

Black Carbon in California: Decreasing Concentrations and Control of Motor Vehicle Emissions

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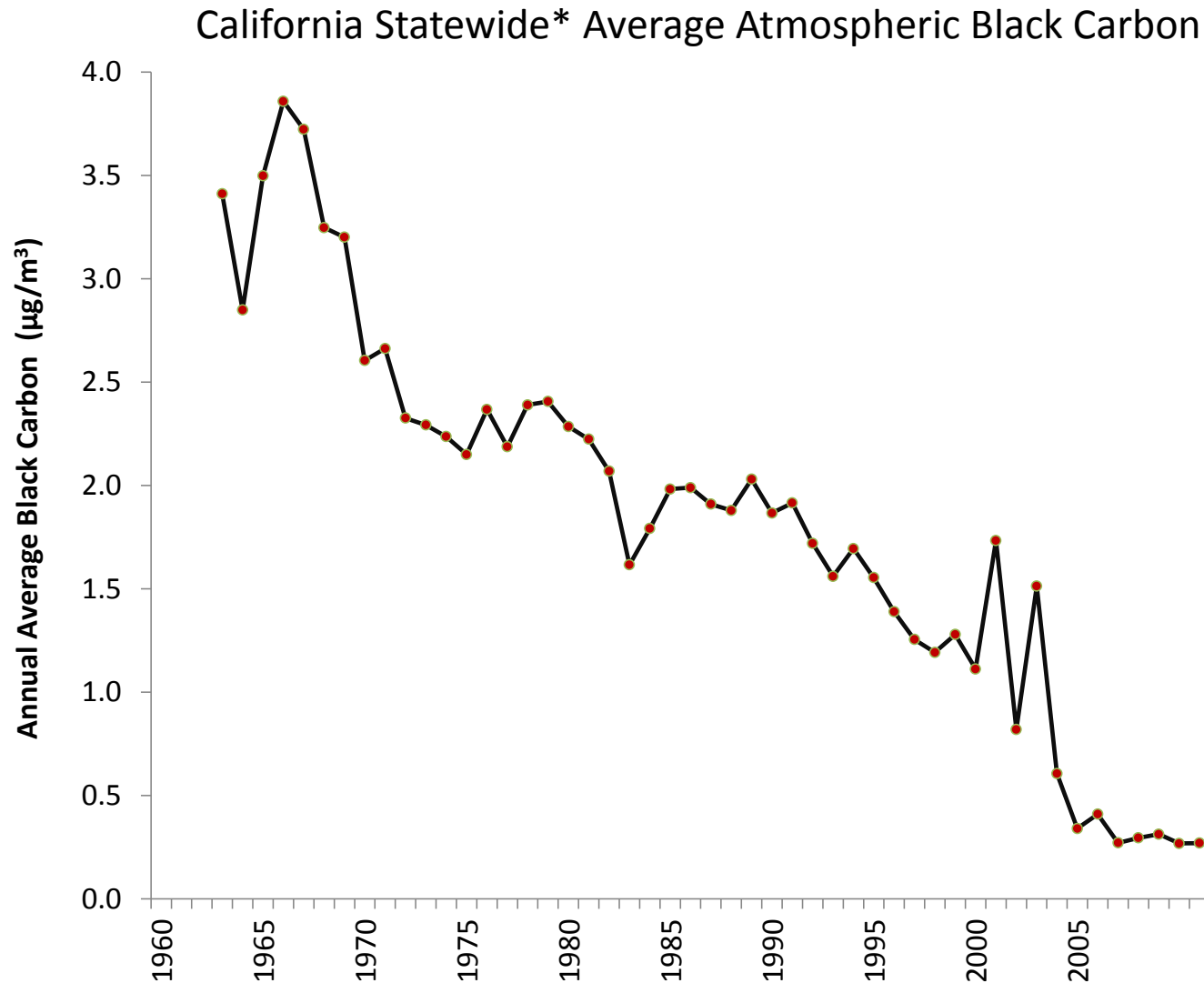
Research collaborators and funding support:

Rob Harley, Chelsea Preble, Tim Dallmann (UCB)

V. Ramanathan (UCSD)

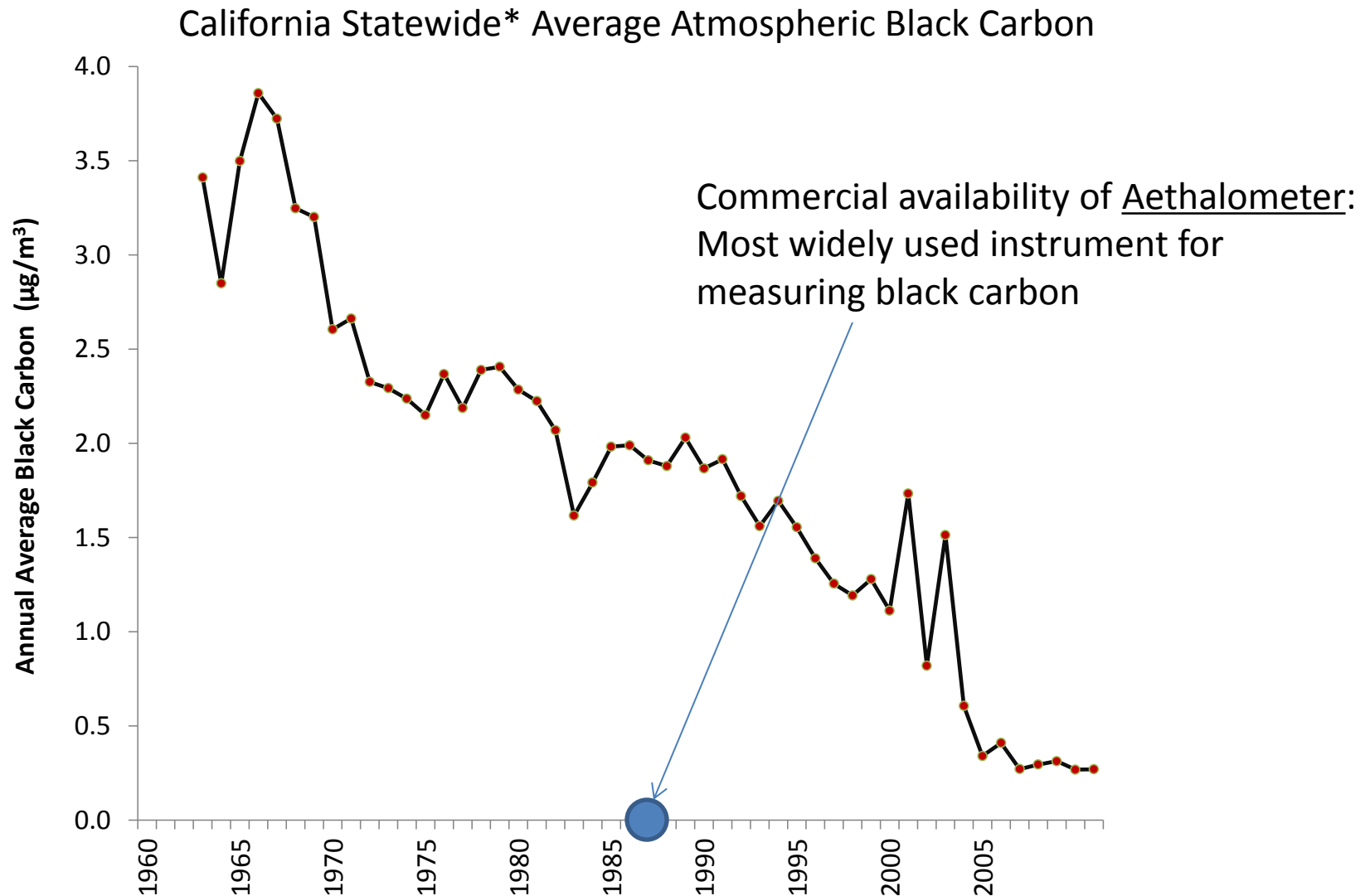
CARB, BAAQMD (Funding)

