Sustainable Shipping: Regulatory Mandate Review

Report to Prince William Sound Regional Citizens' Advisory Council

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The opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC.

Abstract

To protect public health and address climate change, regulatory bodies are directing more attention and effort towards the shipping industry, one of the largest global contributors of greenhouse gas emissions. While Clean Air Act requirements have been in effect for years, new international measures targeting nitrogen oxides, sulfur oxides, carbon dioxide, particulate matter (including black carbon), and other greenhouse gases have taken effect since 2013. Regulations variably address both new and existing vessels and impact vessel design, engines, fuel types and available options, voyage routing, and other aspects of vessel technology and operations. An overview of ongoing and upcoming regulations surrounding vessel air emissions, particularly applicable to Trans Alaska Pipeline System crude oil tankers and supporting tugs in Prince William Sound, are examined in this report. The review highlights specific measures aimed at reducing various air pollutants, minimizing pollution to the marine environment, and increasing the energy efficiency of ships. Even as companies will be required to align their operations with stricter environmental standards and invest in more sustainable technologies to meet current requirements, additional requirements will be forthcoming pending international negotiations.

Executive Summary

As with all engines that burn fossil fuels, adverse health and environmental impacts arise when pollutants are released from vessels, ranging from respiratory illnesses to acid rain to climate change. Within its mandate to promote the environmentally safe operation of the Valdez Marine Terminal and associated tankers, the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) commissioned this report to summarize recent and potential future vessel air emissions requirements.

Current requirements stem largely from agreements at the International Maritime Organization (IMO) which are then passed into U.S. law and implemented by the U.S. Coast Guard (USCG) and Environmental Protection Agency (EPA). Current requirements relate to:

- Vessel fuels (or alternative mitigation measures such as scrubbers that remove certain pollutants after the fuel is burned onboard),
- Engine type, or
- Other aspects of a vessel's design or operations to reduce the amount of fuel needed to conduct its trade.

Each new measure is enacted with some amount of lead time, and allowances depending on whether a vessel is newly built or already in operations. While simply slowing down has proven one of the more advantageous and easiest to implement measures to reduce emissions, ultimately meeting the IMO's long-term goal of net-zero carbon emissions from shipping will require future tanker operations to rely on new types of fuels, more efficient hull designs, sail designs being piloted now, or many other designs and operational changes being explored.

The IMO requirement is beginning implementation in 2023, this time evaluating a vessel's calculated carbon emissions against a negotiated ranking system. Even as this requirement begins, international negotiations continue as countries try to agree on greenhouse gas reduction targets for shipping and regulatory mechanisms for achieving them.

PWSRCAC may consider the following options for continued learning and contributions on this issue:

- Comment on USCG and/or EPA regulations forthcoming to implement the most recent IMO requirements
- Assess emerging technologies and alternative fuels as they develop to identify opportunities relevant to the vessels of interest
- Monitor developments at the IMO and shippers/vessel owners' experiences and results in implementing the latest carbon emissions ranking requirement

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SUSTAINABLE SHIPPING: REGULATORY MANDATE REVIEW

May 2023

1. Introduction

Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) contracted Nuka Research to provide an overview of current and potential upcoming regulations associated with vessel air emissions.

The applicable regulations at the local, state, national, and international levels vary depending on the vessel type and where it operates. This report focuses on measures specifically applicable to the Trans Alaska Pipeline System (TAPS) crude oil tankers as well as the Ship Escort Response Vessel System (SERVS) tugs and barges that support tanker operations in Prince William Sound.

While the SERVS tugs and barges stay in the Prince William Sound area, the tankers travel to other ports. This report focuses on the requirements applicable to Prince William Sound (PWS) and identifies additional measures where they exist at known destinations for TAPS-trade tankers leaving PWS. Known destinations for TAPS-trade tankers exiting PWS in 2021 (based on Automated Identification System, or AIS, data) were used to identify other locations for relevant air emissions requirements. The list in Table 1 shows the destinations noted in AIS when vessels were leaving PWS and is not necessarily exhaustive but provided a focus for identifying a few measures outside of PWS and Alaska with which TAPS-trade tankers must adhere.

Table 1. Known destinations for TAPS-trade tankers in 2021 based on AIS data

U.S. Destinations				**Non-U.S.**
Alaska	California	Hawaii	Washington	China (Dalian, Qingdao, Huizhou, Rizhao) Japan (Kiire) Singapore
Nikiski	El Segundo Long Beach Richmond San Francisco	Oahu	Anacortes Cherry Point Seattle Tacoma	

2. What are the concerns about air emissions from vessels?

Vessels that burn fossil fuels release air emissions when they burn fuel for propulsion or onboard power. Pollutants released into the air are associated with respiratory and other ailments for both people and animals, acid rain, formation of ozone, and climate change (IMO, 2009). (Some pollutants may also be diverted to be released in the water as a means of complying with air emissions regulations. These are discussed in Section 3.) Figure 1 highlights the pollutants that have been the focus of regulatory measures discussed in this report: particulate matter (PM) including black carbon, nitrogen oxides (NOx), sulfur oxides (SOx), and volatile organic compounds (VOCs) (EMSA, 2022). It also includes greenhouse gasses such as carbon dioxide (CO2).

