2022 AQMP Mobile Source Working Group Meeting #1 – Ocean-Going Vessels

February 3, 2021

Cleaning The Air That We Breathe...

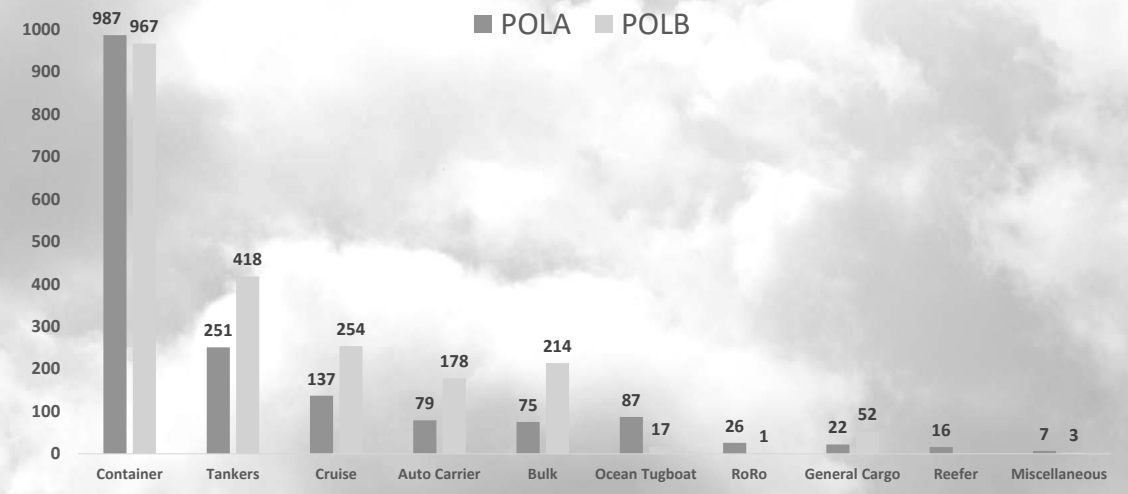
Agenda

1. Ocean Going Vessels Operations and Emissions – AQMD
2. Strategies for Reducing Emissions from Ocean Going Vessels - CARB
3. Current Marine Diesel Engine Emission Requirements – U.S. EPA
4. Pacific Rim Initiatives for Maritime Emission Reductions – AQMD

Agenda Item #1

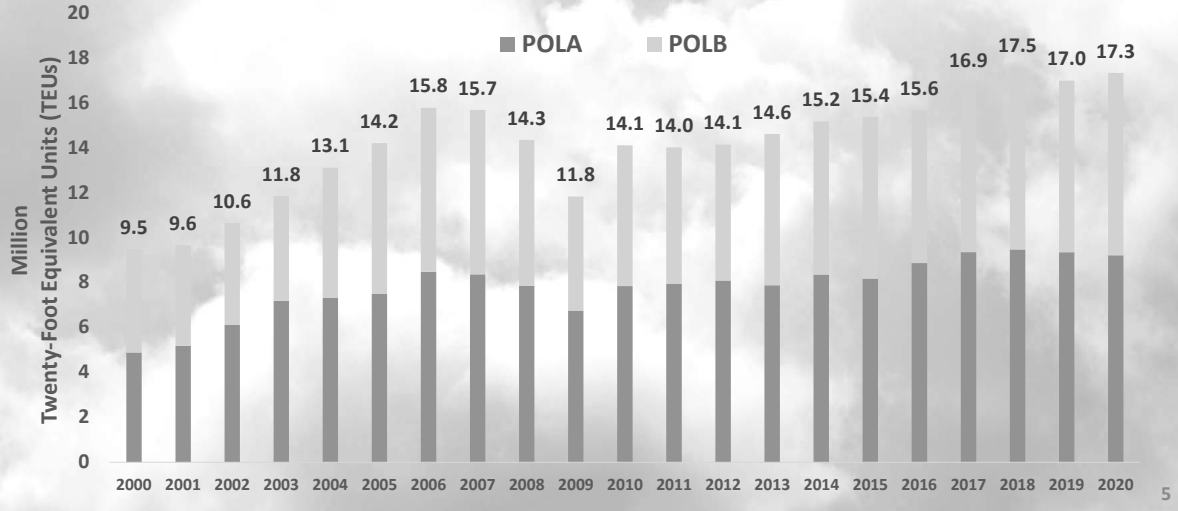
Ocean-Going Vessels Operations and Emissions in South Coast AQMD

