Attachment F:

Ocean-Going Vessel Health Impacts Assessment

California Air Resources Board

1. Health Impacts

In this section, CARB staff have quantified a portion of the health impacts (cardiopulmonary mortality, hospitalizations, and emergency room (ER) visits) expected from different modes of transportation for Ocean Going Vessels (OGV) activities. The emissions are associated with two scenarios, Business-As-Usual (BAU) and port congestion, in five modes of transport including:

- At-berth, anchorage, maneuvering, and transit modes of transport for the BAU scenario
- Anchorage and loitering modes of transport for the port congestion scenario

CARB analyzed four health outcomes in this health impact assessment: cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness, and ER visits for asthma. These health outcomes and others have been identified by U.S. EPA as having a causal or likely causal relationship with exposure to $PM_{2.5}$ based on a substantial body of scientific evidence.[1]

U.S. EPA has determined that both long-term and short-term exposure to $PM_{2.5}$ plays a causal role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between $PM_{2.5}$ exposure and increased risk of death. This relationship persists when other risk factors such as smoking rates, poverty, and other factors are taken into account. U.S. EPA has also determined a causal relationship between non-mortality cardiovascular effects and short- and long-term exposure to $PM_{2.5}$, and a likely causal relationship between non-mortality respiratory effects (including worsening asthma) and short- and long-term $PM_{2.5}$ exposures.[1] These outcomes lead to hospitalizations and ER visits and are included in this analysis.

CARB staff evaluated a limited number of statewide non-cancer health impacts associated with exposure to $PM_{2.5}$ and NOx emissions from OGV. NOx includes nitrogen dioxide, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled.[2] However, the most serious quantifiable impacts of NOx emissions occur through the conversion of NOx to fine particles of ammonium nitrate aerosols through chemical processes in the atmosphere. $PM_{2.5}$ formed in this manner is termed secondary $PM_{2.5}$. Both directly emitted $PM_{2.5}$ and secondary $PM_{2.5}$ from OGV are associated with adverse health outcomes, such as cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, and ER visits for asthma. As a result, reductions in $PM_{2.5}$ and NOx emissions are associated with reductions in these adverse health outcomes.

---

[1] U.S. EPA. (2019). Integrated Science Assessment for Particulate Matter (Issue EPA/600/R-19/188). (web link: *https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534*)

[2] United States Environmental Protection Agency, Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-15/068, January 2016. (web link: *http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=526855*)

A. Incidence-Per-Ton Methodology

CARB uses the incidence-per-ton (IPT) methodology to quantify the health impacts of emissions in cases where dispersion modeling results are not available. A description of this method is included on CARB's webpage.[3] CARB's IPT methodology is based on a methodology developed by U.S. EPA.[4,5,6]

Under the IPT methodology, changes in emissions are approximately proportional to changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to $PM_{2.5}$ for a baseline scenario using measured ambient concentrations and dividing by the emissions of $PM_{2.5}$ or a precursor. The calculation is performed separately for each air basin using the following equation:

$$IPT = \frac{number\ of\ health\ outcomes\ in\ air\ basin}{annual\ emissions\ in\ air\ basin}$$

Multiplying the emissions reductions in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by reducing the emissions. For future years, the number of outcomes is adjusted to account for population growth. CARB's current IPT factors are based on a 2014-2016 baseline scenario, which represents the most recent data available at the time the current IPT factors were computed. IPT factors are computed for the two types of $PM_{2.5}$: primary $PM_{2.5}$ and secondary $PM_{2.5}$ of ammonium nitrate aerosol formed from precursors.

Specifically, for this OGV analysis, we additionally applied an adjustment factor of 0.4 to estimate the health impacts of the $PM_{2.5}$ emissions, based on the health analysis performed for the 2019 rulemaking for OGV At-Berth.[7,8] No adjustment factors were used for secondary $PM_{2.5}$ resulting from NOx emissions.

