Update to Ocean-Going Vessels (OGV) Emissions Inventory

Air Quality Planning & Science Division Public Workshop

California Air Resources Board (CARB)

December 05, 2024

Questions? Comments?

Please include slide numbers, if possible

Via Zoom	Via Phone
Use Raise Hand feature to enter the queue	#2 to Raise Hand *6 to Mute/Unmute

Additional inventory questions/comments may be submitted to OffRoadInventory@arb.ca.gov through January 10, 2025.

Today's Workshop Presentation:
https://ww2.arb.ca.gov/our-work/programs/msei/conferences-and-workshops-offroad

2024 Draft OGV Emissions Inventory:
https://ww2.arb.ca.gov/sites/default/files/2024-11/Draft_OGV2024_Documentation_ADA.pdf

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Inventory Scope

OGV emission inventory covers commercial marine vessels which are:

- Over 400 feet in length,
- Carrying capacity of 10,000 gross tons or more,
- Engine displacements of 30 liters per cylinder or greater,
- Within 100 nautical miles (nm) of California shoreline, and
- Includes vessels not destined for California ports

Emission Inventory

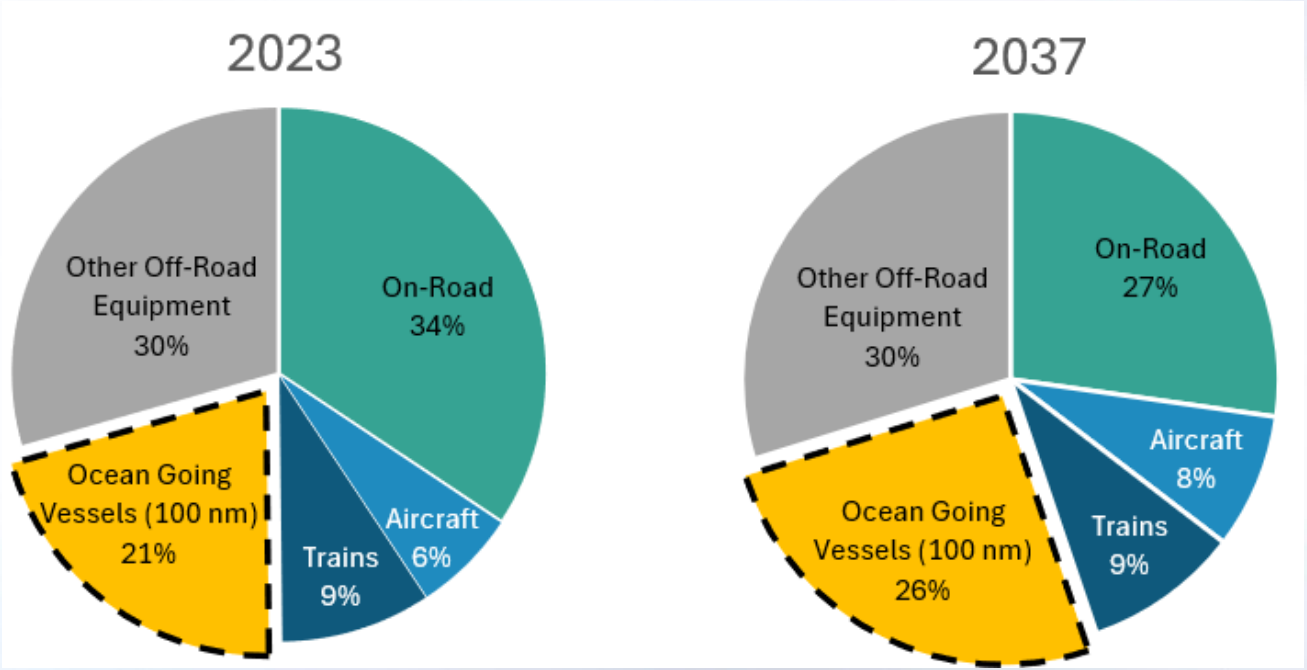
The emission inventory characterizes:

- Number, size, type, and age of vessels visiting California waters
- Energy produced by vessel main, auxiliary and boiler engines
- Location and speed of vessel activity
- Amount of time on shore power while at berth
- Forecasted vessel populations and growth

Purpose: Resulting emissions from all vessels from 2024 to 2050

Contribution of OGV to Statewide Emissions

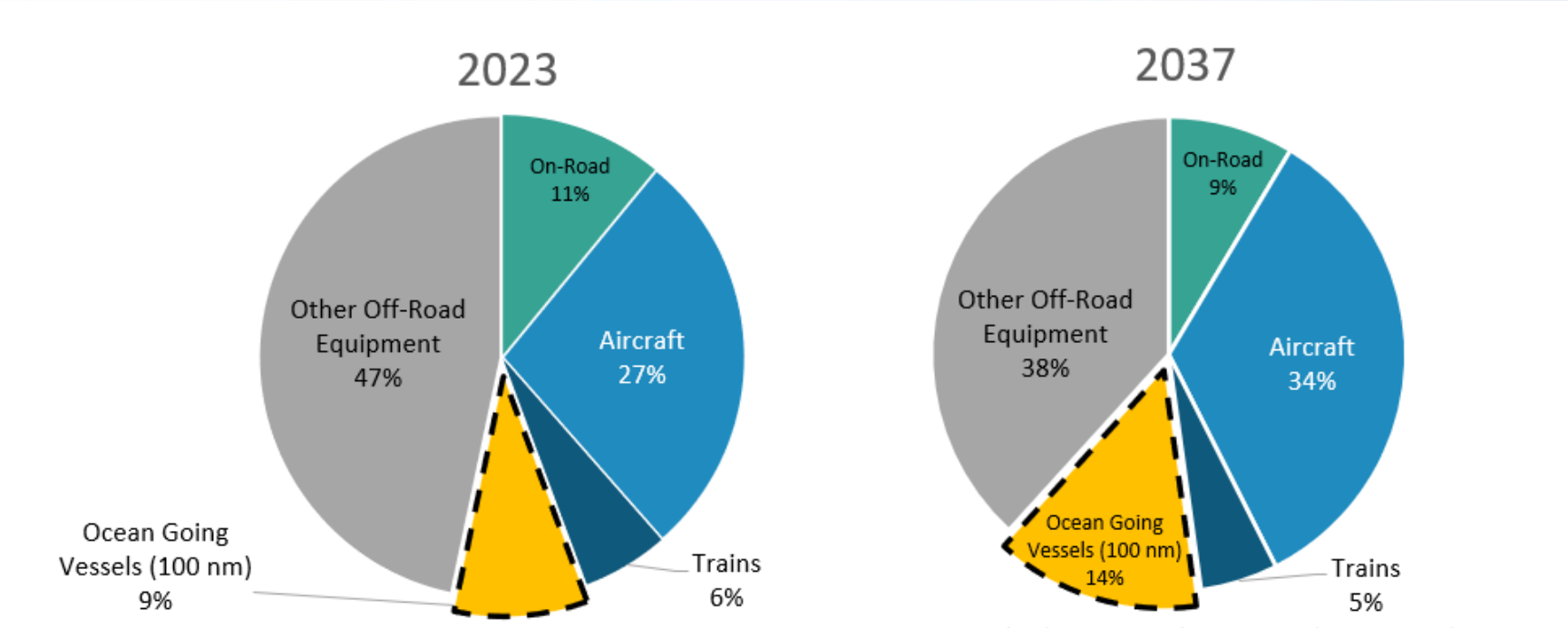
Nitrogen Oxides (NOx)



Source: CEPAM 2019 v1.02 for non-OGV mobile sources

Contribution of OGV to Statewide Emissions

Particulate Matter (PM)



Source: CEPAM 2019 v1.02 for combustion from non-OGV mobile sources

Summary of Data Source Updates

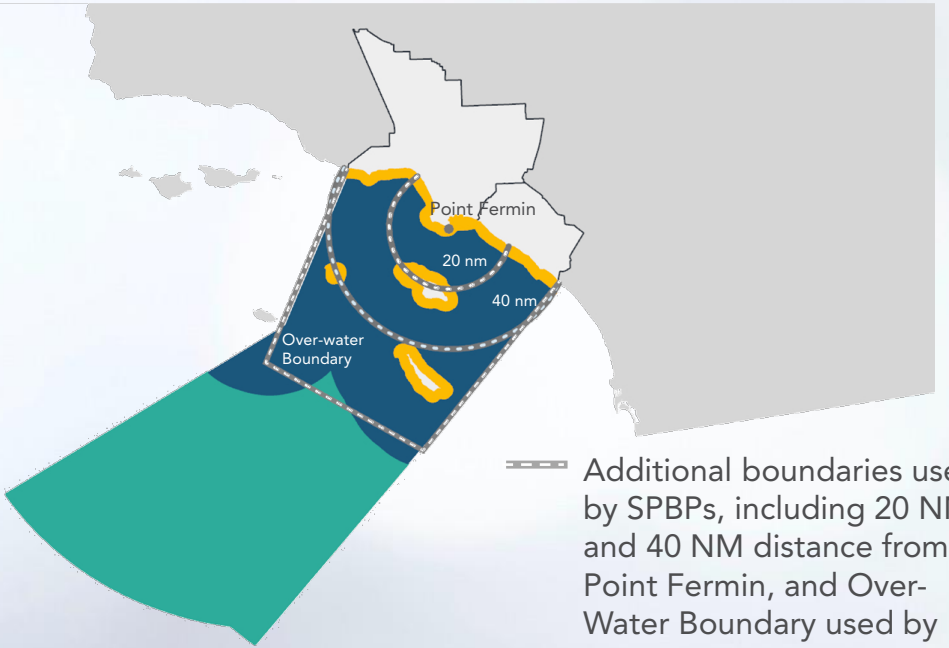
Data Category	2021 Inventory Model	2024 Model Update
Vessel Characteristics		
Max Speed, Type, Size, Engine	2020 IHS Vessel Registry	2023 IHS Vessel Registry
Tier, Fuel Type, Shore Power	2019 CARB Enforcement	2023 CARB Enforcement
Activity		
Location, Speed, Duration	2020 AIS Records	2019-2023 AIS Records (5 years)
Activity Modes	2020 EPA Port Method	2022 EPA Port Method
Emission Factors	2020 EPA Port Method	2022 EPA Port Method
Engine Defaults	2020 IHS Registry, 2020 Starcrest	2023 IHS Registry, 2022 Starcrest
Forecasting		
Growth Rates	FAF 4.4, Port Calls, Tioga Report	FAF 5.1, Port Calls
Tier III Delay	Mercator Report	Mercator Report

AIS: Automatic Identification System - EPA: Environmental Protection Agency - FAF: Freight Analysis Framework

Geographic Domain

Statewide

South Coast Air District



Additional boundaries used by SPBPs, including 20 NM and 40 NM distance from Point Fermin, and Over-Water Boundary used by South Coast AQMD

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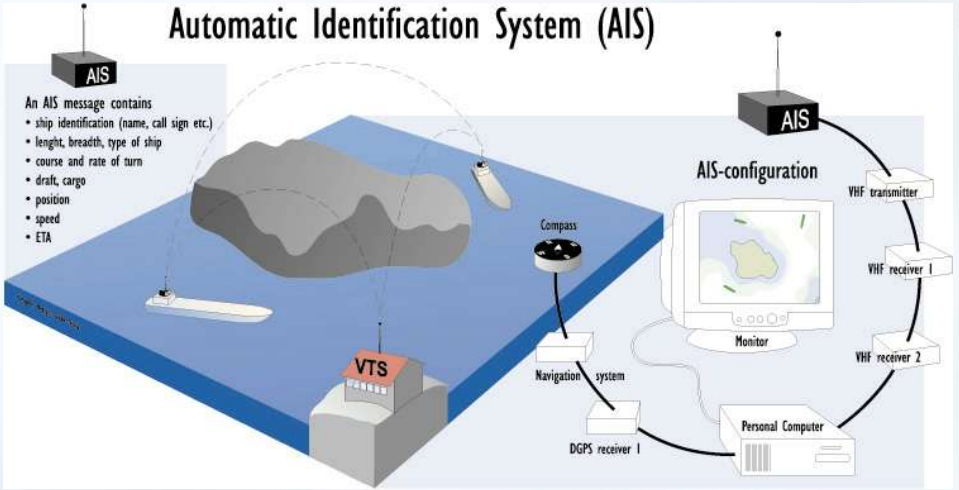
Activity Data Source: AIS

- 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.

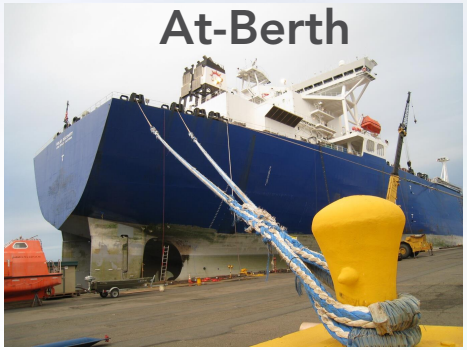
- This massive data source is made public through collaboration of the USCG, NOAA, and the Bureau of Ocean and Energy Management (BOEM) via Marine Cadastre.



https://coast.noaa.gov/htdata/CMSP/AISDataHandler/2023/index.html

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



Base Year Methodology

Methodology Overview

$$Emissions = Time\ OGV\ Engines\ Running * Power * Emission\ Rate$$

Time

Power

Emissions

1. **AIS**: Download full years of AIS data within 100 NM of CA shores
2. **Shore Power**: CARB OGV reporting data shows time on shore power
3. **Vessel Characteristics**: IHS Registry and CARB OGV reporting data provides detailed vessel info (engine size, vessel size, keel laid, etc.)
4. **Power**: Main engine power based on vessel engine size and speed

   Auxiliary and boiler power from Port of LA/LB Vessel Boarding Program (VBP)
5. **Emission Factors:** From U.S. EPA
6. **Low-Load Adjustment:** Curves developed for Ports of LA/LB

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AIS Data: 5-Year Average for Baseline Emissions

- Emission inventory starts with one base year, that is forecasted to 2050
- Previous emission inventories used a **single year of AIS data** for the emission baseline, with potential to be abnormally high or low due to extreme events
- New OGV emission inventory will average the vessel visits from 2019 to 2023 as the new base year
- Years with extreme events will be included but only make up 20 percent of the new base year average