2019 OGV Calls by Vessel Type (3,791)

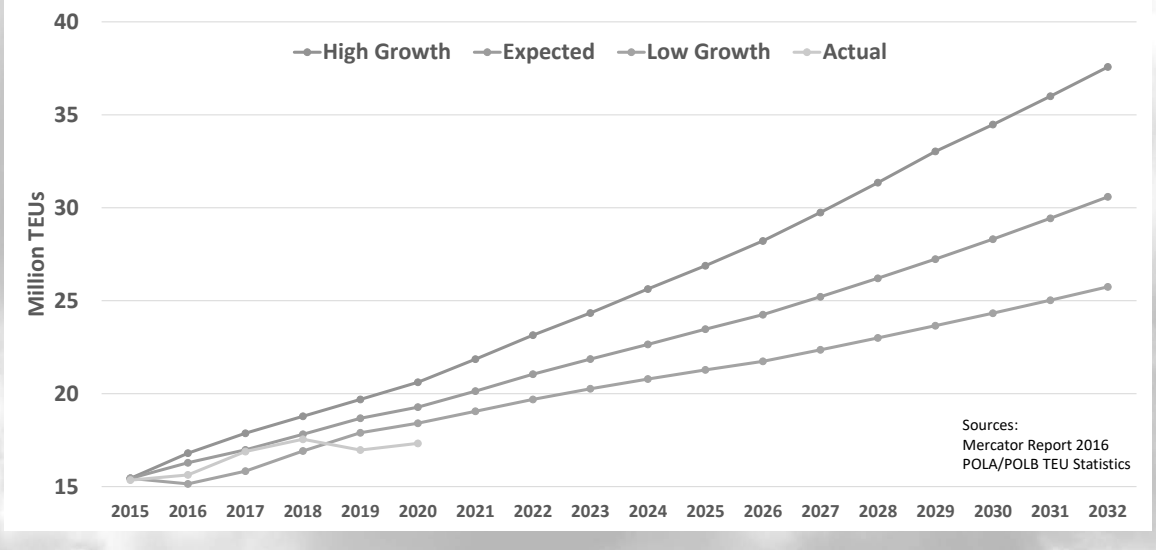


Sources: POLA/POLB 2019 Emission Inventories

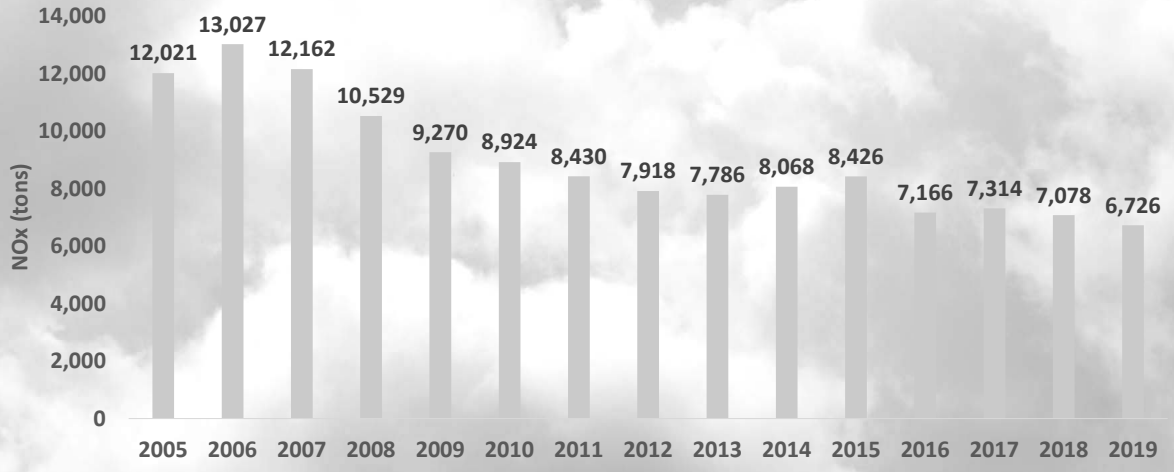
Annual Containers Statistics



Forecasted vs. Actual TEUs

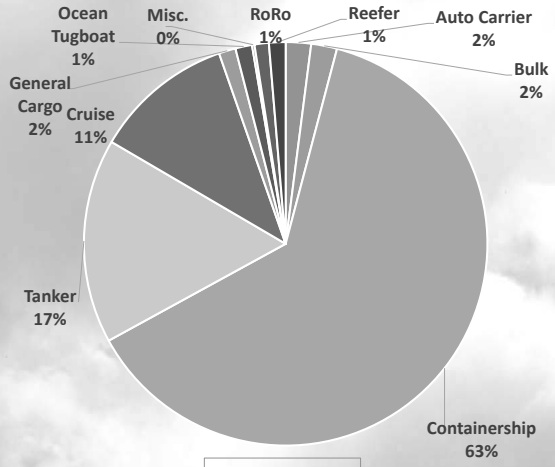


OGV NOx Emissions Trend

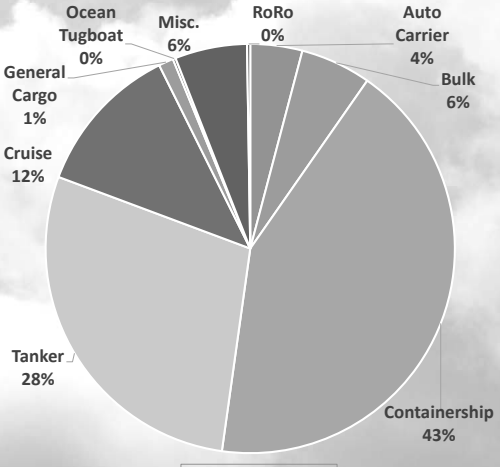


Sources: POLA/POLB Emission Inventories

OGV Emissions by Vessel Type (2019)



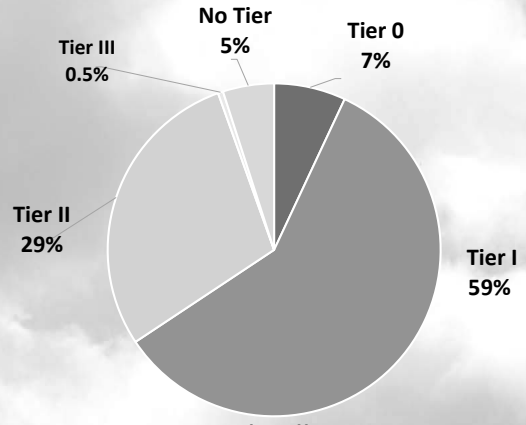
POLA Total: 2,743 tons



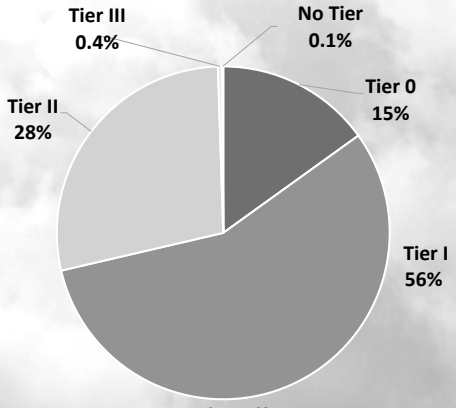
POLB Total: 3,983 tons

Sources: POLA/POLB 2019 Emission Inventories

OGV Main Engine Tiers (2019)



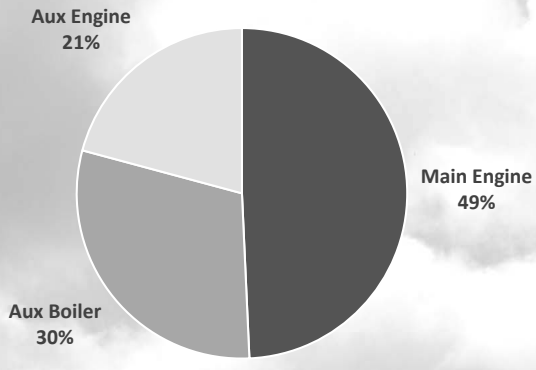
POLA - Total Calls: 1,687



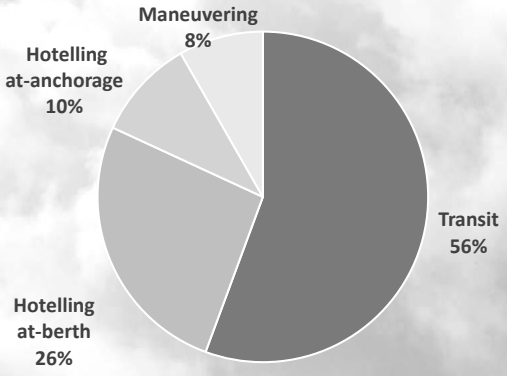
POLB - Total Calls: 2,104

Sources: POLA/POLB 2019 Emission Inventories

2019 OGV NOx Emissions (Two Ports Combined)



By Engine Type



By Operational Mode

Total NOx: 6,726 tons

Sources: POLA/POLB 2019 Emission Inventories

OGV Emissions Contribution

Significant OGV emission reductions are needed for attainment of ozone standards.

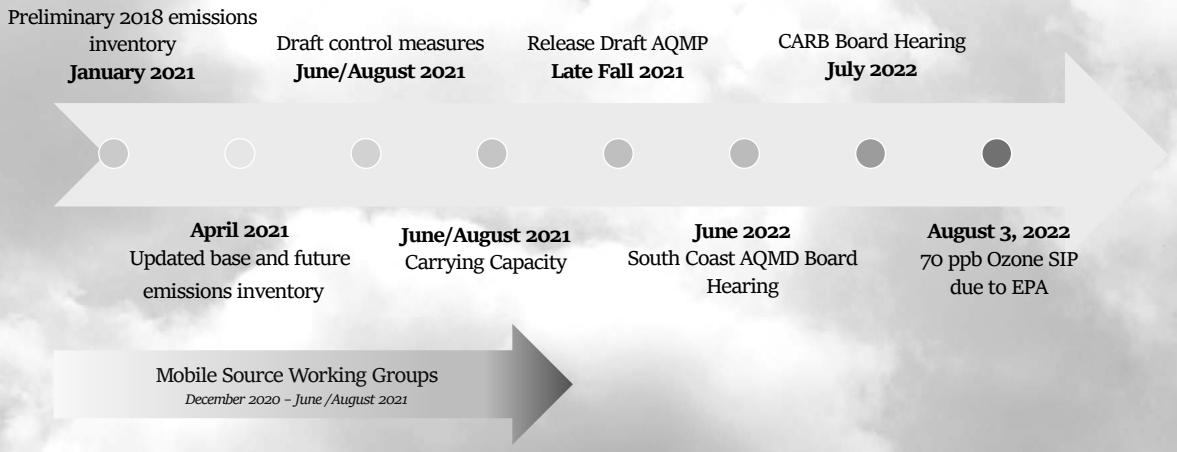
New OGV Emissions category

- Fugitive VOC emissions from tankers carrying petroleum products
  - Crude oil, gasoline, jet kerosene, distillate oil, residual oil
- Draft emission estimates: 8 tons per day
- Emissions estimated based on:
  - Annual throughput data provided by California State Land Commission
  - U.S. EPA's AP-42 emission factors for marine transit loss (Table 5.2-6)
  - Vessel transit duration based on the average anchorage time for non-chemical tankers in the POLA/POLB 2018 EIs
  - 85% non-methane hydrocarbon content assumed for crude oils and 100% for other products
  - Growth forecast based on oil cargo forecast in 2016 Mercator Report

OGV Existing Control Programs

- IMO/U.S. EPA
  - NOx Engine Standards; Fuel Requirements
    - Tier 3 engines for new vessels at Emission Control Areas
- California Air Resources Board
  - At-Berth Regulation
  - Low-Sulfur Fuel Regulation
- Ports of Los Angeles and Long Beach
  - Local incentive programs (e.g., vessel speed reduction)
- Shipping Lines
  - Energy efficiency improvements

