, deep draft vessels. For crews, proper bilge water management then had to focus on several functions:

- minimizing fluids to be collected through reducing leaks, drips, and spills
- managing fluids that have been collected
- promoting use of compatible, non-emulsifying, cleaners in the engine room
- using and maintaining approved processing equipment
- observing rules and regulations regarding where bilge water can be discharged

Minimizing Leaks

Though they are often referred to as the tank tops because their steel forms the top portion of the structural framing and tanks adjacent to the skin of the ship, the engine room bilges are the lowest level of the machinery space. Any liquids from spills, leaks, or general cleaning in the



Oil content monitors prevent the accidental discharge of oily water into the seas. Per the International Convention for the Prevention of Pollution from Ships, or MARPOL, an acceptable discharge contains 15ppm of oil to water, which is regulated by this device. Photo courtesy of Clifford "Sandy" Cameron

engine spaces drain into them. Low points, called bilge pockets, or wells, are outfitted with alarms and piping for monitoring and emptying the many fluids that find their way there.

Minimizing Fluids in Machinery Spaces

The following are the first lines of defense in minimizing fluids freed into the machinery space, which ultimately end up in the bilges:

- staying alert and on task while topping up tanks or venting strainers to prevent spill over or escape of fluid
- maintaining engine cooling water connections by keeping those systems warmed to promote sealing of the rubber pipe coupling elements to stop slow but steady leaks into the bilges
- executing preventive maintenance to stay on top of aging flex joints and gaskets before they fail
- observing proper assembly and tightening methods for flanges, pipe, and tube fittings to ensure lasting liquid tight connections
- keeping a watchful eye for interferences where liquid filled lines may rub or vibrate to prevent wear or fatigue failure
- in humid climates air conditioning cooling coil precipitate can sometimes be diverted from bilge drains and saved to a holding tank to be used for supplemental machinery water
- insulating piping and internal hull surfaces, raising space or system temperatures, or modifying ventilation to minimize condensation collecting and dripping from surfaces that are below dew point
- keeping fuel and lubricant centrifuges maintained and operating properly to minimize break over and other conditions which cause excess discharge of process fluid
- minimizing wash down of decks after cleaning and instead use a bucket and mop with clean water to reduce the volume of water drained to the bilges from cleaning
- placing an absorbent pad or a containment to prevent immediate draining of small oil leaks to the bilges while investigating and correcting the condition causing the leak
- these are just a few examples of practices that an engineering team can adopt to reduce the amount of liquids draining into the machinery space bilge

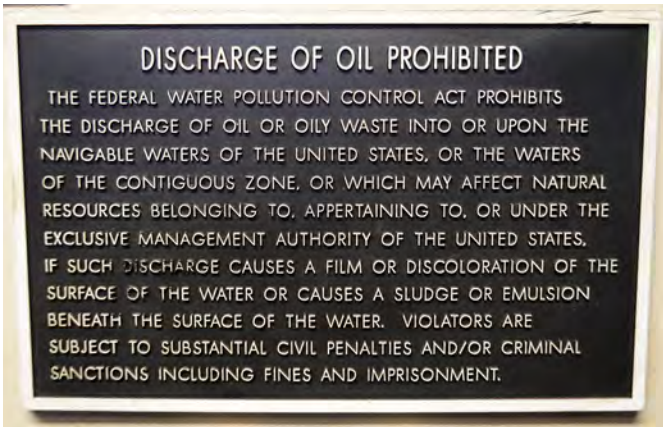
Reducing leaks, drips, and spills into the bilge is achieved through good engineering practice. Machinery operation and maintenance demands attention to detail in every engineering action.

Managing Collected Fluids

Once fluids collect in the bilge pockets in sufficient quantity, they are moved by special pumps and piping systems to holding tanks where they are stored and eventually processed for disposal. Along with bilge pockets, there are myriad specialized tanks where normal process fluids and contaminated oil are drained, ejected, and collected from the engine machinery. These also require regular level monitoring and emptying to holding tanks for eventual processing and disposal. By law, the volumes and types of these fluids must be recorded in an Oil Record Book, an official logbook used in recording specific and regular information detailing collection and disposal of machinery space oily waste fluids "from cradle to grave." False or erroneous entries into this book can be subject to stiff penalties and even incarceration for vessel owners and crewmembers.

In 1994, I was a newly assigned third assistant engineer responsible for bilge system management aboard a car carrier. After having just tied up in Bremerhaven, Germany, we were setting the plant for in-port operations and preparing for maintenance and repair of machinery that we could now take off-line after "crossing the pond."

One of the crew advised that there was someone looking for me in the control room. As I entered, I encountered a huge, clearly agitated, German individual speaking in broken English. After a brief greeting, he announced my Oil Record Book was "not good." I disagreed, having dedicated considerable time and focus to carefully organizing and modeling my records in accordance with the guidelines and examples in the



Every vessel must display a placard of class and regulatory rules, like this one outlining the sanctions that may be taken if oily water producing any sort of sheen, film, or discoloration is deposited into the water. Photo courtesy of Clifford "Sandy" Cameron

front of the book. After a good deal of argument on the validity of my entries the inspector—at that point understood to be Port State—blurted out "book is yellow." His point now settled in. I had been dutifully recording bilge water transactions in an outdated official record book. The chief engineer appeared a few minutes after this revelation and handed me a new, updated, white record book that he had been keeping in his office until the outdated yellow one was filled up, though he made clear to the inspector that it was my fault.

As a newly minted junior-rank engineering officer, I was inexperienced in the nuances of bilge water management and did not understand an updated version of this record book had been issued. Fortunately, I was forgiven for my ignorance and learned my lesson. For senior department officers, trusting the third assistant engineer with this responsibility is a liability and headache, but, functionally, it is, a rite of passage for the "Third."

Managing Bilges

Some of a third assistant engineer's responsibilities in managing collected bilge fluids include:

- keeping bilge water collection and transfer systems in proper condition
- maintaining a timely and accurate oil record logbook, the vessel's legal record of collection, processing, and discharge of bilge water
- transferring fluids to their appropriate holding and processing tanks
- performing regular and accurate soundings of these tanks
- processing the fluids held in tanks in accordance with regulatory requirement and good engineering practice
- avoiding stripping bilge water tanks
- determining and monitoring tank oil/water interface--the natural boundary between oil and water that is created by the differing density of each substance
- understanding each vessel's tank design and internal suction pipe termination
- accounting for engine space ventilation pressure and its effect on soundings taken within the machinery space
- planning bilge tank processing to take advantage of vessel dynamics—heavy seas or cold temperatures can interfere with ease of oily water separation

Promoting Use of Compatible Cleaners

In a perfect world, an engine room's bilges are clean and dry, but an operating machine rarely contains its fluids perfectly. Salt water, cooling water, lubricant, precipitate, condensate, fuel, and cleaners typically make up the mixture of liquids that accumulate in the bilges. For the most part, the oil and water remain separate, but using the wrong cleaner, which can wash down into the bilges, will encourage emulsification of the collected fluids. Once emulsified, oil and water mixtures become difficult to separate back to original substances and severely hamper disposal using vessel equipment.

The cleaning properties desired to release accumulated oils and dirt from the deck and machinery surfaces make cleaning solutions containing surfactants and emulsifiers particularly useful. However, this also makes them an adversary to the effective process of separation. Because of this, engineers must recognize and be proactive to mitigate contamination of bilge water with certain unapproved "household" type cleaning products. Marine chemical manufacturers provide specialized "oil/water separator compatible" cleaners that promise effective removal of oil and grease from surfaces balanced with prevention of emulsification and ease of process separation.

Using and Maintaining Approved Equipment

Oily water separation has advanced through several flights of technology:

Filter Separators

The early days of oily water separation technology was work intensive and messy. As a third, I spent many hours wrestling fibrous filter material, removing and rewinding

Still used today, coalescing filter separators are one of the earlier versions of oily water separators. Through this filter, drops of oil to stick together and rise, separating and removing them from the clean water. Photo courtesy of Clifford "Sandy" Cameron

it onto spools that functioned as renewable filters. The muck that coated this material was an uninviting concoction of everything harvested from the bilge. The final, clean effluent would pass from these filters leaving behind a slurry of muck that stained and stank my clothes and body for weeks. Quite often, it took a few filter renewals to process our bilge tank over the course of a day. What should have taken four or five hours turned into a full day of work as capacity slowed and filter change outs multiplied. They were messy, slow, and maintenance intensive.

Coalescing Filter Separators

The next stage in this evolution was to add coalescing technology to the front end of the filtration section. Here, a bedded chamber of plastic beads provided surface area for oily water to interface with, allowing time and opportunity for oil particles to gather and rise to the top of a chamber where the oil was harvested. This left mostly clean water to continue through the filter section of the separator. However, these units were only as good as the solution processed and were negatively influenced by cleaning agents and chemicals that also made their way into the bilge water.

Centrifugal Separators

For years, vessel lubrication and fuel systems had benefited from high-speed centrifuges to separate and remove water and particle contaminants from a stream of oil. This same technology was reworked to remove oil from a stream of water and effectively produce effluent that could be discharged overboard at concentrations less than 15ppm. Along with this came improved monitoring technology to meet new rules established by the International Maritime Organization's Marine Environment Protection Committee. However, these new centrifugal separators are also prone to reduction of performance by cleaning agents and chemicals washed and drained to the bilge.

Coalescing Filter Membrane Separators

Some of the newest technology now incorporates a final oil repellant membrane, after coalescing and filtration. This membrane strips oil from the water as it passes through, even in emulsified form. These units tend to benefit from prefiltration of the bilge water and can be fitted with filter housings that provide quick change "filter socks" to strain out heavy oils or particles before entering the machines process stages.

Ships use centrifugal force to separate oil from water by means of a centrifuge, a type of oily water separator. The device spins rapidly, dividing the oil from the denser water, allowing ships to meet the 15ppm oil to water limit set by MARPOL. Photo courtesy of Clifford "Sandy" Cameron

MARPOL Annex I includes requirements for the handling of bilge water—water collected in vessel machinery spaces. The rules address mandatory cleanliness of bilge water deposited into surrounding bodies of water as well as regulations on bilge water management for crews to follow. Photo courtesy of Clifford "Sandy" Cameron

Other forms of oil/water separation have been tried, including boiling off water as vapor, leaving heavy oil behind, and incineration of the oily water mix. Neither appear to have been widely adopted compared to properly practiced mechanical separation. Dosing bilge holding tanks with bacteria to digest oils is also offered, but I found it produced undesirable gasses, as well as undependable results due to introduction of other antibacterial substances found in engine cooling water, fuel treatments, and cleaners.

Many vessel operators choose to not discharge overboard at all, but rather hold onto bilge water until it can be disposed of to an in-port approved and vetted shoreside processor. A well-managed and leak-free engine room, along with regularly scheduled access to shoreside collection, is critical to operating successfully within the confines of this plan.

Managing Separation Technology

All of the separation technologies discussed require basic operator awareness and attention including:

- making sure appropriate placards of class and regulatory rules are displayed
- understanding proper operation of bilge oil/water separator and post clear and simple instructions for its operation, on the machine if possible
- monitoring and observing the oil/water separator frequently while it is operating
- performing regular calibration of oil content monitor
- checking diverter valve function and alarm sounding prior to putting the system on-line.
- keeping any pre-process filtration maintained and clean
- monitoring bilge water holding tank suction to make sure fluid being drawn into the separator is not oil saturated or emulsified
- polishing tanks prior to final discharge through approved equipment
- in addition to operational practice, any maintenance and outage time for the oil/water separator must be noted and recorded for both securing and restoration of unit function

Oil Content Monitor

The final device in the process of preventing inadvertent discharge of oily water is the oil content monitor (OCM). It performs continuous sampling of the processed effluent as it enters the pipe to be discharged from the vessel. The OCM must be regularly checked, cleaned, and calibrated to ensure its proper function. While failure of a properly maintained OCM is rare, it is ultimate best practice to immediately stop discharging and notify regulatory governing bodies of any evidence of its failure resulting in a discharge of bilge water exceeding the allowable limits. Prompt notification, honest intention, and best practice will, in most cases, be taken well in any investigation that might follow an incident. Accidents do happen.

Observing Rules for Discharge Areas

There are rules controlling where and under what circumstances waters collected in machinery spaces can be discharged overboard through approved processing and monitoring equipment. These rules, along with the function and certification of a vessel's oily water separating machine, must be thoroughly understood by any engineer in charge of processing bilge water to the sea.

Low points of bilges can accumulate chemicals, oil, and other liquids that could pollute the water. Photo courtesy of Clifford "Sandy" Cameron

The world's littoral nations have mandated that oceans be protected from pollution. There are "special areas" carrying specific requirements for conditions that must be met to discharge bilge water into the sea. Discharging inside a special area requires processing equipment with features not required for discharging outside a special area. As worldwide ecological protective mandates change, so do the size and location of these areas.

Engineering, in coordination with vessel navigation, must have a thorough knowledge and understanding of international regulations, special areas, a ship's voyage plan and position, and company practice when planning to discharge bilge water through an approved oily water separator. Accurate recording of vessel position during effluent discharge is law, and all logbooks are subject to review and owners, operators, and crew can be hit with fines and penalties for illegally discharging in a prohibited area.

Conclusion

The sea is unforgiving of both men and machinery and modern crews must do the best they can with what they have. Bilge water collection, storage, and processing success is subject to myriad conditions encountered in an active engine room. Often, mistakes are what determine new policy and practice. What worked on "my last ship" may or may not be applicable to the present vessel assignment for a new officer. When equipment fails or process effectiveness is in question it is always best to hold bilge water until it can be confidently pumped off to a vetted shoreside reception facility.

During my career, I have seen many improvements of rules and practice, along with significant technological advancement toward efficiently processing the inevitable water that collects in machinery space bilges. In 2022, I had the luck of calling on Port Everglades again, this time as Chief Engineer of my alma mater's training ship. I am happy to say that the sands of those beaches are now clear of residual oil contamination, even with many vessels still attending that busy port.

About the author

Sandy Cameron is a graduate of Maine Maritime Academy. His work experience includes shipbuilding, engineering, and 25 years on U.S.-flagged commercial and sealift vessels. In 2018 he "retired" to become chief engineer of the Training Ship State of Maine. *He resides in Maine with his family.*

Tank Cleaning on Chemical Tankers

Moving toward zero discharge

by Patrick Keffler
Chemical Manager and Region Manager, Americas
INTERTANKO

Chemical tankers carry a variety of chemically diverse substances; everything from alcohols, acids, and aldehydes to heavy paraffin wax, vegetable oils, and coal tar along routes ranging from regional, coastwise trade to international voyages. Tank cleaning, or tank washing, operations are crucial for these vessels to remove chemical vapors, liquids, or residues from the tanks after each different cargo is transported and discharged. This ensures the tank is ready for the next product and the new cargo is not harmed or contaminated by the previous one.

Chemical tankers are designed and equipped in a manner that permits the discharge of tank washings either ashore, to a holding tank onboard, or directly to the sea. Tank cleaning is required for many reasons, such as to carry clean ballast, remove sediments from tank top plating, prepare the tanks for internal inspections or prior to entering dry dock, but the primary purpose of tank cleaning is to prepare the tank for the next cargo. The level of cleaning needed is generally determined by the chemical and physical properties of the cargo that has been discharged; the type of tank coatings, or stainless steel; and the specifications of the cargo to be loaded.

Where MARPOL Annex I contains the regulations for the prevention of pollution by oil from ships, MARPOL Annex II details regulations for the control of pollution by noxious liquid substances (NLS) carried in bulk.

As defined in MARPOL Annex II, "Noxious liquid substance means any substance indicated in the Pollution Category column of Chapter 17 or 18 of the International Bulk Chemical Code (IBC Code) or provisionally assessed under the provisions of regulation 6.3 as falling into category X, Y or Z." The guidelines for the categorization of NLS can be found in Appendix I of MARPOL Annex II. Products are assigned to pollution categories based on an evaluation of their properties by the United Nations, Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). Also included in Annex II is Regulation 13, Operational discharges of residues of noxious liquid substances. This chapter provides the regulations that govern tank washing and discharges from chemical tankers.

Each year IMO issues the MEPC.2/Circular that publishes the provisional categorization of liquid substances based on the GESAMP hazard profile of each substance. The annexes to the circular provide lists of NLS with associated pollution categories, ship types, and minimum carriage requirements, which are established through a tripartite agreement and registered with the IMO Secretariat.

Noxious liquid substances are divided into four pollution categories:

Category X: Those that, if discharged into the sea from tank cleaning or de-ballasting operations, are deemed to present a major hazard to either marine resources or human health and therefore justify the prohibition of the discharge into the marine environment.

Category Y: Those that, if discharged into the sea from tank cleaning or de-ballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea. Therefore limitations on the quality and quantity of the discharge into the marine environment are justified.

Category Z: Those that, if discharged into the sea from tank cleaning or de-ballasting operations, have been deemed to present a minor hazard to either marine resources or human health. Therefore, less stringent restrictions on the quality and quantity of the discharge into the marine environment are justified.

Other Substances: Substances indicated as "other substances" in the pollution category column of chapter 18 of the IBC code have been evaluated and found to fall outside Category X, Y or Z as defined in regulation 6.1. This is because they are, at present, considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning or de-ballasting operations. The discharge of bilge or ballast water, or other residues or mixtures containing only substances referred to as "other substances," shall not be subject to any requirements of the Annex.

Chemical tankers that have discharged cargoes presenting a major hazard to the marine environment—Category X substances—are required to carry out a mandatory prewash before leaving port. The tank washings resulting from the prewash are required to be discharged to a shore reception facility. Additionally,

certain Category Y substances that are persistent floaters are also required to carry out a mandatory prewash when unloading in a Northern European waters port, as defined in Regulation 13.9. Persistent floaters are substances that are less dense than sea water with a viscosity greater than or equal to 50mPa·at 20ºC and/or with a melting point greater than, or equal to 0ºC.

For Category Y and Z substances, generally, tank washing residues may be discharged to the sea provided that the ship is proceeding en route at a speed of at least 7 knots; the discharge is made below the waterline through an underwater discharge outlet; and the discharge is made not less than 12 nautical miles from the nearest land and in a depth of water not less than 25m. Every ship certified to carry Category X, Y, or Z substances is required to have a Procedures and Arrangements Manual approved by its administration. The manual has a standard format and identifies the physical arrangements and operational procedures with respect to cargo handling, tank cleaning, slops handling, and cargo ballasting and de-ballasting. Additionally, each ship that carries MARPOL Annex II products must also have a Cargo Record Book. All NLS cargo, tank washing, prewash, and ballasting operations must be recorded in this book per appendix II of MARPOL Annex II.

While the regulations in MARPOL Annex II and the IBC Code mandate the rules for tank cleaning with respect to safeguarding the environment, there are also commercial concerns, chief among them is protecting the quality of the cargo.

Industry-led Tank Washing Guidelines

INTERTANKO's Cargo Tank Cleanliness Standards for Chemical Tankers (Rev.1, 2017)[1]

In addition to limiting the potential for environmental harm, there are a number of commercial objectives to following a set of prescribed tank cleaning guidelines. Having standardized procedures provides predictability of costs and time required to prepare a tank for the next cargo and also avoids over cleaning the tanks. Less tank cleaning involves less chemical cleaning agents, less energy used for heating systems and tank washing machines, and generates less tanks slops and wash-water, all resulting in a reduced impact on the environment. In

Intertanko Cargo Tank Cleanliness Standards for Chemical Tankers

Standard No.	Standard Name	Definition	Test Methods	On-board test conducted by ship's crew	Comments/description
1	Visually Clean Standard	Clean, dry and visually free of residues of previous cargo and/or foreign matter, no uncharacteristic odour.	NA	In-tank inspection - Dry, and visually free of residues of previous cargo and/or foreign matter no uncharacteristic odour.	Master to confirm that on-board tests were conducted via tank cleanliness certificate. Tanks should only be inspected from deck level, no wall-wash to be taken.
2	Water White Standard	Dry, odour-free, free of visual residues of previous cargoes and/or foreign matter. Colour test: Wall-wash with suitable solvent shows: • colour PtCo (ASTM D 1209) 15 or less[1]	WWM/ WWA	Dry, odour-free, free of visual residues of previous cargoes and/or foreign matter. Colour test: Wall-wash with suitable solvent shows: • colour PtCo (ASTM D 1209) 15 or less[1]	Master will confirm that on-board tests were conducted via tank cleanliness certificate. Charter may choose not to conduct in-tank inspection for wall wash (colour test).
			WsW[3]	N/A	
3	High-Purity Standard	Dry, odour-free, free of visual residues + wall-wash with methanol conforms to: • Water miscibility test (ASTM D 1722) passes • Colour PtCCo (ASTM D 1209) or APHA 10 or less • Chlorides less than 2 ppm • Permanganate time test above 50 min • UV spectrum passes		In-tank inspection - Dry, odour-free, free of visual residues + wall-wash with methanol conforms to: • Water miscibility test (ASTM D 1722) passes • Colour PtCCo (ASTM D 1209) or APHA 10 or less • Chlorides less than 2 ppm • Permanganate time test above • If WWM is used UV spectrum passes	This is the most commonly used standard for the carriage of methanol as a cargo. Master will confirm that on-board tests were conducted via tank cleanliness certificate. Charterer may accept the cleanliness certificate provided by the master or may require an internal visual inspection and a wall-wash test. This should be pre-agreed with the charterer/ shipper.
			WsW[3]	Less than 100ppm of last cargo in final wash-water	
4	Ultra High-Purity Standard	Dry, odour-free, free of visual residues + wall-wash with methanol conforms to: • Water miscibility test (ASTM D 1722) passes • Colour PtCCo (ASTM D 1209) or APHA 10 or less • Chlorides less than 2 ppm • Permanganate time test above 50 min • UV spectrum passes • Non-volatile matter less than 10 ppm • Last cargo by Gas Chromatography or other suitable method less than 2 ppm	WWM/ WWA	In-tank inspection - Dry, odour-free, free of visual residues + wall-wash with methanol conforms to: • Water miscibility test (ASTM D 1722) passes • Colour PtCCo (ASTM D 1209) or APHA 10 or less • Chlorides less than 2 ppm • Permanganate time test above • If WWM is used UV spectrum passes2	This standard is used for the carriage of high-spec cargoes that require a higher level of cleanlineess than that required forr the carriage of methanol. Master will confirm that on-board tests were conducted via tank cleanliness certificate. Charterer may accept the cleanliness certificate provided by the master or may require an internal visual inspection and a wall-wash test.
			WsW[3]	Less than 100ppm of last cargo in final wash-water	

[1] No visible discoloration compared to a blank sample.

[2] Applicable if UV spectometer available on board.

[3] Wash-water test is an alternative test method for the verification of cargo tank cleanliness using wash-water sampled during tank cleaning operations annd is based on the premise that when the wash water is clean and largely free from previous cargo residues, the cargo tanks and lines can also be considered clean.

[4] The operator should use their experience and judgemeent when applying the 100ppm standard to wash-water at this level of cleanliness. Prior cargo compatibility, tank coating, and other such factors should be assessed to ensure that 100ppm standard of wash-water will be sufficient to pass the equivalent wall wash test at this level otherwise a more stringent level of wash water test should be applied at this level.

addition, the use of standardized tank washing requirements contributes to a reduction in the need for in-tank inspections and improves efficiency for faster port turnaround as the entire process is less complex and there are fewer rejections from surveyors inspecting the tanks.

"Protecting the quality of the cargoes carried is a shared goal of charterers, ship owners, cargo insurers, and surveyors. The tank cleanliness requirements in the trade are driven by the following three broad criteria:

1. Cargo contracts place the liability for any on-board contaminations of the cargo on the ship,
2. Cargo insurers normally ask for proof that the cargo tank is clean prior to loading, and
3. Charterers also provide special handling instructions and 'prior cargo' restrictions to mitigate the risk of cargo contamination."

INTERTANKO has recommended:

- owners incorporate the revised tank cleanliness standards into the relevant shipboard management procedures
- owners prepare reporting templates for tank cleanliness certificates that include charterers' required standards and test results following the owner's tank verification methods
- charterers introduce and incorporate these standards into the voyage orders that are provided to owners
- owners make clear the commercial and operational implications of choosing a higher standard than is necessary when discussing and agreeing on the cleanliness standards that are needed

All stakeholders in the industry are encouraged to acknowledge and leverage ship owners' experience and knowledge of cleaning processes to ensure the proper implementation and use of the tank cleanliness standards. There are four standards of cargo tank cleanliness for chemical tankers.

Future of Chemical Tanker Tank Washing Discharges

There are several converging developments relating to the tightening of regulatory controls on ship-sourced marine pollution including the review of the European Union directives on ship source pollution, port reception facilities, and environmental crime. Additionally, there are ongoing calls by IMO Member States for stricter prewash and tank-cleaning requirements through proposed amendments to MARPOL Annex II.

More and more restrictions are placed on vessels with respect to discharges into the sea. This includes the changes to the IBC Code and MARPOL Annex II regarding persistent floating products that require a prewash when discharging in Northern European waters. Concurrent to this, European member states have submitted proposals to IMO to tighten prewash requirements for certain MARPOL Annex II cargoes alongside proposals from Baltic Sea states to establish the Baltic Sea and North Sea as MARPOL Annex II Special Areas and ban all cargo-related discharges. Additionally, European directives seek to tighten the control of discharges to the sea from ships, increase penalties for illegal discharges and enforce tighter controls on the mandatory delivery of cargo residues to port reception facilities in Europe.

In consideration of this continuing focus on tank

Crew members enters a cargo tank on the chemical tanker *Bow Summer*. Photo courtesy of Odfjell

A wall-wash test using methanol is conducted on the chemical tanker *Bow Summer*. Photo courtesy of Odfjell

washing requirements, INTERTANKO has established an aspirational strategy to move towards a future with zero discharge of MARPOL Annex II tank washing materials. This endeavor is referred to as the MARPOL Annex II Zero Discharge Strategy and Roadmap.

There is clearly an increasing public scrutiny, driven by the media, environmental organizations, and local and national government authorities, on the practice of discharging tank washings at sea. There is an increasing focus on defining sustainable economic activities at a regulatory and voluntary level, which includes reporting on marine pollution and discharges to sea. For example, through the European Union's Taxonomy Regulation and Environmental, Social, and Governance (ESG) reporting and the use of the United Nation's Sustainable Development Goal 14 on life under water. The reputational issues associated with tank washing are an increasing concern across the chemical tanker industry. There have been instances where chemical tanker owners have already been asked by European Port State Authorities to justify their operations and validate the legality of their activities.

The increased navigational safety risks, bunkers consumed, and the consequential air emissions associated with departing from a terminal, undertaking tank washing while underway, and returning to the terminal to take the next cargo are also a concern. Each added ship movement not only increases air emissions but will also negatively impact a vessel's carbon intensity index.

A progressive position on tackling these issues should, in principle, allow the chemical shipping community to actively engage with regulators and influence future regulations so that they apply to all stakeholders equally and not just the ship. Terminals need to accept the tank washings, and a mandatory requirement for terminals to receive all tank washings should be introduced and pushed for at every level. Charterers and terminal operators may have to adjust their approach in order to allow for tank washings to be discharged to shore.

Recognizing that the issue is highly complex, INTERTANKO is now continuing to develop more detailed views on such a strategy and importantly, the idea of developing an accompanying Roadmap on what will need to be in place to achieve such an ambition. Initial exchanges suggest the Roadmap should clearly explain the complex nature of the industry and provide examples of the possible additional benefits to ship safety and environmental protection of such an ambition. Possible benefits include fewer voyages in and out of busy ports and fewer bunkers consumed leading to lower air emissions, respectively.

The Roadmap must clearly define and propose solutions to the major barriers that will need to be removed before the chemical tanker industry can fully realize its objective. For example, the objective cannot be achieved without the provision of reception facilities at all chemical tanker ports and terminals. The Roadmap will also provide a plan of action in terms of industry engagement with regional, national, and international regulators, as well as other important players such as charterers and terminals that would be necessary to reach the Strategy's objective.

Conclusion

There is growing public awareness regarding chemical tanker operations, especially with respect to discharges into the marine environment. Balancing the economic and commercial need to safely transport chemical products that are vital to how we live our lives against the potential for environmental harm requires input from ship owners, charterers, legal and insurance companies, and terminal operators and regulators. We look forward to working with all interested stakeholders in developing the Zero Discharge Strategy and Roadmap to address the future needs of the chemical tanker industry.

About the author

Patrick Keffler joined INTERTANKO as its chemical manager and regional manager for the Americas in 2018, following 32 years of combined service on active duty and as a civilian with the U.S. Coast Guard.

Endnotes

1. INTERTANKO Cargo Tank Cleanliness Standards for Chemical Tankers, December 2017

At 50, MARPOL 73/78 Serves the Maritime Industry Well

by John Haeflinger
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Vice President
Environmental Operations
Carnival Cruise Line

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the preeminent international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL 73/78 is celebrating its 50th anniversary this year.

If we think back to what was happening at the time, it should come as no surprise to anyone that the MARPOL Convention was established in 1973. The previous year, the United Nations met to discuss actions to preserve the environment given the increasing speed, scope, and scale of man's impacts on natural and man-made ecosystems. However, the domestic legislation and environmental actions taken by the United States in the years leading up to MARPOL's birth were highly influential in these discussions. Air quality in many of America's cities was reaching crisis levels leading many states to enact state and regional regulations to control emissions from power plants and industrial facilities. For those old enough to remember, the sight of rivers in the United States burning from unrestricted dumping of flammable and toxic chemicals shook the public and galvanized its support for immediate environmental actions to address numerous crisis areas. In 1970, this public pressure led President Nixon and other government leaders to establish the U.S. Environmental Protection Agency, which quickly led to the enactment of the Clean Water Act of 1972, extending protections to our nation's waterways.

