VESSEL SPEED REDUCTION PROGRAM

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PORT of SAN DIEGO
Environment

CONTENTS

Prepared in collaboration with ICF

GLOSSARY OF TERMS

Auto Carrier – A sea going vessel that transports automobiles. Auto Carriers are a type of Roll-on/Roll-off vessel (see below)

Automatic Identification System (AIS) – An automatic tracking system that uses radio transceivers aboard ships to report vessel details to the vessel traffic management services.

Bulk Carrier – A merchant ship specially designed to transport bulk cargo.

Cargo Vessel – A Ocean Going Vessel carrying tangible goods.

California Air Resources Board (CARB) – California State Agency charged with protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change.

Carbon Dioxide Equivalent (CO_2e) – Metric to compare emissions of all greenhouse gases by normalizing them to the equivalent amount of carbon dioxide based on global-warming potential.

Criteria Pollutants – Pollutants for which the federal and state governments have set ambient air quality standards or that are chemical precursors to compounds for which ambient standards have been set.

Cruise Vessel – An Ocean-Going Vessel carrying passengers for hire.

Container Ship – A Cargo Ship carrying containers in twenty- and forty-foot equivalent units.

Climate Action Plan (CAP) – The San Diego Unified Port District's plan which serves as a guide for action, including a targeted set of greenhouse gas reduction policies and measures.

California Environmental Quality Act (CEQA) – California Environmental Law that applies to all discretionary projects proposed to be conducted or approved by a California Public Agency.

Diesel Particulate Matter (DPM) – Solid material contained in diesel exhaust including polycyclic aromatic hydrocarbons, benzene, formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene.

Electronic Chart Display Information System (ECDIS) – Navigation information system which, with adequate back-up arrangements, can be accepted as complying with the chart carriage requirements in regulation V/19 of the 1974 SOLAS Convention, by displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information.

General Cargo – A merchant ship specially designed to transport general cargo.

Green House Gas (GHG) – Gases that trap heat in the atmosphere including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Fluorinated Gasses.

International Maritime Organization (IMO) – The United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine pollution by ships.

Knots (Kt; Kts.) – Measure of speed equal to one nautical mile per hour, equal to 1.15 statute miles per hour.

Maximum Speed – The measure of the highest rate of speed for a given time within the VSR zone.

Maritime Mobile Service Identity (MMSI) – Nine-digit numbers used by maritime digital selective calling (DSC), automatic identification systems (AIS) and certain other equipment to uniquely identify a ship or a coast radio station.

Nautical Mile – Measure of distance in the ocean equal to 1.15 statute miles on land.

Nitrogen Oxides (NOx) - Compound formed by the combination of nitric oxide (NO) and oxygen through internal combustion.

Ocean Going Vessels (OGV/ vessel) – Any merchant vessel meeting either or both of the following criteria:

1. Length Overall (LOA) of 400 feet or more, as defined in 50 CFR § 679.2; or
2. Gross Tonnage ITC (GT ITC) of 10,000 tons or more pursuant to the convention measurement (international system), as defined in 46 CFR §69.51 through §69.61.

PM10 – Particulate matter 10 micrometers or less in diameter.

PM2.5 – Particulate matter 2.5 micrometers or less in diameter.

Reactive Organic Gases (ROG) – Compounds of carbon, excluding carbon monoxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

Roll-on/Roll-Off (RoRo) Ship – Vessels that are similar to auto carriers in that they carry wheeled cargo, such as automobiles, but are also equipped to carry other cargo, such as containers.

Transit Distance – The distance traveled within the vessel speed reduction zone.

Time in Transit – The amount of time measured between points within the vessel speed reduction zone.

Vessel Speed Reduction Zone – A radius arc extending seaward forty nautical miles from the coastline with the center at Point Loma (as illustrated in Figure 2).

Volatile Organic Compounds (VOC) – Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.

Weighted Average Speed – Calculated by dividing the speed weighted time by time in seconds. The weighted average speed calculations shall not factor in any time spent at anchor or any time spent traveling at a rate of speed below one knot (considered as stopped). AIS speed for each position reported within the Vessel Speed Reduction (VSR) zone is multiplied by the number of seconds between the vessel positions. The sum of these vessel position values will then be divided by the total number of seconds while in the VSR zone, which will yield the weighted average speed. The boundary of the VSR zone encompasses a forty nautical mile radius centered at Point Loma and extending seaward.

EXECUTIVE SUMMARY

The Port of San Diego's (Port) Vessel Speed Reduction (VSR) Program is a voluntary emission reduction strategy available to all commercial Ocean-Going Vessels (OGVs / Vessels) calling at the Tenth Avenue Marine Terminal (TAMT), National City Marine Terminal (NCMT), "B" Street Cruise Ship Terminal ("B" Street), and Broadway Pier Cruise Ship Terminal (Broadway Pier), that are engaged in a vessel trip within a forty nautical mile (nm) radius extending seaward from Point Loma (Figure 2). To achieve program objectives, participating Vessels traveling within the VSR Zone must proceed at a weighted average speed of no more than twelve knots for cargo ships and fifteen knots for cruise ships, at a compliance rate no less than ninety percent of total vessel calls measured quarterly each calendar year. If it is determined that a vessel can achieve the same or greater level of NOx and CO2 reductions at a different rate of speed, a waiver may be granted to exceed Vessel Speed Reduction (VSR) Program speed limits while still receiving credit for participating in the Program.

The purpose of the VSR Program is to lower emissions of both criteria air pollutants and greenhouse gases (GHG). This VSR Program has been updated to:

- Expand the geographic boundary of the VSR Zone from twenty nautical miles to forty nautical miles from Point Loma
- Monitor and report all commercial OGV activity within the zone
- Increase the annual participation goal to ninety percent

Assuming vessel calls remain similar to 2019 levels, preliminary estimates suggest that the updated VSR Program could yield the following approximate annual emission reduction benefits and cost savings:

- DPM reductions of 4.3 tons per year
- NOx reductions of 225.5 tons per year
- GHG reductions of 9,791 tons per year
- Annual fuel savings of over 2,794 Metric Tons, and cost savings of over $1,078,000

This document contains updated methods for determining the achievement of the desired program speed limits that are consistent with current industry standards and other port VSR programs (Appendix A). Vessel speeds are measured using weighted average speed, which provides flexibility for operators while continuing to increase associated benefits and VSR Program compliance.

PROGRAM DESCRIPTION

The VSR Program is monitored by Port staff utilizing Automatic Identification System (AIS) data that is cross referenced with vessel call data to determine levels of participation. Vessels are evaluated by the percentage of participation per quarter by trip. A trip is defined as an inbound or outbound leg through the VSR Zone by a vessel calling at Broadway, B-Street, TAMT, or NCMT.

GOAL

The goal of the VSR Program is to reduce engine exhaust emissions from vessels during transit into and out of the Port's cruise and marine terminals. This includes emissions of greenhouse gasses (GHGs), criteria air pollutants such as nitrogen oxides (NOx), carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOCs) and toxic air pollutants - specifically diesel particulate matter (DPM).

BENEFITS TO THE PUBLIC AND VESSEL OPERATORS

Benefits to the public include a reduction in GHG, improved air quality and a mitigation of impacts to marine life. A reduction in GHG emissions helps to combat a global rise in temperature and increased impacts from climate change; reductions in airborne criteria pollutants increase public health; and reductions in underwater noise minimize impacts on local marine life.

In addition to the public benefits described above, ocean carriers and terminal operators will benefit directly from cost savings due to reduced fuel consumption, and public recognition for participation in the program greater than ninety percent.

IMPLEMENTATION STRATEGY

1. **Outreach:** Port staff will continue to reach out and inform vessel and terminal operators about the VSR Program, which will involve explaining the Program's rationale, goals, requirements, and the benefits.
2. **Monthly Tracking:** The Port will assess weighted average vessel speeds on a monthly basis using Automatic Identification System (AIS) data to monitor compliance.
3. **Reporting:** The Port will maintain a reporting dashboard and publish aggregate results to the Port's website to provide public access.
4. **Track/calculate emission reductions:** The Port will calculate direct emission reductions within the defined VSR Zone, based on a vessel's weighted average speed reduction.

1 - THE PROGRAM

This section describes the Port's VSR Program requirements, the defined VSR Zone, and Program participation recognition.

1.1 VSR PROGRAM REQUIREMENTS

1.1.1 VSR PROGRAM

The Port's VSR Program applies to all participating commercial OGVs calling at the TAMT, NCMT, "B" Street, and Broadway Pier, that are engaged in a vessel trip within a forty nautical mile (nm) radius extending seaward from Point Loma[1] (Figure 2). Participating vessels traveling within the Vessel Speed Reduction Zone must proceed at a weighted average speed of no more than twelve knots for cargo ships and fifteen knots for cruise ships, at a compliance rate no less than ninety percent of total vessel calls measured quarterly each calendar year. Operators that demonstrate a compliance rate exceeding ninety percent will be recognized publicly and/or may be considered for other incentives.

Implementation and Monitoring

Vessel speeds will be tracked using Automatic Identification System (AIS) data, which will be calculated using the time-weighted average speed as they transit the VSR Zone, as described in Section 5 of Appendix A. Occasional transmission errors may result in discarded or missing data. Electronic Chart Display Information System (ECDIS) data may also be used to verify vessel speed. All reasonable efforts will be taken to verify missing data using available resources. Any speed below one knot is considered stopped and not counted in the average of speeds. Assessing compliance with the VSR Program requires the Port to determine which vessels are assigned to which operators. This will be accomplished by using the latest ownership information in the Lloyd's Register, an on-line, international database of ship information operated by IHS Markit.[2] Vessel speed monitoring reports will be generated quarterly by Port staff and will be distributed to vessel operators. For each vessel calling, its average speed will be reported for each of its inbound and outbound journeys within the VSR zone (Figure 3 is a sample vessel speed report). Participation levels will be published and updated quarterly.

It is worth noting that the San Diego Air Basin boundaries are not the same as the boundary lines for the VSR Program Zone.[3] California does not have jurisdictional authority over vessel activity across international borders or outside three nautical miles from the California coast, and therefore, boundaries used by CARB for delineating the air basin and calculating emissions of criteria air pollutants do not cross into Mexico's territory or outside the twenty nautical miles Federal jurisdiction boundary. However, for the purposes of the VSR Program, compliance will be encouraged within the area defined by a forty nautical mile radius from Point Loma without truncating the portion that extends into Mexico's waters or the twenty-four nautical miles boundary. For this reason, air basin emissions benefits will be calculated differently than compliance with the VSR Program.

Labor Assignments

Currently, assignments for on-dock labor are determined on a first-come-first-served basis related to the time of arrival at the dock. The Port will continue to communicate with stakeholders on future program updates that may affect vessel arrivals and departures. Program (or modified speed limit) can be granted.

1.1.2 VSR AS A MITIGATION STRATEGY

VSR has been employed as a method of air quality and GHG mitigation for environmental impacts from projects across the Port. Environmental documents for the National City Marine Terminal (NCMT) and Tenth Avenue Marine Terminal (TAMT) have required an eighty percent VSR compliance standard at twelve knot speed for a twenty nautical mile distance as mitigation for programs and projects at these two terminals. However, the existing mitigation measures require that once vehicle throughput at NCMT, or annual vessel calls at TAMT, reach a specific threshold, or by January

[1] Point Loma is located at 32° 39'54" N, 117° 14'33" W.
[2] HS Markit, Sea-Web. Available at: https://ihsmarkit.com/products/sea-web-vessel-search.html
[3] The San Diego Air Basin is defined as "All of San Diego County" per California Code of Regulations (17 CCR § 60110)

1, 2030 regardless of throughput or annual vessel calls, ninety percent compliance beginning at forty nautical miles from Point Loma becomes the standard. The threshold levels that require ninety percent compliance beginning at forty nautical miles from Point Loma are as follows:

1. **Tenth Avenue Marine Terminal**. Prior to annual vessel calls reaching the following:

- 79 calls for dry bulk
- 98 calls for refrigerated containers
- 78 calls for multi-purpose general cargo

Or beginning January 1, 2030 for all vessels irrespective of the number of calls occurring on an annual basis, whichever occurs first.

2. **National City Marine Terminal**. Prior to reaching an annual vehicle throughput of 480,337 vehicles.

The voluntary VSR Program is equivalent to the second phase of compliance with the mitigation measure identified above. Therefore, regardless of annual calls at TAMT or annual vehicle throughput at NCMT, all OGVs are encouraged to abide by the same twelve knot weighted average speed limit for cargo ships and fifteen knots for cruise ships with a ninety percent compliance standard beginning at forty from Point Loma.

Waivers and Exemptions:
Alternative Emission Reduction Speed

For vessels using VSR to fulfill mitigation requirements, it may be necessary to obtain a waiver in order to meet emission reduction requirements without incurring hardship. If it is determined that a vessel can achieve the same or greater level of NOx and CO2 reduction at a different rate or speed greater than twelve knots for cargo ships and fifteen knots for cruise ships and/or by incorporating alternative technologies, a discretionary waiver may be granted to exceed VSR Program speed limits while still be deemed in compliance under an agreed up Alternative Emission Reduction Speed. To be considered for a waiver, the ocean carrier, or a designated agent must proactively contact the Port's vessel speed reduction program manager and provide evidence of an equivalent emission reduction at a higher rate of speed for evaluation. Ocean Carriers also have the option of incorporating alternative emission reduction technologies that are above and beyond regulatory requirements, provided the emission reduction benefits meets or exceeds the VSR Program. The Port's Environmental Specialists will review the information provided to determine if a waiver to the VSR Program/ Alternative Emission Reduction Speed can be granted.