2022 AQMP Overall Schedule



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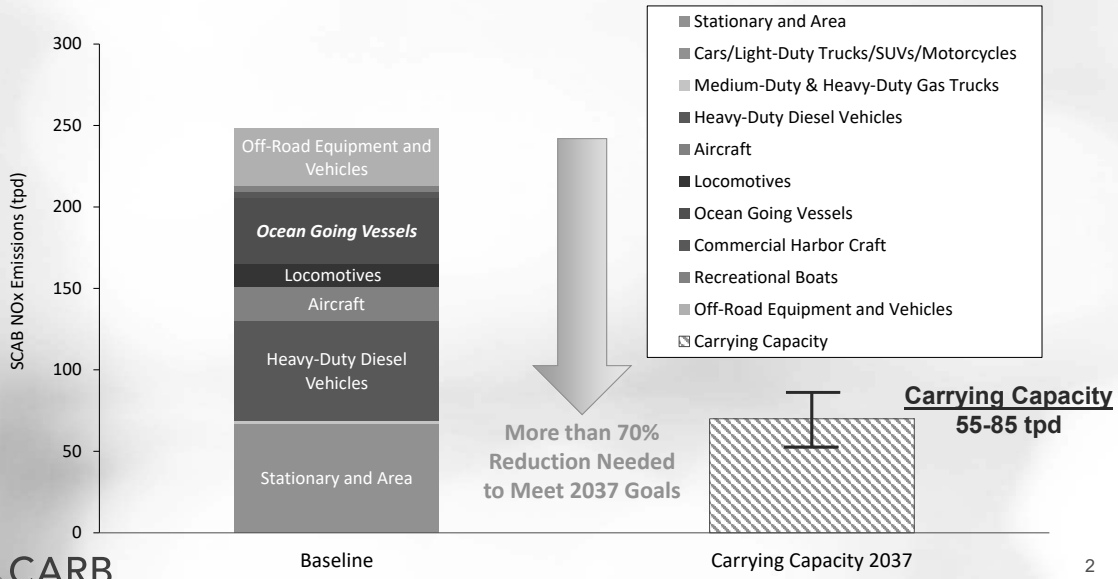
CALIFORNIA
AIR RESOURCES BOARD

Strategies for Reducing Emissions from Ocean Going Vessels

2022 AQMP Mobile Source Working Group

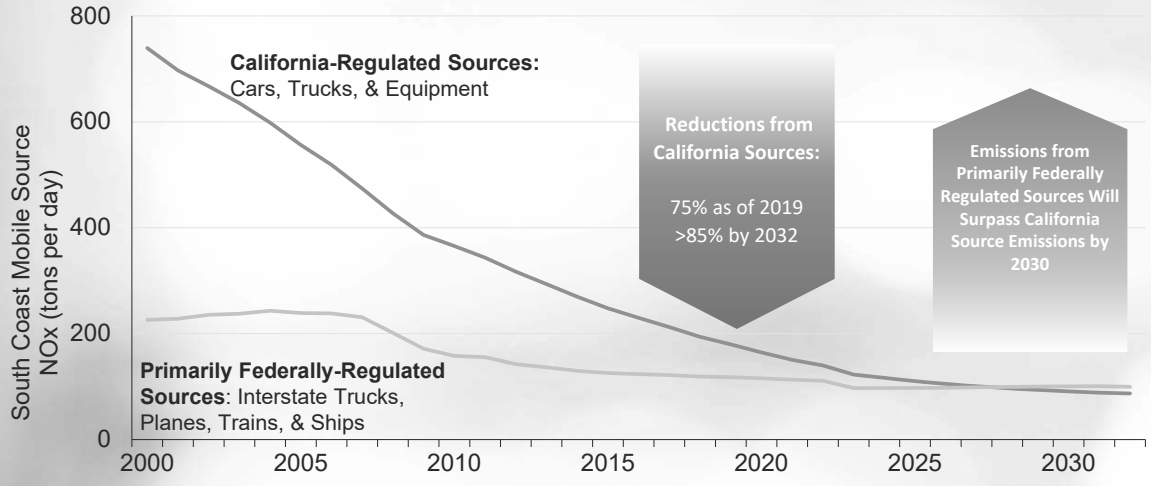
February 3, 2021

South Coast 2037 Draft Attainment Goal



CARB

Controlling Federal Sources is Critical to Achieving our Clean Air and Climate Targets



Source: CARB, CEPAM 2016 SIP - Standard Emission Tool (v1.05), https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php

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Ocean Going Vessels (OGVs)

- Over 400 feet, 10,000 tons, large engine displacement
  - Auto, container, cruise, cargo, reefers, tankers, etc.
- Visit CA port or marine terminal complex at least once per year
- Significant source of emissions around the ports and coastal shipping lanes
  - Transiting
  - Maneuvering
  - Anchoring
  - At berth

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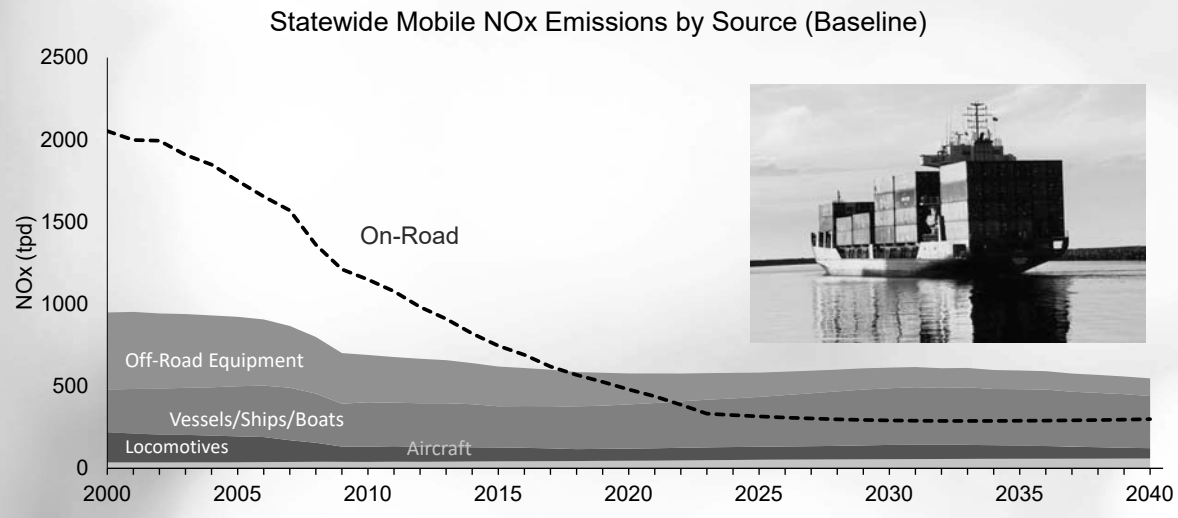
Growing Importance of Marine Emissions



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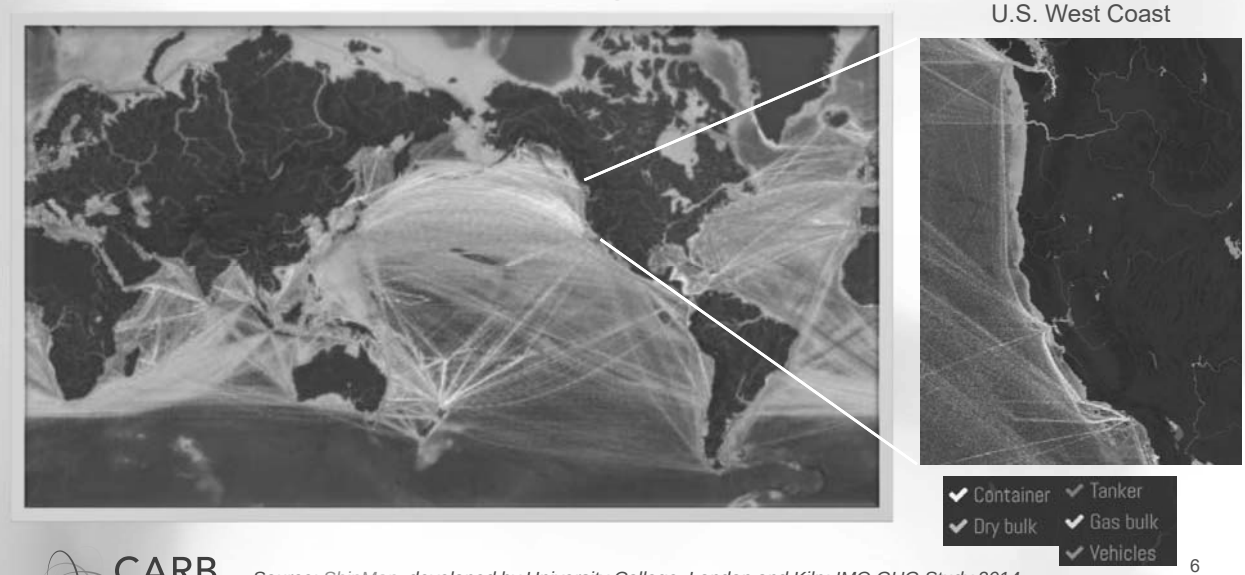
Source: CEPAM 2019 Summer emissions; OGVs includes emissions up to 100 nautical miles

