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Jennifer A. Carpenter
President & CEO

November 15, 2021

Ms. Liane Randolph, Chair
c/o Harbor Craft
California Air Resources Board
1001 "I" Street
Sacramento, CA 95814

Re: Proposed Regulations for Commercial Harbor Craft in California

Dear Chair Randolph:

On behalf of The American Waterways Operators (AWO), thank you for the opportunity to provide comments on the California Air Resources Board (CARB) proposed amendments to the Commercial Harbor Craft (CHC) regulation. AWO is the tugboat, towboat and barge industry's advocate, resource, and united voice for safe, sustainable, and efficient transportation on America's waterways, oceans, and coasts. AWO's more than 300 member companies own and operate towing vessels and barges on the U.S. inland and intracoastal waterways; the Atlantic, Pacific, and Gulf coasts; and the Great Lakes. The tugboat, towboat, and barge industry supports family wage jobs and long-term career opportunities for more than 300,000 Americans. Our industry moves more than 665 million tons of critical cargo each year safely, securely, efficiently, and sustainably.

CARB's CHC regulations are particularly significant given the importance of waterborne commerce to the state of California. California ranks third among states in waterborne commerce by tonnage and fourth in economic impact, with more than $12.2 billion in annual economic activity driven by the domestic maritime transportation industry. **At a time when California ports are experiencing historic congestion and supply chain failures are impacting every American, we are deeply concerned that CARB is proposing to take regulatory action that could decimate maritime commerce by forcing tugboat companies to retire safe and efficient harbor craft and cease doing business in the state.** This is particularly egregious given the abundance of procedural flaws, faulty data, and inaccurate assumptions that have characterized this rulemaking process and CARB's refusal to address these infirmities despite repeated entreaties from the regulated community and other stakeholders.

AWO urges CARB not to proceed with this rulemaking in its current form, but instead to build on the success of the collaborative approach that has yielded significant improvements in engine technology and emissions performance over the last decade or more. Specifically, we urge CARB to replace this flawed rulemaking with a new approach that would:

- **Create more aggressive emission reduction goals but set compliance deadlines further into the future so that companies have time to accommodate new technology.**

- **Emphasize a more holistic regulatory approach that incentivizes all port stakeholders to participate in the state's carbon reduction goals, rather than force individual harbor craft companies to act as system integrators for technology that currently has limited application for maritime operations.**

- **Continue to support existing grant programs (e.g., the Carl Moyer program) that are working well, rather than undercutting them and shortchanging California taxpayers by forcing out of service many of the vessels that have recently undergone retrofits made possible by these very programs.**

- **Exempt oceangoing tugs and barges, either towed on a wire or rigidly connected through an ATB system, which do not operate as harbor craft, and meet all the criteria set by CARB in its decision to exempt the commercial fishing fleet.**

In sum, we recommend that CARB establish more ambitious emission reduction goals on a more realistic timeframe and use grant and other incentive mechanisms to assist port operators, vessel owners, engine manufacturers, and the full suite of California's maritime stakeholders in making investments in emission-reducing technology that helps California advance toward the long-term goal of zero carbon emissions.

If CARB is not willing to redesign the rulemaking in favor of this better approach, we urge the agency to suspend the rulemaking until it addresses the underlying flaws and known errors in the regulatory package. AWO has repeatedly pointed out that CARB has inflated the vessel inventory and will present unassailable evidence showing that towing vessels that have failed to report to CARB account for only a small percentage – less than 2.3% – of total hours in CARB waters. We will also demonstrate that the health risks claimed by CARB are overstated, at minimum by the overestimation of the vessel inventory, but more likely to a much greater extent due to unaddressed flaws in the modeling itself. **It is reckless for CARB to move forward with a rule that could have devastating impacts on California's maritime supply chain when it is so clear that its foundation is based on inaccurate data and an unvalidated model.**

Process Failures, Inaccurate Data, and Bad Policy

On numerous occasions throughout the rulemaking process, both in formal comments on previous iterations of this regulatory proposal as well as at CARB workshop meetings, AWO has pointed out multiple ways in which CARB's assumptions about the California harbor craft fleet are unsupported by accurate data. We have argued that CARB's proposed implementation timelines will force some vessel operators to decommission new equipment that already meets the best-achievable performance standard for air emissions. Disturbingly, this input has continually gone unheeded, and nowhere in CARB's supporting documents can a substantive record of any of this feedback be found. This is a glaring failure of process.

AWO four major concerns with CARB's approach to this rulemaking have been:

- CARB's refusal to acknowledge that the rule will have significant negative cost and operational implications on CHC operators, including AWO-member towing vessel operators. The technical solutions offered by the rule are infeasible, overly prescriptive, pick winners and losers in the commercial marketplace, and fail to allow vessel operators to design innovative solutions to achieve emission reduction goals.

- CARB's unwillingness to address and correct acknowledged errors in its vessel population data that drastically overstate the towing vessel population operating in covered waters.

- The unaddressed and unacknowledged uncertainty of the CARB model's calculations of the health risk created by harbor craft emissions that likely overstates their impact on the public, even beyond the improper inflation created by the overstated vessel inventory.

- The questionable legal authority under which CARB has undertaken this rulemaking.

To date, these concerns have not been adequately addressed. We elaborate on them again below.

CARB Refuses to Account for the Significant Negative Cost and Operational Impacts of the Rulemaking

CARB's Arbitrary and Capricious Exemption of Some Vessels and Not Others

CARB's decision to exempt about 1,570 commercial fishing vessels (approximately 40% of the total CHC population) from the rule while not similarly exempting other vessels that meet the same criteria is arbitrary and capricious. This decision unfairly places 100% of the emission reduction burden of the CHC rule on 60% of the vessel population.

CARB's rationale for excluding these commercial fishing vessels applies equally to towing vessels that operate in coastal and international trade. Specifically:

- Small profit margins;
- Demonstrated lack of feasibility for Tier 4 repowers and retrofits;
- Competition with out-of-state and global markets; and,
- Tendency to conduct most of their operations far from the coast.

Oceangoing tugs and barges, either towed on a wire or rigidly connected through an ATB system, are directly analogous in their operation to commercial fishing vessels and share all four criteria that led CARB to exempt those vessels. AWO submitted information in April 2020 showing that "repowering with EPA Tier 4 engines could be significant and cost prohibitive for some ship assist and escort tugs." Similar technical challenges exist for oceangoing tugs, barges, and ATBs. These vessels commonly operate in interstate commerce in competition with self-propelled vessels in out-of-state and global markets. Additionally, the tugboats and barges operating in these markets are required by law to be U.S.-flagged, U.S.-owned, U.S.-crewed, and U.S.-built. This rule would place U.S.-flagged towing vessels at a competitive disadvantage against self-propelled foreign-flagged vessels that are not covered by CARB's rule. Finally, AIS and Marine Exchange data reveals that these vessels conduct most of their operations far from the California coast, giving them a similar air emission profile in California as the exempted commercial fishing vessels.

CARB should extend the exemption for commercial fishing vessels to oceangoing tugboats and barges to avoid arbitrary and capricious distinctions between similarly situated classes of vessels.

Compliance Costs

The regulation would impose unreasonably high compliance costs and create waste by forcing vessel operators to replace or retire relatively new, clean, and operable engines and vessels. In the towing industry's experience under the 2009 rule, transitioning a towing vessel from a Tier 0 or Tier 1 to a Tier 2 engine often required a vessel rebuild or engine repower. Because vessels often outlive the useful life of engines, rebuilds and repowers are a normal feature of a vessel's lifecycle and compliance deadlines under the previous regulation could be effectively aligned with scheduled vessel rebuilds or repowers.

Under the proposed rule, many towing vessels would have to be retired or removed from service in California before the end of the vessel's or the engine's useful life because space constraints and other limitations do not allow for the installation of the required equipment on existing vessels. This includes towing vessels in which operators have already made significant investments to reduce emissions and improve air quality. In the 2009 regulation, revised in 2011, CARB stated that once a vessel has been retrofitted with Tier 2 engines, no other retrofit would be necessary[1]. Many of the industry's recent investments were thus made with the understanding that CARB's current and forthcoming commercial harbor craft rules would allow vessels to serve out a far greater portion of their useful lives than the proposed rule would allow.