It was against this backdrop that the modern cruise industry was born. This industry has grown significantly over the past 50 years evolving into a global mode of leisure travel. Given the industry's global presence, the portable nature of ships, and the everchanging nature of regional and local environmental regulations, it prefers and has advocated for, consistent requirements. MARPOL has gone a long way to providing that consistency, however, there remain many instances where local and regional regulations complicate compliance with global environmental standards. MARPOL is an overarching regulatory system that is globally consistent and based on well-established and communicated compliance timelines. This has allowed the industry to conduct research and development to drive improved system performance, develop and execute capital investment plans, and optimize itinerary decisions. In stark contrast, there have been several cases where the industry has had to deal with the publication of local regulations that were effective almost immediately with limited or no public comment period. Unfortunately, this can occur after long term itinerary decisions have been made and cruises sold, making compliance unnecessarily complex and disruptive.

Through the participation of its trade association, Cruise Lines International Association, and company representatives, the cruise industry has materially contributed to the evolution of the applicable MARPOL annexes. The industry has also worked closely with

Cruise ships were early adopters of ballast water treatment technology. Treating ballast water is critical to limiting the spread of invasive aquatic species from one port to another. Photo courtesy of Rich Pruitt

the many flag states that register cruise ships to ensure regulations achieve their objectives without unnecessary, burdensome provisions. The industry has also voluntarily gone beyond MARPOL requirements in many cases, both procedurally and technically.

The cruise industry is subject to most MARPOL annexes. Its vessels deal with essentially the same types of waste as other ships and are required to meet the same standards. However, some parts of MARPOL regulate the industry differently. The provision for Annex IV Special Areas (Baltic Sea) for passenger ships is just one example. The provision sets very strict limits on nitrogen and phosphorus levels in treated sewage, and soon after the Annex implemented the concept of sewage special areas a special area in the Baltic Sea entered into force. Aside from that recent change, the biggest differentiator between cargo and cruise is in the volume of certain waste streams, namely solid and liquid wastes.

Dissolved air flotation is a method by which waste water is clarified by removing suspended solids, oils, greases, and metals, among other elements. Photos courtesy of Rich Pruitt

MARPOL Annexes Applicable to Cruise Ships

Annex I: Oil Pollution Prevention

This annex entered into force October 2, 1983, and addresses the prevention of pollution from petroleum products. Among other things, it sets standards for construction, holding capabilities for bilge and sludge, treatment standards for oily water separating (OWS) and oil content meter systems, shoreside offload requirements, transactional recordkeeping, and operational spill cleanup requirements.

The cruise industry has gone above the established standards by fitting every ship with OWS equipment. Also, many companies have equipped their ships with discharge compliance assurance devices which have independent oil content and flow meters and the ability to recirculate the water if it fails to meet the 15ppm of oil content required under the annex.

Annex IV: Sewage

This annex entered into force September 27, 2003, and regulates the treatment and discharge of sewage from passengers, crew, and livestock at sea and to shore. This annex has evolved over the years as concerns with near-shore sewage discharges developed and technology advances allowed for improved treatment standards. Cruise ship wastewater treatment technology advancements were instrumental in driving improvements across the maritime industry. Over the last two decades, the systems found on a growing numbers of cruise ships deliver treated effluent quality on par with, or better than, many municipal wastewater treatment plants. As these systems have become more common on cruise ships, many International Maritime Organization (IMO) member states and nongovernmental organizations have cited this as evidence that the wastewater treatment technology industry could design, test, and install shoreside quality systems at sea.

The cruise industry has put policies and guidance in place that exceed MARPOL requirements, for instance, often discharging treated sewage more than 12NM from the baseline. This standard goes well beyond the Annex IV 3NM requirement and many cruise companies' internal policies further restrict these discharges.

In 2010, more than a decade before the most recent sewage treatment standards were set, the industry began working with wastewater treatment technology suppliers to better treat sewage and introduce grey water, like that from water galleys, laundries, showers, and sinks, into the treatment systems. Currently, in various jurisdictions, grey water is unregulated outside of territorial waters. It is unclear how grey water regulation will evolve or when it will be put into force internationally. While this was somewhat driven by U.S. federal and Alaska state permit requirements for discharges in Vessel General

Permit (VGP) waters, this technology is now standard on virtually all newbuild cruise ships, and many older ships are being retrofitted.

Annex V: Garbage and Food

This annex entered into force December 31, 1988, and regulates the management of solid and operational wastes—deck and superstructure cleaning, cargo hold washings and the detergents used. Some years ago, the approach for controlling the discharge of solid waste at sea was maintaining a small list of what was not allowed to be discharged, like plastics. Today, it specifies a very small list of the types of solid waste that can be discharged, like food waste and cargo washings. Even when it was permitted, the cruise industry committed to a higher standard for at sea discharges of any type of waste, but the best waste management practice is to not generate the waste materials to begin with.

While it is challenging to find solutions, industry officials are searching for ways to reduce the amount of nonrecyclable waste. Single use service items that we are accustomed to seeing in shoreside restaurants, would most likely not be found on an industry ship. Some companies have achieved up to 90 percent reductions in the number of single use items brought on board.

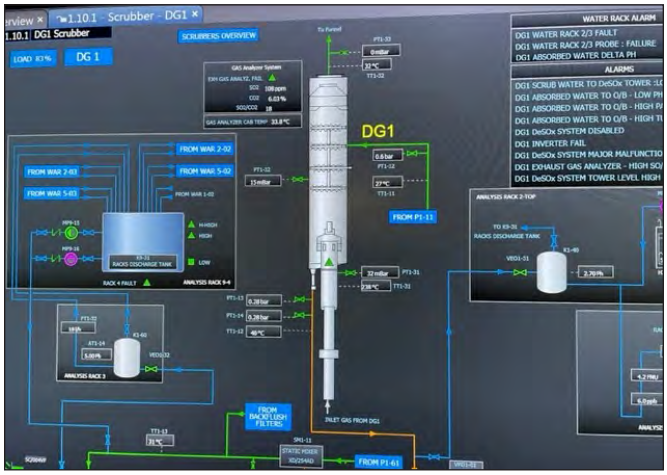
Similar to single use item reduction activities, some industry companies are diligently pursuing lower generation rates for food waste through operational improvements and technologies such as biodigesters and dehydrators. This is being achieved through changes in food preparation techniques and menus, room service charges, and videos informing guests and crew that food waste is an environmental concern. Some companies have made substantial investments in new technology which means their ships no longer have to dispose of food waste at sea.

The cruise industry also largely follows the more restrictive discharge protocol that is required in Special Areas. Food wasted discharges, if performed, are at least 12NM from the baseline, and the discharged material is ground to less than 25mm even when outside those areas.

Annex VI, Air Emissions

This annex entered into force May 19, 2005, and addresses air quality and greenhouse gas (GHG) production through the regulation of harmful substances in exhaust streams and gaseous emissions. In particular, it targets sulfur dioxide, which causes acid rain and is a risk to human health; nitrogen oxides, which negatively impact the climate and leads to smog; particulate matter, a human health risk; and ozone depleting substances.

Pillars of this Annex are the establishment of specific Emission Control Areas with stricter requirements—0.1 percent sulfur content—and the lowering of sulfur



Exhaust Gas Cleaning Systems is just one of the technologies the shipping industry has adopted to help limit its impact on air quality and climate change. This automation screen provides real-time information on the system. Photo courtesy of Rich Pruitt

Biodigesters and dehydrators help cruise ships reduce food waste. Photo courtesy of Rich Pruitt

content to 0.5 percent globally. The cruise industry's adoption of liquefied natural gas-fueled ships also provides air emission benefits such as lower nitrogen oxide and particulate matter emissions. Additionally, the adoption of fuels with low sulfur content; the use of approved Exhaust Gas Cleaning Systems (EGCS); and improved engine exhaust gas treatment technologies have all been introduced to limit the shipping industry's impact on air quality and climate change.

Several cruise companies have worked closely with the Coast Guard and EPA on trialing the EGCS technologies early in their development. There was also coordination with the European Commission to drive improvements in the technology. Work with the EPA on evaluating the pH limits on EGCS wash water in estuarine and brackish water areas, for example Alaska, continues. To reduce risk to the sensitive areas visited by passenger ships, the cruise sector is going beyond MARPOL requirements and introducing technologies like wash water filtration systems and stricter visible smoke limitations to comply with internal voluntary and local regulations.

IMO started its decarbonization strategy to limit the increase of global temperatures by reducing carbon

intensity and GHG emissions from ships. The strategy is driving companies to consider the adoption of fossil fuel alternatives as well as more efficient technologies such as:

- fuel cells, batteries
- alternative fuels like LNG, biofuels, and e-fuels
- air lubrication systems
- steam turbines
- organic Rankine cycle systems
- variable frequency drives
- efficient entertainment and lighting systems
- high efficiency appliances
- propulsion system improvements, like podded propulsion

The cruise industry has been an early adopter of technologies like using waste heat recovery systems to produce water, provide heating, and generate electricity. Capturing energy from fuel consumed reduces not only fuel consumption but lowers carbon and other emissions. Photo courtesy of Rich Pruitt

A reverse osmosis water desalination unit can provide potable water from seawater. This treated water can then be used for anything for which fresh water is required. Photo courtesy of Rich Pruitt

- hull hydrodynamic modifications
- hull coating developments and grooming techniques
- HVAC systems that use low Global Warming Potential refrigerants

The cruise industry has been an early adopter in trialing many different options, like air lubrication systems which reduce hull friction and propulsion power demands. This is in addition to extensive use of waste heat recovery systems to produce water, provide heating, and generate electricity via steam turbines. The future will see the industry moving to the use of Organic Rankine Cycle systems and absorption coolers to capture even more of the energy available onboard that today goes into the exhaust gas stream or cooling water. By capturing more of the energy from fuel consumed, fuel use is reduced along with the resultant carbon and other emissions.

Another important development is the expanding use of "cold-ironing," or shore power. In 2001, a cruise company started using a shore power connection in Juneau, Alaska, that derived its electrical power from surplus hydroelectric power. This has led to a greater number of ports, including many in California, Seattle, Vancouver, and others, pursuing shore power, which has resulted in reductions in local air emissions and global GHG. Today, 40 percent of the cruise industry's ships are outfitted for shore power with more to come. Of the new cruise ships scheduled for delivery through 2028, 98 percent will be shore power capable. However, only 29 ports, or less than 5 percent worldwide, are shore power ready.

Ballast Water Management Convention

Similar to the U.S. Aquatic Nuisance Species Act, the Ballast Water Management Convention was enacted by the IMO to prevent the transportation of invasive aquatic species from one port area to another. There are many examples of how these invasive species, like zebra mussels and lionfish, present severe consequences both to infrastructure and ecosystems, respectively.

In general, cruise companies were early adopters of ballast water technology, opting to install treatment systems on many ships to help improve the technology prior to the Ballast Water Management Convention's enter-into-force date of September 8, 2017. They completed retrofitting ships with this technology ahead of schedule.

Ultimately, the United States did not agree to the IMO treatment standards which led to many companies installing ballast water treatment systems that initially did not receive Coast Guard type approval. This resulted in significant administrative and compliance issues and the retrofitting of additional capabilities after installation.

MARPOL Versus Local Regulations

There are numerous examples where regional, national, and local regulations exist that are not fully aligned with MARPOL standards, creating compliance complexity for operators. In the United States, the Vessel General Permit is one example of a complex environmental regulatory body of standards that differ from those under the MARPOL annexes. In addition, the VGP includes unique state and local standards which further increases the compliance burden on international ships that call on U.S. ports. Fortunately, Congress recently acknowledged the benefits of aligning with international standards with its adoption of VIDA, which the president signed into law. This should help align the Vessel Incidental Discharge Act (VIDA), for which the EPA is currently developing the standards.

Examples of current differences between U.S. law and MARPOL regulations include ballast water treatment standards that differ from the Ballast Water Management Convention, including the sampling regime, as well as state- and port-specific requirements that differ from MARPOL, which adds additional complexity. The VGP's Section 401 State Certification process allows states to regulate environmental standards in excess of the limits established by the U.S. federal government. Additionally, bilge water analysis requirements do not exist in MARPOL Annex I, and EGCS wash water limits differ from MARPOL Annex VI guidelines. Specifically, the wash water pH limit of no less than 6.5 units is set by MARPOL by measuring the pH meters from the discharge port. Measuring the pH of the wash water inside the ship can accurately determine a compliant pH level that is at least 6.5 units within the allowable mixing zone. The VGP, however, mandates that the wash water be measured just before the overboard discharge and may not be more acidic than a pH of 6.0 units. This discounts the mixing effects of the pump flow and the ship's speed through the water. The wash water sampling regime and analytical equipment calibration requirements also differ from MARPOL.

While the cruise industry clearly supports an international approach to environmental standards, there are national laws that have also clearly shown measurable success in protecting the environment. The Oil Pollution Act of 1990 is a good example. Developed shortly after the Exxon Valdez spill, it bolstered prevention procedures and equipment standards to prevent operational spills. It also mandated U.S.-based resources to respond to spills, required local planning, established a trust fund to cover cleanup costs for "mystery spills" and catastrophic incidents, and required companies to have spill cleanup insurance. Equally important, it increased financial liability for operators who cause them.

The Next 50 Years

The IMO is often maligned for being too slow to act or for not going far enough in regulating shipping's environmental footprint. Critics should remember that the IMO is a body comprising nearly 200 member countries and non-governmental and specialized groups, like classification societies and The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, that support the IMO's work. Given the complexity and importance of global shipping, a methodical and scientific approach has benefitted global populations that rely on marine transportation.

Variable frequency drives increase a ship's fuel efficiency by varying the speed and torque of its motors to meet demand. Photo courtesy of Rich Pruitt

Over the last 50 years, the IMO, through development and implementation of the MARPOL Annexes and environmental conventions, has fundamentally changed the way the shipping industry manages waste and has substantially reduced the environmental impacts of shipping on the world's oceans. The cruise industry has not only embraced MARPOL, but it has also influenced its development and actively adopted policies and practices that exceed its requirements. As we look forward to the next 50 years, the industry encourages the international community to align on global environmental standards development, which will encourage the efficient development of new technologies and continue to support shipping's ongoing protection of our oceans around the world.

About the authors

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Advancing Ballast Water Management to Reduce Invasive Species Transfers

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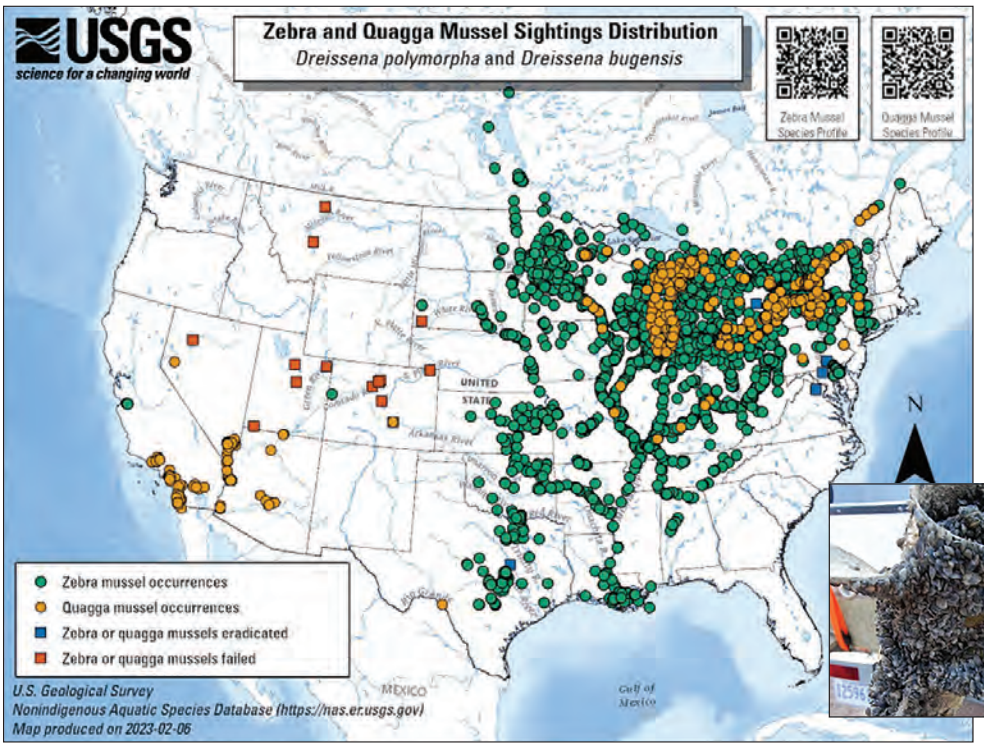
MARPOL, the International Convention for the Prevention of Pollution from Ships, 1973, was an important step toward protection of the marine environment from several major pollution risks associated with maritime transportation. Organized as a set of annexes addressing specific types of pollution, MARPOL now covers oil and oily water; noxious liquids carried in bulk; harmful substances carried in packaged form; as well as sewage, garbage, and most recently air pollution, from ships. The realization that living organisms in ships' ballast water—natural surface waters pumped aboard ships to maintain trim, draft, and stability during navigation and cargo operations—could drastically impact our shared waterways came later.

The introduction of zebra and quagga mussels into the Great Lakes in the mid-1980s attracted widespread public and political attention to the risk of organism transfers in ballast water. Native to European inland freshwaters, these mussels were likely carried in ships' ballast water and discharged to the Great Lakes. They flourished and subsequently spread in lakes and rivers across North America, negatively impacting biodiversity, ecosystem function, and human water-use infrastructure.



Zebra and quagga mussel, or Dreissena polymorpha and D. bugensis, respectively, arrived in the Great Lakes in the late 1980s via the ballast water of ships from Europe, becoming extremely abundant and spreading across North America. Map courtesy of U.S. Geological Survey, 2023

Prolific in U.S. waters, zebra and quagga mussels, impact ecosystem function and water intakes. As seen in this image of a ship 's propeller the mussels have fouled, they can also effect vessel operation.

A ship discharges ballast water while underway. Planktonic organisms, like those collected from ballast water and seen on the right with the aid of a microscope, can introduce non-native organisms into ecosystems where they can have a significant, negative impact. Photo courtesy of the Smithsonian Environmental Research Center

During the same period, impactful investigations of other species occurred elsewhere in the world. The global community began to realize that natural surface waters, when transferred between locations by ships without treatment, carry a diverse assemblage of living organisms that can result in biological invasions with significant and persistent impacts on receiving aquatic ecosystems.

When viewed through a microscope, natural water is teeming with life. Aquatic organisms commonly spend a portion of their lives as plankton in either the adult or larval stage, and reside in surface waters of ports, coastal areas, and oceans. Often small, plankton are unable to swim against currents and travel easily through intake screens and pump impellers. There, they become entrained into ships' ballast water tanks and are discharged in subsequent ports of call where species can colonize, spread, and alter ecosystem function.

Since the arrival of zebra mussels in North America, increasing research and knowledge have brought the extent and risk of species transfers via ballast water into sharper focus. In the United States alone, over 500 non-native species have now colonized our coastlines. It is also clear that the transfer of organisms by ships' ballast water has been a major driver of coastal invasions globally, disrupting ecosystems, fisheries, and local economies.

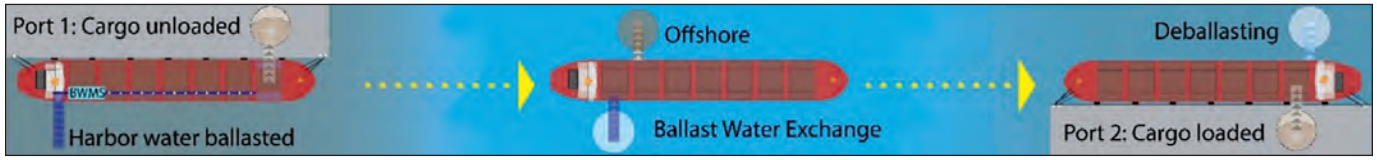
In response to this growing knowledge, policies and regulations emerged over the past 30 years, and the maritime community has made great strides in treating ballast water and reducing the risk of future invasions.

History of Ballast Water Guidelines and Regulations

Responding to several countries' mounting concerns about ballast water invasions, the International Maritime Organization (IMO) began considering the issue in the late 1980s. Initially, IMO explored whether ballast water should be addressed under MARPOL, along with other pollution. However, significant differences between chemical and physical pollutants covered by MARPOL versus the living organisms in ballast water eventually led to a standalone treaty formally known as The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. The Ballast Water Management Convention, or BWM Convention, entered into force in 2017, and has been adopted by over 70 countries.

Although an active participant in developing the BWM Convention, the United States developed its own national legislation and regulatory program to reduce the risks of bio-invasions via ballast water which includes requirements and standards similar to those in the BWM Convention. Starting with the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990, Congress directed the Coast Guard to develop and implement guidelines and regulations to protect the Great Lakes

The International Maritime Organization, or IMO, is the United Nations' specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.



A ship delivers cargo to Port 1, taking in harbor water to compensate for the mass of offloaded cargo. Ballast water exchange occurs offshore in deep waters, and the harbor water is replaced with water containing low concentrations of sediments and organisms. At Port 2, the ship discharges ballast water while loading cargo. The managed ballast water will have only sparse concentrations of organisms, reducing the risk of invasions. Illustration courtesy of Matt First

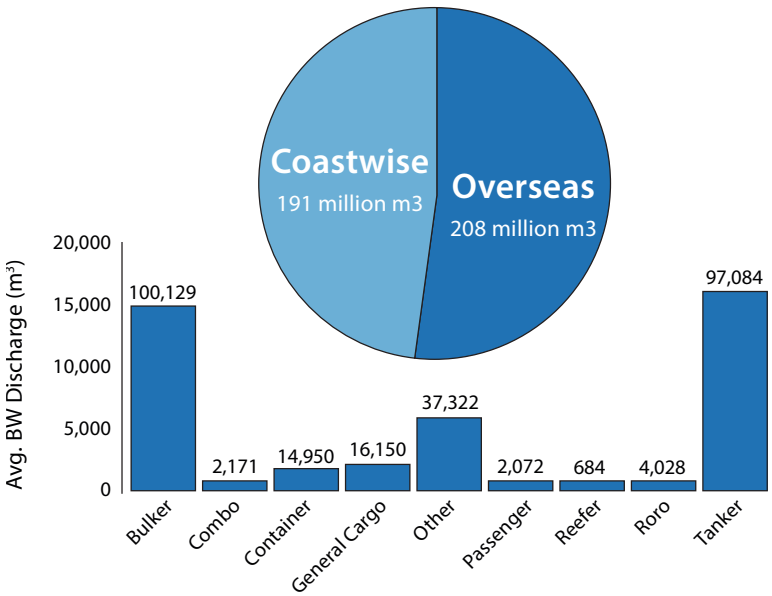
from further ballast water-related introductions. In the National Invasive Species Act of 1996 (NISA), Congress reauthorized and amended NANPCA, directing the Coast Guard to expand the ballast water program nationally. In 1999, acting under NISA, the Coast Guard issued voluntary ballast water management guidelines for ships arriving to U.S. ports outside of the Great Lakes. The service also established the National Ballast Information Clearinghouse (NBIC) to collect and analyze required ballast water management reports submitted by arriving ships.

Following a 2002 assessment that found reporting by ships was insufficient to allow for analysis of the efficacy of the ballast water management guidelines, the Coast Guard established regulations requiring ships to conduct ballast water management in 2004. These regulations consisted of record keeping, reporting, and mid-ocean ballast water exchange (BWE), which entails flushing tanks in open ocean to reduce transfer of coastal organisms among ports, as well as penalties for failure to submit reports.

BWE offered an available stopgap measure to reduce ballast water species transfer because the practice required no retrofitting or new technology, but it was also recognized as impractical for many ships. Ballast water is critical for the maintenance of ship stability, trim, and draft. Yet, many ships were not constructed to conduct BWE safely, especially in rough seas. Ships' ballast water tanks also were not designed to facilitate an effective exchange and many transit routes between ports did not take ships far enough from land to properly conduct open ocean BWE without diversion and delay.

Due to these limitations, the United States and IMO ballast water management programs adopted a phased approach, replacing BWE with other management methods. In 2012, the Coast Guard published new ballast water management requirements for seagoing vessels. Title 33 of the Code of Federal Regulations; CFR 151 subparts C and D included ballast water management practices that are acceptable for use by ships, including a limit on the concentration of living organisms allowed in discharged ballast water, or the discharge standard, for ships using ballast water management systems (BWMS).

These regulations also included a compliance schedule for new and existing ships, provisions for compliance date extensions for ships with extenuating circumstances, and procedures for approval of shipboard ballast water management systems. Ships visiting the United States can use onboard BWMS, discharge ballast water to reception facilities, not discharge in U.S. waters, or use freshwater obtained from U.S. public water systems. Most ship owners install BWMS because, to date, reception facilities have not been widely available, and U.S. public water is expensive and of limited availability to ships.



Section (a) of this chart details total annual ballast water discharge volume divided into overseas and coastwise traffic among North American port sources. Section (b) details the average volume of ballast water discharge by vessel type with maximum reported). Chart courtesy of the Smithsonian Environmental Research Center

The Scale of the Challenge

Implementing ballast water management is a large-scale effort both in the number of vessels and volume of ballast water involved. Roughly 120,000 merchant ships comprise the global fleet of commercial vessels. In the United States alone, there are between 90,000 and 100,000 ship arrivals each year. While most ships do not discharge ballast water on every arrival, those that do can discharge large quantities. Some of the largest ships have capacities of more than 100,000 m^3, or more than 26.4 million gallons. In recent years, the total annual ballast water discharge volume to U.S. waters has exceeded 400 million m^3, or the equivalent of more than 160,000 Olympic swimming

pools.[1] Approximately half of this total discharge into U.S. waters is from vessels arriving from overseas and half is from vessels arriving on coastwise routes within North America. Both average and maximum discharge per arrival differ greatly among vessel types.

Ships are outfitted with high-capacity ballast pumps that can move enormous volumes of water quickly as cargo is loaded and unloaded. Unmanaged ballast water can frequently contain more than 100,000 non-native planktonic organisms per cubic meter. Thus, a single ship carrying unmanaged ballast water can discharge millions to billions of living aquatic organisms that would not otherwise have access to a bay or coastline, creating the opportunity for invasions to occur.

With such high concentrations of organisms, treating the vast quantities of ballast water used by a single ship in an effective, timely, and cost-effective manner poses a major challenge. This is especially true given the constraints of available space, power, and time during vessel operations and range of ship operating conditions. Onboard treatment necessitates dedicated space to accommodate a BWMS, and often additional generator power and chemical supply. Replenishing parts and materials needed for onboard treatment can require careful logistics planning, securing supply chains, and route alterations. These challenges are greatly amplified when considering the entire global fleet. Critically, ballast water taken up in ports around the world varies greatly in water quality characteristics—salinity, temperature, and the concentrations and nature of particulate and dissolved materials—all of which can affect the performance of treatment technologies. Finally, many maritime trade routes are quite short, with voyages taking less than a day, posing additional challenges for treatment processes that may require longer times for necessary efficacy.

Approach to Implementing

Ballast Water Treatment

Under the IMO and U.S. discharge standards, discharged ballast water must not exceed specific concentrations. For organisms as small as 50 micrometers (μm), approximately the diameter of a human hair and including mostly small animals in ocean and coastal waters, the limit is less than 10 living organisms per cubic meter. For organisms that are even smaller and predominantly single-celled organisms of 10 μm to 50 μm, the limit is less than 10 per milliliter. Additionally, for bacteria that are less than 10 μm in size, there are limits on the number of viable cells per 100mL. These "indicator" bacteria are regulated to reduce the likelihood of transporting human diseases among locations.

Three bacteria groups—Escherichia coli, a group of gut bacteria known as enterococci, and two cholera-causing varieties of Vibrio cholerae—serve as indicator species and are regulated to reduce the likelihood of transporting human diseases among location.

A range of technological approaches have been developed for treating ballast water to reduce the number of organisms. These technologies include filtration, use of chemicals such as chlorine and ozone, ultraviolet radiation, deoxygenation, and heat—individually and in combination. In the case of chemicals, these must also be neutralized prior to discharge to meet acceptable water quality standards and minimize the risk to coastal waters.

Ballast water regulations require that BWMS be approved by regulatory authorities, like the IMO and the Coast Guard, prior to installation on vessels. The approval processes under both the IMO and Coast Guard regulations are based on a framework known as type approval, wherein a specific system is tested to demonstrate that it can meet the aforementioned discharge standard under challenging, but not extreme, conditions. Following approval, shipowners may use exact replicas of the tested system. Thus, regulatory authorities have a basic expectation that a ship that operates and maintains an approved system is likely in compliance with the discharge standards, compared to a ship with an unknown system.

The development of type approval testing procedures for BWMS required a concerted effort by numerous technical experts. In the United States, the Coast Guard partnered with the Environmental Protection Agency (EPA) to develop testing procedures under the Environmental Technology Verification (ETV) program. Under this program, a working group of marine biologists and water treatment engineers developed, with input from technology manufacturers and ship operators, a standard protocol to validate the performance of BWMS. The EPA published the ETV protocol in 2010. The ETV protocol served as the basis for the eventual type approval testing requirements adopted by the Coast Guard and the IMO. The type approval process under both the Coast Guard and IMO involves testing conducted by independent laboratories which are officially authorized to perform the tests.

The Coast Guard approved the first independent laboratory for testing BWMS in September 2012, and currently recognizes six such facilities. The service's Marine Safety Center approved the first BWMS in December 2016, and had approved 50 systems by mid-2023.

The Coast Guard assesses compliance with the ballast water management regulations during Port State Control

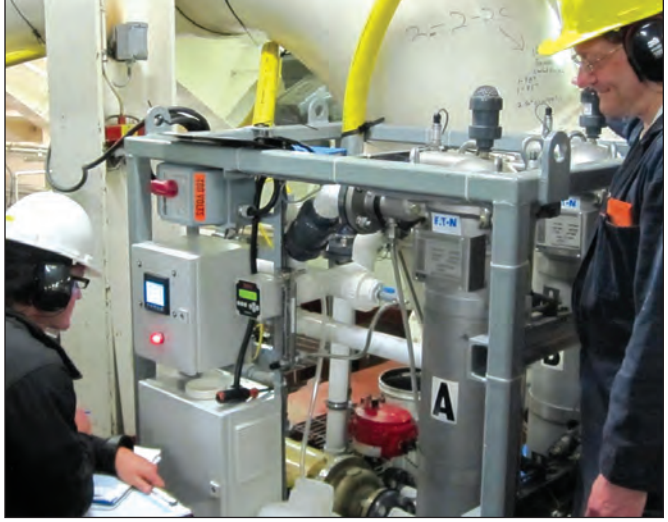
exams of foreign flagged vessels and inspections of U.S.-flagged vessels. To date, these assessments have focused on verifying that:

- ballast water management practices are being used as required
- BWMS installed on vessels has been approved and is appropriately maintained and operated
- ships have and use acceptable ballast water management plans specific to the ship and its operations
- vessels are submitting required reports to the NBIC

Although regulations authorize the Coast Guard to collect and analyze samples of ships' ballast water discharges, to date the agency has not conducted discharge sampling to confirm standards have been achieved. Currently, a lack of sufficiently validated and rapid methods that can be practicably and reliably integrated into the extensive suite of inspection activities, and which do not impede the smooth conduct of vessel and port operations, preclude such sampling.