Decreasing Black Carbon Concentrations



* Includes San Diego, San Francisco, San Joaquin Valley, Sacramento, N. Central Cost, but excludes Los Angeles

Decreasing Black Carbon Concentrations

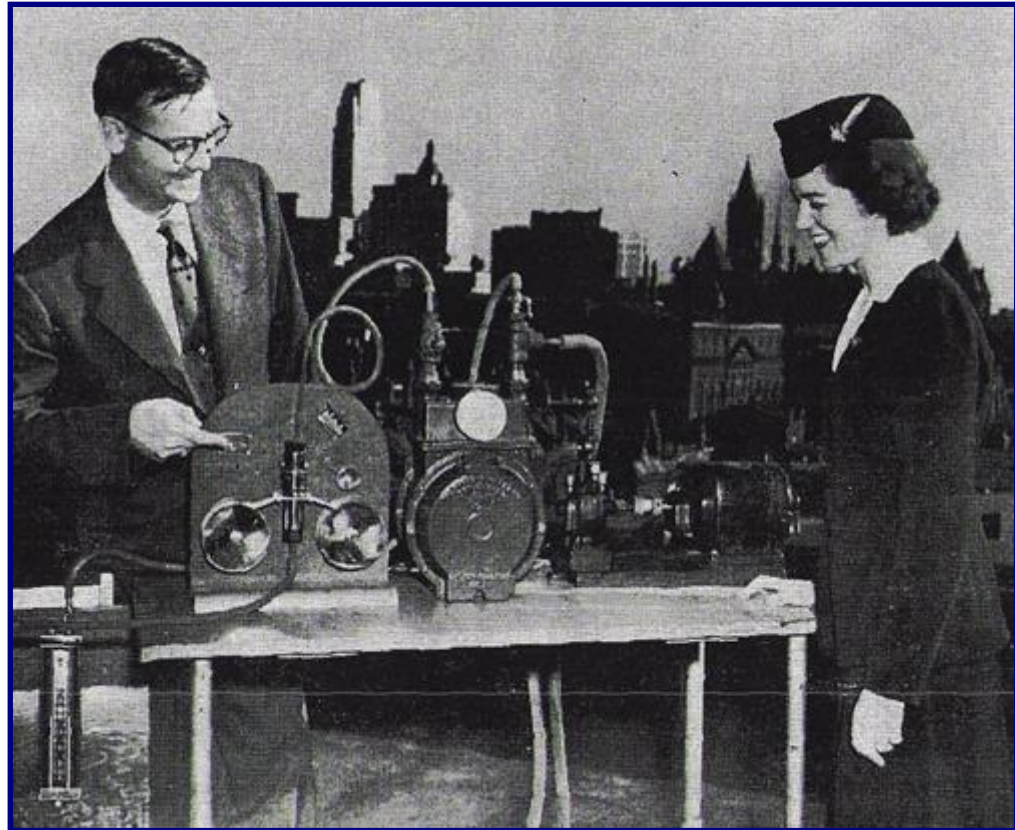


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BC Trend Based on Archived Record of COH

- COH = Coefficient of Haze
- Early measure of particulate matter air quality

Hemeon et al. (1953),
Determination of haze and smoke
concentrations by filter paper
samples, *Air Repair 3*, 22–28