Harbor craft operators typically expect a newly built vessel to have a useful life of 20-25 years. Investment decisions are made with the expectation that they can be recouped over this period. The proposed regulations would dramatically alter this calculus, forcing vessels from service after as little as 10 years, including tugs retrofitted under the previous regulation. Additionally, towing companies that have recently built new vessels with Tier 4 engines would be faced with the possibility of taking these vessels out of service within just a few years to comply with the proposed regulations, attaining a marginal incremental improvement in emissions at the cost of millions of dollars. We are concerned that CARB does not understand how disruptive – and economically untenable – this approach is for towing vessel operators. It is extremely difficult for a company of any size to develop a viable capital plan in an environment with this degree of regulatory uncertainty. Moreover, the net environmental impact of forcing the premature retirement of serviceable vessels and their replacement with newly built vessels (even newbuilds with a lower emissions profile) must be considered as the procurement of materials and disposal of old vessels has a net negative environmental impact.

Feasibility

CARB's proposal to require Tier 4 engines with Diesel Particulate Filters (DPF) on existing vessels is not feasible. Currently, there is little to no marine application of DPF, considerable size and engine space restrictions exist, and back pressure created by DPF on an engine exhaust system is intolerable for the safe operation of existing and known future engines. There is currently no manufacturer-approved DPF available for the engines commonly used on towing vessels, so operators cannot determine the utility of DPF on their vessels. CARB is proposing to require technology that is untested, unproven, and simply unavailable.

In previous letters to the docket, AWO has provided specific examples of more appropriate timelines for the implementation of new technology standards, such as delaying the implementation date for any DPF rules by a minimum of five years after the approval of a compliant Tier 4 with DPF engine and allowing compliance flexibility for vessels with either a Tier 3 engine with a DPF or a Tier 4 engine without a DPF. These suggestions have gone unheeded, and we are troubled that CARB has not acknowledged that there is no available technology that currently meets both the performance standards of the proposed regulation and the propulsion needs of the regulated population of towing vessels.

[1] CHC Regulation 17 CCR 93118, (e)(6)(C)(1)

In sum, CARB has failed to provide realistic relief for vessels that cannot comply with the proposed rules due to space or feasibility constraints. Under the current proposal, a vessel operator has no recourse other than to retire a vessel that cannot physically accommodate the installation of unproven and unavailable technology.

Shore Power for At-Berth Vessels

CARB's proposal to require shore power for vessels at berth depends on the development of shoreside infrastructure beyond the control of vessel operators. Terminal and lay-berth facilities should equitably bear the burden of any proposals requiring specific shoreside infrastructure development. Many towing vessel companies use shore power at their home berths to limit emissions and generator use and decrease idling time for main engines, but vessel operators without long-term leases and control over infrastructure may find it impossible to comply with this proposal.

The proposal also impacts customer berths, where the terminals may have to provide increased infrastructure. AWO is concerned that facilities may decide not to offer short-term lay berths if they cannot comply with CARB's proposed infrastructure requirements. Limited berth space could force towing vessels to idle in the harbor between jobs or burn more fuel to return to an electrified home dock. In this situation, the regulation would have the perverse effect of increasing, not decreasing, air pollution. This scenario also highlights the importance of incentivizing the entire port community to shift to low-emissions technology rather than requiring vessel operators to bear the brunt of the responsibility.

Opacity Testing

The opacity testing proposal is too subjective. Certain types of towing vessels have a highly variable duty cycle and their engines must be tuned to provide the power, maneuverability, and braking necessary to operate safely. CARB's proposal suggests testing should be done during the transitional phase of a vessel's fuel map (i.e., when accelerating or decelerating the engine), and not at steady state (i.e., at constant RPM under a consistent load), where the engines operate most efficiently. Tuning the engine to minimize smoke during the transitional phase could compromise engine integrity when the operator needs maximum responsiveness to ensure safe operation.

The power and torque requirements during the transitional phase of accelerating a marine engine are different from those forces required for highway and off-road applications. For a tugboat, maneuvering a vessel while applying forces to a moving ship or barge is a dynamic process that places a high demand on the propeller, and it has been a challenge for engine manufacturers to ensure the vessel's engines do not stall in the process. Stalling an engine in this environment can be deadly, causing the tug to capsize or be overrun by the ship it is assisting. One way to avoid this risk is to alter the fuel map to ensure there is adequate fuel available when the need arises. This may result in a temporary overfuel event that creates haze. This is not a sign that the vessel's emission controls have failed, but rather the result of a prudent safety measure to avoid the much greater risk to human life and the environment if the tug were to capsize. Opacity testing should be done at a constant RPM, under a constant load, to ensure the engine is operating appropriately.

Legal Considerations

As AWO has expressed in previous comments, we believe that the proposed CHC regulations would, if enacted without express authorization from the U.S. Environmental Protection Agency, violate the federal Clean Air Act as they are "standards and other requirements relating to the control of emissions."[2] Although the Clean Air Act expressly preempts state regulation of emissions from many types of engines, it allows California to seek authorization from EPA to adopt standards for certain nonroad engines and vehicles including harbor craft. Federal law limits the standards available to California without express authorization from EPA to "in-use standards." CARB characterizes certain elements of its proposed regulations as "in-use" standards, which federal courts have determined apply to "use, operation, or movement" of regulated non-road vehicles. Examples of in-use standards include limitations on idling times, carpool lanes, and other use restrictions that control emissions. Despite CARB's characterization, we believe the CHC rule contains emission performance standards (e.g., opacity testing) that necessitate authorization from EPA. The proposed regulation is not an "in-use" rule because it regulates emissions and engines. In previous meetings, CARB has indicated its intention to discuss this issue with EPA but has provided no information in the record to confirm that the agency has received EPA authorization to proceed with the proposed regulations. **It is essential that CARB clarify its legal authority to issue the new rules before proceeding.**

<u>The Proposed Rule is Based on Inaccurate Vessel Population Data that Overstates the Impact of Towing Vessel Emissions</u>

These problematic proposals are based on an inaccurate accounting of the size and emissions impact of the CHC fleet, undermining the entire basis for the rulemaking. Even more troubling, AWO has repeatedly pointed out this shaky foundation to CARB, which has acknowledged erroneous assumptions in its data but, inexplicably, refused to correct them, subjecting this rulemaking to significant legal vulnerability.

Vessel Inventory

Under existing harbor craft regulations, towing vessel operators are required to report to CARB the number of vessels they operate in California waters. Rather than relying on this

[2] Clean Air Act §209(e)(2)

reporting to determine the size of the towing vessel population, CARB used a U.S. Coast Guard database that provides information on vessel ownership and regulatory status, but not area of operation. When CARB identified more towing vessels in the Coast Guard database with a California home port than the number of towing vessels reported to CARB as operating in California waters, the agency assumed, without evidence, that CHC companies have been significantly under-reporting their fleet sizes to CARB.

AWO has repeatedly pointed out that the Coast Guard database is designed to track the ownership and regulatory status of vessels and provides no insight or information into where vessels operate (which can, of course, change as vessels are mobile assets). Despite this, CARB has used home port information from the Coast Guard database to conclude that an additional 52 towing vessels are operating in California waters, on top of the 177 towing vessels reported to the agency, for a total of 229. This has led the agency to overestimate the number of unreported vessels, the population of towing vessels operating in California, and their cumulative impact on air quality.

In past comments, AWO has demonstrated to CARB staff the error of using the Coast Guard database to identify vessels operating in California. We have also provided evidence in both written comments and multiple meetings to show that emissions from vessels that have not reported their hours are only a fraction of the scaling factor CARB has used to inflate the emission inventory. We have explained the basis for these discrepancies and told the agency how it can obtain accurate data. Inexplicably, CARB has rebuffed all our efforts to provide an accurate vessel inventory. Indeed, at the CHC Workshop #4 held on March 16, 2021, CARB acknowledged that the agency was aware that its vessel counts did not accurately reflect the actual number of vessels in the applicable airshed, but informed attendees, without further explanation, that CARB would not be revising the vessel count numbers in the draft regulation. These reckless technical and procedural errors jeopardize the entire basis for the regulation and subject it to heightened legal scrutiny.

