

ON-ROAD MEASUREMENT OF EMISSIONS FROM HEAVY-DUTY DIESEL ENGINES: IMPACT OF DRAYAGE TRUCK REGULATION

Robert Harley (harley@ce.berkeley.edu)

Department of Civil and Environmental Engineering
University of California, Berkeley

Feb 19, 2015

CRC Mobile Source Air Toxics Workshop

Acknowledgments

- UC Berkeley: Chelsea Preble, Tim Dallmann
- Lawrence Berkeley National Lab: Tom Kirchstetter
- Aerosol Dynamics: Nathan Kreisberg, Susanne Hering
- Research funding:
 - California Air Resources Board (Contract no. 09-340)
 - Thanks also to ARB staff (esp. Chandan Misra) and BAAQMD
 - National Science Foundation Fellowship (Chelsea Preble)

Introduction



- Major efforts underway to reduce diesel emissions
 - ▣ stringent emission standards for new engines
 - ▣ accelerated replacement of older engines in California
 - ▣ highly accelerated retrofit/replacement of trucks used for short-haul trips (“drayage”) to/from ports and rail yards

California Drayage Truck Regulation

(Based on Engine Model Year)

Deadline	Engine Banned	OK if Retrofit with Diesel Particle Filter (DPF)	Engine OK as is
Jan 2010	1993 & older	1994-2003	2004 & newer
Jan 2012	1993 & older	1994-2004	2005 & newer
Jan 2013	1993 & older	1994-2006	2007 & newer
Jan 2014	2006 & older	none	2007 & newer

Present study features measurements of in-use emissions from drayage trucks at the Port of Oakland in Nov 2011 and Mar 2013 (plus baseline data from Nov 2009)