1.2 VSR AS AN EMISSION REDUCTION PROGRAM

VSR results in decreased engine load, which in turn, results in reduced fuel consumption and therefore, reduced emissions on a per hour basis. This must be balanced with the fact that slower vessels will have longer transit times, so even though the emissions rate is lower, the vessels will be emitting over a longer period. Vessel emissions vary from case to case, but in general there is a net emissions benefit despite the increase in transit time. The Port has prepared a methodology for calculating emissions (Appendix A) and a technical analysis of emission reduction benefits (Appendix B) within the VSR zone for the representative vessel types including:

- Auto Carriers
- Bulk Carriers
- Container Ships
- General Cargo
- Passenger Ships (both non-diesel-electric and diesel-electric)

Military, police, and harbor craft vessels are not included in the VSR Program.[4] The technical analysis was based on the methodology for calculating emissions for OGVs described in Appendix A.[5]

[4] Military and police vessels are not included in the VSR Program.
[5] Starcrest Consulting Group. 2020. Port of Los Angeles Inventory of Air Emissions for Calendar Year 2019. September. Available: https://kentico.portoflosangeles.org/getmedia/4696ff1a-a441-4ee8-95ad-abe1d4cddf5e/2019_air emissions_inventory. Accessed Nov. 2020.

1.3 OUTREACH TO OPERATORS

As part of the VSR Program, the Port has reached out to stevedores, and terminal and vessel operators to inform them about the VSR Program's requirements; the Port will continue to provide information as updates are developed. Outreach efforts include, but are not limited to, emails, meetings, phone calls and distribution of the VSR Program factsheet (See Appendix D), which contains the following information:

- Background of the VSR Program
- When the VSR Program goes into effect
- Applicability of VSR (i.e., to vessel types)
- Requirements for VSR compliance (i.e., vessel speed reduction requirements within the defined VSR zone)
- Diagram defining the VSR zone (forty nautical mile radius from Point Loma)
- Compliance standards (at least ninety percent of vessel trips complying with the appropriate speed limit within forty nautical miles of Point Loma, during the reporting period) and compliance monitoring (AIS Data and District staff analysis)
- Identifying the incentives for participating in the VSR Program

More specifically, this information will be distributed to all identified stakeholders and made publicly available through the website.

Port staff has also conducted outreach on the proposed VSR Program to other stakeholders that operate in the area, including representatives from the U.S. Navy, Harbor Police, San Diego Harbor Pilots, and the U.S. Coast Guard. While developing specific implementation strategies, Port staff consulted Ocean Carriers and Terminal Operators to obtain their input.

1.4 REPORTING DATA

The Port will generate summary reports to inform aggregate quarterly compliance and annual emissions reports. The reports will be developed from the following data for each vessel calling on both the inbound and outbound legs:

- Vessel name
- Vessel type
- IMO number
- Call sign
- MMSI number
- Flag
- Maximum speed
- Average speed
- Transit Distance
- Time in Transit
- Approach direction in degrees
- Terminal (TAMT, NCMT Broadway CST, B Street CST)
- Date and time (for inbound, when ship arrived at dock; for outbound, time ship left the dock)

2 - BENEFITS OF VSR

This section describes the benefits of implementing a VSR Program. These benefits include positive effects on air quality, climate change and the environment. The Port is committed to track emission reductions under the VSR Program as part of the Maritime Clean Air Strategy.

2.1 ASSOCIATED PROGRAMS

As a state-designated trustee of San Diego Bay and its tidelands, the Port is continuously pursuing multiple paths to achieve its mission which includes championing the environment and promoting commerce, navigation, fisheries, and recreation for the people of the State of California. For more than a decade the Port has been deploying clean air investments and new technologies, as originally envisioned in the Clean Air Plan (2007), Climate Action Plan (2013), TAMT Redevelopment Plan (2016), and the Maritime Clean Air Strategy (2021). These plans look to improve overall air quality and provide the foundation to help alleviate the disproportionate burden the maritime industry may otherwise place on surrounding communities.

Mandatory VSR has been employed as both a method of air quality and GHG mitigation across the Port. Environmental documents for the NCMT and TAMT, both certified in 2016, and relied on vessel speed reduction requirements to help reduce emissions associated with Ocean Going Vessels, as part of their overall mitigation, monitoring, and reporting programs (MMRP). Comparison of emission reductions and other associated benefits from the 2009 VSR program requirements (eighty percent compliance within twenty nautical mile zone) and the new program requirements (ninety percent compliance within forty nautical mile zone) is provided in Appendix C.

AB 617 Background

The California Air Resources Board (CARB) established the Community Air Protection Program (or AB 617 Program) in 2018, which tasks local air pollution control districts to work with communities to develop community-focused emission reduction programs. In September 2018, CARB selected the San Diego Portside Community, which includes the neighborhoods of Barrio Logan, West National City, Logan Heights, and Sherman Heights, for air monitoring. The Portside Community includes Port tidelands between TAMT and NCMT. The Portside Community is identified as having a high cumulative air pollution exposure burden, a significant number of sensitive receptors, and includes census tracts that have been designated as disadvantaged communities, as shown in California's Environmental Protection Agency's CalEnviroScreen 3.0 results (Attachment C - CalEnviroScreen 3.0 and AB 617 Portside Community Boundary). The San Diego Air Pollution Control District (SDAPCD) is responsible for implementing the AB 617 Program and established the AB 617 Steering Committee in October 2018. The AB 617 Steering Committee includes twenty-six members who represent residents, agencies, industry, non-profits, and other pertinent stakeholders.

In December 2019, CARB designated the Portside Community for a Community Emissions Reduction Plan (AB 617 CERP). The purpose of the AB 617 CERP is to focus and accelerate new actions that go beyond existing State and regional programs to provide direct reductions in air pollution emissions and exposure. The AB 617 CERP identifies the vessel speed reduction requirements as a potential strategy to help reduce OGV emissions affecting the Portside Community. The expectation is that the Portside Community's AB 617 CERP will serve as the region's guiding document to advance emission reduction efforts, and it may help attract outside investment into the community. The CERP was adopted by CARB October 2021.

Maritime Clean Air Strategy (MCAS) Background

Based on the AB 617 Program and the State's continued focus on reducing emissions, the Board adopted Board Resolution #2019-084 in June 2019 authorizing staff to update the Port's 2007 Clean Air Plan. The

resolution also directed staff to develop Port-related plans and projects that reduce emissions and improve air quality. In March 2020, Port staff outlined an approach to update its 2007 Clean Air Plan, which it is referred to as the MCAS. The MCAS is a comprehensive study with ambitious goals and objectives that addresses the commercial availability, operational feasibility, and other economic considerations of various emission reduction concepts for seven maritime emission sources, including ocean going vessels (OGVs). Reducing annual emissions from in-transit ocean going vessels and implementing an expanded VSR program are included within the MCAS:

Ocean-going Vessels In-Transit Goal 1: Reduce annual ocean-going vessel in-transit emissions.

Ocean-going Vessels In-Transit Objective 1A: Pursue implementing an expanded Vessel Speed Reduction Program that achieves upwards of 90% participation, subject to further Board of Port Commissioners' approval.

The MCAS was adopted by the Board of Port Commissioners at their October 2021 Board Meeting.

2.2 EFFECTS OF VESSEL EMISSIONS

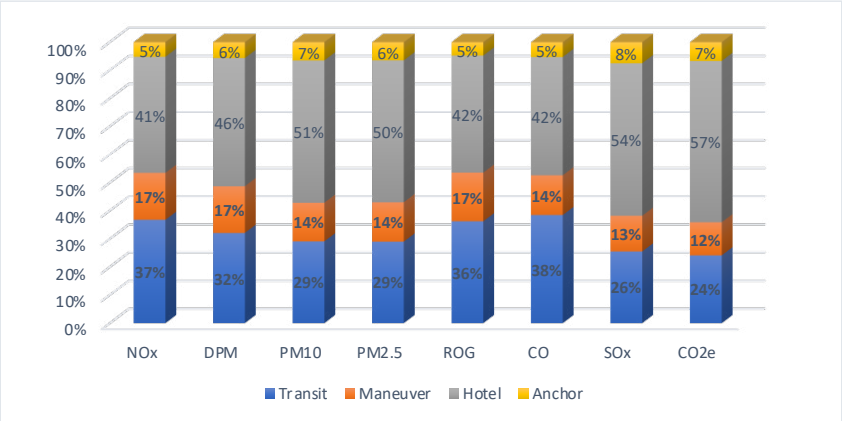
The VSR program is expected to result in emission reductions of NOx, DPM, and GHGs. Vessel call data from 2019 was used to demonstrate the reduction potential of implementing the VSR program. The following subsections discuss these emissions in greater detail and associated health and climate impacts.

2.2.1 CRITERIA AIR POLLUTANTS

Figure 1 shows the relative contribution of emissions from OGVs by mode. As shown, OGV activity in transit accounts for the second highest share of NOx, PM10, and GHG emissions from vessel activity (behind hoteling).[1] Criteria air pollutants are harmful to public health, especially to sensitive populations such as asthmatics, children, and the elderly. Criteria pollutants also can lead to decreased visibility and damage to vegetation, animals, and buildings. San Diego County is in attainment of all National Ambient Air Quality Standards (NAAQS) except the eight-hour ozone standard. However, San Diego County is a non-attainment area for the one-hour ozone, eight-hour ozone, annual PM2.5, and annual PM10 California Ambient Air Quality Standards (CAAQS).[2] Ground-level ozone is formed from reactions of precursor pollutants, such as volatile organic compounds (VOCs) and NOx, rather than from direct emissions. NOx and sulfur oxides (SOx) are precursors to secondary particulate aerosols (PM10). Thus, precursors to ozone and PM10, such as NOx, SOx, and VOC, and direct emissions of particulate matter are the primary criteria pollutants of concern.

[1] ICF. 2018. Port of San Diego 2016 Maritime Air Emission Inventory. June. Available: https://pantheonstorage.blob.core.windows.net/environment/2016-Maritime-Air-Emissions-Inventory.pdf. Accessed December 2020.
[2] San Diego Air Pollution Control District (SDAPCD). 2020. Attainment Status. Available at: https://www.sdapcd.org/content/sdc/apcd/en/air-quality-planning/attainment-status.html. Accessed December 2020.

FIGURE 1. RELATIVE CONTRIBUTION OF POLLUTANTS BY VESSEL ACTIVITY MODE



2.2.2 TOXIC AIR CONTAMINANTS

Toxic air contaminants (TACs) are substances that cause or may cause cancer and/or other serious health effects. They are different from criteria pollutants in that they may have health impacts even at low levels and may accumulate in the body through repeated exposure. CARB has identified over seven hundred TACs, some of which are classified as potentially toxic or have only partially known health effects. TACs include diesel particulate matter (DPM) which is believed to account for approximately seventy percent of the chronic health risks associated with all TAC emissions in California, including cancer, cardiopulmonary, and respiratory heath risks.[3] Based on CARB's efforts, statewide DPM levels have decreased sixty eight percent since 1990.[4] In the most recent Port-wide emissions inventory, OGV DPM emissions from all modes were estimated to be 6.1 tons, or approximately thirty eight percent of Port-related DPM emissions. Of this, 1.9 tons occurred in transit (both within and outside the VSR zone), or approximately twelve percent of Port-related DPM emissions.

2.2.3 GREENHOUSE GASES

Greenhouse gases (GHGs) are gases that absorb radiative heat in the atmosphere, leading to increases in the temperature of the earth's atmosphere. GHGs are not air pollutants that directly cause adverse impact on human health or local air quality. However, there is international scientific consensus that human-caused increases in GHGs have and will continue to contribute to global climate change.

2.2.4 EFFECT OF VSR PROGRAM

The VSR Program is expected to result in a reduction of criteria air pollutants, TACs, and GHGs. In a preliminary study, the California Air Resources Board estimated that a mandatory VSR Program could reduce emissions by fourteen to twenty one percent depending on the pollutant. This estimate assumes a twenty-four nautical mile VSR zone for five major California ports (Los Angeles, Long Beach, San Diego, San Francisco Bay Area, and Port Hueneme).[5]
The magnitude of reductions at the Port of San Diego depends largely on participation in the Program, the specifications of each vessel, and on pre-VSR baseline speeds and emissions. Emission reductions as a result of implementation of the VSR Program at the Port of San Diego are shown in Table 1 using the methodology discussed in Appendix A. As shown, emission reduction potential ranges from twenty-six to

[3]California Air Resources Board (CARB). 2000. Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles. October. Available: https://ww2.arb.ca.gov/sites/default/files/classic//diesel/documents/rrpfinal.pdf. Accessed December 2020.
[4]California Air Resources Board (CARB). 2020 Overview: Diesel Exhaust and Health. Available at: https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health. Accessed December 2020
[5]California Air Resources Board (CARB). 2008. Public Workshop: Vessel Speed Reduction for Ocean Going Vessels. September 9.

fifty on percent when compared to vessels traveling at the service speed in the VSR Zone.
The potential reduction in emissions shown in Table 1 represents the typical reduction in emissions by vessel class in the VSR Zone if all vessels participate in the VSR Program and carriers achieve a ninety percent compliance rate. Other emissions such as reactive organic gases (ROG),[6] CO, PM10, PM2.5, and SO2 would show similar reductions as a result of the VSR Program. These estimates assume a reduction from

TABLE 1. POTENTIAL REDUCTION IN EMISSIONS IN 40-NM VSR ZONE (BASED ON 2019 VESSEL DATA)

SHIP TYPE	SPEED REDUCTION	% REDUCTIONS			
		NOX	DPM	CO2E	FUEL
Auto Carrier	20 kts to 12 kts	51%	50%	47%	47%
RoRo	20 kts to 12 kts	48%	47%	45%	45%
Bulk Carrier	14 kts to 12 kts	27%	27%	26%	26%
Container	20 kts to 12 kts	51%	50%	47%	47%
General Carrier	16 kts to 12 kts	34%	33%	33%	32%
Passenger*	22 kts to 15 kts	30%	30%	30%	30%
*Passenger ships show the same reductions across all pollutants because most passenger ships are electrically driven, and low-load adjustments are not applied to electrically driven vessels.					

typical cruising (service) speed to the VSR speed limit once a vessel participates in the VSR Program. The reduction shown here only represents the potential reduction in emissions and only applies to vessels with baseline emissions (pre-VSR) with speeds greater than twelve knots for cargo ships and fifteen knots for cruise ships. The emissions reduction would only occur in the area where the vessel reduces speed. Overall emission reductions for OGVs transiting in the VSR zone are likely to be less if not all vessels participate in the VSR Program.