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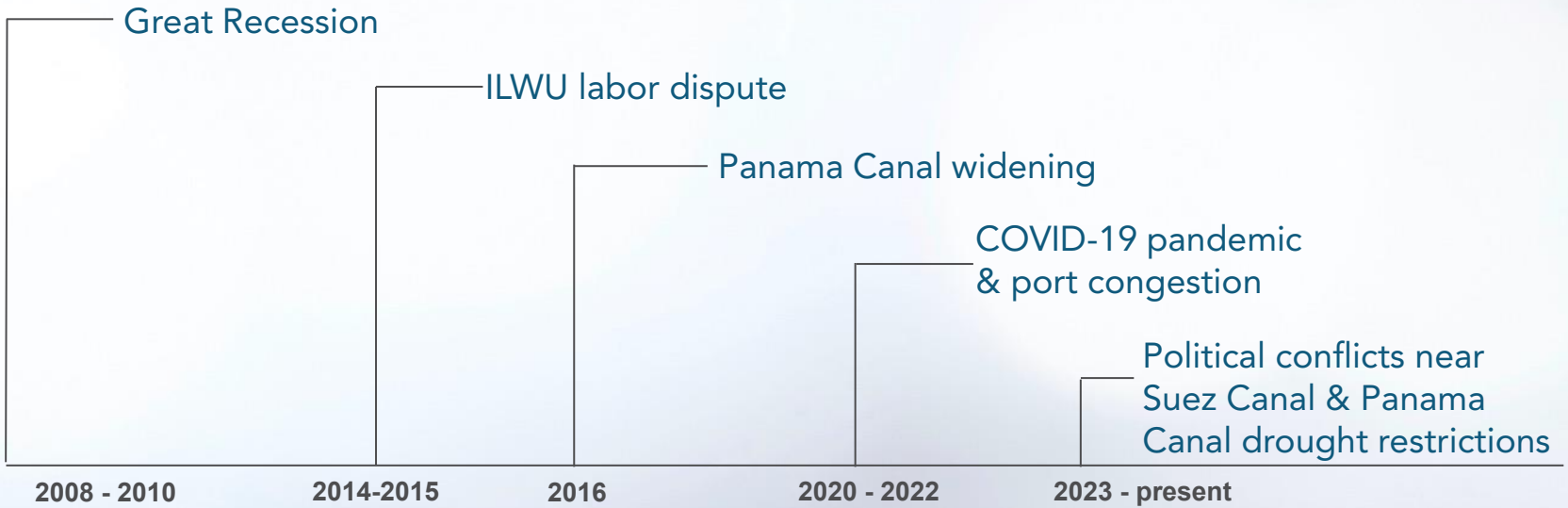
AIS Data: Historical Events Impacting Water Shipping Operations

"Extreme events" occur in any 5-year window in the past two decades, should not be reasonably be excluded from the new 5-year average



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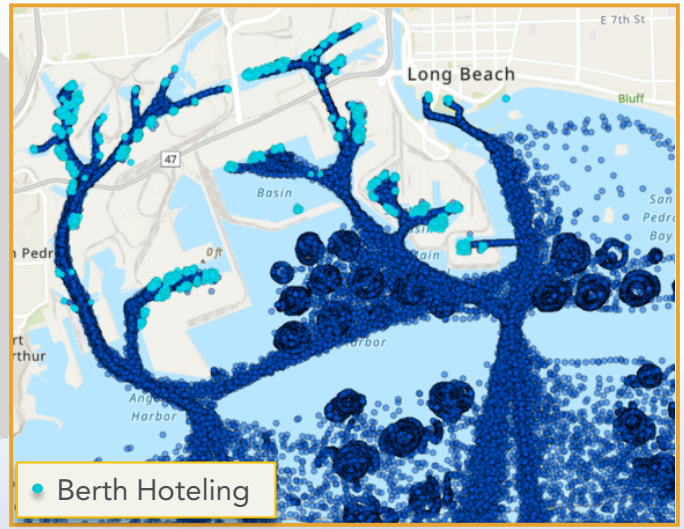
AIS Data: Splitting Records into Different Modes

Emission Inventory splits vessel activity into the four different modes, based on speed and location.

One change in EPA2022 recommendations was to decrease speed thresholds as shown below.



Activity Modes:

Berth Hoteling
- Within 4 km of port, not in anchorage zone, and speed of 0 knots (kts)

Anchorage Hoteling
- Within anchorage zone with speed < 1 kts

Maneuvering < 1 kts
- Within 3 nm, speed ~~< 3 kts~~

Transit > 1 kts
- All areas, speed ~~> 3 kts~~

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

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Emission Controls

- CARB currently requires vessels to reduce emissions at berth, dependent on vessel type and port.
- Vessels can use shore power or another CARB-Approved Emissions Control Strategy.
- 2023 CARB Enforcement reporting results for all terminals shown below, showing the percent of time at berth where the vessel uses shore power.
- The bottom row shows the year each vessel type has At-Berth requirements.

Port	Container	Cruise	Reefer	RoRo	Tanker
Hueneme	85%	N/A	0%	0%	0%
Long Beach	79%	73%	0%	5%	1%
Los Angeles	91%	74%	10%	0%	0%
Oakland	67%	N/A	0%	68%	N/A
San Diego	97%	59%	94%	0%	0%
San Francisco	N/A	54%	0%	0%	0%
At-Berth Req Year:	2023	2023	2023	2025	2025/2027

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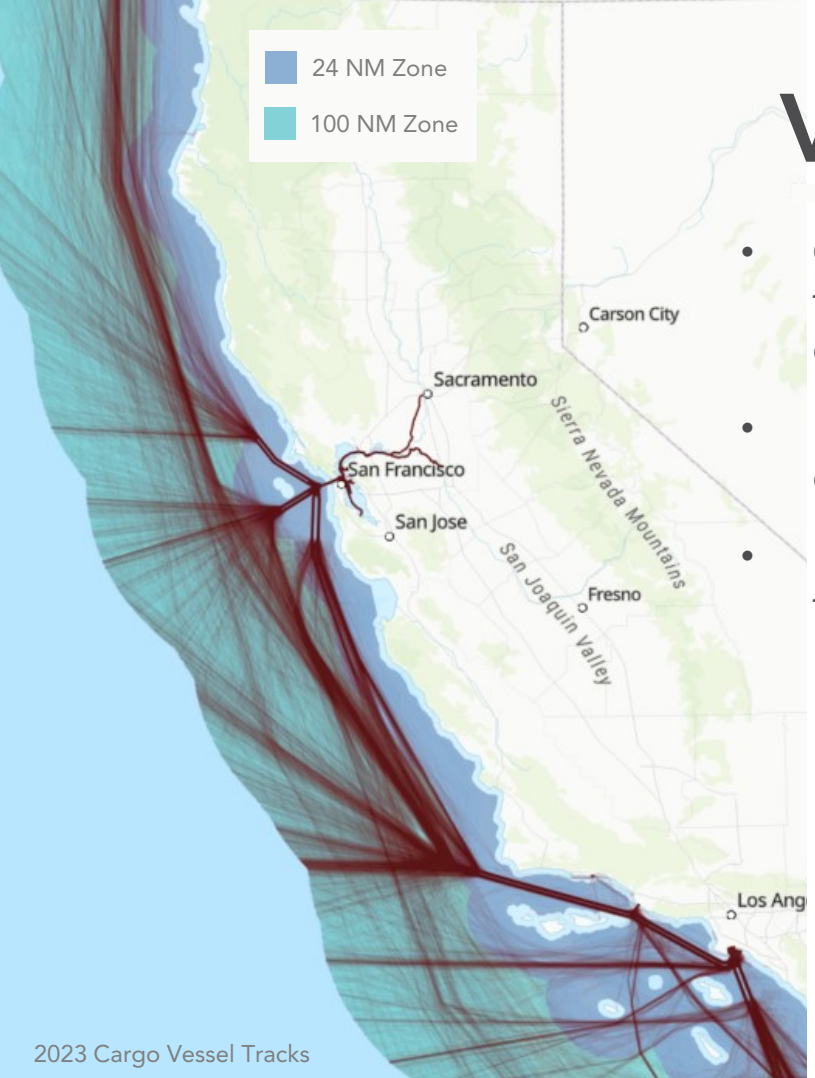


2023 Cargo Vessel Tracks

Vessel Characteristics

- CARB 2023 vessel reporting data was utilized for engine tier, shore power rates, fuel type, and steam-driven pump capabilities wherever reported.
- IHS 2023 vessel registry data was used for all other characteristic data such as max speed, type, engine, size.
- Engine RPM and tier definitions shown below, unchanged from previous inventories.

Engine Type	Speed Range	Engine Stroke
Slow-Speed Diesel, SSD	< 500 rpm	2
Medium-Speed Diesel, MSD	500 – 1,400 rpm	4
High-Speed Diesel, HSD	> 1,400 rpm	4

Engine Tier	Keel Laid Year
Pre-Tier/Tier 0	1999 and prior
Tier I	2000 – 2010
Tier II	2011 – 2015
Tier III	2016 and later

Power: Vessel Speed

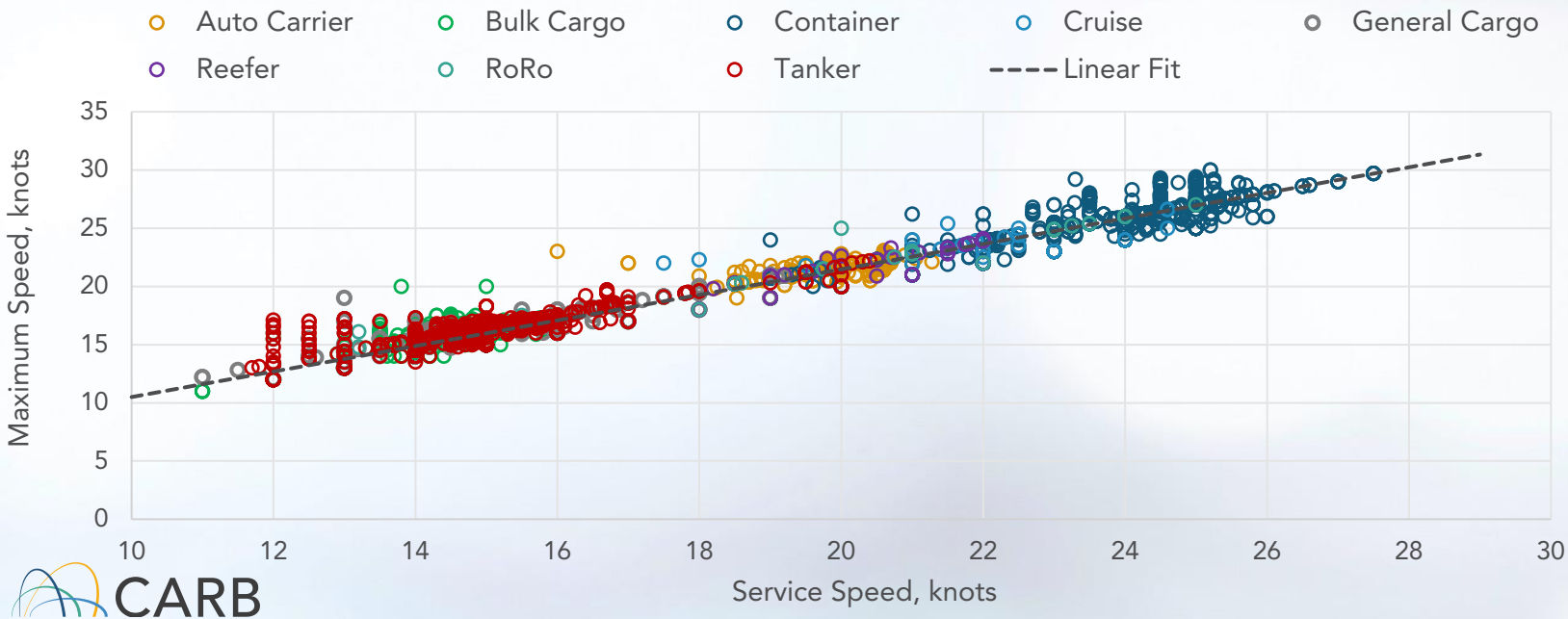
- Vessel speed is calculated each minute from AIS location data
- Emission inventory uses vessel speed to determine engine power using the Propeller Law:

$$Power\ Used = \left(\frac{Current\ Speed}{Maximum\ Speed}\right)^3 x\ Total\ Installed\ Propulsive\ Power$$

- Maximum speed and total installed propulsive power based on IHS vessel registry data

Power: Gap-Filling Vessel Max Speed

- In some cases, maximum speed was not listed but service speed was available from IHS
- Emission inventory uses the relationship between service speed and maximum speed to fill in the gaps



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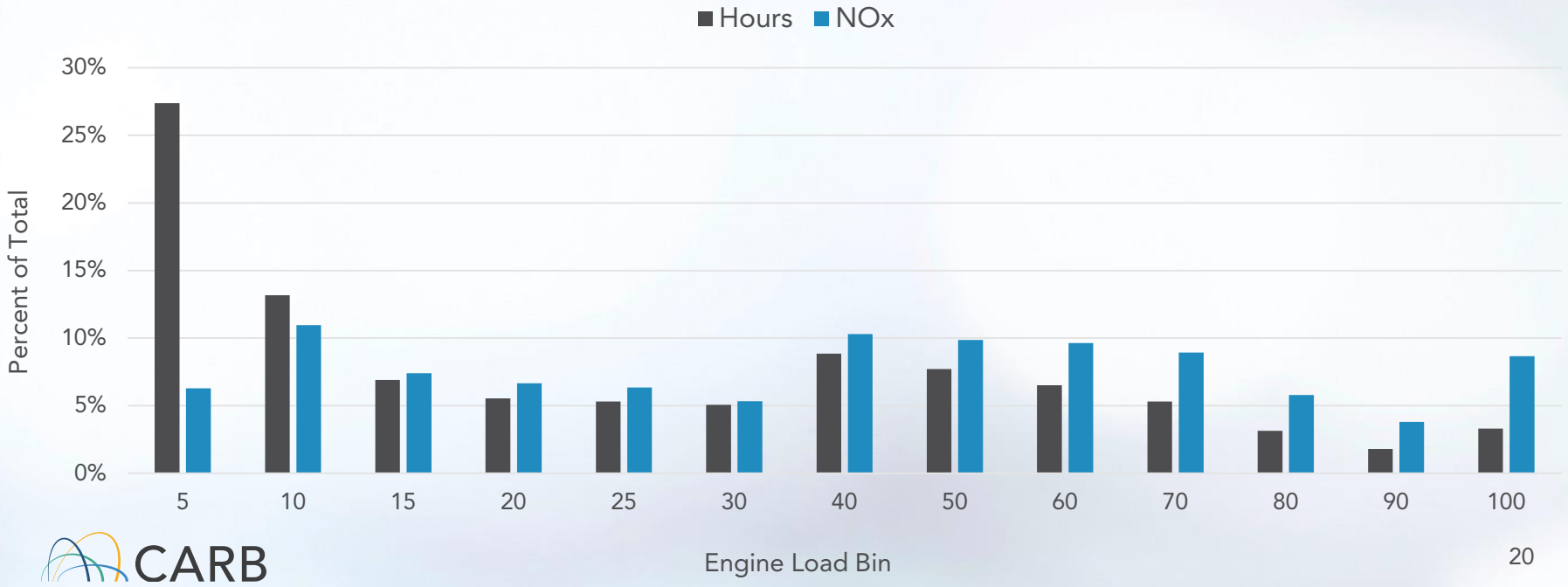
Power: Statewide Main Engine Load

- Based on the vessel speeds and propeller law, main engine time and emissions from each load bin is shown below
- Load is the percent of maximum power being used within 100 NM of shoreline



