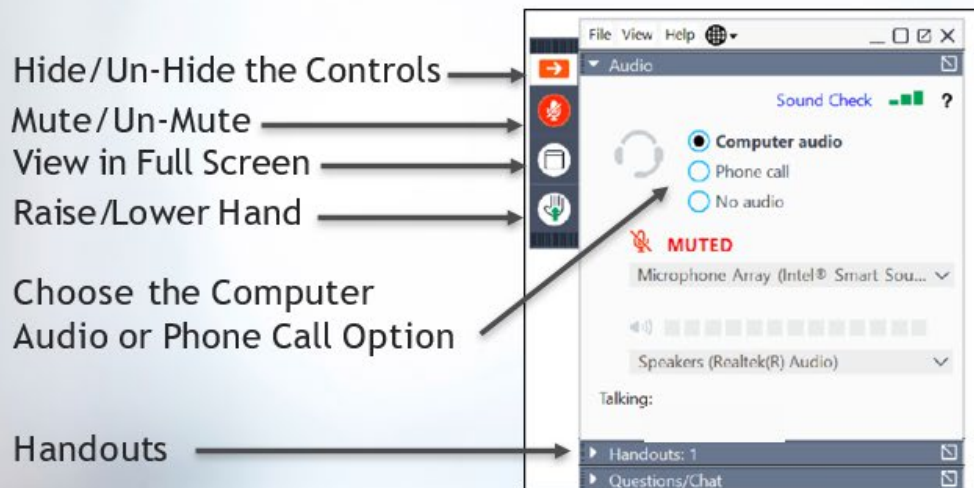


# Questions or Comments???

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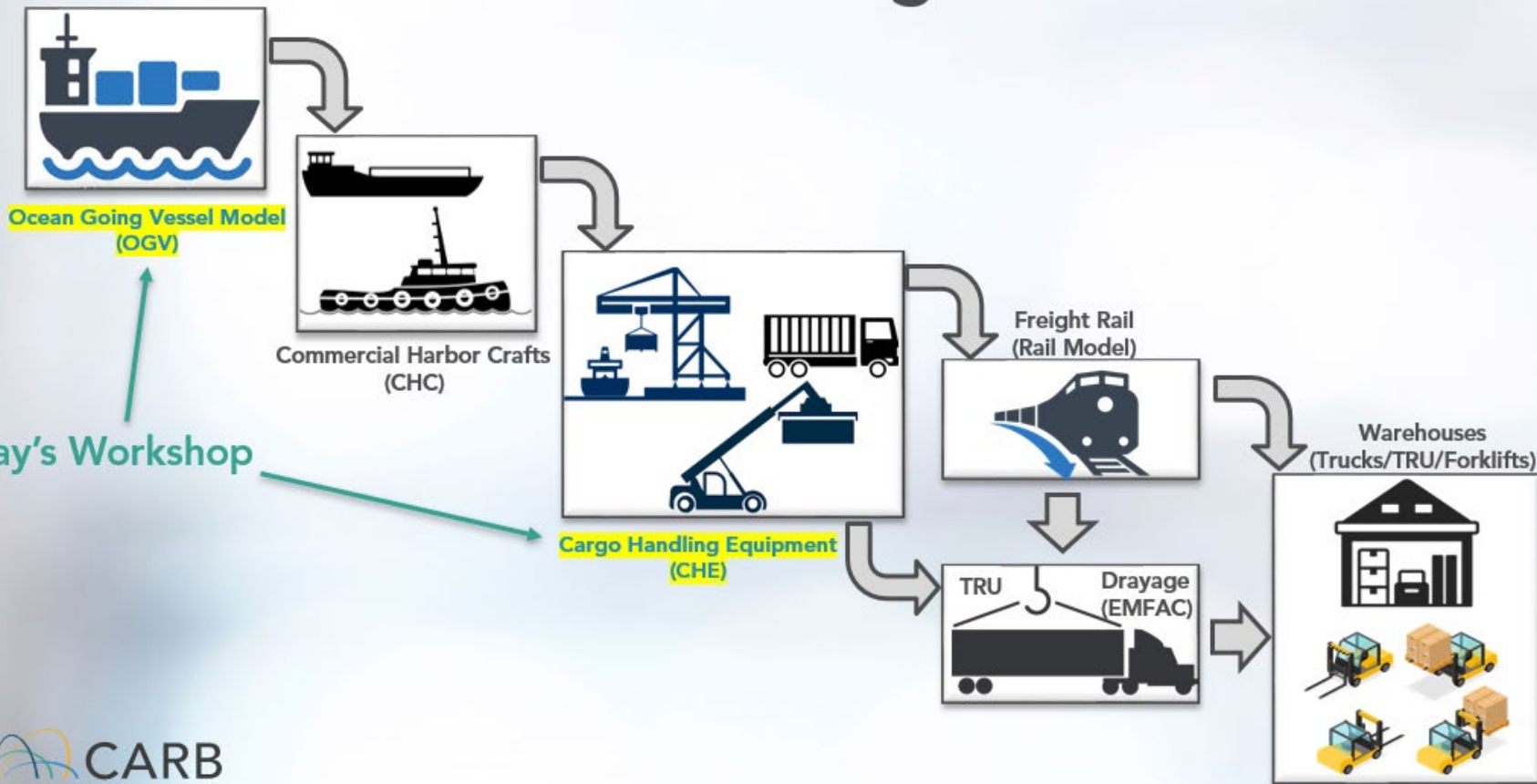


# Update to Cargo Handling Equipment (CHE) & Ocean-Going Vessels (OGV) Emissions Inventories

2021 Off-Road Mobile Sources Public Workshop

September 22, 2021

# Freight Transportation Emissions Modeling

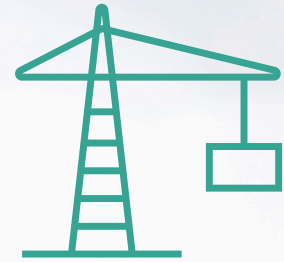




# Overview

## Cargo Handling Equipment (CHE)

CHE includes any motorized vehicles used to handle cargo or perform routine maintenance activities and can be a significant source of diesel PM emissions in communities near the ports and intermodal rail facilities.



## Ocean-Going Vessels (OGV)

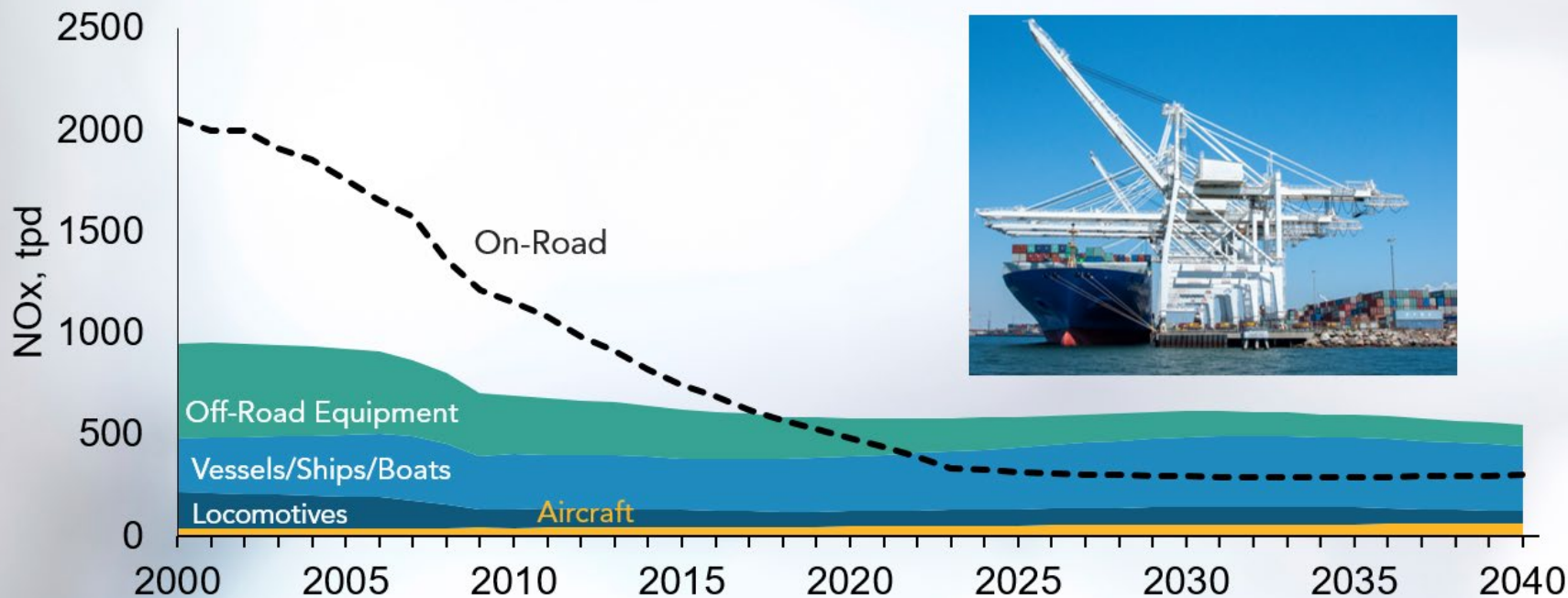
OGV are large vessels designed for deep water navigation and are a significant part of California's trade economy. OGVs are expected to be one of the largest sources of emissions in the near future, being a significant source of GHG emissions, criteria pollutants, and toxic air contaminants near ports and marine terminals.





# Growing Importance of Marine Emissions

## Statewide Mobile NOx Emissions by Source (Baseline)



Cargo Handling Equipment (CHE)

# Background and Major Updates



# What is Cargo Handling Equipment (CHE)

- Mobile cargo handling equipment is any motorized vehicle used to handle cargo or perform routine maintenance activities at California's ports and intermodal rail yards.
- CHE has an impact on air quality in communities near the ports.



Ship-to-shore  
crane



Rubber-tiered  
Gantry Crane



Yard Truck





# What is an Emissions Inventory?

An emissions inventory for an industry sector accounts for:

- *Population* of equipment
- How often it is used (*activity*)
- The equipment *model year* (newer equipment is generally cleaner)
- The region where the equipment is used (generally by *county*)
- The total resulting *emissions* from the equipment

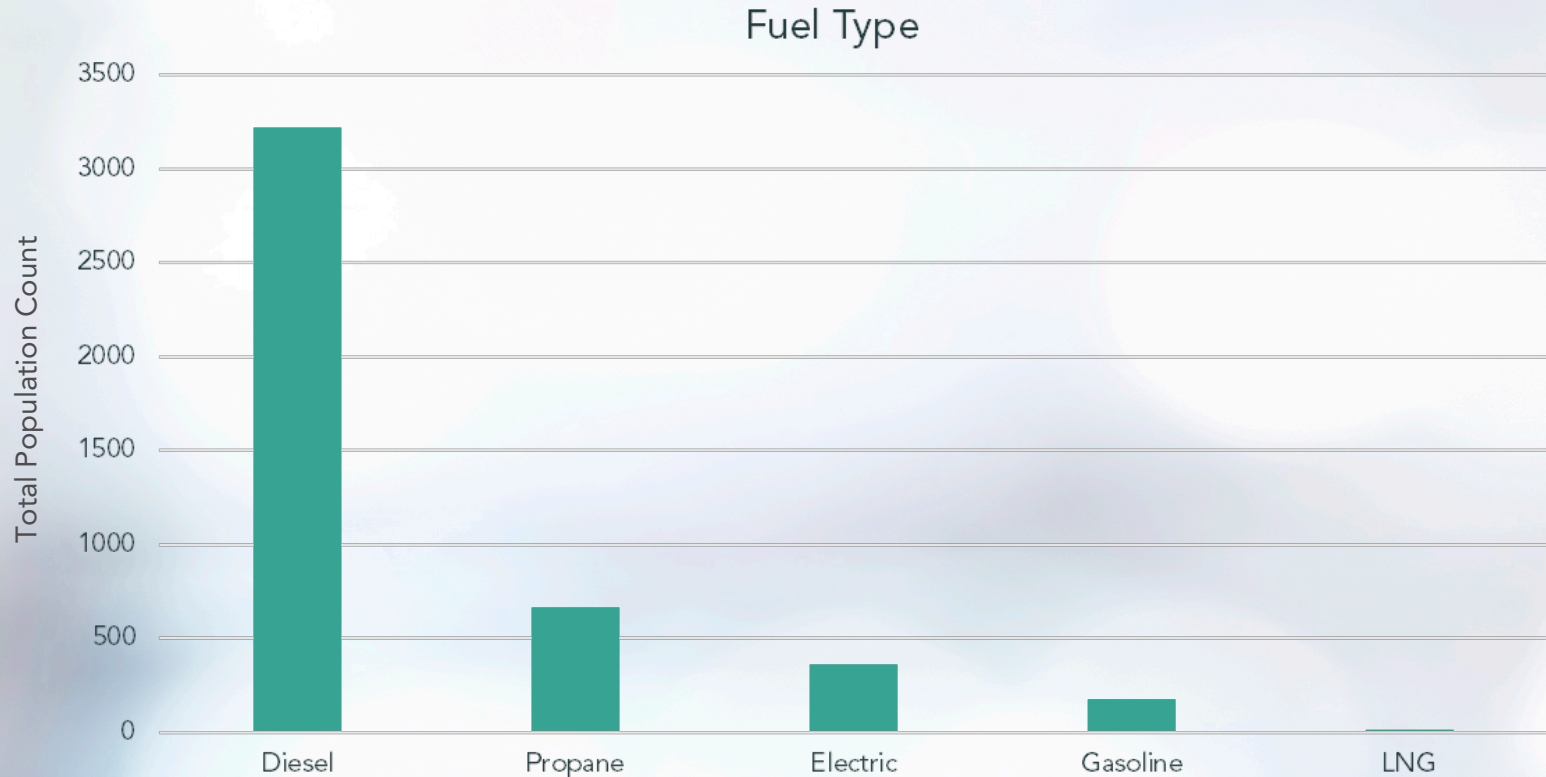
CARB uses emissions inventories to understand where air pollution comes from and to create strategies for emission reductions.

# Data Sources

- **Port Emissions Inventories Data:**
  - Port of Los Angeles, Port of Long Beach, Port of Oakland
- **CARB reporting data:**
  - **Ports:** Bay Area Bulk Terminal, Concord Naval Weapons Station, LA Berth 240, Port of Hueneme, Port of Redwood City, Port of Richmond, Port of Sacramento, Port of San Diego, Port of San Francisco, Port of Stockton
  - **Rail Yards:** UPRR City of Industry, UPRR Commerce, UPRR ICTF, UPRR LATC, UPRR Lathrop, UPRR Oakland, BNSF Commerce, BNSF Los Angeles (Hobart), BNSF North Bay Intermodal Yard, BNSF Oakland, BNSF San Bernardino, BNSF Stockton