BC Trend Based on Archived Record of COH

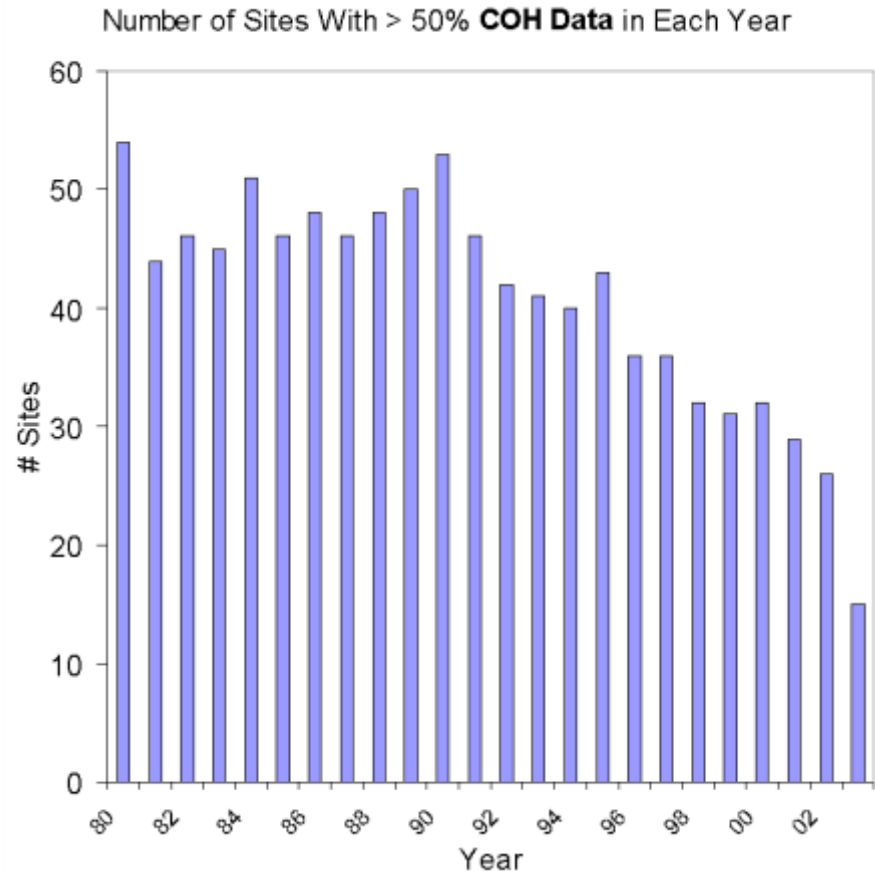
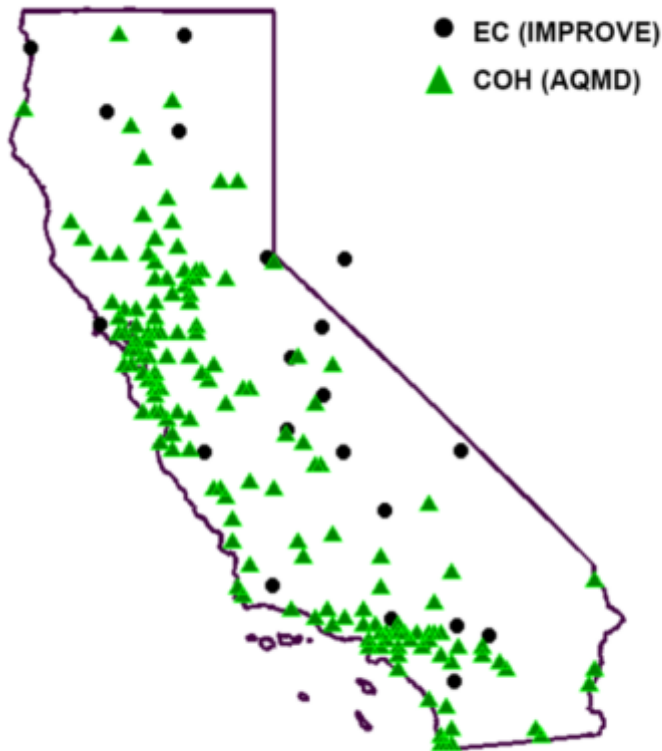
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COH sampler that was extensively deployed in California



BC Trend Based on Archived Record of COH

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- Measurement principle analogous to Aethalometer



Aethalometer



COH

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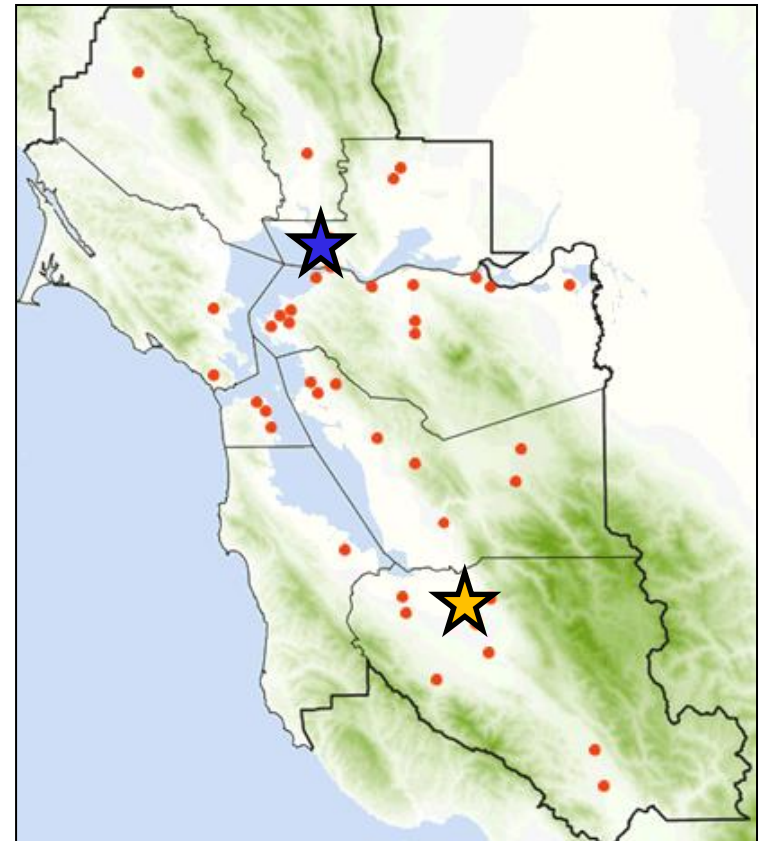
$$BC (\mu\text{g}/\text{m}^3) = \frac{1}{\sigma} \ln(1/T) \frac{\text{spot area}}{\text{air volume}}$$



$$\text{COH} (10^{-3} \text{ ft}^{-1}) = \log(1/T) \frac{\text{spot area}}{\text{air volume}}$$