AWO contracted with Ramboll, a third-party engineering consulting firm, to conduct an independent assessment of the number of towing vessels operating in California and the likely impact of emissions from those vessels. Using Automatic Identification System (AIS) data for 2019, Ramboll was able to account for every towing vessel operating within California waters during that year. The AIS data affirms that CARB has significantly overcounted the size of California's towing vessel fleet. Ramboll found that only 200 towing vessels operated within 100 nautical miles of the California coast, nearly 30 vessels fewer than CARB estimated to be working in California.

The CARB model also assumes that non-reporting vessels operated the same number of hours as reporting vessels. Using the AIS data, Ramboll was able to determine the number of hours the towing vessels operating in California waters were moving, which is a reliable predictor of engine hours. Using a CARB-provided list of vessels that filed reports in 2019, AWO was then able to isolate the reporting vessels from non-reporting vessels.[3] The non-reporting vessels averaged just 18% of the operating hours of the reporting vessels. This means that the total unreported hours are just 2.3% of the total reported hours, not the 29% that the CARB scaling factors had estimated. This discrepancy makes sense considering that CARB's reporting requirements have been in place for more than a decade, and the vessels companies are most likely to overlook in their reports to CARB are either those vessels that are transiting through California waters but not calling on California ports or those that are seldom used in California.

Ramboll then ran emissions estimates based on this accurate assessment of towing vessel operating hours and found that NOx and PM emissions were only 72% and 62%, respectively, of the figures that CARB's improperly inflated model produced.

Health Effects

Given this inflation of the towing vessel fleet size and operating hours, AWO expects that CARB's assessment of harbor craft emissions and their health impact is similarly skewed. Ramboll's estimates of emissions based on accurate fleet size and operating hours data lend credence to AWO's concern that CARB's estimates are overstated.

AWO asked Ramboll to review and comment on the Health Study section of the CARB rulemaking packet. Based on this assessment, Ramboll raised serious questions about the methodology CARB used both in its assessment of cumulative harbor craft emissions as well the resulting health effects. Most concerning is Ramboll's observation that CARB has made no apparent effort to validate its air quality model with verifiable, real-world results. Ramboll conducted a preliminary analysis to validate the agency's harbor craft-related exposure estimates by comparing CARB-modeled air concentrations at receptor points near Long Beach, Anaheim, Pico Rivera, and Los Angeles with the $PM_{2.5}$ concentrations measured at the sampling stations installed at these locations. Because the sampling stations capture emissions from all nearby sources, CARB's modeled concentrations specifically for harbor craft would be expected to be within the range of the total measured emissions or, more likely, lower. Below is the table of results from this exercise, extracted from the Ramboll report.

[3] AWO chose 2019 for two reasons: first, it was the last year not affected by the impacts of COVID on vessel operations, and second, CARB provided vessel reporting status for that year, which allowed us to measure the difference between reported vessels and non-reported vessel hours.

Table 6. Comparison between annual average $PM_{2.5}$ measured concentrations at monitoring stations in the South Coast to modeled concentrations at the nearest receptors.

$PM_{2.5}$ (mg/m^3) annual average	Average of all POCs (daily)	Average of 1hr	Closest Receptors (Modeled $PM_{2.5}$ mg/m^3, Receptor #)			
Long Beach (North)	10.81	-	34.82 (1856)	35.68 (1857)	38.30 (1858)	34.15 (1855)
Long Beach (South)	12.82	14.56	51.57 (1874)	48.44 (1876)	59.88 (1900)	58.13 (1901)
Long Beach-Route 710 Near Road	13.87	15.02	24.01 (1825)	24.80 (1826)	22.29 (1827)	22.35 (1824)
Anaheim	11.05	13.62	15.30 (2602)	14.34 (2604)	16.13 (2601)	14.17 (2588)
Compton	13.24	-	18.05 (1683)	18.41 (1677)	18.96 (1685)	18.03 (1684)
Pico Rivera #2	12.49	-	8.41 (1458)	8.55 (1459)	9.04 (1457)	9.09 (1467)
Los Angeles-North Main Street	11.69	-	7.28 (530)	7.22 (491)		

The second column above shows the average annual $PM_{2.5}$ concentrations measured at the sampling stations listed on the left. Again, these figures show estimated PM concentrations collected from all sources in the area, including cars and trucks, rail and harbor craft as well as other sources. They also reflect locations near the shoreline that are most likely to be impacted by harbor craft emissions. The four columns on the right show CARB's modeled concentrations calculated at four locations nearest to each sampling station. As highlighted in the table, Ramboll found from this preliminary check of the data that CARB's modeled estimates are up to 4 times higher than actual measured concentrations from all sources captured at sampling stations in the same general area. It is not plausible that emissions from harbor craft alone would be higher than the emissions captured in these areas from all possible sources. This raises serious questions about the accuracy of CARB's model and what, if any, efforts CARB has made to validate it.

Ramboll and AWO made numerous requests for information from CARB staff that would help us understand the methodology the agency used to determine health impacts associated with harbor craft emissions. CARB staff were unable or unwilling to provide much of the necessary information, which has forced Ramboll to make more generalized observations about CARB's approach. Those observations are offered in detail in Section 2.2 of the attached report, but the essence is that: (1) there is enormous uncertainty in the health effects data that CARB has presented, calling into question the purported benefits of the proposed rulemaking; and (2) CARB has applied health effects analyses in an unconventional way and failed to report its findings in a manner that transparently acknowledges the lack of certainty inherent in those findings.

What we can say with certainty is that CARB's assessment of the health risks from CHC emissions is overstated, at minimum by the agency's overestimation of the vessel inventory and emissions, but more likely to a much greater extent due to the unaddressed weaknesses in the modeling itself. CARB's overstating the emissions from harbor craft is magnified in each step of the model, with each highly conservative assumption or input that is propagated throughout both risk assessments. Based on the comparison of the model output with actual PM levels at monitoring sites, it seems clear that errors in the model are overestimating the actual exposures to communities along the shoreline, and thus overestimating any potential benefits of the proposed rules, by a significant margin. This is an unacceptably weak foundation for such a consequential rulemaking.

A More Holistic, Supply Chain-Driven Approach is Needed

AWO members are committed to reducing their vessel emissions and lessening their impact on the environment. The most effective approach to emissions reduction begins with recognizing the integrated nature of the maritime supply chain and the roles, interdependency, and limitations of its component parts. Tugboat operators are the individual, end-level users of the kind of engine technology CARB's proposed regulations would mandate and are limited in what they can achieve independently of other actors in the supply chain. For tugboats and other types of harbor craft to successfully comply with aggressive new emissions standards, engine manufacturers must design engine technology that is appropriate for the type of work tugboats are required to perform and port facilities must provide shoreside infrastructure that supports and sustains this new technology. Every part of the maritime supply chain must move together. CARB's proposed regulations would force harbor craft operators to build more advanced equipment themselves, regardless of the availability of supporting infrastructure and in the absence of any meaningful market incentives. This approach is akin to attempting to reduce on-road engine emissions by asking every individual California driver to design an electric car in their garage.

CARB's approach also fundamentally misunderstands the way vessel owners invest in their assets. Towing companies build new vessels at regular intervals and retrofit vessels with new and cleaner engines as they become available and as vessel size constraints allow. The ability to raise and invest capital is dependent on being able to recoup that investment over a vessel's useful life, typically 20-25 years. CARB's incremental approach to emissions requirements undercuts this planning not only by forcing out of California relatively new vessels built with the best engine technology available at the time, but also by cannibalizing the resources companies could otherwise invest in more ambitious future technology. Instead of using revenue from existing vessels to support future investments in zero carbon emissions technology, towing companies would be required under the CARB proposal to devote more resources towards compliance with incremental, interim – but still extremely costly – emissions standards. CARB's regulation would be working at cross-purposes with the state's long-term emission reduction goals.

By extending emissions compliance deadlines, CARB would enable vessel operators to plan for the adoption of technology that achieves more substantial emission reductions, including potentially zero carbon standards. It would allow towing companies that have built new vessels with state-of-the-art equipment to continue operating in California and encourage stakeholders at every point in the supply chain to work together to achieve ambitious goals. This does not mean foregoing progress in reducing emissions in the short term, since companies that build new vessels in the interim will continue to use the best available technology, as required by federal EPA standards and supported by California's existing grant programs that incentivize the adoption of new technologies.