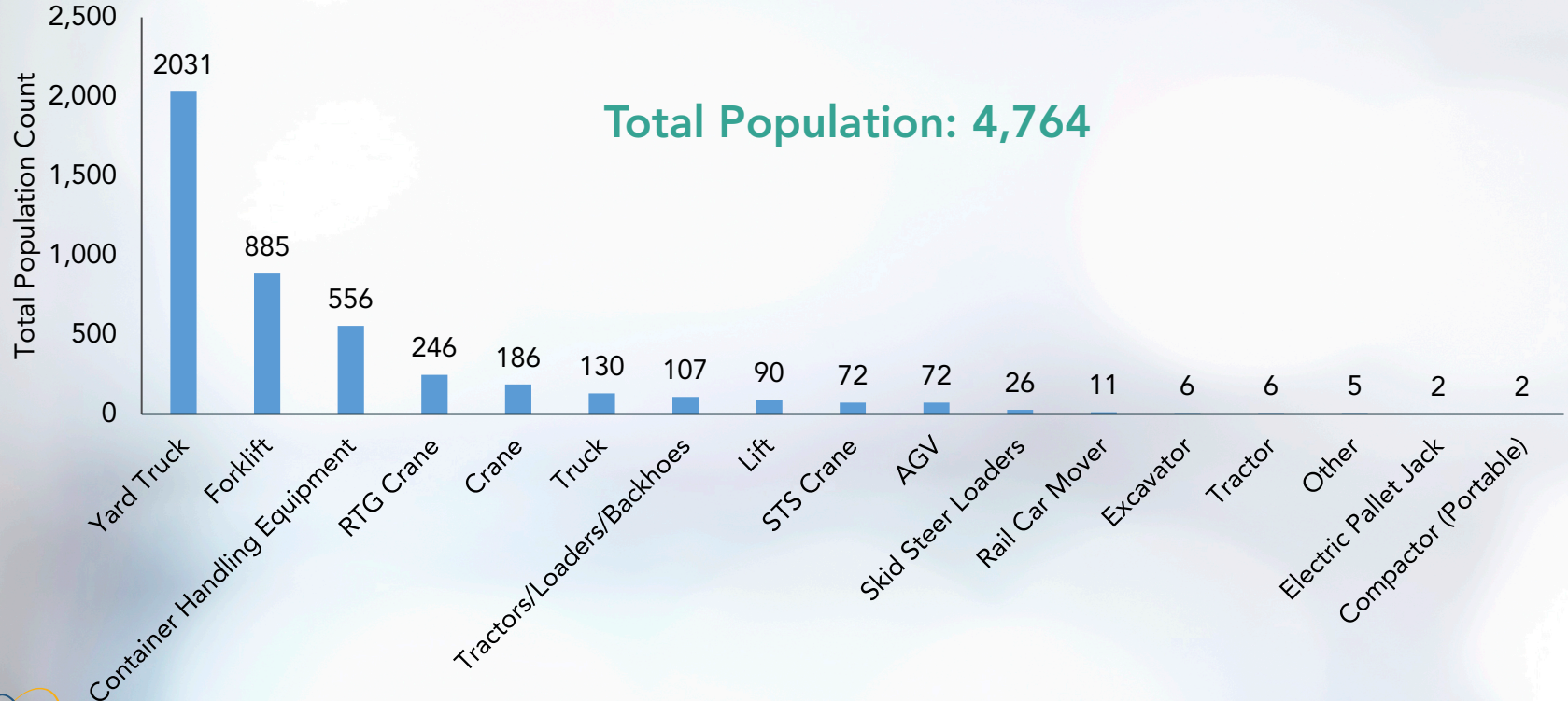


# Statewide CHE Populations

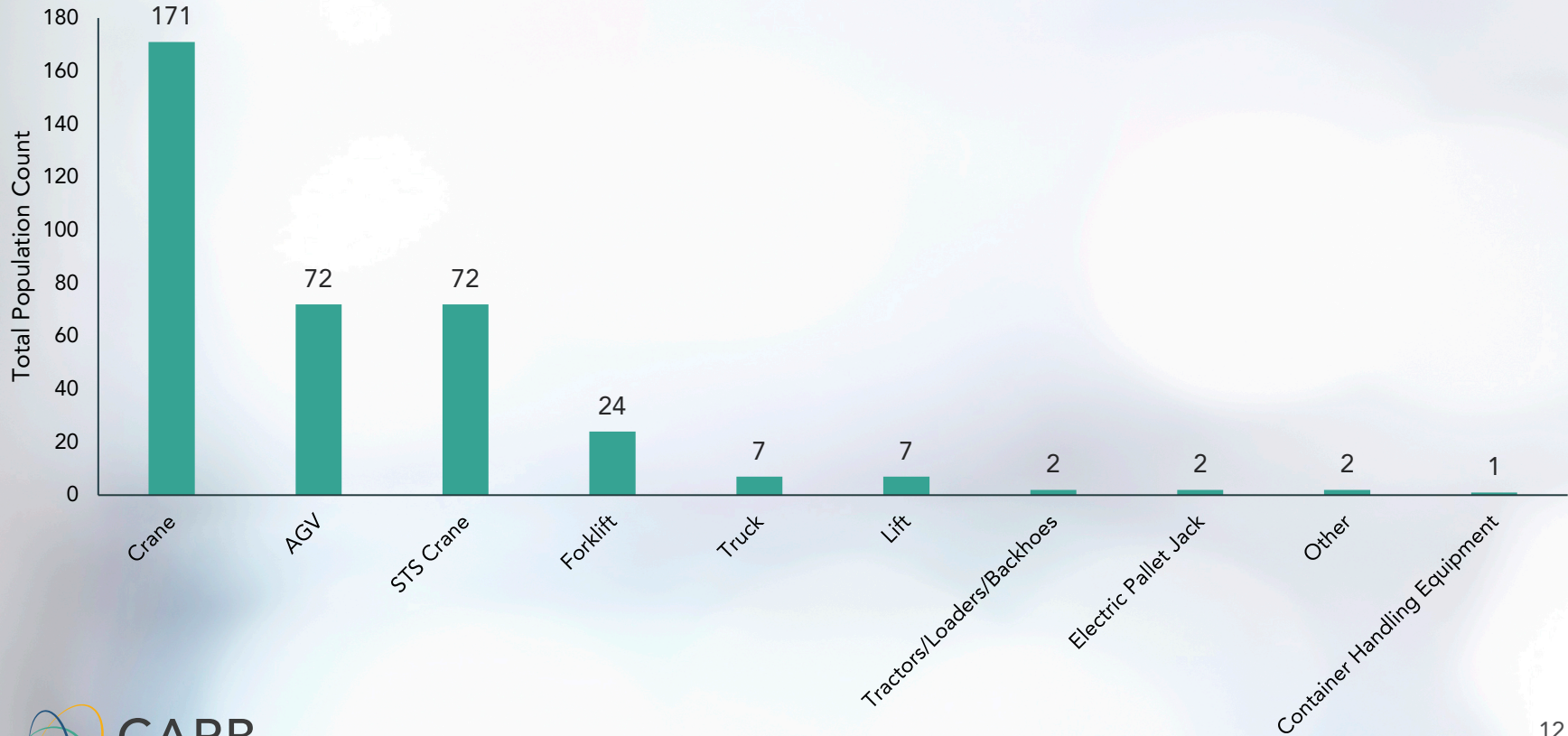




# Statewide CHE Population

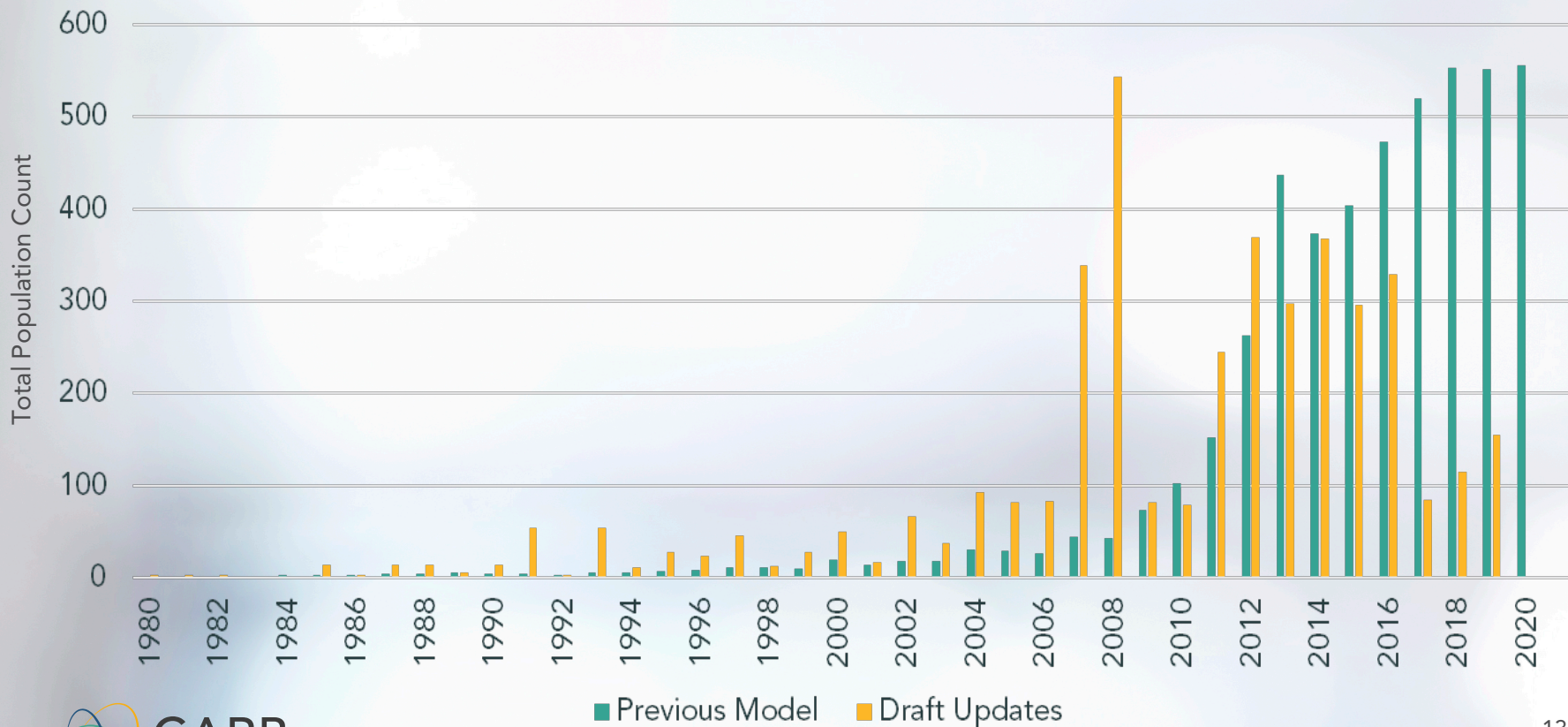


# Statewide Electric Equipment





# Population Comparison by Model Year





# Emission Factors

- Using latest emission factors for diesel, propane, and gasoline off-road equipment
- Using EMFAC2021 rates for on-road yard trucks
- May be further updated with CHE-specific emission factors in next iteration

# Load Factors

- Load factors are the same as the 2011 model and consistent with San Pedro Bay Ports emissions inventories
- Based on CHE operations data from 2007
- Load factors for yard tractors and RTG cranes are based on 2006 and 2009 studies by Starcrest
- Average of 1-4 day period over the span of a month

Equipment	Load Factor
AGV	0.51
Compactor	0.51
Container Handling Equipment	0.59
Crane	0.43
Electric Pallet Jack	0.5
Excavator	0.55
Forklift	0.3
Lift	0.51
Other	0.51
Rail Car Mover	0.51
RTG Crane	0.2
Skid Steer Loaders	0.55
STS Crane	0.43
Tractor	0.55
Loaders/Backhoes	0.55
Truck	0.51
Yard Truck	0.39



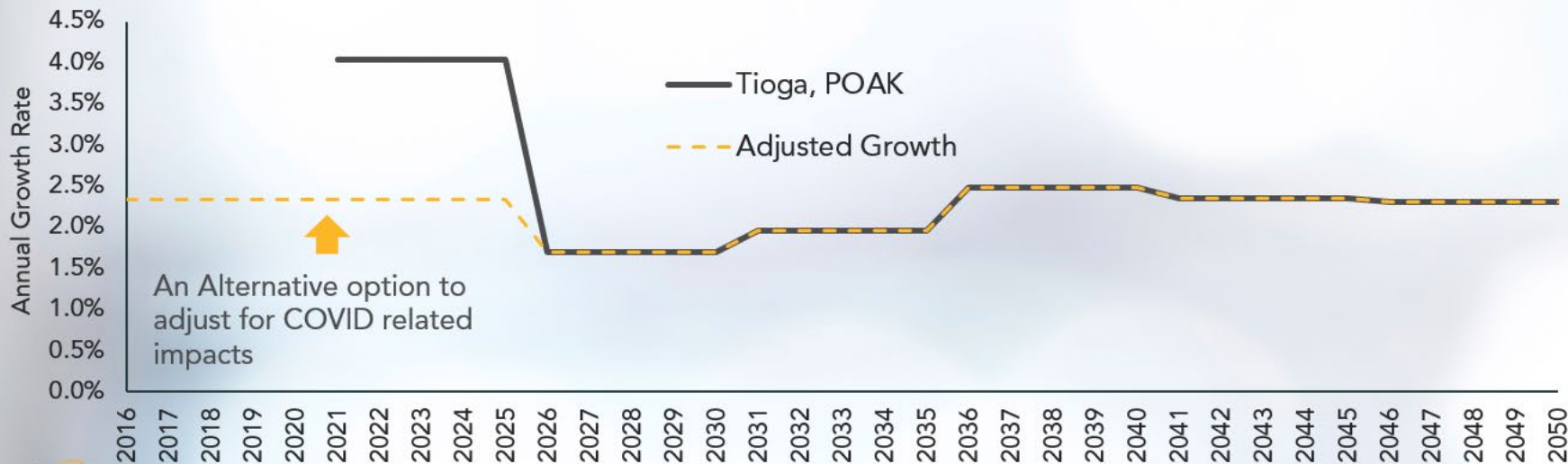
# Cargo Handling Equipment (CHE) **Growth Rates**



# Port of Oakland

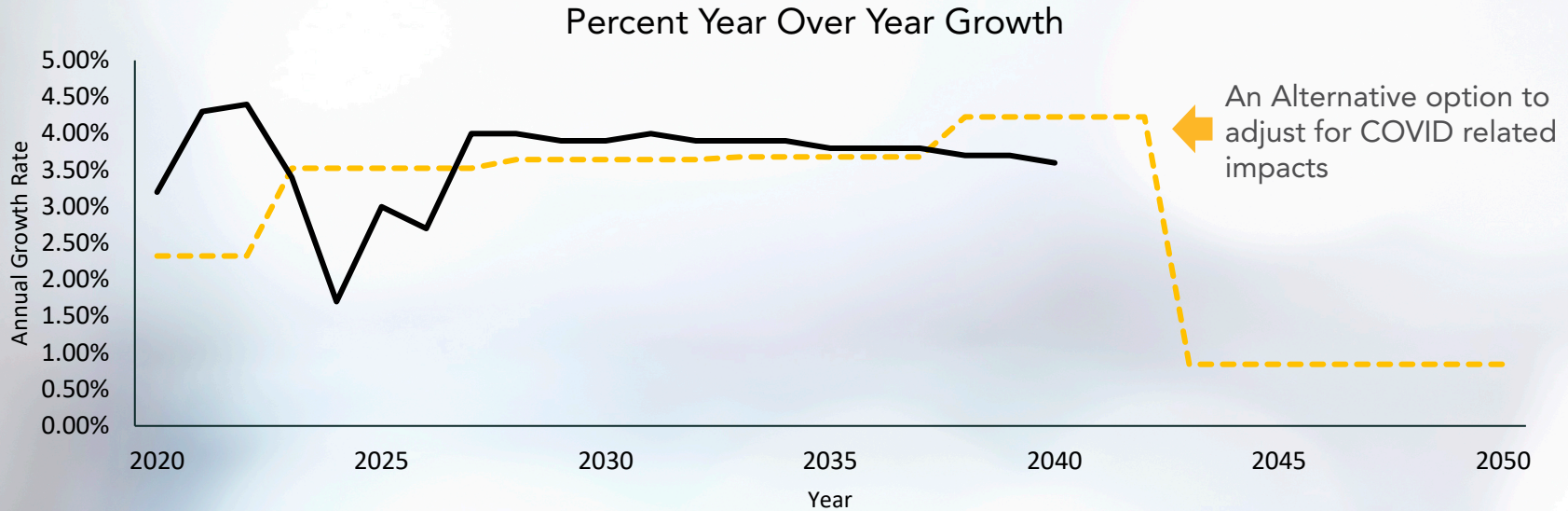
- Using 2019 Tioga Report prepared for Bay Conservation and Development Condition, focused specifically on Port of Oakland

Percent Year Over Year Growth



# Ports of Los Angeles and Long Beach

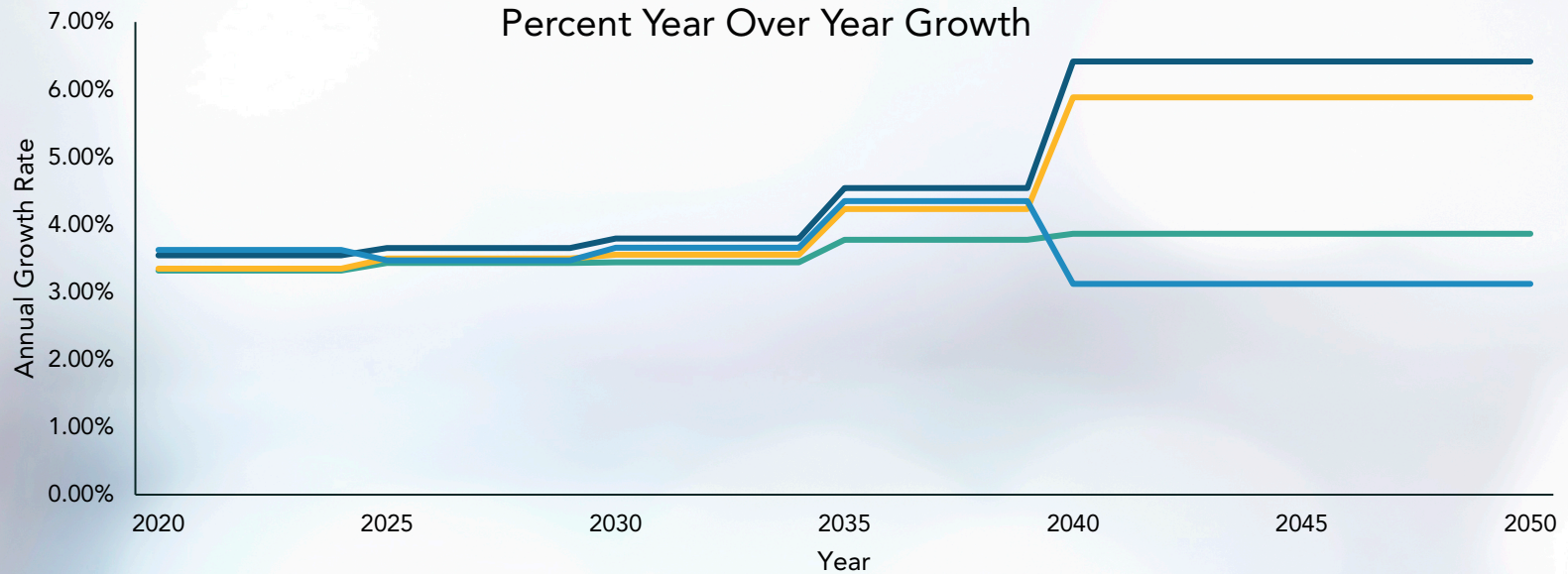
- Using Mercator slow-growth assessment, following discussions with ports and South Coast AQMD