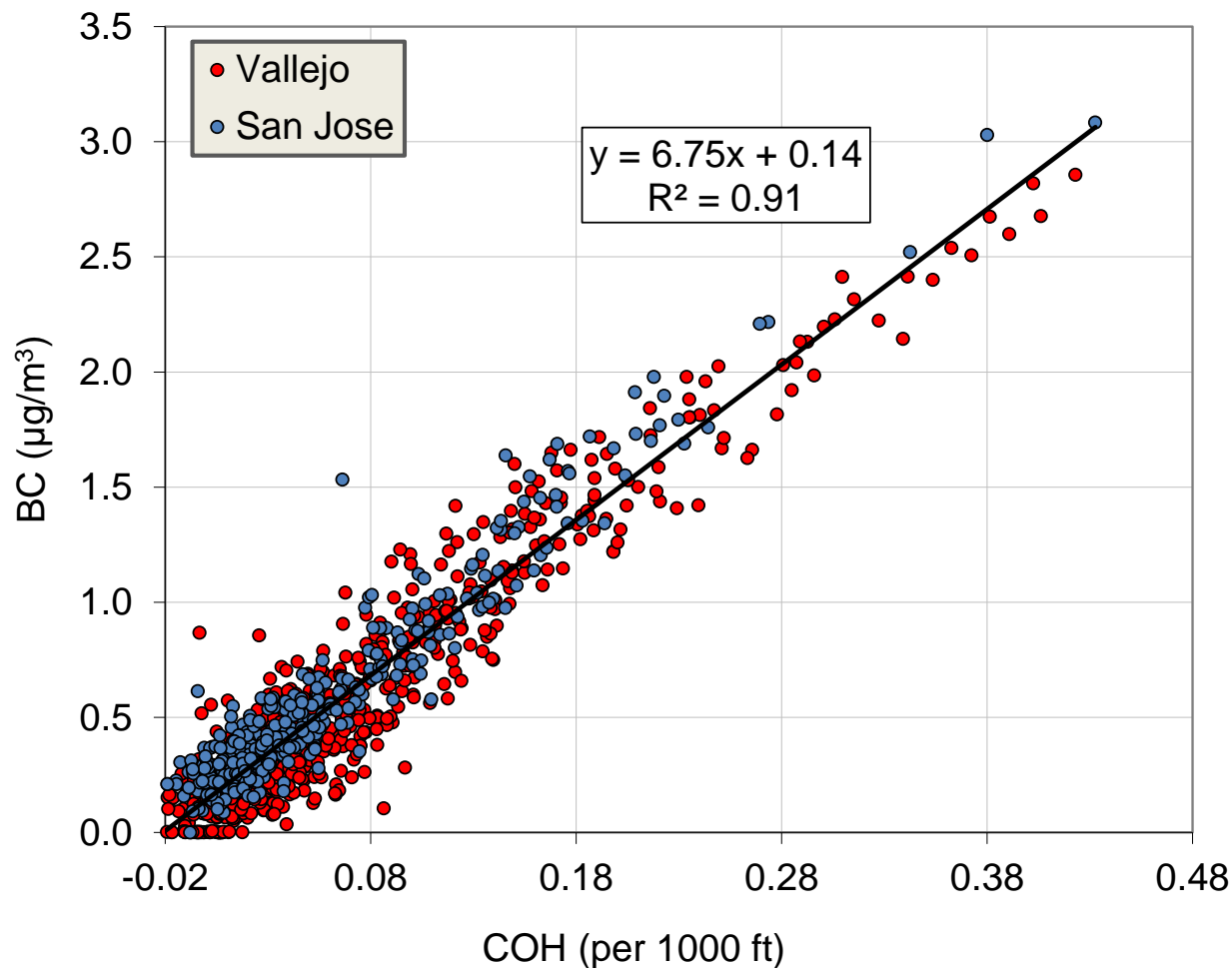
Sampling Study to Compare BC and COH

- Reinstated two COH monitors at BAAQMD sites
- Collocated with aethalometers
- 2 years in Vallejo ★
- 1 year in San Jose ★

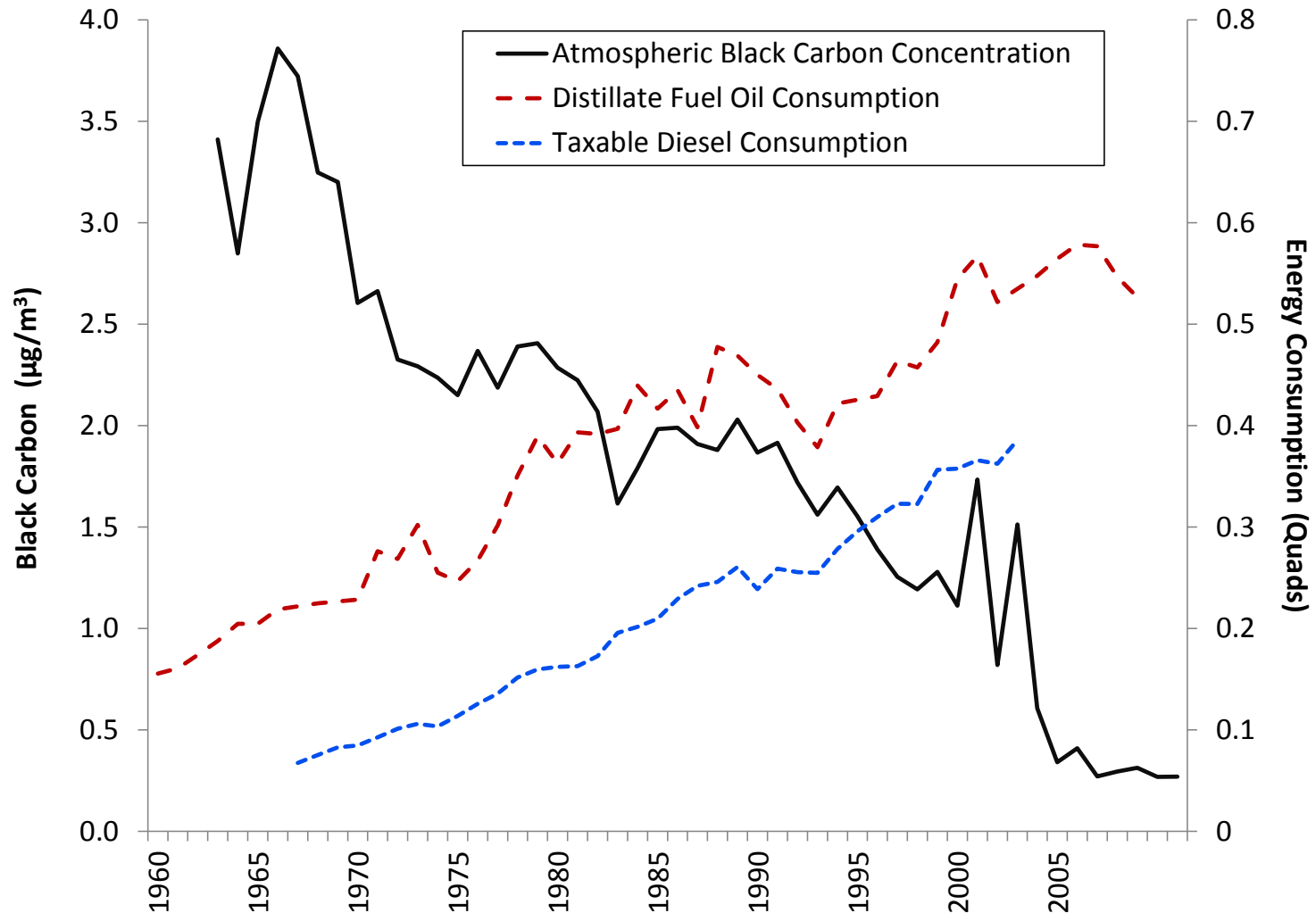


Results of Collocated Sampling

- BC and COH are highly correlated
- Use COH to reconstruct BC history w/ confidence