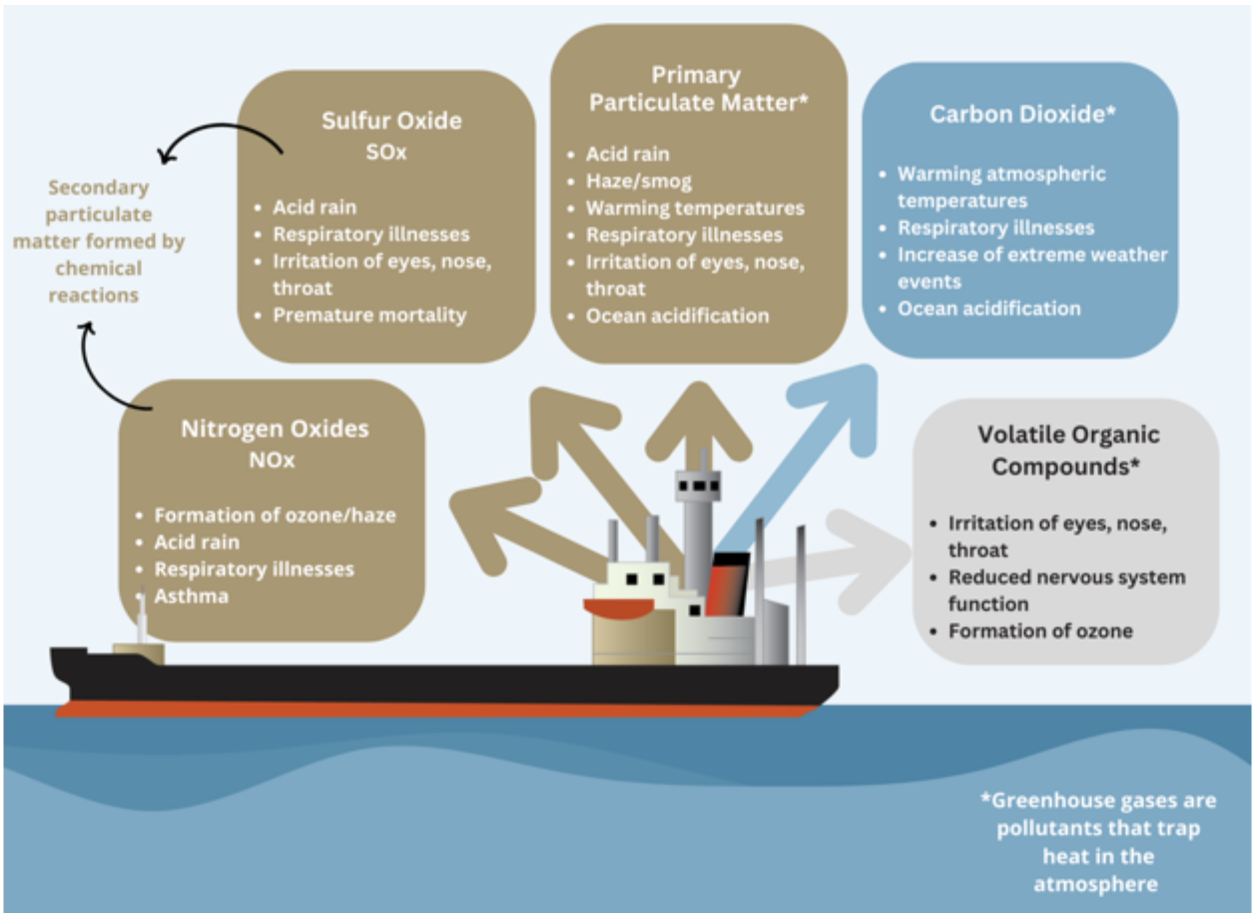

Figure 1. Overview of primary impacts to human health and the environment associated with air emissions from burning fossil fuels (EPA, 1999; EPA, 2022a)

The European Federation for Transportation and Environment stated that, “Poor air quality due to international shipping accounts for approximately 400,000 premature deaths per year worldwide, at an annual cost to society of more than €58 billion ($63.7 billion) according to recent scientific studies,” (Transport & Environment, n.d.).

3. How can air pollution from vessels be reduced?

Emissions vary depending on the type of fuel being used, how much cargo is being shipped relative to the vessel's size, and how much is burned during transit (Greene et al. 2020). Reducing vessel air pollution can be achieved by changing the engine, fuel used, vessel design, operations, or other technologies (aside from the engine). Table 2 shows the general approaches to pollution reduction that are discussed in the regulations in this report and some associated considerations to avoid unintended negative impacts.

Table 2. General approaches to air pollution mitigation for vessels

Category	General approach
Engine	Change engine type to reduce certain emissions and/or increase efficiency (reducing fuel use)
Fuel	Change fuel to reduce sulfur (e.g., a low sulfur fuel) or reduce greenhouse gas emissions
Design	Change vessel design to increase efficiency (use less fuel) or to be able to use less-polluting fuels
Operations	Change operations to reduce fuel used while underway or in port
Other equipment	Add other equipment to capture sulfur emissions on vessel ("scrubbers") or increase efficiency

What are scrubbers?

Exhaust gas cleaning systems, or "scrubbers," are one type of "other equipment" (see Table 2) used to mitigate air emissions. Scrubbers allow a vessel operator to continue to use the same amount and type of fuel, but comply with air emissions requirements by capturing pollutants before they are released into the air (Sethi, 2021). Scrubbers are discussed here because they are used to comply with some air emissions restrictions and because some jurisdictions are imposing restrictions on their use, as explained in the next section.

The way the captured pollutants are treated - and how they may still impact the environment - depends on the type of scrubber (see Table 3). Scrubbers may be "wet" or "dry" depending on whether or not water is used, and they may also be "open" or "closed" depending on whether they release the pollutants into the water directly or send collected waste to be disposed of onshore. (There is also a "hybrid" option that can operate either open or closed depending on the vessel's location.)

Scrubbers, particularly those that are "open" and release captured pollutants to the ocean, are controversial. One analysis found that scrubbers may reduce sulfur emissions more than just using a compliant distillate fuel, but black carbon and other particulate emissions are significantly higher if a heavy fuel oil is used even with a scrubber (Comer et al. 2020).

Table 3. Types of scrubbers and associated considerations (Sethi, 2021)

Scrubber type	Description	Considerations
Dry – Closed	• Exhaust stream is exposed to lime, which combines with SOx to form calcium sulfite • Gypsum pellets form when exposed to air and water	• No circulation pumps or liquid effluent • No waste - pellets can be reused for fertilizer or construction materials • Heavier than wet systems • Reactants are costly and require significant storage
Wet – Closed	• Fresh water used with sodium hydroxide or seawater converted into freshwater via generators as scrubbing medium • SOx are converted into sodium sulfate when treated with water, which is processed and cleaned for reuse within the tower • Particles collected as a dry waste product (LiqTech, 2022a)	• No wastewater discharged to ocean • Requires less water to operate than open-loop systems, but storage is needed (a process tank and a storage tank) • Can be complex to install • Effectiveness is independent of the operating environment
Wet – Open	• Scrubbing process uses seawater, releasing wastewater into the ocean after a sludge removal process • Before the gas is released into the atmosphere, any acid mist that formed is removed in a mist eliminator	• Discharges wash water to ocean • Simplest design, easiest to install, lowest maintenance • No storage needed for waste materials • Uses a large volume of seawater and therefore significant power, which may be limited based on the vessel's engine
Wet – Hybrid	• Scrubbers with the ability to be transitioned between both open- or closed-loop systems	• Allows flexibility regarding whether to discharge waste to ocean

4. What are the key regulatory authorities related to vessel air pollution requirements?

This section describes the primary regulatory authorities and the treaties, laws, and regulations related to vessel air emissions within the project scope. These are:

- International Maritime Organization
- U.S. Environmental Protection Agency (EPA) and U.S. Coast Guard (USCG)
- Alaska Department of Environmental Conservation (ADEC)
- California Air Resources Board

There are no local provisions in Alaska governing vessel air emissions or scrubber use, though there are some examples in other states. Additionally, some of the tankers call at ports outside the U.S. which implement other provisions. These regulations are also discussed in Section 5.