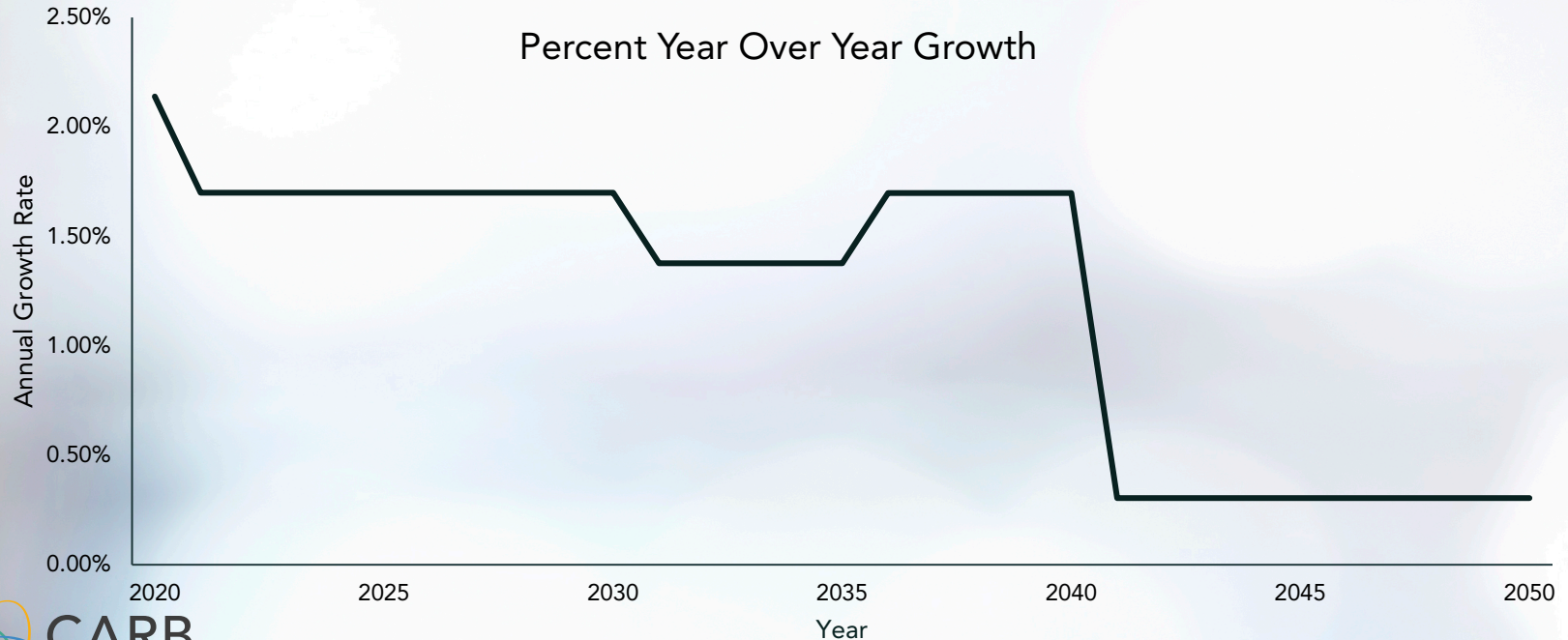
# Smaller Ports Based on Region

- Using Freight Analysis Framework (FAF) low growth scenario for remaining areas



# Rail Yards

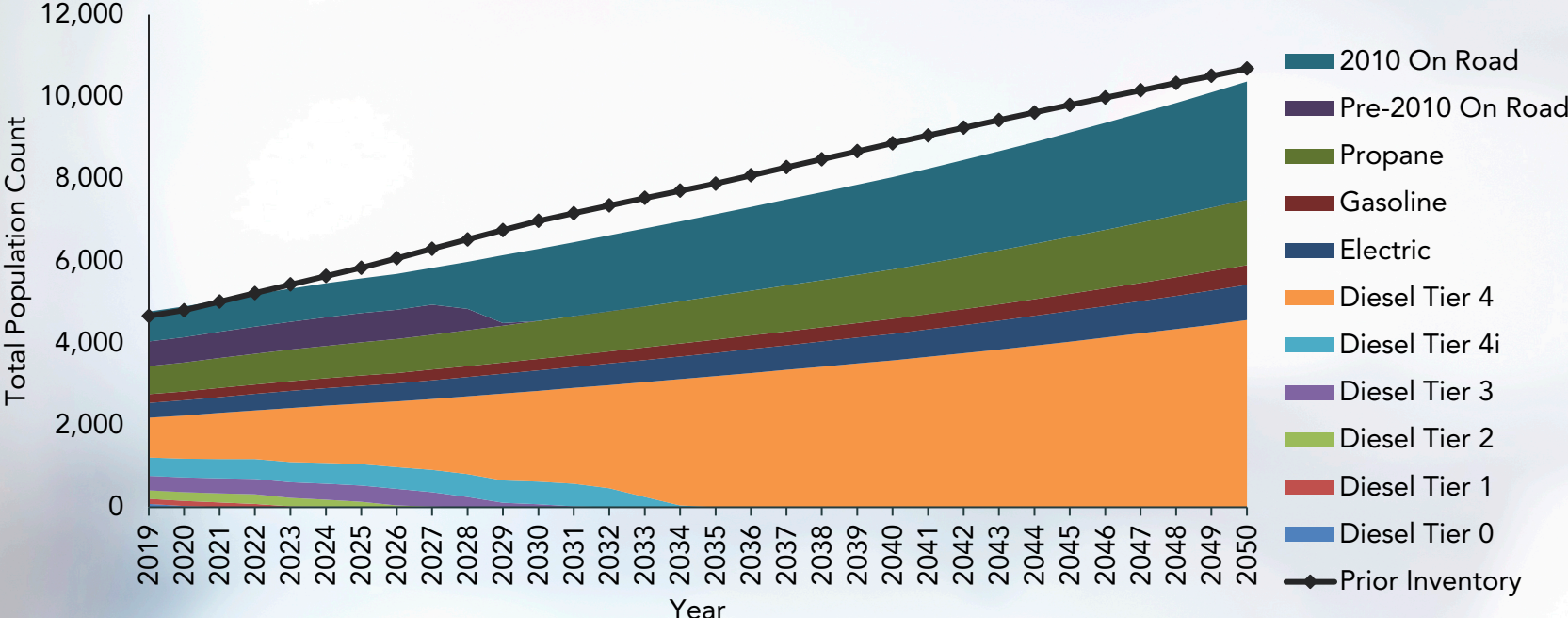
- Using Freight Analysis Framework (FAF) growth scenario for railyard growth





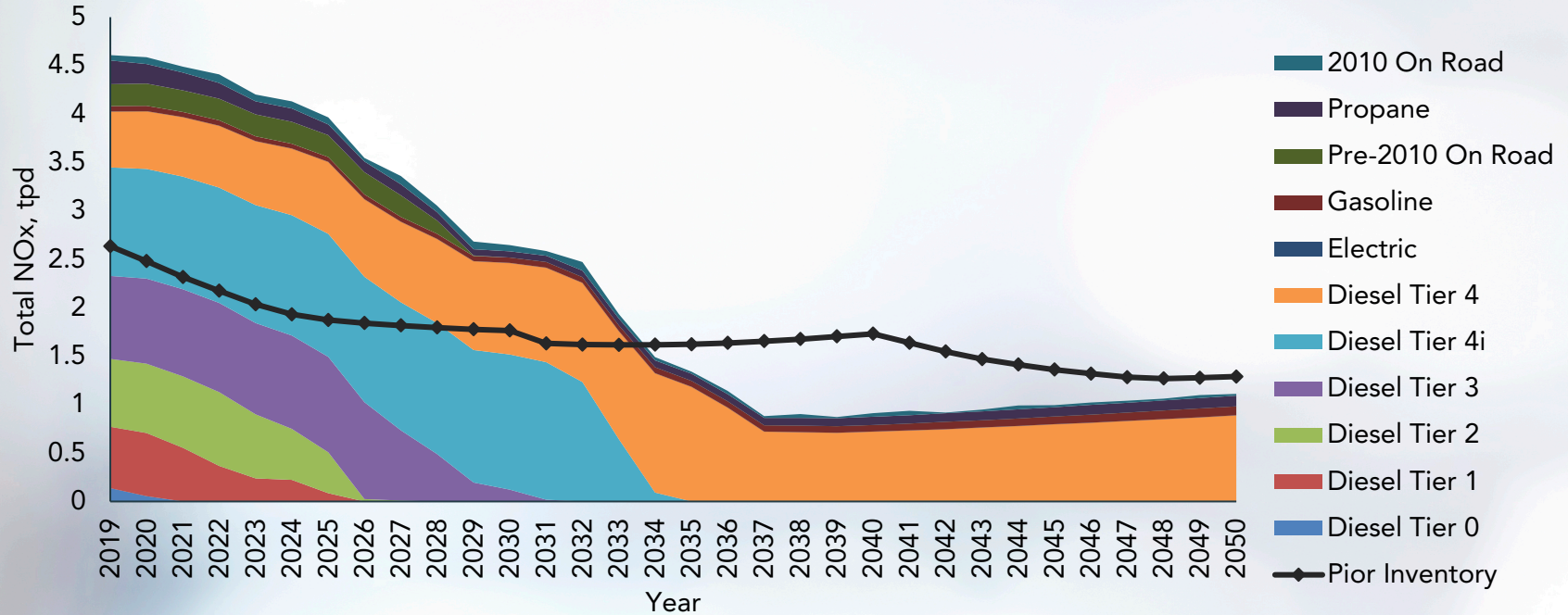
# Cargo Handling Equipment (CHE) **Emissions Results**