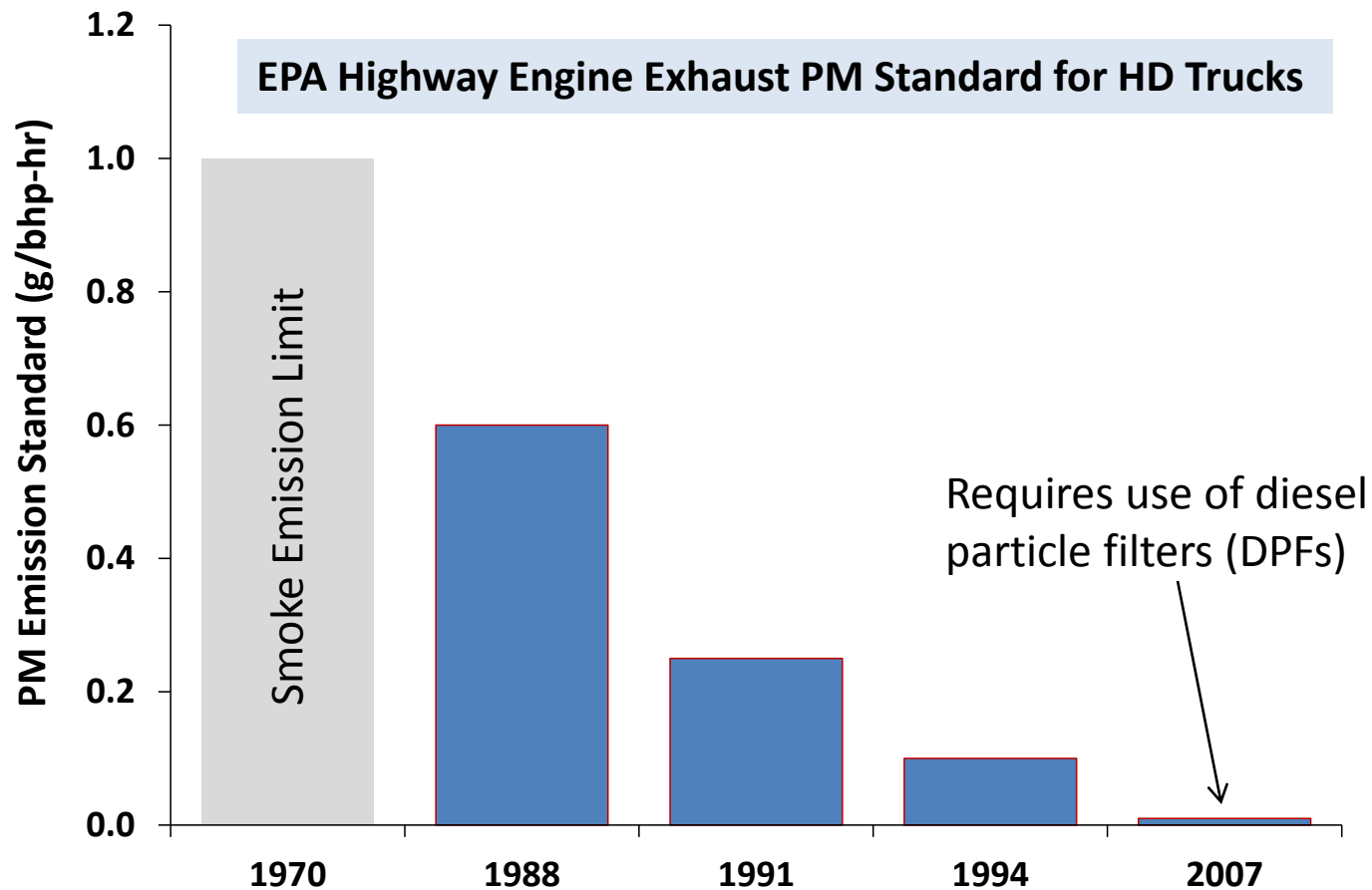


AQ Improved Despite Growth in Fuel Consumption and Vehicle Travel



Drivers of Reduced Diesel Truck PM Emissions

- Emission standards for new trucks
 - Smoke emission limit predates first PM emission standard



Drivers of Reduced Diesel Truck PM Emissions

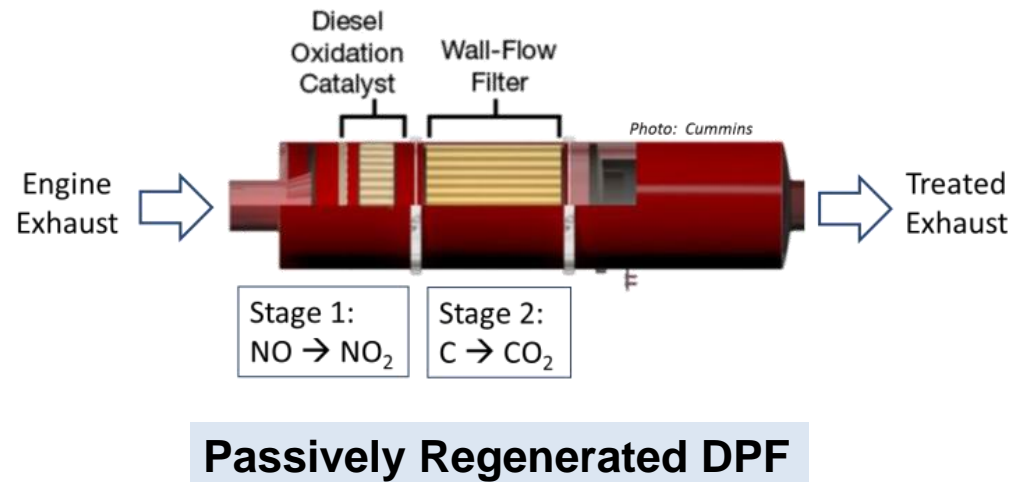
- Emission standards for new trucks
 - Smoke emission limit predates first PM emission standard
- New California rules for in-use trucks accelerate introduction of diesel particulate filters
 - Truck and Bus Rule, Drayage Truck Rule