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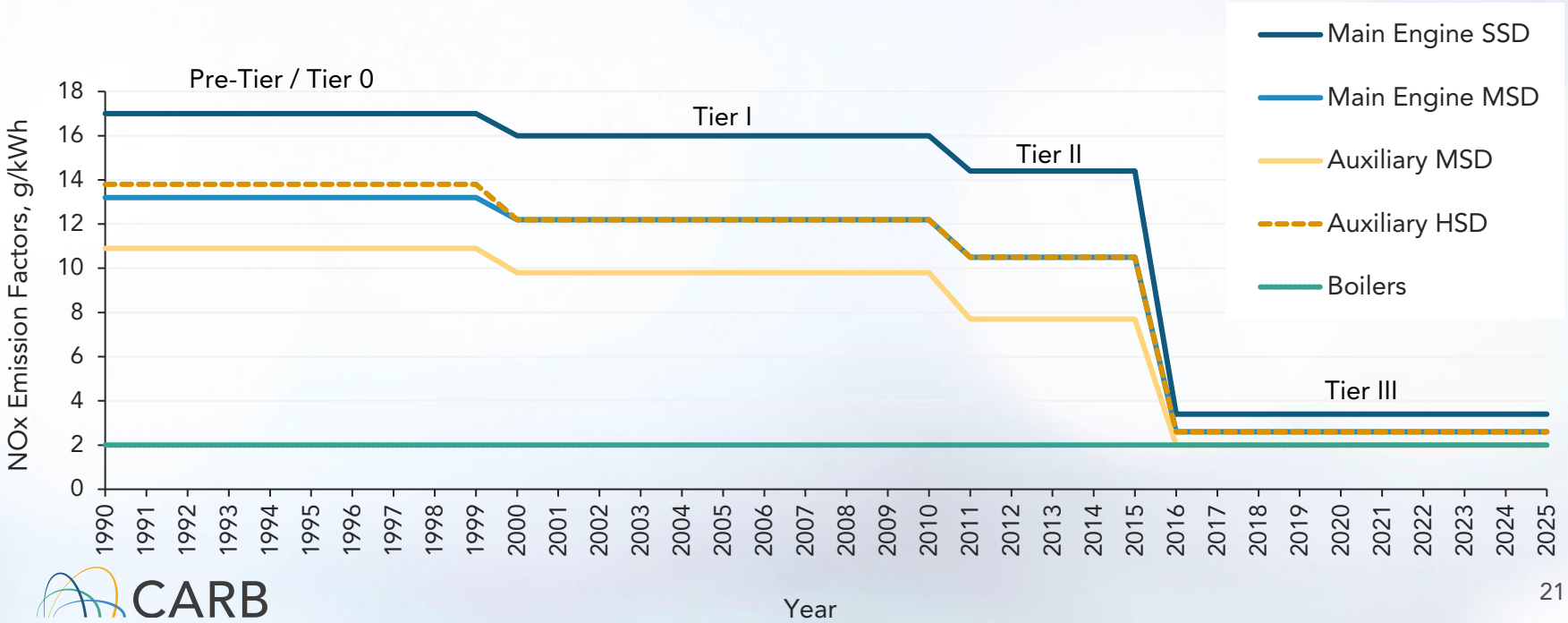
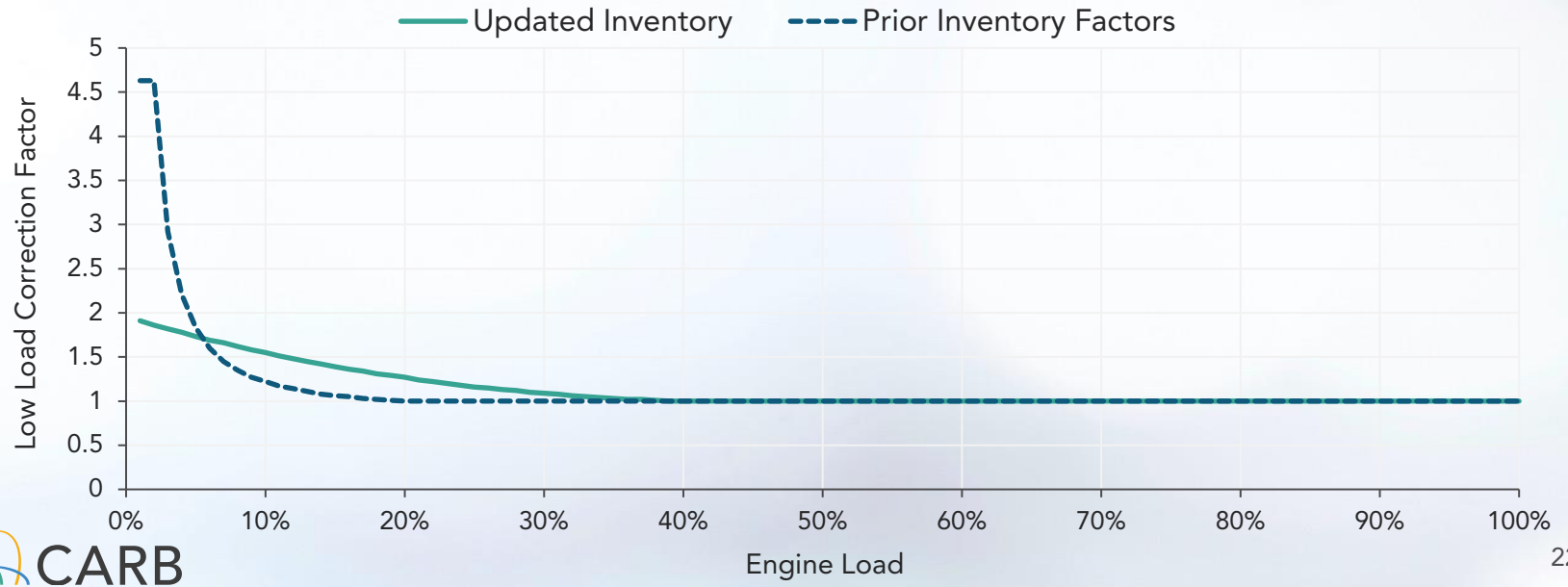
Emission Factors: NOx

- NOx emission factors are based on engine Tier and speed
- Other pollutants (PM) not controlled by engine Tier



Emission Factor: NOx Low Load Adjustments

- Adjustment to NOx at low loads based on real world testing at Ports of LA/LB
- Updates to low-load adjustment curve increase NOx at 5 to 35 percent load, not as high below 5 percent load compared to prior inventory factors



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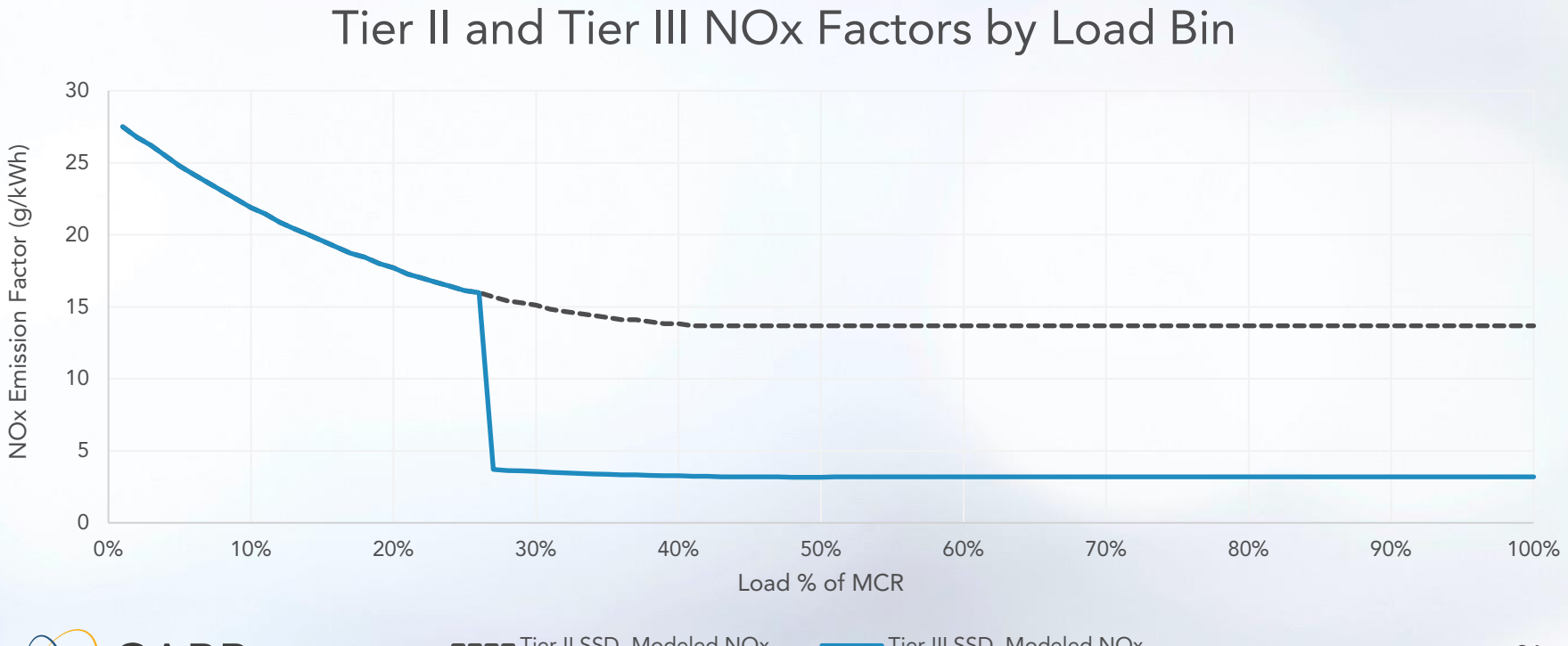
Emission Factors: Changes

- Slight adjustment to main engine Tier III NOx EFs in EPA's 2022 report:

	EPA 2020 NOx	EPA 2022 NOx
Tier III, SSD	3.6	3.4
Tier III, MSD	2.8	2.6

- **Emission inventory reflects all Tier III main engines operating under 25 percent load to be emitting at Tier II levels with low load corrections.**
  - Consistent with U.S. EPA

Impact of Low Load and Tier III Modeling



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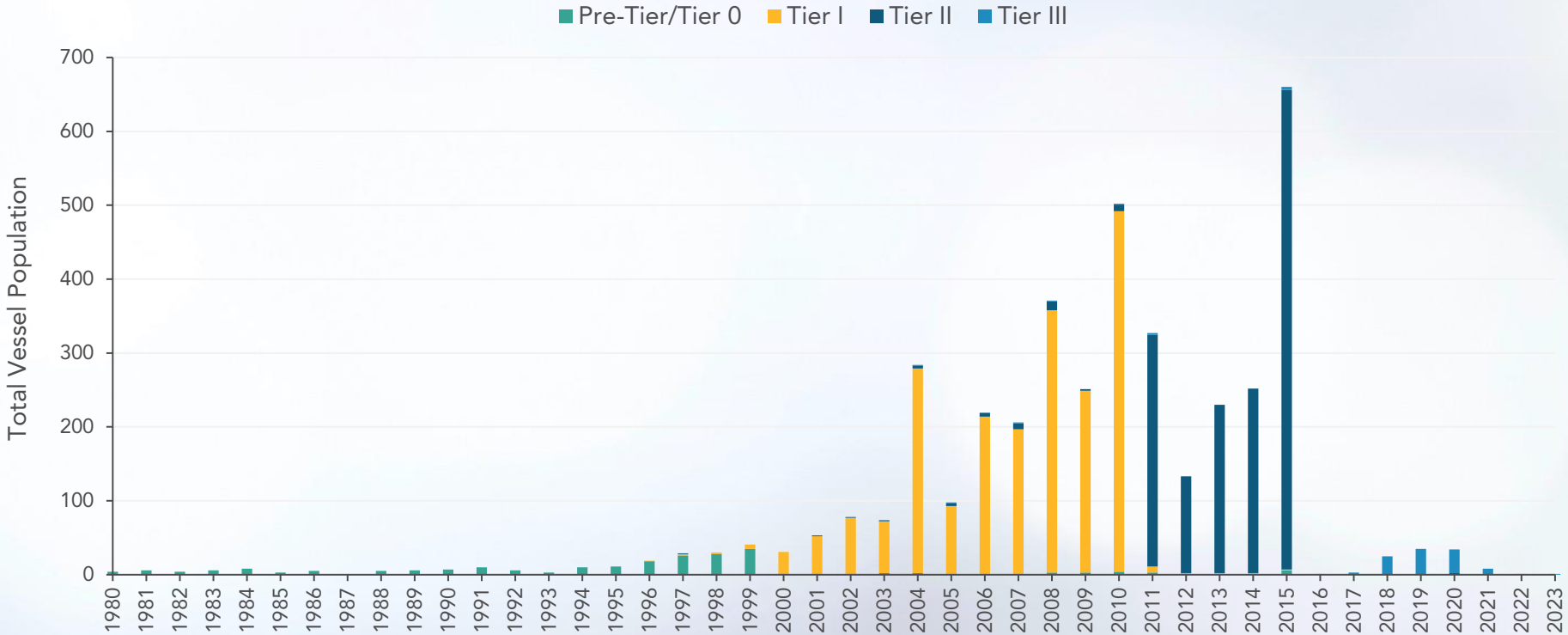
Statewide Tier Distribution, 2019-2023



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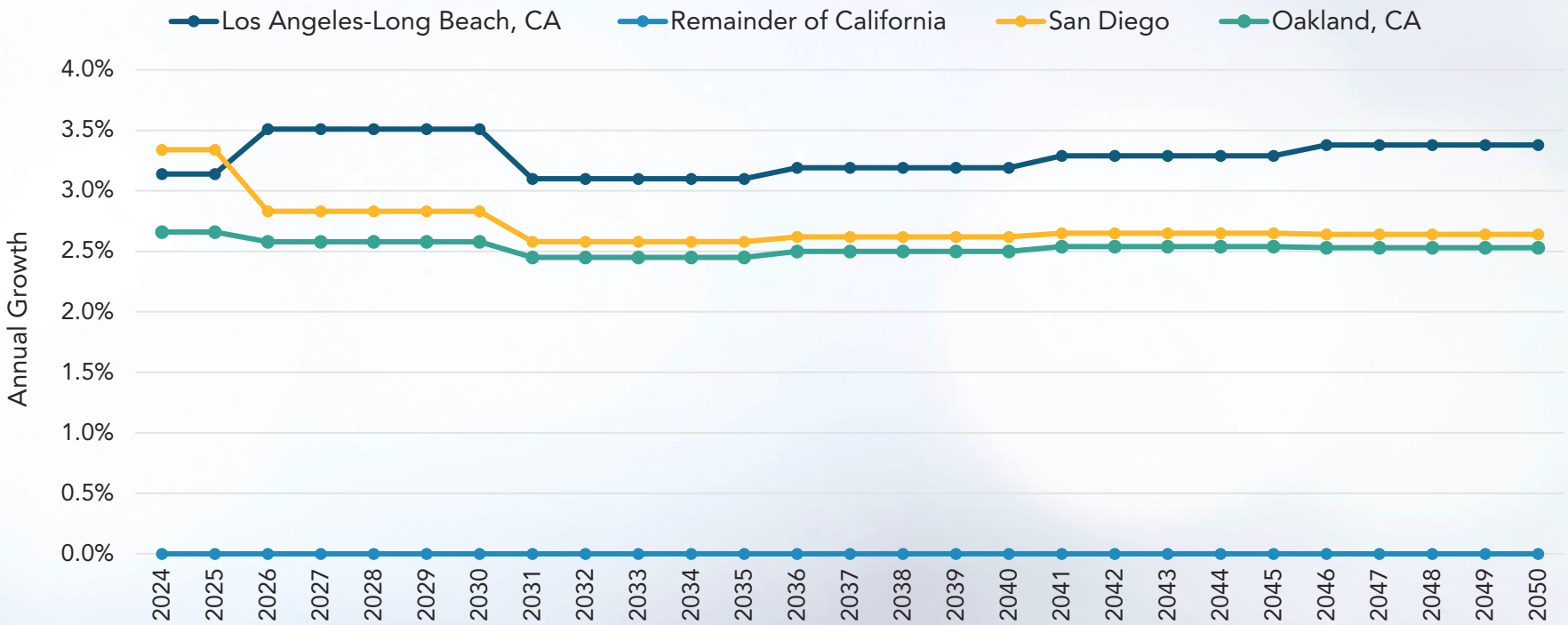
Forecasting Assumptions