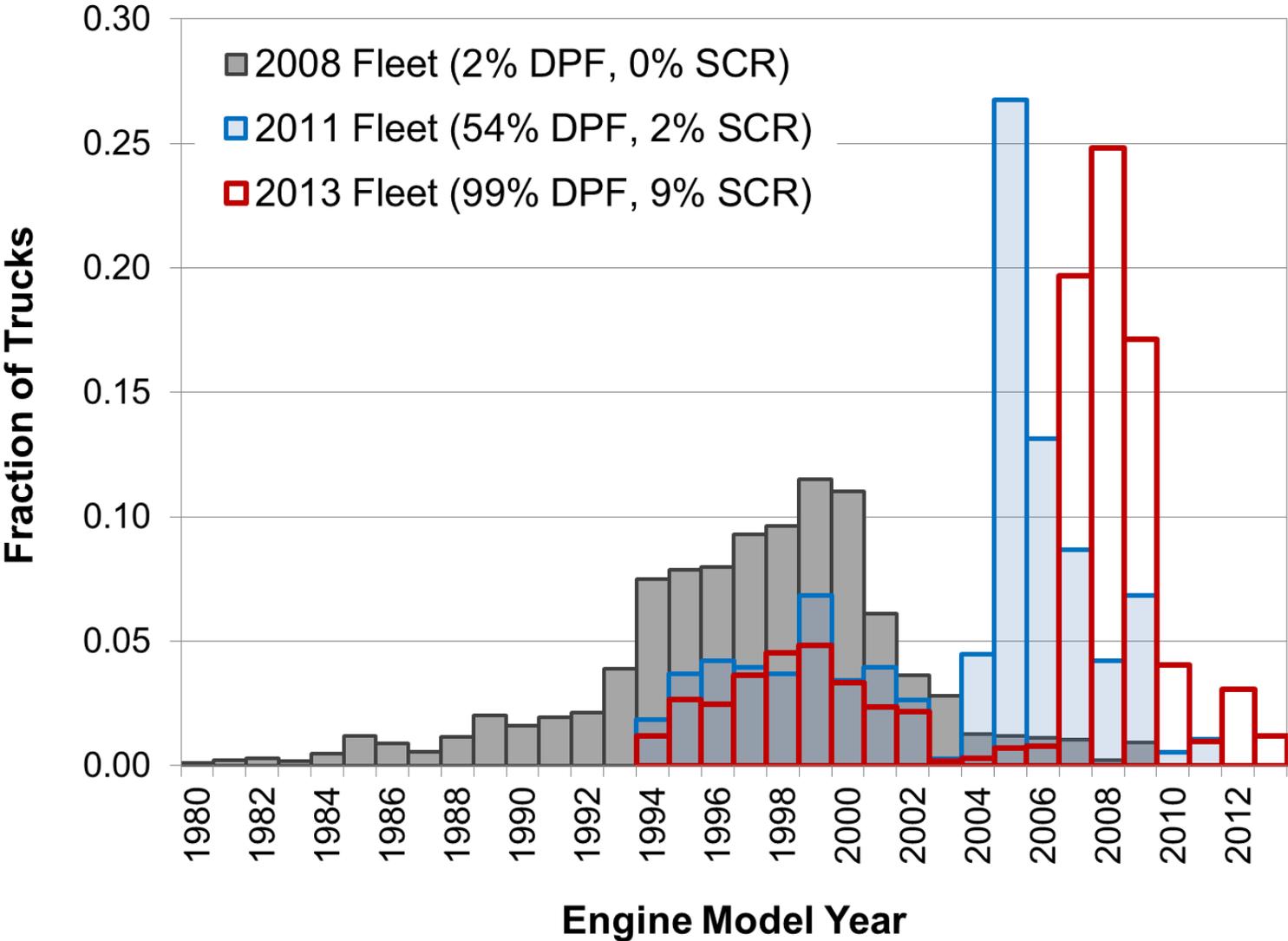
Port of Oakland Field Measurements

- Sample exhaust plumes of individual port trucks:
 - ▣ NO_x and NO₂ (by difference, NO_x – NO, using two analyzers)
 - ▣ Black carbon (BC by aethalometer – light absorption)
 - ▣ Ultrafine particles (UFP by condensation particle counter)
 - ▣ CO₂ (by infrared absorption)