International Maritime Organization

The International Maritime Organization (IMO) is a part of the United Nations that provides a forum for 175 member countries to discuss safety, security, and pollution prevention measures related to international shipping. IMO member countries negotiate treaties, or "conventions," and their related "protocols." Member countries that ratify an IMO treaty then create their own rules to implement the measures nationally. The IMO itself has no direct enforcement authority, but relies on the member countries to comply with and enforce the treaty requirements that relate to vessels flying their flag, calling at their ports, or operating in their waters (IMO, 2019).

International Convention for the Prevention of Pollution from Ships (MARPOL)

The International Convention for the Prevention of Pollution from Ships, or "MARPOL," is the IMO's main pollution prevention convention. MARPOL was first agreed upon in 1973 and has been modified and added to by a series of protocols, annexes, and chapters since then. MARPOL Annexes I - V address oil spill prevention, pollution from bulk and packaged cargos of concern, sewage, and garbage.

MARPOL's Annex VI addresses vessel air emissions. Through a series of revisions since it was adopted in 1997 (NOAA, 2008), Annex VI has decreased the allowable emissions of SOx, NOx, and PM from vessels. (Volatile organic compounds are also addressed but are not discussed further here as they generally relate to the loading/offloading of oil cargo, not the vessel propulsion itself.) Annex VI also establishes emissions standards for marine diesel engines and energy efficiency requirements to reduce fuel consumption overall, resulting in reduced greenhouse gas emissions as well.

U.S Environmental Protection Agency and U.S. Coast Guard

Act to Prevent Pollution from Ships

When the U.S. agrees to implement an IMO convention or protocol (treaty), the relevant requirements are then enacted in U.S. laws and regulations applicable to U.S.-flagged vessels and vessels operating in U.S. waters. The Act to Prevent Pollution from Ships (APPS) at 33 U.S.C. §§ 1901-1905 establishes regulations in the U.S. regarding NOx, SOx, and PM from vessels according to MARPOL. Both the USCG and EPA oversee implementation of regulations under APPS.

Regulations under APPS are updated occasionally as new agreements are made at the IMO. U.S. regulations related to vessel air emissions generally apply to U.S.-flagged vessels or foreign-flagged vessels calling at U.S. ports. (Some also apply to ports or vessel engine manufacturers, for example.)

The USCG is responsible for documentation and verifying compliance of vessels with Regulations 14 and 18 of MARPOL Annex VI, reporting any violations to the EPA for enforcement.

Clean Water Act and *Vessel Incidental Discharge Act*

Under the Clean Water Act (CWA), vessels over a certain size are required to meet certain standards for scrubber wastewater or other releases to the environment that are part of normal vessel operations contained in a 2013 Vessel General Permit. The EPA and USCG are now updating discharge permit requirements and promulgating new regulations under the 2018 Vessel Incidental Discharge Act. The new requirements are not yet final but are expected to extend to 12 miles from shore. At the time of this report, it is not known when these new standards will take effect following the receipt of public comments and release of regulations (EPA, 2023).

Alaska Department of Environmental Conservation

Alaska has regulations on "visible" air emissions from vessels at 18 AAC 50.070. These regulations were established in 1998 under AS 46.03.020 to implement the federal Clean Air Act (CAA). While the regulations do not reference specific pollutants, this primarily targets PM. ADEC oversees Alaska's CAA-implementing program which includes these regulations. Other U.S. states where TAPS-trade vessels call also have these requirements, but we highlight Alaska's in this report.

ADEC retains the authority to issue air quality operating permits under the above regulations in Alaska, which contain requirements for the enforcement of visible emissions monitoring and reporting. Company personnel are required to be certified as Method 9 visible emissions observers under the EPA, and conduct surveillance of a vessel's stack emissions every time a vessel is docked at berth in the Valdez Marine Terminal. The Permittee must keep records of the observed tanker vessels and their emission levels, using Method 9 observations whenever observed opacity from a vessel is greater than 15%, and ADEC enforces these standards by conducting opacity readings (ADEC, 2017).

California Air Resource Board

The California Air Resources Board (CARB) has two relevant regulations that apply to the TAPS-trade tankers calling there:

- Ocean Going Vessel Fuel Regulation (or the "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline"), and
- Ocean Going Vessels at Berth Regulation (or the "Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port")

California also has "visibility" requirements the same as Alaska's under its implementation of the CAA (EPA, 2022b).

Ships waiting outside the port of Long Beach, California

Photo: Matt Gush/Shutterstock

5. Regulation of SOx, NOx, and PM

The regulatory entities described in Section 4 oversee requirements related to the various air pollutants discussed in Section 2. This section describes the requirements for SOx, NOx, and associated PM, while the following section focuses on ship energy efficiency measures that are in place now.

SOx, NOx, and associated PM are regulated in the IMO's MARPOL Annex VI and the U.S.'s APPS. These pollutants are addressed by vessel engine requirements based on size and year built, as well as Emissions Control Areas (which set standards for both fuel sulfur content and engine type for vessels operating within them) based on geography.

Emissions Control Areas

North American ECA

Emissions Control Areas (ECA) under the IMO's MARPOL convention set air emissions standards for specific locations. On the Pacific coast, the North American ECA (see Figure 2) extends from the border with Mexico to Cook Inlet, Alaska, and surrounds Hawaii.