Growth

Growth increases the total OGV activity and emissions in future years based on:

- Statewide OGV Growth
  - Freight Analysis Framework 5.1, a Department of Transportation projection of freight totals by transportation modes
- Ports of LA/LB
  - Forecast of maximum freight throughput based on 2018 Master Plan
- Port of Oakland
  - Reviewing 2020 Bay Conservation & Development Commission (BCDC) forecast

Containerized Cargo Growth Rates by FAF Region



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Forecasted Time Using CAECS

2023 CARB Enforcement reporting results for 2023 compliance years:

Port	Container	Cruise	Reefer	RoRo	Tanker
Hueneme	85%	N/A	0%	85%	85%
Long Beach	79%	73%	0%	79%	79%
Los Angeles	91%	74%	10%	91%	91%
Oakland	67%	N/A	0%	68%	N/A
San Diego	97%	59%	94%	97%	97%
San Francisco	N/A	54%	0%	0%	0%
At-Berth Req Year:	2023	2023	2023	2025	2025/2027

Future year plug-in or use of CAECS for RoRo and Tankers match observed 2023 containership emission reduction rates

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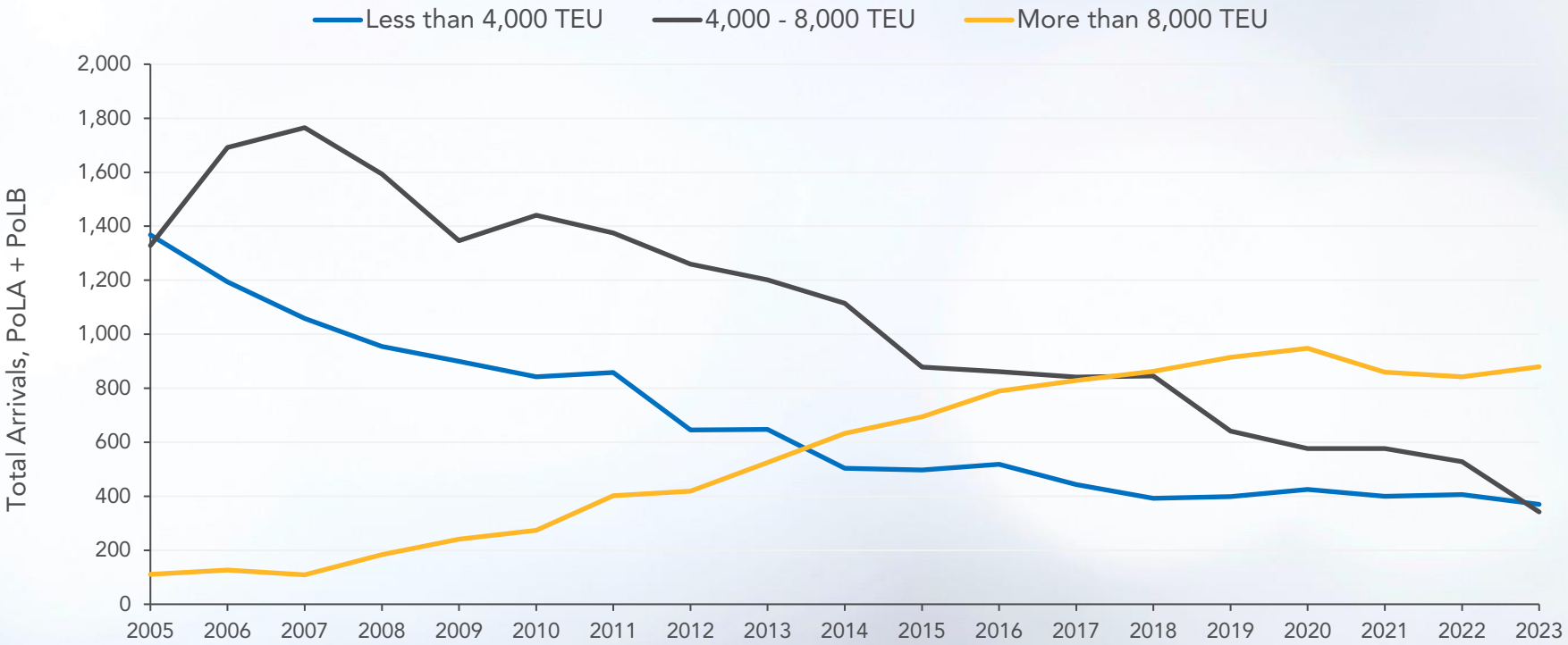
Containership Capacities, SPBPs



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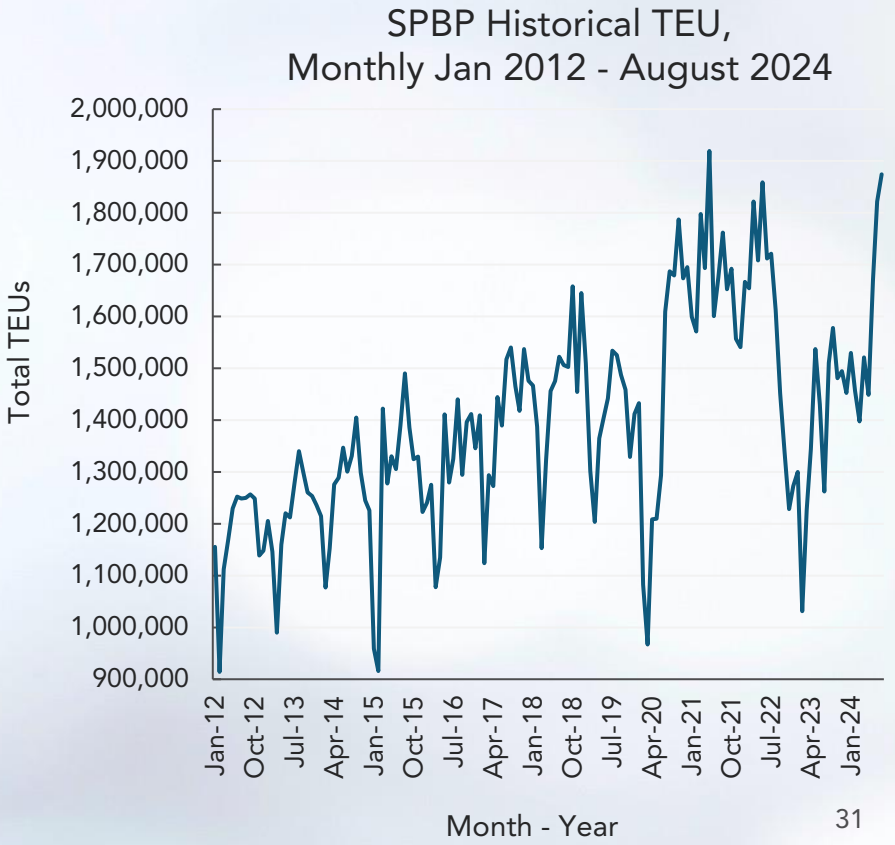
Containership Capacity Adjustment

- TEU (containers) and freight growth since 2012 have largely been met by increases in vessels over 8,000 TEUs
- Container vessels above 8,000 TEU capacity were grown enough to meet increased freight forecast from FAF5.1 slow growth scenario
- Container vessels below 8,000 TEU maintained at current capacity: no growth is applied
- Looking for data regarding vessels below 8,000 TEU serviced through 2050



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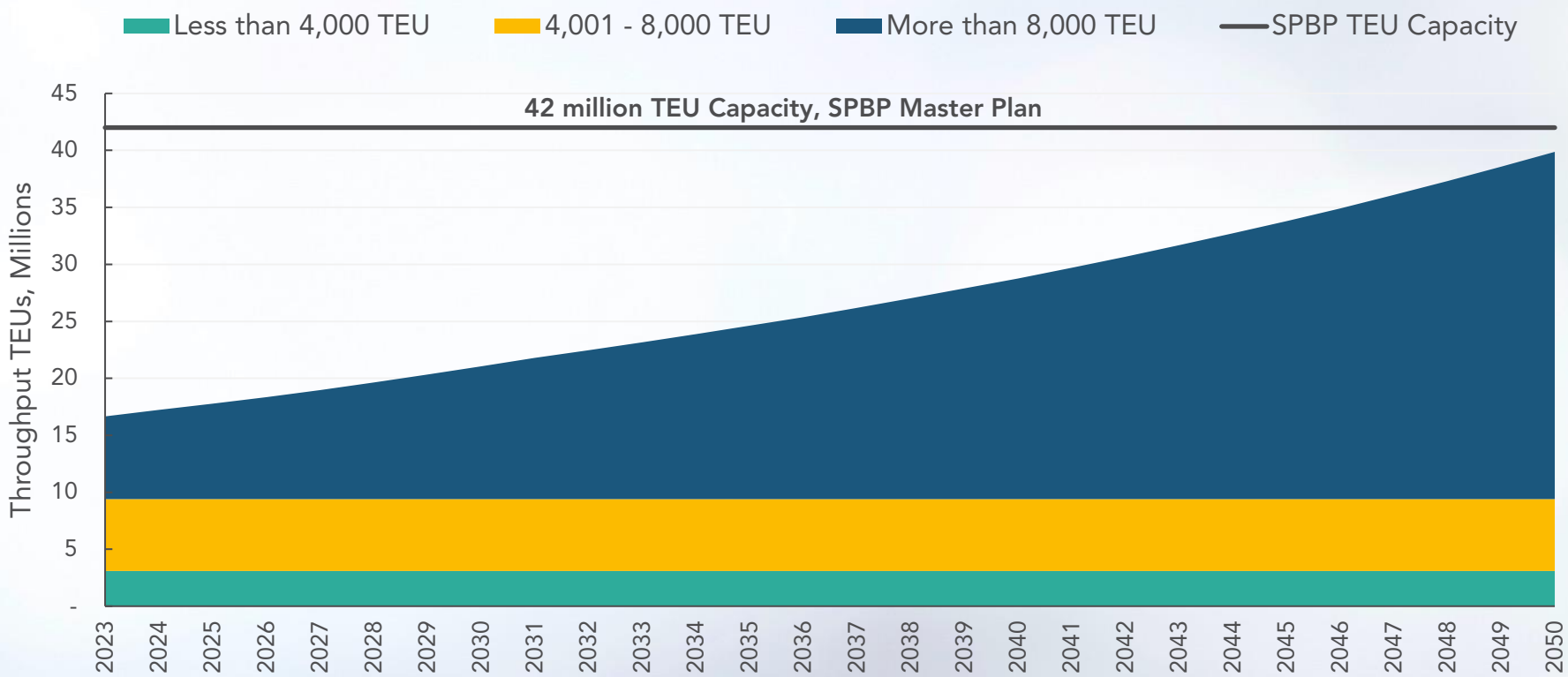
SPBP TEU Capacity by Size Bin Group

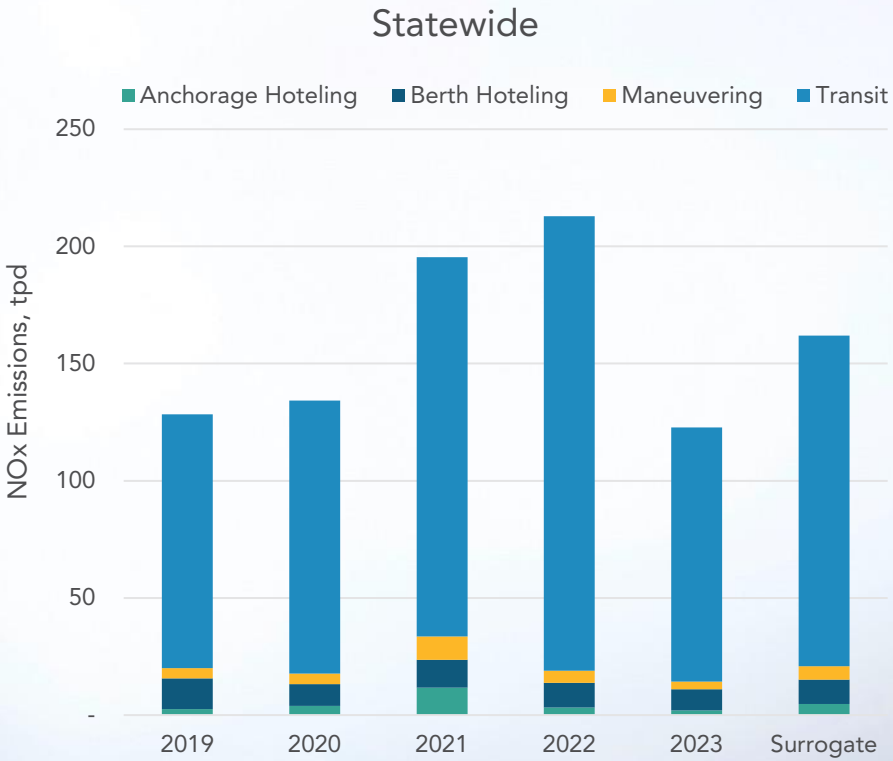


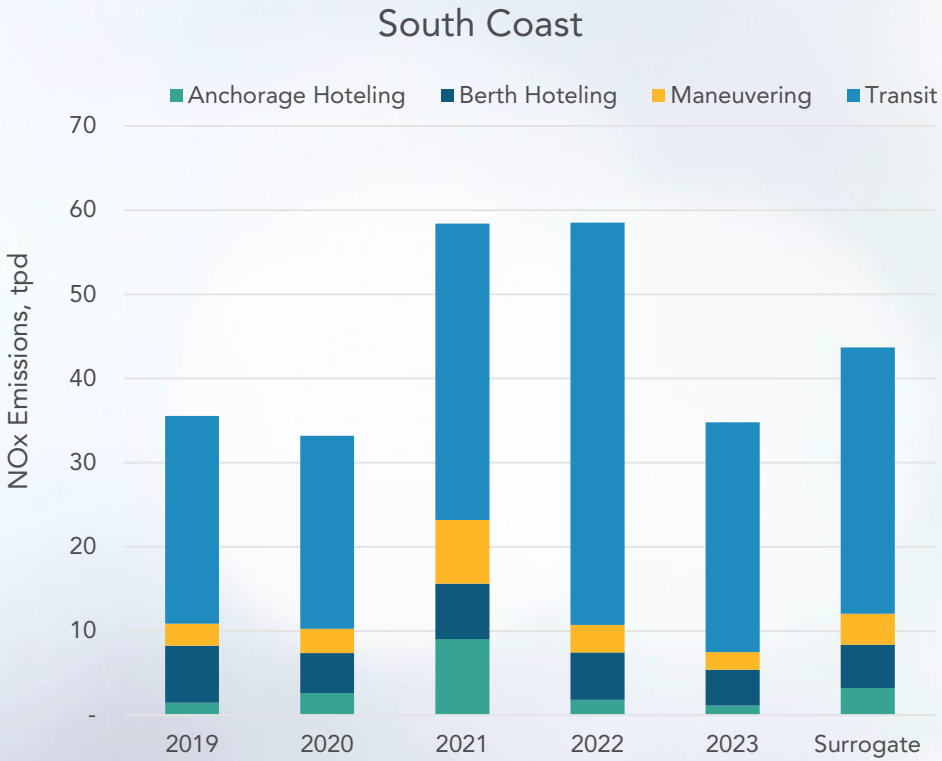
Tier III Arrival Delays

- California ports rarely receiving visits from the newest container vessels that typically service Asian and European freight routes
- Age distribution and vessel build data shows large number of vessel builds ordered immediately prior to the Tier III marine standard introduction in 2016
- Vessel builds that began prior to the Tier III marine engine standards initial date may have Tier II marine engines installed, even if the vessel is put into service later
- Based on a report by Mercator International (consulting firm) commissioned by the Ports of LA/LB, arrival of additional Tier III vessels at California ports is delayed until 2030