# Statewide CHE Population

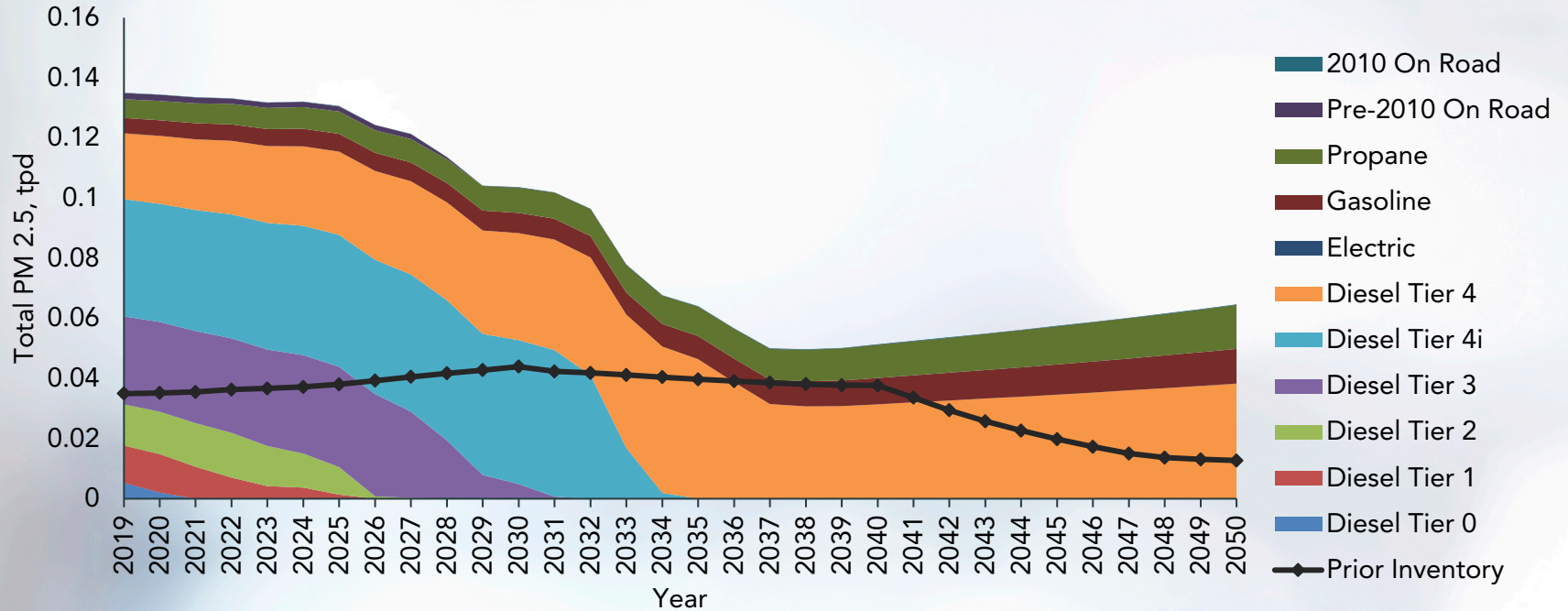




# Statewide NOx

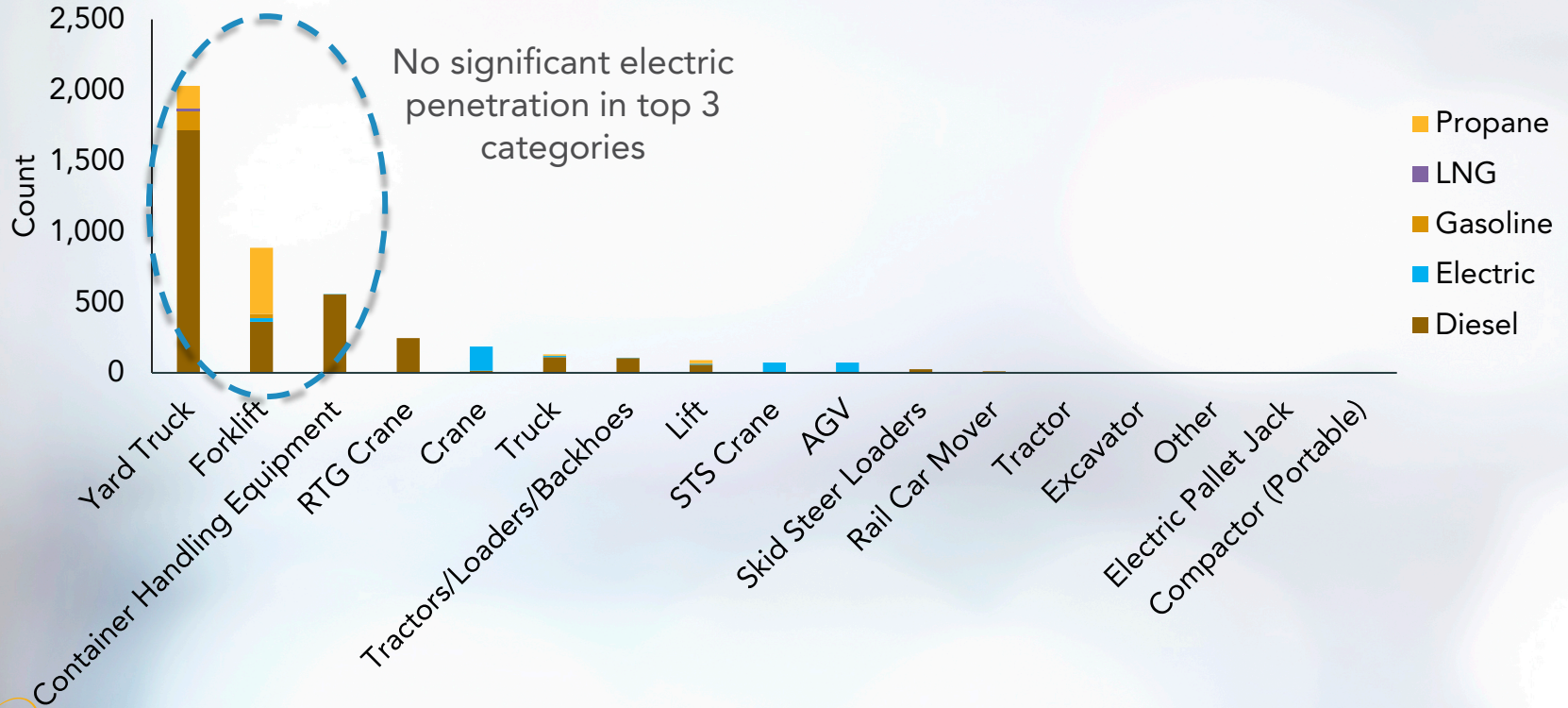


# Statewide PM 2.5



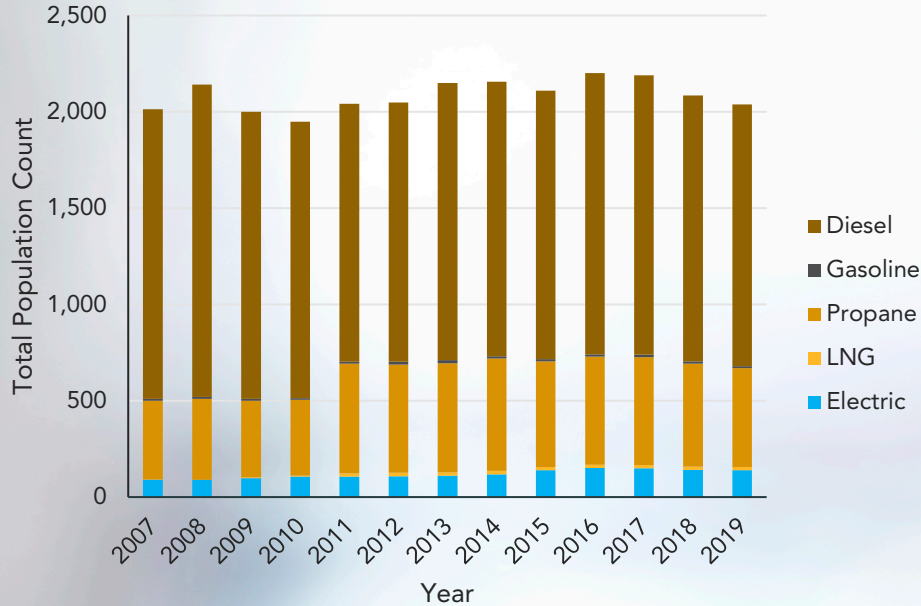


# 2019 Population by Fuel Type

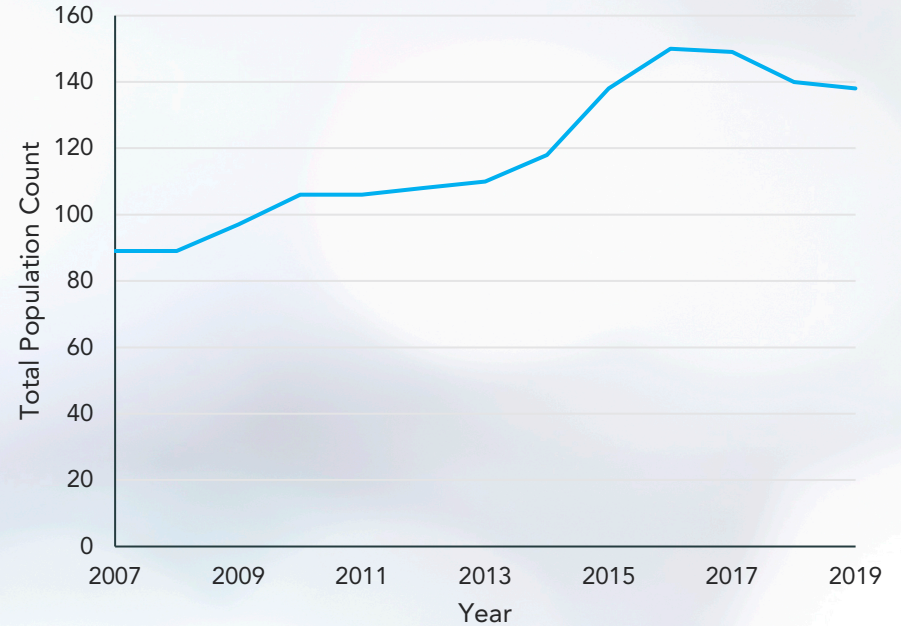


# Voluntary Electrification - POLA

## Equipment by Fuel Type



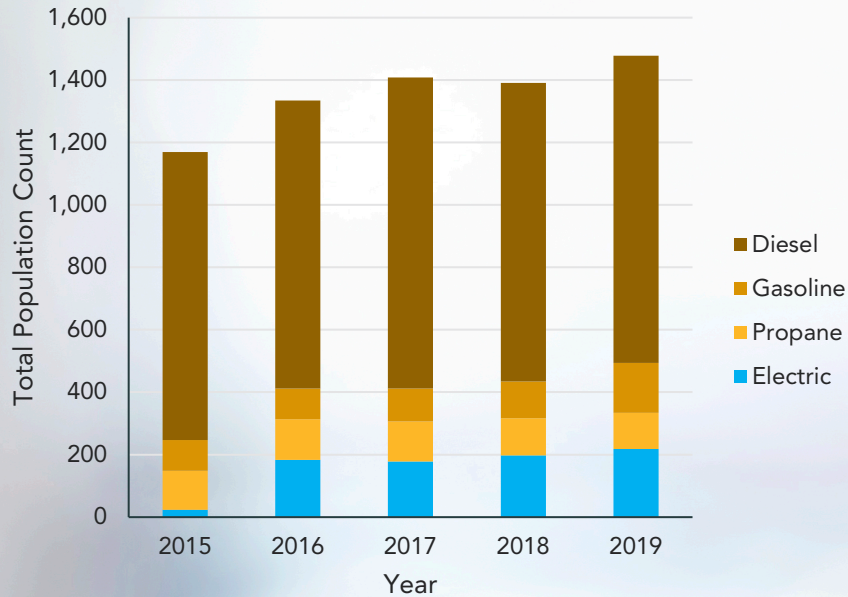
## Electric



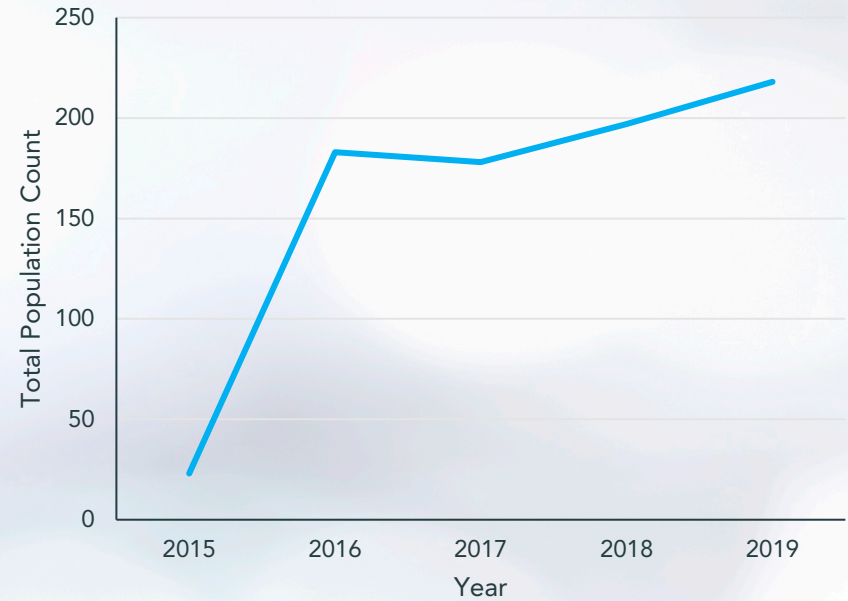


# Voluntary Electrification - POLB

## Equipment by Fuel Type



## Electric



# CHE Inventory Summary

- Electrification not broadly expanding without requirements
- Gasoline, Propane, Electric, LNG equipment is included in the inventory update
- Ports have older equipment inventory than predicted, fewer Tier 4 final and 2010+ on-road engines





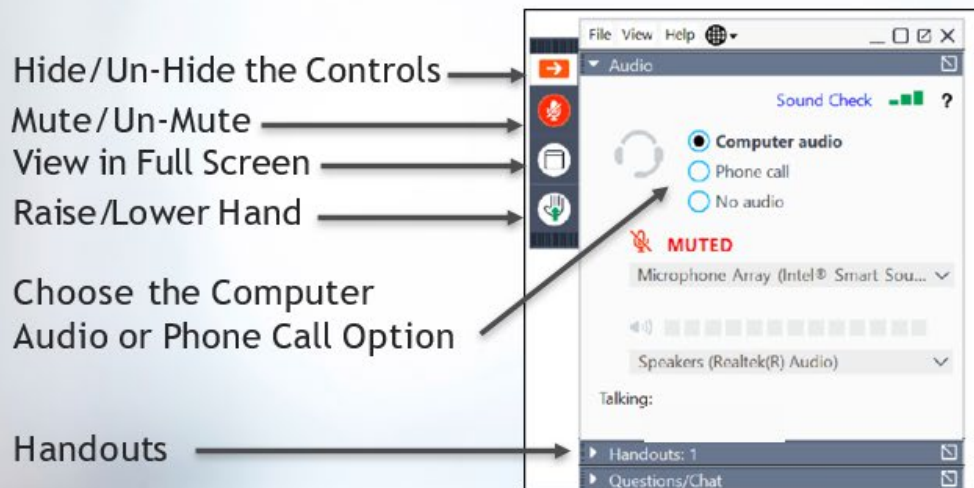
# What Are Your Thoughts

- **Electrification Trends:** There is no obvious trend for increased electrification of Cargo Handling Equipment (CHE) in California. Are there identifiable plans that suggest increases in electrification?
- **Forecasted Freight Growth Rates:** Considering recent congestions at the ports, what are your thoughts about the short term and long-term growth rate assumptions embedded in this draft?
- **Load and Emissions Factors:** Future updates may include PEMS data sampled from approximately 10 units, are there other data sources to consider?
- **Non-Diesel Equipment:** Outside of POLA, POLB and POAK, non-diesel equipment is not reported to either CARB or any port bodies that we are aware of, so may be missing. Are there data sources available?

Send your comments and suggestions to: [Elizabeth.Mazmanian@arb.ca.gov](mailto:Elizabeth.Mazmanian@arb.ca.gov)

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Ocean-Going Vessels (OGV)

# Background and Major Updates

# OGV Inventory

- OGV inventory covers marine vessels over 400 feet, 10,000 tons, with large engine displacement
- At-Berth inventory updated in 2020
- Inventory updates for transit, maneuvering, anchorage are needed
  - 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





# Modes of Operation

- **At-Berth:** Operations while moored to a dock
- **Anchorage:** Operations when vessel drops anchor near the port
- **Maneuvering:** Slow speed vessel operations while in port areas
- **Transit:** Vessel operations between ports



Ocean-Going Vessels (OGV)

# Data Sources and Method



# Data Sources: Overview

## Vessel Activity

2020 AIS Records

## Emission Factors

2020 EPA EFs

## Engine Defaults

2020 IHS Records

2020 Starcrest

2019 Industry

## Forecasting

FAF 4.4

Historical Port Calls

Mercator Report

2020 Tioga Report

## Characteristics

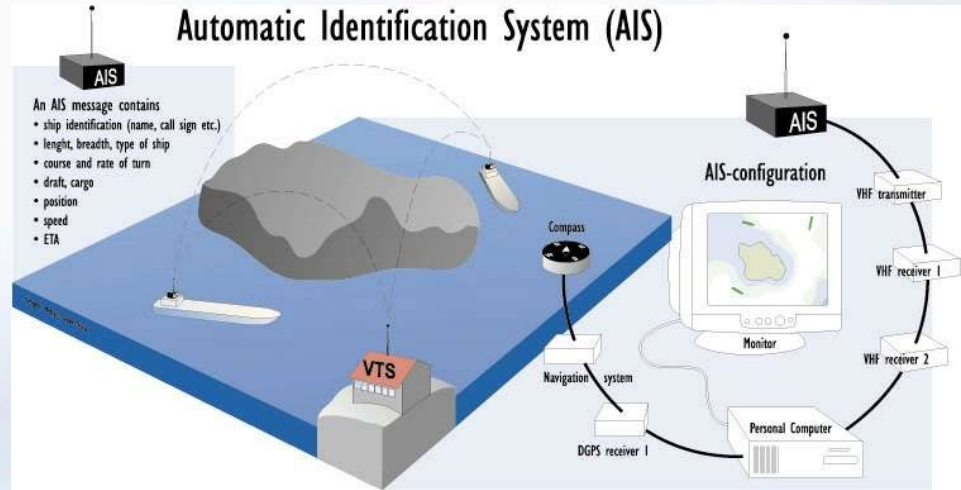
2020 IHS Records

## Control Measures

2019 Compliance

# Activity Data Source: AIS

- Automatic Identification System (AIS) is an onboard navigation safety device that all OGVs are required to equip for improved navigation and collision avoidance.
- AIS reports provide vessel location and movement information in US waterways.
- This massive data source is made public through collaboration of the USCG, NOAA, and the Bureau of Ocean and Energy Management (BOEM) via Marine Cadastre.

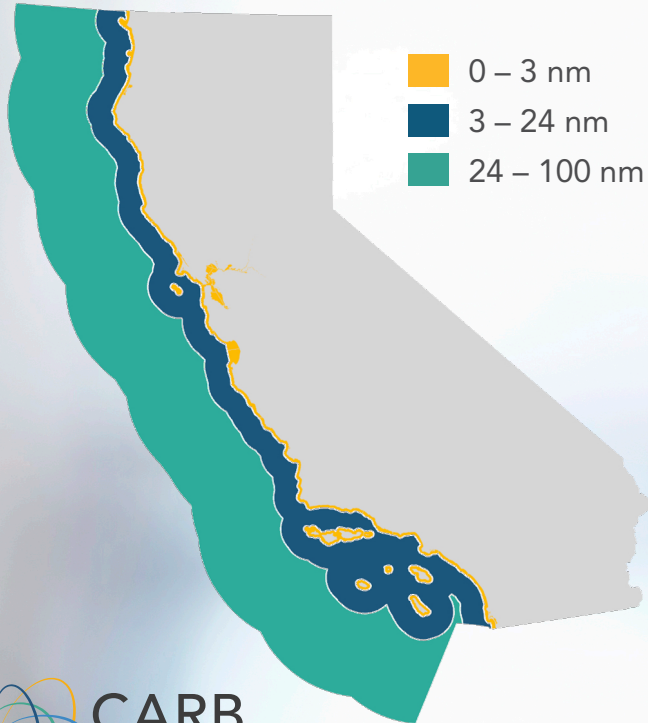


<https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2020/index.html>



# Geographic Domain

## Statewide

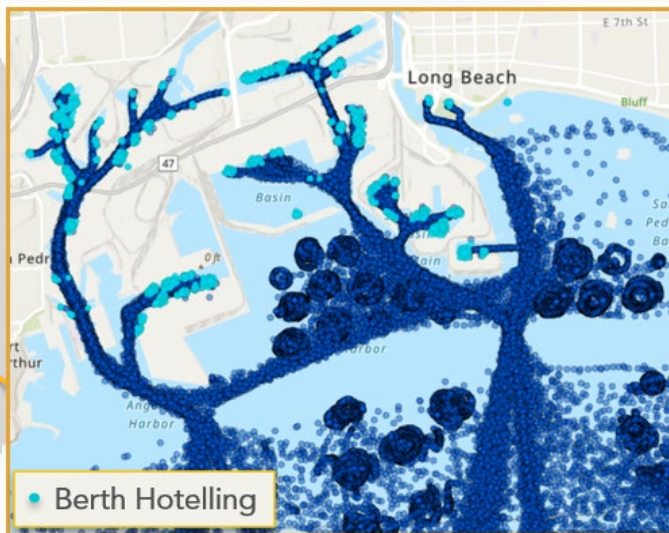


## South Coast



# Processing AIS

- OGV records are matched with EPA emissions factors and default loads by vessel type, engine type, and activity.
- Activity defined by location and speed.