Cargo Vessels and Passenger Vessels will be considered to be within program limits if their average speed is less than or equal to twelve knots or fifteen knots, respectively, within the forty nautical mile VSR Zone. Table 2 summarizes the emission reductions achieved by implementing VSR versus all vessels operating at service speed within the VSR Zone.

TABLE 2. VSR EMISSION SAVINGS WITH 90% COMPLIANCE IN 40 NM

SHIP TYPE	SAVING (TONS)							
	NOX	DPM	PM10	PM2.5	ROG	CO	SO2	CO2E
Auto Carrier	104.6	1.9	1.9	1.7	5.4	6.8	2.6	3,821
RoRo	0.5	<0.0	<0.0	<0.0	<0.0	<0.0	<0.0	16
Bulk Carrier	1.4	0.0	0.0	0.0	0.1	0.1	0.0	54
Container	28.5	0.6	0.6	0.5	1.7	1.5	0.8	1,137
General Carrier	4.5	0.1	0.1	0.1	0.3	0.3	0.1	191
Passenger	86.1	1.8	1.8	1.6	4.3	7.5	2.8	4,578
Total	225.5	4.3	4.3	4.0	11.8	16.2	6.3	9,791
Source: Appendix A								

[6] Reactive organic gases (ROG) refer to organic gases that are photochemically reactive. ROGs are generally a subset of total organic gases or total hydrocarbons. ROGs are generally similar to volatile organic compounds (VOCs) in most regulatory contexts. Generally, ROG is a CARB term, and VOC is an EPA term.

2.3 FUEL SAVINGS AND AIR QUALITY

Full participation in the vessel speed reduction program is estimated to provide 636,434 gallons of fuel savings, resulting in $1,078,463 in cost savings annually (Table 5). The Port's VSR Program would result in reduced emissions from vessel transit, due to lower fuel consumption. When vessels travel at the reduced speed limit within the VSR Zone, their emissions are lower on a per nautical mile basis, reducing diesel particulate matter and greenhouse gas emissions. In addition to air quality improvement, and GHG reduction benefits, lowering a vessels fuel consumption can provide a cost savings.

2.4 UNDERWATER NOISE

The VSR Program has the potential to reduce whale strikes and underwater noise. Port staff will promote and raise awareness to tenants and ship operators calling at the Port's terminals about issues of underwater noise by distributing pertinent information on the effects of underwater noise on marine mammal and sensitive areas via an available website, and factsheet. Vessel operators who assist in the sharing of research and information regarding underwater noise and vessel speed will qualify for special recognition within the VSR Program through awards and marketing efforts.

3 - PROGRAM FEASIBILITY

The CAP, MCAS, and AB 617 CERP strategies all include the VSR Program as a method to reduce emissions from OGVs. The strategies include criterion identified by Port staff and AB 617 Steering Committee and Sub-Committee members to evaluate a control measure. These are generally the same factors that an air agency must consider when adopting and implementing a Program. Each factor is discussed in the context of the VSR Program, below.

3.1 TRACKING EMISSION REDUCTIONS

The strategies require emission reductions under the VSR Program to be tracked in order to verify that emission reductions are achieved. Since the Port's VSR Zone extends into Mexico's waters as well as outside the California twenty-four nautical mile boundary, tracking emission reductions for implementing the VSR Program at Port of San Diego is somewhat unique. The geographic extent of California emission inventories generally stops at the US-Mexico border because California does not have any jurisdiction over vessel activity in international waters. California's authority to enforce air and water quality standards that meet or exceed federal standards extends twenty-four nautical miles into the ocean from the coastline. In the 2016 Maritime Air Emission Inventory, the geographic scope is defined using the US-Mexico border as the southern boundary and the twenty-four nautical mile California authority boundary. However, since the VSR Zone extends into Mexico's waters and past twenty nautical miles from shore, emission reductions are likely to be realized in these non-California international waters. There are two methods in which emission reductions can be tracked: 1) A "direct" method in which emission reductions are estimated wholly within the VSR Zone and 2) an "indirect" method in which emission reductions are estimated by comparing future emission inventories with a baseline emissions inventory.

For tracking purposes for the VSR Program, emission reductions will be estimated using the "direct method". For this method, emission reductions are based solely on the difference between the speed of the vessel after the implementation of VSR Program update (as reported as the average speed within the VSR zone) and the speed of the vessel before or without the implementation of the VSR Program update (i.e., service or normal cruising speed). The average pre-VSR baseline speed profile will be calculated by vessel type based on a sampling of data (two months) for OGV activity within the VSR Zone. Emission reductions within the VSR zone can be estimated for every vessel that calls into port. There are potential costs to the Port and Vessel Operators from the implementation of the VSR Program. However, it is important to note that there will not be any costs associated with capital purchases or new equipment. The Port will incur costs from the administrative efforts to implement the VSR Program including outreach efforts, data analysis and technology management.

Cost effectiveness is generally reported as the dollar cost per ton of emissions reduced. Table 5 summarizes fuel cost savings estimates by ship type assuming ninety percent compliance within the forty nautical mile zone. Estimates are based on 2019 District call data, and calculations are provided in Appendix B. Total fuel savings are based on Regional Average Bunker Prices from November 2020 Ship and Bunker estimates.[12]

TABLE 5. FUEL SAVINGS WITH 90% COMPLIANCE

VESSEL TYPE	FUEL SAVINGS (GALLONS)	FUEL SAVINGS (COST)
Auto Carrier	248,376	$420,883
RoRo	1,020	$1,728
Bulk Carrier	3,514	$5,955
Container	73,894	$125,216
General Cargo	12,390	$20,996
Passenger	297,240	$503,685
TOTAL	636,434	$1,078,463

[12] Ship and Bunker. 2020. Regional Average Bunker Prices. Accessed November 17, 2020. Available: https://shipandbunker.com/prices/av/

3.2 FUNDING

The costs to the Port are expected to be relatively minimal since the VSR Program does not require additional equipment or other capital expenditures. These costs will be for annual access to software, administrative efforts in the implementation of the Program, outreach, and consulting costs, as discussed above. Funding is expected to be covered by the Port's annual budget allocations.

3.3 TECHNOLOGICAL FEASIBILITY

The VSR Program only requires a reduction of vessel speed, which is technically feasible. No additional equipment needs to be installed on the vessel or at the Port. The Port already has an AIS receiver in operation to obtain real-time vessel data. No additional evaluations of technological feasibility are required.

3.4 PROGRAM FEASIBILITY

One practical issue to consider is that VSR Program participation will require slowing down in the VSR Zone, which may result in longer transit times for vessels. Port staff will continue to work with VSR participants and on-dock labor to insure the accurate portrayal of vessel departure and arrival times. No new internal staffing costs are projected as a result of this update. The VSR Program is not expected to compromise safety in any way. Vessel operators at sea will continue to follow "International" and "United States Inland" rules of the road, as well as practice good seamanship, when considering safe speed and maneuverability within the VSR zone.

5 -ADDITIONAL FIGURES

FIGURE 2. PORT OF SAN DIEGO 40-NAUTICAL MILE VESSEL SPEED REDUCTION ZONE

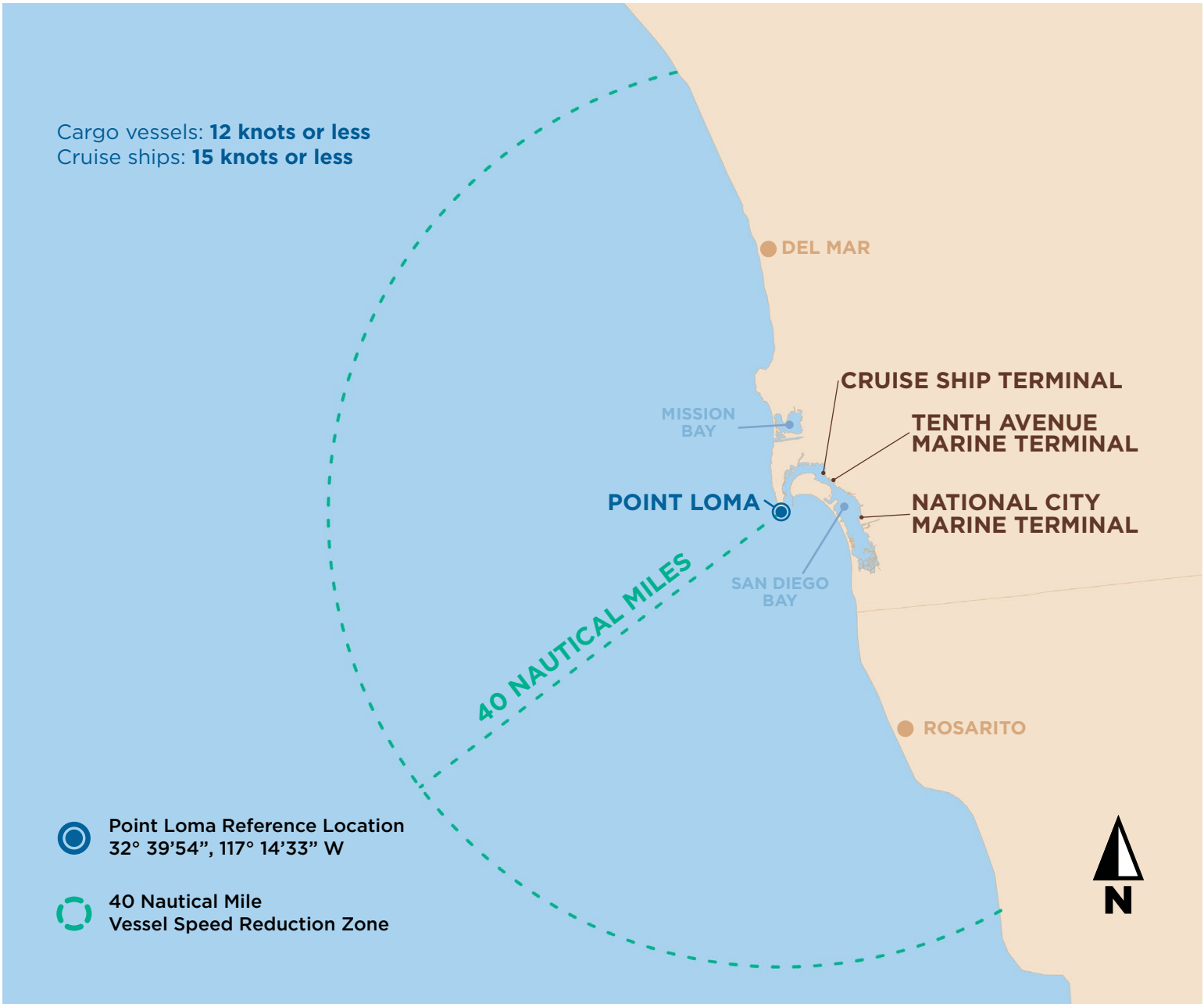
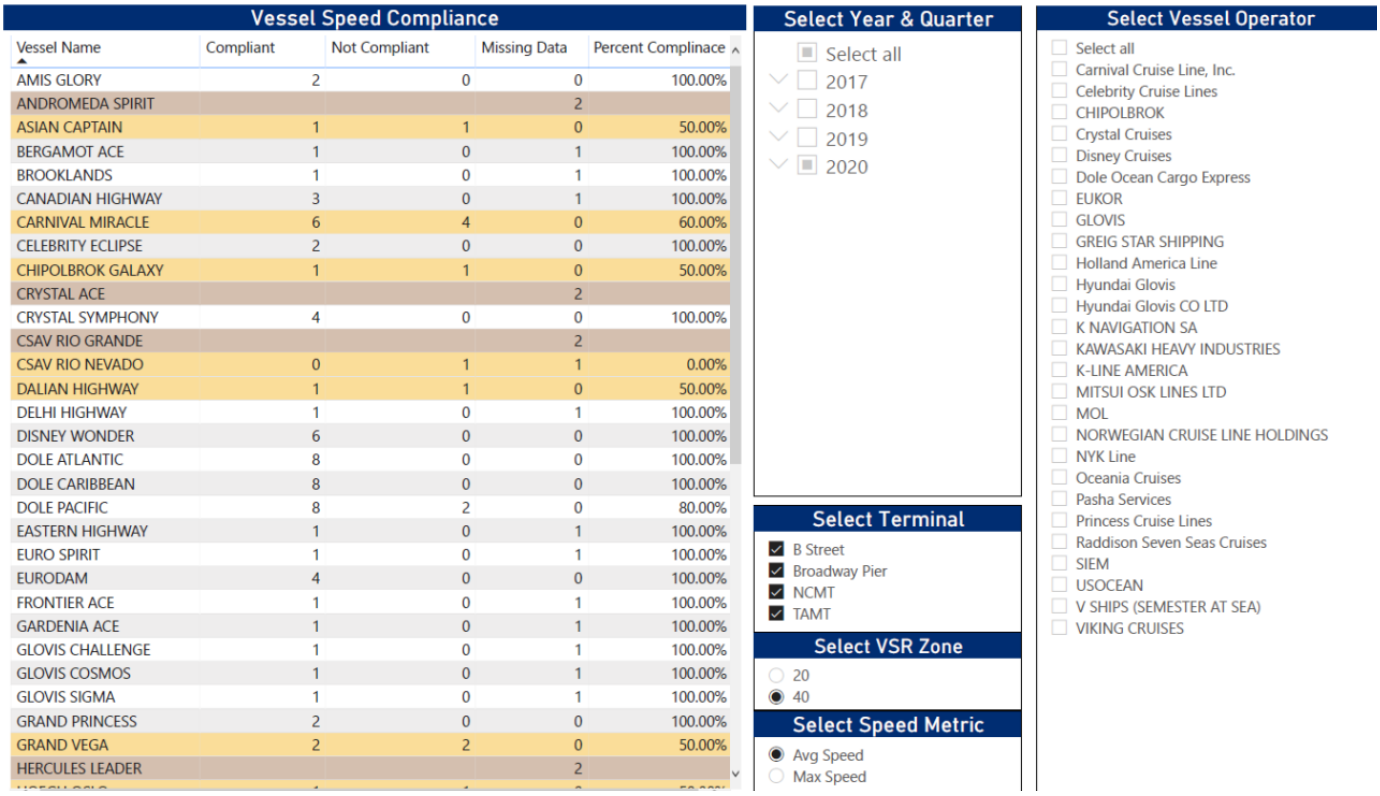