Distribution of Global Shipping Activity from Satellite Tracking in 2012



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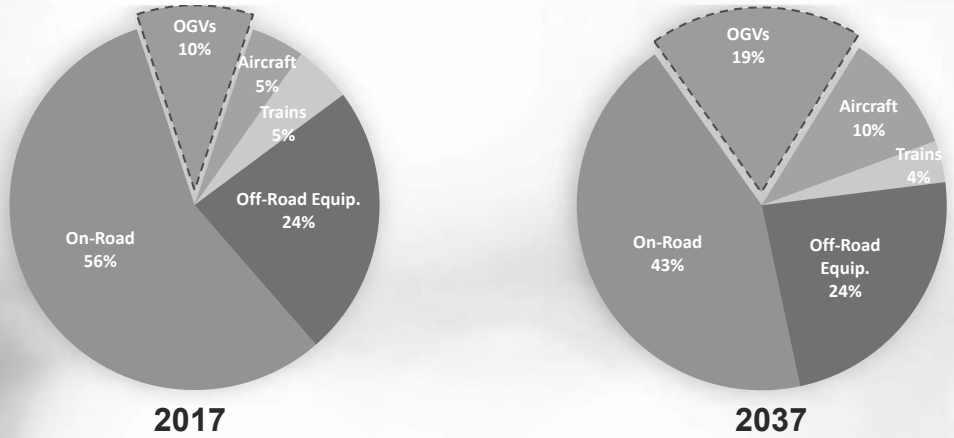
Source: ShipMap, developed by University College, London and Kiln; IMO GHG Study 2014.

OGV NOx Emission Contribution in South Coast

- OGV emissions (up to 100 nautical miles) make up 20% of mobile source NOx emission in 2037, up from 10% in 2017



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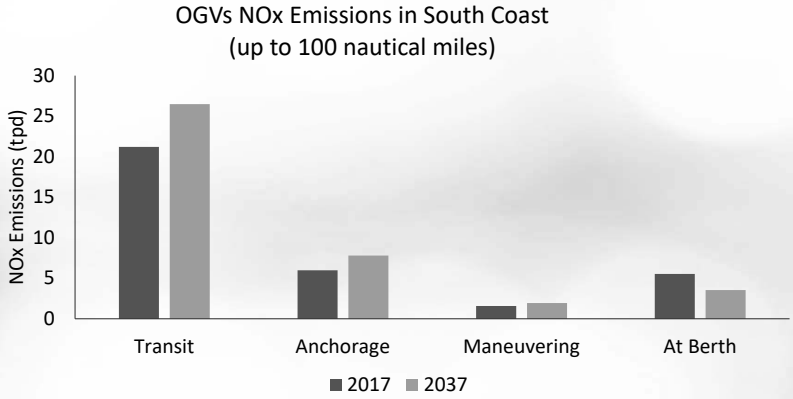
Source: CEPAM 2019 Summer Emissions, with 2020 at-berth amendments

OGV NOx Emission Forecast by Mode

- Emissions for transit, anchorage, and maneuvering increasing
- At berth emissions decreasing due to shore-power requirements
  - Based on 2020 amendments



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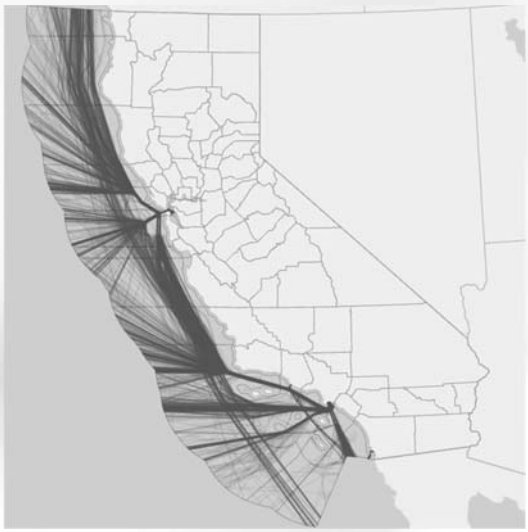
OGV Inventory Status

- At-Berth inventory updated in 2020
- Inventory updates for transit, maneuvering, anchorage in progress, based on Automatic Identification System (AIS) data
  - Improve base year accuracy and location specificity
  - Review growth forecast and future engine Tiers for visiting vessels
  - Review literature on emission factors for main/auxiliary engines and boilers
  - Draft Release: Summer 2021



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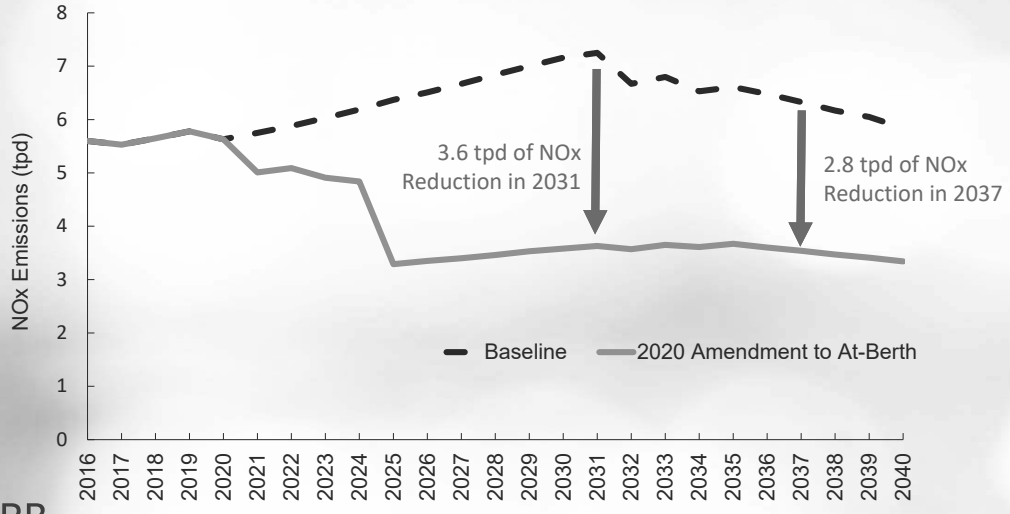
OGV At Berth Regulation

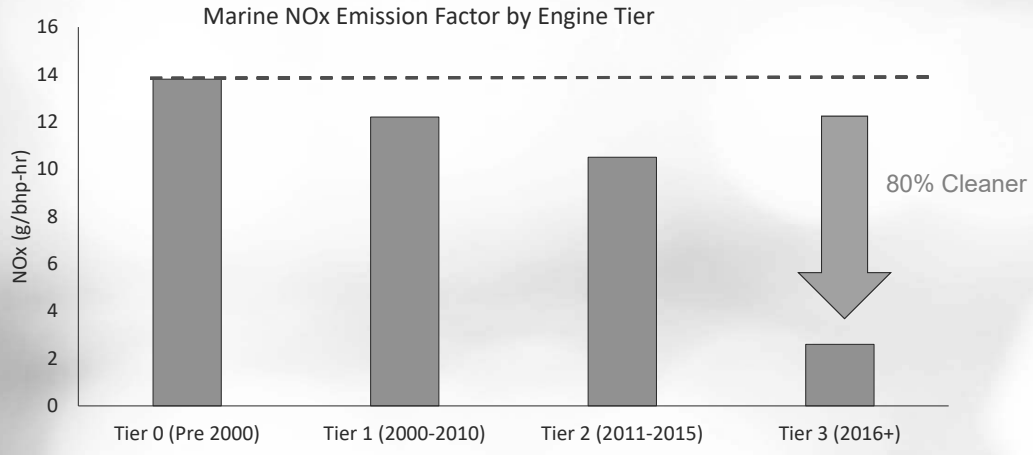
- Every vessel visiting a regulated port/terminal must connect to shore power or alternative control technology
- Reduce emissions from auxiliary engines and some tanker boilers
  - No requirements for main engines or auxiliary engines while not at berth
- Amended rule in 2020:
  - Expansion of At Berth Rule to cover more vessel types and locations
  - Taking effect in 2023

OGV NOx Reductions in SC from 2020 Amendments to At Berth Regulation



Emission Reductions: Tier 3 Vessels

- Tier 3 marine engines offer significant NOx reductions



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Emission Reductions: Tier 3 Vessels

- Projections indicate Tier 3 will not likely arrive in significant numbers for California ports until 2030
  - Large increase in keels laid prior to Tier 3 standards, allowing continued manufacturing of vessels with Tier 2 engines
  - Newer vessels generally used on European-Asian routes, later coming to Asian-American routes

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Emission Reductions: Retrofit Technologies