## Activity Modes:

### **Berth Hotelling**

- Within 4 km of port, not in anchorage zone, and speed of 0 kts

### **Anchorage Hotelling**

- Within anchorage zone with speed < 1 kts

### **Maneuvering**

- Within 3 nm, speed < 3 kts

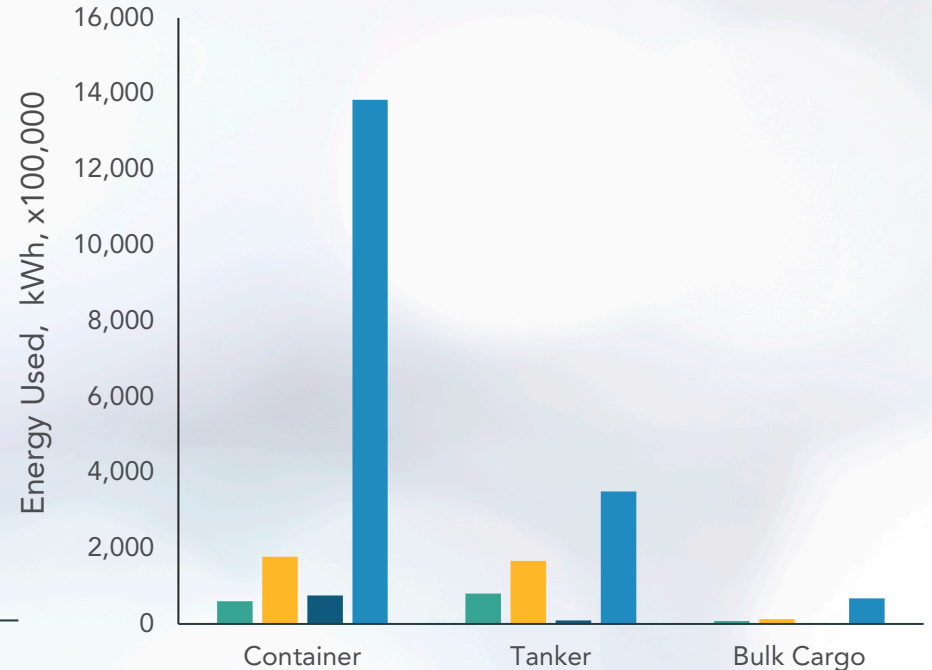
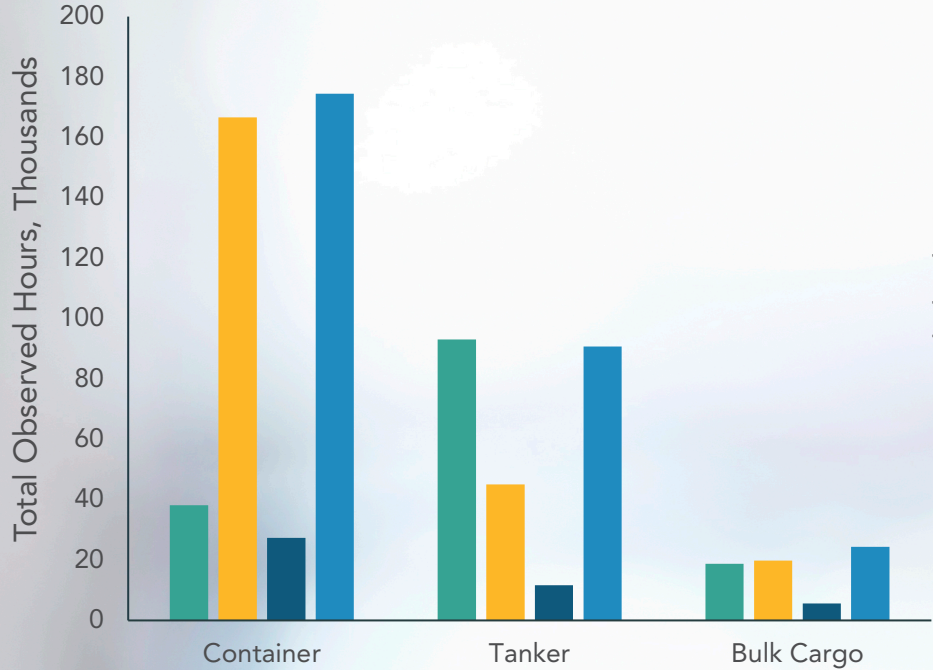
\* This figure depicts one month of cleaned AIS data for illustration purposes only.



# Statewide 2020 OGV by Type

## Out to 24 nm from shoreline

■ Anchorage Hotelling   
 ■ Berth Hotelling   
 ■ Maneuvering   
 ■ Transit



# Engine Default Loads

- Boiler proposed default values from Ports' emissions inventory (developed by Starcrest) were used directly for all vessels.
- Tanker loading and discharge activities in Richmond were adjusted with custom power operations based on 2019 industry data.
- Auxiliary engine max power was derived from **IHS annual averages** by type and size, then combined with **Starcrest** loads by activity.

$$\text{Operational kW} = [\text{engine load}] * [\text{Max aux power}]$$



# Example: Applying Aux Loads

On average, IHS registry shows **3180 kW** max aux power for all 8,000 TEU capacity containerhips identified in 2020 AIS records.

## Records with known max aux power:

2020 activity record shows an 8,401 TEU capacity containerhip at anchor with max installed aux engine power of **3,300 kW**. The estimated operational kW for aux engines for that record would be **1,298 kW**.

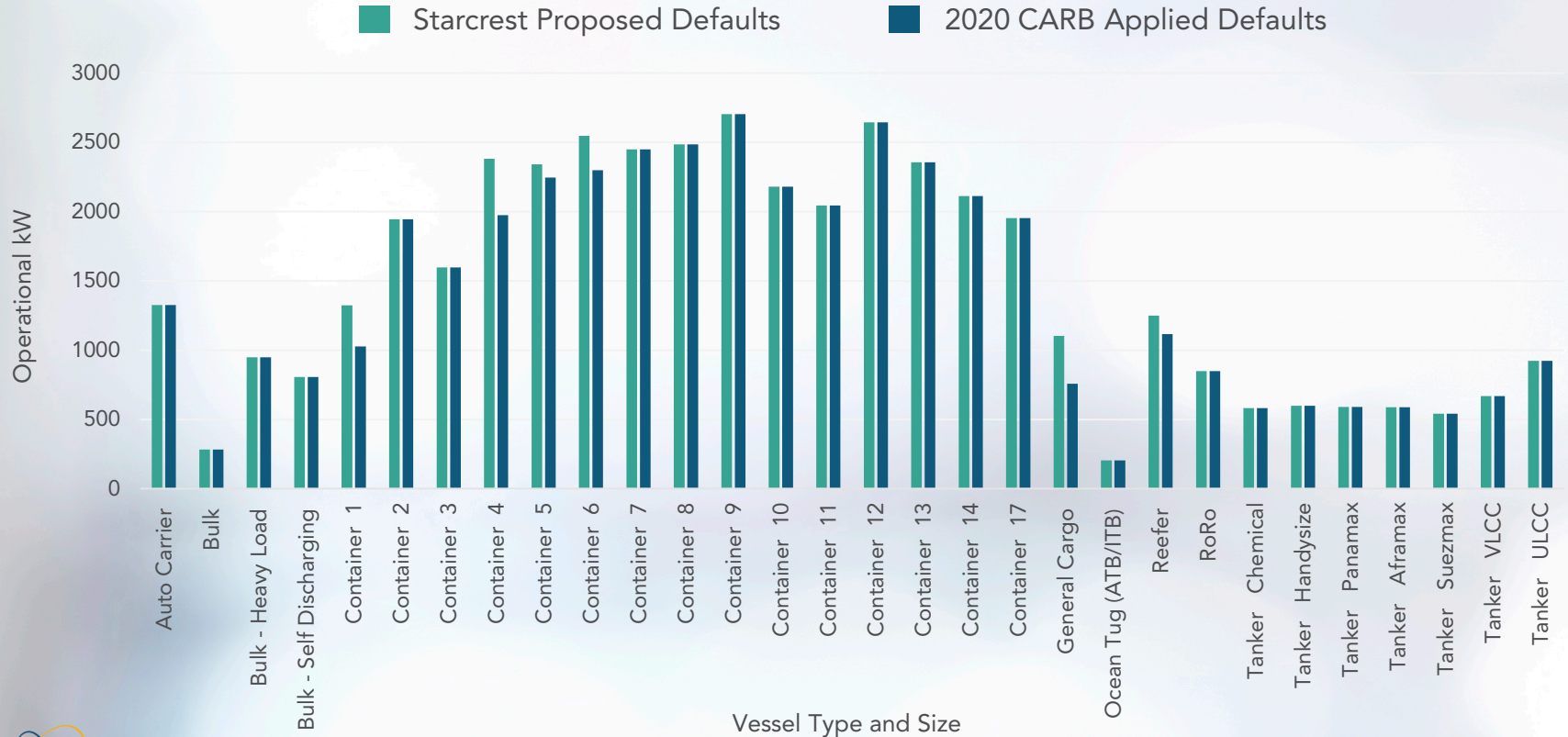
Activity	Starcrest Default	Fractional Load = (Starcrest/IHS)
Transit	1,553	0.4885
Maneuvering	2,485.5	0.7818
Berth	1,116.5	0.3512
Anchorage	1,250.5	0.3933

## Records without known max aux power:

Using **default values** for operating power instead of adjusting unique vessel power. In example record above, the estimated operational aux power in unknown max power case would be **1,250.5 kW**.

Statewide average max power of some vessel types and sizes were lower than Starcrest reported defaults. Fractional loads were adjusted to not exceed 1 for those types and sizes, as shown in following slides.