Retrofit:

Install DPF on in-use truck

Replacement:

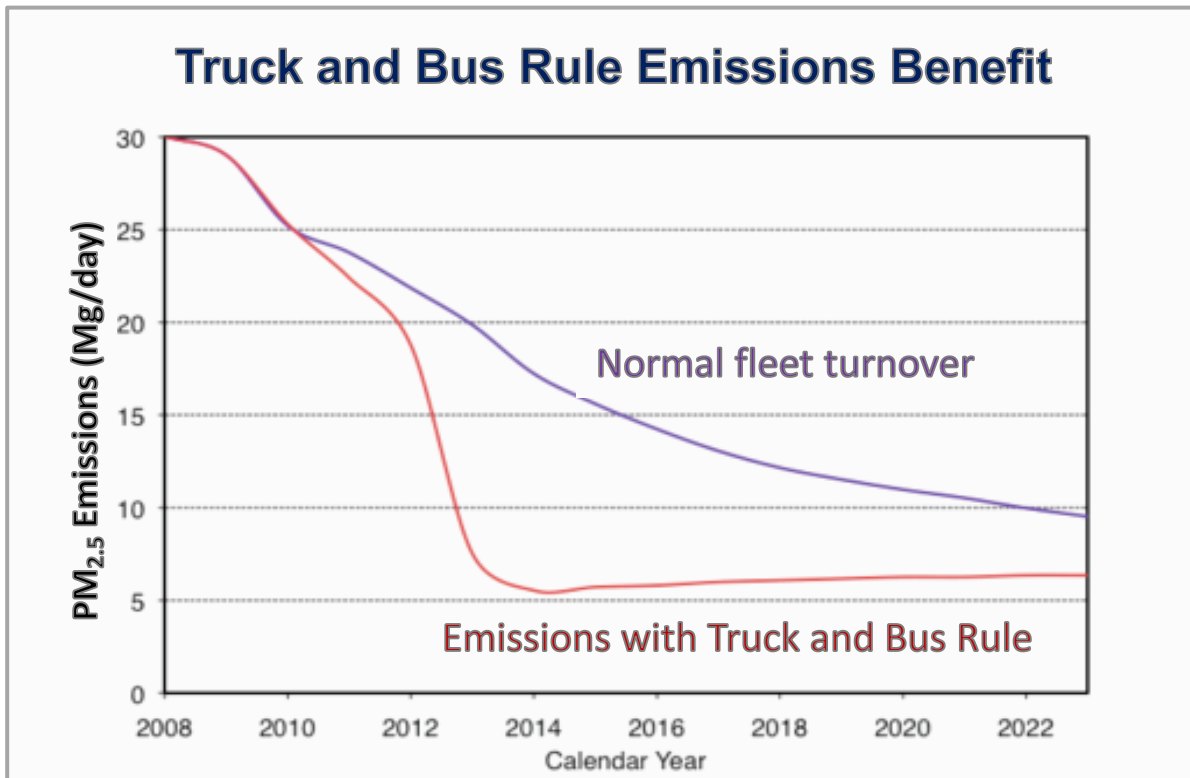
Upgrade to new engine
(originally DPF-equipped)



Diesel Particulate Filters (DPFs) trap and oxidize diesel exhaust PM

Truck and Bus Rule

- Applies to most heavy trucks and buses in state
 - Phase-in started in 2012
 - Major emissions reductions benefits are projected



Drayage Truck Rule

- Applies to trucks at ports and intermodal rail yards
 - DPFs installed on all trucks by Jan 1, 2013
 - Field sampling conducted to evaluate emissions changes at Oakland and Southern California ports



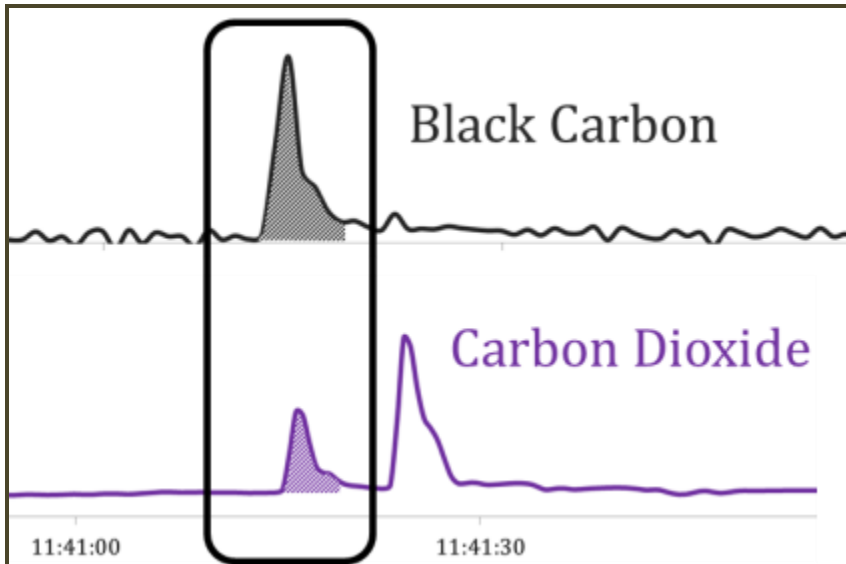
Drayage Truck Rule: UCB Study

- UC Berkeley study at Port of Oakland
 - Sampled exhaust plumes of trucks en route to port