- **Water in Fuel (WiF) Emulsion**
  - Emulsifies the fuel with fresh water prior to combustion
  - 10% - 40% NOx reductions compared to Tier 1
  - May cause incomplete combustion and could increase PM emissions
- **Exhaust Gas Recirculation (EGR)**
  - Recirculates part of cleaned exhaust gas back into engine chamber
  - 10% - 40% NOx reductions compared to Tier 1
  - May result in additional unburned HC, PM, CO_2 emissions, and slight increase in fuel usage
- **Selective Catalytic Reduction (SCR)**
  - Treats exhaust gases and passes the treated exhaust over a catalyst
  - ≥ 80% NOx reductions compared to Tier 1 (comparable to Tier 3)

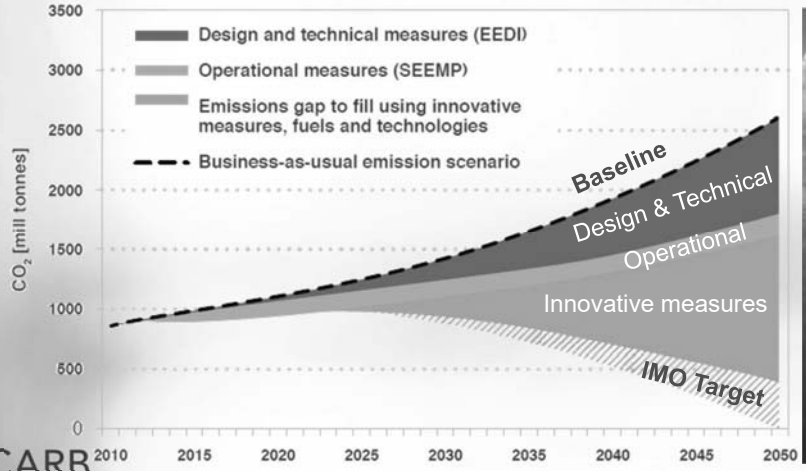
Source: CARB, Draft Technology Assessment: Ocean-Going Vessels
https://ww2.arb.ca.gov/sites/default/files/classic/msprog/tech/techreport/ogv_tech_report.pdf

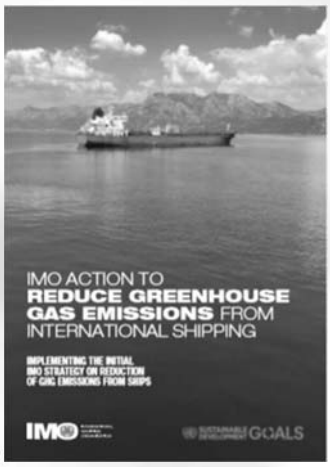
Emission Reductions: Marine Tier 4 Standards

- Would require working with US EPA and IMO on new standards
- Marine tech assessment set a goal of an additional 70% reductions in NOx beyond Tier 3 standards, or 1 gram of NOx per kw-hr
- Scrubber (after-treatment of SOx and PM) manufacturers have claimed PM reductions of 30 to 85 percent

GHG Reductions: IMO Targets

- At least 50% reduction of annual GHG emissions compared to 2008 level by 2050 (requires approximately 85% CO2 reduction per ship)





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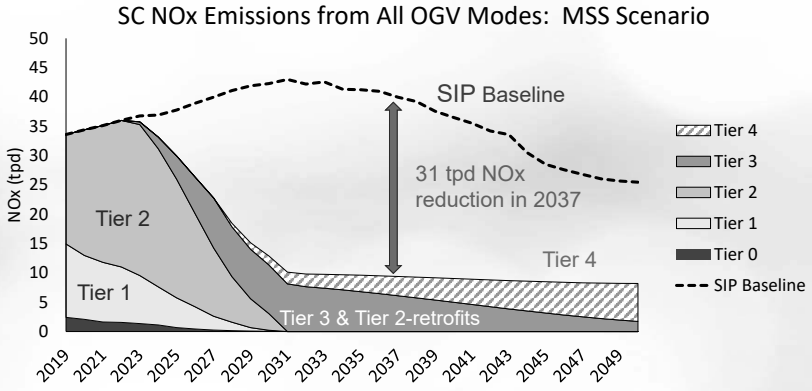
2020 Mobile Source Strategy (MSS)

- Address transit, anchorage, and maneuvering emissions
  - Replace Tier 0/1/2 visits with Tier 3 (or retrofitted Tier 2 visits that achieve similar reductions) by 2031
  - Introduce Tier 4 marine standards in 2028



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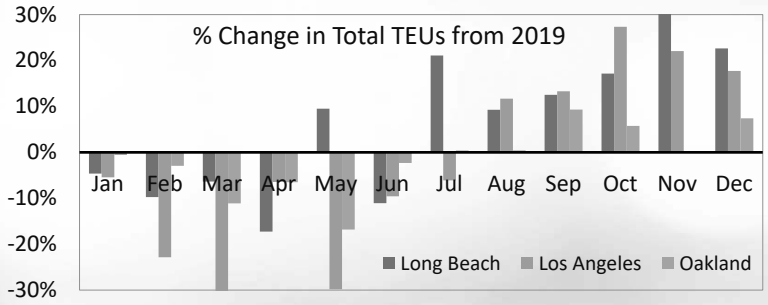
Potential Measures to Consider

- Explore CA state regulatory authority to require cleaner vessel visits
- Work between CARB and U.S. EPA on requirements for visiting vessels
- Incentive programs and possible partnerships with Pacific ports
- Vessel speed reduction programs
- Working with US EPA and IMO for marine Tier 4 standard

COVID-19 Impacts

- Container activity initially down by ~30% in spring, but rebounded ~30% above 2019 level in the forth quarter of 2020, driven by consumer demands



- Cruises stopped sailing in April 2020; no firm date of resumption yet
- Auto carrier visits down 50-75% between Feb-May 2020 compared to 2019
- Refinery crude imports down ~20% in 2020 compared to 2019

Questions, Comments, Feedback

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CARB

2022 AQMP Mobile Source Working Group Ocean Going Vessels (Meeting #1)

Current Marine Diesel Engine Emission Requirements

Wednesday, February 3, 2021, 1:30 p.m.

Presentation by:
Michael J. Samulski, LMAC Director
Assessment and Standards Division
EPA Office of Transportation and Air Quality

Summary

- EPA's Coordinated Strategy to reduce OGV engine emissions
  - Standards
    - Clean Air Act
    - MARPOL Annex VI (ECA and Global)
  - Compliance and Enforcement
- Ongoing International Maritime Organization (IMO) Activity

EPA's Coordinated OGV Strategy

- Set out in EPA's C3 Marine Rule (75 FR 22896, 4/30/10)
  - Combination of national and international action to address emissions from all ships that affect US air quality
  - Result: emission reductions from <u>all</u> OGVs that operate in US waters

Clean Air Act (CAA) program

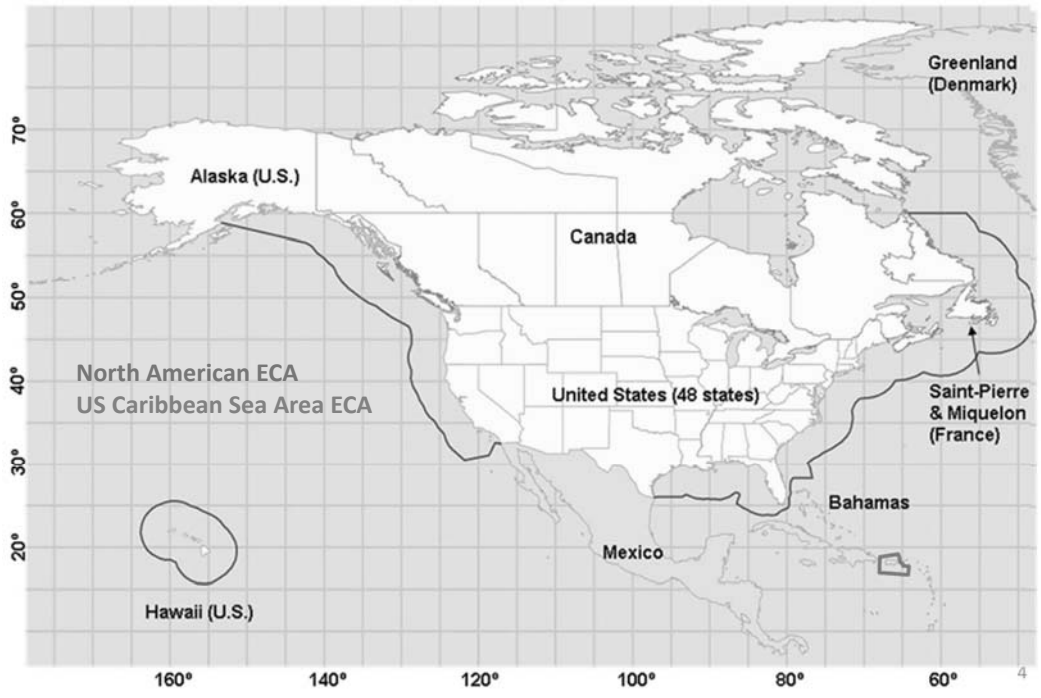
- Engines of any size installed on a US ship, no matter where it is operated
- Fuel sold in the United States, no matter where it is used