Emission Results

NOx by Activity Mode within 100 NM





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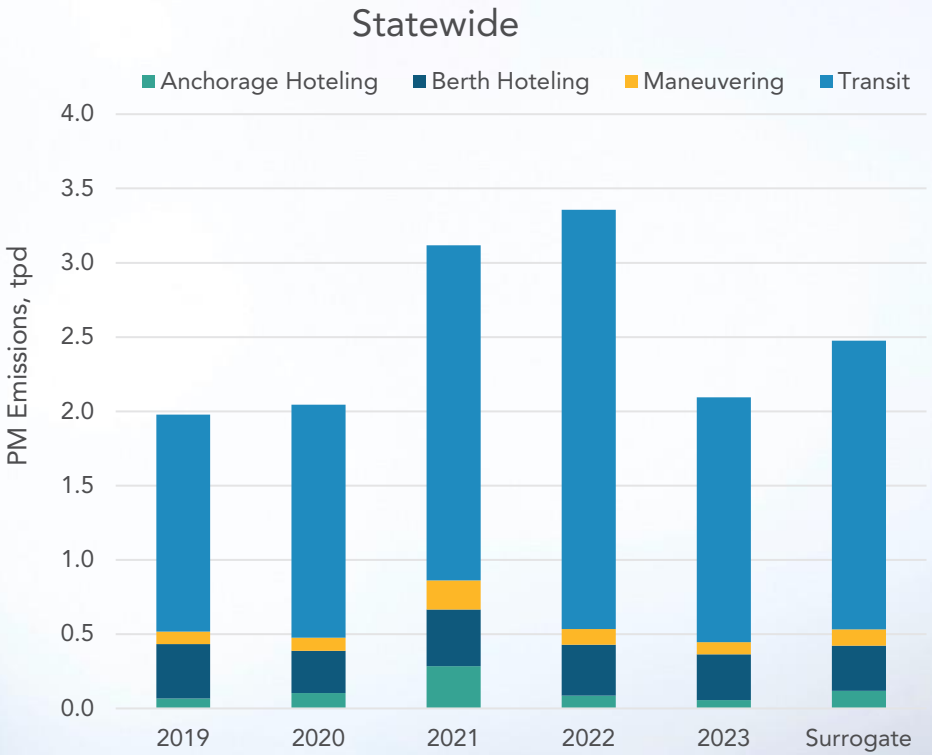
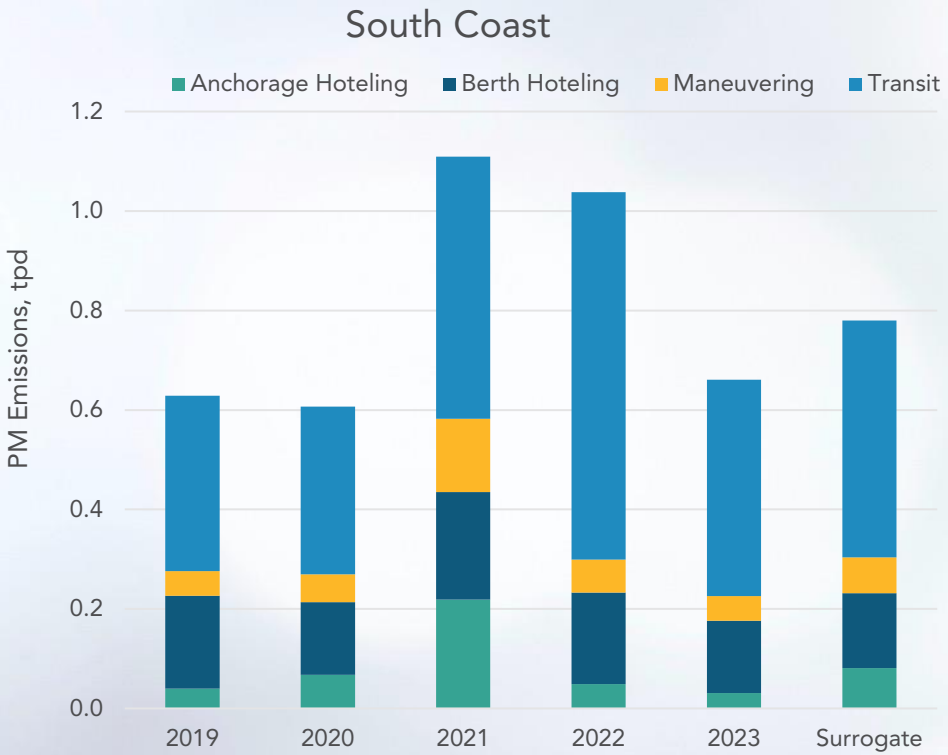
PM by Activity Mode within 100 NM





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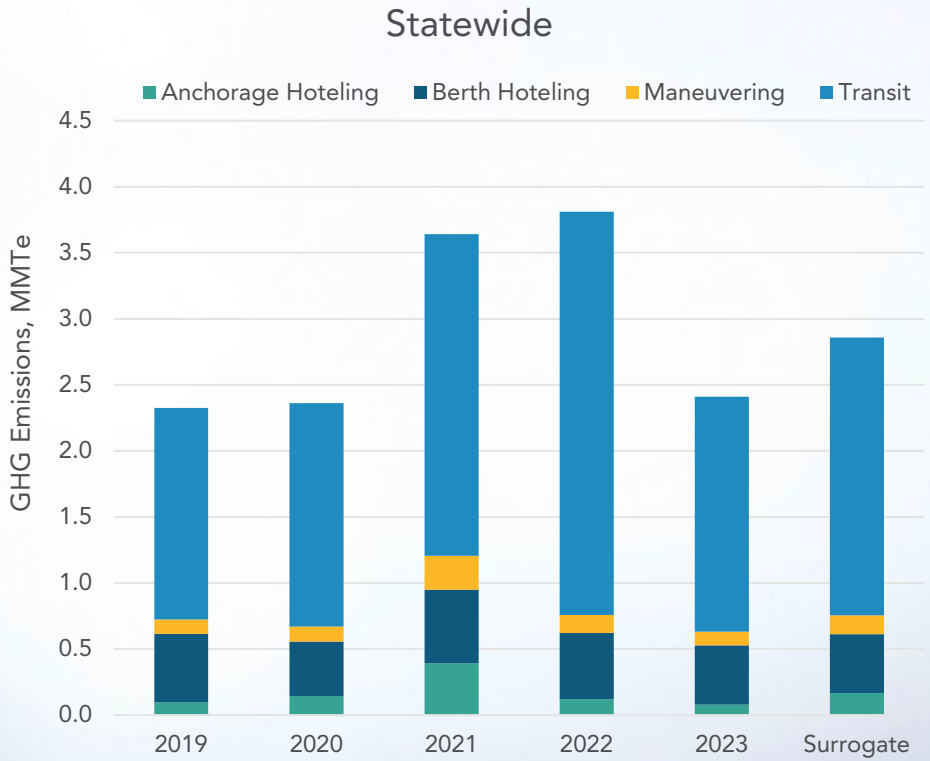
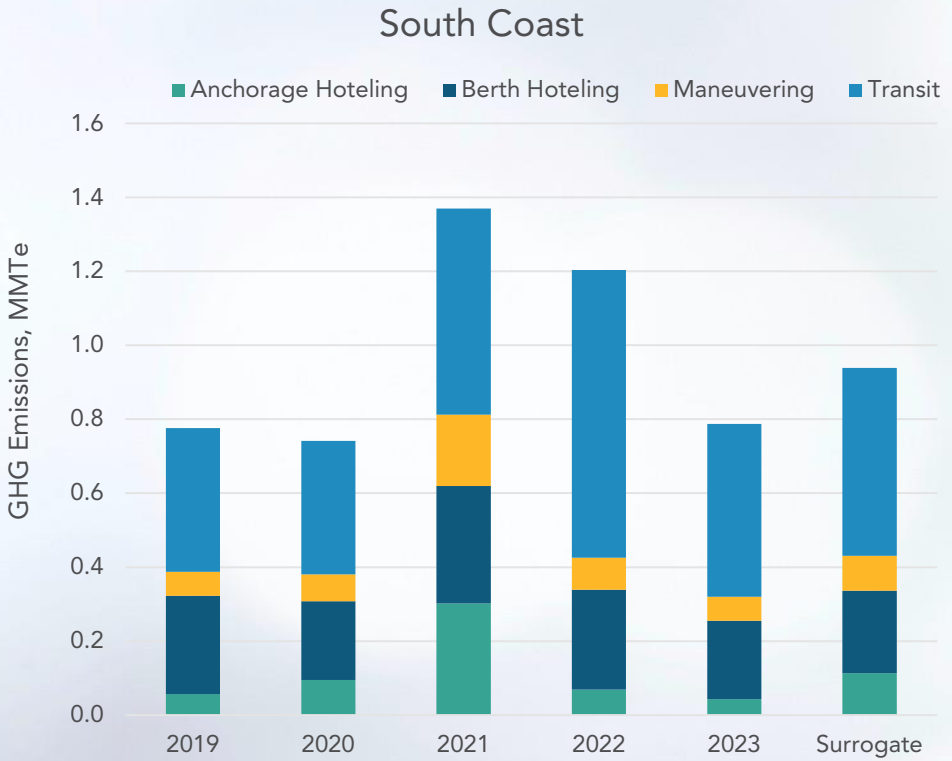
GHG by Activity Mode within 100 NM





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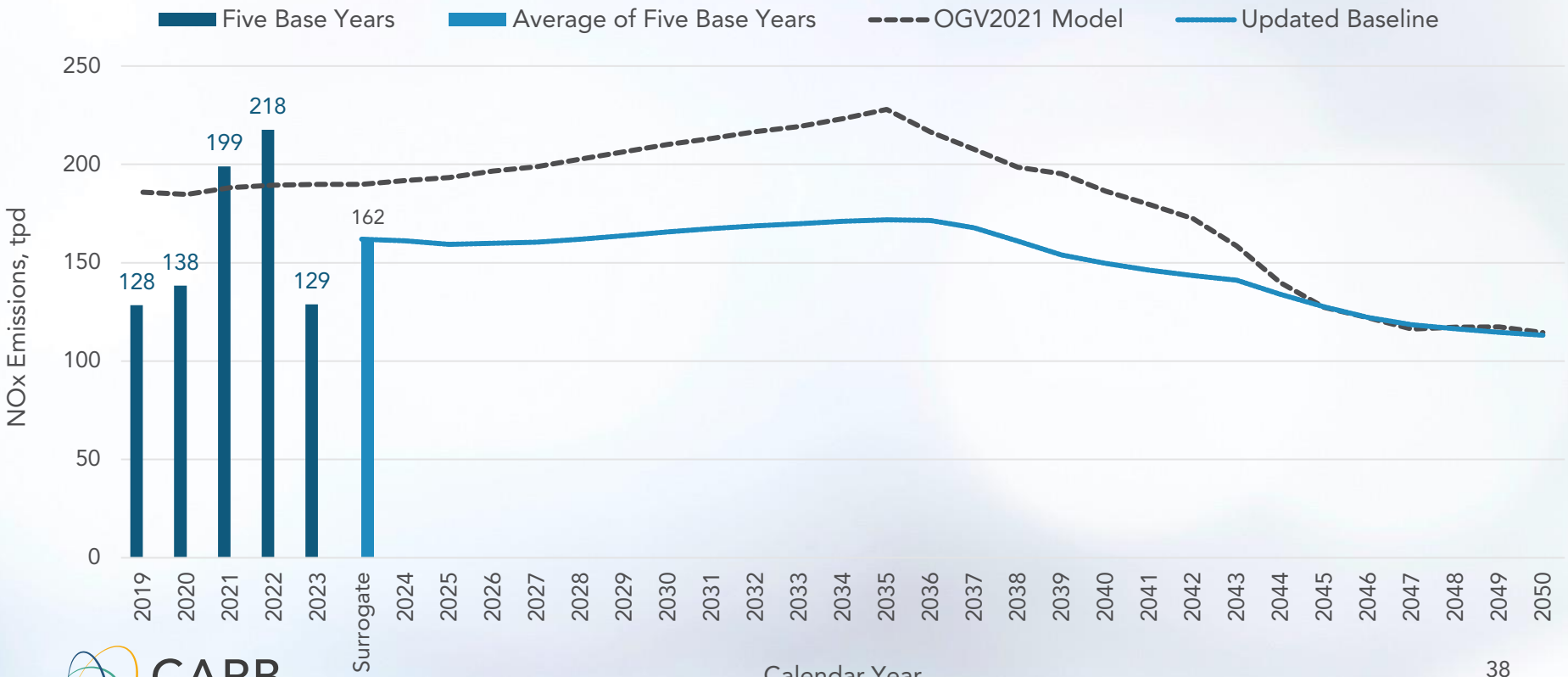
Statewide NOx Forecast