This approach has been working in California for years. California harbor craft operators have long participated in successful, incentive-based air quality programs through CARB and various Air Quality Management Districts, taking advantage of grant and finance plans to upgrade and improve engines, and achieved meaningful results for California air quality. Earlier iterations of progressively higher voluntary standards have led to successful technology innovations, well-managed industry costs, and substantive air quality improvements.

Crowley Maritime's electric tug *eWolf* represents one of the many ways that California harbor craft operators are working with the State to achieve emission reductions through innovative technologies. The *eWolf* is a zero-emissions tug that Crowley expects will begin operations in the Port of San Diego by 2023. It has cost Crowley alone $18 million to develop, and has received additional grant support from federal, state, and district-level partners. It is just one example of the way the California maritime industry proactively partners with government agencies to develop innovative new technologies.

AWO urges CARB both to continue to work with companies to incentivize these types of innovations and to recognize the emissions benefits that new technology provides. Like the Crowley *eWolf*, Foss Maritime's hybrid tugs, first introduced in 2008 to the Los Angeles/Long Beach market, offered the promise of using innovation and new technology to reduce vessel emissions. The vessels were built specifically for the heavy workload of LA/LB and the demand for higher horsepower in the tight confines of the harbor. The tugs were effective and provided a model for future vessel conversions. Foss sought a waiver under the 2009 CHC rulemaking to keep operating the two hybrids with their original engines and to allow the company to convert other similar tugs to hybrid, keeping the Tier 0 and Tier 1 engines, but obtaining lower overall emissions in every category through the use of a hybrid electric system. Unfortunately, CARB did not grant a waiver, and Foss chose to redeploy the vessels to other markets and discontinue plans for future hybrid conversions and newbuilds since the regulatory environment did not support such innovation by providing flexibility for alternative means to achieve the same end. **We urge CARB to design a regulatory system that supports and rewards early adoption of innovative, emission-reducing technology, rather than discouraging innovation through rigid and prescriptive regulation.**

The maritime industry makes trans-oceanic trade possible with up to 20 times less emissions than alternatives like air cargo; meanwhile, short sea shipping and trans-harbor movement generate less than half the emissions of other modes such as road or rail. In California, vessel engines with lower emissions have reduced community health risk and the maritime industry has grown more efficient. In the last ten years, the number of engines in service on harbor craft in California has stayed consistent while the volume of cargo moved has increased and emissions per hours worked have decreased.

We urge CARB to build on this track record of success by replacing the proposed harbor craft regulations, which are based on a flawed legal and technical foundation, with a different framework: one that expands the compliance timeline so as not to force harbor craft operators to adopt technology that is currently unavailable, infeasible, or untested; encourages all parties in the maritime supply chain to work together to achieve more ambitious emission reduction goals; and helps harbor craft operators and other port stakeholders to invest in cleaner equipment through grant funding. If California's ultimate goal is net zero carbon emissions, harbor craft operators must be seen as an essential part of a larger supply chain working to achieve that goal together. As currently proposed, CARB's harbor craft regulations would put companies out of business, deprive Californians of high-quality, family-wage jobs, and further stress an already over-burdened supply chain. We do not believe this is CARB's intent, and we stand ready to work with the agency and other stakeholders in the maritime supply chain to design and implement a better approach to improving California's air quality while keeping vital maritime commerce flowing.

Sincerely,

Jennifer A. Carpenter

Jennifer A. Carpenter
President & CEO

MEMORANDUM

Date: November 11, 2021

To: American Waterways Operators

From: Amnon Bar-Ilan, Christian Lindhjem, Sonja Sax

Subject: Ramboll Comments on the California Air Resources Board (CARB) Proposed Amendments to the Commercial Harbor Craft (CHC) Regulation

1. REVIEW OF HARBOR CRAFT EMISSIONS IMPACTS AND COMPARISON OF CALIFORNIA HARBOR CRAFT EMISSION INVENTORY

1.1 Introduction

The California Air Resources Board (CARB) air emissions inventory and proposed rule effectiveness are presented in Appendix H of the proposed regulation supporting documentation. This 2021 document updates CARB's emission inventory methods from the 2007/2009 Commercial Harbor Craft (CHC) emission inventory methods.[1] In general, the approach is similar, but many of the default inputs were substantially revised to lower overall emissions as shown in Figure 1.

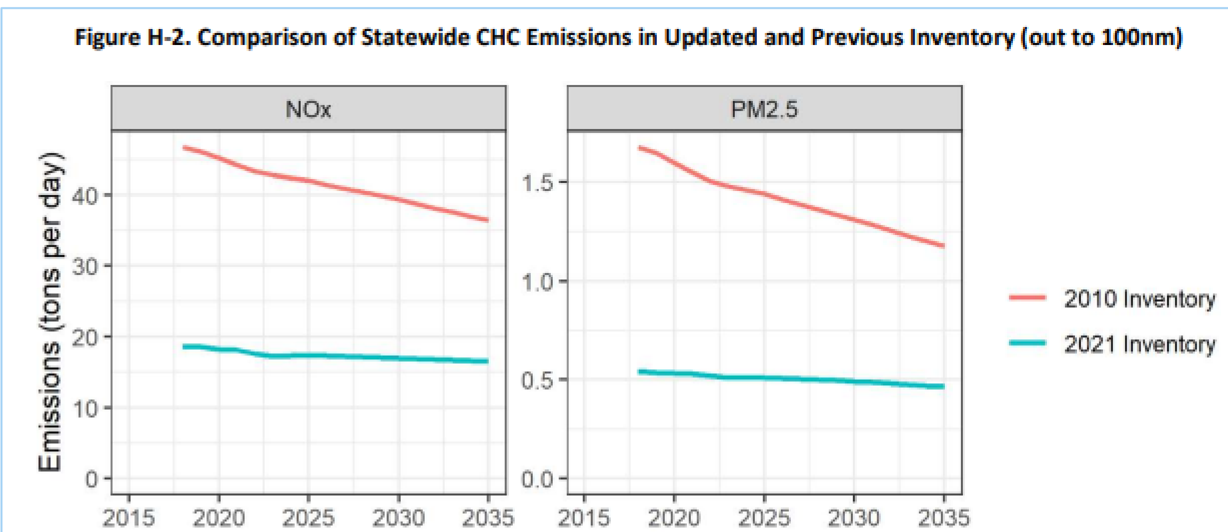

Figure 1. CARB commercial harbor craft emissions inventory comparison. (CARB 2021)

[1] https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/road-documentation/msei-documentation-road

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CARB segregated the vessels by type (including vocation) shown in Figure 2. In this report, we focus on the Tugboat types, which include Tugboat-Escort/Ship Assist, Tugboat-Push/Tow, and Tugboat-Articulated Tug and Barge (ATB).