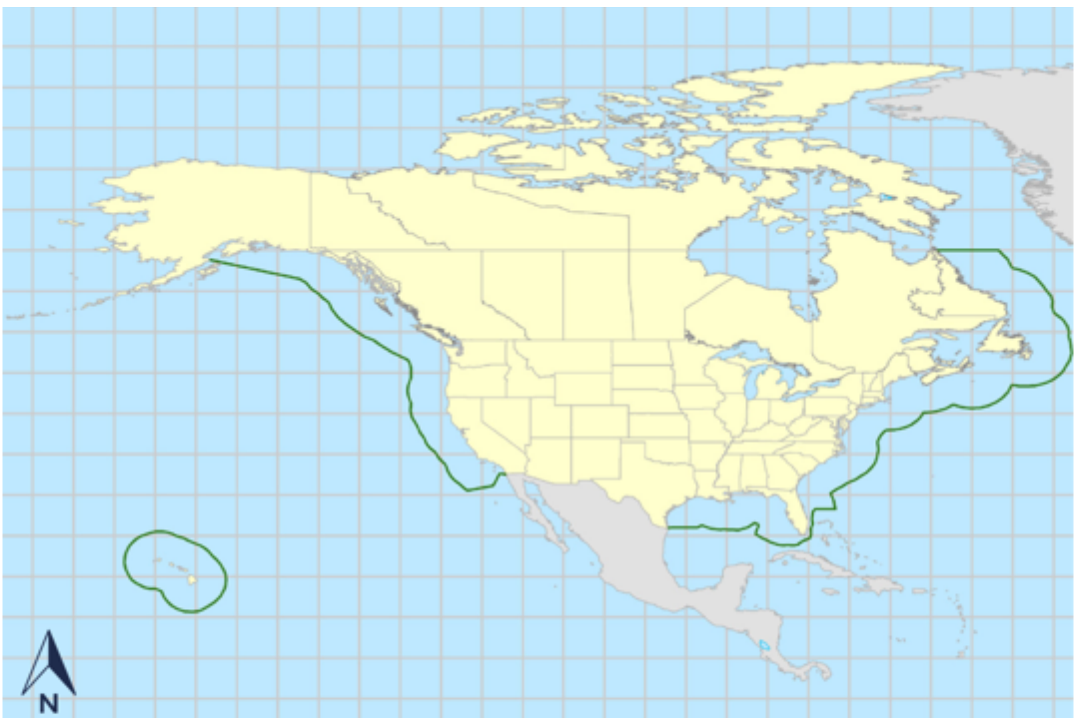

Figure 2. Boundaries of the North American Emissions Control Area (EPA, 2010)

Prince William Sound is located within the North American ECA, as are the ports to which the TAPS-trade tankers travel in Hawaii, Washington, and California. Many tankers traveling south from Prince William Sound to ports in the Lower 48 area still remain within the North American ECA as they pass British Columbia (Robertson et al. 2020), though some will stay far enough offshore that they leave the ECA briefly on their voyage, particularly if headed to or from southern California.

Air emissions standards within the North American ECA have become more stringent since they first took effect in 2010. Today, vessels in the ECA must:

- Meet a 0.1% sulfur cap by fuel weight *or* reduce sulfur emissions through use of scrubbers (allowable sulfur content was reduced over time).
- Use at least a Tier III engine, which includes a NOx emission reduction technology (this varies depending on the year the vessel was built; some vessels are still using Tier I or II engines in this area).

During inspections of both U.S.-flagged and foreign-flagged vessels, the USCG may check vessel records and may take fuel samples to verify compliance with the sulfur content limit, check for approved scrubbers, and confirm that the vessel engine has a valid certificate from EPA indicating the engine meets minimum requirements (USCG, 2020). In 2018, the USCG asked vessel operators in two ports (LA/Long Beach and Baltimore) if they would participate in a voluntary sampling effort to test compliance with the ECA fuel requirement. Thirty-seven vessels agreed (10 declined) to have their fuel and vessel records checked, resulting in six vessels that were using at least some fuel that was over the 0.1% sulfur cap. While this voluntary program did not result in compliance actions, there are cases of enforcement for non-compliance, which brings a penalty of $25,000 per violation, per day (Ship & Bunker News Team, 2016). As one enforcement example, in late 2022, a penalty of $250,000 was announced for violations of an oil tanker which had transferred non-compliant oil cargo to its fuel tanks for use within the ECA that surrounds the U.S. Virgin Islands (DOJ, 2022).

China ECA

China has established its own domestic ECA (not under MARPOL) for coastal waters. Like the North American ECA, the actual sulfur content allowed in fuel has reduced over time. As of the most recent update in 2022, the ECA for the whole coast is at 0.5% sulfur content, which is the same as the rest of the globe (see below). However, a 0.1% cap, the same as the North American ECA, applies to ocean-going vessels that enter coastal waters around Hainan Island in the South China Sea (Ghosh, 2022).

Scrubbers may be used in the ECA, but scrubber water may not be discharged there (EGSCA, 2019). South Korea also has an ECA with a 0.1% sulfur content cap, but with no further requirements related to scrubbers (Ghosh, 2022).

Global Sulfur Cap

As of January 2020, vessels must use a fuel with no more than 0.5% sulfur content anywhere in the world under a MARPOL provision. This standard is more aggressive than the previous versions (it is a reduction from 3.5%), but less aggressive than the 0.1% in the ECA. Vessels can comply by using a fuel with a low enough sulfur content, or by installing scrubbers to limit SOx air emissions. Compliant fuels may be a marine gas oil (MGO), marine diesel oil (MDO), or a modified heavy fuel oil (e.g., very low sulfur fuel oil). As with the ECA, this is enforced through USCG vessel inspections in conjunction with EPA.

Vessel Incidental Discharge Act

The 2013 Vessel General Permit sets standards for scrubber washwater, including limits for acidity, polycyclic aromatic hydrocarbons, turbidity, and nitrates or nitrites as well as monitoring and reporting requirements. The 2013 requirements are still in effect and extend out to 3 miles (Standard Club, 2019; EPA, 2013). New requirements are forthcoming.