FIGURE 3. SAMPLE ZONE SPEED REPORT



Vessel Speed Compliance

Vessel Name	Compliant	Not Compliant	Missing Data	Percent Complinace
AMIS GLORY	2	0	0	100.00%
ANDROMEDA SPIRIT			2	
ASIAN CAPTAIN	1	1	0	50.00%
BERGAMOT ACE	1	0	1	100.00%
BROOKLANDS	1	0	1	100.00%
CANADIAN HIGHWAY	3	0	1	100.00%
CARNIVAL MIRACLE	6	4	0	60.00%
CELEBRITY ECLIPSE	2	0	0	100.00%
CHIPOLBROK GALAXY	1	1	0	50.00%
CRYSTAL ACE			2	
CRYSTAL SYMPHONY	4	0	0	100.00%
CSAV RIO GRANDE			2	
CSAV RIO NEVADO	0	1	1	0.00%
DALIAN HIGHWAY	1	1	0	50.00%
DELHI HIGHWAY	1	0	1	100.00%
DISNEY WONDER	6	0	0	100.00%
DOLE ATLANTIC	8	0	0	100.00%
DOLE CARIBBEAN	8	0	0	100.00%
DOLE PACIFIC	8	2	0	80.00%
EASTERN HIGHWAY	1	0	1	100.00%
EURO SPIRIT	1	0	1	100.00%
EURODAM	4	0	0	100.00%
FRONTIER ACE	1	0	1	100.00%
GARDENIA ACE	1	0	1	100.00%
GLOVIS CHALLENGE	1	0	1	100.00%
GLOVIS COSMOS	1	0	1	100.00%
GLOVIS SIGMA	1	0	1	100.00%
GRAND PRINCESS	2	0	0	100.00%
GRAND VEGA	2	2	0	50.00%
HERCULES LEADER			2	

Select Year & Quarter

- Select all
- 2017
- 2018
- 2019
- 2020

Select Terminal

- B Street
- Broadway Pier
- NCMT
- TAMT

Select VSR Zone

- 20
- 40

Select Speed Metric

- Avg Speed
- Max Speed

Select Vessel Operator

- Select all
- Carnival Cruise Line, Inc.
- Celebrity Cruise Lines
- CHIPOLBROK
- Crystal Cruises
- Disney Cruises
- Dole Ocean Cargo Express
- EUKOR
- GLOVIS
- GREIG STAR SHIPPING
- Holland America Line
- Hyundai Glovis
- Hyundai Glovis CO LTD
- K NAVIGATION SA
- KAWASAKI HEAVY INDUSTRIES
- K-LINE AMERICA
- MITSUI OSK LINES LTD
- MOL
- NORWEGIAN CRUISE LINE HOLDINGS
- NYK Line
- Oceania Cruises
- Pasha Services
- Princess Cruise Lines
- Raddison Seven Seas Cruises
- SIEM
- USOCEAN
- V SHIPS (SEMESTER AT SEA)
- VIKING CRUISES

APPENDIX A
VESSEL SPEED EMISSION REDUCTION METHODS AND ESTIMATES

PORT of SAN DIEGO
Environment

CONTENTS

TABLES

I. EMISSION ESTIMATE METHODOLOGY

Ocean going vessel (OGV) emissions are generally calculated by using energy-based emission factors together with activity profiles for each vessel. OGVs include two types of engines: main engines and auxiliary engines. The main engine is a large diesel engine used primarily to propel the vessel at sea. Auxiliary engines provide power for uses other than propulsion (except for diesel-electric vessels). Additionally, most ships have auxiliary boilers to provide steam heat for a variety of uses, including fuel heating and hot water.

Propulsion (main) engine emissions for each entrance and clearance (inbound and outbound directions) are calculated according to the general equation

$$E = PP \times LFP \times A \times EF \times EAF$$

Where E = Emissions (grams [g])
P_P = Maximum Continuous Rating Power for propulsion engines (kilowatts [kW])
LF_P = Propulsion Load Factor (percent of vessel's total propulsion power)
A = Activity (hours [h])
EF = Emission Factor (grams per kilowatt-hour [g/kWh])
EAF = Emission Adjustment Factor

Auxiliary engine emissions are calculated according to the general equation:

$$E = LA \times A \times EF$$

Where E = Emissions (g)
L_A = Auxiliary Load (kW]
A = Activity (h)
EF = Emission Factor (g/kWh)

Auxiliary boiler emissions are calculated using the general equation below:

$$E = LB \times A \times EF$$

Where E = Emissions (g)
LB = Boiler Load (kW)
A = Activity (h)
EF = Emission Factor (g/kWh)

Auxiliary boiler loads are only applied if the propulsion load factor is less than 20 percent. Steam needs are supplied by the propulsion engine exhaust economizer when propulsion loads are above 20 percent and the auxiliary boiler is shut off.

The emission factor is in terms of emissions per unit of energy from the engine. It is multiplied by the energy consumed while in each mode.

1 SHIP CHARACTERISTICS

OGVs vary greatly in speed and engine sizes based on ship type. Vessel types have been broken out by the cargo they carry. Table A-1 lists the OGV types analyzed herein.

TABLE A-1. VESSEL TYPES

SHIP TYPE	DESCRIPTION
Auto Carrier	Self-propelled dry-cargo vessels that carry containerized automobiles.
Bulk Carrier	Self-propelled dry-cargo ship that carries loose cargo.
Container Ship	Self-propelled dry-cargo vessel that carries containerized cargo.
General Cargo	Self-propelled cargo vessel that carries a variety of dry cargo.
Passenger Ships	Self-propelled cruise ships.
Ro-Ro	A vessel designed to carry large wheeled cargo such as large off-road equipment, trailers or railway carriages. RORO is an acronym for "roll on/roll off".

Emission sources from OGVs include propulsion engines, auxiliary engines and auxiliary boilers. Propulsion engines are used to propel the ship and are usually either medium speed diesel (MSD) or slow speed diesel (SSD). In addition, one passenger ship was powered by a gas turbine (GT). Passenger ships are typically powered by electrical powered propulsion (ED) and all engine power is used to generate electricity. Auxiliary engines on non-passenger ships are used to power the ship's electrical needs and are assumed here to be Category 2 MSD engines. Auxiliary boilers are used to heat residual oil in the fuel tanks (used outside the 200 nautical mile North American Emission Control Area boundary) as well as supply heat for engines and cabin heat and hot water for crew or passenger needs.

Lloyd's data was purchased from IHS Markit, headquartered in London, England. The list of vessel characteristics that were used for the inventory include:

- Vessel type,
- Engine model year,
- Propulsion power,
- Propulsion engine type,
- Vessel service speed, and
- Vessel size.

2 PROPULSION LOAD FACTOR

Propulsion load factor is based on the propeller law:

$$LF = (AS/MS)^3$$

Where LF = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

Maximum speed was calculated as 1.066 times service speed in all cases based upon CARB methodology.[1]

For electric drive passenger ships, all engines are used to generate electricity and propulsion is electrically driven. Since the propulsion load factor should be applied to the propulsion engine power, total power in electrically driven ships needs to be reduced to that which would commonly be used for propulsion. Propulsion power is determined for electric drive passenger ships by subtracting auxiliary load from total ship power.

[1] California Air Resources Board, Emissions Estimation Methodology for Ocean-Going Vessels, May 2011. Available at http://www.arb.ca.gov/regact/2011/ogv11/ogv11appd.pdf

3 AUXILIARY ENGINE AND BOILER LOADS

To determine load estimates for the Port of San Diego (Port), ICF analyzed the 2018 U.S. Army Corps of Engineers entrances and clearances data[2] for the Po rts of Los Angeles and Long Beach and obtained vessel characteristics (vessel type, propulsion power, vessel size) from Lloyd's data. Since propulsion power is a reasonable and accurate measure of vessel size, ratios were determined between average propulsion power by ship type and published auxiliary engine and boiler loads for the two ports for 2018. Load factors calculated in this method are shown in Table A-2. These factors are multiplied by the ship's total propulsion power (or total power for diesel-electric passenger ships) to obtain auxiliary engine and boiler loads by vessel. Loads calculated for the Port's 2019 vessel activity is outlined in Table A-3.

TABLE A-2. CALCULATED AUXILIARY ENGINE AND BOILER LOAD FACTORS

SHIP TYPE	LOAD FACTORS	
	Engine	Boiler
Auto Carrier	0.058	0.006
Bulk Carrier	0.035	0.004
Container 0-1000 TEU	0.082	0.006
Container 1000-2000 TEU	0.056	0.006
General Cargo	0.053	0.009
Passenger < 1500 passengers	0.160	0.000
Passenger 1500 – 2000 passengers	0.127	0.000
Passenger 2000 – 2500 passengers	0.202	0.000
Passenger 2500 – 3000 passengers	0.227	0.000
Passenger 3000 – 3500 passengers	0.133	0.000
Passenger 3500 – 4000 passengers	0.138	0.000
RoRo	0.058	0.006

[2] U.S Army Corps of Engineers, Vessel Entrances and Clearances – 2016, February 2018.
Available at http://www.navigationdatacenter.us/data/dataclen.htm#Foreign%20Traffic%20Vessel%20Entrances%20and%20Clearances

TABLE A-3. AVERAGE AUXILIARY ENGINE AND BOILER LOAD

SHIP TYPE	AUX ENGINE LOADS (KW)	AUX BOILER LOADS (KW)
Auto Carrier	789	84
Bulk Carrier	273	32
Container	1,078	119
General Cargo	463	80
Passenger	11,904	0
RoRo	1,101	118

4 EMISSION FACTORS

Emission factors for propulsion engines, auxiliary engines and auxiliary boilers are discussed below.

4.1 PROPULSION EMISSION FACTORS

Emission factors for propulsion engines were also taken from the 2014 Port of Long Beach inventory and are listed in Table A-4.[3] ROG was calculated from the hydrocarbon emission factor presented in the inventory document referenced using a CARB conversion factor.[4]

TABLE A-4. PROPULSION ENGINE EMISSION FACTORS

ENGINE TYPE	TIER	MODEL YEARS	PROPULSION ENGINE EMISSION FACTORS (G/KWH)									
			NO_x	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2	CH_4	N_2O
Medium Speed Diesel	0	Pre-2000	13.2	0.26	0.26	0.24	0.63	1.1	0.40	649	0.010	0.029
	1	2000 – 2010	12.2	0.26	0.26	0.24	0.63	1.1	0.40	649	0.010	0.029
	2	2011-2015	10.5	0.26	0.26	0.24	0.63	1.1	0.40	649	0.010	0.029
	3	2016+	2.6	0.26	0.26	0.24	0.63	1.1	0.40	649	0.010	0.029
Slow Speed Diesel	0	Pre-2000	17.0	0.26	0.26	0.24	0.76	1.4	0.40	589	0.012	0.029
	1	2000 – 2010	16.0	0.26	0.26	0.24	0.76	1.4	0.40	589	0.012	0.029
	2	2011-2015	14.4	0.26	0.26	0.24	0.76	1.4	0.40	589	0.012	0.029
	3	2016+	3.4	0.26	0.26	0.24	0.76	1.4	0.40	589	0.012	0.029
Gas Turbine	All	All	5.7	-	0.01	0.01	0.13	0.2	0.60	922	0.002	0.075

[3] Starcrest Consulting Group, Port of Long Beach Air Emissions Inventory -- 2014, September 2015. Available at http://www.polb.com/civica/filebank/blobdload.asp?BlobID=13033

[4] CARB, Factors For Converting THC Emission Rates TOG/ROG. Available at https://www.arb.ca.gov/msei/onroad/downloads/tsd/HC_Conversions.pdf

4.2 EMISSION ADJUSTMENT FACTORS

In previous inventories, emission factors were considered to be constant down to about 20 percent load. Below that threshold, emission factors tend to increase as the load decreases. This trend results because diesel engines are less efficient at low loads and fuel consumption (or Brake-Specific Fuel Consumption [BSFC]) tends to increase. Thus, while mass emissions (grams per hour) decrease with low loads, the engine power tends to decrease more quickly, thereby increasing the emission factor (grams per engine power) as load decreases. The Energy and Environmental Analysis Inc. (EEA). demonstrated this effect in a study prepared for US EPA in 2000.[5] The resultant emission adjustment factors (EFA) are shown in Table A-5. These are applied only to non-MAN-B&W engines.