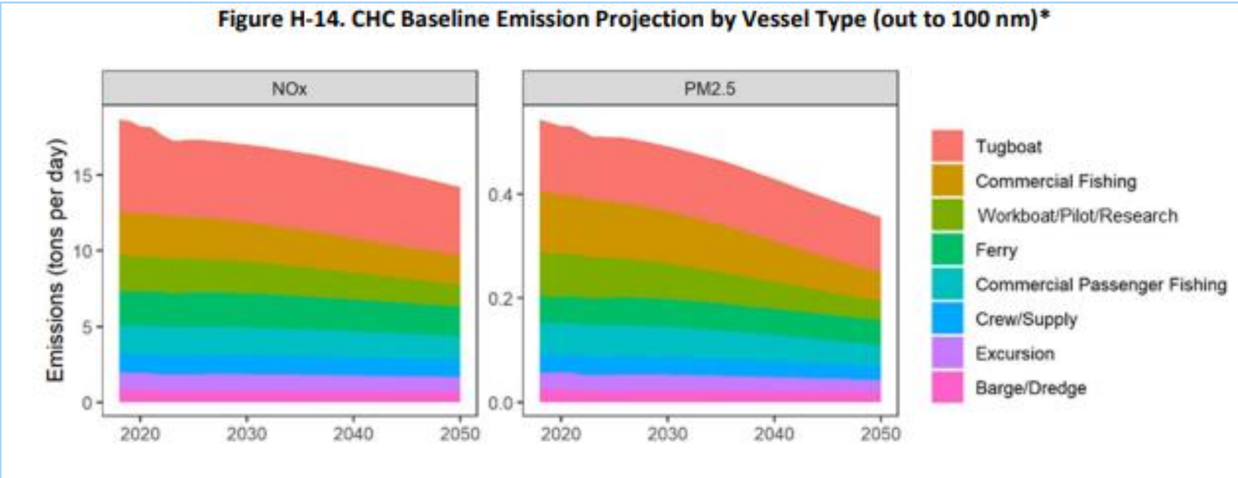

Figure 2. CARB commercial harbor craft emissions inventory by vessel type. (CARB 2021)

Alternative source of activity data includes AIS data that is publicly and freely available from a trusted source.[2] The AIS data identifies tug and towboats using vessel codes 31 for towboats and 52 for tugs and provide position, speed, and course. The AIS data identifies every vessel operating in US continental waters identified by MMSI for a given year.

Emissions estimates depend on input factors related to the vessel activity and engine characteristics. The AIS data provides the population and activity for all vessels operating in a defined domain. Emissions estimates also require that the new engine emission factors be identified by Tier level in Table H-5 of Appendix H of CARB (2021), age, and fuel correction.

Emissions = Pop x Power x Activity (hrs) x Load Factor x (zhEF + DF x (Age/Life)) x Fuel Correction

Pop – Population of vessels (activity input)
Power – Engine power (activity input)
Activity – Hours of engine operation (activity input)
Load Factor – Average fraction of available power (CARB input estimate)
zhEF – Emission factor when new (zero-hour) (CARB input estimate)
DF – Deterioration factor (CARB input estimate)
Age – Engine age (activity input)
Life – Useful Life (CARB input estimate)
Fuel Correction – In-use relative to engine certification fuel (CARB input estimate for 2011+ engines is 0.948 – NOx and 0.852 - PM[3] and PM correction is more significant for older engines)

[2] https://marinecadastre.gov/ais/
[3] https://ww3.arb.ca.gov/msei/chc-appendix-b-emission-estimates-ver02-27-2012.pdf

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The vessel types average load factor estimates according to primary vocation for the range for tugs and towboats is shown in Table 1. Because of the difference in assumed load factor, it is important to appropriately characterize the activity that each vessel performs.

Table 1. CARB Load Factor input by vessel type. (Table H-9, CARB 2021)

Vessel Type	Load Factor	
	Main	Auxiliary
Tugboat-ATB	0.50	0.50
Tugboat-Push/Tow	0.33	0.37
Tugboat-Escort/Ship Assist	0.16	0.34

1.2 Vessel and Emission Inventory and Comparison with CARB Estimates

We used the AIS records to identify tug and towboats using vessel identification numbers 31 and 52, and American Waterways Operators (AWO) provided more detailed input for their vessel fleet including primary vocation, engine power, Tier level, and, in some cases, hours of operation in California waters. Table 2 shows the comparison of the vessel population found operating within 100 nm of the California coast during 2019. CARB (2021) reported that they identified the population of 177 tugs and towboats through the harbor craft reporting in Table H-3 and upwardly adjusted that inventory to account for unreported vessels through Coast Guard lists at California home ports. The AIS records find only 200 tug and towboats (23 vessels or about 13% more than reported by CARB) during 2019 compared with CARB's estimate in Table H-3 of 229 vessels or 29 more than were reported in the AIS records.

Table 2. Vessel population found in California waters <100 nm in 2019

Vessel Type	CARB App. H			AIS Records		
	Table H-3	Adjusted Total Table H-3	Average Hours Table H-4	Population	Average Hours (>0.1 knots)	Average Hours (<0.1 knots)
Tugboat-ATB[a]	11	19	2,466	14[a]	1,991	1,380
Tugboat-Push/Tow	108	147	1,550	118	817	1,216
Tugboat-Escort/Ship Assist	58	63	2,676	68	2,141	3,855
Combined Tug and Towboat	177	229	1,936	200	1,350	

[a] – AIS does not distinguish ATBs from Towboats; AWO identified six fleet vessels and eight others found in AIS records as ATB.

We used the AIS records to determine hours of operation for each tug and towboat operating in California waters out to 100nm during 2019. The average hours for AIS compared favorably with the CARB averages except for towboats where the operating hours about half that estimated by CARB. Total and average hours at less than 0.1 knots speed were considered to use no propulsion power, but auxiliary engines running at normal loads, though many tugs at their base will use shore power for auxiliary loads such as to keep the AIS transponders emitting a signal.

AWO supplied tier and power of the main and auxiliary engines for their members' fleets as summarized in Table 3. For other tugs and towboats found in the AIS data, we used CARB default information with Tier 1 emissions rates to towboats (including ATB) and Tier 2 to tugboats to hours of operation. The AWO supplied fleets generally had higher installed power

than the CARB averages by vessel type, so using the CARB default for AIS extra (non-AWO) fleets leads to a conservative overestimate of emissions.

Table 3. Vessel population and inputs use found in California waters <100 nm in 2019

Vessel Type	CARB App. H Default Inputs			AWO Fleet		
	AIS Extra Population	Main Engines (hp)	Tier	AIS AWO Population	Main Engines (hp)	Tier
Tugboat-ATB[a]	8	4395	1	6[a]	6400	2, 3
Tugboat-Push/Tow	94	731	1	24	2700	0 – 3
Tugboat-Escort/Ship Assist	7	2450	2	61	3898	0 – 4
Combined Tug and Towboat	109			91		

[a] – AIS does not distinguish ATBs from Towboats, AWO identified six vessels in AWO fleets and eight in AIS records as ATB.

The CARB default and AIS hours of operation were combined in the emissions to estimate tug and towboat emissions for 2019 as shown in Table 4. When applied, deterioration and fuel corrections primarily increase PM emissions relative to our baseline estimate. We also investigate the impact that fleet mix of engine Tier levels could have on average emissions rates primarily increasing PM emissions rates. The Tier levels for the AWO fraction of all vessels was provided, while CARB default fleet mix was used for the other tugs and towboats found in the AIS records.

Table 4. Tug and towboat emissions in California waters <100 nm in 2019.

Vessel Type	AIS Emissions Estimates		AIS (with deterioration, fuel correction)		AIS Additional Correction for Fleet Mix	
	NOx tpd	PM tpd	NOx tpd	PM tpd	NOx tpd	PM tpd
Tugboat-ATB[a]	1.36	0.020	0.92	0.019	0.85	0.020
Idle <0.1 knots	*4%*	*5%*				
Fraction within 24 nm	*87%*	*83%*				
Tugboat-Push/Tow	0.97	0.023	1.11	0.032	1.05	0.039
Idle <0.1 knots	*9%*	*15%*				
Fraction within 24 nm	*82%*	*85%*				
Tugboat-Escort/Ship Assist	2.04	0.041	2.31	0.057	2.31	0.057
Idle <0.1 knots	*17%*	*26%*				
Fraction within 24 nm	*99%*	*99%*				
Sum Tug and Towboats	4.37	0.086	4.34	0.109	4.22	0.117
CARB App. H (Estimated from Figure H-14)	6.1	0.14				
Relative to CARB Figure H-14	72%	62%	71%	78%	69%	83%

1.3 Assumptions

- **AIS data using a <0.1 knot cutoff to eliminate vessel activity when main (and often auxiliary) engines are at least low power or entirely off. The '<0.1knot' criteria best matched the propulsion engine time for tugboat (4% overestimate) and towboats and others identified in AWO fleets (4% underestimate).**
    - **Under <0.1 knot, the auxiliary engines were assumed to continue to be used to supply power for the AIS and other electrical demands. This is a known overestimate because many tugs plug into shore power while at base.**
- **Based on the CARB default model year, we used Tier 1 engines for towboats (both ATB and others) and Tier 2 for tugboat-Escort/Ship Assist.**
    - **CARB reported to have used a distribution of Tier levels; Andrew Daminao (CARB, email to Charles Constanzo, Friday, September 3, 2021 8:55 AM) provided a file 'Towing Vessel Inventory 2019' that provided information about the fleet mix by tier level.**
    - **Shown in Table 5 is a comparison of the impact on emissions that fleet mix could have compared with either Tier 1 or Tier 2. The small fraction of Tier 0 in the fleet has a significant impact (greater than 50% for DPM) on towboat emissions rates estimated and less but still significant on the tugboats.**
    - **AWO provide fleets' engines characteristics for 2019 that had generally higher Tier levels and averaged lower emissions levels than the fleets provided by CARB.**

Table 5. Fleet mix emissions impacts from CARB towing vessels file and AWO Submittals for 2019.