California Distillate Fuel and Shoreside Power Requirements

Vessels operating within 24 nautical miles of the California coast must use a distillate grade fuel such as MGO or MDO, with a maximum sulfur content of 0.1%. These requirements are enforced through both operator reporting and inspections that include taking fuel samples. Vessels passing through the area without intent to stop are exempted, as are government vessels and non-tank vessels smaller than 400 feet or 10,000 gross tons (13 CCR, section 2299.2).

The sulfur content requirements were phased in roughly in parallel to the North American ECA, landing at the current 0.1% limit in 2014. Beginning in 2020, when the IMO global sulfur cap came into force, CARB issued an updated notice to mariners regarding how fuel sampling would be conducted. The reason for this update was to ensure that compliant distillate fuels are being used, not just fuels that meet the sulfur content limit (CARB, 2020).

Because California requires use of a distillate fuel - instead of allowing for a modified heavy fuel oil - it effectively bans the use of scrubbers there. (A ship could still have scrubbers and use heavy fuel oil (HFO) outside 24 nautical miles from the California coast but would have to switch fuels to enter that area.)

Under another California regulation, ocean-going vessels at berth are increasingly being required to use shore power while at berth. This was a requirement for a portion of the vessel fleet since 2007 – and focused only on container, refrigerated cargo, and cruise vessels – but as of 2020 it has been updated to include all individual vessels (including tankers). While reporting starts in 2023, the actual requirement for tankers to use shore power rolls in more slowly: in 2025 this will be required only for tankers at Long Beach and Los Angeles, and it will apply to all tankers in 2027 (CARB, 2023). (This obviously depends on the availability of shoreside power at a port. The law includes requirements for port operators as well.)

6. Reducing greenhouse gas emissions: current requirements

In 2018, the IMO developed greenhouse gas (GHG) emissions reduction goals of continuing to reduce the intensity of emissions and add the goal of reducing total GHG emissions by 50% (compared to 2008 levels) by 2050, eventually phasing them out completely. Those goals are being debated for possible revision as of 2023, while the IMO collects more information through mandatory reporting requirements (IMO, 2018). Current IMO requirements in place related to vessel energy efficiency (measured based on carbon intensity) took effect in 2013, before the goals were agreed to. Additional "near term" measures to meet those goals are beginning to take effect in 2023. This year, the IMO is also planning to revisit the goals as well as developing medium- and long-term measures for GHG emissions reduction.[1]

Three key concepts underly both current and – possibly – future IMO efforts in this area:

- Unlike the *prescriptive* approaches the IMO took for SOx, NOx, and PM emissions, the IMO has so far taken an approach that sets requirements and a way to measure those requirements but does not specify how vessel owners must go about doing so.
- Currently, carbon dioxide is the only GHG measured in IMO requirements.
- Requirements focus on *carbon intensity* -- the amount of CO_2 emitted per unit of work (the movement of cargo). In this context, therefore, *increasing* "energy efficiency" is the same thing as *reducing* "carbon intensity." It is also possible to continue to reduce *carbon intensity* while still increasing the total CO_2 emissions from vessels.

This section describes the current requirements. Because medium- and long-term measures have not been resolved and the goals themselves may change, these are not described but some options discussed.

2018 Initial IMO GHG Strategy

The IMO Initial Strategy on the reduction of GHG emissions from shipping sets key ambitions. This is a policy framework. The main goals are:

- Cut annual greenhouse gas emissions from international shipping by at least half by 2050, compared with their level in 2008, and work towards phasing out GHG emissions from shipping entirely as soon as possible in this century.
- The Initial GHG Strategy envisages a reduction in carbon intensity of international shipping (to reduce CO_2 emissions per transport work), as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008.

The Initial Strategy will be revised by 2023.

Figure 3. Current IMO GHG reduction goals as stated on IMO website (IMO, 2023)

Initial IMO requirements to improve energy efficiency

IMO energy efficiency requirements are based on requiring ship operators to increase the efficiency of individual vessels over time, or to use less energy to do the same amount of work.

[1] This report does not attempt an exhaustive list of the reporting requirements, studies, negotiations, and capacity development efforts of the IMO on this subject. Instead, we focus on the mandates most directly related to emissions reductions. For a more complete list, see: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx.

Starting in 2013, new ships over 400 gross tons (GT) must meet an Energy Efficiency Design Index (EEDI) requirement (DNV, n.d.; ABS, n.d.). Based on ships built from 1999 – 2009, the IMO calculated a reference efficiency based on CO2 emitted (calculated from fuel type and usage) per unit of work (e.g., distance over which deadweight tons are transported, or "ton-miles"). A lengthy formula builds in assumptions and variability.

The acceptable EEDI value reduces (meaning efficiency *increases*) over time, with the final step down marked for 2025. By that time, newly built tankers will be required to be 30% more efficient than they were in 2013 (Marine & Offshore, 2023).

At the same time that new ships were required to meet the EEDI, the IMO also required all vessels over 400 GT, regardless of when they were built, to have a Ship Energy Efficiency Management Plan (SEEMP) (Marine & Offshore, n.d.). The SEEMP describes procedures or technology used to improve the energy efficiency of a ship. Table 4 shows some of the options for increasing efficiency that may be relevant to tankers, though there are many ways to combine and estimate potential efficiency gains. In another approach, simply going slowly (how slowly is not specified) is estimated to yield up to 60% carbon reduction, though this will depend on the type of vessel and how fast it goes to begin with, among other factors (Issa et al. 2022).[2]

Table 4. Tanker's energy efficiency mechanisms, adapted from Maritime Decarbonization Strategy 2022 (MMM Center, 2022)

	Category	**Applications**	**Potential energy efficiency gains per ship**	**Current tanker fleet uptake**
Operational measures	Voyage optimization	Voyage planning, weather routing, trim and draft, optimization, energy management, hull and propeller fouling management	1-10%	Growing adaptation
	Fleet strategies	Fleet portfolio optimization, vessel deployment and utilization, scheduling, and speed optimization	1-15%	Limited adaptation
Technological solutions	Hull & propeller efficiency	Hull form optimization, propeller design, anti-fouling systems, propulsion-improving devices, and air lubrication	1-8%	Limited adaptation
	Engines and systems	Engine technology, electrification and hybridization, waste heat	1-5%	Limited adaptation

[2] Consistent "slow steaming" may also increase engine wear (Issa et al., 2022).

		recovery system, and shaft generator		
	Alternative power systems	Wind assisted propulsion	1-8%	Pilot installations

New requirement to rank carbon intensity of ships

At the beginning of 2023, ship owners were required to submit an enhanced SEEMP. This requires owners of ships over 5,000 GT to report their annual Carbon Intensity Indicator (CII).[3] The CII calculation is essentially the CO2 emitted per cargo carrying capacity (not actual cargo carried) for distance traveled in a year.[4] The CII allows for variations and corrections based on vessel type or service, assumptions regarding fuel use, and other factors included in the actual calculation. The final guidance on how to make the calculations was completed in 2022, and it is going to be revisited in 2026 (Ship Nerd News, 2022).