MARPOL Annex VI program

- Engines >130 kW installed on any ship
- Fuel used on any ship
- Limits depend on whether the ship is operating inside or outside an Emission Control Area (ECA)

IMO

U.S. Emission Control Areas



OGV Engine and Fuel Standards

Program	Engines	Fuels	Applicability
CAA 40 CFR 1042 40 CFR 80	Engines >30 l/cyl displ • 80% NOx reduction from Tier I • HC and CO caps • PM measurement Engines <30 l/cyl displ • EPA Tier 4 limits*	C3 vessels • 1,000 ppm S – fuel used inside ECAs • 5,000 ppm S – fuel used outside ECAs C1, C2 vessels: 15 ppm S	Engines installed on US vessels Fuel sold in US
Annex VI - ECA 40 CFR 1043 40 CFR 80	Engines >130 kW Tier III: 80% reduction NOx from Tier I	1,000 ppm S limit	All OGV operated in ECAs
Annex VI - Global 40 CFR 1043 40 CFR 80	Engines >130 kW Tier II: 20% NOx reduction from Tier I	5,000 ppm S limit	All OGV operated outside ECAs

*Auxiliary engines on US-flag C3 vessels can comply with either CAA Tier 4 or Annex VI Tier III (to simplify foreign port state control inspections)

Marine Remanufacture

- EPA's CAA and Annex VI both have engine remanufacture programs
  - They cover different engines, focus on different pollutants
- CAA: 40 CFR 1042, Subpart I
  - Engines >600 kW, built from 1973 through Tier 2
  - Applies at time of remanufacture, if a certified reman kit is available
    - Replace all cylinder liners, either all at once or over a 5-year period
  - 25% reduction in PM
    - Kits subject to a cost cap of $45K/ton PM
- MARPOL Annex VI: Regulation 13.7
  - Engines >5,000 kW and > 90 l/cyl displacement, built 1990-1999
  - Applies at time of vessel survey (renewal or intermediate) if there is an approved method available
  - Tier I NOx limits

Compliance and Enforcement

- Engines
  - EPA has sole authority to certify engines: Certificate of Conformity (CoC), Engine International Air Pollution Prevention (EIAPP) Certificate
  - Compliance and enforcement
    - Engine and vessel manufacturers: EPA (OECA)
    - Vessel compliance: USCG with EPA assistance

- Fuels
  - Fuel providers: EPA (OECA)
  - Vessel compliance: USCG with EPA assistance

Transition to Tier III NOx

- OGV turnover to Tier III is slow
  - Only applies to ships that operate in ECAs
  - Applicability is based on keel lay date
  - Long service lives
- Very few vessels built beginning 2016 have Tier III engines
  - Originally, Tier III was meant to be retroactive, applying to engines on any vessel built beginning 2016 regardless of when a NOx ECA is designated
  - 2014 amendment changed this: Tier III effective date now tied to ECA designation date
  - NOx ECAs for Baltic and North Sea apply to 2021 and later vessels
- IMO's Marine Environment Protection Committee is focused on climate change regulations and is not currently working on additional NOx limits

IMO GHG Activities

- Initial IMO GHG strategy adopted in 2018; 3 parts

1. More stringent Energy Efficiency Design Index for new ships
   - Pulled ahead Phase 3 EEDI (30-50% improvement from baseline)
   - Currently considering new Phase 4 EEDI
   - Result: new ships have less total power

$$EEDI = \frac{P \bullet SFC \bullet C_f}{DWT \bullet V_{ref}}$$

2. Reduce CO2 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
   - Design index (EEXI) for existing ships in EEDI categories
   - Carbon Intensity Indicator for all ships >5,000 GT
   - Amendments approved in November 2020, expected to be adopted in June 2021 – would be effective April 2023
   - Main compliance measure is expected to be speed reduction

IMO GHG Activities (cont.)

3. Peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals
   - Committee will soon begin considering medium- and long-term measures to achieve this goal
   - Some technologies to achieve long-term goal have potential to reduce criteria pollutants (e.g., hydrogen)

IMO GHG Activities (Cont.)

- In addition to the Initial IMO GHG strategy, there are 3 other important GHG actions:
  - 4th IMO GHG study
    - Estimates 10% increase in OGV GHG emissions from 2012 to 2018 (2.9% of global anthropogenic emissions)
    - Over the same time period, the study estimates a 2.5% and 4.0% increase in NOx and PM2.5, respectively
  - IMO Fuel Consumption Database
    - Ships >5,000 GT report annual fuel consumption, operating data
    - Use this data to inform future energy efficiency requirements, as part of a 3-step program
  - Ship Energy Efficiency Management Plan
    - Ships to develop plan to evaluate, track, improve energy efficiency
    - SEEMP is mandatory; current amendments will require approval and SEEMP will be enforceable

Questions?

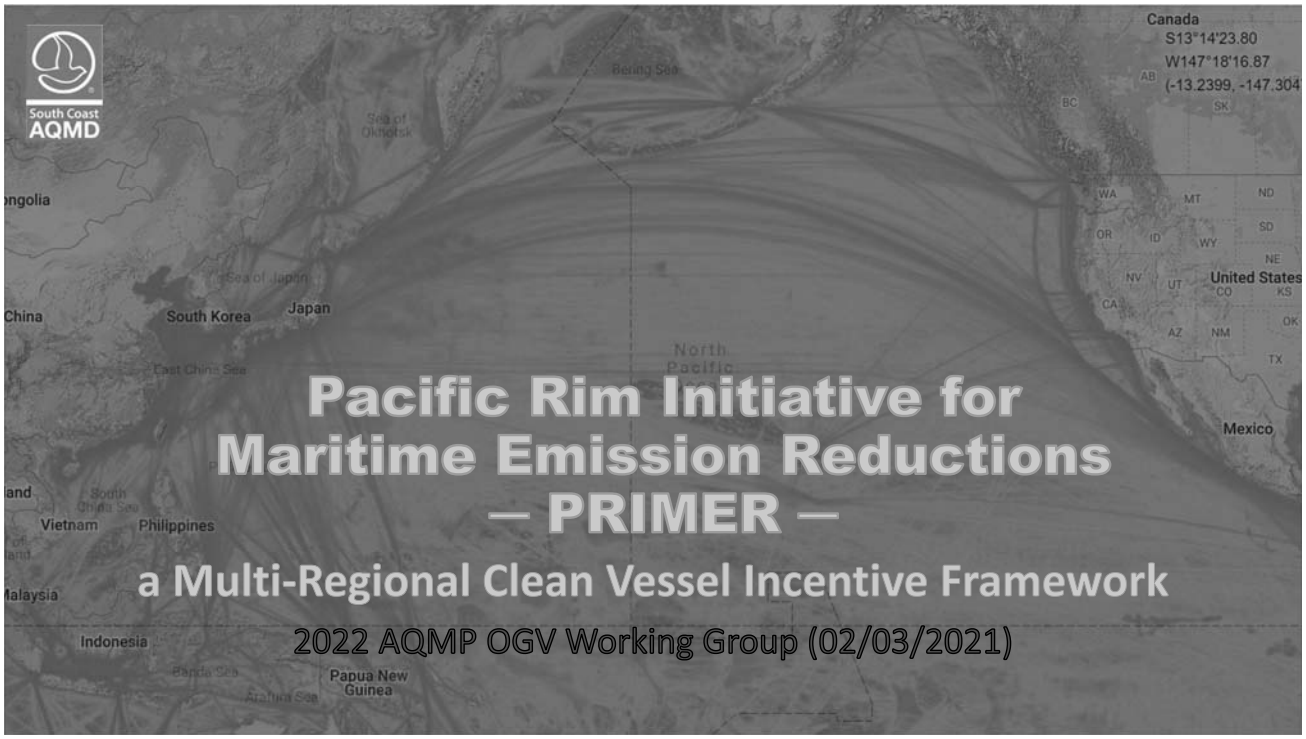
Wednesday, February 3, 2021, 1:30 p.m.