TABLE A-5. EMISSION ADJUSTMENT FACTORS FOR OTHER ENGINES

Load	NO_x	PM	ROG	CO	SO_2	CO_2	CH_4	N_2O
1%	4.63	7.29	21.18	9.68	3.36	3.28	21.18	4.63
2%	4.63	7.29	21.18	9.68	3.36	3.28	21.18	4.63
3%	2.92	4.33	11.68	6.46	2.49	2.44	11.68	2.92
4%	2.21	3.09	7.71	4.86	2.05	2.01	7.71	2.21
5%	1.83	2.44	5.61	3.89	1.79	1.76	5.61	1.83
6%	1.60	2.04	4.35	3.25	1.61	1.59	4.35	1.60
7%	1.45	1.79	3.52	2.79	1.49	1.47	3.52	1.45
8%	1.35	1.61	2.95	2.45	1.39	1.38	2.95	1.35
9%	1.27	1.48	2.52	2.18	1.32	1.31	2.52	1.27
10%	1.22	1.38	2.20	1.96	1.26	1.25	2.20	1.22
11%	1.17	1.30	1.96	1.79	1.21	1.21	1.96	1.17
12%	1.14	1.24	1.76	1.64	1.18	1.17	1.76	1.14
13%	1.11	1.19	1.60	1.52	1.14	1.14	1.60	1.11
14%	1.08	1.15	1.47	1.41	1.11	1.11	1.47	1.08
15%	1.06	1.11	1.36	1.32	1.09	1.08	1.36	1.06
16%	1.05	1.08	1.26	1.24	1.07	1.06	1.26	1.05
17%	1.03	1.06	1.18	1.17	1.05	1.04	1.18	1.03
18%	1.02	1.04	1.11	1.11	1.03	1.03	1.11	1.02
19%	1.01	1.02	1.05	1.05	1.01	1.01	1.05	1.01
20%+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Starting in 2014, Starcrest adjusted the emissions for MAN 2-stroke propulsion (main) engines as a function of engine load using test data from the San Pedro Bay Ports' (SPBP) MAN Slide Valve Low-Load Emissions Test Final Report (Slide Valve Test) completed under the SPBP Technology Advancement Program in conjunction with MAN and Mitsui. They produced EFAs for MAN-B&W engines with both conventional valves and slide valves. EFAs for MAN-B&W engines with conventional valves (pre-2002) are shown in Table A-6. EFAs for MAN-B&W engines with slide valves (2002+) are shown in Table A-7.

[5] Energy and Environmental Analysis Inc., Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data, EPA420-R-00-002, February 2000. Available at https://www3.epa.gov/otaq/models/nonrdmdl/c-marine/r00002.pdf

[6] San Pedro Ports Clean Air Action Plan Technology Advancement Program – 2013 Annual Report, April 2014. Available at http://www.cleanairactionplan.org/documents/2013-tap-annual-report.pdf

TABLE A-6. EMISSION ADJUSTMENT FACTORS FOR MAN-B&W ENGINES WITH CONVENTIONAL VALVES

Load	NO_x	PM	ROG	CO	SO_2	CO_2	CH_4	N_2O
1%	1.91	0.84	2.53	1.38	1.11	1.11	2.53	1.91
2%	1.86	0.83	2.45	1.36	1.11	1.11	2.45	1.86
3%	1.82	0.83	2.37	1.34	1.10	1.10	2.37	1.82
4%	1.77	0.82	2.30	1.33	1.10	1.10	2.30	1.77
5%	1.72	0.82	2.23	1.31	1.10	1.10	2.23	1.72
6%	1.68	0.81	2.16	1.29	1.09	1.09	2.16	1.68
7%	1.64	0.81	2.10	1.28	1.09	1.09	2.10	1.64
8%	1.60	0.80	2.03	1.26	1.09	1.09	2.03	1.60
9%	1.56	0.80	1.97	1.25	1.08	1.08	1.97	1.56
10%	1.52	0.79	1.91	1.24	1.08	1.08	1.91	1.52
11%	1.49	0.79	1.86	1.22	1.08	1.08	1.86	1.49
12%	1.45	0.78	1.80	1.21	1.07	1.07	1.80	1.45
13%	1.42	0.78	1.75	1.20	1.07	1.07	1.75	1.42
14%	1.39	0.78	1.70	1.19	1.07	1.07	1.70	1.39
15%	1.36	0.77	1.65	1.18	1.06	1.06	1.65	1.36
16%	1.33	0.77	1.61	1.17	1.06	1.06	1.61	1.33
17%	1.30	0.77	1.56	1.16	1.06	1.06	1.56	1.30
18%	1.28	0.77	1.52	1.15	1.06	1.06	1.52	1.28
19%	1.25	0.76	1.48	1.14	1.05	1.05	1.48	1.25
20%	1.23	0.76	1.44	1.13	1.05	1.05	1.44	1.23
21%	1.20	0.76	1.41	1.13	1.05	1.05	1.41	1.20
22%	1.18	0.76	1.37	1.12	1.05	1.05	1.37	1.18
23%	1.16	0.76	1.34	1.11	1.04	1.04	1.34	1.16
24%	1.14	0.75	1.31	1.10	1.04	1.04	1.31	1.14
25%	1.12	0.75	1.28	1.10	1.04	1.04	1.28	1.12
26%	1.11	0.75	1.25	1.09	1.04	1.04	1.25	1.11
27%	1.09	0.75	1.22	1.08	1.04	1.04	1.22	1.09
28%	1.07	0.75	1.20	1.08	1.03	1.03	1.20	1.07
29%	1.06	0.75	1.17	1.07	1.03	1.03	1.17	1.06
30%	1.05	0.75	1.15	1.07	1.03	1.03	1.15	1.05
31%	1.03	0.75	1.13	1.06	1.03	1.03	1.13	1.03
32%	1.02	0.75	1.11	1.06	1.03	1.03	1.11	1.02
33%	1.01	0.75	1.09	1.05	1.02	1.02	1.09	1.01
34%	1.00	0.75	1.08	1.05	1.02	1.02	1.08	1.00
35%	0.99	0.76	1.06	1.04	1.02	1.02	1.06	0.99
36%	0.98	0.76	1.05	1.04	1.02	1.02	1.05	0.98
37%	0.98	0.76	1.04	1.03	1.02	1.02	1.04	0.98
38%	0.97	0.76	1.02	1.03	1.02	1.02	1.02	0.97
39%	0.96	0.76	1.01	1.02	1.01	1.01	1.01	0.96
40%	0.96	0.76	1.00	1.02	1.01	1.01	1.00	0.96

41%	0.95	0.77	0.99	1.01	1.01	1.01	0.99	0.95
42%	0.95	0.77	0.99	1.01	1.01	1.01	0.99	0.95
43%	0.94	0.77	0.98	1.01	1.01	1.01	0.98	0.94
44%	0.94	0.78	0.97	1.00	1.01	1.01	0.97	0.94
45%	0.94	0.78	0.97	1.00	1.01	1.01	0.97	0.94
46%	0.94	0.78	0.96	0.99	1.01	1.01	0.96	0.94
47%	0.94	0.79	0.96	0.99	1.00	1.00	0.96	0.94
48%	0.93	0.79	0.96	0.98	1.00	1.00	0.96	0.93
49%	0.93	0.79	0.96	0.98	1.00	1.00	0.96	0.93
50%	0.93	0.80	0.96	0.98	1.00	1.00	0.96	0.93
51%	0.94	0.80	0.95	0.97	1.00	1.00	0.95	0.94
52%	0.94	0.81	0.95	0.97	1.00	1.00	0.95	0.94
53%	0.94	0.81	0.95	0.96	1.00	1.00	0.95	0.94
54%	0.94	0.82	0.95	0.96	1.00	1.00	0.95	0.94
55%	0.94	0.82	0.96	0.96	1.00	1.00	0.96	0.94
56%	0.94	0.83	0.96	0.95	1.00	1.00	0.96	0.94
57%	0.95	0.84	0.96	0.95	1.00	1.00	0.96	0.95
58%	0.95	0.84	0.96	0.95	1.00	1.00	0.96	0.95
59%	0.95	0.85	0.96	0.94	1.00	1.00	0.96	0.95
60%	0.95	0.86	0.97	0.94	0.99	0.99	0.97	0.95
61%	0.96	0.86	0.97	0.93	0.99	0.99	0.97	0.96
62%	0.96	0.87	0.97	0.93	0.99	0.99	0.97	0.96
63%	0.96	0.88	0.98	0.93	0.99	0.99	0.98	0.96
64%	0.97	0.89	0.98	0.93	0.99	0.99	0.98	0.97
65%	0.97	0.89	0.98	0.92	0.99	0.99	0.98	0.97
66%	0.98	0.90	0.99	0.92	0.99	0.99	0.99	0.98
67%	0.98	0.91	0.99	0.92	0.99	0.99	0.99	0.98
68%	0.98	0.92	0.99	0.91	0.99	0.99	0.99	0.98
69%	0.99	0.93	1.00	0.91	0.99	0.99	1.00	0.99
70%	0.99	0.94	1.00	0.91	0.99	0.99	1.00	0.99
71%	0.99	0.94	1.00	0.91	0.99	0.99	1.00	0.99
72%	1.00	0.95	1.01	0.91	0.99	0.99	1.01	1.00
73%	1.00	0.96	1.01	0.91	0.99	0.99	1.01	1.00
74%	1.00	0.97	1.01	0.91	0.99	0.99	1.01	1.00
75%	1.01	0.98	1.01	0.90	0.99	0.99	1.01	1.01
76%	1.01	0.99	1.01	0.90	0.99	0.99	1.01	1.01
77%	1.01	1.00	1.01	0.90	0.99	0.99	1.01	1.01
78%	1.01	1.01	1.01	0.91	0.99	0.99	1.01	1.01
79%	1.02	1.03	1.01	0.91	0.99	0.99	1.01	1.02
80%	1.02	1.04	1.01	0.91	0.99	0.99	1.01	1.02
81%	1.02	1.05	1.01	0.91	0.99	0.99	1.01	1.02
82%	1.02	1.06	1.01	0.91	0.99	0.99	1.01	1.02
83%	1.02	1.07	1.01	0.92	0.99	0.99	1.01	1.02
84%	1.02	1.08	1.00	0.92	0.99	0.99	1.00	1.02

85%	1.02	1.10	1.00	0.92	0.99	0.99	1.00	1.02
86%	1.02	1.11	0.99	0.93	0.99	0.99	0.99	1.02
87%	1.02	1.12	0.99	0.93	0.99	0.99	0.99	1.02
88%	1.02	1.13	0.98	0.94	0.99	0.99	0.98	1.02
89%	1.01	1.15	0.97	0.95	0.99	0.99	0.97	1.01
90%	1.01	1.16	0.97	0.95	0.99	0.99	0.97	1.01
91%	1.01	1.17	0.96	0.96	0.99	0.99	0.96	1.01
92%	1.00	1.19	0.94	0.97	0.99	0.99	0.94	1.00
93%	1.00	1.20	0.93	0.98	0.99	0.99	0.93	1.00
94%	0.99	1.22	0.92	0.99	0.99	0.99	0.92	0.99
95%	0.99	1.23	0.91	1.01	0.99	0.99	0.91	0.99
96%	0.98	1.24	0.89	1.02	0.99	0.99	0.89	0.98
97%	0.97	1.26	0.87	1.03	1.00	1.00	0.87	0.97
98%	0.97	1.28	0.86	1.05	1.00	1.00	0.86	0.97
99%	0.96	1.29	0.84	1.07	1.00	1.00	0.84	0.96
100%	0.95	1.31	0.82	1.08	1.00	1.00	0.82	0.95