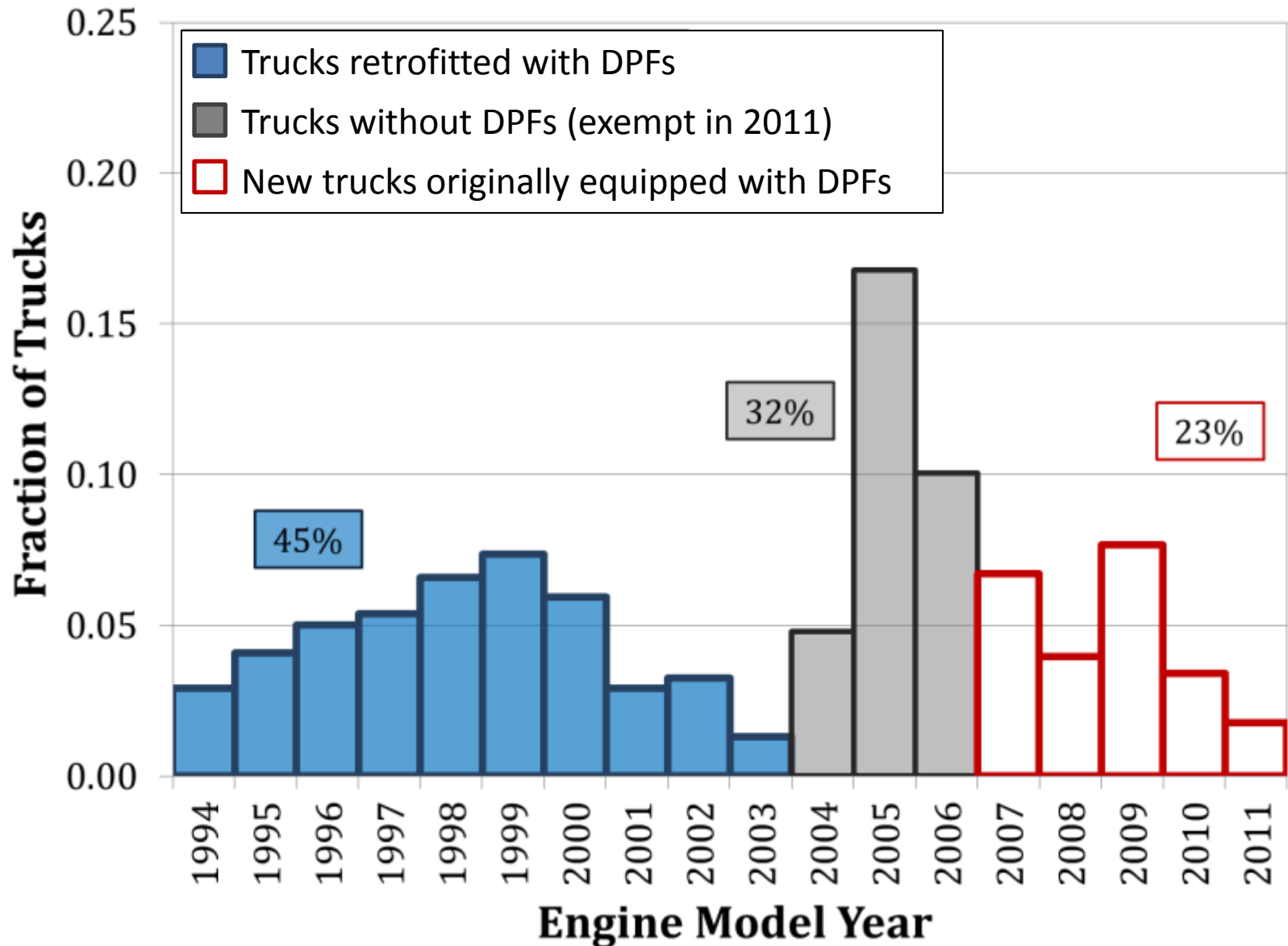


Drayage Truck Rule: UCB Study

- UC Berkeley study at Port of Oakland
 - Sampled exhaust plumes of trucks en route to port
 - Linked emissions to age & retrofit status via license plate



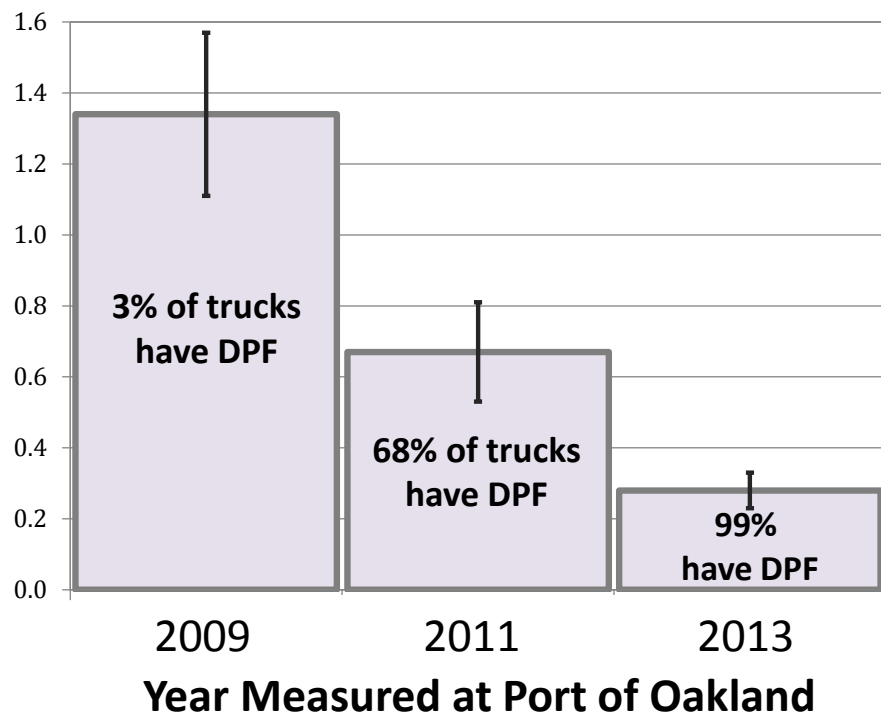
Composition of Oakland Port Trucks in 2011