Vocation	Tier	Count	AWO Count	Emission Factor by Tier (g/hp-hr)		CARB Tier 0, 1 Contribution	
				NOx	DPM	NOx	DPM
Tugboat-ATB	0	2	0	7.34	0.37	25%	49%
Tugboat-ATB	1	1	0	6.97	0.12	12%	8%
Tugboat-ATB	2	6	2	5.08	0.09		
Tugboat-ATB	3	2	4	3.69	0.05		
Tugboat-ATB	4	0	0	1.04	0.03		
Average ATB (CARB)		11		5.41	0.136		
Average ATB (CARB)		Ratio vs. Tier 1		0.78	1.14		
Average ATB (AWO)		6		4.15	0.063		
Tugboat-Push/Tow	0	32	1	7.34	0.37	39%	65%
Tugboat-Push/Tow	1	14	4	6.97	0.12	16%	9%
Tugboat-Push/Tow	2	42	8	5.08	0.09		
Tugboat-Push/Tow	3	17	11	3.69	0.05		
Tugboat-Push/Tow	4	0	0	1.04	0.03		
Average Towboat (CARB)		105		5.80	0.173		
Average Towboat (CARB)		Ratio vs. Tier 1		0.83	1.44		
Average Towboat (AWO)		24		4.85	0.088		
Tugboat-Escort/Ship Assist	0	4	5	7.34	0.37	15%	34%
Tugboat-Escort/Ship Assist	1	8	12	6.97	0.12	28%	22%
Tugboat-Escort/Ship Assist	2	18	22	5.08	0.09		
Tugboat-Escort/Ship Assist	3	6	21	3.69	0.05		
Tugboat-Escort/Ship Assist	4	0	1	1.04	0.03		
Average Tugboat (CARB)		36		5.52	0.121		
Average Tugboat (CARB)		Ratio vs. Tier 2		1.09	1.35		
Average Tugboat (AWO)		61		5.09	0.104		

- The deterioration of emissions due to age is a large uncertainty given that engines are regularly rebuilt and that historic regulations have encouraged engine rebuilds with emission upgrades to higher Tier levels.
    - CARB (2021) assumed that towboats would average a model year of 2003 (Table H-1), which in 2019 is 16 years old and past their useful life (Table H-8) of 14 years for main engines. This would increase NOx emission rates by 24% and PM by 77% for towboats.
    - CARB (2021) assumed that tugboats would average a model year of 2009 and be 10 years old in 2019. This would increase NOx emission rates by 15% and PM by 48% for towboats.

1.4 Conclusion

We demonstrated using publicly available AIS records that it is possible to accurately identify vessel activity spatially defined. Individual vessels are identifiable through MMSI numbers unique to the AIS transmitters along with their actual activity within California waters. Using the AIS data, CARB can more accurately identify the unreported vessels and not rely on a less reliable list of vessels by home port.

Overall, the number and emissions from tugs for both NOx and PM (including towboats) appear to have been overestimated in Appendix H. The emissions overestimate depends on several input variables, but engine emissions deterioration and fleet fraction, especially the remaining Tier 0 engines still in operation, have a significant effect on PM emissions rates.

2. COMMENTS ON THE HEALTH STUDY (APPENDIX G)

2.1 Health Risk Assessment for South Coast and Bay Area Air Basins

CalPuff Modeling

The CalPuff modeling conducted in support of the Proposed Amendments to the CHC Rulemaking involve a number of model inputs and assumptions as outlined in Appendix G. Ramboll reviewed the modelling methodology as well as supporting documentation provided by CARB.

A missing element of the modeling was any validation of the key model inputs as well as the model results. Because of the complex nature of the modeling, including a number of assumptions regarding the emissions inventory, spatial and temporal allocation of emissions, complex terrain and meteorology, it is paramount that CARB validate to the extent possible the model inputs and results.

With regards to model inputs, at the very least CARB should verify that the meteorological estimates used in the model compare to actual measured estimates from a relevant meteorological station. In addition, CARB used a single year of meteorological data and it would also be important to consider using more than one year in order to capture any variability in meteorological parameters that tend to vary from year to year.

With regards to model results, one important way to validate results includes comparing modeled results with measured values at monitor locations at or near the modeled receptor points. While we understand that the CARB is only considering contributions from CHCs in the form of diesel particulate matter, the modeling is used to estimate exposures to diesel particulate matter and $PM_{2.5}$. We also understand that ambient monitors will be measuring $PM_{2.5}$ from all sources. Therefore, we expect that modeled concentrations would be within the range of measured estimates or lower.

Ramboll conducted a check of how modeled PM concentrations compare to measured $PM_{2.5}$ concentrations for the South Coast Air Basin. Table 6 shows the results of the comparison between measured concentrations at monitoring sites in the South Coast Air Basin and nearby receptors.

As shown in Table 6, the results from this preliminary check of the data show that the modeled estimates are overestimating exposures as these estimates are up to 4 times higher than actual measured concentrations of $PM_{2.5}$ particularly in the most impacted regions (i.e., near the shoreline). Inland modeled estimates (which are expected to be less impacted by CHC emission) are closer to the measured concentrations although still exceed these concentrations for some receptors. This indicates that overall the modeled estimates are overestimating exposures. CARB should similarly verify the results for the Bay Area Air Basin.

An additional source of uncertainty is associated with scaling the concentrations for future years based on changes in emissions. Because the concentrations are not only based on the changes in emissions, but other key factors including meteorology, this introduces a significant amount of uncertainty, making the validation of model estimates even more critical. Also, because we believe that emissions are overstated this will contribute to even more uncertain exposure estimates based on simply scaling.

Table 6. Comparison between annual average $PM_{2.5}$ measured concentrations at monitoring stations in the South Coast to modeled concentrations at the nearest receptors.

$PM_{2.5}$ (mg/m³) annual average	Average of all POCs (daily)	Average of 1hr	Closest Receptors (Modeled $PM_{2.5}$ mg/m³, Receptor #)			
Long Beach (North)	10.81	-	34.82 (1856)	35.68 (1857)	38.30 (1858)	34.15 (1855)
Long Beach (South)	12.82	14.56	51.57 (1874)	48.44 (1876)	59.88 (1900)	58.13 (1901)
Long Beach-Route 710 Near Road	13.87	15.02	24.01 (1825)	24.80 (1826)	22.29 (1827)	22.35 (1824)
Anaheim	11.05	13.62	15.30 (2602)	14.34 (2604)	16.13 (2601)	14.17 (2588)
Compton	13.24	-	18.05 (1683)	18.41 (1677)	18.96 (1685)	18.03 (1684)
Pico Rivera #2	12.49	-	8.41 (1458)	8.55 (1459)	9.04 (1457)	9.09 (1467)
Los Angeles-North Main Street	11.69	-	7.28 (530)	7.22 (491)		

Cancer Health Risk Assessment

The cancer risk assessment also relies on a number data inputs and assumptions, starting with the estimates from the CalPuff modeling. Many of the inputs and assumptions are considerably conservative as they are meant to be health protective and are screening-level analyses. It is important to note that screening level analyses are often followed by more targeted analyses with refined parameters that are more site-specific and/or based on more realistic parameters in order to yield more realistic risk results. Importantly, the numerous levels of conservativeness in screening level analyses result in risk values that are often highly overestimated and do not necessarily reflect actual risks.