The Coast Guard has partnered with the U.S. Naval Research Laboratory (NRL) to develop methods for collecting and analyzing samples, and for testing rapid discharge assessment technologies. Together, the Coast Guard and NRL have participated in international efforts under the International Organization for Standardization (ISO) to establish standard methods for collecting and analyzing ships' ballast water to determine compliance with the discharge limits. These methods are being published by the ISO as standard ISO 11711, which includes three parts that specify:

A Coast Guard member inspects a ballast water treatment system during a ballast water management exam on a foreign-flagged vessel in the Port of Baltimore. Photo courtesy of Richard Everett



Engineers with the U.S. Naval Research Laboratory work on a prototype ballast water sample collection apparatus developed as part of a Coast Guard-sponsored project. Photo courtesy of Matt First

- the location and characteristics of ports to be installed in the ballast system piping from which samples may be drawn
- the characteristics of extraction equipment used to collect samples
- the methods and procedures for analyzing the samples, which are currently under development

The Coast Guard and NRL are also partnering in the ISO effort to develop standard test methods for verifying rapid analysis technologies used to evaluate ballast water samples. Several such compliance monitoring devices have been developed by industry, but none have been tested and verified as having an acceptable level of accuracy.

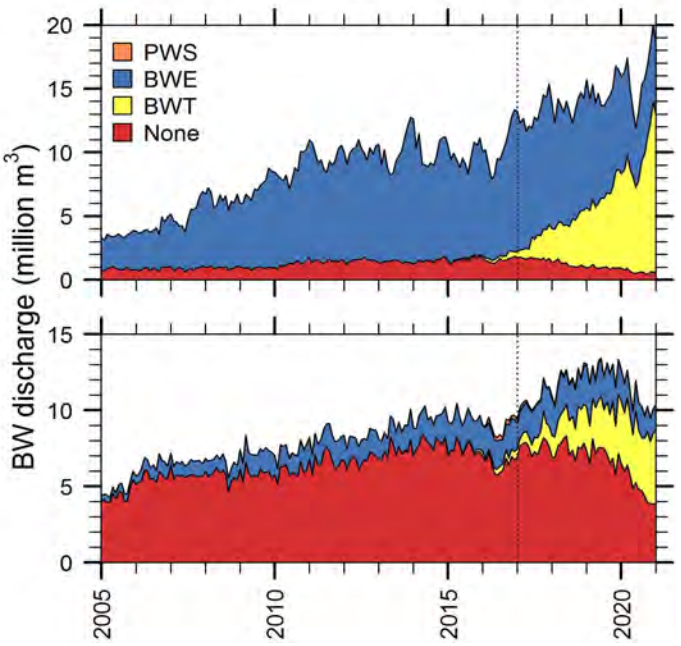
Current Status of Ballast Water Management in the United States

Today, the vast majority of ballast water is managed prior to discharge in U.S. waters. As directed by Congress in NANPCA 90, the Coast Guard and the Smithsonian Environmental Research Center (SERC) established the NBIC to evaluate implementation of ballast water management over time. This evaluation applies to commercial ship arrivals to U.S. ports and places, whether arriving from overseas, including Canada, or coastwise. Reporting by vessels expanded dramatically when penalties took effect in 2005, providing a detailed and near-complete record of ballast water management for about 90,000 vessel arrivals per year.

Due to expanding trade, total ballast water discharge from overseas has increased since 2005, and vessels report that nearly all of the approximately 200 million m^3 of discharge is being managed. Initially this management was BWE but it has rapidly been replaced by management with approved BWMS following Coast Guard type approval of the first systems. Before passage of NANPCA in 1990, any form of ballast water management, including exchange or treatment, was a rare occurrence in the

United States, except to reduce sediments in tanks. Since this time, the maritime industry implemented BWE on an extensive scale as an initial stopgap management strategy. In the past five years, BWE has been rapidly replaced by ballast water management.

Mid-ocean BWE has not been fully feasible nor required for coastwise transits, because these routes rarely transit the open ocean. Nonetheless, since 2017, coastwise operating vessels have rapidly adopted ballast water management in many regions of the United States. Thus, the availability of new management systems has expanded the scope and feasibility of ballast water management to include vessels which previously had few options available.



These charts represent the total monthly ballast water discharge reported in U.S. waters by management type. The top panel shows the volume of ballast water from overseas sources, where most water was treated by ballast water exchange prior to 2017 (vertical dotted line), when ballast water treatment systems rapidly increased, with a small, declining portion of unmanaged water. The bottom panel shows a predominance of untreated water for coastwise water of North American origin until 2017, when ballast water treatment use rapidly expanded. Chart courtesy of the Smithsonian Environmental Research Center

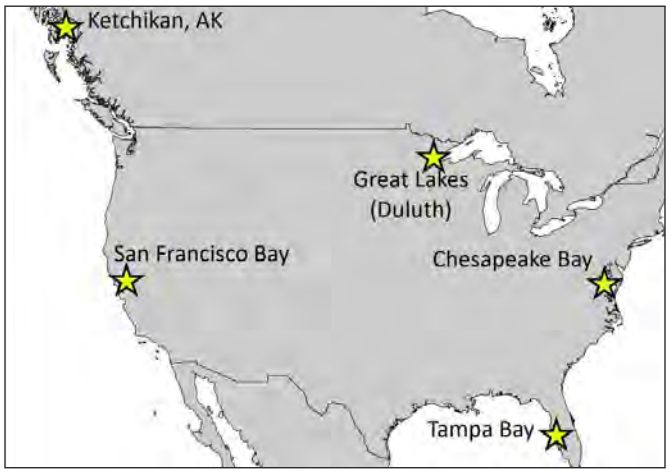
Effect of Ballast Water

Management on Invasion Risk

This broadscale implementation of ballast water management is expected to greatly reduce the delivery of organisms in ballast water and the likelihood of invasive species introductions. For example, considering the larger sized organisms, > 50 μm, alone, untreated ballast water has on average 1,000 - 10,000 organisms per cubic meter depending on route and season. When BWE is used properly, approximately 10 percent of these organisms are retained in ballast tanks, which cannot be emptied completely during the exchange. While BWE reduces invasion risk, there can still be thousands of residual coastal organisms per cubic meter. Ballast water management is expected to consistently achieve a much lower concentration of < 10 organisms per cubic meter. Each step in this phased implementation provides greater protection against invasions. Simply put, the probability of colonization increases with the number of organisms delivered.

While there is no question that this ballast water management is reducing invasion risk, there is still uncertainty about how much risk remains. Considering only those organisms > 50 μm in size, even the current standard and numeric limit of 9 organisms per m^3 scales to an estimated 900,000 organisms in a single ship discharge of 100,000 m^3. Thus, despite the strong reduction in organisms provided by existing management actions, the total vessel discharge of approximately 400 million m^3 each

Smithsonian Environmental Research Center scientists conduct ballast water sampling and analysis of organism concentrations aboard a commercial ship in the Chesapeake Bay. Photo courtesy of Kimberly Holzer



Sentinel Sites were established to evaluate the effect of ballast water management on reducing new invasions of U.S. waters using repeated field sampling campaigns every 1-3 years. Major ports in different coastal regions are represented to provide robust measure, since each region differs in environmental conditions and vessel trade patterns. Map courtesy of the Smithsonian Environmental Research Center

year in the United States[2] still contains some residual organisms with unknown invasion risk. Recognizing this critical knowledge gap, the NBIC was tasked with assessing implementation of ballast water management of vessel arrivals in the United States over time, evaluating efficacy in reducing the concentrations of organisms on operating vessels, and monitoring new invasions at a national scale. All three components are key performance measures tracked over time, and assessing the extent of new invasions is the ultimate tool to evaluate management success and remaining risks.

In partnership with Coast Guard, SERC is evaluating declines in organism abundance in ships' ballast water over time by sampling vessels during normal operating conditions and across a diverse range of environments. During these sampling events, a team of SERC scientists sample and analyze organism concentrations on ships upon arrival to selected U.S. ports on the Pacific, Atlantic, and Gulf coasts, as well as the Great Lakes. This is not compliance testing, but the work aims to provide a robust measure of changes that result from ballast water management, beyond the initial type-approval assessment.

In parallel, as part of NBIC, SERC evaluates invasions over time on a national scale, using continuous analysis of published records, as well as repeated field surveys at key sentinel sites, or port systems, in five U.S. regions. Conducting field surveys and in-tank ballast water sampling, this program aims to evaluate the extent to which new invasions are detected in association with ships' ballast water.

The Future of Ballast Water Management

Since 2017, there has been a dramatic and rapid increase in ballast water management by vessels in the United States, adding to the protection of the aquatic environment, yet ballast water management is continuing to evolve. In 2018, the U.S. Vessel Incidental Discharge Act was enacted into law, amending the Clean Water Act to direct the EPA to establish discharge standards. Simultaneously, the Act directed the Coast Guard to establish compliance requirements for a suite of 20 ship discharges, including ballast water. It is still too soon to know what associated changes may result in regulations and requirements. In the case of ballast water management, it is clear there is already a solid foundation and framework in place to build upon.

About the authors:

Dr. Greg Ruiz is a senior scientist and leads the Marine Invasion Research Laboratory at the Smithsonian Environmental Research Center. In partnership with Coast Guard, his team of 40 scientists have established and run the National Ballast Information Clearinghouse over the past 25 years, evaluating ballast water management and invasion dynamics.

Dr. Matt First and others at the U.S. Naval Research Laboratory have been supporting the Coast Guard and other federal agencies to address technical issues related to the implementation of the ballast water discharge standard. In 2022, the research team was awarded the Coast Guard Meritorious Civilian Service Award for its contributions over two decades.

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Dr. Mark Minton is the senior data analyst for the National Ballast Information Clearinghouse at the Smithsonian Environmental Research Center since 2004.

Dr. Rich Everett is a senior scientist with Excet, Inc, supporting the Naval Research Laboratory. From 1999 through 2021 he was an environmental protection specialist working on ballast water management issues with the Coast Guard.

References

Albert RJ, Lishman JM, Saxena JR 2013. Ballast water regulations and the move toward concentration-based numeric discharge standards. Ecol. Applications 23, 289–300

Commercial Vessel Ballast Water Management: Report to Congress 2022. Washington, D.C.: United States Department of Homeland Security, September 30, 2022. https://doi.org/10.5479/10088/115375

Miller AW, Minton MS, Ruiz GM 2011. Geographic limitations and regional differences in ships' ballast water management to reduce marine invasions in the contiguous United States. Bioscience 61(11), 880-887

Minton MS, Verling E, Miller AW, Ruiz GM 2005. Reducing propagule supply and coastal invasions via ships: effects of emerging strategies. Frontiers Ecol. Environ. 3, 304–308

National Ballast Information Clearinghouse (NBIC) 2023. https://nbic.si.edu/

National Estuarine and Marine Exotic Species Information System (NEMESIS) 2023. https://invasions.si.edu/nemesis/

National Research Council (NRC) 2011. Assessing the relationship between propagule pressure and invasion risk in ballast water. National Academy of Sciences, Washington, D.C.

Ruiz, GM, Fofonoff PW, Steves BP, Carlton JT. 2015. Invasion history and vector dynamics in coastal marine ecosystems: a North American perspective. Aquat. Ecosyst. Health Manag.t 18, 299-311

United States Department of Homeland Security 2012. Standards for living organisms in ship's ballast water discharged in U.S. waters. Federal Register 77(57), 17254–17320

Endnotes

[1] National Ballast Information Clearinghouse (NBIC) 2023. https://nbic.si.edu/

[2] Ibid

Present Efforts

Maritime Environmental Enforcement

Past, present, and future

by LCDR Benjamin M. Robinson
Environmental Standards Division
Office of Operating and Environmental Standards
U.S. Coast Guard

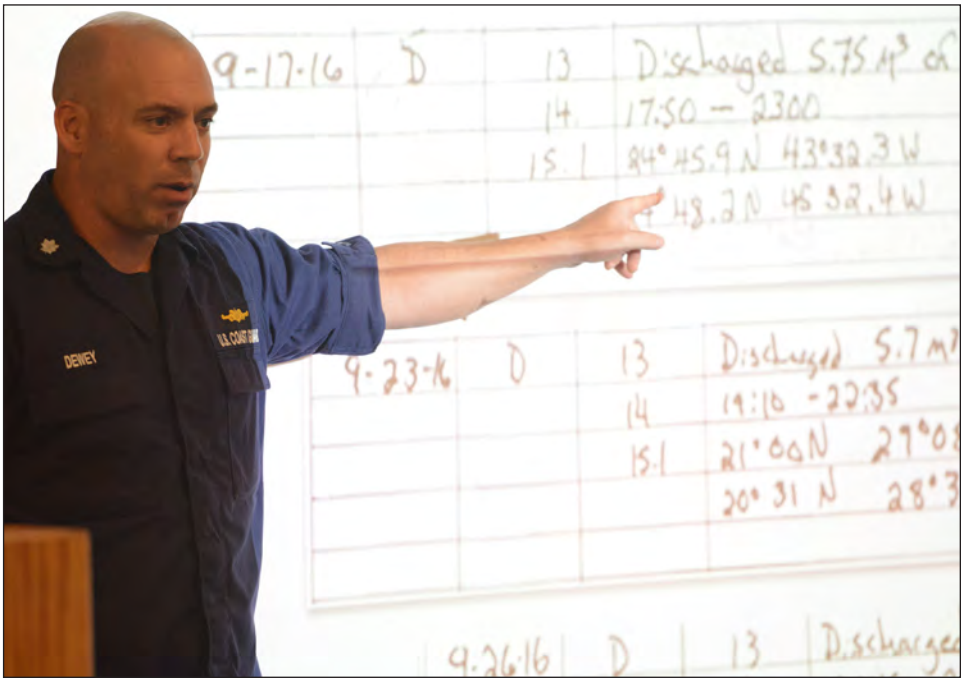
Shipping has changed immensely since the Rivers and Harbors Act of 1899 enacted the first federal criminal penalties for water pollution in the United States. Often referred to as the Refuse Act, the law made it a misdemeanor "to throw, discharge, or deposit … from or out of any ship, barge, or other floating craft of any kind … any refuse matter." Although the concerns that led to the enactment of the Rivers and Harbors Act were unrelated to maritime oil pollution, the law entered into force just as the first generation of oceangoing ships was being fitted with bulk oil tanks. That generation included the Norwegian *Zoroaster* in 1878 and the U.S. *Falls of Clyde* in 1907. At about the same time, steamships began transitioning from coal-fired boilers to oil and shipbuilders began experimenting with diesel propulsion engines.

These technological shifts brought with them consequences for the marine environment, prompting prosecutors to look to the Rivers and Harbors Act to address the emerging problem of oil in U.S. waters. Despite the absence of "oil" in the Act's language, federal courts had no difficulty concluding that oil could constitute "refuse" and its discharges into U.S. navigable waters was prohibited. Oil pollution also was also on the mind of legislators in the United States, who passed the Oil Pollution Act of 1924 (OPA 24) to reinforce the existing prohibitions on discharges of oil into U.S. navigable waters.

The domestic legislation of the 1920s highlighted the international law issue prompted by coastal discharges beyond the territorial seas—then just three nautical miles. Following passage of OPA 24, the U.S. government called an international conference that ultimately led to agreement on a prohibition of discharges of oil in concentrations above 500ppm within 50 miles of shore. Despite agreeing on a standard, the 1926 conference did not lead to a treaty. Further work languished until the United Kingdom called a conference in 1954, leading to the International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL 54).

OILPOL 54 further developed discharge standards, reducing the concentration for non-tank vessel discharges from 500 to 100ppm. It also introduced the Oil Record Book (ORB) as a means of verifying compliance.

The convention also contained provisions aimed at



Commander John Dewey points out examples of a falsified Oil Record Book during an Oceania Oil Spill Response Workshop at Coast Guard Base Honolulu. Oil Record Books were introduced in OILPOL 54 to verify compliance with discharge standards. Coast Guard photo by Petty Officer 2nd Class Tara Molle

enforcement, including expressly allowing signatory port states to examine the ORB. The admissibility of certified copies of the ORB in judicial proceedings demonstrates that, from the outset, it was seen as an important enforcement device. OILPOL Article III also stated that discharges in violation of the standards "shall be an offence punishable under the laws of the territory in which the ship is registered" and required that the amount of penalties for discharges outside territorial seas be no less than those within them. OILPOL was amended in 1962 to expand its scope in terms of vessel size and the extent of the pollution prohibition zones, and again in 1969. This last time to reduce oil discharges associated with cargo tank washing by requiring use of the load on top method, which uses decanting to separate oil cargos from washings. Although many vessel operators followed the 1969 amendments, they were not ratified by enough parties to enter into force.

In 1966, Congress amended OPA 24 to require vessel owners to remove spilled oil. Several years later, it was repealed and replaced by provisions under the Federal Water Pollution Control Act enacted through the Water Quality Improvement Act of 1970. These amendments reshaped marine pollution law in the United States by introducing the "harmful quantity" concept and the requirement to report oil discharges or face criminal penalites. The 1970 Act also brought OILPOL 54 within the domain of U.S. domestic law for the first time.

A Watershed Moment for Maritime Pollution

In 1973, a conference was held to draft a new convention, with far broader goals—the "complete elimination of intentional pollution to the marine environment by oil and other harmful substances and the minimization of accidental discharges of such substances." Preventing accidental pollution was a major impetus for the 1973 conference, and a priority for the United States, which hoped to impose an international requirement for segregated protective ballast tanks—double hulls—on oil tankers. This single change was meant to reduce likelihood and magnitude of catastrophic oil spills like the 1967 *Torey Canyon* stranding and sinking.

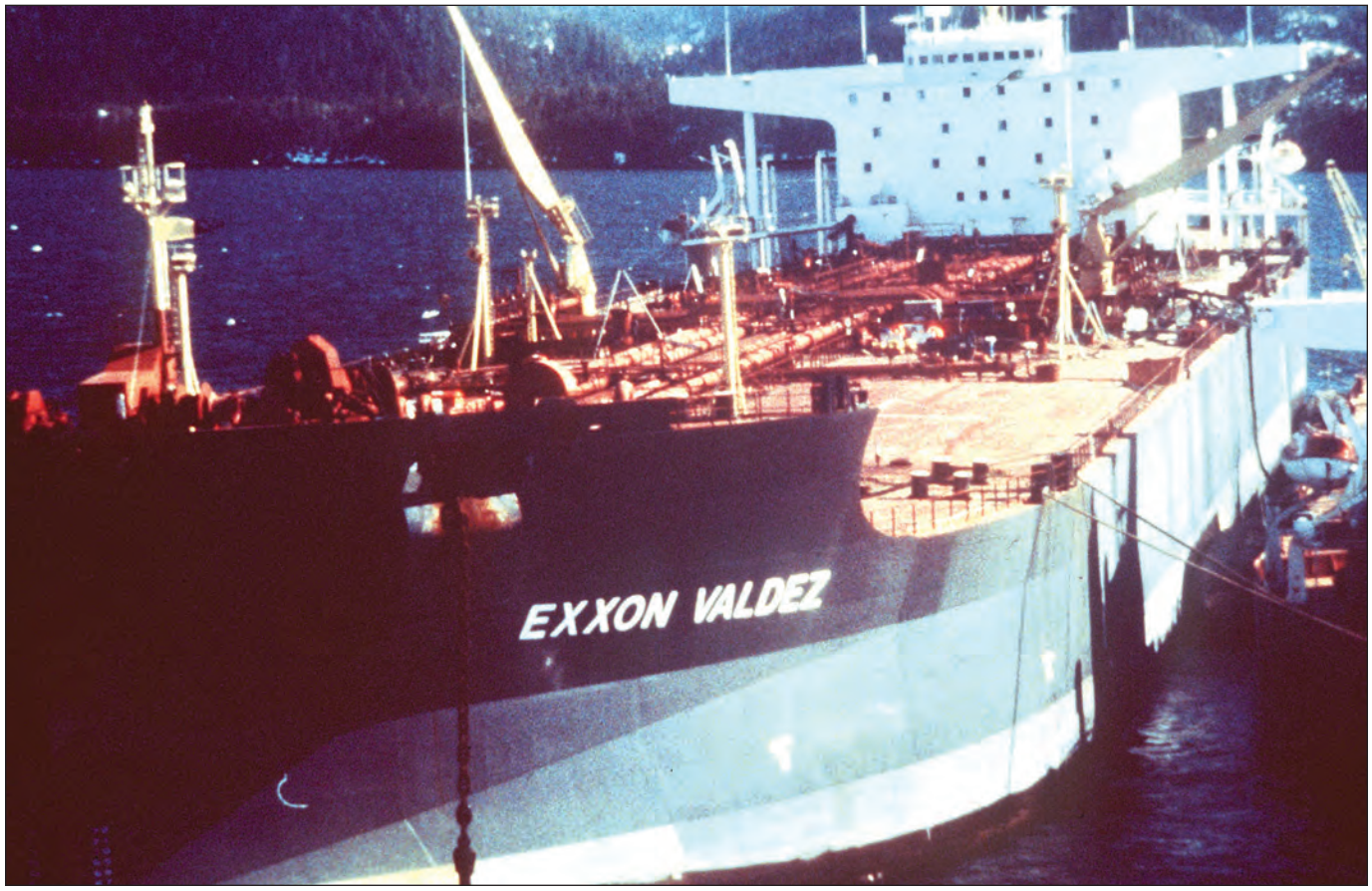
Beyond stating a commitment to eliminating, not just reducing, intentional pollution, the conference recognized the work to be done in addressing marine pollution other than oil. The resulting International Convention for the Prevention of Pollution from Ships (MARPOL) achieved the double-hull standard and implemented other important pollution prevention measures, like the requirement for oily water separating equipment.

Another significant development occurred in 1973 when the international Maritime Consultative Organization—now the IMO—established the Marine Environmental Protection Committee, thereby providing a permanent forum for marine environmental concerns. The committee originated in a U.S. proposal with the goal of putting maritime pollution on equal footing with safety as matters within the agency's competence and jurisdiction.

During a Port State Control Exam, Chief Warrant Officers Scott Stykel and Darrel Howells, Coast Guard Sector Anchorage, inspect the oily water separator aboard the *Albany Sound*. Oily water separators were one of the three pieces of equipment MARPOL 73 required be installed on all ships. Coast Guard photo by Petty Officer 1st Class Sara Francis

On the enforcement front, MARPOL made several significant advances. The first was creating a port state to inspect vessels for compliance with MARPOL's requirements as set forth in a ship's certificate. The second was the adoption of the 15ppm standard for machinery space discharges. More than just decreasing the quantity of oil entering the oceans, this change improved the enforceability of the limit.

Effluents containing oil in concentrations of 15ppm, however, do not produce a visible sheen and thus every visible sheen from a discharging vessel indicates a violation. Studies showed that discharges containing concentrations of oil as low as 50ppm can be visually observed from aircraft. Consequently, visible sheen emanating from a vessel was not concrete proof of a prohibited



In 1989, the *Exxon Valdez* ran aground, spilling 11 million gallons of oil into Alaska's Prince William Sound causing the worst oil spill in U.S. history at the time. While catastrophic, it made many Americans aware of how destructive oil spills can be. Coast Guard photo

discharge under the 100ppm standard adopted by OILPOL 54.

The third notable development of MARPOL 73 was the requirement for three pieces of equipment—oil-water interface detectors for tankers, oily water separators, and oil content meters for machinery spaces on all ships. The technological development of these pieces of equipment remained in flux through the 1970s, but the equipment was available by the time the 1978 MARPOL Protocol opened the way to MARPOL's entry into force. With these three elements in place, the stage was set for earnest efforts to enforce international maritime pollution standards.

In 1989, a catastrophic oil tanker grounding—the *Exxon Valdez*—again bought maritime pollution to the fore. It also provided prosecutors an opportunity to bring to bear federal environmental law authorities enacted in the 90 years preceding the action. The result was a case with charges under a diverse array of statutes—the Clean Water Act, the Refuse Act of 1899, the Migratory Bird Treaty Act, the Ports and Waterways Safety Act, and the Dangerous Cargo Act, 46 U.S.C. § 3718(b).

Renewed interest following the *Exxon Valdez* led the way to Coast Guard aerial surveillance via radar and infrared sensors in the first half of the 1990s. While initial investigatory effort was prompted by oil discharges observed by Coast Guard aircraft, it soon became apparent that falsified Oil Record Books were a key aspect of the illegal practices that went along with the prohibited discharges. The prosecution of the discharges spotted by Coast Guard aerial surveillance laid out theories of responsibility that continue to underpin the U.S. approach to MARPOL enforcement.

First, the oil samples were used to match discharged oil from its source on the defendant's vessel. The matching "fingerprint" of the samples supported charges for discharging oil in violation of the Clean Water Act. Another charge addressed the vessel operator's failure to report the discharges as required by the Act. Finally, a number of charges addressed falsified Oil Record Books entries under the federal false statement statute 18 U.S.C. § 1001 and a host of related charges for false statements to Coast Guard personnel, witness tampering, obstruction of justice, and related conspiracies.

The legal issues raised in these initial vessel discharge cases have also proved enduring facets of U.S. maritime environmental crimes cases. Defendants challenged whether the prosecution went beyond the bounds laid out by the Law of the Sea Convention on coastal state

Response vessels recover an oil discharge using a technique called "herding" off the coast of Brunswick, Georgia, in 2021. Vessel discharges are necessary during the course of operations, but the discharge must meet the standard of <15 ppm ratio of oil to water. At that ratio, there is no oil sheen on the water surface like that seen around this discharge. Coast Guard photo

jurisdiction over the territorial seas or violated the "law of the flag" doctrine. Although neither challenge was successful, these issues continue to define the contours of U.S. maritime pollution cases.

Subsequent cases have also relied significantly on the Act to Prevent Pollution from Ships (APPS)—the U.S. law that implements MARPOL requirements in our legal system. Moving beyond the federal false statements statute, these cases have relied on APPS's criminal enforcement provision, which allows criminal charges for knowingly violating MARPOL and U.S. regulations issued under them. Prominent among these is the U.S. regulation implementing the Oil Record Book requirement—33 CFR 151.25.

Under this approach, vessel owners and operators can be held liable for Oil Record Books used in U.S. waters that contain false entries or omit required entries about operations that occurred outside U.S. waters. At first blush, this appears to be an end-run around the law of the sea division of authority between port state and flag state. However, the charge relies on conduct in U.S. waters and has thus withstood scrutiny by U.S. appellate courts in several judicial circuits. Moreover, the Coast Guard's environmental crimes voluntary disclosure policy provides an avenue for vessel owners and operators to disclose and correct violations without exposing themselves to liability. This policy, and the even more basic opportunity for vessel operators to audit and correct their own environmental compliance, reinforces the fairness of the approach.

Tackling Technicality: MEPC.107(49)

Much as the development of oil concentration sensor and oily water separator technology proved to be a precondition of enforcement of discharge standards, improvements in sensor and separator design have played an important role in improving and enforcing compliance. Paramount in this regard has been the revised standards for oily water separators adopted by the IMO in 2003. This standard both improved the minimum allowable performance for approved oily water separators and oil content meters, and drastically reduced the avenues available to circumvent or frustrate the proper functioning of the equipment. Several of these remain significant today.

First, the oil content meter sensor was sealed, preventing shipboard personnel from recalibrating it to allow excessive oil in discharged effluent. Second, a requirement was added for an alarm to activate when clean water was supplied to the sensor in lieu of effluent sample from the oily water separator's discharge side. These two changes thwarted the most common methods of tricking sensors to discharge in violation of MARPOL.

Third, the new standard required that the oil content meter record operational status and alarms together with the associated time and date. The recording device must be capable of storing a record of the data from operations on board a ship for 18 months. This requirement has resulted in significantly stronger evidentiary bases for prosecutions.

Because maritime oil pollution was the impetus for the MARPOL convention, it should not be surprising that even at its 50th anniversary most MARPOL enforcement under U.S. law addresses violations of MARPOL Annex I, the oil pollution annex. That said, the United States has taken enforcement action under MARPOL's other annexes, too. Vessels with inaccurate Oil Record Books have also been prosecuted for similar inaccuracies in garbage record entries about the ship's plastic wastes. MARPOL enforcement marked another significant milestone in 2019 with the first APPS conviction for violations of Annex VI, which addresses maritime air pollution.

MARPOL Enforcement in the Next 50 Years

If one thing can be gleaned by tracing U.S. oil pollution enforcement efforts from their inception to the present, it is that the right regulatory measures must be developed and implemented before effective enforcement is possible. Among recent regulatory developments under MARPOL, three stand out as significant in the enforcement arena in the years ahead:

- the adoption of electronic record keeping systems for MARPOL compliance
- implementation of carbon intensity reduction regulations under Annex VI, Chapter 4
- proposed amendments related to sewage Annex IV

A diesel engine is installed on the USS *Freedom*. Around the start of the 20th century, shipbuilders started shifting from coal-fired boilers to oil, as well as experimenting with the diesel propulsion engines we use today. These new technologies caused grave environmental repercussions and required new regulations. Navy photo by Cassandra Eichner

In October 2020, amendments to MARPOL Annexes I, II, V, and VI allowed for Electronic Record Books (ERB) as an alternative to the paper record books that have been in use since their introduction by OILPOL 54. Alongside the amendments, IMO's Marine Environment Protection Committee put forward guidelines for the technical requirements for these electronic record books. These guidelines contain requirements for data integrity and system access controls that should improve the integrity of the record. Even more significant, is the possibility for electronic records keeping systems to receive data in the form of direct input from engine room sensors and automation. Much as the improvements in oily water separators have helped more accurately document both compliance and noncompliance, automated inputs to the electronic record books should likewise provide inspectors and investigators with new insights on shipboard environmental compliance.