# Aux Operational kW: Maneuvering

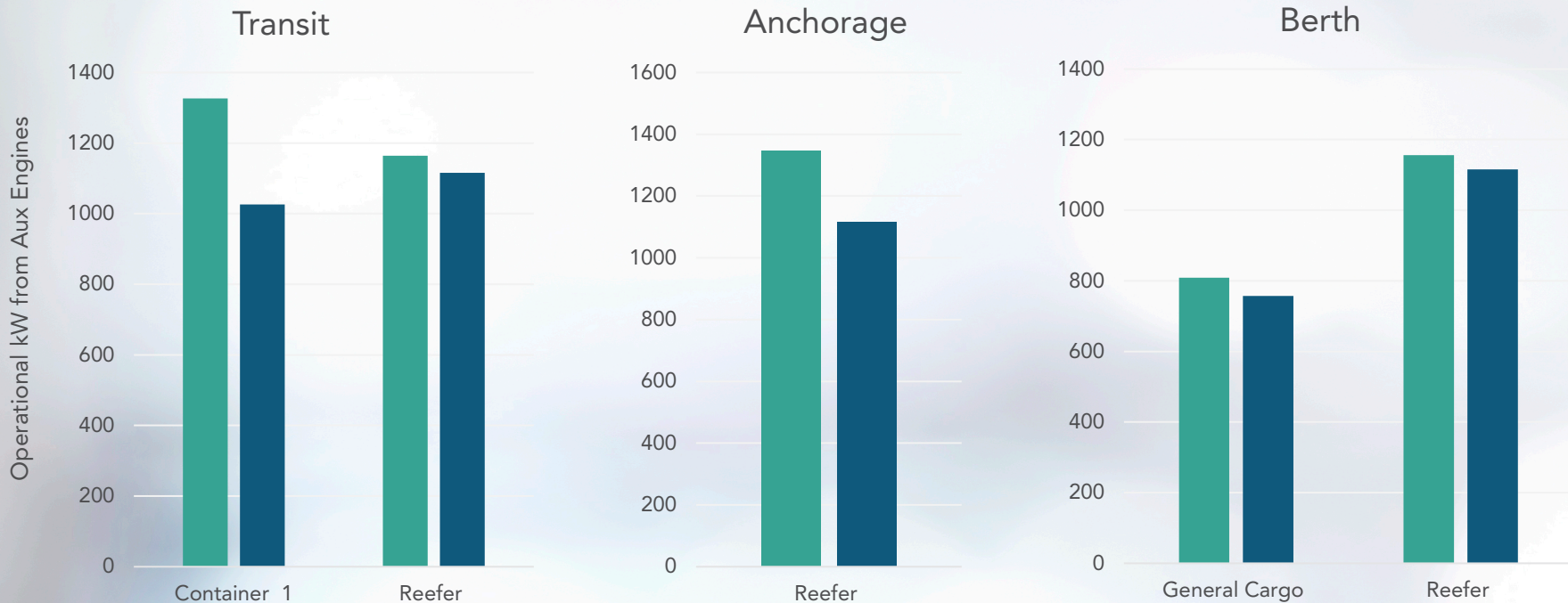




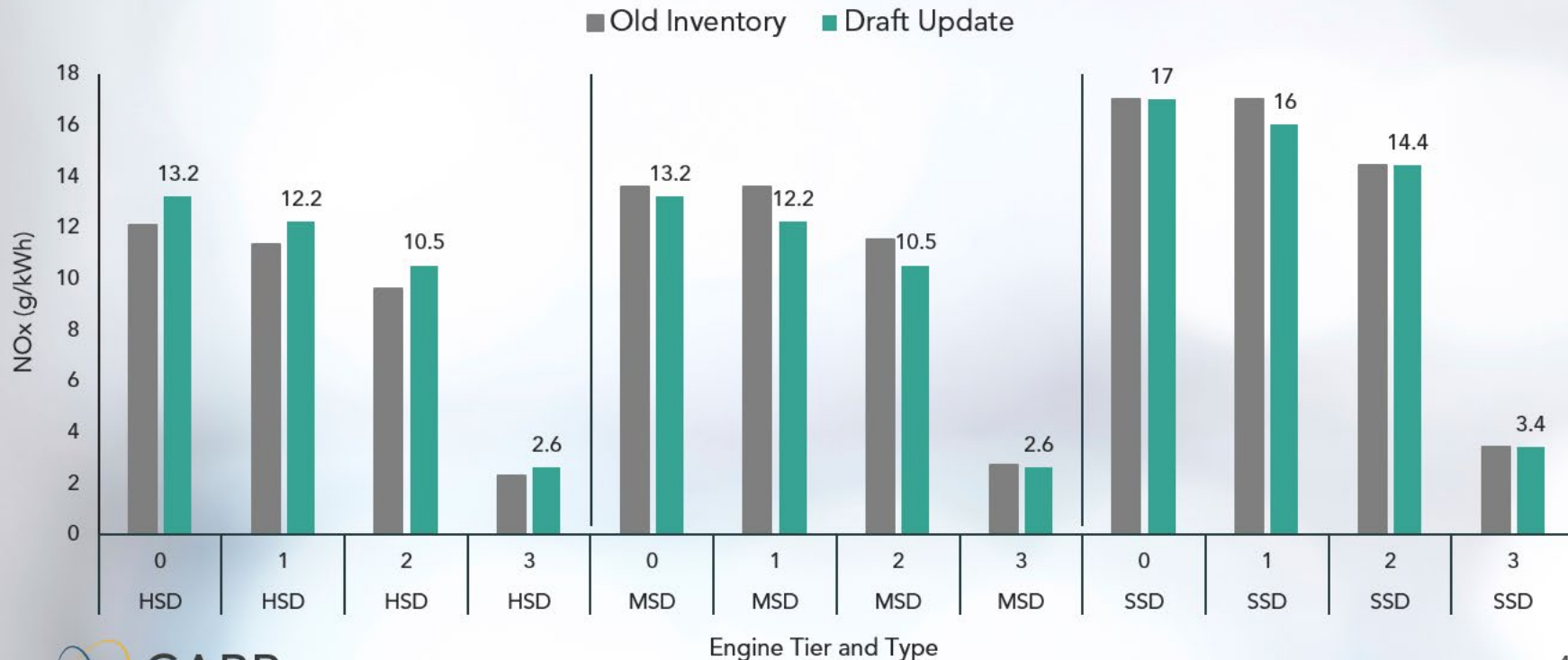
# Aux Operational kW: Other Modes

■ Starcrest Proposed Defaults

■ 2020 CARB Applied Defaults

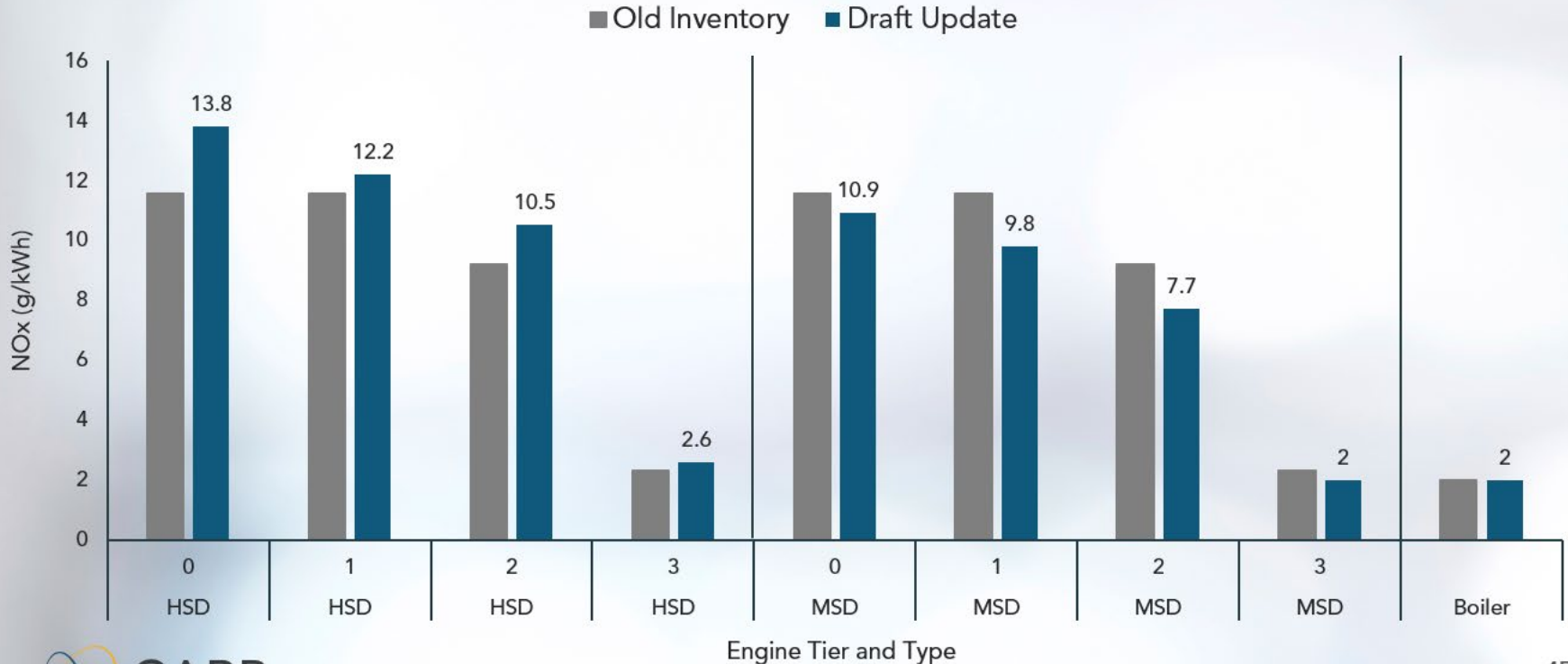


# NOx Emissions Factors Comparison: Main Engines

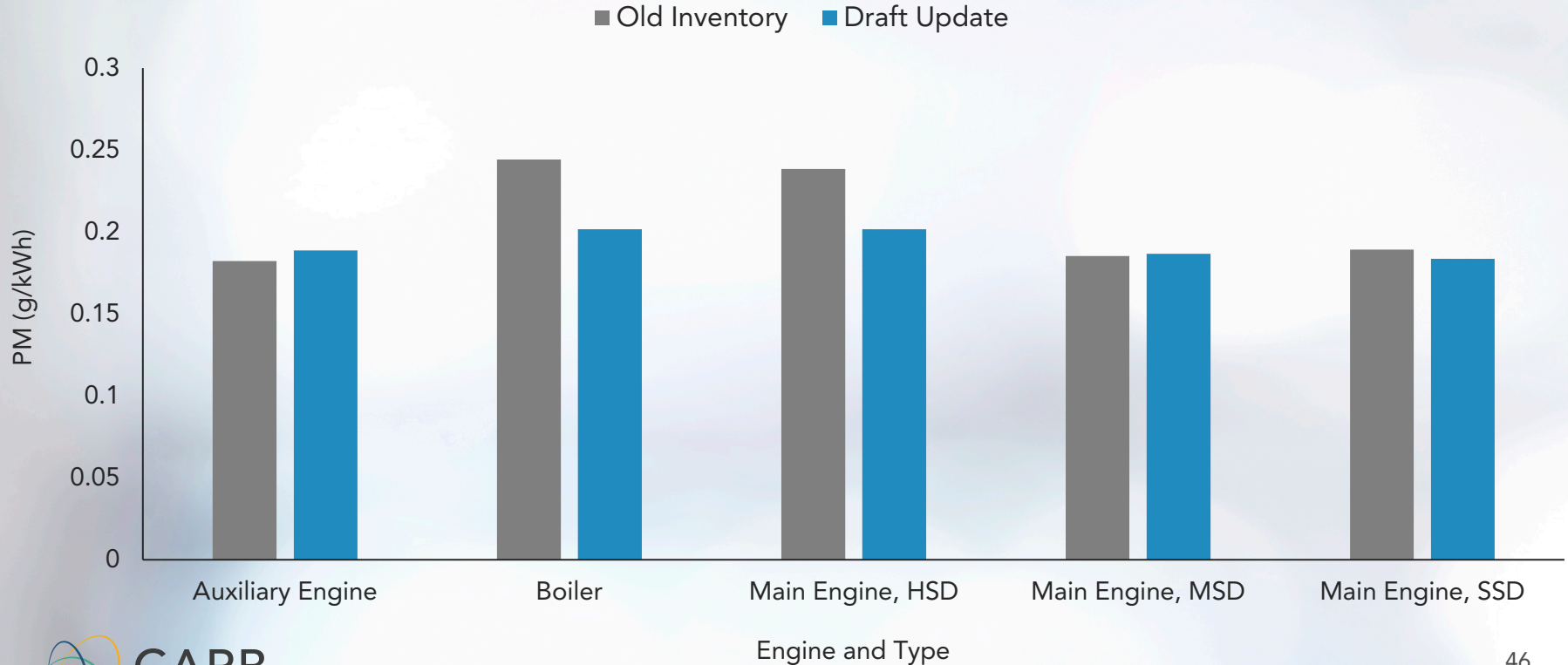




# NOx Emissions Factors Comparison: Auxiliary Engines and Boilers



# PM Emissions Factors Comparison: Distillate Fueled Engines and Boilers



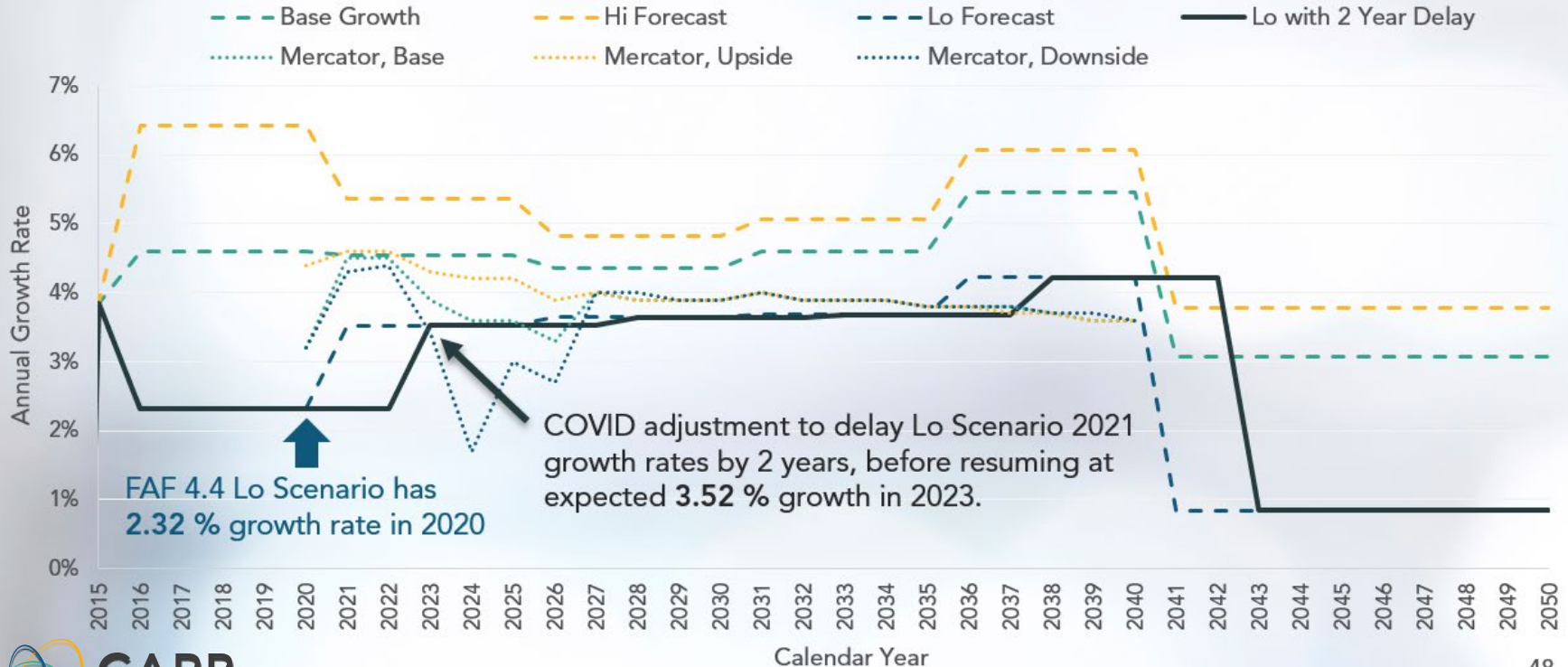


Ocean-Going Vessels (OGV)

# Forecasting Assumptions

# Forecasting Data Source: FAF

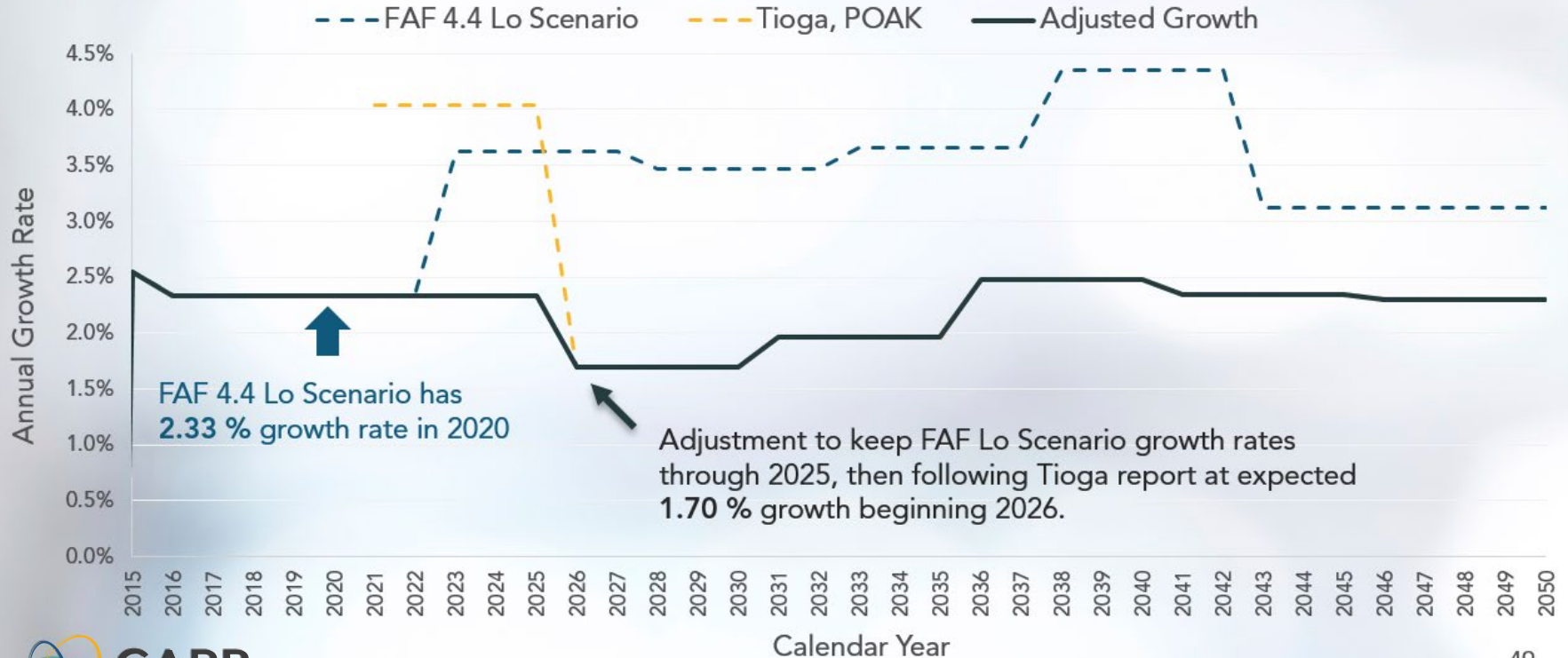
## Containership FAF4.4 Growth in LA Region





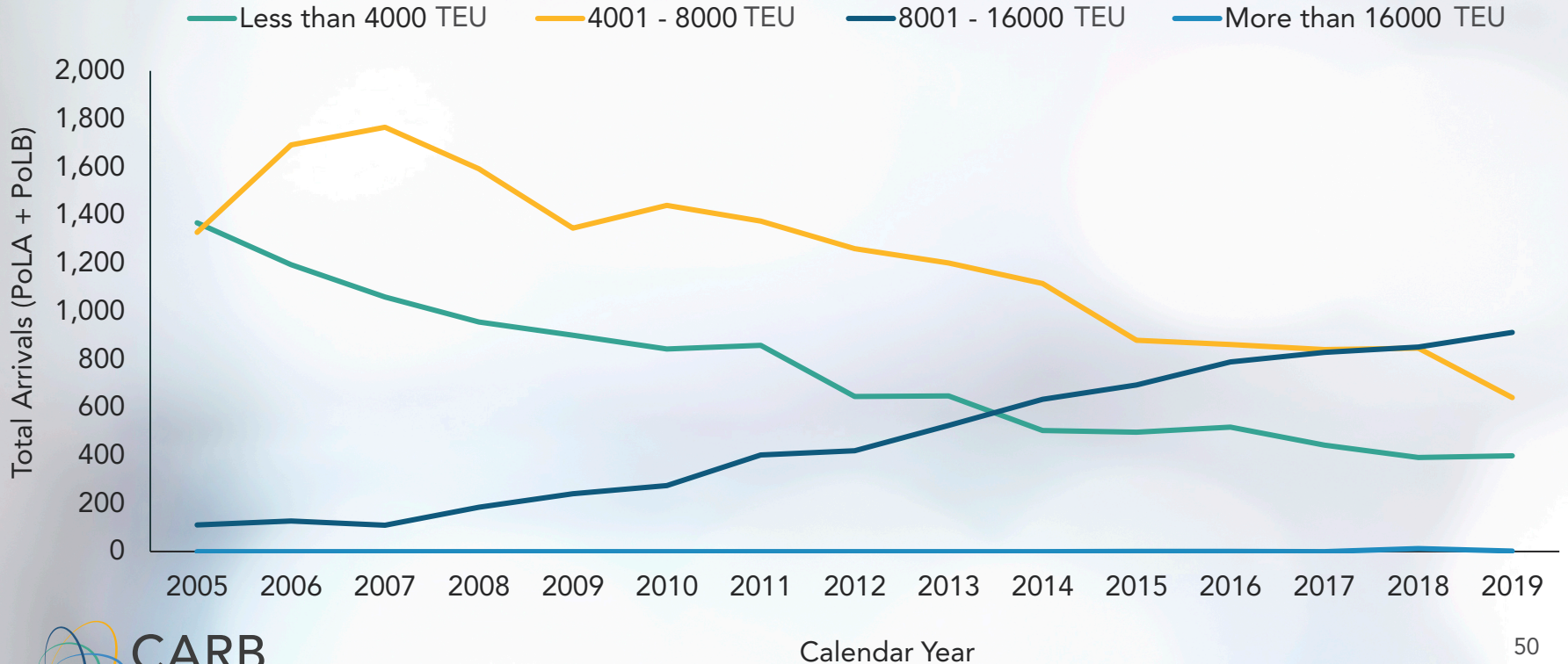
# Forecasting Data Source: Tioga

## Containership Growth in SF Region



# Containership Capacity Trends

Containerships Calling to SPBP Have Larger Capacity Over Last 14 Years

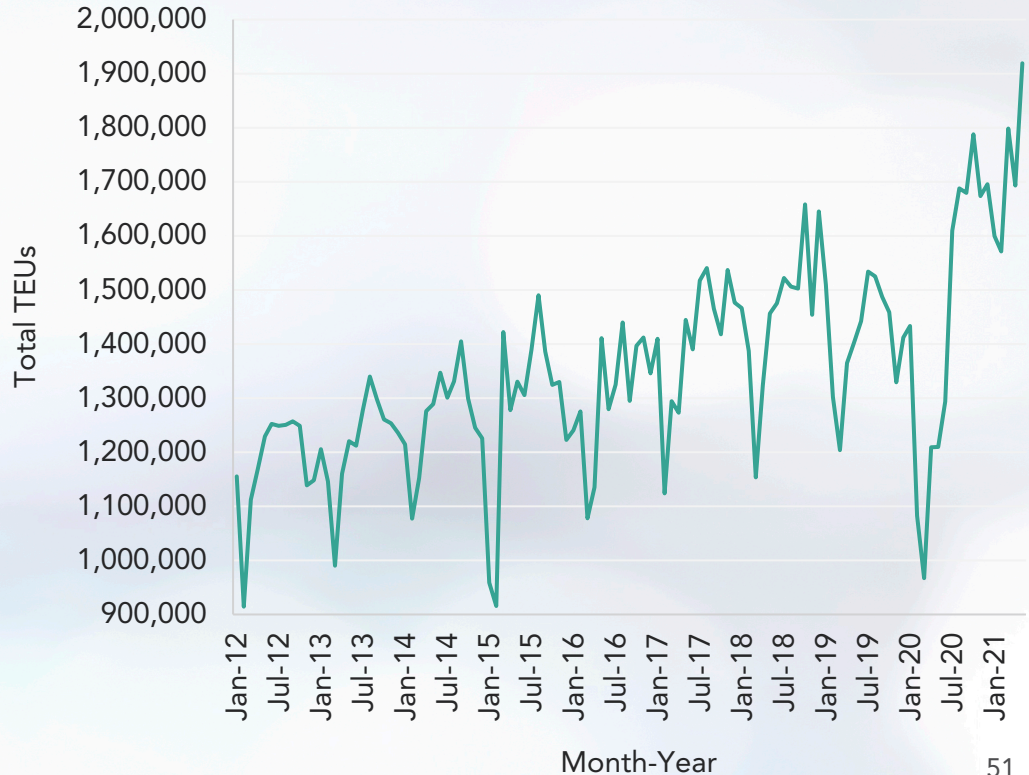




# Containership Capacity Adjustment

- TEU and freight growth from 2012 have largely been met by increase in vessel sizes
- Container vessels above 8000 TEU capacity were grown enough to meet increased freight forecast from FAF4.4 slow growth scenario.
- Container vessels below 8000 maintained at current capacity, no growth