- Emission factors calc. by carbon balance for each truck

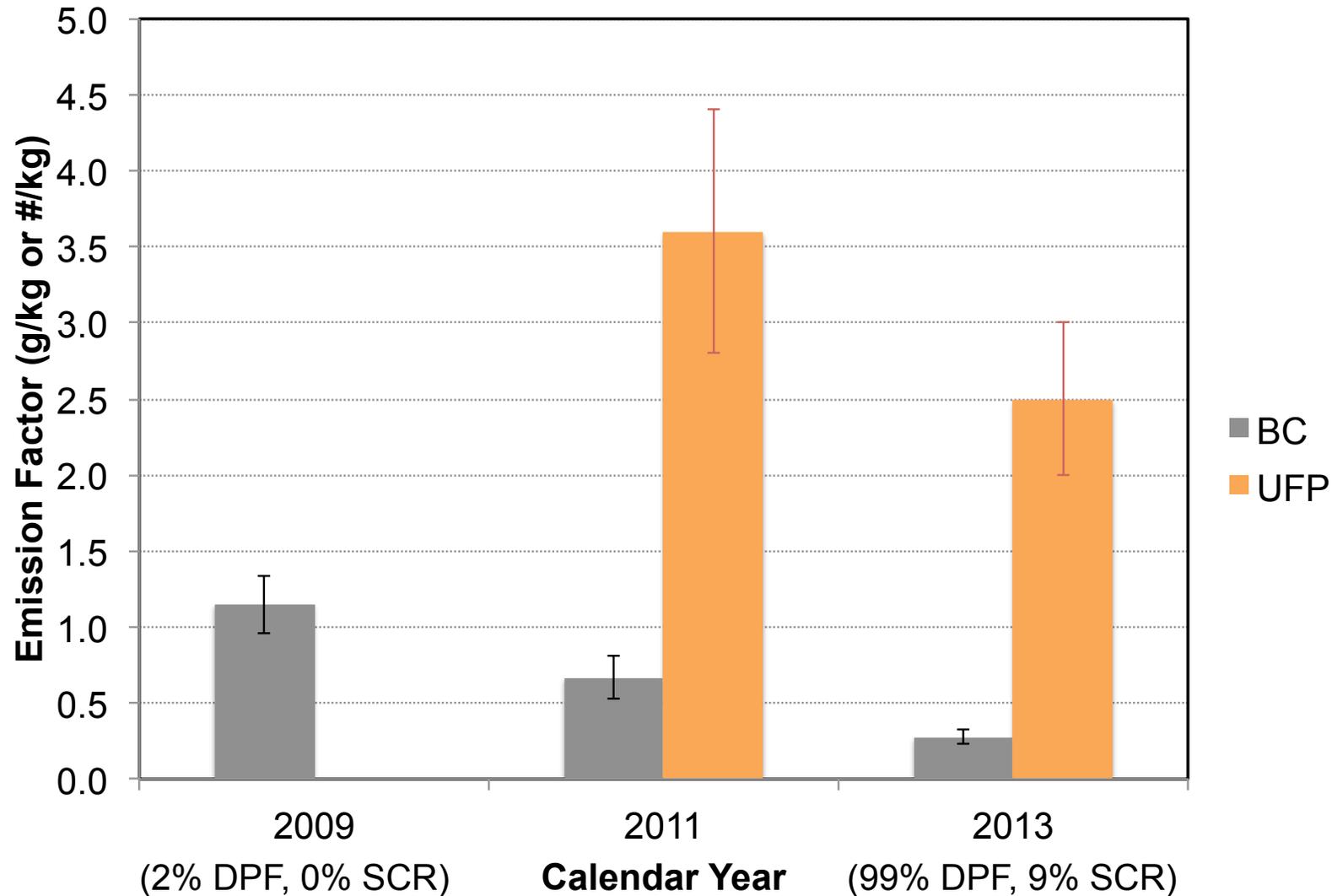
- License plate images used to obtain info about each truck
 - ▣ engine make & model year, retrofit control devices