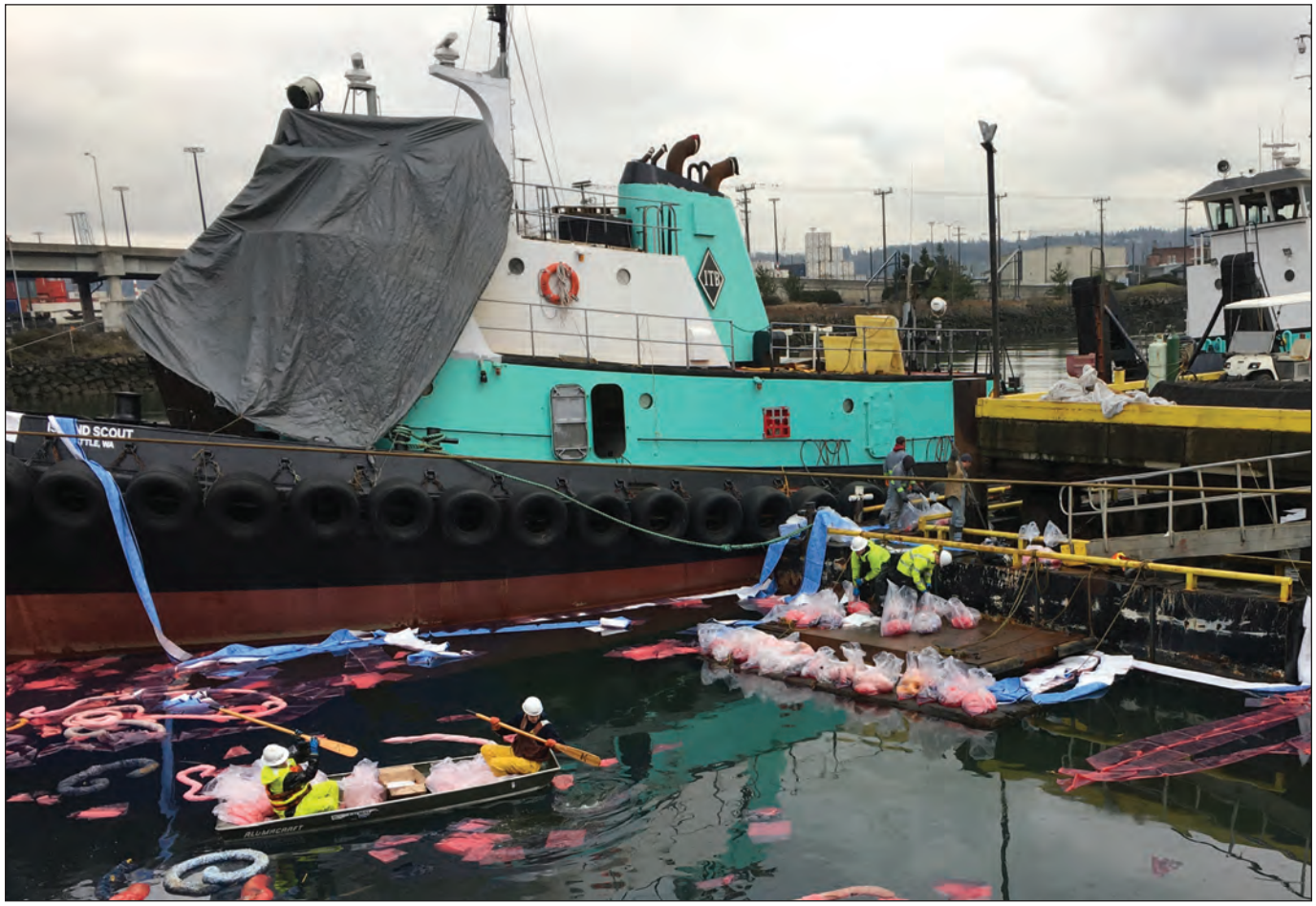
Recent work at IMO under MARPOL Annex IV, sewage, also portend significant changes in the enforcement realm. Using the sewage treatment system on the ship as means of bypassing the oily water separator has proven increasingly popular in recently years. At the same time, a sampling survey by the Netherlands found that most ships were discharging effluents that did not meet the standards, despite having approved sewage treatment plants.

Based on these findings, an extensive overhaul of Annex IV regulations has been proposed that would impose new regulations. Generally, the proposed regulations would require more robust testing, including an onboard system commissioning tests, installation of turbidity sensors with data recording, not unlike an oil content meter, a sewage management plan, and Sewage Record Book.

These requirements will go a long way toward reducing the environmental impacts of discharging sewage from ships, and they will make the sewage plant a less appealing bypass for other shipboard waste streams. They will also, however, increase the regulatory overhead for shipboard engineering departments and possibly present a new temptation to noncompliance.

The final, recent maritime environmental regulatory development that may prove significant on the enforcement front is the IMO's work on ship-generated

A change to MARPOL reduced the amount of oil allowed in a vessel discharge from 100 ppm, as established by OILPOL 54, to 15 ppm. The OILPOL 54 limit was ineffective in proving a prohibited discharge since oil concentrations of 50 ppm produce a visible sheen. Army National Guard photo



Oil spill responders cleanup a diesel fuel spill in the Duwamish River near Seattle after a tug's hull was damaged in a 2017 allision with a barge. While not required for tugs or barges, there is an international requirement for oil tankers to be constructed with double hulls to help prevent oil spill incidents. Coast Guard photo by Chief Petty Officer Donal Warden

greenhouse gas reduction. The most recent regulations on this front just took effect at the start of 2023. These regulations are fundamentally different in nature from both early air pollution regulations in Annex VI addressing NOx and SOx and the regulatory approach in earlier MARPOL annexes.

MARPOL's greenhouse gas regulations part ways with the regulatory approach applied in the past. They do not set emissions standards for CO2, nor do they impose equipment or design standards, like the requirement for an oily water separator. Rather, they employ two vessel-specific indexing calculations coupled to a schedule of progressive reductions to achieve a 40 percent reduction of CO2 emissions by 2030.

The two indexes—one, the energy efficiency design index, rating the energy efficiency of the ship and the other, its carbon intensity—will rely heavily on changes in vessel operations to reduce CO2 emissions. The Carbon Intensity Index will be calculated based on the type and amount of fuel a ship consumes in proportion to its size and distance traveled, all of which must be reported by vessel owners. Given the financial stakes involved in fuel, speed, and routing decisions and the long history in the maritime industry of treating fuel consumption as propriety information, it is reasonable to expect enforcement challenges ahead.

These challenges are now just barely discernable. It may be that the best analogy between enforcing regulations on oil pollution prevention and greenhouse gas reduction is in the gradual and stepwise process toward an effective regime. Nearly a half century passed between the emergence of interest in maritime oil pollution in the 1920s and the formulation of an enforceable regulatory approach under MARPOL so many decades later. If the past is any guide, today's maritime environmental challenges will remain dynamic for many years to come.

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MARPOL Annex VI

26 Years and Counting!

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In the early 1990s, countries around the world became more aware of the damaging impacts of air pollution to human health and the environment. Countries worldwide were experiencing high levels of smog and associated increases in respiratory and cardiac illnesses. Additionally, forests, croplands, rivers, lakes, and buildings were showing the effects of acid rain. As countries developed detailed emission inventory modeling to support the development of their domestic air pollution control programs, it became clear that international shipping was a significant contributor.

In 1990, Congress passed amendments to the Clean Air Act. These amendments called on the Environmental Protection Agency (EPA) to determine whether emissions from nonroad engines, including those on marine vessels, "cause, or significantly contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." If so, the EPA was to set emission standards that "achieve the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the engines or vehicles."[1]

For more information on the Clean Air Act go to *https://www.epa.gov/clean-air-act-overview/clean-air-act-title-ii-emission-standards-moving-sources-parts-through-c*

Exhaust released from ships is a primary contributor to air pollution, causing acid rain and perpetuating respiratory and cardiac health issues. MARPOL Annex VI seeks to gradually reduce these emissions regionally and globally. Photo by danaibe | iStock/Getty Images

About the same time, there was general recognition that air pollution from international shipping would be most efficiently addressed through harmonized emission standards that would apply equally to all ships engaged in international trade. This would avoid a patchwork of national standards that would increase the price of marine transportation and cause unnecessary confusion. The problem was presented to the International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) which comprises 156 countries responsible for making amendments to the International Convention for the Prevention of Pollution from Ships, also known as MARPOL. MEPC was tasked with developing a new MARPOL annex to address international marine air pollution, which it completed in 1997. After a major revision in 2008, the resulting MARPOL Annex VI protocol became a comprehensive program that contains global and regional measures to reduce emissions from international shipping.

While Annex VI addresses many sources of marine air pollution, this article focuses on nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter (PM), and greenhouse gases. Additionally, Annex VI is part of the EPA's coordinated strategy to reduce air emissions from large marine diesel engines and their fuels.

Annex VI: The 1997 Protocol

The MEPC's efforts to address ship air pollution began in the late 1980s. At its March 1990 session, the committee agreed to make addressing air pollution from ships a high priority. It also agreed that "the first step would be to prepare recommendations in a form that could easily be transformed into regulations." At the November 1990 meeting, a working group established—and the committee agreed to—the air emission targets set out in Table 1. It took several years to translate these targets into requirements that could be included in an additional MARPOL annex to be called Annex VI.

For SOx controls, the MEPC decided early in negotiations to set a standard based on the sulfur content of fuel. The program evolved into a two-part approach that would achieve greater reductions in areas that were more damaged from the effects of sulfur dioxide emissions while promoting more moderate reductions elsewhere. At the regional level, the sulfur content of fuel used by ships operating in what would later be defined as a designated Emission Control Areas (ECA) was quickly agreed to be set at 15,000 ppm. This was significantly higher than the fuel sulfur content limit for most land-based fuel. For example, sulfur content of diesel fuel sold in the United States was about 5,000 ppm in 1990. Under the Clean Air Act, the EPA reduced the sulfur content of highway diesel fuel to 500 ppm in 1993, and then 15 ppm in 2006. EPA applied similar limits of 500 ppm to diesel fuel used in nonroad engines, including marine engines, in 2007, and 15 ppm between 2010 and 2012. Although the MEPC had not yet agreed on the criteria for ECA designation, it was already understood that the Baltic Sea would be included as the first ECA in the new Annex VI.

Pollutant	Target level	Target Date
Ozone depleting CFCs	80% of present level	1993
	15% of present level	1997
	Elimination	2000
Halons	50% of present level	1995
	Elimination	2000
Sulfur dioxide (SO2)	50% of present level	2000
Nitrogen oxides (NO2)	70% of present levell	2000
Volatile organic compounds (VOCs)	70% of present levell	2000
Incineration of garbarge and ship generated waste	Criteria to be developed	2000
70% of current value to be achieved by employment of best available technology not entailing excessive cost without increasing other sources of air pollution.		

For SOx control at the global level, the sulfur content limit applicable to fuel used outside ECAs was more challenging. Options for the global fuel sulfur cap ranged from 32,000 ppm to 50,000 ppm. Eventually, a 45,000 ppm cap was settled on, representing a small reduction to the global average.

Ships did not need significant new technology to reduce their SOx emissions through these fuel sulfur controls. However, switching between ECA and global fuel led to the development of new lubricants to reduce sludge formation and cylinder wear.

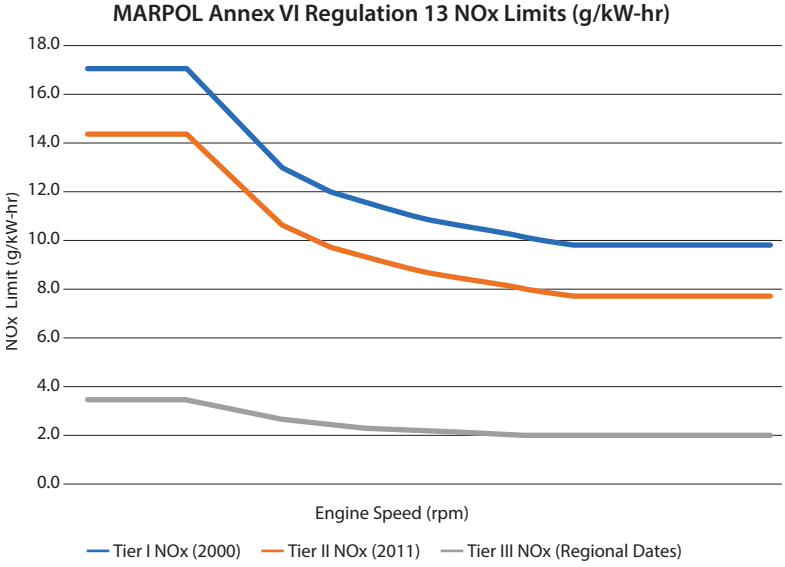
Tentative agreement on NOx engine emission standards was quickly reached in 1994. The initial standards were set at a level that was almost equivalent to the average NOx emissions of the global fleet at the time. This meant that the standard would achieve meaningful reductions only from those new engines that emitted above the limit at the time they were manufactured. While this was not a very aggressive approach, it was the first time marine diesel engines were subject to standards, and the manufacturers of engines and ships needed time to adjust to the certification requirements. This approach also reflected the technologies that were in place in the early 1990s. By the mid-1990s, there was a much greater understanding of the emission reduction potential of newer technologies, leading EPA to adopt more stringent standards in its first marine diesel engine program for U.S. ships. However, the MEPC decided to revisit the NOx engine standards later rather than try to revise them.

The Annex VI NOx standards, which applied to all marine diesel engines above 130 kW, were based on the curve fit described in Figure 1 where low-speed, high-power engines were subject to a less stringent standard than high-speed, low-power engines. To meet the NOx engine standards, engine manufacturers were expected to apply engine-based controls like injection timing and temperature management—turbochargers—which were well-understood. The more challenging part of the NOx negotiations was the design of the engine certification and compliance program, set out in the NOx Technical Code (NTC). The NTC describes the test procedures and requirements that engine manufacturers must comply with to certify an engine for compliance to the emission standards. This took many years, in part, due to differences in countries' engine certification approaches which made it important to draft a program that could apply across all of them.

An important difference between the Annex VI NOx and SOx standards is their compliance dates. While the initial agreement was for each program to be effective in 2000, there were practical obstacles. Specifically, SOx standards could not be effective until the fuel was required, which would not happen until the Annex was adopted by the MEPC and went into effect. However, the SOx emission reductions would be immediate. NOx reductions, on the other hand, relied on turnover of the fleet to cleaner, certified engines. Because ships can remain in service more than 20 years, any delay in implementing the standards would significantly postpone the air quality improvements the standards were intended to achieve. Also, compliance with the NOx limits relies on engine manufacturers building and making available compliant new engines. Therefore, it was possible to set a specific NOx compliance date in the Annex which would apply no matter when the annex went into effect. That date was January 1, 2000, meaning any engine installed on a ship built after that date would be required to demonstrate compliance even if, as expected at the time, the new annex did not enter into force until later. In essence, countries agreed to early implementation of the NOx limits to achieve the targeted emission reduction goals and they agreed to voluntary compliance prior to enforcement.

After the 2008 amendments to MARPOL Annex VI, an increase in the use of exhaust gas cleaning systems, or scrubbers, helped lower sulfur fuels and reduced the cost of using compliant fuel. Photo by Antony Velikagathu | iStock/Getty Images

Negotiations were eventually completed, and Annex VI was adopted by a Conference of the Parties in September 1997. The Annex required ratification by at least 15 IMO Member States, the combined merchant fleets of which accounted for not less than 50 percent of the gross tonnage of the world's merchant shipping, before it could be enforced. It was many years before that happened, but the Annex finally entered into force in May 2005. The Baltic Sea ECA, which was included in the protocol, would go into effect one year later. The NOx standards, as explained above, began to apply in 2000, but then ships would demonstrate compliance through Engine International Air Pollution Prevention certificates.



Annex VI: The 2008 Amendments

When the Conference of the Parties adopted MARPOL Annex VI in 1997, it they also adopted several resolutions. One of them, Resolution 3, invited MEPC to review the NOx limits at five-year intervals after entry into force. This provided the framework for new work and eventually led MEPC to develop and adopt significant amendments to MARPOL Annex VI in 2008. New provisions were added to reduce NOx and SOx emissions even more.

Coast Guard inspectors from Marine Safety Unit Toledo, Ohio, and members of the Environmental Protection Agency observe the installation of an exhaust cleaning system, or scrubber, on the motor vessel *American Spirit* in March 2015 in Toledo Harbor. The scrubber brought the vessel into compliance with new regulations. Coast Guard photo by LT Jerry Federer

The new efforts began at MEPC's July 2005 session, when the committee initiated a general review of MARPOL Annex VI and the NTC. The review would consider advances in marine diesel engine emission control technology and additional fuel sulfur controls. The review would also consider "greenhouse gas emissions (GHGs), alternative fuel use, and propulsion systems other than diesel engines that are not addressed by MARPOL Annex VI." In October 2008, the committee adopted amendments setting new SOx and NOx standards that entered into force in July 2010. The GHG program, as described below, came later.

The 2008 amendments retained the essential features of the original international ship air emission control programs for SOx and NOx. The SOx program remained a fuel-based program but with two new sets of fuel sulfur limits, each occurring over two periods. For ECAs, the sulfur content of fuel was reduced in the short-term from 15,000 ppm to 10,000 ppm beginning in July 2010. The long-term limit was set at 1,000 ppm beginning in 2015. Similarly, the global fuel sulfur content limit was reduced in the short-term from 45,000 ppm to 35,000 ppm beginning in January 2012. The long-term limit was set at 5,000 ppm beginning in January 2015. At this point there were two ECAs for sulfur control—the original Baltic Sea ECA and the North Sea ECA. Again, technology changes were not necessary to accommodate the use of these lower sulfur fuels, but an increase in the installation and use of exhaust gas cleaning systems, scrubbers that remove SOx from the exhaust gas, was expected to reduce the costs of using compliant fuel. In addition, the revisions recognize that the fuel sulfur limits also reduce PM emissions.

The NOx program was amended by including two new sets of engine emission standards. The initial standards were renamed "Tier I" and continue to apply to engines built from 2001 through 2010. A second set of engine NOx standards, called "Tier II," or sometimes the "global NOx limit," applies to engines built beginning January 1, 2011. The Tier II limits are a modest 20 percent reduction from the Tier I limits and can be met through engine-based technologies and exhaust gas recirculation.

The third set of NOx emission standards, called "Tier III," are also known as the ECA standards because they apply to engines only while they are operated in a designated NOx ECA. These ECA standards are a more significant 80 percent reduction from the Tier I limits. They can be met using liquified natural gas (LNG) or, more typically, the application of selective catalytic reduction (SCR) technologies or exhaust gas recirculation (EGR), both of which can be turned off when the ship is operating outside an ECA. SCR is an aftertreatment technology that uses urea injection in conjunction with the catalyst to reduce NOx to nitrogen. EGR is an engine-based technology that recirculates some of the engine exhaust into the engine intake air supply which acts to lower peak cylinder combustion temperature leading to lower NOx emissions.

It should be noted that the application date for the Tier III standards was changed after the Annex VI 2008 amendments were adopted. Initially, the Tier III limits were to apply to engines installed on ships constructed beginning in 2016 and which were intended or expected to operate in any NOx ECA. This meant that future ECAs would achieve larger air quality benefits more quickly since ships would have been built to comply with the Tier III standards and operators would simply have to activate the systems. However, in 2014, MEPC adopted an amendment to the Annex that significantly changed this

For more information on MARPOL amendments, including Annex VI, go to *https://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Pages/MEPC.aspx*

approach. Instead of a fixed date for the ECA controls, 2016, the effective date would be ECA-specific, linked to the date of adoption of a NOx ECA, or even a later date specified by the party proposing the ECA. As a result, there are fewer ships equipped with Tier III engines in the global fleet than originally expected, and the benefits of these important standards continue to be delayed.

The initial Tier I standards, as well as Tiers II and III, apply to engines that are installed on a vessel when it was built. However, there continue to be thousands of ships built prior to 2000 that are equipped with engines that do not meet any NOx standard. These pre-control engines can have very high NOx emissions. To address this, the 2008 amendments include a provision that applies NOx standards to pre-control engines with a power output greater than 5,000 kW and a per cylinder displacement at or above 90 liters installed on ships built in 1990 through 1999. Ships with these engines are required to install an approved system that will reduce emissions to Tier I levels. This new provision for existing engines was expected to provide additional NOx emission reductions.

Air Pollution Results in the United States

The Annex VI air pollution prevention program is an important part of our national coordinated strategy to reduce emissions from large marine vessels. The United States became party to MARPOL Annex VI in October 2008 and soon thereafter sought designation of ECAs on its coasts to reduce emission of PM, SOx, and NOx from large marine vessels. The ECA fuel sulfur requirements began to apply in August 2012 for the North American ECA and in January 2014 for the U.S. Caribbean Sea ECA. The Tier III NOx limits began to apply in both ECAs for engines installed on ships constructed beginning 2016.

The impacts of the MARPOL Annex VI control measures on U.S. air pollution are substantial with respect to SOx and PM emissions, but less so for NOx emissions. EPA estimates that PM impacts from residual fuel combustion on the East and West Coasts were reduced by as much as a 60 percent due to the 10,000 ppm fuel sulfur limit. The reduction was 80 percent with the 1,000 ppm fuel sulfur limit. Both figures were as compared to pre-ECA air quality.[2,3]

While the results for the Gulf Coast were not as impressive, they were still significant. The NOx reduction results, however, are much less when compared to the PM reductions achieved by the Annex VI program. The number of Tier III, or even pre-control, ships that visit U.S. ports is still very small compared to Tier I and Tier II ships. There are concerns that their SCR units are often not operational in the ECA because these aftertreatment devices are not engaged during low engine power/load operation. This has led to a smaller reduction of NOx emissions than expected in the ECA.

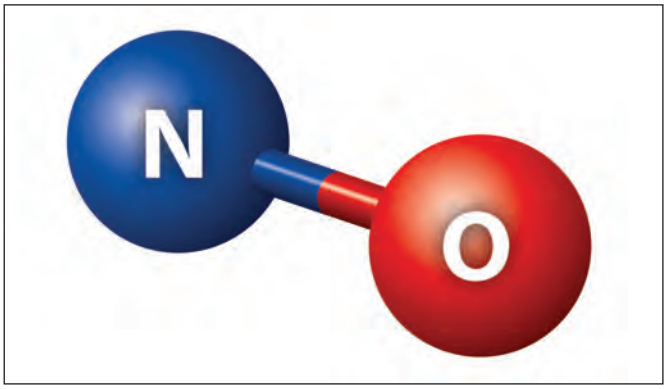


Photo by PeterHermesFurian | iStock/Getty Images

Annex VI: Evolution Since 2008

Annex VI has been revised several times since the 2008 amendments, reflecting changing circumstances and improvements in technologies. Key amendments are below, and the full slate of amendments can be found on the IMO website.

Key changes to the NOx program include provisions related to auxiliary control devices. These devices can lead to an increase in NOx emission and are applied to prevent engine damage in defined operating conditions and irrational control strategies, which are intended to reduce the effectiveness of the NOx emission controls and are not allowed.

In addition, two NOx ECAs—the North American and the U.S. Caribbean Sea—have been designated. In July 2017, the Baltic and North Sea SOx ECAs were designated as NOx ECAs, as well. The NOx ECA requirement went into effect for engines installed on ships built beginning January 2021 and which operate in the ECA. The committee also adopted various amendments to the NTC, as well as guidelines on NOx reduction technologies.

More recently, the Mediterranean Sea ECA was adopted by the committee in December 2022. The Mediterranean SOx ECA expects to be in force by May 1, 2024, with the sulfur standards becoming enforceable on May 1, 2025. In addition, the compliance program has been improved through changes to the information that must be provided to the ship with the bunker delivery note, as well as the procedures for testing fuel samples to verify sulfur levels. The committee also adopted various guidelines and best practices to assist stakeholders in their compliance responsibilities.

The Annex VI GHG Program

One of the resolutions adopted at the Conference of the Parties in 1997 that added Annex VI to MARPOL concerned GHG emissions from ships. Resolution 9 invited the committee to study greenhouse gas emissions from ships. Additionally, it prompted the consideration of "what CO2 reduction strategies may be feasible in light of

the relationship between CO2 and other atmospheric and marine pollutants, especially NOx since NOx emissions may exhibit an inverse relationship to CO2 reduction."

The first IMO GHG study was published in 2000 and estimated that international shipping accounted for 1.8 percent of global anthropogenic CO2 emissions in 1996. A second study, published in 2009, estimated international shipping's share increased to about 2.7 percent in 2007.

Then in July 2011, the committee agreed to a significant revision of MARPOL Annex VI that added Chapter 4 to address GHG emissions from shipping. This new program, which began to apply in 2013, was applicable to all ships 400 GT and above that engage in international voyages. Initially, there were two parts to the program. The first part is a requirement for new ships to calculate and report their ship Energy Efficiency Design Index (EEDI), beginning with those whose contracts were finalized in 2013. Some ship categories were also required to meet an EEDI limit which phased in over time and reflected up to a 30 percent reduction from an agreed-upon reference line based on calculated EEDI values for ships built in 1990 through 1999. The goal of this design standard is to incentivize the installation of energy reducing technologies—better hull design, more efficient engines, improved propulsion systems, and alternative sources of energy.

The second part of the Chapter 4 GHG program required all ships, regardless of age, to have a Ship Energy Efficiency Management Plan (SEEMP) that details what strategies they will apply to reduce energy consumption. These can be operational, maintenance, or equipment strategies like slow steaming, hull cleaning, or retrofitting a bulbous bow or Flettner rotors, respectively.

Since 2011, three more elements were added to the GHG program. In October 2016, the Annex was amended to require ships over 5,000 GT to report their annual fuel consumption to the IMO Ship Fuel Oil Consumption Database. These data will be used to assess improvements in ship energy efficiency and the reduction in GHG emissions across the international fleet of these vessels.

In April 2018, the committee adopted the Initial IMO GHG Strategy as a roadmap for reducing the impact of ships on the climate. The final element was the June 2021 amendment of the annex to include new Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Index (CII) requirements. The EEXI applies a design index to existing vessels for specified ship type and size categories. Like the EEDI, all ships in the specified categories must report their EEXI value. Some categories of ships are required to reduce their index over time until the ship achieves a reduction of 15 percent to 50 percent compared to the EEDI baseline. Like the EEDI requirement, the EEXI reductions phase in over time, beginning in 2022 a continuing through 2025. The CII requirement is applicable to ships over 5,000 GT in specified categories. The CII is used to rate these ships—A, B, C, D, E—based on actual annual fuel consumption and work performed. Ships with a D rating for three consecutive years, or a E rating for one year, are required to take corrective action to improve their energy efficiency. Ships subject to the fuel oil consumption and CII requirements must revise their SEEMP to describe how they will comply with those programs.

For more information on EPA's Clean Air Act and IMO MARPOL Annex VI programs go to *https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-marine-vessels*

The Future of Annex VI

The MARPOL Annex VI air pollution control program started slowly, with easily attainable emission limits. Over time, it has become more meaningful with revised standards that reflect improvements in control technologies and the need to address GHG as well as the initial slate of pollutants. The evolution of Annex VI will continue in the coming years with more action on climate change, including black carbon emissions and the recognition of the need for cleaner fuels with a lower sulfur content to reduce air pollution and enable effective NOx and particulate matter aftertreatment technologies. The work ahead will be challenging, but if past is prologue, then we can hope for good things to come.

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References

Lloyd's Register Engineering Services (1995), Marine Exhaust Emission Research Programme. This report is available from: Engineering Services Group, Lloyd's Register House, 29 Wellesley Road, Croydon, CR0 2AJ, UK.

Starcrest Consulting Group, LLC (2017). San Pedro Bay Ports Clean Air Action Plan 2017: Bay Wide Ocean-Going Vessel International Maritime Organization Tier Forecast 2015-2050. https://kentico.portoflosangeles.org/getmedia/a23bdf8e-7df2-42f5-873f-803c36be8a57/CAAP_Vessel_Tier_Forecasts_2015-2050-Final

MARPOL 73/78

A lookback and a glimpse ahead

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The international community is celebrating 50 years of MARPOL and preventing pollution in our seas and waterways. With its origins in preventing oil pollution in the marine environment, the International Convention for the Prevention of Pollution from Ships, 1973, the Protocol of 1978 (MARPOL 73/78), and each annex, has expanded the scope and tackled different types of pollution from ships. In this article, we examine some of the notable points in MARPOL's history and its future role in addressing issues like greenhouse gas emissions from ships.

A Look Back

Devastating maritime disasters in the late 1960s and 1970s spurred international action to improve standards to protect the marine environment from ship-produced pollution, particularly oil tanker spills. In 1967, the supertanker *SS Torrey Canyon*, a Liberian-flagged vessel, grounded off the coast of Cornwall, England, spilling nearly 120,000 tons of oil. This massive spill, the first major supertanker accident and the worst in the United Kingdom's history, had far-reaching consequences for the marine environment. Ecosystems were damaged, thousands of sea birds killed, and hundreds of miles of coastline in the United Kingdom, France, and Spain oiled. The disaster illustrated the dangers of pollution from shipping.

Following the disaster, efforts to develop more stringent international standards to prevent oil pollution from ships were launched in earnest, resulting in the adoption of the MARPOL Convention on November 2, 1973. However, the Convention had not yet entered into force when a series of oil tanker accidents in the late 1970s sparked further multilateral negotiations leading to the development of the MARPOL 1978 Protocol.

In 1978, the *Amoco Cadiz*, a Liberian-flagged crude carrier, struck the coast of France resulting in another record-breaking oil spill and reignited calls for stricter international regulation to prevent these disasters. Five years after the Amoco Cadiz spill, the 1973 Convention, as modified by the 1978 Protocol, finally entered into force.