TABLE A-7. EMISSION ADJUSTMENT FACTORS FOR MAN-B&W ENGINES WITH SLIDE VALVES

Load	NO_x	PM	ROG	CO	SO_2	CO_2	CH_4	N_2O
1%	1.90	0.36	1.36	0.12	1.10	1.10	1.36	1.90
2%	1.86	0.37	1.32	0.12	1.10	1.10	1.32	1.86
3%	1.82	0.38	1.28	0.12	1.09	1.09	1.28	1.82
4%	1.78	0.38	1.24	0.12	1.09	1.09	1.24	1.78
5%	1.74	0.39	1.20	0.12	1.09	1.09	1.20	1.74
6%	1.70	0.40	1.17	0.12	1.08	1.08	1.17	1.70
7%	1.67	0.41	1.14	0.12	1.08	1.08	1.14	1.67
8%	1.63	0.41	1.11	0.12	1.08	1.08	1.11	1.63
9%	1.60	0.42	1.08	0.12	1.07	1.07	1.08	1.60
10%	1.57	0.43	1.05	0.12	1.07	1.07	1.05	1.57
11%	1.53	0.44	1.02	0.26	1.07	1.07	1.02	1.53
12%	1.50	0.45	0.99	0.39	1.07	1.07	0.99	1.50
13%	1.47	0.45	0.97	0.52	1.06	1.06	0.97	1.47
14%	1.45	0.46	0.94	0.64	1.06	1.06	0.94	1.45
15%	1.42	0.47	0.92	0.75	1.06	1.06	0.92	1.42
16%	1.39	0.48	0.90	0.85	1.06	1.06	0.90	1.39
17%	1.37	0.49	0.88	0.95	1.05	1.05	0.88	1.37
18%	1.34	0.49	0.86	1.04	1.05	1.05	0.86	1.34
19%	1.32	0.50	0.84	1.12	1.05	1.05	0.84	1.32
20%	1.30	0.51	0.82	1.20	1.05	1.05	0.82	1.30
21%	1.28	0.52	0.81	1.27	1.04	1.04	0.81	1.28
22%	1.26	0.53	0.79	1.34	1.04	1.04	0.79	1.26
23%	1.24	0.54	0.78	1.40	1.04	1.04	0.78	1.24
24%	1.22	0.54	0.76	1.46	1.04	1.04	0.76	1.22
25%	1.20	0.55	0.75	1.51	1.03	1.03	0.75	1.20
26%	1.19	0.56	0.74	1.55	1.03	1.03	0.74	1.19
27%	1.17	0.57	0.73	1.59	1.03	1.03	0.73	1.17
28%	1.16	0.58	0.72	1.63	1.03	1.03	0.72	1.16
29%	1.14	0.59	0.71	1.66	1.03	1.03	0.71	1.14
30%	1.13	0.60	0.70	1.68	1.02	1.02	0.70	1.13
31%	1.12	0.60	0.70	1.70	1.02	1.02	0.70	1.12
32%	1.10	0.61	0.69	1.72	1.02	1.02	0.69	1.10
33%	1.09	0.62	0.69	1.74	1.02	1.02	0.69	1.09
34%	1.08	0.63	0.68	1.75	1.02	1.02	0.68	1.08
35%	1.07	0.64	0.68	1.75	1.02	1.02	0.68	1.07
36%	1.06	0.65	0.68	1.75	1.01	1.01	0.68	1.06
37%	1.05	0.66	0.67	1.75	1.01	1.01	0.67	1.05
38%	1.05	0.67	0.67	1.75	1.01	1.01	0.67	1.05
39%	1.04	0.68	0.67	1.74	1.01	1.01	0.67	1.04
40%	1.03	0.69	0.67	1.73	1.01	1.01	0.67	1.03

41%	1.03	0.70	0.67	1.72	1.01	1.01	0.67	1.03
42%	1.02	0.70	0.68	1.71	1.01	1.01	0.68	1.02
43%	1.02	0.71	0.68	1.69	1.01	1.01	0.68	1.02
44%	1.01	0.72	0.68	1.67	1.00	1.00	0.68	1.01
45%	1.01	0.73	0.69	1.65	1.00	1.00	0.69	1.01
46%	1.00	0.74	0.69	1.62	1.00	1.00	0.69	1.00
47%	1.00	0.75	0.70	1.60	1.00	1.00	0.70	1.00
48%	1.00	0.76	0.70	1.57	1.00	1.00	0.70	1.00
49%	0.99	0.77	0.71	1.54	1.00	1.00	0.71	0.99
50%	0.99	0.78	0.71	1.51	1.00	1.00	0.71	0.99
51%	0.99	0.79	0.72	1.48	1.00	1.00	0.72	0.99
52%	0.99	0.80	0.73	1.45	1.00	1.00	0.73	0.99
53%	0.99	0.81	0.74	1.41	1.00	1.00	0.74	0.99
54%	0.99	0.82	0.75	1.38	1.00	1.00	0.75	0.99
55%	0.98	0.83	0.75	1.35	0.99	0.99	0.75	0.98
56%	0.98	0.84	0.76	1.31	0.99	0.99	0.76	0.98
57%	0.98	0.85	0.77	1.27	0.99	0.99	0.77	0.98
58%	0.98	0.86	0.78	1.24	0.99	0.99	0.78	0.98
59%	0.98	0.87	0.80	1.20	0.99	0.99	0.80	0.98
60%	0.98	0.88	0.81	1.16	0.99	0.99	0.81	0.98
61%	0.98	0.89	0.82	1.13	0.99	0.99	0.82	0.98
62%	0.98	0.90	0.83	1.09	0.99	0.99	0.83	0.98
63%	0.99	0.91	0.84	1.06	0.99	0.99	0.84	0.99
64%	0.99	0.92	0.85	1.02	0.99	0.99	0.85	0.99
65%	0.99	0.93	0.87	0.98	0.99	0.99	0.87	0.99
66%	0.99	0.94	0.88	0.95	0.99	0.99	0.88	0.99
67%	0.99	0.95	0.89	0.92	0.99	0.99	0.89	0.99
68%	0.99	0.97	0.91	0.88	0.99	0.99	0.91	0.99
69%	0.99	0.98	0.92	0.85	0.99	0.99	0.92	0.99
70%	0.99	0.99	0.93	0.82	0.99	0.99	0.93	0.99
71%	0.99	1.00	0.95	0.79	0.99	0.99	0.95	0.99
72%	0.99	1.01	0.96	0.76	0.99	0.99	0.96	0.99
73%	0.99	1.02	0.98	0.74	0.99	0.99	0.98	0.99
74%	0.99	1.03	0.99	0.71	0.99	0.99	0.99	0.99
75%	0.99	1.04	1.00	0.69	0.99	0.99	1.00	0.99
76%	0.99	1.05	1.02	0.66	0.99	0.99	1.02	0.99
77%	0.99	1.06	1.03	0.64	0.99	0.99	1.03	0.99
78%	0.99	1.07	1.05	0.63	0.99	0.99	1.05	0.99
79%	0.99	1.09	1.06	0.61	0.99	0.99	1.06	0.99
80%	0.99	1.10	1.08	0.60	0.99	0.99	1.08	0.99
81%	0.99	1.11	1.09	0.58	0.99	0.99	1.09	0.99
82%	0.99	1.12	1.10	0.57	0.99	0.99	1.10	0.99
83%	0.98	1.13	1.12	0.57	0.99	0.99	1.12	0.98
84%	0.98	1.14	1.13	0.56	0.99	0.99	1.13	0.98
85%	0.98	1.15	1.15	0.56	0.99	0.99	1.15	0.98

86%	0.98	1.16	1.16	0.56	0.99	0.99	1.16	0.98
87%	0.97	1.18	1.18	0.56	0.99	0.99	1.18	0.97
88%	0.97	1.19	1.19	0.57	0.99	0.99	1.19	0.97
89%	0.96	1.20	1.20	0.58	0.99	0.99	1.20	0.96
90%	0.96	1.21	1.22	0.59	0.99	0.99	1.22	0.96
91%	0.95	1.22	1.23	0.61	1.00	1.00	1.23	0.95
92%	0.95	1.23	1.24	0.63	1.00	1.00	1.24	0.95
93%	0.94	1.25	1.25	0.65	1.00	1.00	1.25	0.94
94%	0.93	1.26	1.27	0.67	1.00	1.00	1.27	0.93
95%	0.93	1.27	1.28	0.70	1.00	1.00	1.28	0.93
96%	0.92	1.28	1.29	0.73	1.00	1.00	1.29	0.92
97%	0.91	1.29	1.30	0.77	1.00	1.00	1.30	0.91
98%	0.90	1.31	1.31	0.81	1.00	1.00	1.31	0.90
99%	0.89	1.32	1.32	0.85	1.00	1.00	1.32	0.89
100%	0.88	1.33	1.34	0.90	1.00	1.00	1.34	0.88

In addition, MAN-B&W S50, S60, and S70 engines, produced between 1990 and 1999, would also have slide valves due to Under the EPA retrofit rule,[7] Tier 0 engines built between 1990 and 1999 with at least 90 liters per cylinder and 5000 kW must be rebuilt to Tier 1 standards if retrofit kits are available. MAN-B&W built retrofit kits for their S50MC, S60MC, S70MC and . L50MC engines using slide valves.[8] Therefore, those engines built between 1990 and 1999 should be Tier 1 and use the slide valve EAFs. However, because auxiliary engines on those vessels would be less than 90 liters per cylinder, they would still be Tier 0.

Finally, emission adjustment factors are not applied to diesel or gas turbine electric drive systems or auxiliary engines. In these cases, several engines are used to generate power and some can be shut down to allow others to operate at a more efficient setting.

4.3 PROPULSION EMISSION FACTORS

Emission Factors for auxiliary engines and boilers are shown in Table A-8. Again, these emission factors are based on the 2014 Port of Long Beach inventory. For passenger ships, the propulsion engine load factor was used for all calculations as engines on passenger ships are Category 3 engines.

TABLE A-8. AUXILIARY ENGINE AND BOILER EMISSION FACTORS

ENGINE TYPE	TIER	MODEL YEARS	AUXILIARY ENGINE AND BOILER EMISSION FACTORS (G/KWH)									
			NO_x	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2	CH_4	N_2O
Auxiliary	0	Pre-2000	13.8	0.26	0.26	0.24	0.51	1.10	0.50	686	0.008	0.029
	1	2000 – 2010	12.2	0.26	0.26	0.24	0.51	1.10	0.50	686	0.008	0.029
	2	2011-2015	10.5	0.26	0.26	0.24	0.51	1.10	0.50	686	0.008	0.029
	3	2016+	2.6	0.26	0.26	0.24	0.51	1.10	0.50	686	0.008	0.029
Boiler	All	All	2.0	0.00	0.14	0.13	0.13	0.2	0.60	922	0.002	0.075

[7] U.S. Environmental Protection Agency, *Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder*, Federal Register, Vol. 73, No. 126, June 30, 2008.
Available at https://www.gpo.gov/fdsys/pkg/FR-2010-04-30/pdf/2010-2534.pdf.
[8] U.S. Environmental Protection Agency, Control of Emissions of Air Pollution From Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder, Federal Register, Vol. 73, No. 126, June 30, 2008.
Available at https://www.gpo.gov/fdsys/pkg/FR-2010-04-30/pdf/2010-2534.pdf.

5 ACTIVITY

Average speed and distance traveled are determined from the AIS data while the vessel is in the VSR Zone. Times and distances calculated using AIS data is determined for each vessel entrance (inbound) and clearance (outbound). Reported speeds below 1 knot are considered stopped and not included in the entrance or clearance sum of time and distance.

AIS-equipped vessels periodically send out AIS signals, the frequency of which is based on the vessel's speed. These signals include the vessel's current speed and position, among other data points. The speed in knots for each position will be called "A", and the time in seconds between each position will be called "B". While in the VSR, the vessel's speed in knots is multiplied by the time in seconds between the current and previous positions. The resulting value is called "X". Next, the sum of the time in seconds between each position and the previous position for all positions in the data set are taken. This value is called "Y". Finally, the sum of all "X" values in the data set are taken. This value is called "Z". The Weighted Average Speed is then calculated by dividing "Z" by "Y".

$$\frac{(A * B) + (A * B) + (A * B) + (A * B) + (A * B) = Z}{B + B + B + B + B = Y} = \textit{Weighted Average Speed}$$

Emission benefits were calculated for all vessels on an entrance and clearance basis. For vessels where no AIS data was available, average speed was assumed to be 12 knots for cargo ships and 15 knots for cruise ships. Average speeds below or equal to 12 knots for cargo ships and 15 knots for cruise are considered within the bounds of the program. Table A-9 shows the compliance rates by ship type within the 40-nm zone in 2019. It should be noted that only auto carriers were required to meet the 12 knot requirement for the 40 nm VSR in 2019.

TABLE A-9. VSR COMPLIANCE RATES

SHIP TYPE	COMPLIANCE RATE
Auto Carrier	47%
Bulk Carrier	88%
Container	39%
General Cargo	80%
Passenger	62%
RoRo	50%
Total	52%

II. EMISSION ESTIMATES

Emission estimates are calculated for those trips (either an entrance or a clearance) which complied with the VSR requirements. The emission savings are calculated as the difference between the vessel moving through the VSR Zone at service speed (time is adjusted by to be the distance traveled divided by service speed) and the same vessel moving through the VSR Zone at the average speed determined. Table A-10 shows the savings by ship type for 2019 in the 40-nm VSR zone.

TABLE A-10. VSR EMISSION DIFFERENCES IN 2019

SHIP TYPE	SAVING (TONS)							
	NO_x	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_{2E}
Auto Carrier	87.17	2.34	2.36	2.18	5.02	4.00	3.09	3,807
Bulk Carrier	1.71	0.06	0.06	0.06	0.08	0.04	-0.10	88
Container	22.71	0.85	0.86	0.79	2.03	0.67	0.69	1,192
General Cargo	4.70	0.17	0.17	0.15	-0.87	0.14	-1.04	242
Passenger	98.33	2.01	2.02	1.86	5.90	8.52	3.67	5,221
RoRo	0.46	0.01	0.01	0.01	-0.09	0.04	-0.32	16
Total	215.08	5.45	5.47	5.05	12.08	13.42	5.98	10,566

When the program is completely implemented, emission reductions shown in Table A-11 should be realized.