Based on the CII, a ship will be rated A, B, C, D, or E. The values will change over time as well, meaning that a vessel owner must keep making changes to retain a good CII rating (See Figure 4).

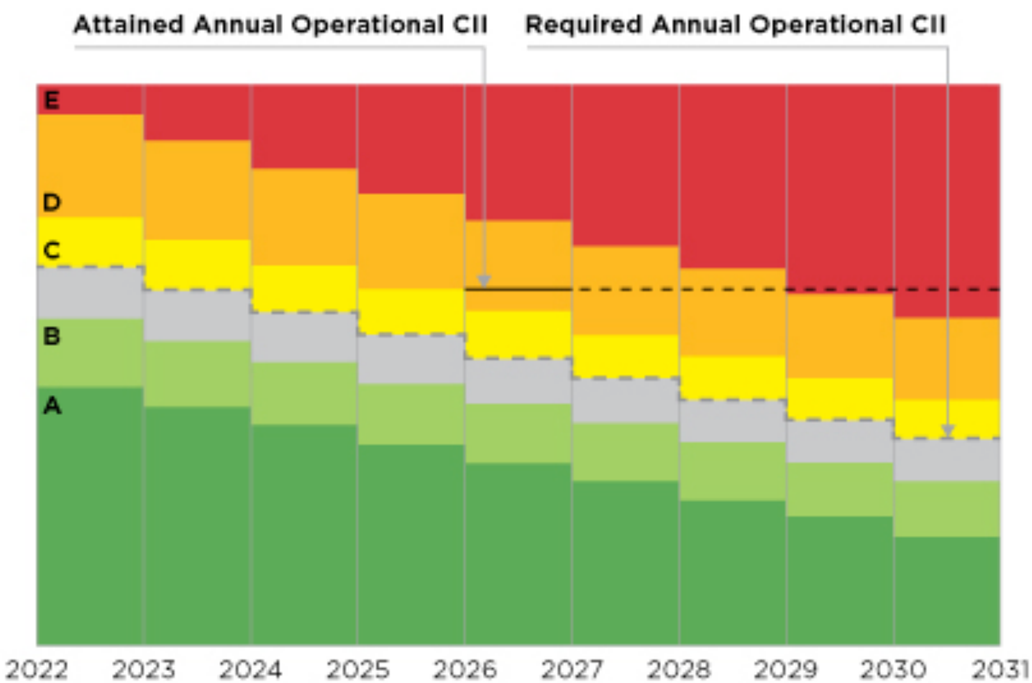

Figure 4. Depiction of the progressive nature of CII rankings as of now (noting that the procedure will be revisited in 2026) (INTERTANKO, n.d.)

[3] This also includes calculating an Energy Efficiency Existing Ship Index (EEXI), which is like the EEDI discussed in the previous section but for existing ships and actual voyages, not new builds. These indices as well as the CII were established by the IMO based on prior years of required data reporting on fuel use and other factors that are not described in this report. The IMO has conducted – and considered – numerous studies. For more information, see: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx.

[4] For detailed explanations of how the CII is calculated, see: https://www.shipnerdnews.com/cii-calculation-carbon-intensity-indicator/ and https://www.dnv.com/maritime/insights/topics/CII-carbon-intensity-indicator/answers-to-frequent-questions.html.

A ship rated D for three consecutive years or rated as E will need to develop a plan of corrective actions. For now, there are no penalties beyond creating and implementing a corrective action plan. Vessel rankings and efficiency plans will be stored at the IMO, which is working to engage port authorities to use this information to apply differentiated port fees (INTERTANKO, n.d.).

The highly refined, lower-sulfur fuels such as those required under the measures discussed in Section 5 have a higher carbon factor in the CII calculations than heavy fuel oil (Anh Tran, 2016). However, the ECAs and other measures already discussed remain in place.

The U.S. has not yet promulgated regulations specific to how these IMO requirements will be enforced for U.S.-flagged vessels or vessels in U.S. waters but has indicated the intent to do so (Reid et al. 2022).

Considering CO2 and terminology

When reading studies or media articles about vessel fuel options, it is important to consider whether they are describing emissions associated with the full lifecycle of the fuel (well-to-wake), breaking it down to discuss only the well-to-tank (production and delivery of the fuel to the vessel's fuel tank), or tank-to-wake (the actual combustion/use of the fuel on board the vessel). In some cases, "propeller" is used instead of "wake," but they are interchangeable in this context.

In the IMO's approach, the current focus is on tank-to-wake emissions, but guidelines are being developed so that a consistent approach can be applied in future consideration of well-to-wake emissions.

7. Possible future measures and solutions to reduce GHG emissions from ships

Discussions at the IMO in 2023 and beyond will focus on whether to revise the GHG emissions reduction goals and how to structure measures to implement those goals. Along with Canada and the United Kingdom, the U.S. has indicated support for more aggressive reduction goals, including getting to zero carbon emissions from shipping by 2050 (Canada, UK & US, 2023). These could include a long-term CII standard, a carbon tax, or other measures agreed upon through a process that involves assessing impacts to the states along with extensive negotiations (IMO, 2023).

Regardless of the policy mechanism(s) used, there is no single "silver bullet" for meeting efficiency targets or carbon/GHG reduction goals. Ultimately, efficiency measures must be combined with available fuel options to achieve the IMO's long-term goal of eliminating GHG emissions from ships in this century. Some examples are provided here for illustrative purposes – and to complement the information in Table 4 – without regard for the exact circumstances of the in-scope vessels.