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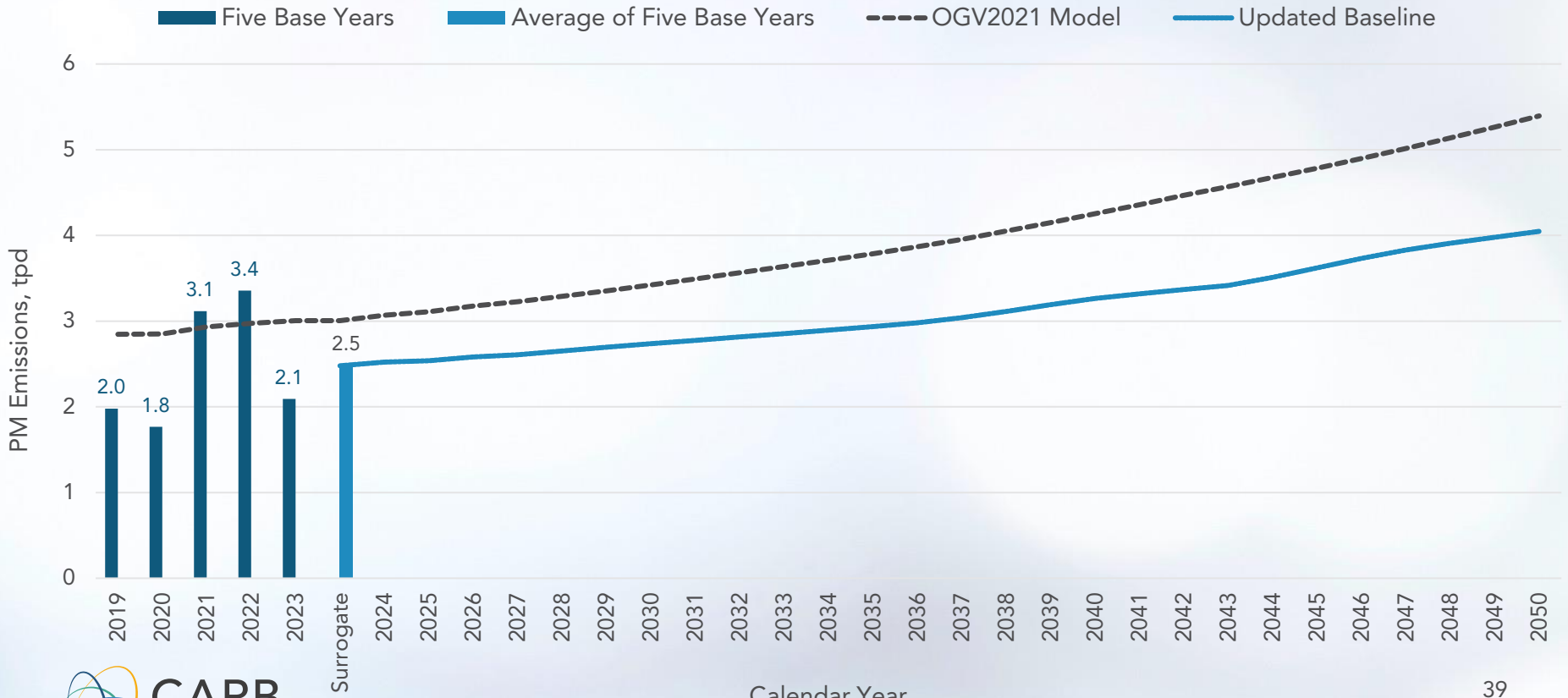
Statewide PM Forecast



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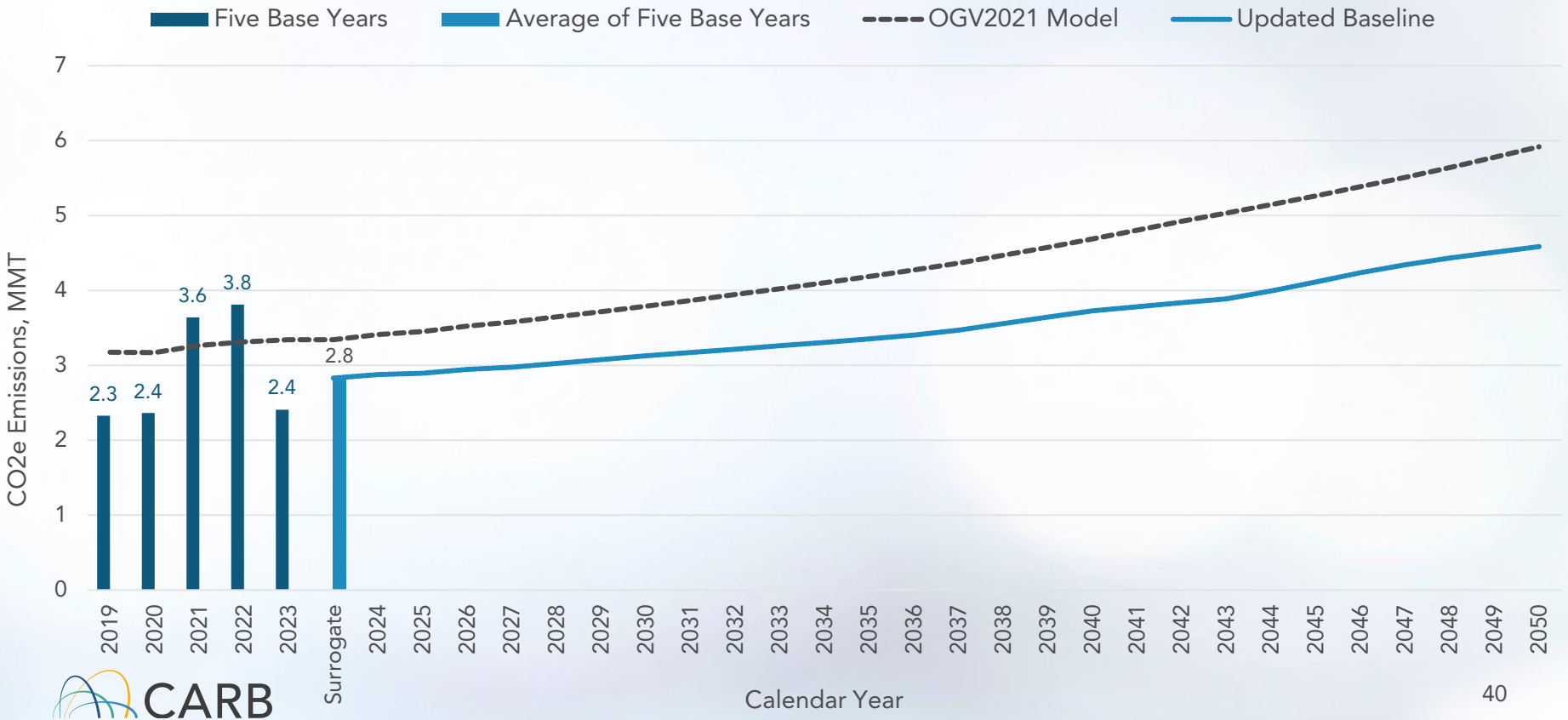

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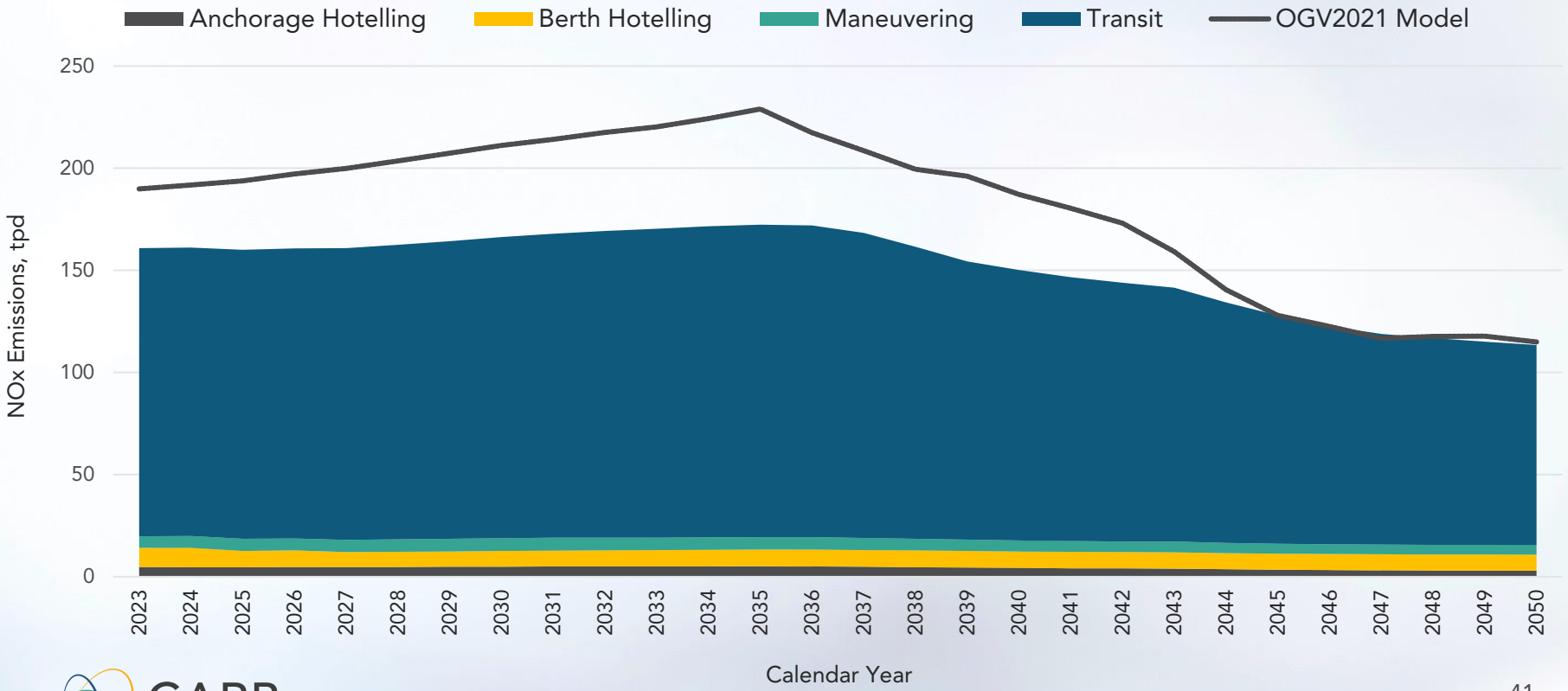
Statewide NOx by Mode



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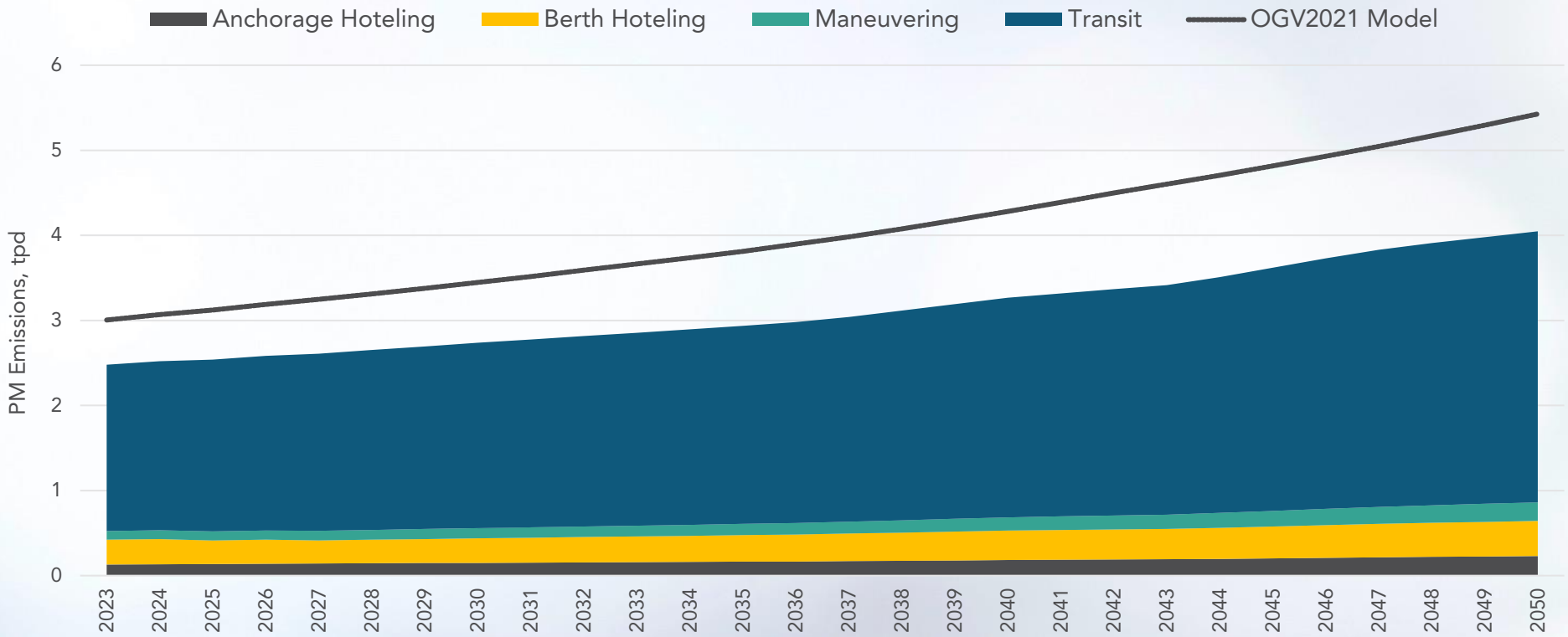
Statewide PM by Mode



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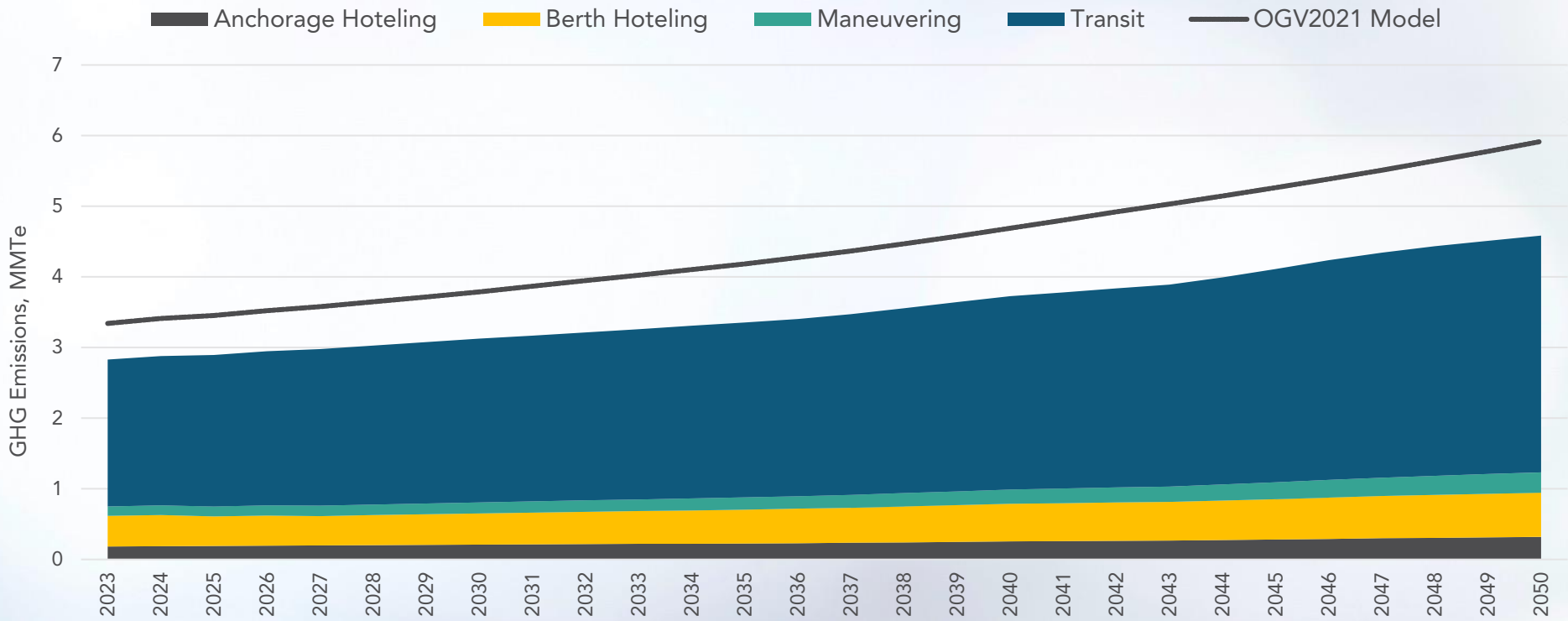
Statewide GHG by Mode