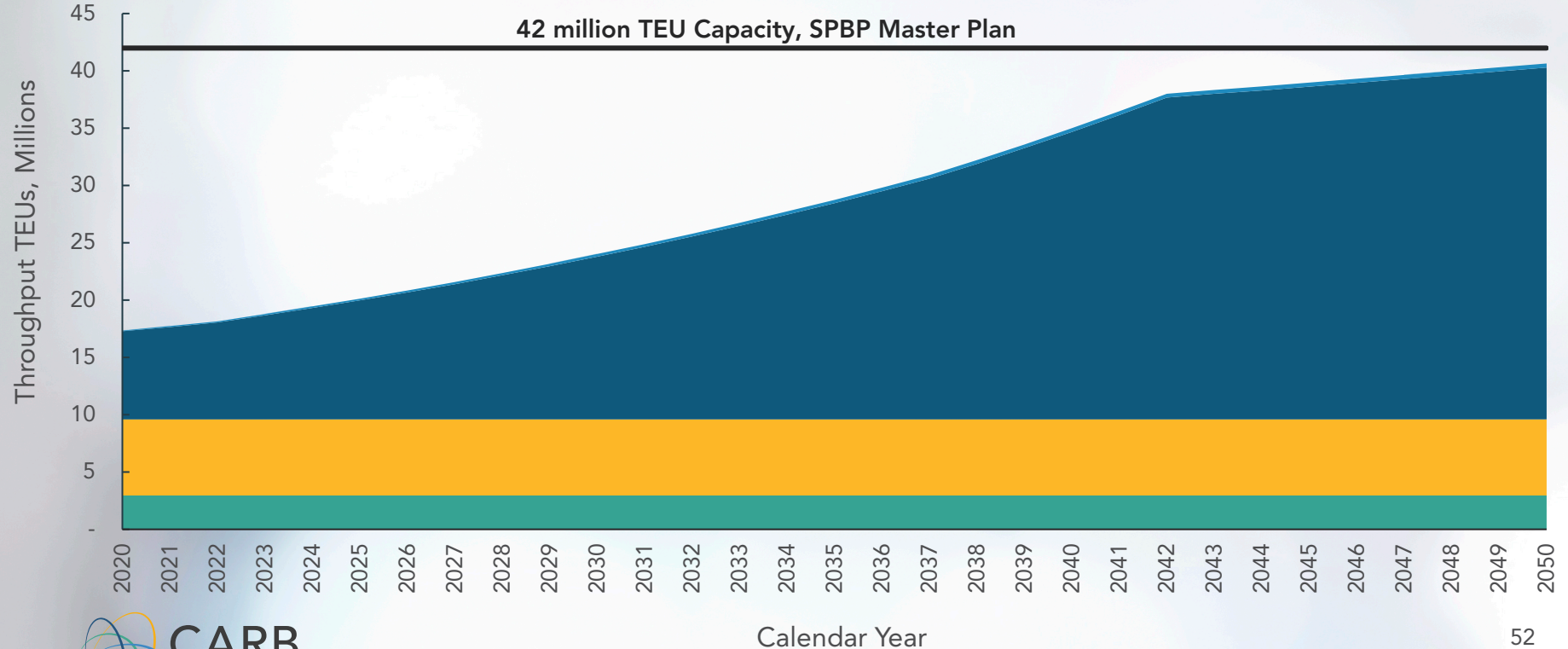
SPBP Historical TEU, Monthly Jan 2012 - May 2021



# SPBP TEU Capacity by Size Bin Group

■ Less than 4000 TEU   ■ 4001 - 8000 TEU   ■ 8001 - 16000 TEU   ■ More than 16000 TEU

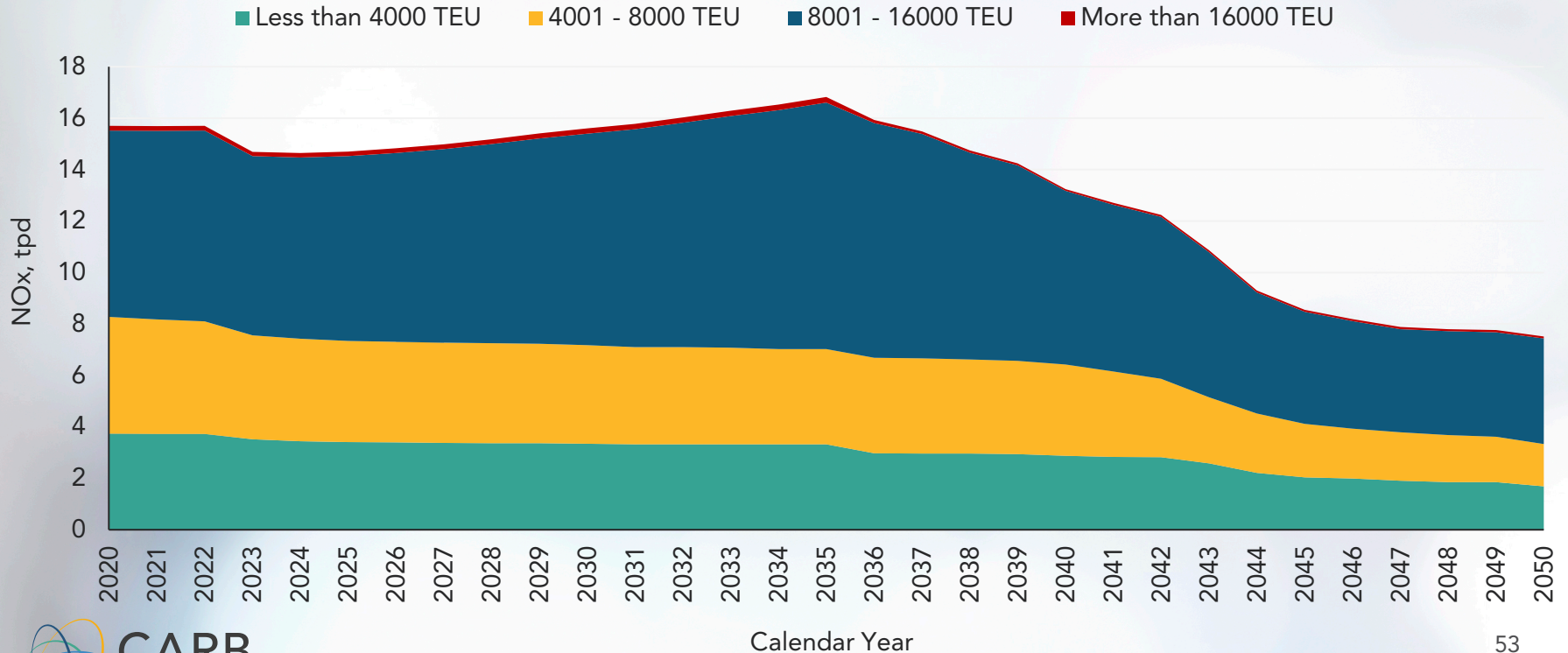
42 million TEU Capacity, SPBP Master Plan





# Containership Capacity NOx Impacts

South Coast Containership NOx by Size Bin Group



# Tier Assumptions

- Based on Mercator report, growth of Tier III vessels delayed until 2030.
- Main engine duty cycle adjustment: All Tier III main engines operating at less than 25% load are assumed to be operating at Tier II levels.

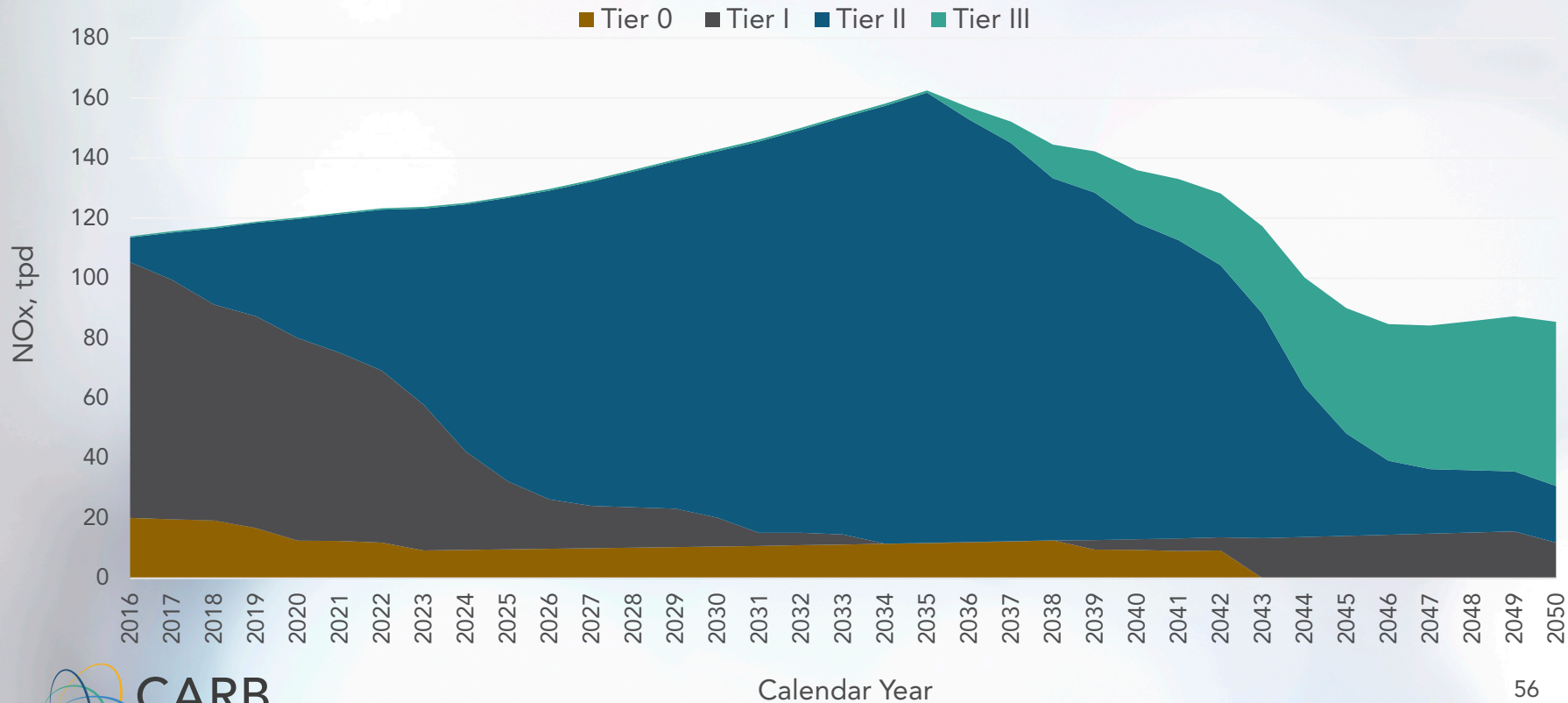


Ocean-Going Vessels (OGV)