One key data input includes the exposure estimates, which are based on the CalPuff model inputs and a number of additional key assumptions. As noted above, based on Ramboll's check of the modeled DPM estimates, it is likely that these estimates are overestimating exposures, both due to overestimated emissions (see Section 1) contributing to overestimates of about least about 20-60%, in addition model assumptions that result in overestimates compared to measured estimates by as much as a factor of 4 (see comments above) at some receptor locations.

Exposure estimates are also based on updated methodology that also increases the risk estimates because of the application of high (95/80%) breathing rates and multiplicative factors for greater susceptibility in children. In addition, the risk assessment includes several conservative assumptions for estimating exposures including exposures across a residence time of 70 years[4] and assuming a person is home 24 hours a day over these 70 years. All of these conservative assumptions compound to generate highly inflated risks.

Another key input for the risk assessment is the use of a cancer potency factor (CPF). CARB relied on the estimate developed by OEHHA of 1.1 $(mg/kg\text{-}day)^{-1}$ or 3 x 10^{-4} per $\mu g/m^3$. This cancer potency value, which represents a 95% upper confidence interval of the lifetime risk, is dated and overly conservative compared to more recent evaluations of the literature on which the cancer potency is based.

At the time of the development of the cancer potency EPA deemed the evidence to be too uncertain to use for cancer risk assessment (US EPA 1994[5]). An HEI study (HEI 1995[6]) found similar limitations associated with the studies that were the basis of the OEHHA value. These limitations included (1) questions about the quality and specificity of the exposure assessments for diesel exhaust, (2) a lack of quantitative estimates of exposure to allow derivation of an exposure–response function, and (3) lack of adequate data to account quantitatively for individual other factors that might also be associated with lung cancer, such as smoking. In 2002, EPA[7] again concluded that data were too uncertain for developing a cancer potency, but using more qualitative methods determined the risk to be in the range of 10^{-5} to 10^{-3}. Therefore, the risk could potentially be about 300 times lower than the OEHHA value.

Another important issue in extrapolating results from older epidemiology studies, as OEHHA did, is that diesel exhaust exposure in these studies is based on diesel exhaust composition that is very different compared to more contemporary diesel exhaust, and also quite different from marine vessel emissions (as these studies evaluated exposures in railroad workers and truck drivers). Specifically, because of the long latency period for lung cancer, epidemiology studies need to examine workers whose exposures started more than 20 years earlier. These particular studies are based on exposures from the 1950s and 1960s. However, the US EPA and CARB have progressively tightened standards for particulate emissions from diesel engines, including marine engines, resulting in the development of new technology diesel engines with significantly lower emissions and also likely different composition. Because these

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[4] A 30 year residence time is considered to be a more realistic residence time period.
[5] US EPA. Health Assessment Document for Diesel Emissions (External Review Draft, 1994) - Volume 1. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/8-90/057Ba (NTIS PB95192092)
[6] HEI. Diesel Exhaust: A Critical Analysis of Emissions, Exposure, and Health· Effects. 1995. Diesel Exhaust New Scan.pdf (healtheffects.org)
[7] U.S. EPA. Health Assessment Document for Diesel Engine Exhaust (Final 2002). U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington Office, Washington, DC, EPA/600/8-90/057F, 2002

changes have resulted in not only quantitative reduction in mass emitted, but have also resulted in differences in the composition with respect to size and chemicals associated with the exhaust (e.g., Hesterberg et al. 2011[8]), the epidemiology studies based on old generation engines may not be applicable to current emission conditions.

Even if the epidemiology data were deemed robust enough for use in quantifying the cancer risks of DPM, the uncertainty suggests that cancer risks could be over 100 fold lower than estimates by CARB, which would bring the cancer risks into an acceptable range by US EPA and California standards (i.e., 10^{-6} to 10^{-4}) under the current regulations, without the need for application of the proposed regulations.

At a minimum, CARB should provide a more detailed discussion of the uncertainties noted in these comments and the impact on the estimated risks, which we note are likely highly inflated. The cumulative impact of application of multiple conservative assumptions needs to be acknowledged.

2.2 Regional $PM_{2.5}$ Mortality and Illness Analysis for California Air Basins

CARB used two different methods to estimate the impacts of the Proposed Amendments to the CHC Regulation on mortality and other health effects (hospital admissions for cardiovascular and respiratory diseases and emergency department visits for asthma). The first method relies on the modeled estimates for the two air basins (San Francisco Bay and South Coast) and the second method is a reduced form analysis that is applied to other air basins as well as to impacts from reductions in NOx.

While the CARB health analysis is based on standard methodology used by EPA to calculate health impacts, we were not able to check the results based on the data provided by CARB as many of the model inputs were missing. Also, even though the methods appear to be applied correctly, given what we were provided for review, the approach taken by CARB is unconventional. First, CARB is using two different methods to calculate health impacts, one based on modeled results and a second based on a reduced-form method with large simplifying assumptions. Both methods are subject to large uncertainties, but the reduced-form method has significantly more uncertainty.

Also, the way the CARB approaches the health analysis is also significantly different from the way EPA and others have conducted similar analyses (i.e., using BenMAP). CARB essentially is computing effects based on changes in $PM_{2.5}$ modeled estimates (or PM emission reductions) for each year starting in 2023 and up to 2038 between the current regulations and the proposed amendments. The impacts are summed across air basins for each year, and then summed across all years. To our knowledge, this type of cumulative assessment of health benefits across a long time period in the future has not been conducted previously using the methods CARB is using. We welcome other examples where this has been done.

The implications are that these impacts are cumulative over time. In addition, the impacts actually increase over the years (presumably as the difference in emissions or concentrations increase between current and proposed regulations).

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[8] Hesterberg, T. W., Long, C. M., Sax, S. N., Lapin, C. A., McClellan, R. O., Bunn, W. B., & Valberg, P. A. (2011). Particulate Matter in New Technology Diesel Exhaust (NTDE) is Quantitatively and Qualitatively Very Different from that Found in Traditional Diesel Exhaust (TDE). *Journal of the Air & Waste Management Association*, *61*(9), 894–913.

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The amount of uncertainty associated with this analysis is very large and propagated across all the steps in the risk assessment process including 1) emissions estimation, 2) modeling and scaling of PM concentrations (which rely on emission inputs), 3) deriving PM from diesel PM, 4) assumptions regarding conversion of NOx to PM, 5) application of health functions from epidemiology studies, and 6) estimation of baseline health statistics and population statistics for future years. The magnitude of the uncertainty and the impact on the direction of bias has not been evaluated by the CARB, but our analysis, based on available data, suggest that the magnitude is quite large (and larger than expressed by the 95% confidence intervals provided by CARB) and most likely are overstating the health benefits of the proposed amendments.

In light of the significant amount of uncertainty in the health analysis, we strongly suggest that CARB present the findings so that they are more transparent and in a way that acknowledges the level of uncertainty, as well as amount of confidence that can be placed on the results. For example, we don't think it is appropriate to present the combined results for the health analysis based on modeled data and those based on the IPT methodology, because the IPT results would tend to be much more uncertain and less reliable. Also, instead of presenting a total number of deaths as the sum across air basins and years, CARB should present results as a range on potential annual impacts for each air basin, separately. This again, with the acknowledgement that year to year there is uncertainty and the numbers could be more or less than estimated depending on many different model assumptions at every step in the risk assessment process.

Some of the key limitations and sources of uncertainty of these two methodologies for estimating the potential health impacts from the Proposed Amendments are discussed below.

Analysis for the San Francisco Bay and South Coast

As is the case for the cancer health risk assessment, the PM mortality and illness analysis relies on a number of model inputs and assumptions, many that are associated with significant uncertainty that tends to overstate the risks.

In interpreting the mortality and illness results, it is important to consider that the health impacts are based on a single population-based epidemiological study that infer statistical associations between health effects and air pollution exposures, but that cannot provide definite evidence of a cause and effect. This is because these studies have important limitations that preclude definite conclusions regarding a causal link between PM and mortality or illness, including uncertainty regarding the exposure estimates, the potential role of other pollutants or factors that might explain the effects, and evidence that there is likely a threshold below which health impacts are unlikely. In addition, the components of PM that may be associated with adverse health effects are yet unknown, but the analyses assume that all PM is equally toxic, making it a very conservative analysis.