Changes Over Time

While oil tanker disasters prompted the creation of MARPOL 73/78, its structure allowed it to serve as the basis for wider regulation of other forms of pollution from ships via operational or accidental causes. Optional technical annexes were expanded and added over time to regulate additional types of pollution from ships. In their present forms, Annexes I and II, covering the carriage of oil and noxious liquid substances in bulk respectively, are mandatory for all MARPOL signatories. However, Annex III, harmful substances in packaged form; Annex IV, sewage; Annex V, garbage; and Annex VI, air pollution are all optional. Despite their optional nature, Annexes III through VI have all entered into force and have been widely implemented. For instance, there are now more than 100 member states that are parties to Annex VI, representing 96.65 percent of shipping's international tonnage. The United States has joined annexes III, V and VI.

Part of MARPOL's success comes from its structure. Countries that join an annex undertake implementation of its obligations in their national laws. Additionally, MARPOL's "tacit acceptance procedure" has contributed to its ability to incorporate and refine additional pollution prevention measures over the last half century.

Instead of establishing a lengthy amendment process which requires parties to express consent to to be bound by every amendment to an Annex, the tacit acceptance procedure is employed. Tacit acceptance allows technical amendments to be accepted on an established date unless one-third of the parties object. Amendments enter into force six months after acceptance unless a party has specifically expressed an objection. In which case, they are exempt from its obligations. MARPOL 73/78 was one of the first International Maritime Organization (IMO) conventions to incorporate this new approach which has streamlined the amendment process and aided in the progressive development of tighter controls to prevent pollution from ships.

Protecting the Environment from International Shipping Operations through Polar Waters

Over the past two decades the IMO has developed a

Part of MARPOL Annex I, binding limitations on the carriage of heavy fuel oil through polar regions helps protect the arctic environments and animals from catastrophic oil spills. The characteristics of heavy fuel oil, polar weather conditions, and the lack of response assets nearby would make spills in these areas even more devastating. Photo by NiseriN | iStock/Getty Images

combination of mandatory measures and guidelines to mitigate environmental and safety risks from the projected increase in international shipping through the polar regions. In particular, MARPOL has been amended to more stringently regulate ship operations to protect the vulnerable and pristine marine polar regions.

The IMO's work on this topic, which included designating Antarctic waters as areas to prohibit the discharge of particular pollutants from ships, initially focused on developing optional guidelines for these operations. Ultimately this work led to the development of the consolidated International Code for Ships Operating in Polar Waters, or The Polar Code. Entering into force in 2017, this code was principally developed "to supplement existing IMO instruments in order to increase the safety of ships' operation and mitigate the impact on the people and environment in the remote, vulnerable, and potentially harsh polar waters."

Under MARPOL Annex I, binding limitations on the use and carriage for use of heavy fuel oil (HFO) in the polar regions have also been phased-in to more stringently protect these areas from vessel-source pollution. A HFO spill in the polar regions would be especially disastrous, partly due to its tar-like characteristics, the regions' traditionally harsh weather conditions, and the limited number of response assets in these regions. In 2011, Annex I was amended to prohibit, with limited exceptions, the carriage of HFO and its use as fuel through Antarctic waters. Though restricting the use and carriage of HFO through Arctic waters proved to be a more contentious issue, further Annex I amendments were carefully negotiated over the course of several years and ultimately adopted in 2021. The effective date for the Arctic HFO ban is July 1, 2024, with a temporary waiver permitted until July 1, 2029.

Annex VI: Progressive amendments to control air pollution

Efforts at the IMO have also led to tighter controls on air pollution from ships through amendments to MARPOL. The Protocol of 1997 was adopted to add Annex VI, which aims to prevent and control air pollution from ships. It entered into force on May 19, 2005. Annex VI includes limits on sulfur oxide (SOx) and nitrogen oxide (NOx) emissions from ships and allows for the designation of Emission Control Areas (ECAs), among other measures. Progressive Annex VI measures have more tightly controlled SOx and NOx emissions and broadened the scope and use of ECAs over time.

Along with harmful environmental impacts, SOx and NOx are also damaging to human health. To reduce these impacts from the international shipping sector, the Protocol of 1997 originally limited the sulfur content of any fuel used on board ships to a maximum of 4.5 percent m/m (mass by mass). Extensive amendments to Annex VI were adopted in 2008, ultimately entering into force on July 1, 2010. These amendments included a gradual approach, enabling industry to develop necessary changes in engine technology and fuel supplies to further limit the sulfur content of any fuel used on board ships over time. The limit in effect on or after January 1, 2012, was 3.50 percent m/m, and then further limited to 0.50

percent m/m on and after January 1, 2020, (the so-called 2020 sulfur cap). NOx emissions controls were similarly tightened over time through tiered amendments based on a ship's construction date.

Under Annex VI even tighter controls on emissions in certain areas have been incorporated through the designation of ECAs. Originally covering SOx emissions only, the definition of an ECA under Annex VI was broadened by the 2008 amendments to prevent, reduce, and control air pollution from either SOx, NOx, particulate matter, or all three types of emissions. These amendments also included a gradual approach to limit sulfur content of fuel oil used on board ships operating within an ECA. Limits started at 1.50 percent m/m prior to July 1, 2010, and ultimately dropped to 0.10 percent m/m on January 1, 2015. To date, four ECAs have been established in the Baltic and North Sea areas, the North American area, and the United States Caribbean Sea. A fifth ECA for SOx and particulate matter is expected to take effect in the Mediterranean Sea beginning in 2025.

These various MARPOL amendments demonstrate how changes over time have been adopted to progressively tighten measures that prevent and control pollution sources from ships. As international consensus for the need to ratchet up standards in each of these areas formed, MARPOL has served as a reliable tool for doing so.

Reducing Greenhouse Gas Emissions

Today, the most prominent discussion around MARPOL's future is its role in reducing greenhouse gas emissions from shipping. Total emissions from all forms of shipping account for approximately 2.89 percent of global greenhouse gas emissions. If the shipping industry was a country, it would be the eighth-largest emitter in the world. Yet MARPOL's role in addressing these emissions was not initially clear.

The challenge of tackling greenhouse gas emissions from international shipping has been long understood, even if the road to action was less certain. In 1995, the newly formed United Nations Framework Convention on Climate Change (UNFCCC) issued a report on accounting for shipping emissions. After several years of discussion within the UNFCCC's Subsidiary Body for Science and Technological Advice on the best approach to allocate emissions from international shipping, the 1997 Kyoto Protocol effectively assigned responsibility to limit or reduce greenhouse gas emissions from shipping to the IMO.

Also in 1997, as MARPOL Annex VI was adopted, member states adopted Resolution 8 on CO2 Emissions from Ships at the same International Conference of the Parties to the MARPOL Convention. While the resolution recognizes that "Annex VI of MARPOL 73/78 does not address CO2 emissions from ships," it also invites the IMO Marine Environment Protection Committee (MEPC) to consider what CO2 reduction strategies may be feasible. After publication of the first comprehensive IMO Study on Greenhouse Gas Emissions from Ships in 2000, IMO member states strengthened their approach through Resolution A.963(23) in 2003. This resolution,

MARPOL Annex VI has gradually tightened the amount of sulfur content ships are allowed to emit, allowing time to develop and update engine technology to come into compliance with new regulations. Photo by diegocardini | iStock/Getty Images

The International Maritime Organization's member states adopted the Initial Strategy on the Reduction of GHG Emissions from Ships in 2018. This Strategy includes four ambitions to combat greenhouse gas emissions, including achieving a 40 percent reduction in carbon intensity from 2008 levels by 2030. Photo courtesy of International Maritime Organization

"urges the Marine Environment Protection Committee to identify and develop the mechanism or mechanisms needed to achieve the limitation or reduction of GHG emissions from international shipping."

From 2003-2011, negotiations progressed slowly on this directive for climate action. Finally, a breakthrough at MEPC 62 led to the adoption of a package of amendments to MARPOL Annex VI incorporating two new regulatory programs—the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). The measures were contentious, and their adoptions occurred after one of the only roll-call votes among parties to Annex VI in the organization's history. Over 75 percent of parties, including the United States, voted in favor of the EEDI amendments.

Under EEDI, new ships are required to meet a minimum energy efficiency level per tonne mile, according to ship type and size. Similar to the Polar Code and sulfur cap regulations, the regulation is not technology prescriptive and instead sets goals to be achieved with the design of new ships. To date, the Annex VI parties tightened the EEDI's reduction levels three times, leading to a mandated reduction of 30 percent from ships built in 2025 when compared to the average efficiency from 2000-2010. Newly built ships now regularly incorporate features like air lubrication or a bulbous bow to improve efficiency and reduce fuel consumption as a direct result. The SEEMP provides operators with tools to monitor their fuel efficiency and make further improvements to operations. Subsequently in 2016, the IMO also adopted the Data Collection System, a mandatory reporting requirement on fuel consumption by all ships of 5,000 GT or above, to help provide a baseline on the sector's climate emissions.

On the Climate Horizon

While the IMO has been the leading body for addressing greenhouse gas emissions from international shipping, its actions do not occur in a political vacuum. On December 12, 2015, parties to the UNFCCC adopted the Paris Agreement, a landmark agreement in international climate negotiations. The Agreement sets a goal of limiting the increase in the global average temperature to well below 2 Celsius above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 Celsius above pre-industrial levels. Notably, the IMO is not mentioned in the Paris Agreement, leaving the sector's path to emissions reductions ambiguous. Shortly afterwards, the

International Civil Aviation Organization, was also tasked with addressing emissions from the aviation industry and resolved to work toward a collective medium-term global aspirational goal to achieve carbon-neutral growth from 2020 emissions. With pressure mounting, in 2018 the IMO's member states adopted the Initial Strategy on the Reduction of GHG Emissions from Ships.

The Initial Strategy included four overall ambitions:

- peak greenhouse gas emissions as soon as possible
- achieve a 40 percent reduction in carbon intensity from 2008 levels by 2030
- reduce absolute emissions by at least 50 percent by 2050, while pursuing efforts to phase out CO2 emissions entirely on a pathway consistent with the Paris Agreement
- introduce new phases of the EEDI

Using these ambitions as its aspiration, IMO member states have continued to use MARPOL Annex VI as a vehicle to combat greenhouse gas emissions from ships. In 2021, MEPC 76 adopted the Carbon Intensity Indicator (CII) and the Energy Efficiency Existing Ship Index— both designed to reduce emissions from existing ships—as amendments to Annex VI.

However, these ambitions fell well short of the reductions necessary to limit warming to 1.5 C. The United States' Special Presidential Envoy for Climate John Kerry called for an increase in the Strategy's levels of ambition consistent with the 1.5 C goal, which has been echoed by many other member states. At MEPC 80 in July 2023, the IMO's member states adopted a revised 2023 strategy by consensus which constitutes a strong contribution from the shipping sector as we work to keep the 1.5-degree goal within reach.

With the short-term measures adopted, a list of additional midterm measures is under negotiation by member states, with some calling to adopt as early as 2025. These include potential greenhouse gas fuel intensity standards, enhancements to the CII, and potential economic measures. Through these measures, MARPOL and Annex VI may become the tool that delivers on the promise of zero-emission shipping.

Conclusion

Since its twin adoptions in 1973/1978, MARPOL has addressed the need for regulation of pollution from international shipping. Key aspects of the Convention's amendment procedure and the use of optional annexes have contributed to its longevity and expanding usefulness over time. These aspects have allowed MARPOL to incorporate new topics and geographic areas such as greenhouse gas emissions or the linked issue of increased shipping in polar waters, as well as providing new solutions to longstanding challenges like air pollution.

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Endnotes:

1 "Torrey Canyon: The world's first major oil tanker disaster." Safety4Sea. October 3, 2019. https://safety4sea.com/cm-torrey-canyon-the-worlds-first-major-oil-tanker-disaster/

2 Ibid

3 Kifner, John. "Wreck of the Amoco Cadiz Revives Issue of Safety in Transporting Oil." The New York Times. March 23, 1978. https://www.nytimes.com/1978/03/23/archives/wreck-of-the-amoco-cadiz-revives-issue-of-safety-in-transporting.html

4 https://www.imo.org/en/MediaCentre/PressBriefings/pages/MARPOL100State.aspx

5 "Conventions." The International Maritime Organization. accessed June 14, 2023, https://www.imo.org/en/About/Conventions/Pages/default.aspx

6 Ibid

7 "IMO Goal-based standards." The International Maritime Organization. accessed June 14, 2023, https://www.imo.org/en/OurWork/Safety/Pages/Goal-BasedStandards.aspx

8 "The International Code for Ships Operating in Polar Waters." entered into force January 1, 2017

9 International Maritime Organization, Marine Environment Protection Committee." Amendments to the Annex of the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973," Resolution MEPC.189(60), adopted on March 26, 2010

10 International Maritime Organization, Marine Environment Protection Committee." Amendments to the Annex of the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973," Resolution MEPC.329(76), adopted on June 17, 2021

11 Ibid. The temporary waiver may be issued by the Administration of a Party the coastline of which borders on Arctic waters for ships flying the flag of that Party while operating in waters subject to the sovereignty and jurisdiction of that Party

12 Regulation 14. "The Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 thereto," entered into force on May 19, 2005

13 International Maritime Organization, Marine Environment Protection Committee." Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 Relating Thereto." Resolution MEPC.176(58), adopted on October 10, 2008.

14 "IMO 2020 – cutting sulfur oxide emissions." The International Maritime Organization. accessed June 14, 2023, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

15 Ibid

16 "Fourth Greenhouse Gas Study 2020." The International Maritime Organization. accessed June 15, 2023, https://www.imo.org/en/ourwork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx

17 https://unfccc.int/resource/docs/convkp/kpeng.pdf

18 International Maritime Organization. "IMO Policies and Practices Related to the Reduction of Greenhouse Gas Emissions from Ships" Resolution A.963(23), adopted on December 5, 2003

19 "Energy Efficiency Measures," The International Maritime Organization. accessed June 15, 2023, https://www.imo.org/fr/ourwork/environment/pages/technical-and-operational-measures.aspx

20 "IMO Data Collection System (DCS)." The International Maritime Organization. accessed June 15, 2023, https://www.imo.org/en/ourwork/environment/pages/data-collection-system.aspx

21 "Vision and Level of Ambition of the Initial IMO Strategy." The International Maritime Organization. accessed June 15, 2023, https://www.imo.org/en/OurWork/Environment/Pages/Vision-and-level-of-ambition-of-the-Initial-IMO-Strategy.aspx

Future Efforts

Reducing PFAS discharges and exposure in our waters

Protecting public health and the environment

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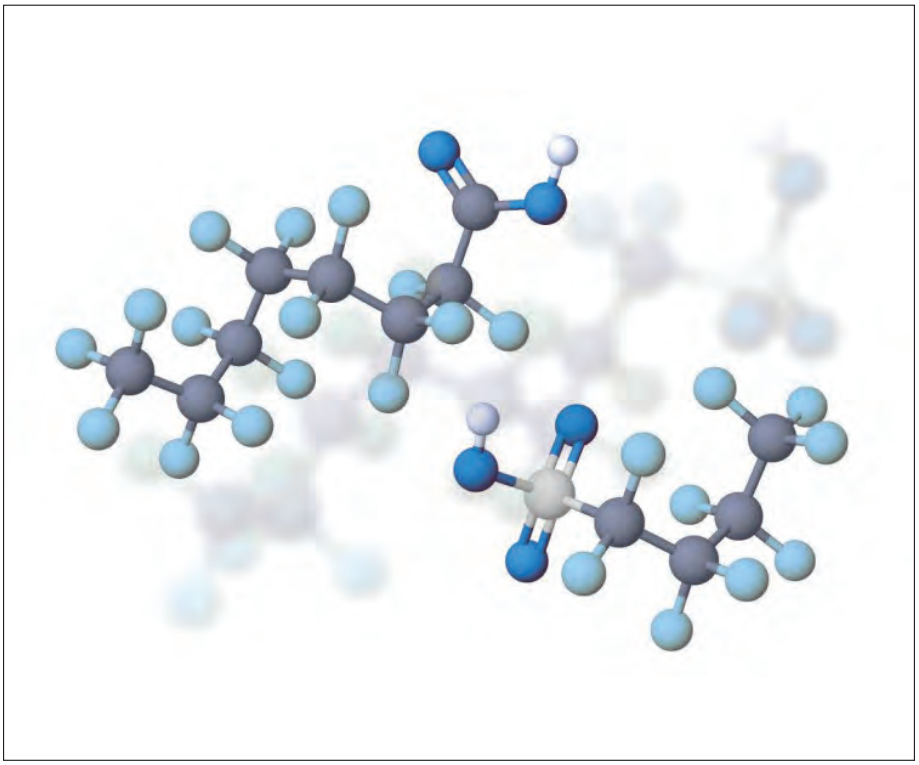
The shipping industry has made great strides in reducing pollution from ships since the adoption of The International Convention for the Prevention of Pollution from Ships in 1973 and subsequent modification in 1978, known as MARPOL 73/78. In the decades since, other environmental protection agreements, negotiated by the International Maritime Organization and others, have come into force further improving environmental and human health protection.

Moving forward, mariners face ongoing challenges to reduce the use, discharge, and accompanying environmental and human health impacts from per- and polyfluorinated substances, known collectively as PFAS. Among their many uses, PFAS are common ingredients in firefighting foams, like Aqueous Film Forming Foam (AFFF), because of their ability to smother fuel, which prevents oxygen from reaching the fire, and suppress the flames. These chemicals are toxic and, because they stay in the environment for long periods of time, they can build-up in animals, plants, soils, and sediments when discharged into surrounding waters. Therefore, PFAS can cause long-term environmental contamination and pose significant human health risks.



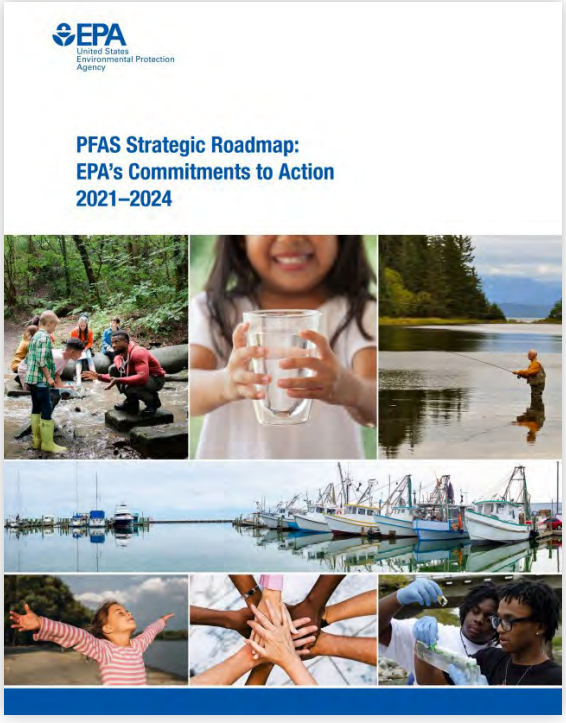
PFAS chemicals are found in everyday products from paints to textiles and pose major health risks to humans, animals, and the environment. This substance contaminates water, soil, and air, yet PFAS itself cannot be seen by the naked eye like many other forms of pollution. Photo courtesy of the U.S. Environmental Protection Agency

The Environmental Protection Agency (EPA) and other federal agencies are taking numerous actions to reduce the environmental and public health impacts of PFAS. This article discusses these chemicals and their impacts, what the EPA is doing to reduce pollution and exposure to them, and how the agency and mariners have protected, and can further protect, the marine environment from PFAS pollution.

Environmental and Public Health Effects

PFAS are a group of chemicals found in many consumer, commercial, and industrial products that have been used around the world since the 1940s. Their ability to withstand heat and repel water make them useful in a variety of applications including, but not limited to, non-stick cookware, waterproof items, textiles, paints, and, as noted earlier, firefighting foams. However, because of these properties, they break down very slowly and can build up in people, animals, and the environment over time. Current scientific evidence shows that exposure to some PFAS can lead to negative health effects for pregnant people and developing babies. They can also weaken the body's ability to fight disease, increase the risk for some types of cancers and liver damage, and elevate cholesterol levels, increasing the risk for heart attack and stroke.

Humans and animals can be exposed to PFAS in a variety of ways, including via drinking water, air, soils, and household products, among other sources. On board ships, PFAS are a component in many firefighting foams and other firefighting equipment used for preventing loss of life at sea. Foams containing PFAS, including AFFF, were initially developed for extinguishing fires involving gas tankers and oil refineries due to their ability to quickly extinguish fires and prevent reignition.



The U.S. Environmental Protection Agency's PFAS Strategic Roadmap proposes new solutions on issues such as protecting our drinking water, ocean life, and the environment from dangerous PFAS. Photo courtesy of the U.S. Environmental Protection Agency

While effective for these intended uses, studies show that firefighters have higher concentrations of PFAS in their blood due to higher exposure rates, as compared to non-firefighting populations.

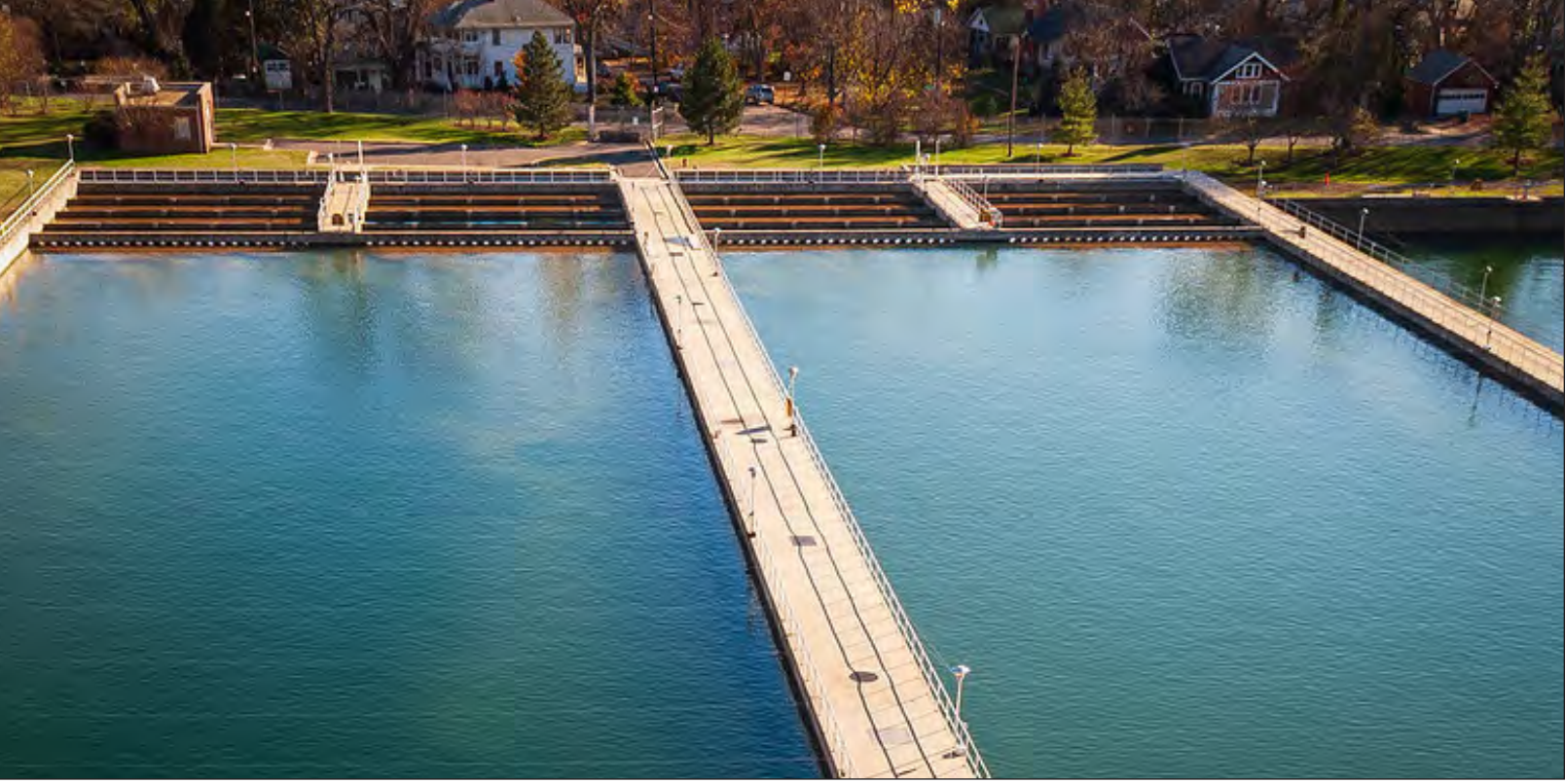
These foams are not only an occupational risk, but also pose a significant risk to our marine and estuarine environments. Documented adverse effects of PFAS have been shown in freshwater and marine vertebrates like fish and amphibians; invertebrates like insects and shellfish; and aquatic plants, all of which are critical components of aquatic and marine environments. An important consideration for managing environmental and human health effects of PFAS is balancing the need for critical uses—protecting vessels and the safety of life at sea—with the potential risk for adverse effects. Agencies across the federal government are working to address the PFAS crisis both on land and at sea.

How Is EPA Addressing PFAS?

In 2021, the EPA announced its PFAS Strategic Roadmap which laid out a whole-of-agency approach focused on research, restriction, and remediation. The PFAS Roadmap sets timelines by which EPA plans to take specific actions between 2021 and 2024 to safeguard public health, protect the environment, and hold polluters accountable. Additionally, the agency has committed to demonstrating strong federal leadership on PFAS while also supporting the important work of its state, tribal, local, and federal partners. Some tribal, state, and local governments have already begun to regulate PFAS chemicals in various contexts.

A key priority in EPA's Roadmap is considering the lifecycle of PFAS, including the potential discharge of these pollutants into waterways. EPA is addressing multiple parts of the PFAS lifecycle, such as its manufacturing, past and present releases into the environment, , and disposal, using various environmental authorities to reduce human and environmental exposures.

To address the PFAS lifecycle, the EPA leans on authorities granted by laws like the Safe Drinking Water Act; the Clean Water Act the Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; and the Toxic Substances Control Act.



Water supplies such as this one could become contaminated with PFAS. Repeatedly drinking this water, in addition to using household items containing PFAS, may expose people to excessive amounts of chemicals that increase the likelihood for serious health risks like cancer and strokes. Photo courtesy of the U.S. Environmental Protection Agency

The PFAS Roadmap outlines the many current and ongoing, agency-wide, water-related actions to address these chemicals, many of which have the potential to interface with maritime applications. EPA is also monitoring fish tissues for PFAS in the nation's lakes and is working closely with their partner agencies who have relevant authorities, like the Food and Drug Administration and the National Oceanic and Atmospheric Administration, to protect aquatic life.

As one of the foundational actions in the PFAS Roadmap, EPA published a proposed drinking water regulation this spring to reduce health effects from PFAS in drinking water. This is a proposed rule and is not yet finalized, so no action is currently required to be taken by drinking water utilities. If finalized, the rule will affect those who consume public drinking water and drinking water utilities and is anticipated to provide significant public health benefits by preventing tens of thousands of serious PFAS-related illnesses and deaths. Moreover, it would also be the first regulation to set federal limits for PFAS chemicals in drinking water which, among other things, may encourage PFAS dischargers and others to phase out their usage and/or find safer alternatives. Its limits, and therefore its protections, would also apply to any potable water bunkered onto a vessel from a U.S. community water system.

Additionally, EPA is conducting research and development on PFAS in tandem with other federal agencies like the Department of Defense, the Federal Aviation Administration, and the Coast Guard, to protect human health and the environment. This research will further support EPA's ability to take future actions to limit discharges and emissions of PFAS, including for vessels.

Drinking water is one of the many ways humans can be exposed to PFAS chemicals. According to peer.org, PFAS has been found in the blood of nearly every American. Photo courtesy of the U.S. Environmental Protection Agency

PFAS discharge from ships, particularly through a firefighting foam called Aqueous Film Forming Foam, can contaminate large areas of ocean water and harm marine life. The EPA is now regulating this PFAS-containing foam as part of the Clean Water Act. Photo courtesy of Eric Vance/ U.S. Environmental Protection Agency

How is EPA protecting our marine environment?

Under the Clean Water Act, EPA established vessel discharge requirements for AFFF. The agency established the first regulatory requirements applicable to AFFF discharges from commercial vessels in the 2008 Vessel General Permit (VGP), and again when the permit was reissued in 2013. The requirements were designed to reduce AFFF discharges pragmatically, while considering the importance of maritime safety. Among other things, the VGP requirements prohibit most ocean-going vessels from discharging AFFF from training and maintenance into U.S. waters, as well as prohibiting non-emergency discharges into protected waters such as marine sanctuaries. Other VGP requirements include that most non-ocean-going ships are to reduce AFFF training activity discharges, collect any fluorinated foam discharged, and for all vessels to switch to alternate foaming agents—nonfluorinated foams—where possible. In short, mariners implementing these VGP requirements were among the first major industries reducing the discharge of PFAS into U.S. waters.

The 2018 Vessel Incidental Discharge Act (VIDA) restructures how EPA and the Coast Guard are to regulate discharges, including firefighting foams, that occur as part of the normal operation of commercial vessels. More specifically, VIDA requires EPA to first develop uniform national standards of performance for commercial vessel discharges, and then for the Coast Guard to develop corresponding implementing regulations to ensure, monitor, and enforce compliance with those standards. Once finalized, these regulations will replace the VGP and could affect nonemergency discharges of firefighting foam. The proposed VIDA standards published in the Federal Register in October 2020 incorporate many aspects of the VGP's "AFFF" requirements as discharges from "fire protection equipment." The final rule and implementing regulations are forthcoming and may pave the way for the future, as EPA is required to revisit standards every five years. Regulations such as these can help safeguard our nation's water resources, while maintaining safety and continuing to foster the important economic driver that is the maritime sector.

Separately, for vessels of the armed forces, the Uniform National Discharge Standards set national standards that require the use of marine pollution control devices for discharges that occur due to the normal operation of a vessel in non-emergency situations. Firefighting foam—listed as AFFF—was addressed in a 2017 final rule, and internal Department of Defense implementing regulations went into effect in 2019.