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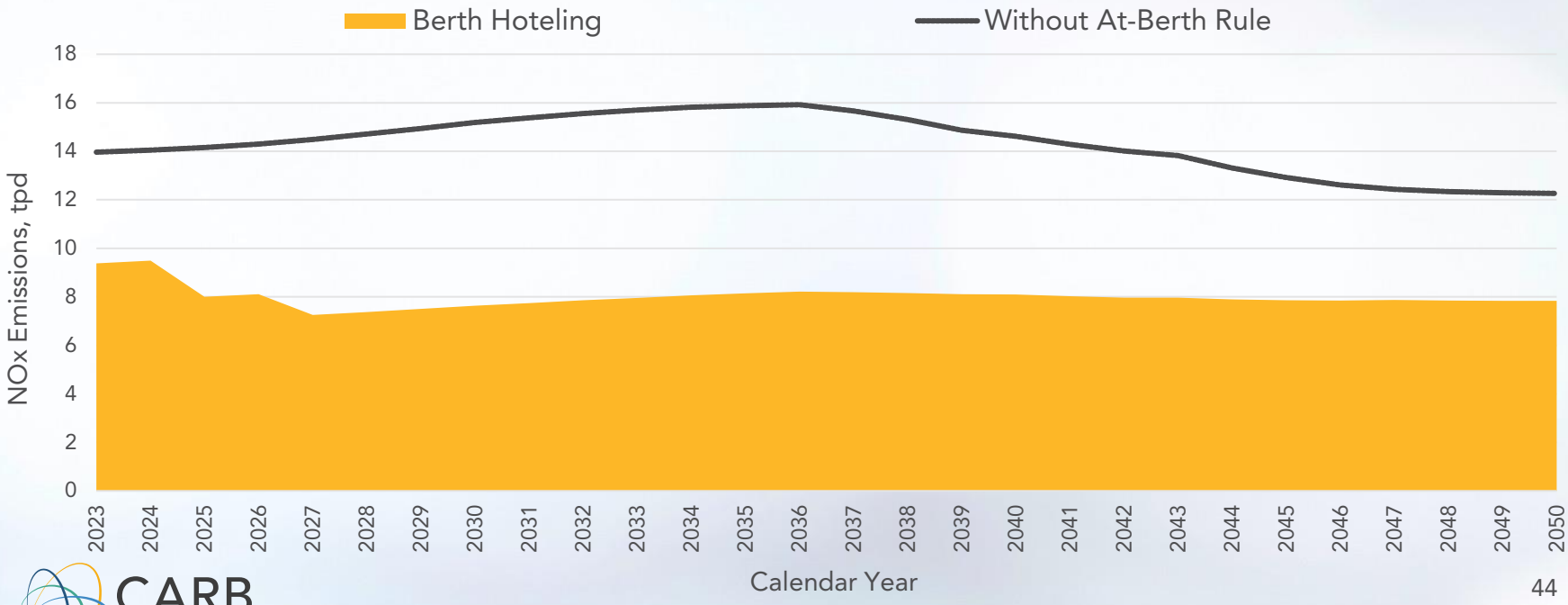
Statewide NOx, At-Berth Rule

Considering only emissions while at-berth, the graph below shows reductions from the At-Berth Rule, as amended in 2020



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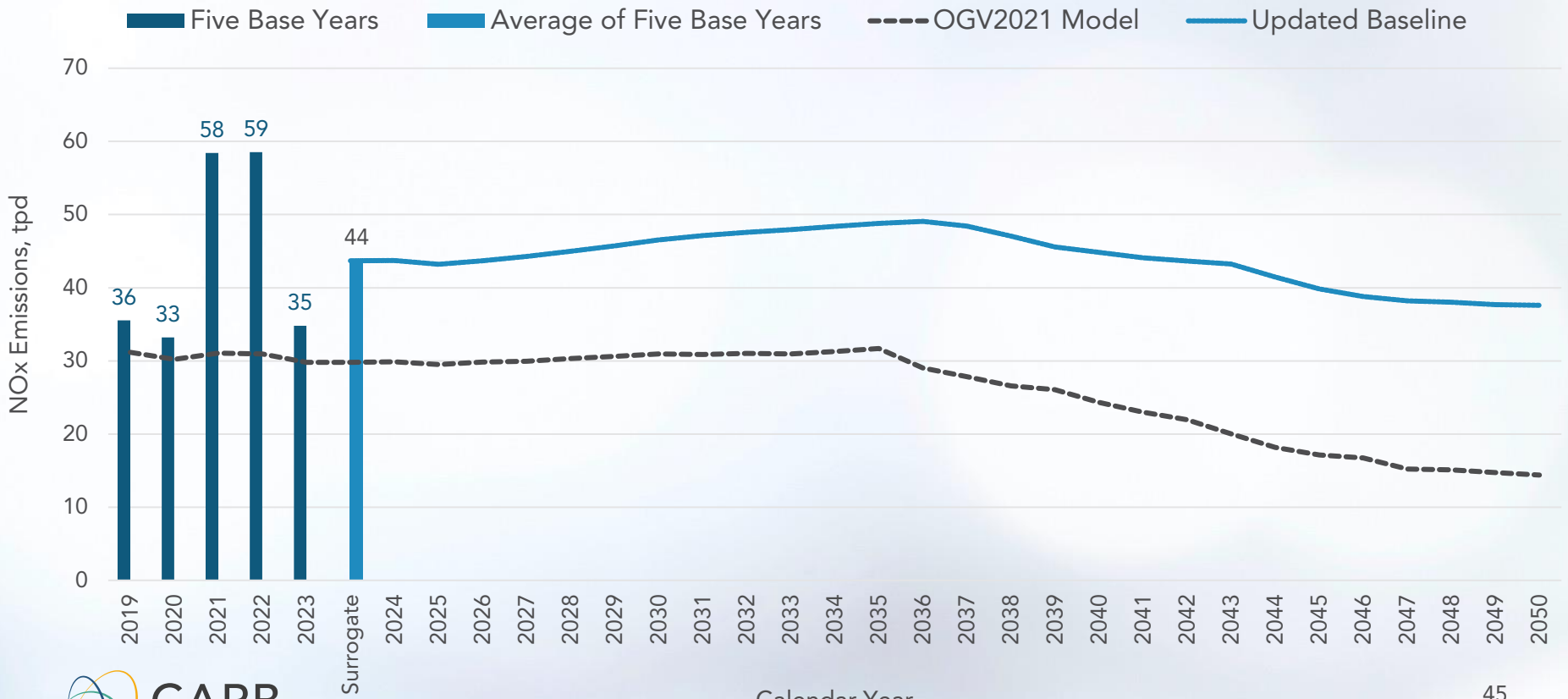
South Coast NOx Forecast



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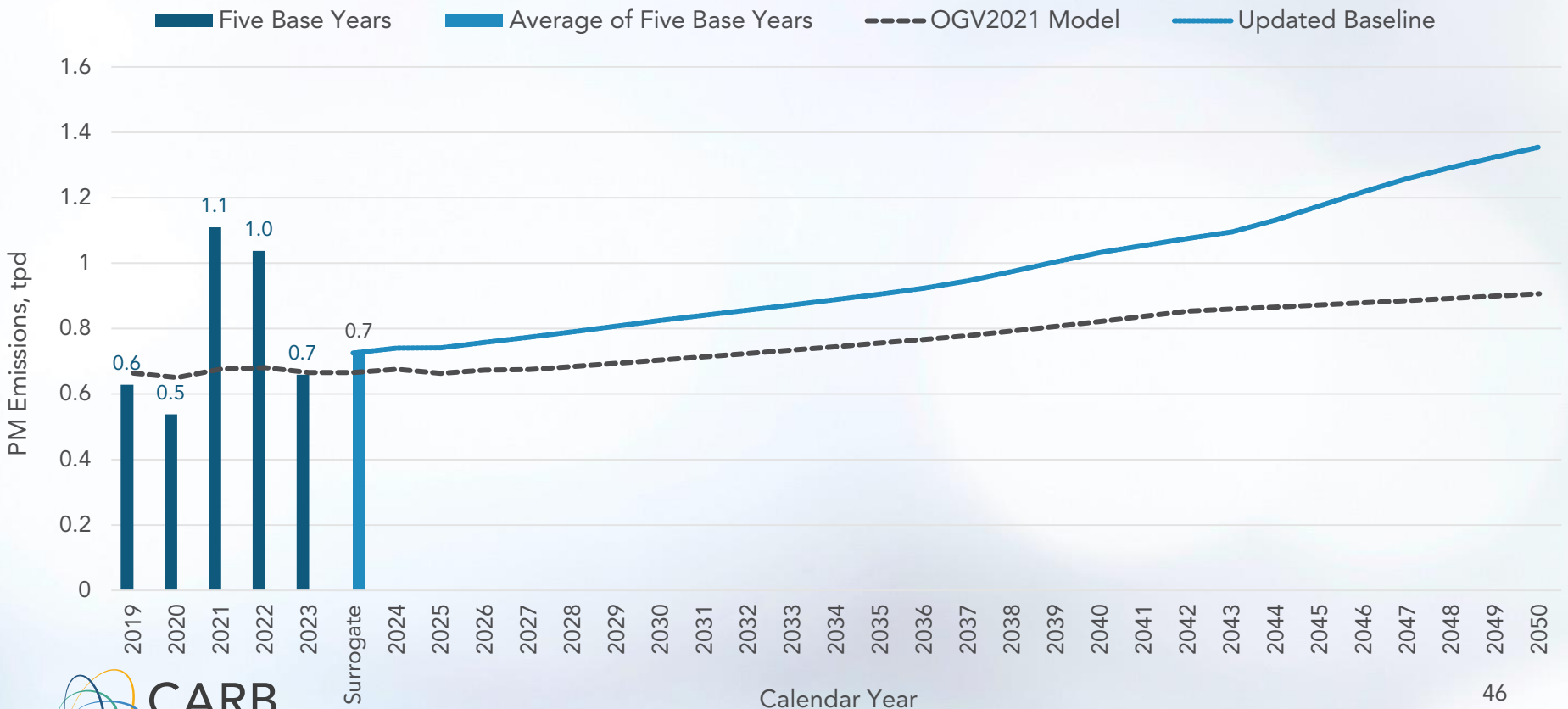
South Coast PM Forecast



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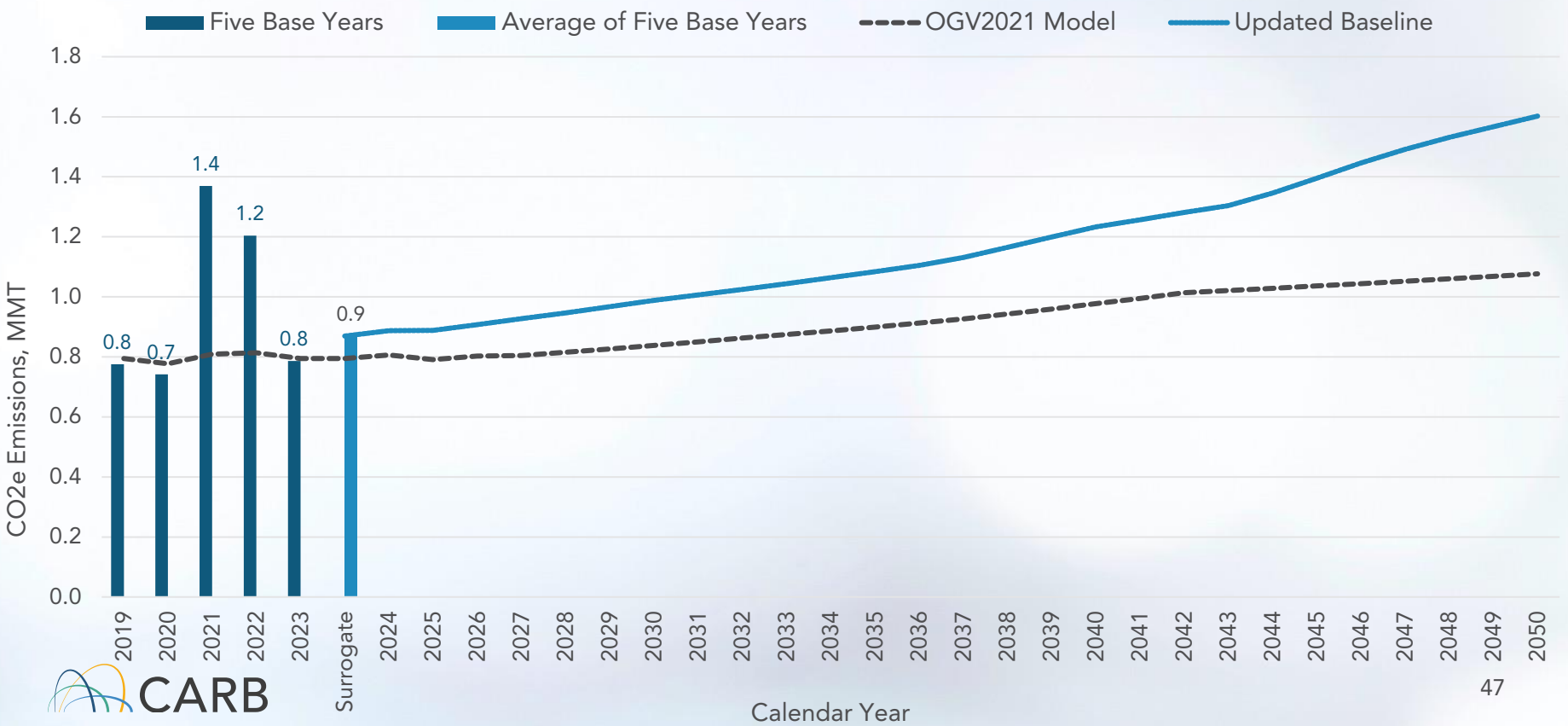
South Coast GHG Forecast