TABLE A-11. VSR EMISSION DIFFERENCES FOR VSR PROGRAM UPDATE (BASED ON 2019 VESSEL DATA)

SHIP TYPE	SAVING (TONS)							
	NO_x	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_{2E}
Auto Carrier	104.6	1.9	1.9	1.7	5.4	6.8	2.6	3,821
Bulk Carrier	0.5	<0.0	<0.0	<0.0	<0.0	<0.0	<0.0	16
Container	1.4	0.0	0.0	0.0	0.1	0.1	0.0	54
General Cargo	28.5	0.6	0.6	0.5	1.7	1.5	0.8	1,137
Passenger	4.5	0.1	0.1	0.1	0.3	0.3	0.1	191
RoRo	86.1	1.8	1.8	1.6	4.3	7.5	2.8	4,578
Total	225.5	4.3	4.3	4.0	11.8	16.2	6.3	9,791

APPENDIX B
VESSEL SPEED REDUCTION PROGRAM BENEFITS

PORT of SAN DIEGO
Environment

CONTENTS

TABLES

I. EMISSIONS REDUCTION ESTIMATE

1 EMISSION SCENARIOS

To understand the benefit of reducing speeds within the VSR Zone, the Port's 2019 vessel call data was used. Table B-1 below summarizes the OGVs and total calls for 2019, which were used to analyze benefits of the VSR Program.

TABLE B-1. OCEAN GOING VESSEL CALLS AT POSD IN 2019

Vessel Type	Calls in 2019
Auto Carrier	243
Bulk Carrier	8
Container Ship	52
General Cargo	23
Passenger Ships	97
RoRo	1
Total	*424*

OGV emissions are generally calculated by using energy-based emission factors together with activity profiles for each vessel. These emission factors were applied to the OGV trips to and from the Port's cruise and marine terminals for 90% of vessels observing the VSR speeds and 10% operating at the service speed within 40-nm of Point Loma.

The total emissions from vessels traveling at the service speed within the VSR Zone is outlined in Table B-2 below. The emissions from vessels participating in the VSR program at 90% compliance are outlined in Table B-3.

TABLE B-2. TOTAL VESSEL EMISSIONS AT SERVICE SPEED WITHIN THE 40 NM VSR ZONE (TONS PER YEAR)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
Auto Carrier	206.0	3.7	3.7	3.5	10.5	13.9	5.5	8,101
Bulk Carrier	5.0	0.1	0.1	0.1	0.3	0.3	0.1	207
Container Ship	56.1	1.2	1.2	1.1	3.3	3.3	1.6	2,418
General Cargo	13.4	0.3	0.3	0.2	0.7	0.9	0.4	582
Passenger	287.9	5.9	5.9	5.4	14.4	25.0	9.4	15,257
RoRo	1.0	0.0	0.0	0.0	0.0	0.1	0.0	35
Total	569.5	11.2	11.2	10.3	29.3	43.5	17.0	26,598

TABLE B-3. TOTAL VESSEL EMISSIONS AT 90% COMPLIANCE WITH VSR SPEEDS WITHIN THE 40 NM VSR ZONE (TONS PER YEAR)

Vessel Type	Saving (tons)							
	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
Auto Carrier	104.6	1.9	1.9	1.7	5.4	6.8	2.6	3,821
RoRo	0.5	<0.0	<0.0	<0.0	<0.0	<0.0	<0.0	16
Bulk Carrier	1.4	0.0	0.0	0.0	0.1	0.1	0.0	54
Container	28.5	0.6	0.6	0.5	1.7	1.5	0.8	1,137
General Cargo	4.5	0.1	0.1	0.1	0.3	0.3	0.1	191
Passenger	86.1	1.8	1.8	1.6	4.3	7.5	2.8	4,578
Total	225.5	4.3	4.3	4.0	11.8	16.2	6.3	9,791

2 CALCULATING EMISSION REDUCTIONS FROM THE VSR PROGRAM

To understand the impact of the VSR Program on emissions of criteria pollutants and GHGs, emission reductions were calculated as the difference between all vessels operating at the service speed within the 40 nm VSR Zone, and vessels meeting the designated 90% VSR compliance of 12 knots for cargo vessels and 15 knots for passenger vessels through the 40 nm VSR Zone.

2.1 PROPULSION EMISSION FACTORS

The impact of 90% of vessels complying with the VSR Program within the VSR Zone is summarized in Tables B-4, B-5, and B-6 below. Table B-4 shows annual emission reduction totals, Table B-5 shows the reductions per leg of vessel trip into Port cruise and marine terminals, and Table B-6 shows the emission reductions per nautical mile (nm).

TABLE B-4. TOTAL EMISSION REDUCTIONS WITH 90% VSR COMPLIANCE WITHIN 40-NM OF POINT LOMA (TONS PER YEAR)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
Auto Carrier	104.6	1.9	1.9	1.7	5.4	6.8	2.6	3,821
Bulk Carrier	1.4	0.0	0.0	0.0	0.1	0.1	0.0	54
Container Ship	28.5	0.6	0.6	0.5	1.7	1.5	0.8	1,137
General Cargo	4.5	0.1	0.1	0.1	0.3	0.3	0.1	191
Passenger	86.1	1.8	1.8	1.6	4.3	7.5	2.8	4,578
RoRo	0.5	0.0	0.0	0.0	0.0	0.0	0.0	16
Total	225.6	4.4	4.4	3.9	11.8	16.2	6.3	9,797

TABLE B-5. EMISSION REDUCTIONS PER LEG WITH 90% VSR COMPLIANCE WITHIN 40-NM OF POINT LOMA (LBS PER LEG)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
Auto Carrier	430.5	7.6	7.6	7.0	22.4	27.8	10.5	15,724
Bulk Carrier	168.9	3.3	3.3	3.0	9.6	10.8	4.5	6,757
Container Ship	547.3	11.1	11.1	10.2	32.4	29.2	14.6	21,860
General Cargo	197.3	3.9	3.9	3.6	10.9	12.3	5.4	8,287
Passenger	1062.7	21.8	21.8	20.1	53.3	92.4	34.5	56,269
RoRo	461.4	7.0	7.0	6.4	20.8	38.1	10.5	15,691
Average Reduction[a]	571.9	11.0	11.0	10.1	29.8	41.6	16.1	25,179

[a]*Average reduction is weighted by total number of vessel calls for each vessel type.*

TABLE B-6. EMISSION REDUCTIONS PER NAUTICAL MILE WITH 90% VSR COMPLIANCE WITHIN 40-NM OF POINT LOMA (LBS PER NM)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
Auto Carrier	10.8	0.2	0.2	0.2	0.6	0.7	0.3	393
Bulk Carrier	4.2	0.1	0.1	0.1	0.2	0.3	0.1	169
Container Ship	13.7	0.3	0.3	0.3	0.8	0.7	0.4	547
General Cargo	4.9	0.1	0.1	0.1	0.3	0.3	0.1	207
Passenger	26.6	0.5	0.5	0.5	1.3	2.3	0.9	1,407
RoRo	11.5	0.2	0.2	0.2	0.5	1.0	0.3	392
Average Reduction[a]	14.3	0.3	0.3	0.3	0.7	1.0	0.4	629

[a]*Average reduction is weighted by total number of vessel calls for each vessel type.*

II. FUEL SAVINGS

One benefit to participation in the VSR Program is the fuel savings from lowering vessel speeds. This benefit can be presented as total weight or volume, or as total cost savings on the purchase of fuel. Both benefits were calculated here. Methodology and results for these calculations are presented below.

1 TOTAL FUEL SAVINGS

Total fuel used by each vessel was calculated from their total CO2 emissions using the following equation: Fuel rate (g/kWh) = CO2 emission factor (g/kWh) x ratio of molecular weights for carbon and CO2 (12/44) divided by the carbon weight fraction of the fuel (86.7%).

This equation results in 3.179 g CO2 per g of fuel. Thus, total CO2 emissions in grams are divided by 3.179 to obtain the grams of fuel. There are 1,000,000 grams in a metric tonne. Marine diesel oil has a density of 4.39 kg/gallon.[1]

Total fuel consumption was calculated for vessels at service speed and at VSR compliance and speed. Fuel consumption for vessels operating at service speed through the VSR Zone is summarized in Table B-7 below. Total fuel is provided in gallons and metric tonnes (MT). Operators of OGVs generally buy fuel by the MT because of the large quantities necessary.

TABLE B-7. TOTAL FUEL USED BY VESSELS TRAVELING AT THE SERVICE SPEED THROUGH THE 40 NM VSR ZONE

Vessel Type	Total Fuel (MT)	Total Fuel (gallons)
Auto Carrier	2,312	526,582
Bulk Carrier	59	13,469
Container Ship	690	157,178
General Cargo	166	37,803
Passenger	4,354	991,752
RoRo	10	2,243
Total	*7,590*	*1,729,027*

Fuel consumption for vessels operating at the VSR compliance and speed through the VSR Zone is summarized in Table B-8 below.

TABLE B-8. TOTAL FUEL USED BY VESSELS OPERATING AT 90% VSR COMPLIANCE THROUGH THE 40 NM VSR ZONE

Vessel Type	Total Fuel (MT)	Total Fuel (gallons)
Auto Carrier	1,221	278,206
Bulk Carrier	44	9,954
Container Ship	366	83,284
General Cargo	112	25,413
Passenger	3,409	694,513
RoRo	5	1,223
Total	*4,796*	*1,092,593*

[1] Chevron Global Marine Products. 2012. Everything You Need to Know About Marine Fuels. June. Available: https://www.chevronmarineproducts.com/content/dam/chevron-marine/fuels-brochure/Chevron_Everything%20You%20Need%20To%20Know%20About%20Fuels%20v3_1a_2012.pdf. Accessed December 2020

To understand the impact of VSR on total fuel use, fuel reductions were calculated as the difference between fuel use of all vessels operating at the service speed within the VSR Zone, and fuel use of vessels meeting the designated VSR compliance and speed through the VSR Zone. The total fuel savings for 90% compliance within the 40-nm VSR Zone is summarized in Table B-9.

TABLE B-9. ANNUAL FUEL SAVINGS WITH THE VSR PROGRAM

Vessel Type	Total Fuel Savings (MT)	Total Fuel (gallons)
Auto Carrier	1,090	248,376
Bulk Carrier	15	3,514
Container Ship	324	73,894
General Cargo	54	12,390
Passenger	1,305	297,240
RoRo	*4*	*1,020*
Total Savings	*2,794*	*636,434*

2 TOTAL COST SAVINGS

The fuel reductions were also used to understand the monetary benefit associated with the VSR Program. Fuel cost per MT factors were applied to the reduction values in Table B-9 above to estimate the total cost savings associated with compliance with the VSR Program. Fuel cost was obtained from Ship and Bunker Average Bunker Prices in November 2020, which assumes $386 per MT[2]. Fuel cost savings from participation in the VSR Program at the 90% compliance rate are outlined in Table B-10.

TABLE B-10. TOTAL FUEL COST SAVINGS ASSOCIATED WITH VSR PROGRAM

Vessel Type	Total Cost Savings
Auto Carrier	$420,883
Bulk Carrier	$5,955
Container Ship	$125,216
General Cargo	$20,996
Passenger	$503,685
RoRo	*$1,728*
Total Savings	*$1,078,463*

[2] Ship and Bunker. 2020. Regional Average Bunker Prices. Available: https://shipandbunker.com/prices/av/ Accessed November 17, 2020.

APPENDIX C
VESSEL SPEED REDUCTION PROGRAM OLD AND NEW GUIDELINES COMPARISON

PORT of SAN DIEGO
Environment

CONTENTS

TABLES

I. INTRODUCTION

To understand the benefit of reducing speeds within the VSR Zone, the Port's 2019 vessel call data was used. Table B-1 below summarizes the OGVs and total calls for 2019, which were used to analyze benefits of the VSR Program.
In 2009, the Port established a voluntary Vessel Speed Reduction (VSR) Program (2009 VSR Program) that encouraged oceangoing vessels to lower their speeds within 20 nm from Point Loma. The 2009 VSR Program targeted an 80% compliance rate and was adopted by Board Resolution. VSR has also been employed as both a method of Air Quality and GHG mitigation across the Port. Environmental documents for the National City and Tenth Avenue Marine Terminals, both certified in 2016, relied on VSR requirements to help reduce emissions associated with OGV's, as part of their overall mitigation, monitoring and reporting programs (MMRPs). Overall compliance with the 12-knot weighted average speed limit for 20 nautical miles exceeded an 80% compliance rate at both terminals from 2017 to present (September 2020), as required in the mitigation measures

The updated VSR Program builds upon and expands the previous program in three important ways:

- Expands the geographic boundary of the VSR Zone from 20 nm to 40 nm from Point Loma;
- Increases the requested annual participation rate from 80% to 90%; and
- Addressed underwater noise issues.

The 2009 VSR Program was a strategy of both the Port's 2009 Clean Air Program and its 2013 Climate Action Plan (CAP), which targeted 80% compliance with the VSR Program. With this update, the Port is enhancing the 2009 VSR Program to achieve additional emission reductions beyond past targets. The impact of updating the VSR Program to its current format from the original 2009 strategy is discussed below.

II. EMISSION REDUCTION ESTIMATE

1 EMISSION SCENARIOS

To understand the benefit of expanding the VSR Zone and requested participation rate, potential emission reduction benefits were calculated based on the Port's 2019 vessel call data. As described in further detail in Appendix A, OGV emissions were calculated by using energy-based emission factors with activity profiles for each vessel. The emission factors were applied to the OGV trips to and from the Port's cruise and marine terminals for the following four scenarios:

- All vessels operating at the service speed within the 20 nm VSR zone;
- All vessels operating at the service speed within the 40 nm VSR zone;
- 80% of vessels observing the VSR speeds and 20% of vessels operating at the service speed within 20 nm of Point Loma (2009 VSR Program)
- 90% of vessels observing the VSR speeds and 10% of vessels operating at the service speed within 40 nm of Point Loma (VSR Program Update)

The total emissions from vessels traveling at the service speed within the VSR zones are outlined in Table C-1 below. The emissions from vessels participating in the VSR program at 80% compliance and 90% compliance are outlined in Table C-2. Emissions are based on the Port's 2019 vessel call data.