Rule Significantly Reduced BC and NO_x Emissions

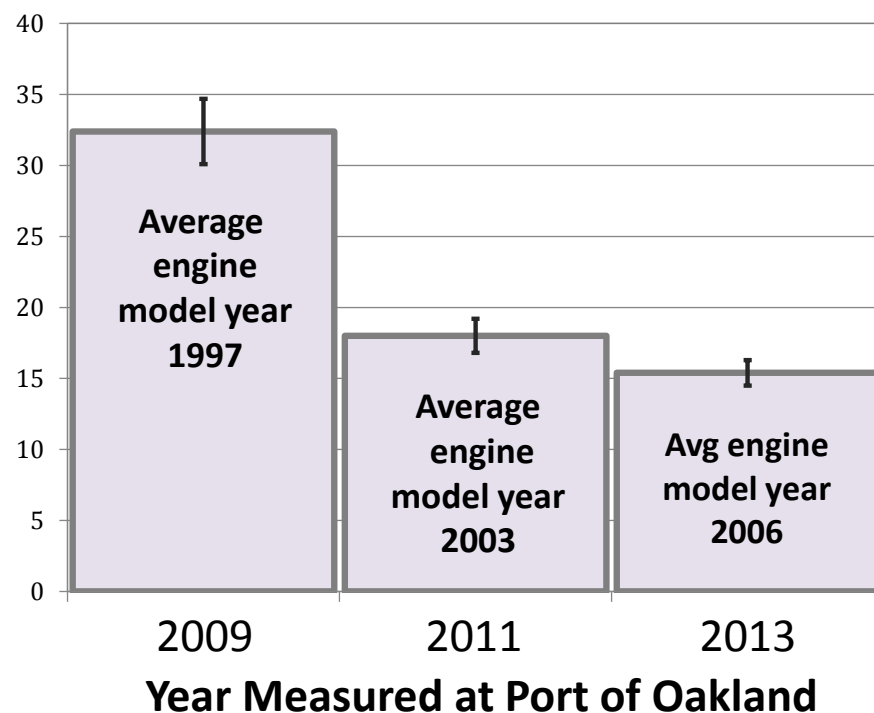
Measured Emission Rates of BC and NO_x (g/kg fuel)

Fleet Average BC Emission Rate



80% BC Reduction Overall

Fleet Average NO_x Emission Rate

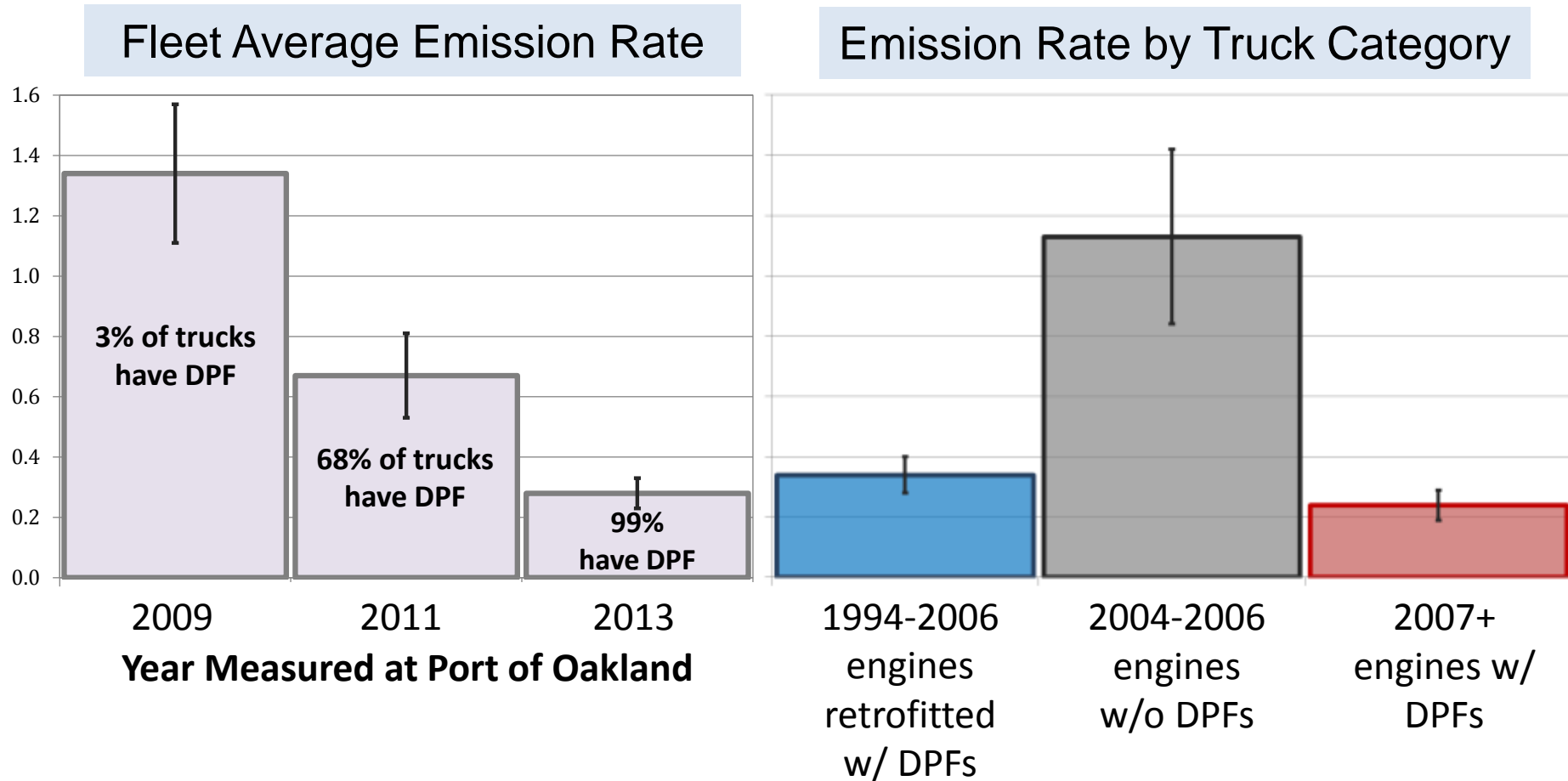


50% NO_x Reduction Overall

(Further reduction pending Phase 2 of Drayage Truck Rule)

Trucks without Filters Emit Much More BC

Measured Emission Rates of BC (g BC/kg fuel)



Summary

- California achieved an order of magnitude reduction in black carbon between 1965 and 2005, despite rapid growth in population and vehicle travel
- Truck and Bus Rule will continue to reduce black carbon emissions:
 - Anticipate further ~80% reduction in BC from on-road diesel trucks and buses in California in next several years