Presentation by:

Michael J. Samulski, LMAC Director

Assessment and Standards Division

EPA Office of Transportation and Air Quality



PRIMER Concept

- Trans-Pacific partnerships of multiple port regions around the Pacific Rim
- Coordinated efforts to incentivize cleaner ocean-going vessels (OGV) on shared routes

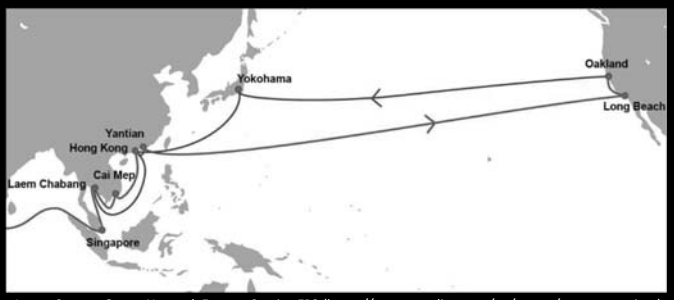
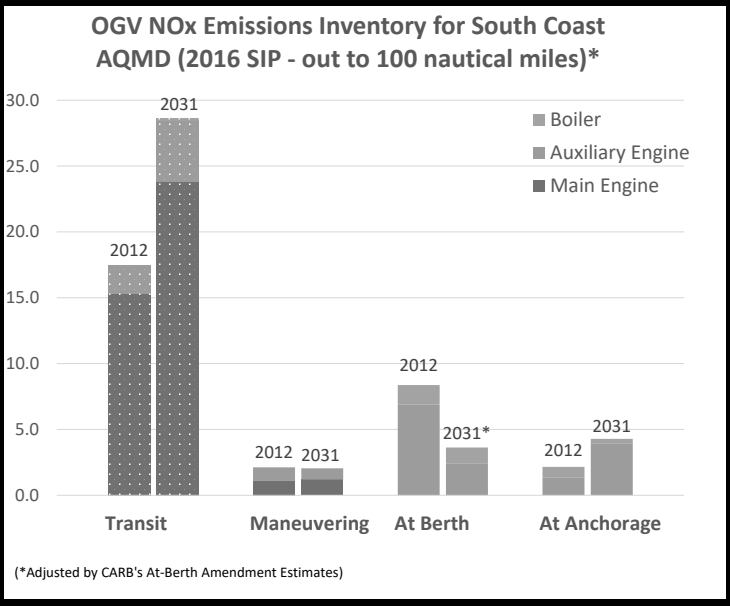


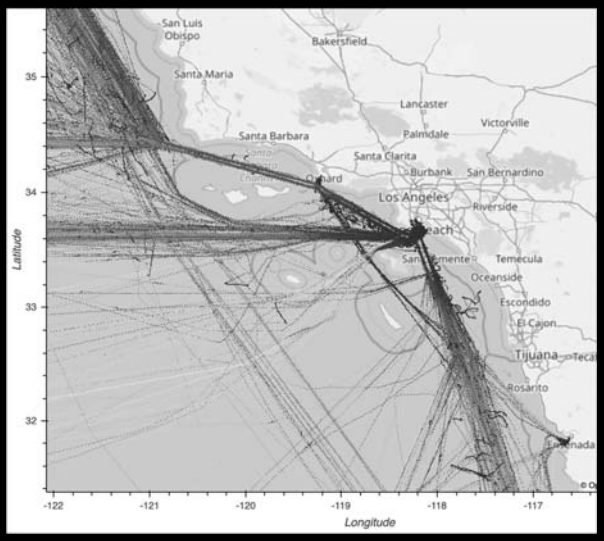
Image Source: Ocean Network Express Service FP2 (https://www.one-line.com/en/routes/current-services).

PRIMER's Main Focus: Transit Emissions



(*Adjusted by CARB's At-Berth Amendment Estimates)

Emissions Occur While Ships Transit Nearshore



Note: Lighter colors denote faster speeds.
Source: EERA Analysis of the 2016 Marine Cadastre data for the South Coast AQMD.

OGV NOx Reduction Pathways for Transit Emissions

IMO INTERNATIONAL MARITIME ORGANIZATION

IMO Tier III Technologies

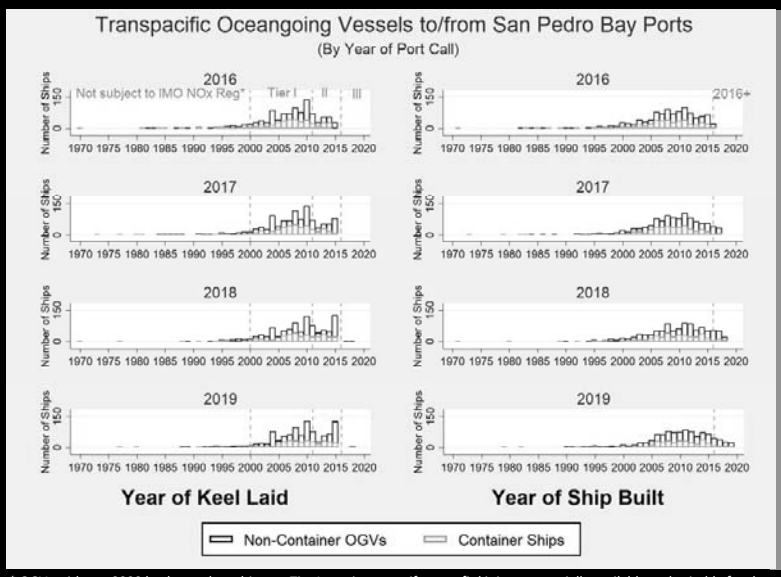
- Mandatory for newbuilds operating in NOx ECAs
- Certified & market ready (current options: SCR, EGR, and Otto Cycle LNG)
- Large capital investment
- Retrofit technically possible in some cases

Tier II+ Retrofit Technologies

- Technologies developed (e.g., water in fuel emulsion)
- Verification needed
- Lower capital investment and potentially more cost-effective than Tier III
- Voluntary: currently no market demand

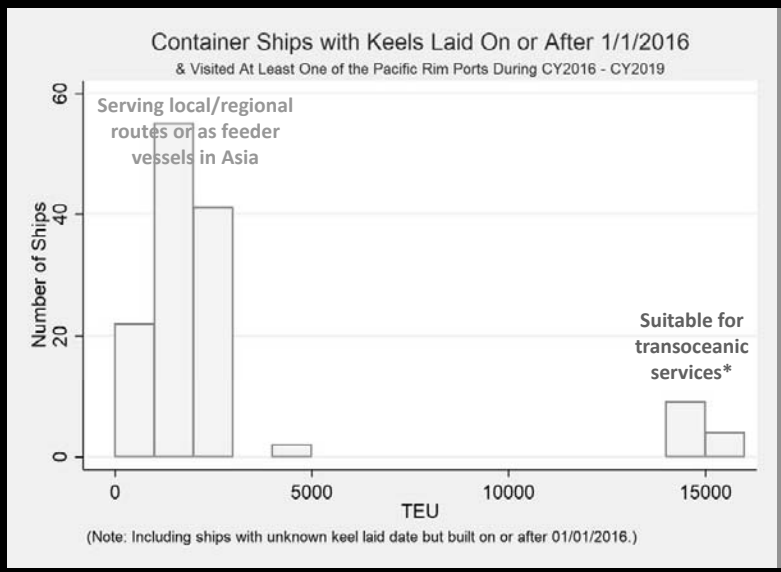
Efficiency Measures

- Voluntary or required by IMO for newbuilds; potential new requirements for in-use fleets
- Reduce fuel consumption, thus GHG and potentially NOx emissions
- Certain measures may increase NOx emission rate (g/kWh)
- Could be more difficult to track and verify NOx reductions



Few Tier III Ships Have Been Deployed to the Transpacific Trade Lane

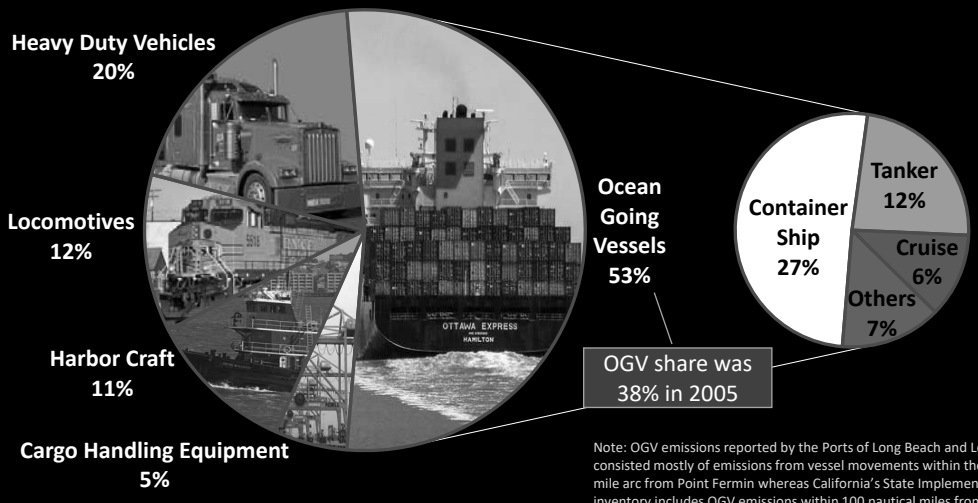
* OGVs with pre-2000 keels may be subject to Tier I requirements if a retrofit kit is commercially available and suitable for the vessel's engine and other specs.
Source: South Coast AQMD staff analysis of the IHS-Seaweb data.