Port Truck Engine Age Distribution

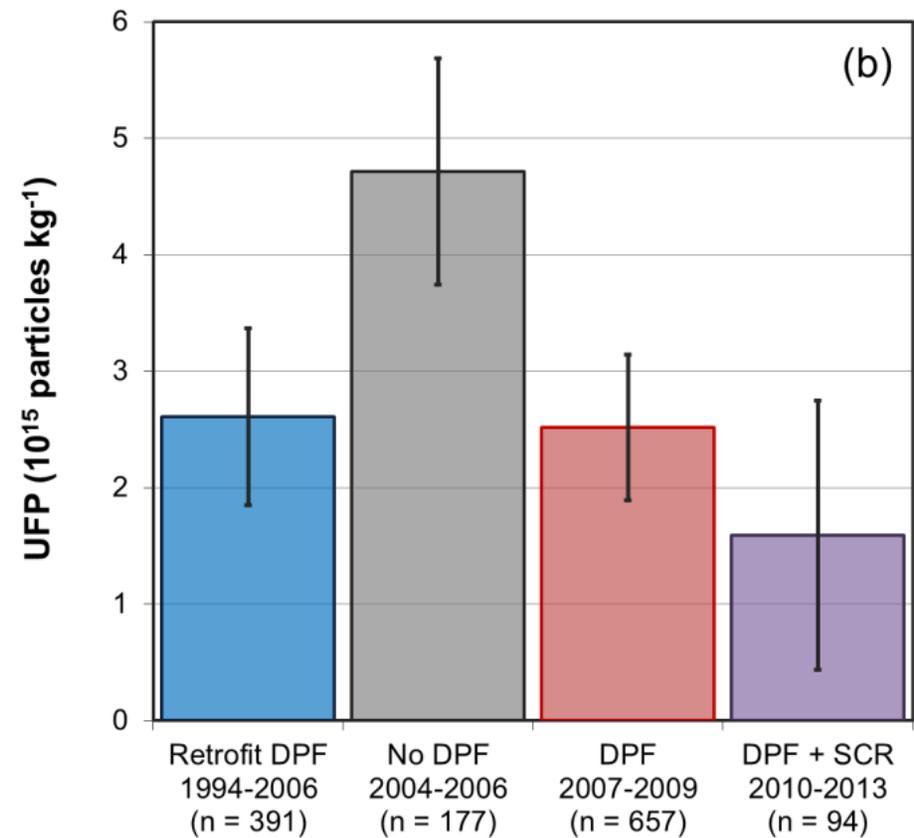
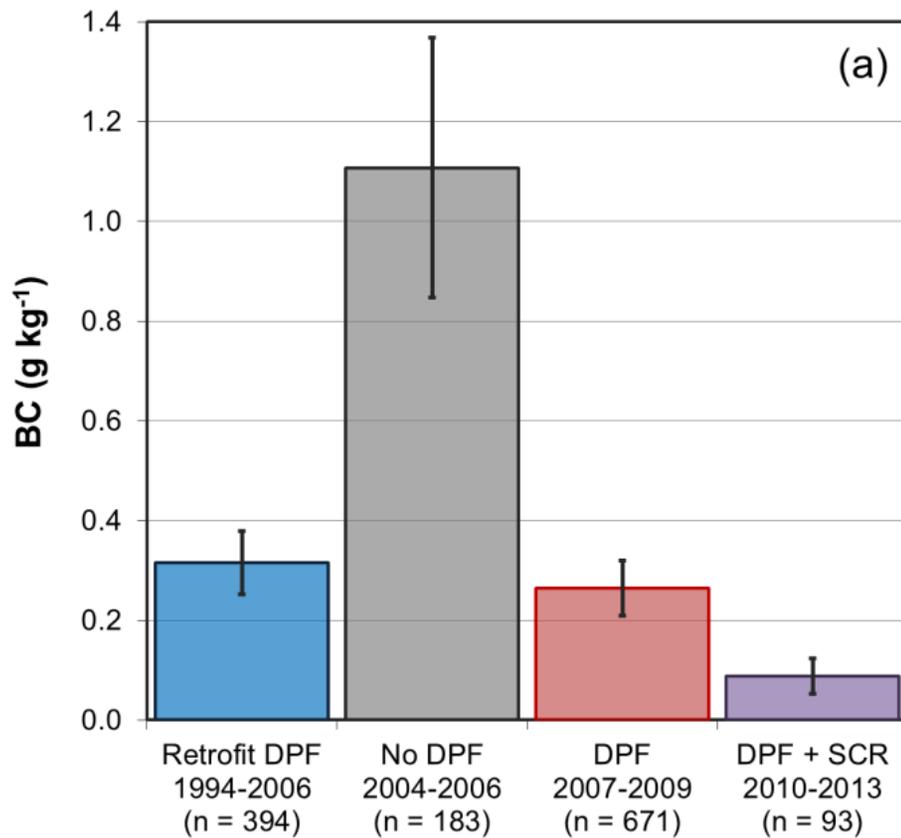