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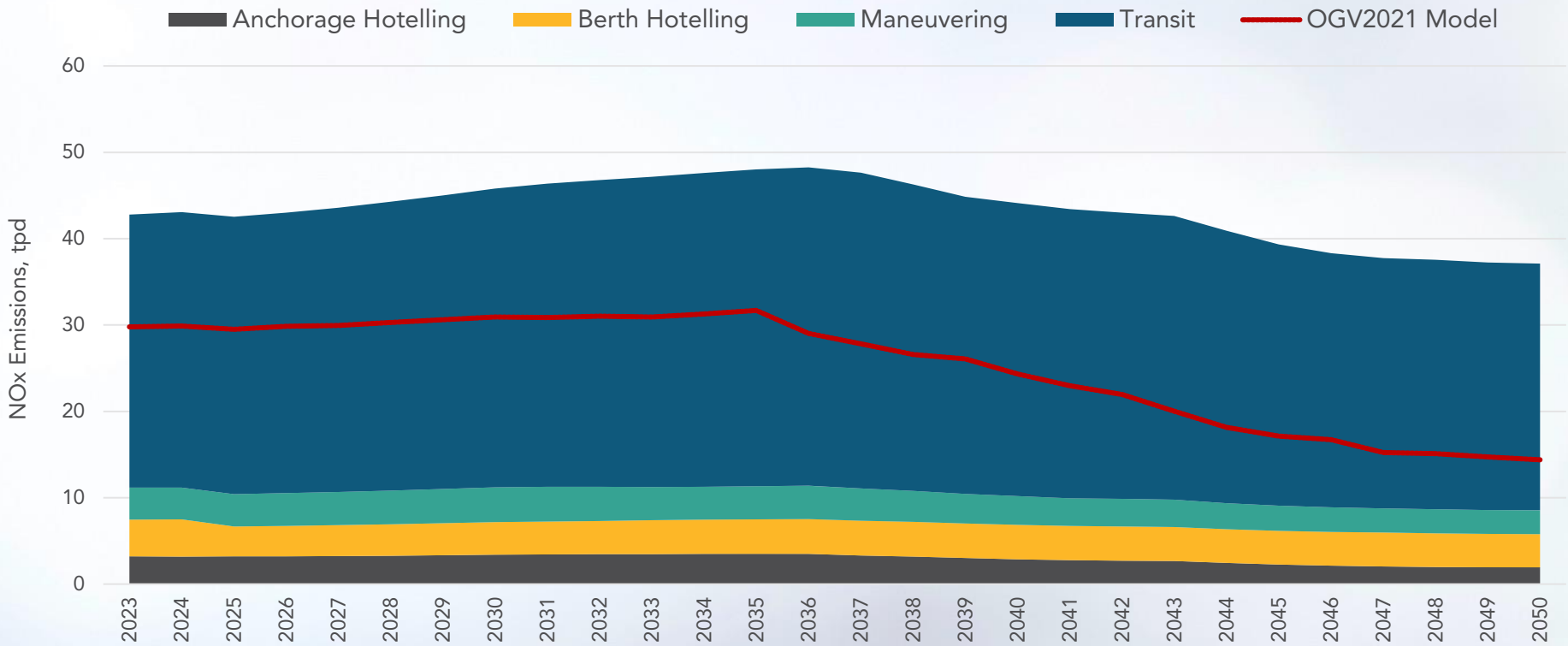
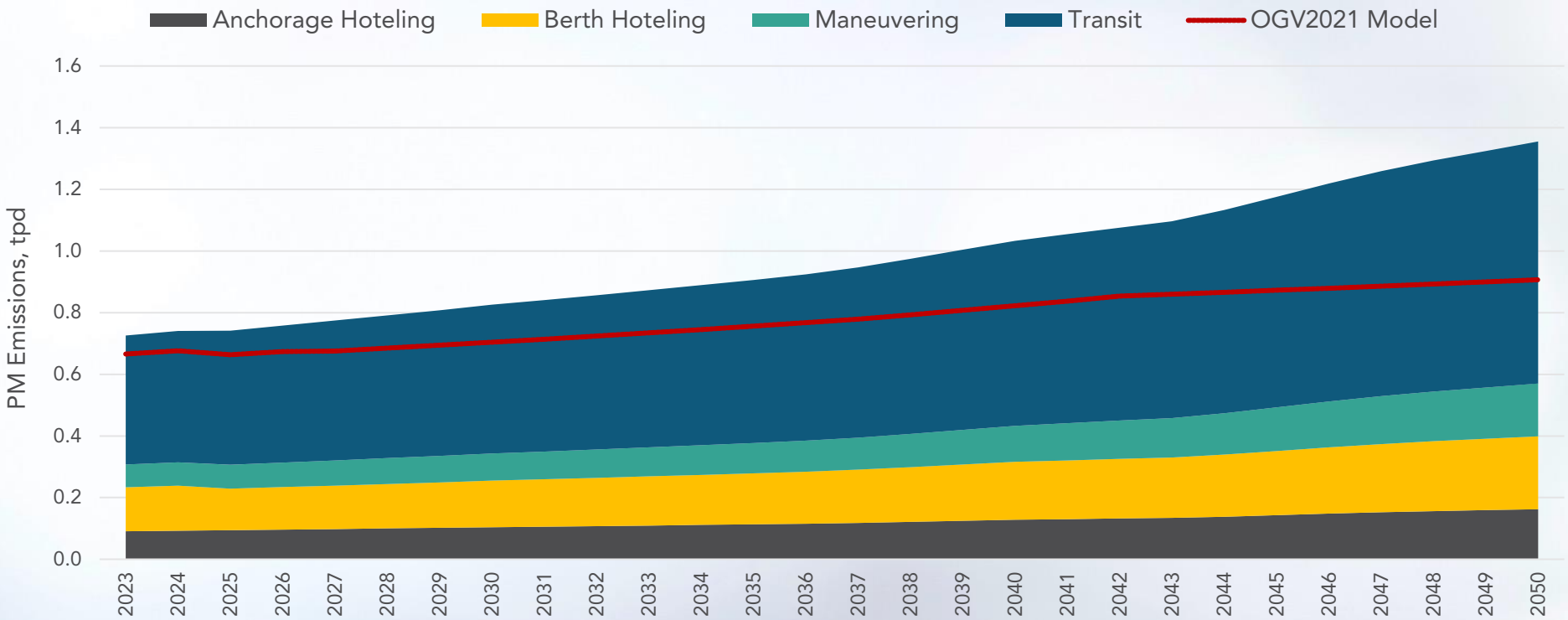
South Coast NOx by Mode



South Coast PM by Mode



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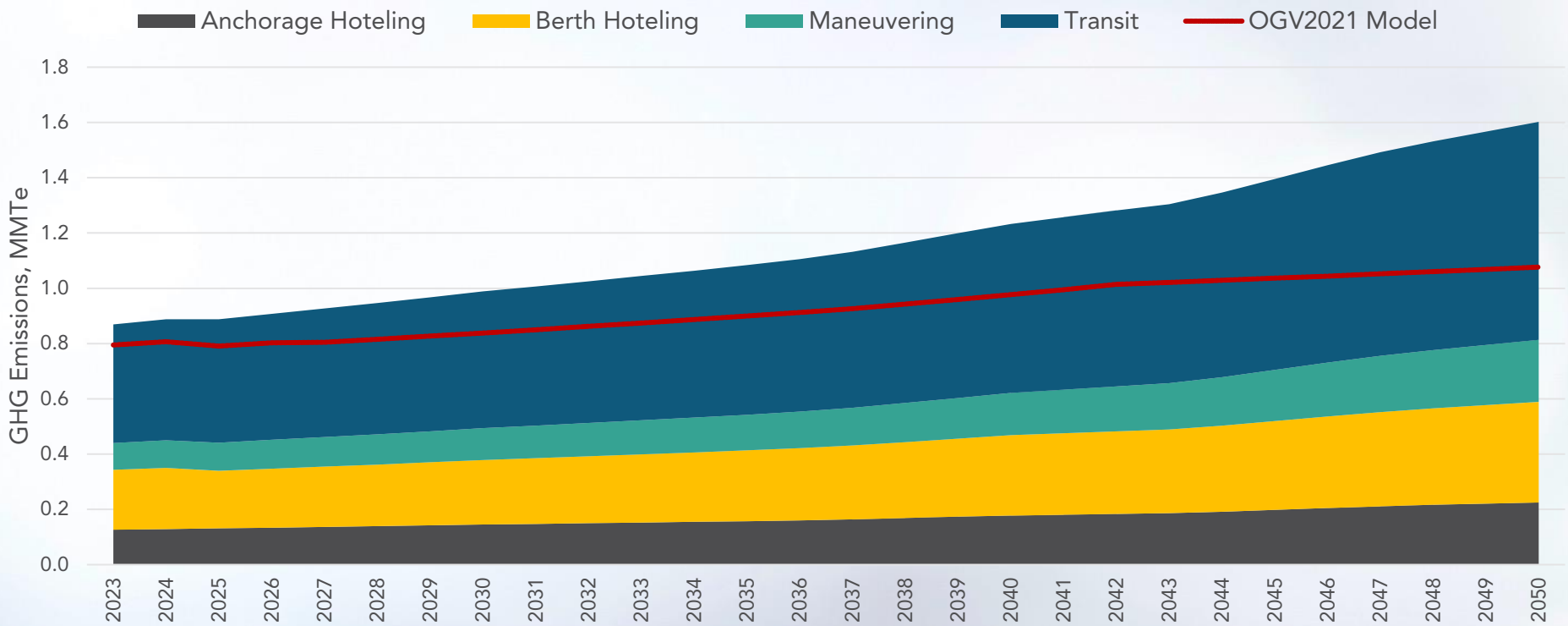

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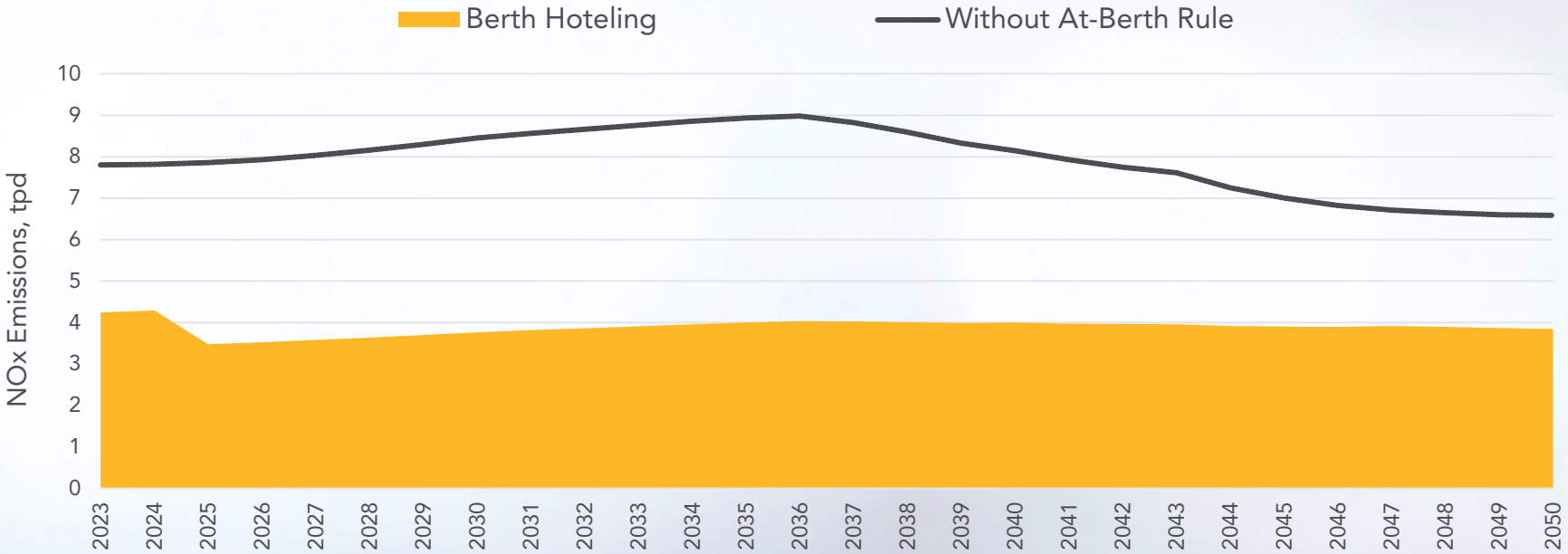
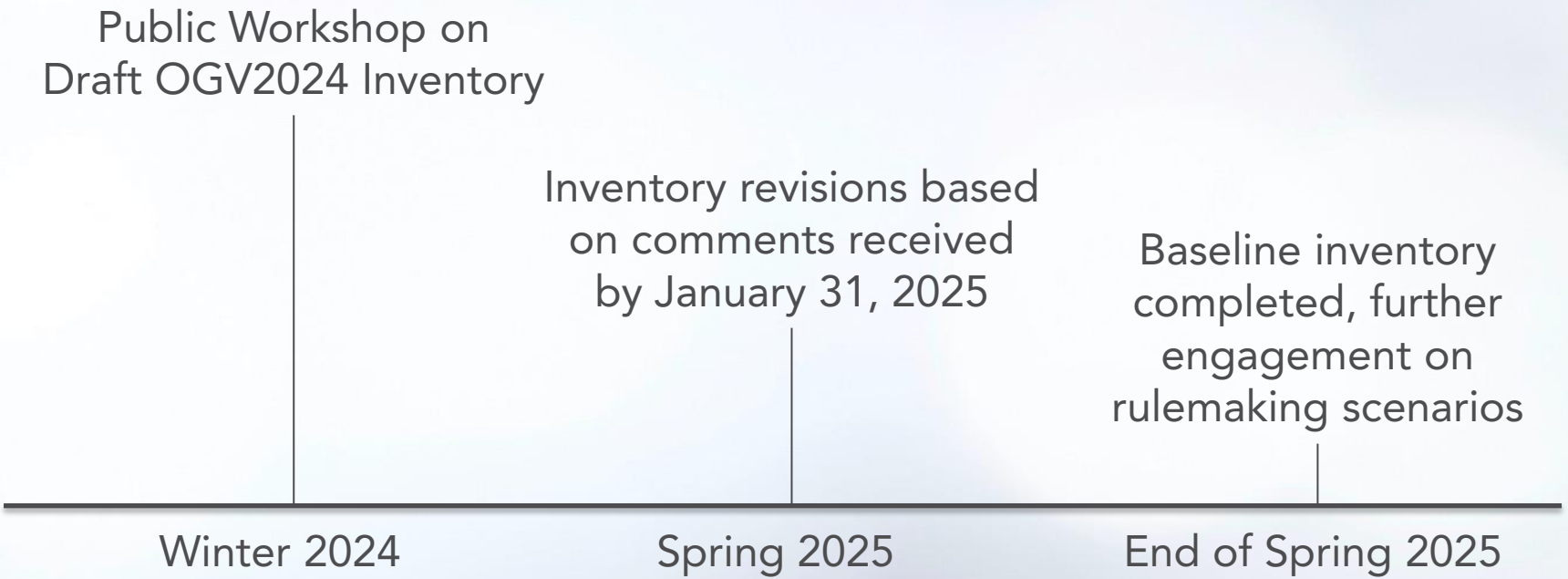


Next Steps



CARB

What are your thoughts?

Please include slide numbers, if possible

Via Zoom	Via Phone
Use Raise Hand feature to enter the queue	#2 to Raise Hand *6 to Mute/Unmute

Additional inventory questions/comments may be submitted to OffRoadInventory@arb.ca.gov through January 31, 2025.

2024 Draft OGV Emissions Inventory:
https://ww2.arb.ca.gov/sites/default/files/2024-11/Draft_OGV2024_Documentation_ADA.pdf

2021 OGV Emissions Inventory:
https://ww2.arb.ca.gov/sites/default/files/2022-06/CARB_2021_OGV_Documentation_ADA.pdf