Addressing the Past and Looking Forward

As it continues its efforts to research, restrict, and remediate PFAS, the EPA and other entities are supporting efforts to identify safe alternatives and reducing the procurement of products containing these chemicals. Under EPA's Office of Chemical Safety and Pollution Prevention, actions are underway to regulate the use of abandoned PFAS, such as PFAS that are no longer actively manufactured or used, and to improve PFAS reporting. EPA also has published, and is implementing, its National PFAS Testing Strategy for deepening our understanding of the chemicals' hazards.

As new PFAS or alternatives are proposed, EPA is ensuring they undergo rigorous review and safeguards to ensure health protections prior to use. EPA is striving to reduce the federal government's levels of PFAS procurement and is working towards providing resources to aid federal purchasers in meeting this goal. There has been much progress in the United States and internationally to phase out or restrict the use of some of the most studied PFAS chemicals—PFOA and PFOS—and therefore modern foams are mostly made with PFAS that are

PFAS is harmful to more than just humans, therefore, it is important to look at its impact on wildlife and on our pets. The EPA's new regulations such as the PFAS Roadmap and the Clean Water Act are steps toward preventing further damage to not only us, but to our animals and environment. U.S. Environmental Protection Agency photo by Ryan Albert/

generally thought to be less toxic.

There are alternatives available that do not contain PFAS, but concerns remain about potential residual PFAS contamination from equipment reuse. The Department of Defense recently released a new military specification for PFAS-free foams, leading an upcoming transition away from them as the department reviews potential replacement products and certifies them under this new specification.

Although this specification does not work for saltwater uses of AFFF, this is a step towards protecting environmental and human health by shifting most U.S. military AFFF applications to PFAS-free foam. There are still opportunities for advances, as PFAS-containing foams are still used by the U.S. military, petrochemical, and aviation industries to prevent loss of life. As supported by this Department of Defense specification, some industries are heading in a direction of PFAS-free products, including development of firefighting foams that continue to safeguard mariners while having reduced public health and environmental impacts. Continued collaboration across the federal government and its agencies can make a future with far lower PFAS pollution and exposures a reality.

Conclusion

Looking ahead, EPA and its federal and nonfederal partners will continue to leverage their authorities and work hard to reduce the environmental and public health impacts of PFAS pollution. EPA's PFAS Strategic Roadmap reflects efforts to research, restrict, and remediate to prevent current and future pollution of our waters with PFAS. These efforts are aimed at protecting our nation's waters, aquatic life, and everyone who may be exposed to these chemicals. This is especially important for those who may be directly exposed to PFAS-containing products like firefighters and mariners.

EPA continues to put human health and the environment at the forefront of its work in addressing PFAS pollution now and in the future. Similar to the environmental and human health protections offered by MARPOL, EPA and its partners' actions to reduce PFAS pollution and exposure will meaningfully protect present and future generations to come.

Editor's Note:

The views expressed in this article are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

For more information

For more information on VIDA , please see https://www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Commercial-Regulations-Standards-CG-5PS/Office-of-Operating-and-Environmental-Standards-CG-OES/Environmental-Standards/VIDA/

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Ryan Albert leads EPA's Risk Reduction Branch in EPA's Office of Ground Water and Drinking Water. Among other things, the Risk Reduction Branch is responsible for promulgating EPA's National Primary Drinking Water Regulation for PFAS. Prior to joining the Office of Ground Water and Drinking Water, he spent seven years as EPA's technical lead for developing and implementing EPA's Vessel General Permits.

Alexis Lan is a physical scientist and policy analyst in EPA's Office of Water. He is actively working on drinking water issues related to PFAS and is currently serving as the team lead in developing the National Primary Drinking Water Regulation for PFAS under the Safe Drinking Water Act.

Amanda Santoni is an ecologist at the EPA. Specifically, she works in the Ocean and Coastal Management Branch on the Vessels, Marinas and Ports Team developing the Vessel Incidental Discharge National Standards of Performance under VIDA. She also leads the Coastal Wetlands Initiative and Interagency Coastal Wetland Workgroup.

Matt Klasen serves as the manager of the U.S. Environmental Protection Agency's Council on PFAS, which developed and implements EPA's PFAS Strategic Roadmap. He joined EPA in 2007 and has since served in diverse program and coordination roles with national, regional, and state partners.

References

U.S. Environmental Protection Agency. PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 [Overviews and Factsheets]. October 14, 2021. Accessed: https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024

U.S. Environmental Protection Agency. Key EPA Actions to Address PFAS [Overviews and Factsheets]. March 13, 2018. Accessed: https://www.epa.gov/pfas/key-epa-actions-address-pfas

Laitinen, J. A., Koponen, J., Koikkalainen, J., & Kiviranta, H. (2014). Firefighters' exposure to perfluoroalkyl acids and 2-butoxyethanol present in firefighting foams. Toxicology Letters, 231(2), 227–232. https://doi.org/10.1016/j.toxlet.2014.09.007

Lucas, K., Gaines, L. G. T., Paris-Davila, T., & Nylander-French, L. A. (2023). Occupational exposure and serum levels of per- and polyfluoroalkyl substances (PFAS): A review. American Journal of Industrial Medicine, 66(5), 379–392. https://doi.org/10.1002/ajim.23454

Nilsson, S., Smurthwaite, K., Aylward, L. L., Kay, M., Toms, L. M., King, L., Marrington, S., Barnes, C., Kirk, M. D., Mueller, J. F., & Bräunig, J. (2022). Serum concentration trends and apparent half-lives of per- and polyfluoroalkyl substances (PFAS) in Australian firefighters. International Journal of Hygiene and Environmental Health, 246, 114040. https://doi.org/10.1016/j.ijheh.2022.114040

Peaslee, G. F., Wilkinson, J. T., McGuinness, S. R., Tighe, M., Caterisano, N., Lee, S., Gonzales, A., Roddy, M., Mills, S., & Mitchell, K. (2020). Another Pathway for Firefighter Exposure to Per- and Polyfluoroalkyl Substances: Firefighter Textiles. Environmental Science & Technology Letters, 7(8), 594–599. https://doi.org/10.1021/acs.estlett.0c0041

Řiháčková, K., Pindur, A., Komprdová, K., Pálešová, N., Kohoutek, J., Šenk, P., Navrátilová, J., Andrýsková, L., Šebejová, L., Hůlek, R., Ismael, M., & Čupr, P. (2023). The exposure of Czech firefighters to perfluoroalkyl substances and polycyclic aromatic hydrocarbons: CELSPAC – FIREexpo case-control human biomonitoring study. Science of The Total Environment, 881, 163298. https://doi.org/10.1016/j.scitotenv.2023.163298

Silver, G., Krastev, Y., Forbes, M. K., Hamdorf, B., Lewis, B., Tisbury, M., Taylor, M. P., & Gasiorowski, R. (2021). Study protocol for a randomised controlled trial examining the effect of blood and plasma donation on serum perfluoroalkyl and polyfluoroalkyl substance (PFAS) levels in firefighters. BMJ Open, 11(5), e044833. https://doi.org/10.1136/bmjopen-2020-044833

U.S. Environmental Protection Agency & Department of Defense Federal Register Notice, 40 CFR Part 1700. Uniform National Discharge Standards for Vessels of the Armed Forces – Phase II Batch One. January 11, 2017. Vol. 82, No. 7. Accessed: https://www.gpo.gov/fdsys/pkg/FR-2017-01-11/pdf/2017-00153.pdf

Department of Defense & Office of the Secretary. Notice of the Availability of Uniform National Discharge Standards (UNDS) for Vessels of the Armed Forces – Phase III Batch One. July 3, 2019. Vol. 84, No. 128. Accessed: https://www.govinfo.gov/content/pkg/FR-2019-07-03/pdf/2019-14211.pdf

Department of Defense. Military Specification for Fire Extinguishing Agent Fluorine Free Foam (F3) Liquid Concentrate for Land-Based Fresh Water Applications. Performance Specification, January 6, 2023. https://media.defense.gov/2023/Jan/12/2003144157/-1/-1/1/MILITARY-SPECIFICATION-FOR-FIRE-EXTINGUISHING-AGENT-FLUORINE-FREE-FOAM-F3-LIQUID-CONCENTRATE-FOR-LAND-BASED-FRESH-WATER-APPLICATIONS.PDF

U.S. Environmental Protection Agency. Final issuance of National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP) for discharges incidental to the normal operation of vessels. Finalized December 19, 2008. Accessed: https://www.epa.gov/npdes/final-2008-vessel-general-permit-vgp-documents

U.S. Environmental Protection Agency. Final issuance of National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP) for discharges incidental to the normal operation of vessels. Finalized March 28, 2013. Accessed: https://www.regulations.gov/document/EPA-HQ-OW-2011-0141-0949

U.S. Environmental Protection Agency. Fact Sheet: 2010/2015 PFOA Stewardship Program. Accessed May 30, 2023: https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/fact-sheet-20102015-pfoa-stewardship-program

U.S. Coast Guard. Recap of the 9th session of the IMO sub-committee on ship systems and equipment. Maritime Commons. March 24, 2023. Accessed: https://mariners.coastguard.blog/2023/03/24/recap-of-the-9th-session-of-the-imo-sub-committee-on-ship-systems-and-equipment/

Ship Sources of Plastic Pollution

Can MARPOL adapt to the changing demands?

by Galia Kaplan
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From an early age, the ocean has simultaneously amazed and terrified me. This paradox was amplified by the stories brought to us by Jacques Cousteau, Sir David Attenborough, and the movies *Jaws* and *The Big Blue*, two films whose soundtrack still send shivers down my spine for different reasons.

Born to parents with no affinity for the ocean and raised in London, my desire to study all things maritime struck them as odd. After all, I feared swimming in most bodies of water, seasickness was a constant companion when crossing the Channel, and London is far from any shore. But the fascination and fear persisted. I graduated with a degree in maritime studies from Cardiff University and dreamed of returning to London and working at the International Maritime Organization (IMO) located on the banks of the River Thames.

Fast forward to April 24, 2023—a day worth remembering—and I am standing in front the very building I pictured myself employed in. I was part of the U.S. delegation leading a group of smart, dedicated women from the National Oceanic and Atmospheric Agency (NOAA) and the United States Coast Guard in discussions with about 84 countries and 49 organizations[1] on ways to reduce plastic pollution from ships.

The evolution of plastic at the IMO

The IMO pioneered the prohibition of plastics disposal from ships into the sea in 1988 when the requirements of MARPOL Annex V, Prevention of Pollution by Garbage from Ships, came into force. First adopted in 1973, MARPOL stands for the International Convention for the Prevention of Pollution from Ships and is the primary international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It consists of six annexes, each one dealing with different types of pollution. For example, Annex I addresses oil; Annex III is harmful substance in packaged form; and Annex V deals with different types of garbage and specifics of disposal with respect to distance from land and methods, among other topics. The most important feature of this annex is the complete ban imposed on the disposal all forms of plastics into the sea, including synthetic ropes and fishing nets, plastic garbage bags, and incinerator ash from plastic products. In addition to the ban on discharging plastics from ships, MARPOL Annex V includes requirements for garbage record-keeping and reporting of accidentally lost fishing gear.

The initial 25 years of MARPOL Annex V[2] focused on incorporating inspection and enforcement provisions to cover the operational requirements of pollution prevention. In the context of the United States, Coast Guard vessel inspectors can inspect a foreign-flagged vessel in U.S. waters to ensure compliance with MARPOL's pollution prevention requirements. A foreign country signatory to Annex V may similarly conduct a Port State inspection on a U.S.-flagged vessel when it is in their waters.

According to the Department of Justice's Environment and Natural Resources Division, the United States is the leader in MARPOL enforcement, which it does through the Act to Prevent Pollution from Ships (APPS). Part of this success is due to the whistleblower reward provision within APPS that recognizes that numerous incidents of ocean pollution remain undetected unless a witness comes forward. APPS permits federal courts to grant rewards of up to 50 percent of the total fine to whistleblowers whose disclosures regarding pollution on the high seas result in a successful prosecution.

According to the National Whistleblower Center's 2018 analysis of 100 recent APPS prosecutions available on Public Access to Court Electronic Records, whistleblowers were responsible for 76 percent of all successful cases from 1993 to 2017. In many of those cases the defendant plead guilty to falsifying or failing to make required entries in the oil and garbage record books.

Since 2012, recognizing the continued violations of the annex, garbage regulations, growing environmental concerns, and the shipping industry's evolving needs, the IMO adopted amendments to the annex. These amendments increased application of the regulations within Annex V, expanding their scope by broadening the definition of what constitutes garbage and introducing a general

prohibition of its discharge into the marine environment, with very limited exceptions. The IMO also issued a series of guidelines to help governments, ship owners/operators, and ports with the implementation of Annex V requirements, including those related to fishing gear.

Meanwhile, the issue of plastics polluting our oceans gained momentum. Carried by the currents of oceanic gyres, marine debris, is coalescing and creating garbage patches such as the Great Pacific Garbage Patch (GPGP), the largest of five garbage patches. According to NOAA's marine debris program, the debris ranges in size, from large, abandoned fishing nets to tiny microplastics, which are plastic pieces smaller than 5mm in size. This makes it possible to sail through some areas of the GPGP and see very little to no debris, but according to a study,[3] microplastics make up approximately 94 percent of the estimated 1.8 million pieces of debris floating in the area.

Plastic debris in the ocean can range from large, abandoned fishing gear and plastic pellets used to manufacture plastic products, to microplastics—pieces of plastic less than 5mm in size. The latter makes up about 94 percent of the 1.8 million pieces of debris that comprises the Great Pacific Garbage Patch and can be found on many beaches around the world. Angela Compagnone | Ocean Image Bank

Plastic pollution in the marine environment affects marine ecosystems, the species that depend upon them, and human health. According to NOAA, to prevent marine debris we need to understand where it is coming from, and one of those sources is the shipping industry.

With respect to sea-based sources of plastic pollution, the vast amounts of lost, abandoned, or derelict fishing gear floating in the ocean that washes ashore, entangles in reefs and continues to fish is of specific ongoing concern. It is estimated that in some regions, up to 20 percent of fishing gear is lost at sea because of accidents, adverse weather conditions, gear conflicts and entanglement, and intentional abandonment.[4]

Scientists with The Nature Conservancy and the University of California, Santa Barbara, along with the Pelagic Research Group and Hawaii Pacific University, released a 2021 peer-reviewed study that provides the first global estimate of plastic pollution from industrial fisheries. It reveals that more than 100 million pounds of plastic pollution enters the ocean each year from lost fishing gear.

Learn more about Hawaii Pacific University's Derelict Fishing Gear Bounty Project at *https://www.hpu.edu/about-us/the-ohana/article.php?nid=nc01092301*

Microplastics, litter our beaches and oceans and are ingested by birds, fish, sea turtles, and mammals alike. While theses microplastics originate from multiple sources some, like plastic pellets, the raw material used for manufacturing plastic products—have caused significant damage when accidentally released into the environment. A Fauna & Flora International report entitled *Stemming the tide: putting an end to plastic pellet pollution* calculated that since the first recorded shipping incident in 2011, there have been seven other shipping events that released an estimated 1 trillion plastic pellets, also known as nurdles, into the marine environment.

The infancy of the plastic pellet pollution response equipment and strategies, together with the characteristics of the plastic pellets once released in the marine environment, make cleanup operations—different from established oil spill response—challenging and ineffective. The lessons learned from these plastic pellet spill responses spurred IMO member states to conduct further study on plastic pellet pollution and to draft practical guidance for responding to any future pellets spills.[5]

In response to these identified shipping sources of plastic pollution, IMO member states and nongovernmental organization's pushed for action in 2018. In 2021, they adopted the Action Plan to Address Marine Plastic Litter from Ships and an accompanying strategy to guide

its implementation. Many of the measures in the plan identified MARPOL as the appropriate IMO instrument to expand the enforcement of existing requirements or implement new ones.

Following the plan's proposed measures specific to fishing vessels the IMO has been working on amendments to MARPOL Annex V and the associated Annex V guideline that:

- expands the garbage record bookkeeping requirement from vessels of 400 gross tons and above to vessels of 100 gross tons and above, capturing a vessel population, such as smaller fishing vessels, that previously was not required to keep a garbage record
- introduces a new requirement to make the marking of fishing gear mandatory
- enhances the existing requirement to make all fishing gear losses—not just accidental losses—from ships subject to mandatory reporting

As seen with some of the whistleblower cases, record keeping requirements aid the successful prosecution of MARPOL violations. Regarding the mandatory marking of fishing gear and reporting of all lost gear, the logic follows that these proposed amendments, which could include marking of fishing gear with the vessel name and/or owner's contact information, would keep fishing vessel operators more accountable and provide a deterrent to the illegal discharge of gear. On the flip side, gear marking programs can also be used to incentivize gear retrieval and buy-back programs.

While amendments to the MARPOL Annex V garbage record keeping requirements received wide support from IMO member states, development of new gear marking language in Annex V was delayed by debate over using MARPOL as the legal instrument to do so.

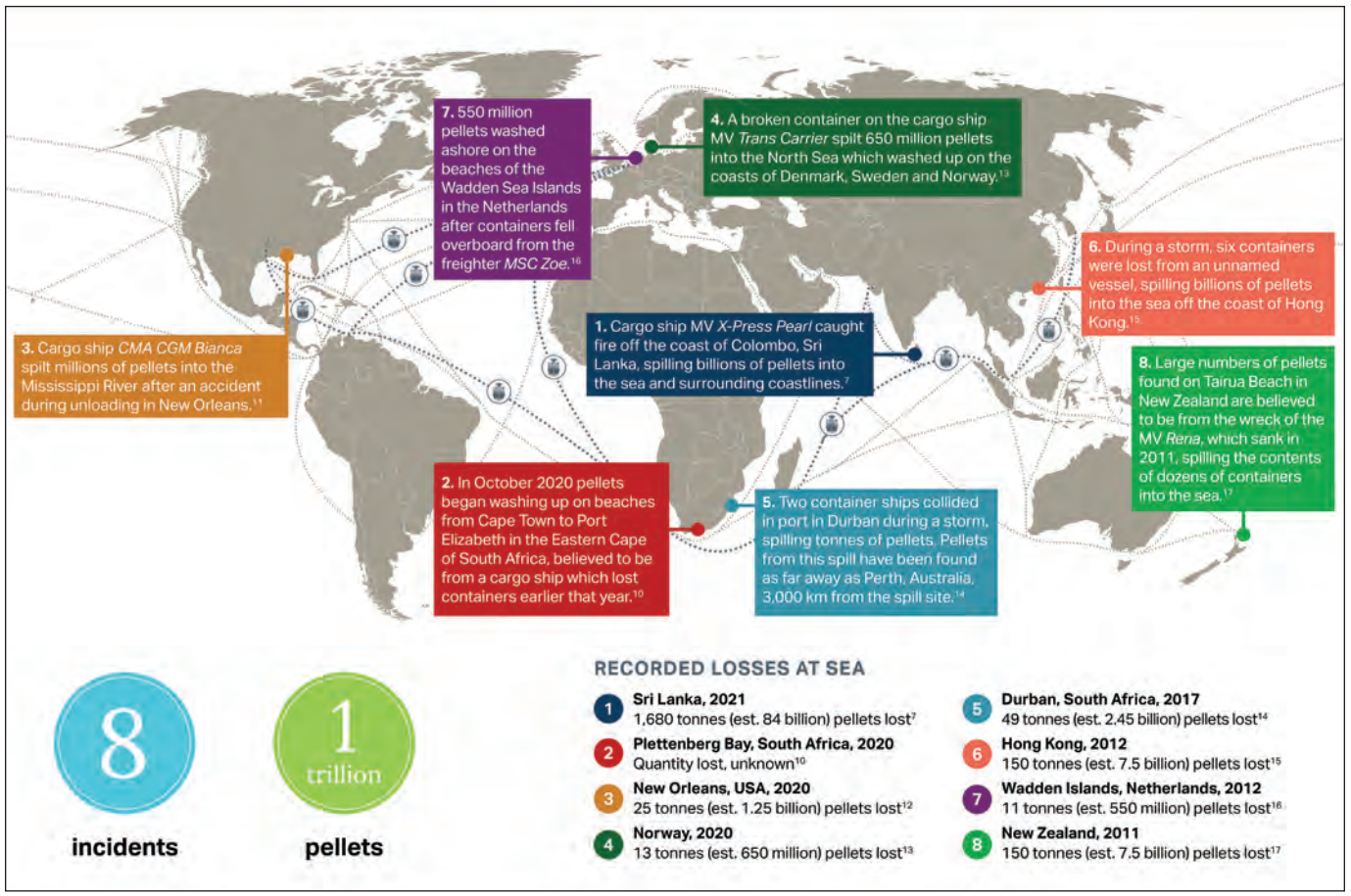
The Impacts of Gear Marking

The United States has established gear marking requirements across many of our domestic and international fisheries to address a suite of management and conservation issues, as well as navigational safety, monitoring, and compliance efforts. However, there is no overarching regulation. Rather, the marking of fishing gear is required under many individual fisheries management plans issued by federal or local fisheries authorities. These regulations are part of a comprehensive science-based management framework, building on extensive consultations with stakeholders, and tailored to the individual characteristics of the fishery in question, including the type of gear and how the gear is used.

Marking fishing nets and crab pots with owners' telephone numbers can assist with recovery of lost gear. Additionally, changing what the gear is made of can reduce the amount of plastic in the ocean. Together, these actions can reduce the impacts on marine life and their environment. Toby Matthews | Ocean Image Bank

In the mid-2010s, the Dungeness crab fishery received scrutiny from California and federal authorities due to increased gear entanglements with humpback and other protected whales. The local Dungeness crab fishing industry agreed to reduce the threat of entanglement and ghost fishing by lost gear by making modifications to how the pots were fabricated and by creating gear retrieval incentives. The local fishing community, in collaboration with a non-governmental organization, developed a lost-gear recovery program that includes a gear buy-back program as well as mandatory annual reporting of lost pots to the fisheries authorities. The gear retrieval and buy-back programs work in part due to gear marking requirements. Crab pots must be marked with the owner's telephone number which then allows those permitted to retrieve the pots to contact the owners who have the option to buy the gear back. Complementing these efforts are California state requirements for buoys and traps to be marked visibly to minimize interactions with vessels and identify ownership. These requirements are part of a broad suite of management measures w hich include limits on the capacity of the fishery, fishery closures due to potential interaction with whales, and restrictions on how gear is used and deployed.

Pellet Petrochemicals Factories and Route



Courtesy of Fauna & Flora International

Many member states, including the United States, took the position that gear marking is not a pollution prevention issue but a fisheries management one, and as such should not be included in MARPOL.

The plan also includes measures aimed at addressing the loss of containers. While these measures are limited to the compulsory reporting of lost containers, nongovernmental organizations and IMO member states pushed for a measure that would reduce the risk associated with the maritime transportation of containers carrying plastic pellets. Again, MARPOL was identified as the appropriate regulatory instrument by which such measures could be implemented, as Annex III contains the regulations for the prevention of pollution by harmful substances carried by sea in packaged form. However, the applicability of Annex III hinges on the definition and understanding of a "harmful substance." Currently, a harmful substance is defined as harmful by its toxicity criteria. While we can all agree that plastic pellets are harmful to the marine species and environments, that is not directly related to their toxic components. As such they would not meet the current definition of a harmful substance as regulated under Annex III.

As demonstrated by the recent incorporation of Annex VI to address pollution by air emission, MARPOL has aged well, expanding in breadth and depth of knowledge in response to the growing environmental concerns and needs of the shipping community. However, ship sources of plastic pollution are challenging MARPOL's current structure. Active fishing gear is not garbage, yet IMO has been asked to incorporate fishing gear marking requirements into MARPOL Annex V. Similarly, plastic pellets are not harmful substances, yet amendments to Annex III have been proposed. Therefore, both annexes are being used to house requirements that fall outside of their original intent and scope.

While we would like to think MARPOL has had a positive mitigating impact on the quantity of plastics entering the marine environment, accidental and intentional discharges of plastic garbage, cargo, or equipment happen all too often. Oceans are large, solitary environments which often allow discharges of plastics to go undetected by enforcement agencies. Vessel operators may perceive that polluting is likely to be undetected and there is little cost to being caught. Additionally, not all countries have the resources available to enforce the

As the amount of plastic in the oceans increases, more beaches around the world could look like this city beach in the Dominican Republic capital of Santo Domingo. Photo by JordiStock | iStock/Getty Images

requirements or prosecute violations.

Plastics: International and Domestic

Plastics are ubiquitous and, in many cases, essential to the global economy. These same two characteristics are why plastics have also become a pollution problem. According to the United Nations Environment Programme:

The rapidly increasing levels of plastic pollution represent a serious global environmental issue that negatively impacts the environmental, social, economic and health dimensions of sustainable development. Under a business-as-usual scenario, and in the absence of necessary interventions, the amount of plastic waste entering aquatic ecosystems could nearly triple from some 9–14 million tonnes per year in 2016 to a projected 23–37 million tons per year by 2040.

The United Nations Environment Assembly, UNEA-5.2, adopted resolution 5/14, End plastic pollution: towards an internationally legally binding instrument, in February 2022, and included plastic pollution of the marine environment. The ambition is to complete the negotiations by end of 2024. The instrument is to be based on a comprehensive approach that addresses the full life cycle of plastic. How this binding instrument will address plastic pollution in the marine environment is yet to be determined. However, the initial intent is to capture plastic issues that are not or cannot be addressed by existing international instruments, like MARPOL, which is limited to shipping or the London Protocol/London Convention that more broadly protects the marine environment from human activity.

As a globally binding instrument, approximately 20 U.S. agencies attend the interagency meetings coordinated by Department of State's Office of Environmental Quality, bringing their expertise on trade, health, the environment, standards and technology, energy, and shipping, among others. Of these 20 agencies, only NOAA, the Environmental Protection Agency (EPA), and the Coast Guard have the primary authorities to prevent or respond to plastics in the marine environment.

In the United States, the Department of State's Office of Oceans and International Affairs is leading the charge. Until recently, the office was led by the Assistant Secretary Ms. Monica Medina who urged great ambition in searching for solutions that will turn the tide on plastic pollution.

As directed by the Save our Seas Act, NOAA's Marine

In April 2023, the U.S. Delegation participated in International Maritime Organization Pollution Prevention and Response meetings in London. Members of the delegation are, from bottom left, Rakhi Kasat; Nicolette Pavlovics; and CAPT Jerry Butwid; from top left, Rebecca Reese; CDR Emily Rose; LCDR Max Walker; Galia Kaplan; Wanye Lundry; LT Thomas Ashley. Photo courtesy of Galia Kaplan

Women in Maritime

The same year that the IMO pioneered the ban on plastic pollution from ships, it also initiated its Women in Maritime program. Within this historically male-dominated industry, IMO has been making a concerted effort to help the industry move forward and support women to achieve representation. I can attest, through my own experience, that in the beginning of my career in shipping I was one of few women in the industry. Now I am in good company with many dedicated women working both domestically and internationally on maritime issues. Other initiatives and the mission driven work of government agencies have successfully attracted women. This is clearly visible at the IMO and during DoS ENV's intergovernmental meetings, where the majority of the people discussing ideas for a globally binding agreement and measures to prevent plastic pollution from ships are women. This tide has turned.

Debris Program works on understanding the effects of marine debris and reducing its introduction into the marine environment around the world. In doing this, the administration generates reports and studies specifically on the sources and impacts of derelict fishing gear, innovative uses of plastic waste, and the United States' contribution to global plastic pollution. However, NOAA's involvement in sea-based sources of plastic pollution is not limited to marine debris. Its National Fisheries Management Service is a key contributor to the U.S. delegation at IMO, providing guidance and insight when discussing proposals specifically targeting fishing vessels.

As we continue looking at U.S. authorities that impact plastics in the marine environments, the EPA is responsible for keeping U.S. waters clean through the Clean Water Act. The agency implements pollution control programs through mandatory water quality standards and voluntary partnerships programs. Trash Free Waters is one such program that focuses on reducing the source of trash entering waters, trash capture, and research and community engagement projects at the municipal, state, and regional levels. Specific to plastics, the EPA released its Draft National Strategy to Prevent Plastic Pollution, which builds upon its National Recycling Strategy and focuses on actions to reduce, reuse, collect, and capture plastic waste. One of the objectives is to prevent trash and microplastics from entering waterways and remove escaped trash from the environment.

Of these three agencies, the Coast Guard has the narrowest set of authorities. However, it is the only agency that can directly impact vessel operations by developing, implementing, and enforcing pollution prevention regulations, such as the newly adopted garbage record keeping requirement. Coast Guard vessel inspectors are responsible for ensuring vessel operators follow MARPOL Annex V requirements, which have been incorporated in 33 US Code of Federal Regulation. While actively involved in the prevention of plastic pollution, until such as time that plastics are considered a hazardous substance, or unless plastic pollution presents a hazard to navigation, the Coast Guard is limited in its authority to respond, as it would to an oil spill, which emphasizes the importance of its pollution prevention missions. MARPOL is also limited in its ability to accommodate the new demands being made of it with regards to non-garbage ship sources of plastic pollution. It will eventually adapt, but the maritime community first needs to move through its process before it collectively turns its attention to new and proposed alternatives, such as a maritime plastic code, an idea currently simmering on the sidelines.

About the author:

Galia Kaplan has more than 30 years of experience in the maritime field. In her current position at Coast Guard Headquarters, she is responsible for developing domestic and international pollution prevention regulations. She received her bachelors in Maritime Studies from Cardiff University in Wales and an MBA from ESADE while living in Spain.