Black Carbon and Ultrafine Particles

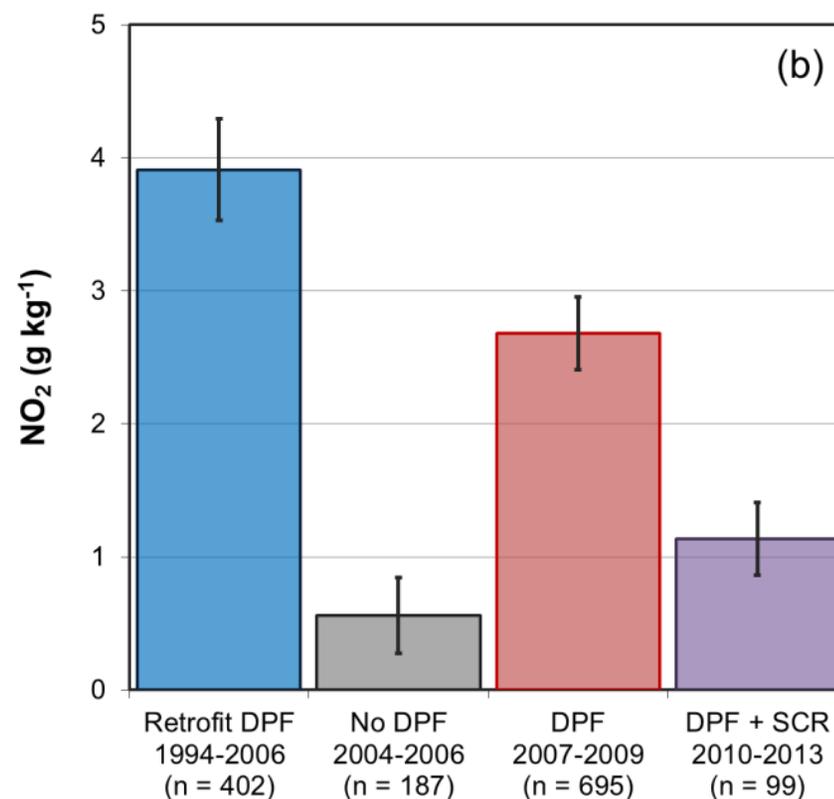
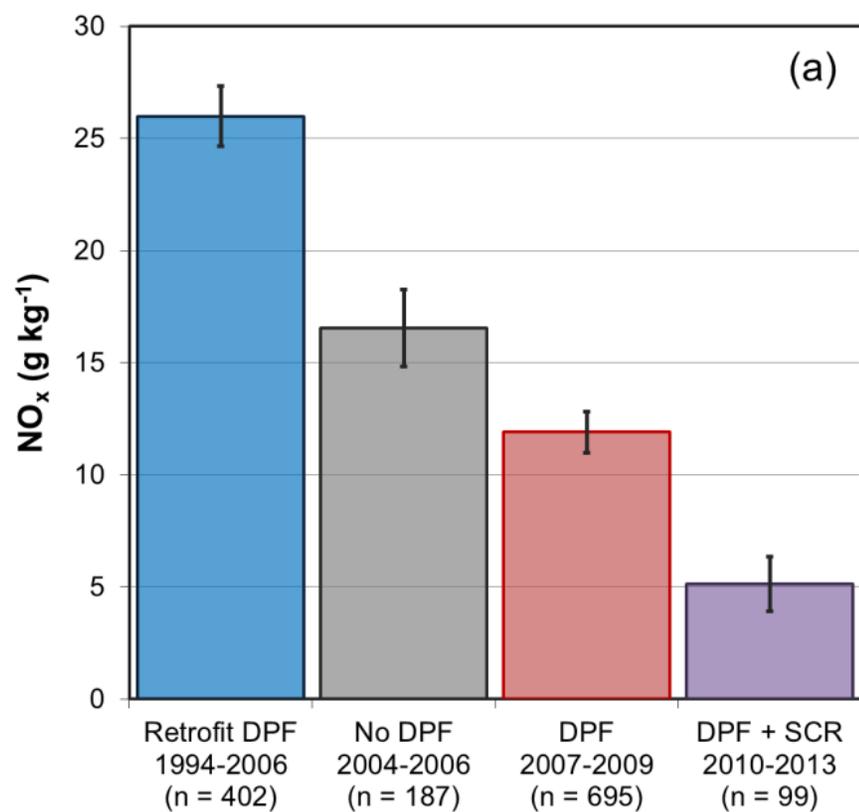
(Apply 10^{15} Scale Factor to UFP Emission Factors)