Still Few Tier III in the Global Fleet of Transoceanic Container Ships

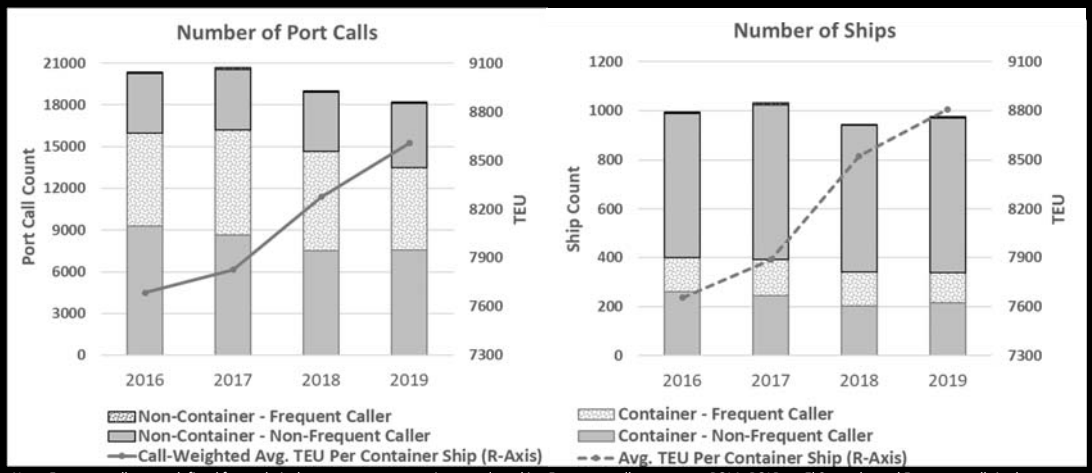
* Including 4 Iran-flagged container ships that may not be Tier III. The remaining 9 ships belong to two groups of sister ships, and some--if not all--of the ships from each group have visited one or more U.S. ports since maiden voyage. Additional newly constructed Tier III ships have come in service in CY 2020.
Source: South Coast AQMD staff analysis of the IHS-Seaweb data.

NOx Emission Source Categories in Ports of LA/LB (2019)



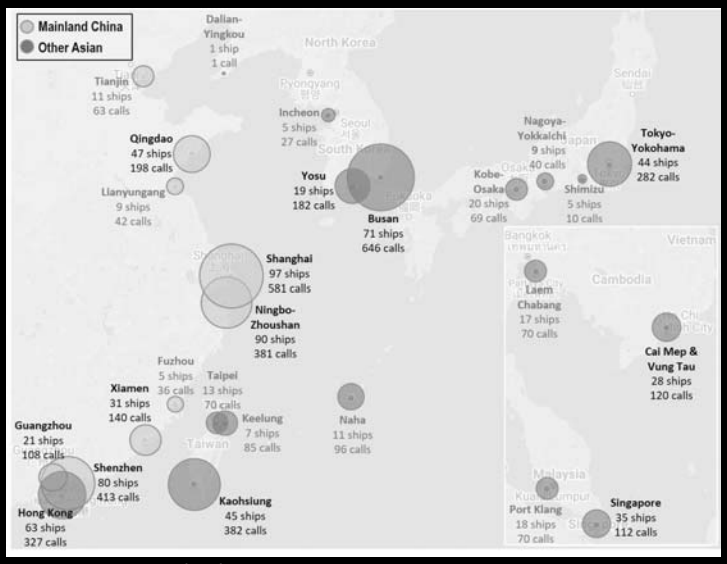
Note: OGV emissions reported by the Ports of Long Beach and Los Angeles consisted mostly of emissions from vessel movements within the 40 nautical mile arc from Point Fermin whereas California's State Implementation Plan inventory includes OGV emissions within 100 nautical miles from the coast.
Data sources: Ports of Long Beach and Los Angeles.

Opportunity:
Transpacific Containerized Cargo Movement

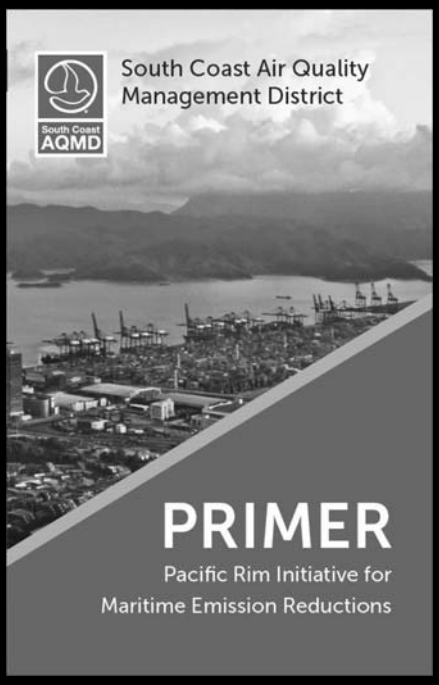


Note: Frequent callers are defined for analytical purposes as ocean-going vessels making 5 or more calls per year at POLA, POLB, or El Segundo, and 5 or more calls in the same year at one or more of the large-scale East and Southeast Asian ports.
Source: South Coast AQMD staff analysis of the IHS-Seaweb data.

Transpacific Frequent Caller Container Ships in 2019



Note: Frequent callers are defined for analytical purposes as ocean-going vessels making 5 or more calls per year at POLA/LB, and 5 or more calls in the same year at one or more of the large-scale East and Southeast Asian ports.
Source: South Coast AQMD staff analysis of the IHS-Seaweb data.



PRIMER: Transpacific Partnerships for Cleaner OGVs

- Partner with local/regional authorities to coordinate individual programs to attract cleaner OGVs on shared routes
  - Harmonize programs requirements in overlapping areas
  - Voluntary incentive-based programs: monetary or non-monetary
  - Incentives provided on a per-port-call basis – most suitable for non-captive OGV fleet
- Each port's individual program is then leveraged to encourage changes in shipping behavior
  - Deployment of existing and new Tier III OGVs to shared routes
  - Encourage construction of Tier III vessels on pre-2016 keels
  - Encourage retrofits of existing vessels to be cleaner than Tier II

Retrofit Technologies are Key

- Slow fleet turnover to Tier III
- Significant NOx reductions possible through retrofits
  - Tier I/II to Tier II+/III: 10-80%
  - Developed but require demonstration, validation, and emission reduction verification
  - Retrofit priority: optimizing abatement performance for nearshore operations
- Can contribute to advancing NOx control technology development for low-to-zero carbon fuels in ICE applications
- Suitable retrofit technologies should have minimal dis-benefits in GHG and directly emitted PM
- OGV tech demo at South Coast AQMD
  - Water in Fuel Emulsion: launched in 2020, in partnership with MAN, MSC, Ports of Los Angeles and Long Beach
  - Other retrofit and emissions testing/monitoring projects under active discussion

Optimizing Per-Port-Call Incentive

- Optimal level of per-port-call incentive depends on:
  - *Cost of technology:* capital investment + operating and maintenance expenditures
  - *Payback period:* length of time to reach break-even point of technology investment
  - *Port calls:* total calls made across all partnering port regions within the payback period
- Draft estimates derived to entice adoption of cleaner technology by OGVs frequently calling Pacific Rim ports
  - Much more cost-effective than stationary source emission controls
  - Currently refining assumptions and data inputs – will share finalized study results

PRIMER's Current Status in a Nutshell

Engagement with Asia

- Ongoing discussions with officials in China and various Chinese port regions
- Expanding engagement with officials in Japan and South Korea
- Promoting PRIMER at high-level policy forums in Asia

Technical analysis to support program development

- Researching ship deployment and movement patterns
- Finalizing incentive optimization analysis
- Preparing a PRIMER policy paper

Industry partnerships

- Partnering with engine manufacturers, shipping lines, ports and other stakeholders in demonstrating OGV retrofit technology
- Continuing discussions with vessel operators to seek feedback for PRIMER

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