New fuels

Many discussions are underway regarding alternative fuels to meet GHG emissions reduction goals. According to the IMO, "Potential future fuels and propulsion for shipping include: ammonia, biofuels, electric power, fuel cells, hydrogen, methanol, [and] wind" (IMO, 2023). Most of these emerging options are in early stages of development or demonstration. In addition to considerable investment, further analysis of costs and lifecycle impacts is needed, along with assessments of their safe use (and transport and storage), impact on vessel operations or navigational safety, logistics, costs, and cleanup methods (Foretich et al. 2021).

Table 5. Overview of emerging vessel fuels, based on (DNV, 2022) and (DNV, 2018)

Fuel Type	Advantages	Disadvantages
Ammonia	• Potentially zero-carbon (if produced with renewable energy) • Cheaper than batteries • Relatively easy to store	• Toxic and corrosive • Some conventional fuel still needed in vessel engines • Emissions vary with source of energy
Batteries	• Potentially zero-carbon (if produced with renewable energy) • Can be used with conventional fuels as in hybrid vehicles	• Requires significant electricity generation • Expensive • Requires space on board
Hydrogen	• Potentially zero-carbon (if produced with renewable energy)	• Requires significant space on board and for storage • Must be kept at extremely cold temperatures
Methanol	• Potentially very low GHG emissions	• Emissions benefits depend on source and can be relatively high if produced from methane

Liquefied natural gas (LNG), on the other hand, is a fossil fuel that has lower tank-to-wake *carbon* emissions and has become available ahead of the "future" fuels described above. While previously the only LNG-powered ships were those transporting LNG as cargo, the number of LNG powered ships has increased in recent years, up 41% from 2021 to 2022. While most of the new ordered LNG-powered ships are container ships, there are LNG-powered crude oil tankers in operation (LNG Prime, 2023). However, there are reasons this "bridge" fuel may not last long. LNG is predominantly liquefied methane - a potent GHG, with a warming effect 80 times more powerful than CO2 in the first 20 years. Even though methane emissions from international vessels are not currently regulated, initiatives like the Global Methane Pledge and regional approaches such as the FuelEU Maritime demonstrate a growing momentum for future limitations on LNG use (Global Methane Pledge, 2023; European Council, 2023).

Green corridors

Any viable future fuel(s) must be available in a reliable supply at the ports where they are needed. One way ports are beginning to coordinate on this and other efforts to reduce GHG emissions is through developing "green corridors," through which ports and vessel operators who regularly call at those ports can explore and develop changes such as fuel supplies, electrification, and waste handling improvements. Although there is no clear standard for what constitutes a "green" corridor or port, there is some funding and momentum behind such efforts as part of U.S. GHG emissions reduction efforts (U.S. Department of State, 2022).

In 2022, a green corridor effort was launched that connects Southeast Alaska, British Columbia, and Washington. This collaborative effort is exploring options to accelerate the deployment of zero GHG emission ships and operations (Port of Seattle, n.d.).[5]

Alternative propulsion (sails)

Different styles of sails are being tested on tankers to supplement the vessel's diesel engines. A Chinese supertanker (very large crude carrier) with four sails was launched in fall 2022. The sails are made of carbon fiber composite blades that can be raised, lowered, and adjusted automatically (Blain, 2022).

Electrification

A Japanese consortium developed an electric oil tanker that uses a 3.5 mega-watt-hour battery pack. With the first vessel launched in 2022, it is intended for coastal service and is quieter than a typical tanker of its size (Prevljak, 2021).

Another example identified was a tanker outfitted to rely fully on electricity in port. The Swedish tanker operator collaborated with the Port of Gothenburg, which was reported to be the first port capable of connecting tankers to electricity. (The tanker is also biofuel compatible

[5] Participants include Port of Seattle, City and Borough of Juneau, Vancouver Fraser Port Authority, Carnival Corporation, Norwegian Cruise Line Holdings, Royal Caribbean Group, Cruise Lines International Association, the Global Maritime Forum, Blue Sky Maritime Coalition, Washington Maritime Blue; Sitka, Skagway, and Haines in Alaska; and the Greater Victoria Harbour Authority.

along with other efficiency measures such as optimized hull and rudder design (Chambers, 2022)).

In 2023, Crowley Maritime Corporation will deploy a fully electric ship assist tug with just over 60 metric tons (MT) of bollard pull (Crowley, 2021). The tug has its own charging station located in the Port of San Diego (Bourscheid, 2021).

Sail-assisted large crude carrier launched in China

Photo: China Classification Society (Blain, 2022)

8. What does all this mean for vessels in scope?

SUMMARY OF REQUIREMENTS

****

Tankers regardless of location

Ship fuel maximum 0.5% sulfur or comply with an ECA when operating within one

As of 2013, new builds must meet EEDI standard (which reduces over time)

Must have SEEMP and, as of 2023, must calculate and report CII

*Tankers while in Prince William Sound**

Ship fuel maximum 0.1% sulfur (or scrubbers) *and* Tier III engine (depending on year built) due to being within North America ECA

Vessels discharging scrubber water must comply with EPA's Vessel General Permit

Alaska visibility requirements while in port (applies to other U.S. ports as well)

Tankers voyaging to California

Use distillate fuel (not scrubbers) within 24 nautical miles of California coast if headed to/from a California port

Use shoreside power if/when available (rolling in as of 2025 at some ports)

Ship fuel maximum 0.1% sulfur (or scrubbers) *and* Tier III engine (depending on year built) due to being within North America ECA at least most of the voyage

Tankers voyaging to China

Meet ECA requirements in China (same as global 0.5% sulfur cap); scrubbers banned in some areas but not those to which TAPS-trade tankers traveled on 2021 TAPS voyages

****

SERVS Tugs (assumed in PWS)

Within North American ECA must meet same requirement as above for tankers – but as they already use distillate fuels, scrubbers are not used but exhaust after treatment systems using urea are employed

Meet EPA engine requirements depending on year built

New builds must meet EEDI and all vessels must have SEEMP, but no CII requirement

**Also applies to voyages in Cook Inlet*

Table 6 summarizes how regulations discussed in this report relate to the vessels within the project scope. The table does not indicate anything about compliance, it simply summarizes which of the requirements discussed in this report apply to in-scope vessels using 2021 as a snapshot in time for illustrative purposes only.[6] While the U.S.-flagged vessels are consistent participants in the TAPS trade, the foreign-flagged charters may or may not return.