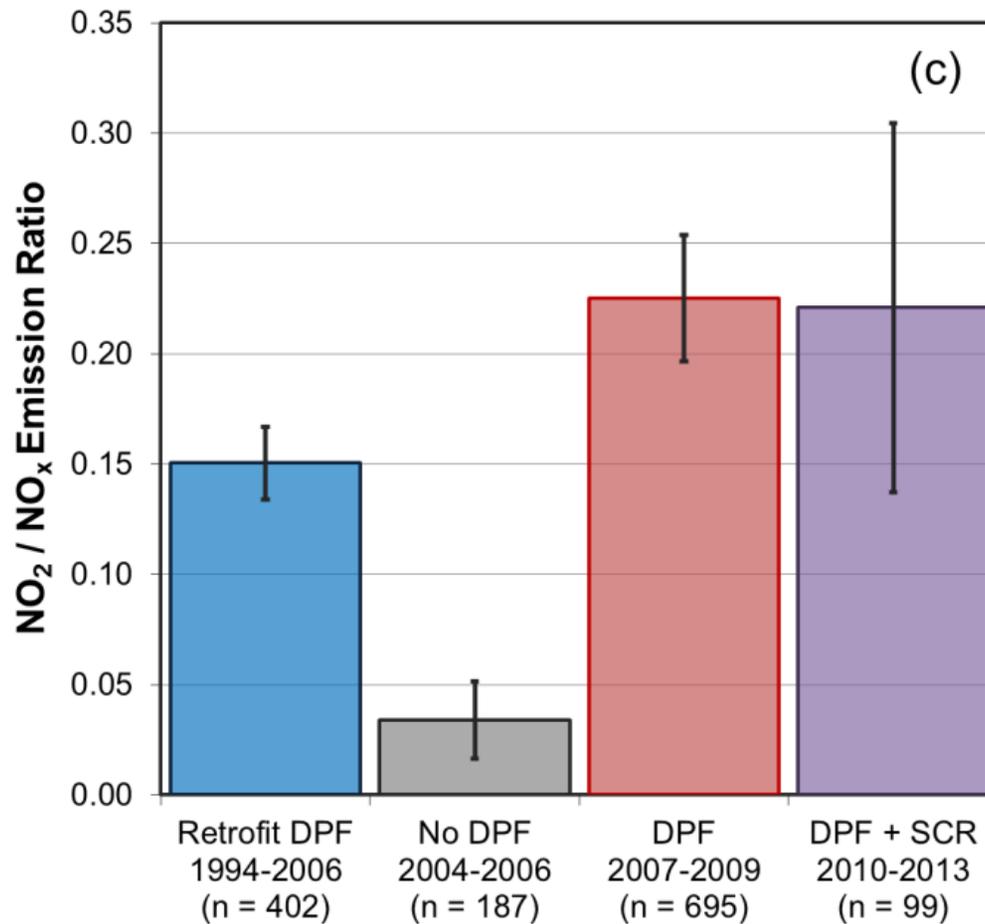
Black Carbon and Ultrafine Particles



NO_x and NO₂ Emission Factors



NO₂/NO_x Emission Ratio



Summary

- Between Nov 2009 and Mar 2013, fleet-avg emission factors for Port trucks changed as follows:
 - ▣ BC decreased by $76 \pm 22\%$
 - ▣ NO_x decreased by $53 \pm 8\%$
 - ▣ NO_2 increased from 3 to 18% of total NO_x emissions

- Main drivers: fleet modernization and universal use of DPF
 - ▣ Diesel SCR did not contribute much to observed NO_x reductions

- UFP emfacs highest for 2004-06 engines without DPF
 - ▣ UFP emissions did not increase (and probably decreased) as use of DPF became standard for Port drayage trucks

NO_x and NO₂ Emission Factors