# Statewide Emissions Impacts

# Statewide Containership NOx by Tier

Out to 100 nm from shoreline

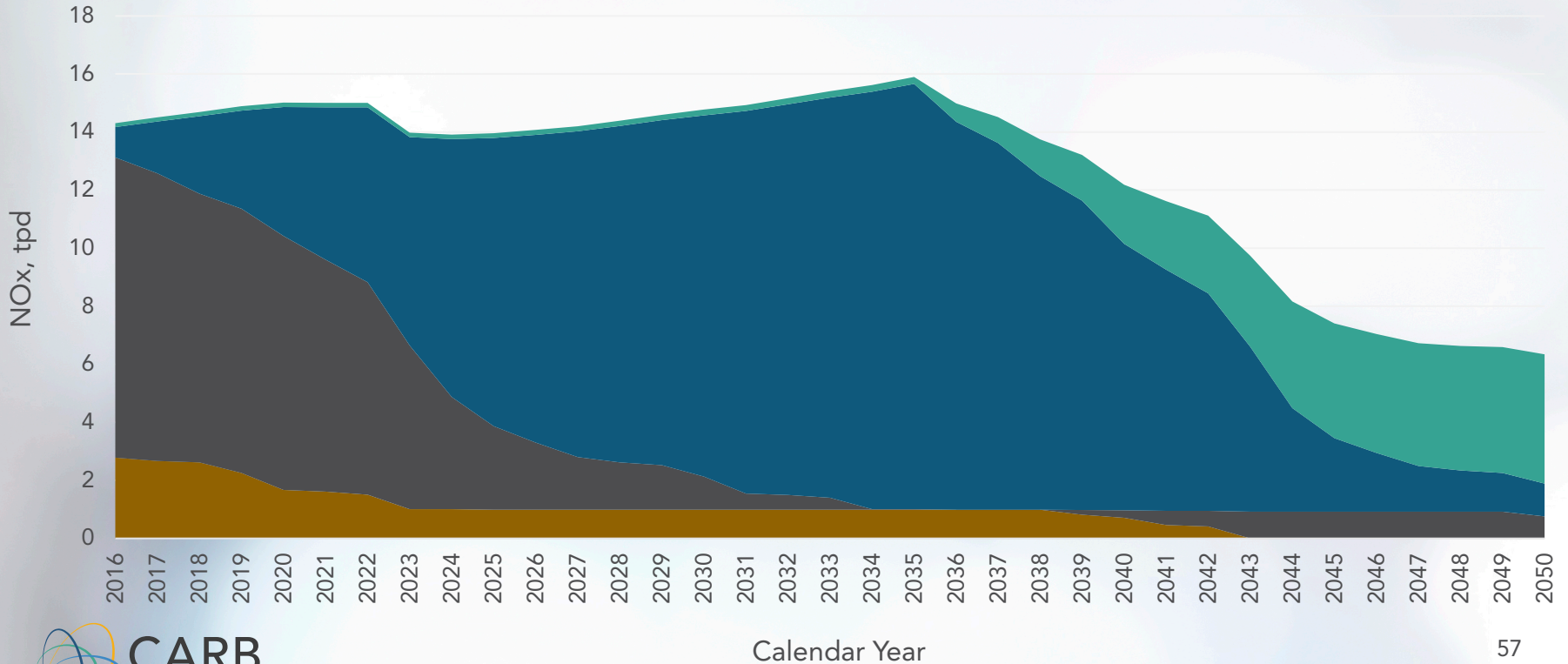




# South Coast Containership NOx by Tier

Out to 100 nm from shoreline

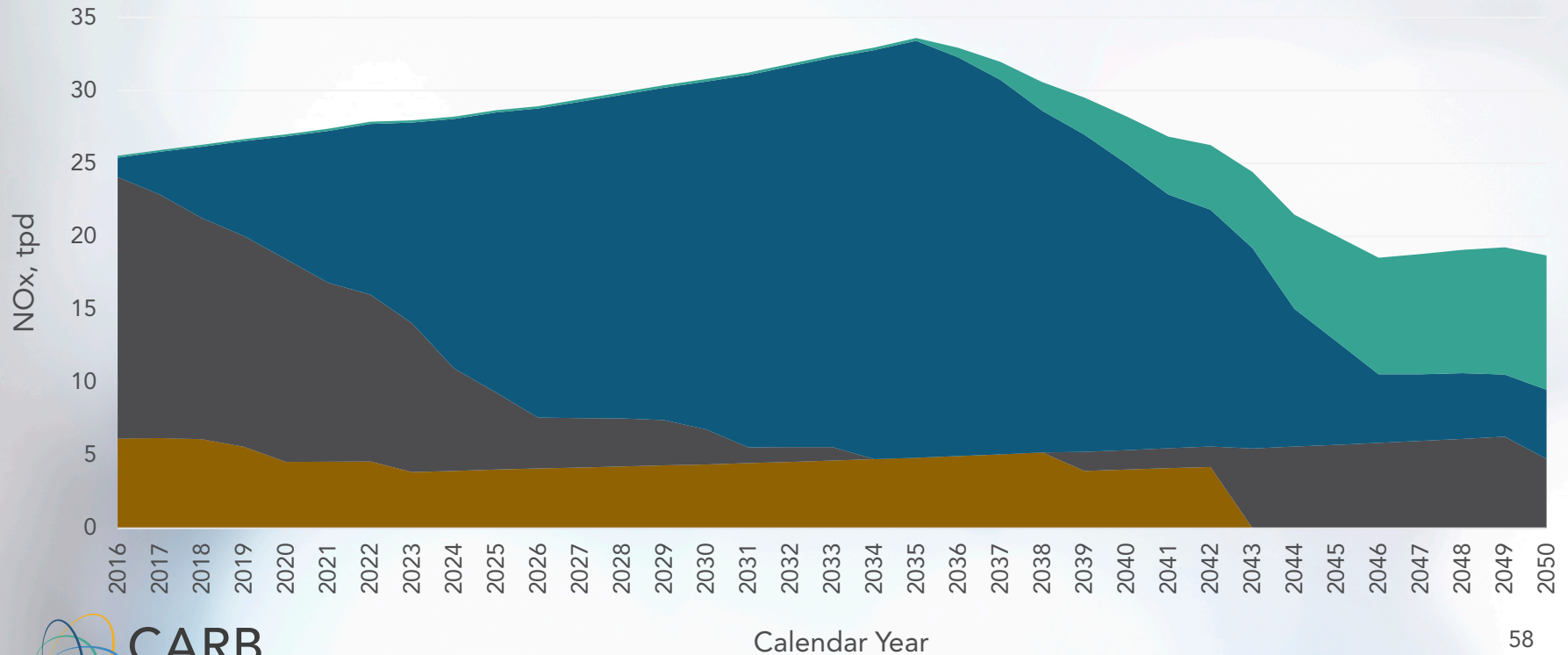
■ Tier 0 ■ Tier I ■ Tier II ■ Tier III



# Bay Area Containership NOx by Tier

Out to 100 nm from shoreline

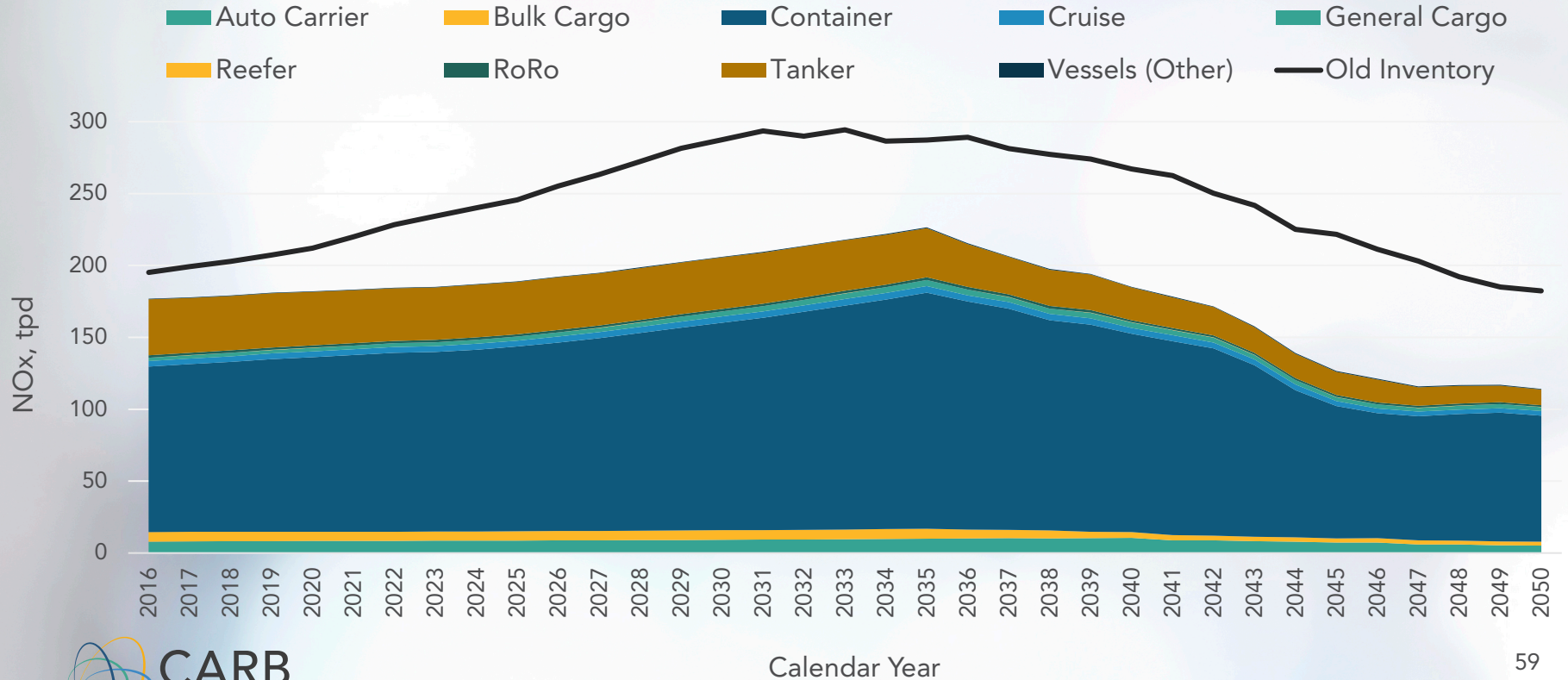
■ Tier 0 ■ Tier I ■ Tier II ■ Tier III





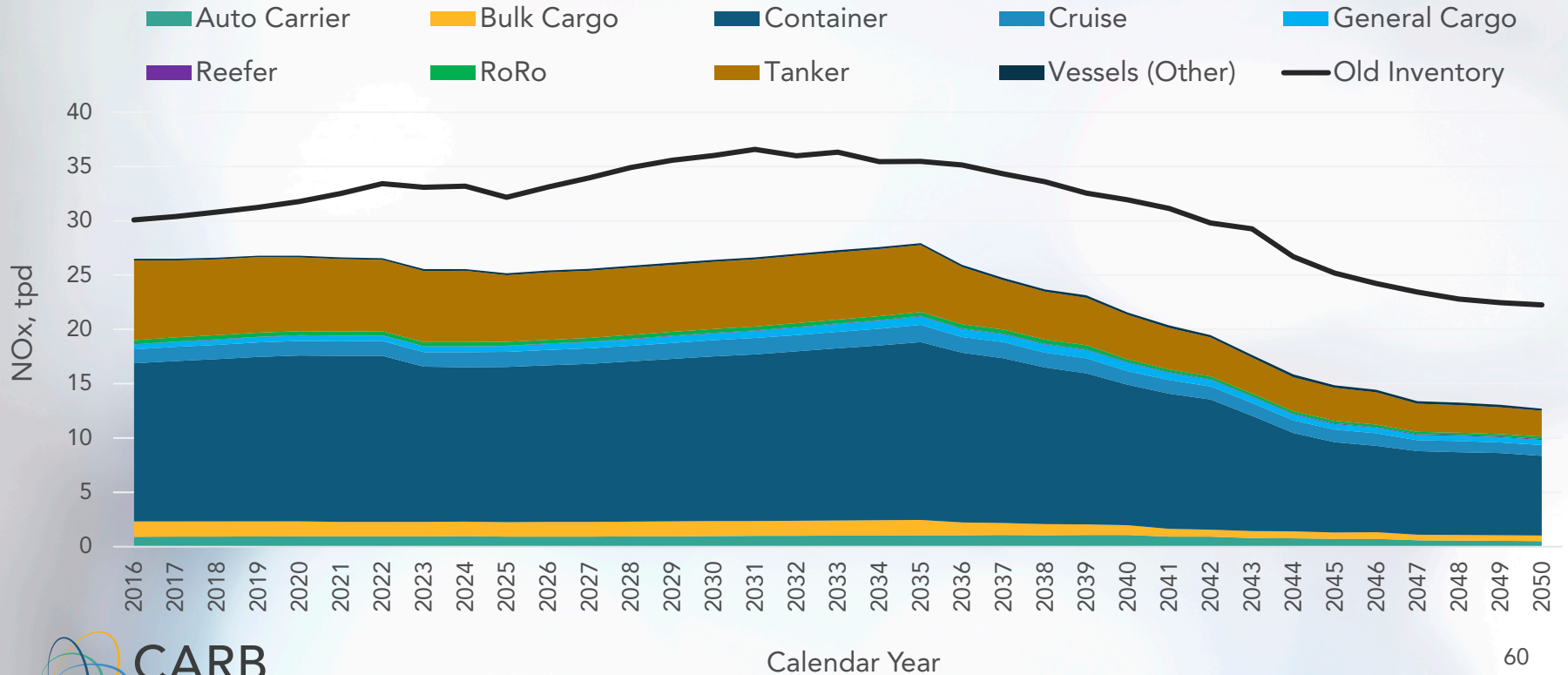
# Statewide NOx Emissions Out to 100 nm

Draft AIS Update by Vessel Type



# South Coast NOx Emissions Out to 24 nm

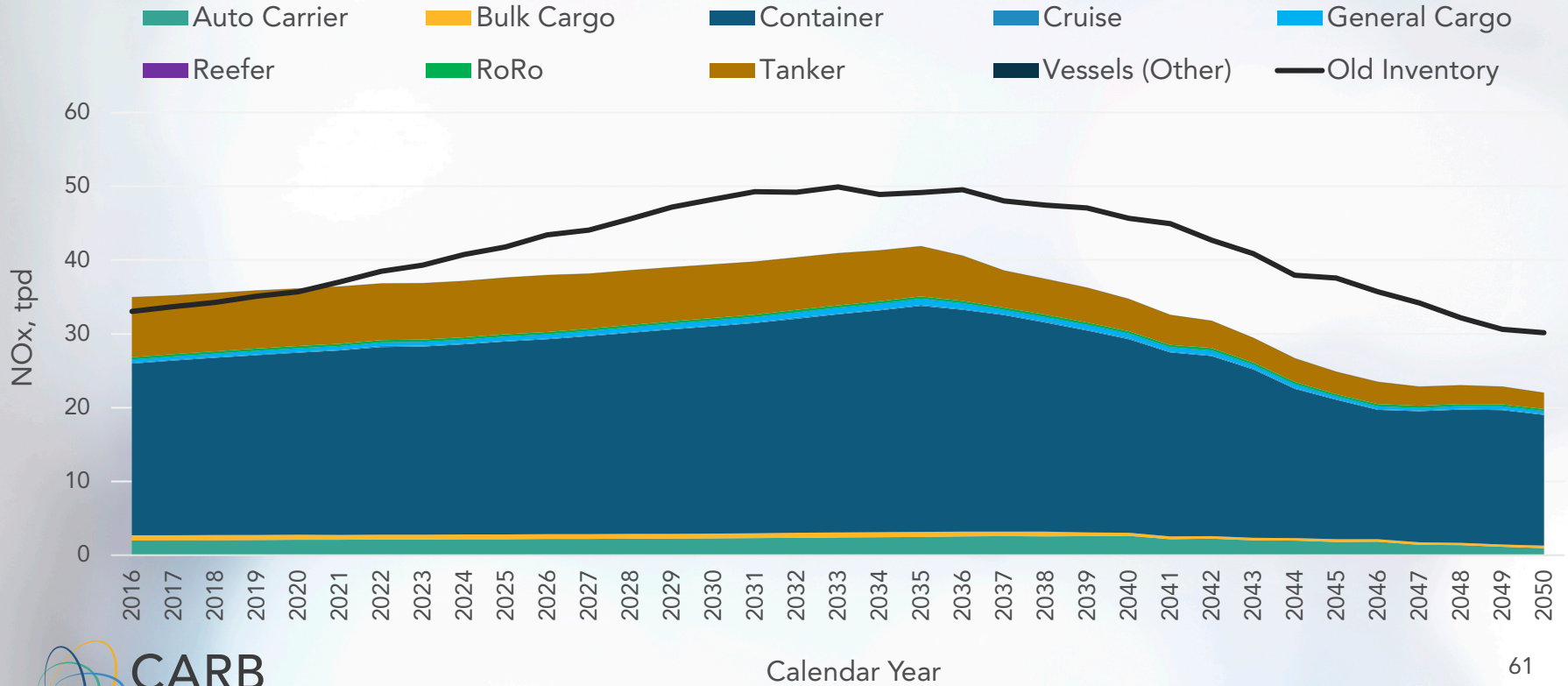
Draft AIS Update by Vessel Type





# Bay Area NOx Emissions Out to 24 nm

Draft AIS Update by Vessel Type



# Topics to Consider

- **Tier III Penetration:** Are there current or ongoing studies showing different values for the large-scale arrival of Tier III vessels at CA ports?
- **Tier III Low Load Operation:** How can we improve data on the emissions from Tier III engines operating under 25% load?
- **Forecasted Freight Growth Rates:** Considering recent congestions at the ports, how will long term growth be impacted, and should congestion be reflected in the forecast?

Send your comments and suggestions to: [Nancy.Bui@arb.ca.gov](mailto:Nancy.Bui@arb.ca.gov)



# Recent Congestion at the Ports

- Major seaports in California have been experiencing a substantial increase in cargo imports, resulting in significant congestion at terminals and in surrounding areas.
- According to the Marine Exchange of Southern California, as of September 17, 2021, there were 65 container vessels (total of 86 vessels) at anchor near the San Pedro Bay Ports
- CARB's assessment of the emissions impact of recent congestion at major seaports can be found at: [https://ww2.arb.ca.gov/sites/default/files/2021-09/port\\_congestion\\_anchorage\\_locomotives\\_truck\\_emissions\\_final\\_%28002%29.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-09/port_congestion_anchorage_locomotives_truck_emissions_final_%28002%29.pdf)



# Next Steps





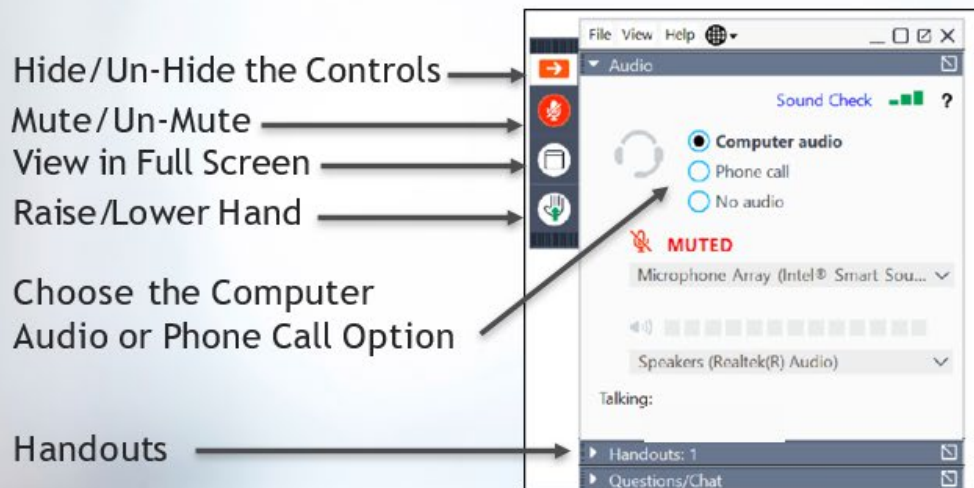
# Contact Information

- Liz Mazmanian, CHE Inventory Staff  
[Elizabeth.Mazmanian@arb.ca.gov](mailto:Elizabeth.Mazmanian@arb.ca.gov)
- Nancy Bui, OGV Inventory Staff  
[Nancy.Bui@arb.ca.gov](mailto:Nancy.Bui@arb.ca.gov)
- Cory Parmer, Manager, Off-Road Diesel Analysis Section  
[Cory.Parmer@arb.ca.gov](mailto:Cory.Parmer@arb.ca.gov)
- Sam Pournazeri, Chief, Mobile Source Analysis Branch  
[Sam.Pournazeri@arb.ca.gov](mailto:Sam.Pournazeri@arb.ca.gov)
- **Useful Links:**
  - 2011 CHE Emissions Inventory:  
<https://ww2.arb.ca.gov/sites/default/files/classic/regact/2011/cargo11/cargoappb.pdf>
  - 2019 At Berth Emissions Inventory:  
<https://ww2.arb.ca.gov/sites/default/files/classic/regact/2019/ogvatberth2019/apph.pdf>
  - 2011 OGV Emissions Inventory:  
<https://ww2.arb.ca.gov/sites/default/files/classic/regact/2011/ogv11/ogv11appd.pdf>
  - 2022 State Strategy for the State Implementation Plan:  
<https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy>



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