Table 6. Applicability of regulations discussed in this report to TAPS tankers (2021) and tugs

<table>
<tr><th>Vessel</th><th>Build year (Engine Tier)[a]</th><th>Scrubber used?</th><th>Fuel used?</th><th>EEDI standard[g]</th><th>CII (2023)</th></tr>
<tr><td colspan="6">US-flagged tankers</td></tr>
<tr><td>Alaskan Explorer</td><td>2005 (I)</td><td>no[b]</td><td>MGO[b]</td><td>no</td><td rowspan="14">yes</td></tr>
<tr><td>Alaskan Navigator</td><td>2005 (I)</td><td>no[b]</td><td>MGO[b]</td><td>no</td></tr>
<tr><td>Alaskan Legend</td><td>2006 (I)</td><td>no[b]</td><td>MGO[b]</td><td>no</td></tr>
<tr><td>American Freedom</td><td>2016 (III)</td><td>no[d]</td><td>MGO[d]</td><td>yes</td></tr>
<tr><td>American Endurance</td><td>2016 (III)</td><td>no[d]</td><td>MGO[d]</td><td>yes</td></tr>
<tr><td>California</td><td>2015 (II)</td><td>no[d]</td><td>MGO[d]</td><td>yes</td></tr>
<tr><td>Florida</td><td>2013 (II)</td><td>no[d]</td><td>MGO[d]</td><td>yes</td></tr>
<tr><td>Louisiana</td><td>2016 (III)</td><td>no[d]</td><td>MGO[d]</td><td>yes</td></tr>
<tr><td>Polar Endeavour</td><td>2001 (I)</td><td>no[f]</td><td>MGO[f]</td><td>no</td></tr>
<tr><td>Polar Resolution</td><td>2002 (I)</td><td>no[f]</td><td>MGO[f]</td><td>no</td></tr>
<tr><td>Polar Discovery</td><td>2003 (I)</td><td>no[f]</td><td>MGO[f]</td><td>no</td></tr>
<tr><td>Polar Enterprise</td><td>2006 (I)</td><td>no[f]</td><td>MGO[f]</td><td>no</td></tr>
<tr><td>Polar Adventure</td><td>2006 (I)</td><td>no[f]</td><td>MGO[f]</td><td>no</td></tr>
<tr><td>Washington</td><td>2014 (II)</td><td>no[d]</td><td>MGO[d]</td><td>yes</td></tr>
<tr><td colspan="6">Foreign-flagged tankers</td></tr>
<tr><td>Dilong Spirit</td><td>2009 (I)</td><td>no[c]</td><td>?</td><td>no</td><td rowspan="6">yes</td></tr>
<tr><td>Stena Sunrise</td><td>2013 (II)</td><td>?</td><td>?</td><td>yes</td></tr>
<tr><td>Sofia</td><td>2010 (I)</td><td>?</td><td>?</td><td>no</td></tr>
<tr><td>Sonangol Cabinda</td><td>2013 (II)</td><td>?</td><td>?</td><td>yes</td></tr>
<tr><td>Vail Spirit</td><td>2009 (I)</td><td>no[c]</td><td>?</td><td>no</td></tr>
<tr><td>Zenith Spirit</td><td>2009 (I)</td><td>no[c]</td><td>?</td><td>no</td></tr>
<tr><td colspan="6">SERVS tugs</td></tr>
<tr><td>Tugs</td><td>2018 (IV)[e]</td><td>no</td><td>MGO</td><td>no</td><td rowspan="2">no (too small)</td></tr>
<tr><td>Ross Chouest</td><td>1996 (I)</td><td>no</td><td>MGO</td><td>no</td></tr>
</table>

[a] Engine type based on build year (build years provided by PWSRCAC); [b] Provided by Alaska Tanker Company, March 9, 2023; while MGO is the primary fuel used, low sulfur heavy fuel oil may be used for transits to/from shipyards in Asia; [c] Teekay Corporation, 2022; report does not specify type of low sulfur fuel used; [d] Crowley, 2021 and information provided by Crowley, May 30, 2023; low sulfur fuel oil may be used outside ECA; [e] APSC, n.d.; [f] exclusively burns MGO in all waters (information provided by Andrea West, Polar Tankers Inc., May 30, 2023); [g] Based on build year

[6] U.S.-flagged tankers in the 2021 AIS data that were known by PWSRCAC to have retired from the fleet as of 2022 are not included in the table.

9. Conclusion

It is difficult to write a conclusion to this report because the story is not over. The past decade has brought significant changes in requirements related to air emissions from vessels, during a time overlapping with a global pandemic and associated supply chain disruptions. Even greater changes will come, as the IMO begins implementing near-term measures while assessing and negotiating long-term requirements to achieve its GHG emissions reduction goals.

PWSRCAC may consider the following options for continued learning and contributions on this issue:

- Comment on USCG and/or EPA regulations forthcoming to implement the most recent IMO requirements
- Assess emerging technologies and alternative fuels as they develop to identify opportunities relevant to the vessels of interest
- Monitor developments at the IMO and shippers/vessel owners' experiences and results in implementing the CII

It must also be acknowledged that the many other GHG emissions reduction efforts underway across the economy today will also impact the market served by today's crude oil tankers at some time - and in some way - that is outside the scope of this project yet significant to their decision-making.

Acronyms

ADEC	Alaska Department of Environmental Conservation
AIS	Automated Identification System
APPS	Act to Prevent Pollution from Ships
CAA	Clean Air Act
CARB	California Air Resources Board
CII	Carbon Intensity Indicator
CO2	Carbon Dioxide
CWA	Clean Water Act
ECA	Emissions Control Areas
EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency Existing Ship Index
EPA	United States Environmental Protection Agency
GHG	Greenhouse Gas
GT	Gross Ton
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
LNG	Liquified Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MT	Metric Tons
NOx	Nitrogen Oxides
PM	Particulate Matter
PWS	Prince William Sound
PWSRCAC	Prince William Sound Regional Citizens' Advisory Council

SEEMP	Ship Energy Efficiency Management Plan
SERVS	Ship Escort Response Vessel System
SOx	Sulfur Oxides
TAPS	Trans Alaska Pipeline System
USCG	United States Coast Guard
VOCs	Volatile Organic Compounds

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