Endnotes:

1 PPR10/INF List of Participants, IMO

2 Focus on IMO, October 1998, IMO

3 Lebreton, L., Slat, B., Ferrari, F. et al. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. Sci Rep 8, 4666 (2018). https://doi.org/10.1038/s41598-018-22939

4 Guidelines for the monitoring and assessment of plastic litter in the ocean. (2019). GESAMP. Retrieved June 15, 2023, from http://www.gesamp.org/publications/guidelines-for-the-monitoring-and-assessment-of-plastic-litter-in-the-ocean

5 PPR10/INF.13 Guidelines on clean-up of plastic pellets rom ship-source spills, submitted by Norway, South Africa, ITOPF, and P7I Clubs; MEPC 80. INF.15 Study on pollution by plastic pellets, submitted by France

MARPOL at 50

Navigating a sea of environmental change

by Gerard Pannell
Director of Training
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American Maritime Officers

It is hard to believe that not long-ago vessels in transit used the ocean waters like a garbage disposal. As recently as 50 years ago, it was common to see seafarers throwing everything from cigarette butts and paint cans to galley trash over the side of a vessel underway with little consideration for the environmental effects.

Pollution Prevention and Response (PPR) awareness and subsequent training for seafarers has evolved dramatically over time. As environmental awareness has grown, shipowners and seafarers have experienced the impacts of pollution through increased regulatory requirements as well as social and political pressure to address pollution,

Captain K. Michele Laycock, master on the *Maersk Peary*, monitors evolutions during an underway replenishment operation with the U.S. Navy Ship *Supply*. Photo courtesy of Captain K. Michele Laycock/American Maritime Officers

U.S. Merchant Marine deck officers secure lines onboard a tanker operated by U.S. Marine Management, Inc., during a 2021 resupply mission for two Military Sealift Command vessels. The tanker served in an underway replenishment mission in for U.S. Navy Ships *Supply* and *William McLean* in the extreme North Atlantic area. Photo courtesy of Captain Everett Hatton/American Maritime Officers

including prevention of, and response to, environmental incidents. This has been driven, in large part, by serious maritime incidents at home and abroad that have resulted in compounding environmental damage. Today, seafarers globally are trained and drilled in the full spectrum of PPR activities including prevention requirements, pollution sources, and mitigation of risk in relation to their vessel's specific operations.

Good prevention initiatives, like specialized training, certifications, and endorsements being required for seafarers working on vessels carrying hazardous cargos and bulk dangerous liquids and substances can go a long way in reducing the risk of pollution from shipping. Overall, these requirements and practices have led to a decrease in environmental incidents through more effective preparedness and response to both major and minor pollution events.

Today's seafarers receive training in shipboard waste streams, operational procedures, and regulatory requirements appropriate for their operational and emergency duties, and company responsibilities. PPR training for seafarers concentrates on high consequence and liability discharges with particular attention given to oil and hazardous materials and substances.

It is important to recognize that shipboard pollutants are regulated at multiple levels. U.S. PPR requirements are promulgated through the United States Code and related Code of Federal Regulations (CFR). Internationally, conventions of the International Maritime Organization (IMO) address marine pollution from ships. Fifty years later, the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978, or MARPOL 73/78, remains one of the most important international marine environmental conventions.

The United States implements these international conventions through national laws and regulations. The Act to Prevent Pollution from Ships is the U.S. law that implements the provisions of MARPOL and the annexes to which the United States is a party. The most recent U.S. action concerning MARPOL occurred in April 2006 when the U.S. Senate approved Annex VI, which regulates air pollution.

U.S. seafarers are required to complete training in PPR applicable to the type of vessel they serve on and the types of cargoes a vessel carries. Multiple parts of 46 CFR Subchapter B outline general training required to receive a merchant mariner credential and associated national and international endorsements. These regulations further provide requirements for familiarization with vessel specific operations, such as 46 CFR 15.1105 which requires seafarers to have completed safety related basic training and be familiar with the equipment, operations, and emergency procedures related to their function and responsibilities onboard.

Through the Coast Guard credentialing process, a seafarer's knowledge in the requirements for pollution prevention and response is verified and validated through written examinations and practical assessments of competence. National requirements for vessel operations and onboard pollution prevention and response training are found in title 33 CFR Subchapter O.

The Foundation

Basic foundational training for seafarers starts with ensuring a knowledge of solid waste and garbage discharge and associated record-keeping requirements and expands from there. There are additional U.S. Department of Transportation (DOT) requirements for all individuals involved in the shipment of hazardous materials by water, including seafarers, which are contained in 49 CFR Part 176. Furthermore, the Environmental Protection Agency's National Pollution Discharge and Elimination System Vessel General Permit regulates shipboard discharges incidental to the normal operation of vessels. This includes, among others, bilge water, ballast water, deck runoff/washdown, and graywater—wash water from showers and sinks, etc. Seafarers onboard are responsible for ensuring adherence to the permit.

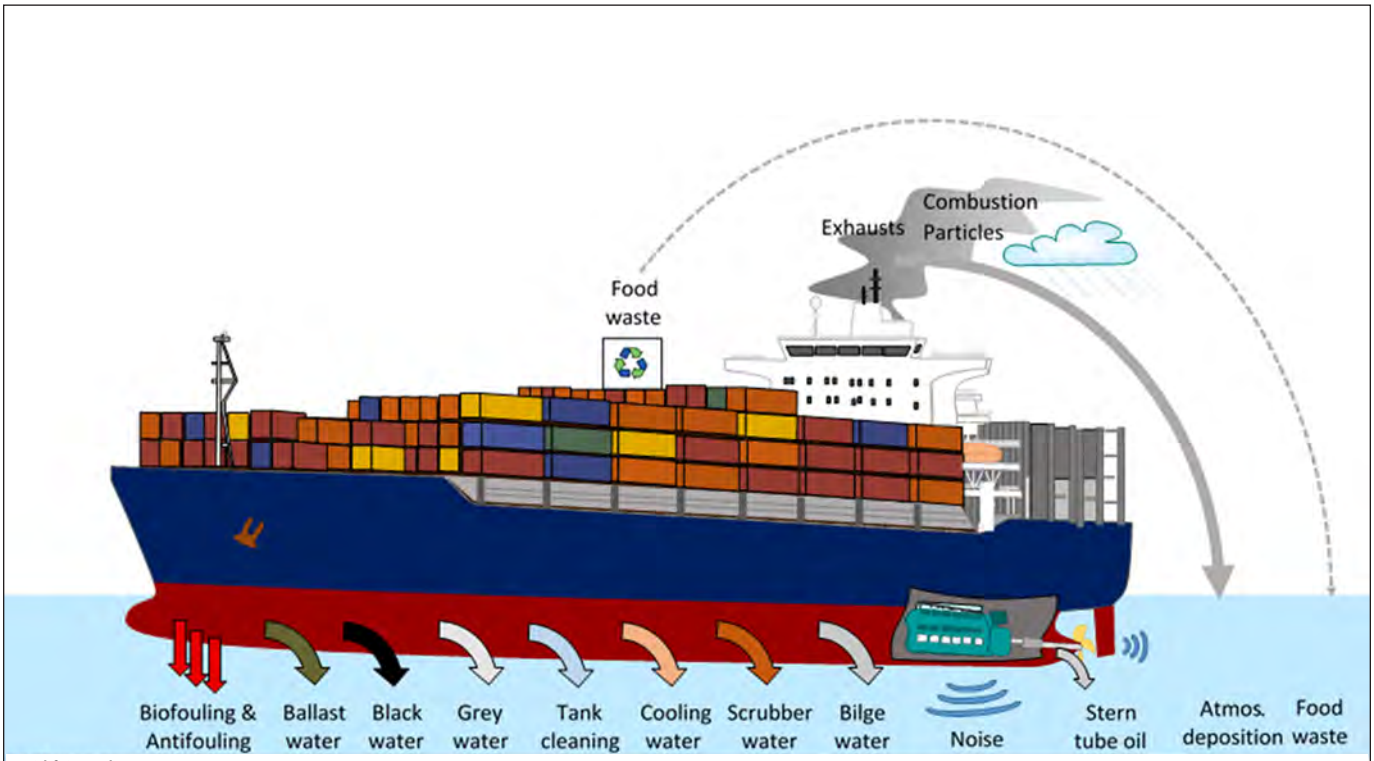
Supplementing national regulations, the IMO provides the international instrument that addresses required standards of competence for seafarers when engaged on a vessel operating internationally. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) prescribes minimum standards related to training,

certification, and watchkeeping for seafarers, which administrations are obliged to meet or exceed. These standards are incorporated into national regulations applicable to vessels operating outside of their domestic national waters. In the United States, seafarers can obtain an STCW endorsement on their merchant mariner credential (MMC) after meeting service and training requirements and demonstrating they have achieved a standard of competence under real-world conditions. STCW competence requirements include knowledge, understanding, and proficiencies in the requirements for marine pollution prevention and response included in the MARPOL and related conventions.

National Requirements

National requirements for PPR training on U.S. vessels are primarily addressed in 33 CFR Part 155, Oil or Hazardous Material Pollution Prevention Regulations for Vessels. PPR training for tank vessels and non-tank vessels included in this subpart is specific to the vessel response plan. Approved vessel response plans must contain a section addressing training and exercise procedures. Under 33 CFR Part 155, the vessel owner or operator is required to have procedures in place to ensure that all personnel with duties and responsibilities under the plan receive training in their assignments, and refresher training as necessary, as well as participate in exercises. It should be noted that within Part 155, it specifically acknowledges that to operate in compliance with the vessel response plan means to conduct the necessary training and exercises.

In practice, both formal training in operational procedures and response, as well as documented work experience are used to meet this requirement. Through familiarization training, onboard training programs, and operational practices and drills, the vessel master will ensure the crew has appropriate competence to prevent and respond to pollution incidents based on the vessel's equipment, systems, operations, and the environment in which it is engaged.



	Biofouling & Antifouling	Ballast water	Black water	Grey water	Tank cleaning	Cooling water	Scrubber water	Bilge water	Noise	Stern tube oil	Atmos. deposition	Food waste
Acidifying substances							X				X	
BOD/COD		X	X	X								X
Halocarbons, POP		X										
Hydrocarbons, PAH		X		X	X		X	X		X	X	
Litter, PM					X						X	
Metals	X			X		X	X	X		X		
NIS	X	X	X	X								X
Nutrients, N, P		X	X	X	X		X	X			X	X
Energy/noise									X			
Shipping regulations	APS	BWMC	MARPOL Annex IV	MARPOL Annex IV	MARPOL Annex I		MARPOL Annex VI	MARPOL Annex I		MARPOL Annex I	MARPOL Annex	MARPOL Annex V

Waste streams from ships and constituents in terms of stressors on the marine environment are regulated through several international conventions, like the IMO MARPOL, Antifouling and Ballast Water Management conventions. Releases of excess energy—noise, heat, light—to the sea are not currently regulated. Illustration courtesy of Ocean Science/Copernicus Publications[1]

When hazardous materials are carried on vessels, 49 CFR Part 176 includes training provisions for employees involved in hazmat operations. This training directly relates to hazard communications and informs those responsible for prevention and response of potential risks and incidents involving the hazardous materials. Seafarers receive training focused on the DOT requirements for shipping hazardous materials by water, which includes operating, handling, and stowage requirements; segregation of hazardous materials; requirements for explosives; and requirements for reporting an incident.

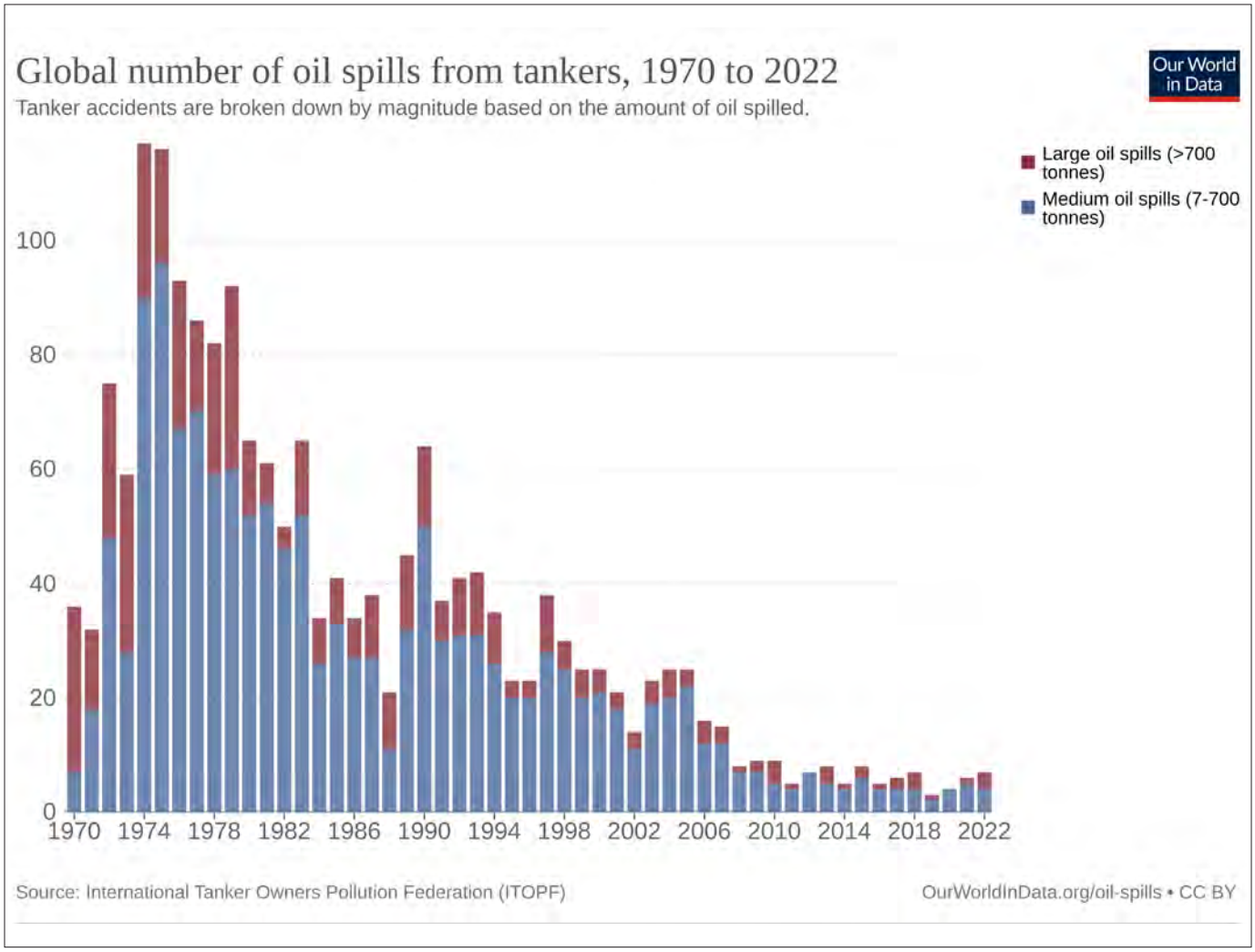
Tank Vessels

In the spring of 1989, the *Exxon Valdez* ran aground in Prince William Sound, Alaska, spilling 11 million gallons of oil and resulting in one of the largest environmental disasters in U.S. history.[2] The spill resulted in a close examination of the status of oil spill prevention, response, and cleanup in the United States, resulting in The Oil Pollution Act of 1990 (OPA 90). This Act addressed many of the issues the *Exxon Valdez* incident brought to light regarding preventing, responding to, and paying for oil pollution incidents in the navigable waters of the United States.

OPA 90 greatly increased federal oversight of maritime oil transportation while providing greater environmental safeguards. In addition to setting new requirements for vessel construction, there were also new provisions and requirements for the manning of tank vessels, as well as the training and certification of seafarers on these vessels.

Regulations on manning[3] of tank vessels are found in 46 CFR Part 15. These include appropriate minimum numbers of seafarers holding an MMC endorsement and serving as tankerman assistant, tankerman engineer, and tankerman person-in-charge (PIC)[4] on tank vessels carrying bulk dangerous liquids or liquified gases as a cargo.

Each of the designated personnel on tankers has a



While the number of tanker spill incidents sharply declined since 1970, there was a significant growth in the crude and other tanker trade, from 1500 million metric tons in 1970 to high of 3000 million metric tons in 2018. Map courtesy of Our World in Data. All info based on data published by the International Tanker Owners Pollution Federation.

specialized role and responsibility for the safe and environmentally responsible operation of the vessel, its systems and, in turn, pollution prevention and response. The tankerman assistant supports and carries out the orders of the designated tankerman PIC. The tankerman engineer maintains the cargo handling, pollution prevention and response equipment onboard the tank vessel to meet the required equipment standards.

While all crew members are required to undertake familiarization and safety training prior to assuming their duties, to receive a Coast Guard-issued MMC endorsement, tankerman assistants, engineers, and persons-in-charge have additional requirements. They must complete approved training commensurate with the level of their designated duties and responsibilities in the following subject areas:

- tanker design systems
- safe operations
- cargo and ballast transfer operations
- regulatory compliance
- pollution prevention and response
- system components and instruments
- inert gas and vapor control systems, including gas freeing operations
- failures and emergencies
- confined spaces

In addition to completing approved training, to qualify for an MMC endorsement as tankerman engineer and tankerman PIC, seafarers must meet additional, strict service requirements. These include 90 days onboard a tanker specific to the types of cargo for which they are seeking endorsement—dangerous liquids or liquefied gases. Due to their overall role in the cargo transfer operation, the tankerman PIC must also document participation in five load and five discharge cargo operations. This additional requirement demonstrates the individual's competence and ability to safely manage the overall transfer operation of bulk oil, chemicals, or liquefied gases. To renew MMC tanker endorsements, individuals must maintain competence in the appropriate knowledge and skills every five years.

International

All seafarers on international voyages must adhere to and be properly certified by their administration in the requirements of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, which establishes minimum qualification standards for personnel on seagoing ships. The United States is party to the STCW Convention and has incorporated its requirements, which are separate from U.S. requirements, into national regulation and policy. The STCW requirements include knowledge, understanding, and proficiencies on pollution prevention and response and are categorized by the three functional of levels of seafarers'[5] responsibility onboard.

- Support level is responsible for performing assigned tasks, duties, or responsibilities onboard a seagoing vessel under the direction of an individual serving in the operational or management level. This applies to seafarer ratings forming part of a navigational or engine watch.
- Operational level is responsible for maintaining direct control over the performance of all functions within the designated area of responsibility in accordance with proper procedures. This is done under the direction of an individual serving in the management level for that area of responsibility and applies to the officer in charge of a navigational or engineering watch.
- Management level is responsible for ensuring all functions within the designated area of responsibility are performed properly. This applies to master, chief mate, chief engineer officer, or second engineer officer.

All seafarers complete STCW basic training and are required to recertify every 5 years. Pollution prevention and response topics within basic training allow seafarers to demonstrate the ability to "take precautions to prevent pollution to the marine environment." This training allows seafarers to become proficient in understanding the complexity and diversity of the marine environment; basic environmental protection procedures; the impact of shipping on the marine environment; and effects of operational or accidental pollution on it.

These requirements ensure all seafarers comprehend organizational procedures designed to safeguard the marine environment and that they observe them at all times. All seafarers also receive training in observing safe working practices which include familiarization with accident prevention and occupational health measures.

Operational level officers receive additional training to ensure compliance with pollution prevention requirements in the following relevant areas:

- prevention of pollution of the marine environment and anti-pollution procedures
- precautions to be taken to prevent pollution of the marine environment
- anti-pollution procedures and all associated equipment
- importance of proactive measures to protect the marine environment

This ensures that officers can effectively demonstrate the procedures for monitoring shipboard operations

and helps ensure compliance with MARPOL and other environmental requirements, like the Ballast Water Management Convention.

In addition to the support and operational training requirements, management-level officers receive training to monitor and control compliance with legislative requirements and measures to ensure safety of life at sea, security, and the protection of the marine environment. This includes competence in all vessel and cargo operations, as well as the carriage of dangerous goods, and the development of emergency and damage control plans including the ability to respond in emergencies.

As you would expect of a senior officer onboard, the training required to understand and demonstrate proficiencies and competence in their responsibilities are expansive and detailed. They include, but are not limited to:

- responsibilities under MARPOL as amended, as well as other conventions
- methods and aids to prevent pollution of the marine environment by ships
- ability to establish procedures for safe cargo handling in accordance with the provisions of the relevant instruments such as the IMDG Code, IMSBC Code, and MARPOL 73/78.

There are also STCW requirements for specialized vessels including tank ships which correlate to the U.S. requirements on these types of vessels and personnel onboard.

Additionally, there are nationally and internationally mandated requirements for hours of work and hours of rest. These address the risks associated with fatigue and must be implemented by operating companies and adhered to by seafarers.

Pollution prevention and response is at the foundation core competencies for seafarers which, in turn, contributes to the safe and environmentally sound operation of all vessels. It makes sense that there is overlap in many of the pollution prevention and response training and requirements nationally and internationally. These requirements have grown and matured through the years, but not without impact to the seafarer.

It must be recognized that initial and ongoing training and drills onboard, as well as the ongoing vessel operational requirements, present challenges to seafarers. Due to the transient nature of shipping, seafarers must complete their professional training while on vacation which greatly impacts their quality of life. They are aware of the role their actions have in protecting the marine environment and understand that, while training in pollution prevention and response is required, it is also socially responsible.

As regulations and training requirements have increased, benefits in the reduction of marine pollution from ships have been recognized. Oil pollution in the marine environment has the most significant, immediate, and long-term impacts worldwide, but statistics show a reduction in the number of tanker spills over time, particularly after 1990, though the worldwide tanker trade doubled.

Domestically, the Coast Guard reported to Congress that in the 10-year period following the passage of OPA 90 there was "a dramatic reduction in the volume of oil spilled into U.S. waters from tankers per million gallons shipped ...." The report noted a decline from 9.7 gallons spilled per million gallons shipped in 1990 to 2.7 gallons per million gallons shipped in 1999, a decrease of over 70 percent.[6] Other recent national and international statistics show net reductions in other marine pollutants, including greenhouse gases, which can be attributed to compliance with regulatory requirements.

Conclusion

The maritime industry has come a long way since its years of treating the oceans as a trash bin. Through the implementation of pollution prevention and response training, there has been a noticeable reduction of pollution incidents and more timely and effective responses. In addition to the obvious acute and long-term benefits to the marine environment, there are additional benefits realized by upholding the positive environmental reputation of shipping. PPR training has also improved the health and safety of seafarers and the public, while also lowering owners' and coastal states' liability and cleanup costs.

About the author:

Captain Gerard Pannell is a master mariner with 20 years seagoing experience, including 10 years as captain of unlimited tonnage merchant cargo and tank vessels in domestic coastwise and international trades. He holds a B.S. in marine transportation from the State University of New York Maritime College and graduate certificate in pollution compliance for seafarers from Massachusetts Maritime Academy. He is currently director of training for American Maritime Officers, Simulation Training, Assessment and Research Center in Dania Beach, Florida.

Endnotes:

1 Jalkanen, J.-P., Johansson, L., Wilewska-Bien, M., Granhag, L., Ytreberg, E., Eriksson, K. M., Yngsell, D., Hassellöv, I.-M., Magnusson, K., Raudsepp, U., Maljutenko, I., Winnes, H., & Moldanova, J. (2021). Modelling of discharges from Baltic Sea shipping. Ocean Science, 17(3), 699 -728. https://doi.org/10.5194/os-17-699-2021

2 Valdez | Oil Spills | Damage Assessment, Remediation, and Restoration Program (noaa.gov)

3 "The manning of a vessel" is the complement of offi cers and ratings considered by the Coast Guard to be necessary for safe operation, as described in 46 U.S.C. 8101(a)

4 46 CFR 10.107 defi nes: Tankerman assistant means a person holding a valid "Tankerman-Assistant" endorsement on his or her MMC. See 46 CFR, part 13, Subpart D Tankerman engineer means a person holding a valid "Tankerman-Engineer" endorsement on his or her MMC. See 46 CFR part 13, Subpart E.

5 Tankerman PIC means a person holding a valid "Tankerman-PIC" endorsement on his or her MMC. See 46 CFR part 13, Subpart B

6 Jan 9, 2023- UNITED STATES SENATES hearing of the COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, statement of Rea Admiral Paul J. Pluta, Assistant Commandant for Marine Safety, Security and Environmental Protection, United States Coast Guard

Sailing Towards Uniformity

A Coast Guard perspective on the Vessel Incidental Discharge Act of 2018

by LCDR Matthew Odom
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The Vessel Incidental Discharge Act (VIDA) of 2018 is an important step in the United States' effort to prevent and mitigate risks to the marine environment from discharges incidental to the normal operation of a vessel. These risks include the spread of aquatic nuisance species and introduction of harmful pollutants and pathogens. With its passage in December 2018, VIDA, which seeks to harmonize the current patchwork of federal and state regulations pertaining to vessel incidental discharges, became the most significant expansion of Coast Guard's environmental authority since the Oil Pollution Act of 1990.

"Incidental discharges" refers to discharges that are a byproduct of the normal operation of a vessel. For example, most commercial vessels need to conduct ballast water operations to maintain safe stability. VIDA regulates a number of incidental discharges including ballast water, exhaust gas cleaning systems, graywater, and fire protection equipment residues, among others.

Background and Regulatory Framework

The first comprehensive legislation intended to protect U.S. navigable waters from vessel incidental discharges was the Clean Water Act of 1972. However, those discharges were left largely unregulated until 2008 when the Environmental Protection Agency (EPA) introduced the Vessel General Permit (VGP) under the National Pollutant Discharge Elimination System. Under the current VGP framework, states and tribes can set more stringent requirements and enforcement measures than those established by the EPA. Concurrent to the VGP, the Coast Guard has its own ballast water management requirements and enforcement activities under the authority of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 which was later amended by the National Invasive Species Act.

Positive changes have been made to the regulatory landscape governing commercial vessel discharges over the past 50 years, however it remains fragmented with vessels having to comply with both federal and varying state regulations on their voyages. VIDA was enacted to address these regulatory challenges and is intended to establish uniform national standards and requirements for the management of these discharges. The statute redefines both the Coast Guard and EPA's responsibilities for marine inspections and environmental protection

An inspector checks a ballast water sample through a refractormeter. The Coast Guard inspects all vessels' ballast water before they enter the Great Lakes to prevent invasive species inhabiting ecosystems. Coast Guard photo by Petty Officer 3rd Class William B. Mitchell

activities related to discharges that are incidental to the normal operation of vessels.

As a baseline, the EPA and the Coast Guard are required to develop regulations that, with some exceptions, are not "less stringent" than the requirements set in the VGP. Currently, the EPA is developing the national performance standards for all vessel incidental discharges. These standards are required to be based on the best available technology that is economically achievable. Within two years of their finalization, the Coast Guard must then finalize the associated implementing regulations, including a unified approach to compliance oversight and enforcement. Furthermore, EPA's discharge standards must be reviewed at least once every five years, and revised if appropriate, ensuring they remain effective with changing environmental conditions and technological advancements. This new regulatory approach established under VIDA is expected to provide greater clarity and consistency for vessel managers and operators.

Other Statutory Requirements

VIDA also directs the Coast Guard to evaluate its ballast water management system (BWMS) testing methods for type approval. The Coast Guard published the policy letter *Type-Approval Testing Methods for Ballast Water Management Systems that Render Organisms Nonviable in Ballast Water* in Spring 2022. This policy outlines the Coast Guard's approach to evaluating and approving BWMS that make organisms incapable of reproduction, or nonviable. Current Coast Guard approved BWMS must be tested in accordance with the Environmental Technology Verification protocol methods. The policy letter serves as a guide for the Coast Guard's process of reviewing and the possibility of accepting alternative viability testing methods. Founded on the best available science, strict evaluation methods such as peer reviewed data and risk documentation, are required. As of this date, no viability testing methods have been submitted to the Coast Guard for consideration, however, once an alternative method is approved, it will be integrated into the type-approval process for BWMS.

The Coast Guard is also directed to share certain types of ballast water and vessel information with federal and state agencies. Specifically, it is required to provide interested states access to ballast water reporting information. This information includes details such as the source of ballast water, volume discharged, and any treatments applied. Sharing this information is vital to the unified approach of coordinating and managing the risk of invasive species and harmful organisms from ballast water discharge.

Upon a governor's request, the Coast Guard is also required to share Vessel Automatic Identification System data with states. Access to this data provides real-time information about a vessel's location and can be used to track movement patterns. The combination of ballast water information and vessel movements will provide a more complete picture of potential risks and pathways for the spread of invasive species.

Engagement with States

VIDA recognizes the importance of state involvement and establishes a federal framework for regulating vessel incidental discharges, superseding most individual state requirements. However, it grants states the authority to enforce the federal standards set by the Coast Guard and EPA. While VIDA does largely preempt states from setting state-level requirements for vessel incidental discharges, it does not infringe upon states' authority to regulate other non-VIDA vessel discharges, such as sewage.

The Environmental Protection Agency's discharge standards must be reviewed every five years to keep up with changing environments and technology. Photo by LD | iStock/Getty Images

The legislation requires that the EPA and Coast Guard consult with state authorities in the development of the national performance standards and vessel implementing regulations. Additionally, it outlines a petition process for states to request more stringent national standards from either the EPA or the Coast Guard. It also provides the opportunity for states to coordinate with the Coast Guard on compliance and

Incidental discharge is a byproduct of the normal operation of a vessel. Releasing ballast water to increase stability while offloading is one example of an incidental discharge. The Vessel Incidental Discharge Act was enacted to regulate these discharges and establish uniform standards and requirements. Photo by antoni_halim | iStock/Getty Images

enforcement related activities including inspections, monitoring, data sharing, and enforcement procedures. The Coast Guard began this coordination in March 2023 to ensure a consistent and uniform approach to development and future implementation of these national standards.

Further opportunities for states include participation in an intergovernmental framework focused on the prevention of and response to invasions and spread of aquatic nuisance species. The framework is designed to improve collaboration and coordination efforts such as the sharing of best practices and resources.

The aforementioned opportunities not only provide states with the ability to engage in the VIDA rulemaking process, but also help foster relationships between the Coast Guard, EPA, and state agencies. These interagency partnerships will help further identify regional issues, leverage geographic expertise, and promote effective collaboration on enforcement and compliance efforts.

Conclusion

VIDA is an essential tool in the effort to prevent pollution from vessels and protect the United States' marine ecosystems. By streamlining and unifying requirements for vessels, VIDA addresses the regulatory complexity currently faced by the shipping industry. As we navigate past the 50th anniversary of MARPOL, VIDA underscores the Coast Guard's commitment to facilitating commerce while preserving the marine environment.