---

[3] CARB's Methodology for Estimating the Health Effects of Air Pollution. Retrieved February 9, 2021, from *https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution*

[4] Fann N, Fulcher CM, Hubbell BJ., The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution, Air Quality, Atmosphere & Health, 2:169-176, 2009. (web link: *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/*)

[5] Fann N, Baker KR, Fulcher CM., Characterizing the PM2.5-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S. Environ Int.; 49:141-51, November 15, 2012. (web link: *https://www.sciencedirect.com/science/article/pii/S0160412012001985*)

[6] Fann N, Baker K, Chan E, Eyth A, Macpherson A, Miller E, Snyder J., Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025, Environ. Sci. Technol. 52 (15), pp 8095–8103, 2018. (web link: *https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050*)

[7] CARB, Appendix G: Health Analyses: Control Measure for Ocean-Going Vessels At Berth. Retrieved August 12, 2022. (web link: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/ogvatberth2019/appg.pdf*)

[8] CARB, Attachment D: Analyses Supporting the Proposed 15-Day Changes to the Proposed Regulation: Updates to the Health Analyses: Control Measure for Ocean-Going Vessels At Berth. Retrieved August 12, 2022. (web link: *https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/ogvatberth2019/15dayattd.pdf*)

B. Adverse Health Impacts from OGV Emissions

CARB staff evaluated the adverse health impacts including cardiopulmonary mortality, hospitalizations for cardiovascular and respiratory illness, and ER visits for asthma associated with OGV emissions for 2021 in California. The health impacts presented in this document are an aggregation of impacts from all modes of transport associated with OGV emissions. BAU scenarios include emissions from eight air basins (listed in Table 1), whereas the port congestion scenario only includes emissions from the South Coast air basin. Staff estimates that the total number of statewide health impacts associated with (for the year 2021) the BAU and port congestion scenarios are (Table 1):

- 507 cardiopulmonary deaths were associated with BAU, and 59 added deaths due to port congestion;
- 63 hospital admissions for cardiovascular illness associated with BAU scenario and 8 added cases due to port congestion scenario;
- 75 hospital admissions for respiratory illness associated with BAU scenario and 9 added cases due to port congestion scenario; and
- 263 ER visits for asthma associated with BAU scenario and 32 added cases due to port congestion scenario.

Table 1. Air Basin-Level Estimated Mortality and Morbidity Incidents for 2021 under the BAU and Port Congestion Scenarios.

Scenarios	Health endpoints / Air basins	Mortality, cardiopulmonary	Hospital admissions, cardiovascular	Hospital admissions, respiratory	ER visits
BAU	NORTH CENTRAL COAST	18	2	3	11
	NORTH COAST	5	0	0	2
	SACRAMENTO VALLEY	0	0	0	0
	SAN DIEGO	40	4	5	17
	SAN FRANCISCO BAY AREA	75	9	11	44
	SAN JOAQUIN VALLEY	1	0	0	0
	SOUTH CENTRAL COAST	155	18	22	74
	SOUTH COAST	214	28	34	115
	STATEWIDE TOTAL*	**507**	**63**	**75**	**263**
Port Congestion	**SOUTH COAST**	**59**	**8**	**9**	**32**

*The statewide sum may not match the sum of air basins due to rounding.

C. Uncertainties Associated with the Mortality and Illness Analysis

Although the estimated health outcome presented in this report is based on a well-established methodology, they are subject to uncertainty. Other sources of uncertainty include the following:

- The relationship between changes in pollutant concentrations and changes in pollutant or precursor emissions is assumed to be proportional, although this is an approximation.
- Emissions are reported at the air basin level and do not capture local variations.
- Baseline incidence rates can experience year-to-year variation.

2. Potential Future Evaluation of Additional Health Impacts

Note that the OGV emissions will result in additional health impacts beyond what CARB staff has quantified. CARB's current $PM_{2.5}$ mortality and illness evaluation focuses on select air pollutants and health outcomes and therefore captures only a portion of the health impacts of OGV emissions. For example, while the current analysis considers the impact of NOx on the formation of secondary $PM_{2.5}$ particles, NOx can also react with other compounds to form ozone, which can cause respiratory problems. Expanding CARB's health evaluation to include additional health outcomes would allow the public to reach a better understanding of the impacts of air pollution and staff are updating methodologies that will allow these additional health outcomes to be quantified in the future.