TABLE C-1. TOTAL VESSEL EMISSIONS AT SERVICE SPEED WITHIN THE VSR ZONE (TONS PER YEAR)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
20-nm VSR Zone								
Auto Carrier	103.0	1.9	1.9	1.7	5.3	7.0	2.7	4,050
Bulk Carrier	2.5	>0.1	>0.1	>0.1	0.1	0.2	0.1	104
Container Ship	28.1	0.6	0.6	0.5	1.6	1.6	0.8	1,209
General Cargo	6.7	0.1	0.1	0.1	0.4	0.4	0.2	291
Passenger	144.0	2.9	3.0	2.7	7.2	12.5	4.7	7,628
RoRo	0.5	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	17
Total	*285*	*6*	*6*	*5*	*15*	*22*	*9*	*13,299*
40-nm VSR Zone								
Auto Carrier	206.0	3.7	3.7	3.5	10.5	13.9	5.5	8,101
Bulk Carrier	5.0	0.1	0.1	0.1	0.3	0.3	0.1	207
Container Ship	56.1	1.2	1.2	1.1	3.3	3.3	1.6	2,418
General Cargo	13.4	0.3	0.3	0.2	0.7	0.9	0.4	582
Passenger	287.9	5.9	5.9	5.4	14.4	25.0	9.4	15,257
RoRo	1.0	>0.1	>0.1	>0.1	>0.1	0.1	0.0	35
Total	*569*	*11*	*11*	*10*	*29*	*44*	*17*	*26,598*

TABLE C-2. TOTAL VESSEL EMISSIONS AT VSR SPEEDS WITHIN THE VSR ZONE (TONS PER YEAR)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
20-nm VSR Zone								
Auto Carrier	44.9	0.8	0.8	0.8	2.2	3.2	1.3	1,928
Bulk Carrier	1.8	>0.1	>0.1	>0.1	0.1	0.1	>0.1	74
Container Ship	12.3	0.3	0.3	0.2	0.7	0.8	0.4	577
General Cargo	4.2	0.1	0.1	0.1	0.2	0.3	0.1	185
Passenger	96.1	2.0	2.0	1.8	4.8	8.4	3.1	5,088
RoRo	0.2	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	9
Total	*159*	*3*	*3*	*3*	*8*	*13*	*5*	*7,860*
40-nm VSR Zone								
Auto Carrier	89.7	1.7	1.7	1.6	4.5	6.4	2.6	3,855
Bulk Carrier	3.5	0.1	0.1	0.1	0.2	0.2	0.1	147
Container Ship	24.5	0.5	0.5	0.5	1.4	1.6	0.8	1,155
General Cargo	8.4	0.2	0.2	0.2	0.5	0.6	0.2	370
Passenger	192.3	3.9	3.9	3.6	3.6	16.7	6.3	9,192
RoRo	0.5	>0.1	>0.1	>0.1	>0.1	>0.1	>0.1	17
Total	*319*	*6*	*6*	*6*	*16*	*26*	*10*	*15,720*

2 EMISSION REDUCTION COMPARISON OF THE OLD AND NEW VSR SCENARIOS

The impact of the VSR Program on emissions of criteria pollutants and GHGs is presented as emission reductions achieved when vessels go from operating at the service speed within the VSR zones to meeting the designated VSR compliance and speed through the VSR zones. To understand the benefit of updating the VSR program requirements, emission reductions from 80% of vessels complying with the VSR Program within the 20-nm zone are presented together with the reductions achieved from 90% of vessels complying with the VSR program within the 40-nm zone. Emissions are presented as total annual reductions, reductions achieved per leg (entrance and clearance), and reductions achieved per nautical mile (nm) in Tables C-3, C-4, and C-5, respectively.

TABLE C-3. TOTAL ANNUAL EMISSION REDUCTIONS UNDER OLD AND NEW VSR PROGRAM SCENARIOS (TONS PER YEAR)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
80% Compliance within the 20-nm VSR Zone								
Auto Carrier	46.5	0.8	0.8	0.8	2.4	3.0	1.1	1,698
Bulk Carrier	0.6	0.0	0.0	0.0	0.0	0.0	0.0	24
Container Ship	12.6	0.3	0.3	0.2	0.7	0.7	0.3	505
General Cargo	2.0	0.0	0.0	0.0	0.1	0.1	0.1	85
Passenger	38.3	0.8	0.8	0.7	1.9	3.3	1.2	2,032
RoRo	0.2	0.0	0.0	0.0	0.0	0.0	0.0	7
Total Reductions	*100.2*	*1.9*	*1.9*	*1.8*	*5.2*	*7.2*	*2.8*	*4,351*
90% Compliance within the 40-nm VSR Zone								
Auto Carrier	104.6	1.9	1.9	1.7	5.4	6.8	2.6	3,821
Bulk Carrier	1.4	0.0	0.0	0.0	0.1	0.1	0.0	54
Container Ship	28.5	0.6	0.6	0.5	1.7	1.5	0.8	1,137
General Cargo	4.5	0.1	0.1	0.1	0.3	0.3	0.1	191
Passenger	86.1	1.8	1.8	1.6	4.3	7.5	2.8	4573
RoRo	0.5	0.0	0.0	0.0	0.0	0.0	0.0	16
Total Reductions	*225.5*	*4.3*	*4.3*	*4.0*	*11.8*	*16.2*	*6.3*	*9.791*

TABLE C-4. EMISSION REDUCTIONS PER LEG UNDER OLD AND NEW VSR PROGRAM SCENARIOS (LBS/LEG)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
80% Compliance within the 20-nm VSR Zone								
Auto Carrier	191.3	3.4	3.4	3.1	10.0	12.4	4.7	6,988
Bulk Carrier	75.0	1.5	1.5	1.3	4.2	4.8	2.0	3,003
Container Ship	243.2	4.9	4.9	4.5	14.4	13.0	6.5	9,716
General Cargo	87.7	1.7	1.7	1.6	4.9	5.5	2.4	3,683
Passenger	394.5	8.1	8.1	7.5	19.8	34.3	12.9	20,951
RoRo	205.1	3.1	3.1	2.9	9.3	16.9	4.7	6,974
Average Reductions[a]	*236.4*	*4.5*	*4.5*	*4.2*	*12.4*	*17.0*	*6.6*	*10,263*
90% Compliance within the 40-nm VSR Zone								
Auto Carrier	430.5	7.6	7.6	7.0	22.4	27.8	10.5	15,724
Bulk Carrier	168.9	3.3	3.3	3.0	9.6	10.8	4.5	6,757
Container Ship	547.3	11.1	11.1	10.2	32.4	29.2	14.6	21,860
General Cargo	197.3	3.9	3.9	3.6	10.9	12.3	5.4	8,287
Passenger	887.7	18.2	18.2	16.8	44.5	77.2	28.9	47,140
RoRo	461.4	7.0	7.0	6.4	20.8	38.1	10.5	15,691
Average Reductions[a]	*531.9*	*10.2*	*10.2*	*9.4*	*27.2*	*38.2*	*14.8*	*23,091*
[a]Average reductions weighted by total calls for each vessel type.								

TABLE C-5. EMISSION REDUCTIONS PER NAUTICAL MILE UNDER OLD AND NEW VSR PROGRAM SCENARIOS (LBS/NM)

Vessel Type	NOx	DPM	PM10	PM2.5	ROG	CO	SO_2	CO_2e
80% Compliance within the 20-nm VSR Zone								
Auto Carrier	9.6	0.2	0.2	0.2	0.5	0.6	0.2	349
Bulk Carrier	3.8	0.1	0.1	0.1	0.2	0.2	0.1	150
Container Ship	12.2	0.2	0.2	0.2	0.7	0.6	0.3	485
General Cargo	4.4	0.1	0.1	0.1	0.2	0.3	0.1	184
Passenger	19.7	0.4	0.4	0.4	1.0	1.7	0.6	1,047
RoRo	10.3	0.2	0.2	0.1	0.5	0.8	0.2	348
Average Reductions[a]	*11.8*	*0.2*	*0.2*	*0.2*	*0.6*	*0.8*	*0.3*	*513*
90% Compliance within the 40-nm VSR Zone								
Auto Carrier	10.8	0.2	0.2	0.2	0.6	0.7	0.3	393.1
Bulk Carrier	4.2	0.1	0.1	0.1	0.2	0.3	0.1	168.9
Container Ship	13.7	0.3	0.3	0.3	0.8	0.7	0.4	546.5
General Cargo	4.9	0.1	0.1	0.1	0.3	0.3	0.1	207.2
Passenger	22.2	0.5	0.5	0.4	1.1	1.9	0.7	1178
RoRo	11.5	0.2	0.2	0.2	0.5	1.0	0.3	392.3
Average Reductions[a]	*13.3*	*0.3*	*0.3*	*0.2*	*0.7*	*1.0*	*0.4*	*577*

[a]Average reductions weighted by total calls for each vessel type.

III. FUEL SAVINGS

1 TOTAL FUEL SAVINGS

One benefit to updating the VSR Program is the fuel savings from potentially more vessels (80% to 90% compliance) lowering their speeds for longer distance (20 nm to 40 nm). This benefit can be presented as total weight or volume, or as total cost savings on the purchase of fuel. Both benefits were calculated here. Methodology for these calculations are described in Appendix B.

TABLE C-6. TOTAL FUEL USED BY VESSELS TRAVELING AT THE SERVICE SPEED THROUGH THE VSR ZONES

Vessel Type	Total Fuel (MT)	Total Fuel (gallons)
20-nm VSR Zone		
Auto Carrier	1,156	263,291
Bulk Carrier	30	6,734
Container Ship	345	78,589
General Cargo	83	18,902
Passenger	2,177	495,876
RoRo	5	1,121
Total	*3,795*	*864,514*
40-nm VSR Zone		
Auto Carrier	2,312	526,582
Bulk Carrier	59	13,469
Container Ship	690	157,178
General Cargo	166	37,803
Passenger	4,354	991,752
RoRo	10	2,243
Total	*7,590*	*1,729,027*

Total fuel consumption for vessels operating at the old and new VSR compliance rates and speeds through the VSR zones is summarized in Table C-7 below.

TABLE C-7. TOTAL FUEL USED BY VESSELS COMPLYING WITH VSR SPEED REQUIREMENTS

Vessel Type	Total Fuel (MT)	Total Fuel (gallons)
80% Compliance, 20-nm VSR Zone		
Auto Carrier	671	152,902
Bulk Carrier	23	5,172
Container Ship	201	45,747
General Cargo	59	13,395
Passenger	1,597	363,770
RoRo	3	668
Total	*2,553*	*581,654*
90% Compliance, 40-nm VSR Zone		
Auto Carrier	1,221	278,206
Bulk Carrier	44	9,954
Container Ship	366	83,284
General Cargo	112	25,413
Passenger	3,409	694,513
RoRo	5	1,223
Total	*4,796*	*1,092,593*

To understand the impact of VSR program updates on total fuel use, fuel reductions were calculated as the difference between fuel use of vessels operating at the service speed within the VSR Zone, and fuel use of vessels meeting the designated VSR compliance and speed through the VSR Zone. The total fuel savings for 80% compliance within the 20-nm VSR Zone and 90% compliance within the 40-nm VSR Zone are summarized in Table C-8. Over 400,000 gallons of fuel will be saved by updating the VSR Program to 90% compliance within 40-nm of Point Loma.

TABLE C-8. FUEL SAVINGS WITH THE OLD AND NEW VSR PROGRAM REQUIREMENTS

Vessel Type	Total Fuel (MT)	Total Fuel Savings (gallons)
80% Compliance, 20-nm VSR Zone		
Auto Carrier	485	110,389
Bulk Carrier	7	1,562
Container Ship	144	32,842
General Cargo	24	5,507
Passenger	580	132,107
RoRo	2	453
Total Savings	*1,242*	*282,860*
90% Compliance, 40-nm VSR Zone		
Auto Carrier	1,090	248,376
Bulk Carrier	15	3,514
Container Ship	324	73,894
General Cargo	54	12,390
Passenger	1,305	297,240
RoRo	4	1,020
Total Savings	*2,794*	*636,434*

2 TOTAL COST SAVINGS FROM FUEL REDUCTIONS

The fuel reductions were also used to understand the monetary benefit associated with the update to the VSR Program. Fuel cost per MT factors were applied to the reduction values in Table 8 to estimate the total cost savings associated with the old and new VSR Program requirements. Fuel cost was obtained from Ship and Bunker Average Bunker Prices in November 2020, which assumes $386 per MT[1]. Fuel cost savings from participation in the 2009 and updated VSR Program requirements are outlined in Table C-9. Approximately $700,000 additional dollars will be saved by updating to the new VSR Program requirements.

TABLE C-8. FUEL SAVINGS WITH THE OLD AND NEW VSR PROGRAM REQUIREMENTS

Vessel Type	Total Cost Savings
80% Compliance, 20-nm VSR Zone	
Auto Carrier	$187,059
RoRo	$768
Bulk Carrier	$2,647
Container Ship	$55,652
General Cargo	$9,331
Passenger	$223,860
Total Savings	*$479,317*
90% Compliance, 40-nm VSR Zone	
Auto Carrier	$420,883
RoRo	$1,728
Bulk Carrier	$5,955
Container Ship	$125,216
General Cargo	$20,996
Passenger	$503,685
Total Savings	*$1,078,463*

[1] Ship and Bunker. 2020. Regional Average Bunker Prices. Accessed November 17, 2020. Available: https://shipandbunker.com/prices/av/