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Nicole Schindler is the VIDA coordinator and a technical advisor to the Office of Operating and Environmental Standards at Coast Guard Headquarters. She has a 20+ year career in the federal government working for the U.S. Environmental Protection Agency and the U.S. Department of Agriculture in environmental protection and domestic infrastructure development. She is a graduate of Virginia Polytechnic Institute with a B.S. in environmental resource management and a M.S. in environmental engineering from the University of Maryland, College Park.

References:

16 U.S.C Chapter 67 Aquatic Nuisance Prevention and Control

33 U.S.C 1322 (p) Uniform national standards for discharges incidental to normal operation of vessels [VIDA].

Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP)" Effective December 19, 2013

Historical Snapshot

U.S. Revenue Cutter Lawrence

Tamer of America's martime frontier and first PACAREA cutter

by William Thiesen
Atlantica Area Historian
U.S. Coast Guard

When it is remembered that you have been in a harbor where from five to six hundred vessels were riding at anchor—in the midst of a great excitement—with crews insubordinate & lawless—without the aide of civil authorities or civil process & when day & night you have been called upon to render assistance & to aid masters of vessels in suppressing mutiny & violence, surely it becomes me to bear willing testimony to the necessity of your presence & your promptness in the discharge of your onerous duties.
— Customs Collector James Collier to Capt. Alex Fraser (RCS), San Francisco, 1850

Many believe that the "Wild West" existed in the 19thcentury frontier towns of the American West. However wild the American West may have been, it was no worse than the violence and lawlessness experienced on board the ships that sailed to the west coast during the 1800s. The laws of this maritime frontier had only one enforcer, the U.S. Revenue Cutter Service and *C.W. Lawrence* was the first cutter sent to the west coast to enforce laws on the high seas. And, as the first cutter to enter the Pacific Ocean, Lawrence established the Coast Guard's area of responsibility in the Pacific.

Cornelius W. Lawrence

Alexander Fraser

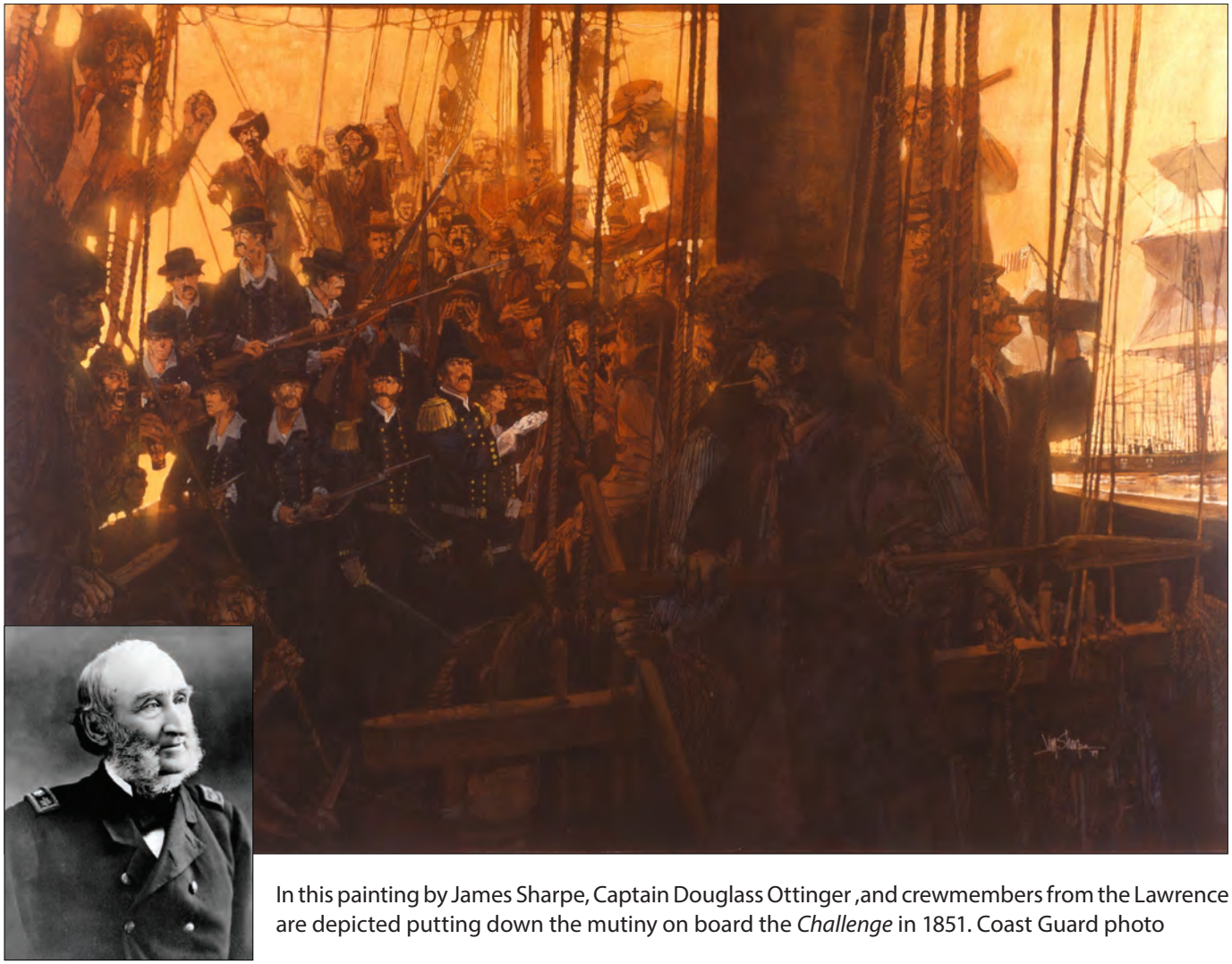
C.W. Lawrence was built as one of seven replacements for cutters lost during the Mexican War. The cutter was named for Cornelius Lawrence, the collector of customs at the Port of New York, who also served as mayor of that city. Lawrence was a black-hulled brig-rigged Baltimore clipper carrying raked masts with a length of 96 feet, beam of 24 feet, and displacement of 144 tons. For armament, Lawrence carried two 32-pounders, one long 18-pounder, and two 6-pounders. This was in addition to smaller weapons such as carbines, percussion pistols, Colt revolvers, boarding pikes, and cutlasses.

The *Lawrence* was launched on August 20, 1848, at William Easby's shipyard at Foggy Bottom in Washington, D.C., and spent the next several weeks fitting out before the Revenue Cutter Service accepted it for service on October 11. The cutter's first commanding officer, who also oversaw her construction, was Captain Alexander Fraser. Fraser had under his command 43 men, including an executive officer, two second lieutenants, two third lieutenants, a surgeon, and 35 enlisted men. On November 1, 1848, *Lawrence* set sail on a maiden voyage to the Pacific Ocean by way of treacherous Cape Horn.

During *Lawrence*'s nearly year-long odyssey from the Atlantic to the Pacific, the cutter's crew suffered many hardships. The cutter hit foul weather as soon as it sailed into the Gulf Stream to begin the southbound leg along the southeast United States. The consequent damage to the cutter proved so severe it took nearly two months in Rio de Janeiro to repair its hull, spars and rigging. After Rio, *Lawrence* spent five weeks facing raging seas, howling headwinds, and fierce storms trying to round Cape Horn. When the cutter finally entered the Pacific in June 1849, it became the first of numerous cutters to serve in that ocean.

On *Lawrence*'s way to its new home in San Francisco, the cutter also visited Hawaii and recruited 17 Hawaiians for its crew. These were the first Pacific Islanders to serve in the Coast Guard. After an arduous voyage of more than 11 months, including over a month to sail around Cape Horn, *Lawrence* arrived in San Francisco on October 31, 1849.

During the cutter's odyssey from the east coast to



In this painting by James Sharpe, Captain Douglass Ottinger ,and crewmembers from the Lawrence are depicted putting down the mutiny on board the *Challenge* in 1851. Coast Guard photo

the west coast, gold had been discovered in the foothills of California. Difficulties soon visited the cutter in San Francisco when the crew learned of the fortunes made by those prospecting for gold. One after another, his officers resigned their commissions and his enlisted men deserted in droves, so Fraser soon found himself with a skeleton crew. The local customs collector chartered a small schooner, the *Argus*, and purchased another, *Catherine*, to carry out law enforcement patrols because they required smaller crews. For much of the next year, *Lawrence* remained idle on the San Francisco waterfront.

Described as a "forest of masts," the anchorage off San Francisco held derelict ships in various states of disrepair—many with fouled anchors and cables. In 1850 alone, *Lawrence* was struck five times by drifting ships causing damage to the cutter's hull, spars, and yards. With his few remaining men, Fraser did his best to enforce the law, assist ships in distress and perform the duties of the Revenue Cutter Service. For example, when the steamer *Sagamore* burst its boilers on the waterfront, *Lawrence* deployed its boats to rescue survivors from the water and deliver them to the hospital.

Fraser did his best to enforce U.S. law, though. In 1850, smuggling illicit goods into San Francisco reached a level not seen again until Prohibition and the criminalization of liquor sales. In the evenings, a crew from the *Lawrence* would use the cutter's launch to patrol San Francisco Harbor for smugglers. Fraser and his men also prevented mutinies on board merchant vessels newly arrived in San Francisco Bay when "gold fever" swept their crews. After *Lawrence*'s first few months in port, the cutter held so many mutineers in irons that it was little more than a prison ship. Later, the number of prisoners exceeded the capacity of the cutter's brig, so mutineers had to be placed in irons on board other vessels.

In late 1850, after Revenue Cutter *Polk* arrived to patrol San Francisco Bay, *Lawrence* was fitted-out for a cruise down the coast to chart the California's inlets, bays and waterways—the first federal survey of the California coast. *Lawrence* cleared the Golden Gate on the night of

December 26 and headed south along the coast. The cutter arrived in San Diego on January 19, 1851, and then sailed for the Hawaiian Islands, arriving at Hilo on March 7. After making a port call in Honolulu, Lawrence sailed for California, returning to San Francisco in early May.

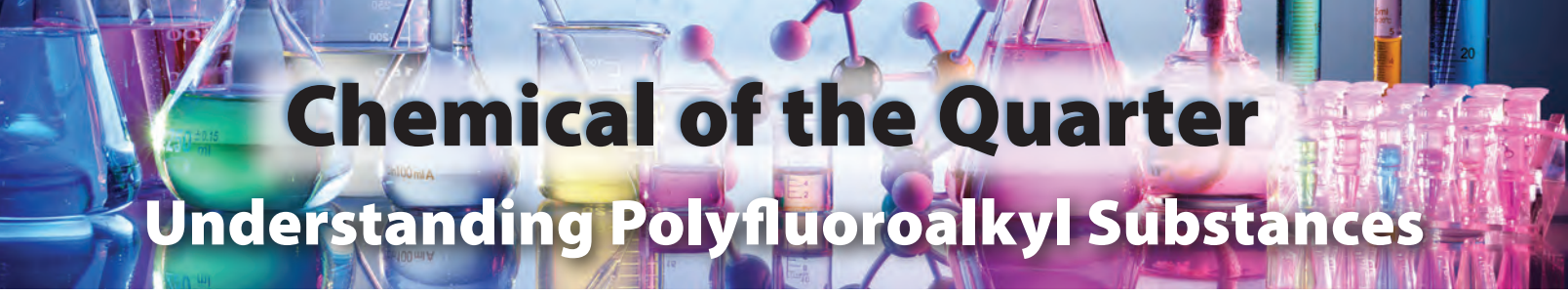
Having overseen *Lawrence*'s construction, commanding the cutter during its epic journey to the West Coast and serving a year in San Francisco's lawless waters, Fraser requested a leave of absence. His request was granted and Revenue Cutter Service Captain Douglas Ottinger relieved him on June 7, 1851. Like Fraser, Ottinger oversaw the cutter's missions of law enforcement, interdicting smugglers and quelling mutinies. In October, Ottinger and his crew participated in the infamous Challenge Affair, when the crew of the clipper ship *Challenge* mutinied and a mob of 1,000 San Franciscans ransacked the ship and tried to lynch the ship's captain and first mate. Ottinger and local authorities finally brought the situation under control. At the same time the *Challenge* Affair took place, Ottinger dealt with several vessels rumored to have weapons and filibusters on board preparing to depart San Francisco for Hawaii to overthrow the Hawaiian monarchy. Somehow, Ottinger and his men averted an armed conflict with these vessels and kept them from carrying out their plan.

Unlike Captain Ottinger's career, the *Lawrence*'s career was over not long after this event. In the dark of night on November 25, 1851, with heavy seas, and visibility too poor to determine his location or judge the tide, Captain Ottinger ran the *Lawrence* onto a beach, near the approaches to San Francisco Bay. None of the crew were lost and the cutter's ordnance and equipment were salvaged. For this accident, the service absolved Ottinger of fault and he went on to serve a lengthy career in the Revenue Cutter Service. However, the cutter could not be saved and the local customs collector sold the beached hull and damaged equipment to salvers. Meanwhile, the cutter's crew, armament, and equipment were transferred to another cutter.

As the Pacific's first revenue cutter, the *Lawrence* had served a career of less than four years. However, during that time, it saw more action than cutters several times its age, including putting down mutinies, interdicting smugglers, saving vessels in distress, charting the California coast and taming America's maritime frontier. And, 170 years ago, the Lawrence began serving on the west coast, establishing the Coast Guard's Pacific area of responsibility.

About the author:
William H. Thiesen, Ph.D., is the Atlantic Area historian for the United States Coast Guard. He earned an M.A. from East Carolina University's Program in Maritime History, and a Ph.D. in the History of Technology from University of Delaware's Hagley Program. His books include Industrializing American Shipbuilding: The Transformation of Ship Design and Construction, 1820–1920 and Cruise of the Dashing Wave: Rounding Cape Horn in 1860. His articles appear frequently in naval, maritime, and Coast Guard publications and the online history series, The Long Blue Line, featured weekly on the Coast Guard Compass web site.

The schooner, *Californian*, is a replica of the United States Revenue Cutter *C.W. Lawrence*. Photo courtesy of Jon Sullivan



Chemical of the Quarter

Understanding Polyfluoroalkyl Substances

by LT Jeff Bors
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Lifesaving & Fire Safety Division
Office of Design and Engineering Standards
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Dr. Pock Utiskul
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What is it?

Per- and polyfluoroalkyl substances (PFAS) are man-made chemicals renowned for their durability and heat resistance. These qualities have led to their widespread use in various industrial and consumer products, including nonstick cookware, waterproof materials, paints, and marine industry applications like firefighting foams.

PFAS' heat-resistant properties have made them particularly valuable in firefighting applications, specifically in the formulation of Aqueous Film Forming Foams (AFFFs). While these foams are exceptional at combating flammable liquid fires—they both remove heat and cover the fuel source under a durable blanket of foam that smothers the fire and helps prevent reignition—the foam layer does not easily break down.

Why should I care?

➤ *Health and Environmental Concerns:*

The persistent nature of these chemicals, however, poses long term environmental concerns and adverse heath affects to humans if exposed. The Centers for Disease Control recently reported that 95 percent of the U.S. population has some level of PFAS in their bodies.

The chemical stability that makes PFAS so effective in firefighting also poses significant environmental challenges. These robust chemical chains do not break down naturally, leading to long-term environmental persistence. PFAS have been found in various marine species, a result of marine ecosystems contaminated by runoff from sites where PFAS-based foams were used. This bioaccumulation can detrimentally impact these species affecting their growth, reproduction, and overall survival. Human consumption of contaminated water or foods can lead to potential health impacts including liver and immune system damage.

What is being done about it?

Addressing the issues associated with PFAS contamination is a multifaceted challenge. Safer alternatives to PFAS-containing firefighting foams need to be developed and widely adopted, and effective cleanup strategies for contaminated sites must be implemented. Further, comprehensive regulations restricting PFAS use and managing their disposal are also critical. The biggest challenge for firefighting is finding alternatives that provide a level of protection similar to AFFF. While this challenge is addressed, proposals are being considered at the International Maritime Organization to ban firefighting foam containing certain PFAS.

The process of regulating PFAS is already underway, with restrictions being progressively implemented at the international, federal, and state levels. The Environmental Protection Agency's Notice of Proposed Rulemaking on Vessel Incidental Discharge National Standards and Performance prohibits discharge of PFAS firefighting foam under certain conditions. The National Defense Authorization Act directs all Department of Defense fire departments to cease use of PFAS foam by 2024.

What is the Coast Guard doing about it?

The environmental impact of these chemicals, particularly on marine environments, underscores the urgent need for innovative solutions. While the development and implementation of these solutions remain a work in progress, the Coast Guard is taking steps toward eliminating this hazard from the environment while maintaining safety.

Information and news on PFAS can be found at www.epa.gov/pfas. For questions, please contact CGENG@uscg.mil.

About the authors:

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Dr. Pock Y. Utiskul is a fire protection engineer at the Lifesaving and Fire Safety Division at Coast Guard Headquarters. Prior to joining the Coast Guard, he worked in the private sector as a managing engineer consulting on fire protection systems, building fire and life safety codes for high-risks occupancies, and fire origin and cause investigations. He obtained his doctorate in 2006 from the University of Maryland at College Park.

References:
www.epa.gov/pfas

Nautical Engineering Queries

Questions

Prepared by NMC Engineering Examination Team

1. A loud buzzing noise at the contacts of a magnetic controller could indicate what condition?

A. Weak contact spring pressure
B. Misalignment of the magnet faces
C. Excessive line current
D. Mechanical binding

---

2. The function of seal cages, or lantern rings installed in the centrifugal pump stuffing boxes, is to _____ ?

A. Cool the shaft
B. Clean the packing
C. Seal air from entering along the shaft
D. Distribute the sealing liquid within the stuffing box

---

3. Which of the turbocharging systems listed operates with the least average back pressure in the exhaust manifold?

A. Constant volume
B. Constant pressure
C. Pulse pressure
D. Radial flow

---

4. The horizontal fore and aft movement of a vessel is called _____ .?

A. Yaw
B. Sway
C. Heave
D. Surge

Engineering Answers

1. A. Weak contact spring pressure — Incorrect answer

B. Misalignment of the magnet faces — **Correct Answer.** This is one of four possible causes for AC controllers, the others being: Broken shading coil; Dirt on magnet faces; Low voltage

C. Excessive line current — Incorrect answer

D. Mechanical binding — Incorrect answer

Reference: Operating, Testing, and Preventive Maintenance of Electrical Power Apparatus, *Hubert, page 479, Table 22-1*

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2. A. Cool the shaft — Incorrect answer

B. Clean the packing — Incorrect answer

C. Seal air from entering along the shaft — Incorrect answer

D. Distribute the sealing liquid within the stuffing box — **Correct Answer.** Water or some other sealing fluid is introduced under pressure into the space, causing flow of seal fluid in both axial directions.

Reference: Centrifugal Pumps, *Karassik; pages 75 to 77*

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3. A. Constant volume — Incorrect answer

B. Constant pressure — Incorrect answer

C. Pulse pressure — **Correct Answer.** The pulse system permits operation of the turbine with much less average back pressure in the exhaust manifold.

D. Radial flow — Incorrect answer

Reference: Diesel Engineering Handbook, *12th Ed, Stinson; page 206*

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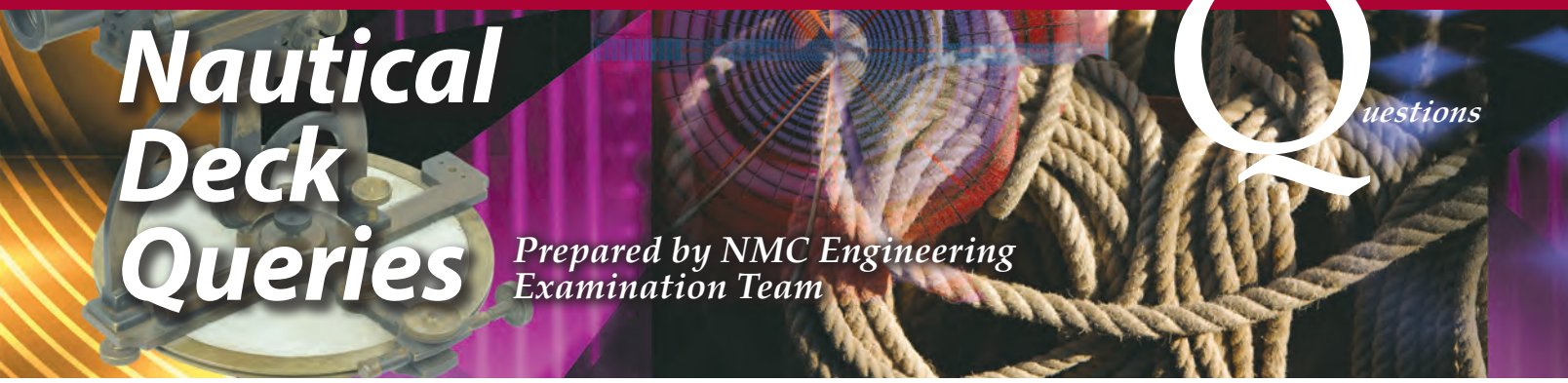
4. A. Yaw — Incorrect answer

B. Sway — Incorrect answer

C. Heave — Incorrect answer

D. Surge — **Correct Answer.** … it is desirable for a vessel to maintain constant speed. This would require that the vessel have stability along the surge axis of motion. AND Motion table item 5, Surge – is stability in motion ahead or astern.

Reference: Stability and Trim for the Ship's Officer, *3rd Ed., George, page 3, 4*



Nautical Deck Queries

Questions

Prepared by NMC Engineering Examination Team

1. INTERNATIONAL ONLY: You are on a vessel that cannot comply with the spacing requirement for masthead lights. What is required in this situation?

A. The vessel must be altered to permit full compliance with the Rules.
B. An all-round light should be substituted for the after masthead light and the stern light.
C. The vessel must carry only the lights that comply with the Rules; the others may be omitted.
D. The vessel's lights must comply as closely as possible, as determined by its government.

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2. Of the required life ring buoys for a 100-foot length OSV in oceans service, what is the minimum that must be equipped with a waterlight?

A. One-half the total number but not less than eight
B. One-half the total number but not less than four
C. One-half the total number but not less than two
D. One-half the total number but not less than one

---

3. Which is TRUE of the term negative slip on a vessel?

A. The distance a vessel travels when all propulsion has been stopped
B. The ship is moving faster than the theoretical propeller speed
C. The ship is moving slower than the theoretical propeller speed
D. The distance a vessel travels in the same direction when the rudder has been applied

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4. Which term is given to a position that is obtained by using two or more intersecting lines of position taken at nearly the same time?

A. Fix
B. Estimated position
C. Running fix
D. Dead-reckoning position

1. A. The vessel must be altered to permit full compliance with the Rules. — Incorrect answer

B. An all-round light should be substituted for the after masthead light and the stern light. — Incorrect answer

C. The vessel must carry only the lights that comply with the Rules; the others may be omitted. — Incorrect answer

D. The vessel's lights must comply as closely as possible, as determined by its government. — **Correct answer.** "Whenever the Government concerned shall have determined that a vessel of special construction or purpose cannot comply fully with the provisions of any of these Rules with respect to the number, position, range or arc of visibility of lights or shapes … such vessel shall comply… as its Government shall have determined to be the closest possible compliance with these Rules in respect to that vessel."

Reference: International Rule 1(e)

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2. A. One-half the total number but not less than eight — Incorrect answer

B. One-half the total number but not less than four — Incorrect answer

C. One-half the total number but not less than two — **Correct answer.** "Except for an OSV in coastwise service and under 30 meters in length, at least one-half the total number of lifebuoys, but not less than two, must each be fitted with a self-igniting light…"

D. One-half the total number but not less than one — Incorrect answer

Reference: 46 CFR 133.70(a)(4)(ii)

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3. A. The distance a vessel travels when all propulsion has been stopped — Incorrect answer

B. The ship is moving faster than the theoretical propeller speed — **Correct answer.** "Following seas and winds help push a ship and can result in a negative slip which indicates the ship is moving faster than the theoretical propeller speed."

C. The ship is moving slower than the theoretical propeller speed — Incorrect answer

D. The distance a vessel travels in t he same direction when the rudder has been applied — Incorrect answer

Reference: Merchant Marine Officer's Handbook, *Hayler, 5th. Ed., page 319*

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4. A. Fix — **Correct answer.** "Instead of knowing that you are somewhere along either (LOP), you know that you are at a point defined by the intersection of two (or more) lines."

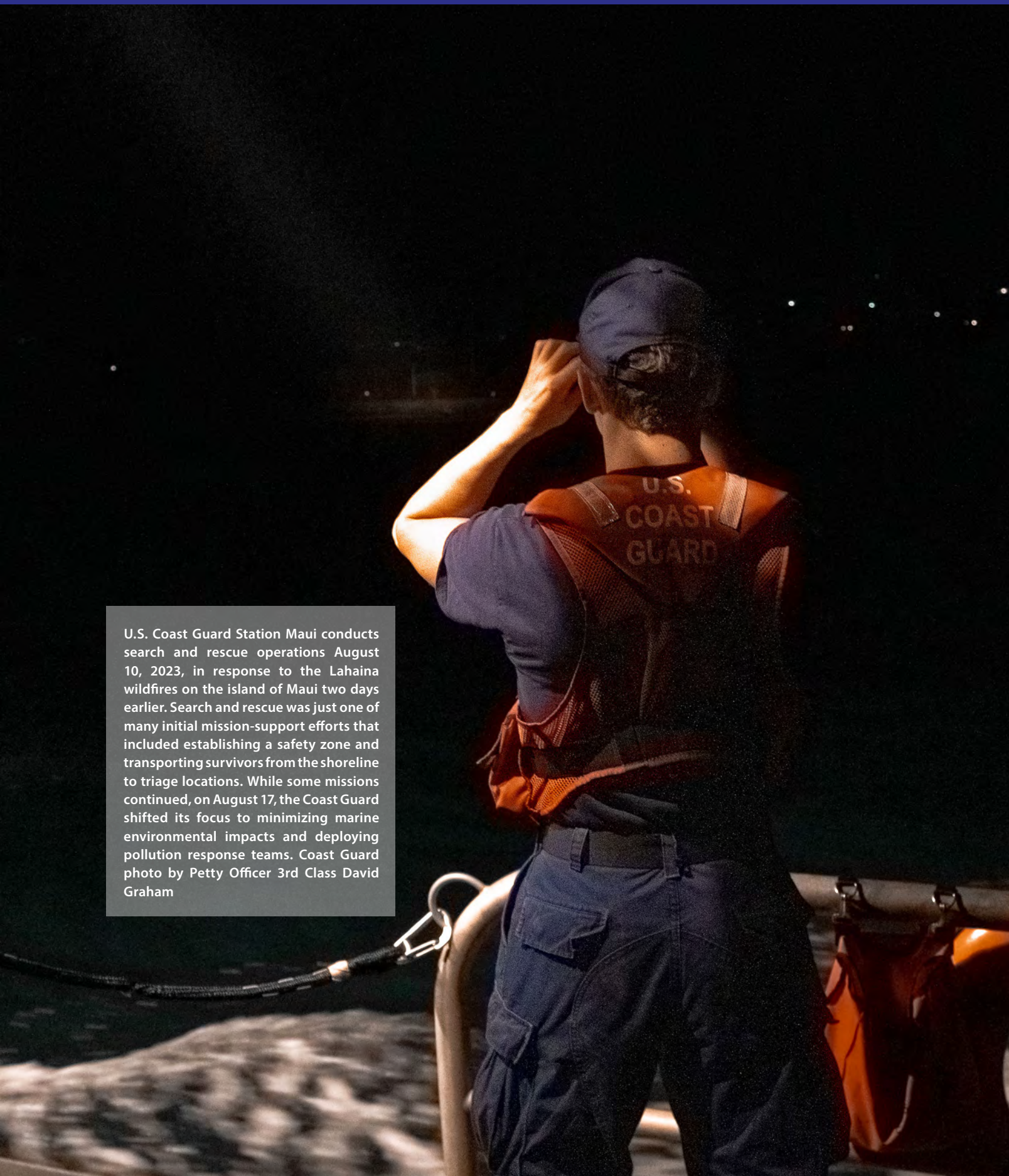
B. Estimated position — Incorrect answer

C. Running fix — Incorrect answer

D. Dead-reckoning position — Incorrect answer

Reference: Dutton's Nautical Navigation, *Cutler, 15th Ed., page 130*

In the News: USCG's Maui Wildfire Response



U.S. Coast Guard Station Maui conducts search and rescue operations August 10, 2023, in response to the Lahaina wildfires on the island of Maui two days earlier. Search and rescue was just one of many initial mission-support efforts that included establishing a safety zone and transporting survivors from the shoreline to triage locations. While some missions continued, on August 17, the Coast Guard shifted its focus to minimizing marine environmental impacts and deploying pollution response teams. Coast Guard photo by Petty Officer 3rd Class David Graham

COMMANDANT (CG-5PS-D)
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Reducing Shipping's Impact

Congratulations to the winners of the 2023 North American Marine Environment Protection Association's annual student art contest! Students in Kindergarten through 12th grade were invited to artistically interpret "MARPOL at 50—Our Committment Goes On" reflecting the importance of MARPOL in protecting the environment, and especially our oceans, from shipping pollution. The contest was co-sponsored by the U.S. Coast Guard and The Inter-American Committee on Ports of the Organization of the American States. To learn more go to https://namepa.net/education/art-contest

Abigail C., 3rd Grade
New Hyde Park, New York

Johnathan S., 7th Grade
Union City, Indiana


Sharon G., 2nd Grade
Tampa, Florida

Elishka L., 4th Grade
Philadelphia, Pennsylvania


Alina W., 11th Grade
Ontario, Canada

Aditya Y., 6th Grade
Sterling Heights, Michigan


Joanna M., 7th Grade
Philadelphia, Pennsylvania

Sophia C., Kindergarten
Seminole, Florida

Benjamin S., 4th Grade
Union City, Indiana


Serena W., Kindergarten
Ann Arbor, Michigan


Neema J.,7th Grade
Elicott City, Maryland


Liam D., 7th Grade
Philadelphia, Pennsylvania