The epidemiological studies that form the basis of the health study, including the mortality study by Krewski *et al*. (2009)[9] rely on data from central-site monitors to estimate personal exposures. This results in exposure measurement error because central-site monitors may not accurately capture population mobility, the uneven distribution of PM exposure attributable to local sources, pollution patterns that can be affected by terrain features and weather, and daily variations in PM concentrations or composition that may differ from variations experienced by

[9] Krewski, D. et al., 2009. Extended Follow-up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality Report. Health Effects Institute, 140 https://www.healtheffects.org/system/files/Krewski140.pdf

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individuals. These factors can bias the results of an epidemiology analysis in either direction. The direction and magnitude of the bias depends on the type of measurement error. For $PM_{2.5}$, however, because of the spatial variability of air pollutant concentrations the bias is likely to result in effects being overestimated (e.g., Goldman *et al*., 2011[10], Rhomberg *et al*. 2011[11]).

The bias associated with confounding effects is particularly difficult to address in epidemiology studies because it is challenging to account for all potential confounding factors. A confounder is a factor that is associated with both an exposure and an outcome, and may make it appear that the exposure is associated with (or caused) the outcome. In PM mortality studies there is evidence that co-pollutants can confound the PM mortality association, especially because many of the pollutants are strongly correlated, and disentangling the effects of any single pollutant (if any) is difficult. Even if potential confounders are accounted for in studies, there may still be issues of how well the confounding variables are measured and controlled for. For example, in the study by Krewski *et al.* (2009), which is used by CARB for the mortality estimates, data on potential confounders such as smoking and body mass index were determined at the beginning of the study for all participants, but were not re-evaluated over the follow up study period. Changes in these variables over time could alter confounding effects. The issue of confounding relates to both the assumption of causality, where another factor may actually be the causal agent, and to the magnitude of the association, where a co-factor may account for some of the observed risk. In either case, ignoring the effects of confounding results in overstated effects estimates.

Another source of uncertainty is the assumption of a log-linear response between exposure and health effects, without consideration for a threshold below which effects may not be measurable. The issue of a threshold for $PM_{2.5}$ is highly debated and can have significant implications for health impacts analyses as it requires consideration of current air pollution levels and calculating effects only for areas that exceed threshold levels. Without consideration of a threshold, effects of any change in air pollution below or above the threshold are assumed to impact health. Interestingly, although EPA traditionally does not consider thresholds in its cost-benefit analyses, the NAAQS itself is a health-based threshold level that EPA has developed based on evaluating the most current evidence of health effects. Most epidemiological studies do not indicate that a threshold exists, but these studies often do not have the statistical power to detect thresholds. Some studies that have employed different statistical methods have shown evidence of a threshold for PM-mortality effects. For example, Abrahamowicz et al. (2003)[12] found evidence for a $PM_{2.5}$ threshold at about 16 □g/m³ below which mortality effects were not observed. Considering a threshold for PM effects would mean that effects would occur only when threshold levels of PM is exceeded.

Sensitivity analyses are often warranted using different health functions from different studies in order to evaluate the potential variability and/or uncertainty in health estimates. For example, some epidemiological studies have reported no mortality impacts from $PM_{2.5}$

[10] Goldman, GT; Mulholland, JA; Russell, AG; Strickland, MJ; Klein, M; Waller, LA; Tolbert, PE. 2011. "Impact of exposure measurement error in air pollution epidemiology: Effect of error type in time-series studies." *Environ. Health* 10 (1) :61. 211-5049
[11] Rhomberg, LR; Chandalia, JK; Long, CM; Goodman, JE. 2011. "Measurement error in environmental epidemiology and the shape of exposure-response curves." *Crit. Rev. Toxicol.* 41 (8) :651-671. 211-7617
[12] Abrahamowicz M, Schopflocher T, Leffondré K, du Berger R, Krewski D. Flexible modeling of exposure-response relationship between long-term average levels of particulate air pollution and mortality in the American Cancer Society study. J Toxicol Environ Health A. 2003 Aug 22-Oct 10;66(16-19):1625-54.

exposures (Beelen et al., 2009[13]; Enstrom, 2005[14], Lipfert et al., 2006[15]). This means that if the BenMAP analyses used different concentration-response functions, the actual impacts may be very different from those reported in this analysis and could include a zero effect.

One additional important uncertainty stems from the assumption that all $PM_{2.5}$, regardless of composition, is equally potent in causing health effects such as mortality. This is important because $PM_{2.5}$ varies significantly in composition depending on the source, and this is particularly important because the composition of particulate matter from diesel has also changed over time as a function of changes in both diesel fuel composition as well as the use of emission controls. Several reviews have evaluated the scientific evidence of health effects from specific particulate components (e.g., Rohr and Wyzga 2012[16]; Lippmann and Chen, 2009[17]; Kelly and Fussell, 2007[18]). These reviews indicate that the evidence is strongest for combustion-derived components of PM including elemental carbon (EC), organic carbon (OC) and various metals (e.g., nickel and vanadium), however, there is still no definitive data that points to any particular component of PM as being more toxic than other components. EPA also stated that results from various studies have shown the importance of considering particle size, composition, and particle source in determining the health impacts of PM (US EPA, 2009[19]). Further, EPA (2009) found that studies have reported that particles from industrial sources and from coal combustion appear to be the most significant contributors to PM-related mortality, consistent with the findings by Rohr and Wyzga (2012) and others. Therefore, by not considering the relative toxicity of PM components, BenMAP analyses are likely to be conservative.

Analysis Using the IPT methodology for Other Air Basins (and NOx)

In addition to the analysis conducted on modeled $PM_{2.5}$, CARB applied a reduced-form methodology (IPT) to estimate additional health impacts for other air basins and from $PM_{2.5}$ derived from NOx emissions. These reduced-form analyses involve important simplifying assumptions that can greatly affect the reliability of the estimated health impacts.

The uncertainties described in the previous section also apply to the development of the IPT factors that are used to estimate the impacts for other air basins. Additional uncertainty is introduced when applying these IPT factors to the estimated emissions for this rulemaking. The IPT factors are based on a specific time period, and therefore important variability due to meteorological changes and or spatial differences are not accounted for. Most of these uncertainties were not discussed or considered by CARB. Importantly, a large majority of the assumptions and uncertainties likely result in overestimated benefits, particularly when considering the compounding effects of the uncertainties in the various modeling inputs, starting with the emissions estimates, on the final calculation.

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As noted previously, we don't believe it is appropriate for CARB to combine the results from this analysis with the analysis for the two air basins, for which modeled estimates are available. In addition, the estimated range of annual impacts for each air basin should be reported instead of summing the cumulative results across years.

2.3 Conclusions

The health risk assessments conducted by CARB are subject to a significant number of uncertainties that are propagated through the risk assessment steps and that we have shown to overestimate the health impacts. We first show that emissions estimates are inflated (see Section 1) and these estimates are inputs to the CalPuff modeling used to estimate exposures and risks for the Bay Area and South Coast Air Basins. We also note that CARB did not validate the model estimate against measured levels of $PM_{2.5}$. Our preliminary analysis indicates that the modeled estimates are overestimating the measured levels for receptors near monitoring stations, particularly in highly impacted areas. Lastly, we highlight many of the risk assessment model assumptions that will also contribute to overstated health impacts in both the cancer risk assessment and the mortality and illness assessment.

Specifically, in the cancer risk assessment the use of highly conservative exposure assumptions (e.g., high breathing rates, 70 years of exposures 24 hours a day), application of sensitivity factors, and use of a highly conservative cancer slope factor all add up to highly inflated cancer risks. Similarly, in the mortality and illness analysis, risks are also likely to be overstated because of assumptions related to the choice of epidemiological study as the basis of the analysis, as well as the assumptions regarding the year to year changes in emissions across the air basins. Importantly, because the two methods used by CARB are associated with significantly different amount of uncertainty, the mortality and illness results should be presented as annual effects, and shown separately by air basin and by methodology, noting that results using the IPT approach will be more uncertain that those based on modeled results.

Overall, CARB needs to provide a more robust validation of modeled assumptions, a more thorough discussion of the underlying uncertainties and impact on the results, and a more transparent representation of the study results.