State of California
Air Resources Board

Proposed Amendments to the Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft Operated within California Waters and 24 Nautical Miles of the California Baseline

Standardized Regulatory Impact Assessment (SRIA)

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A. Introduction

1. Background and Introduction

Commercial Harbor Craft (CHC or harbor craft) are a vital part of California's economy, and are essential to moving cargo and people throughout the various ports, harbors, and marinas in California. These vessels are reliable and operationally efficient but are predominantly powered by diesel engines that can emit significant amounts of toxic air contaminants (TAC) and other harmful pollutants, including diesel particulate matter (DPM), fine particulate matter (PM2.5), oxides of nitrogen (NOx), oxides of sulfur (SOx), Reactive Organic Gases (ROG), and greenhouse gases (GHGs). Coastal areas throughout the State continue to be impacted by the emissions generated from roughly 3,200 CHC operating in California seaports, marinas, and harbors, and additional emissions reductions are necessary to further protect public health, address disproportionate exposure burdens in disadvantaged communities, and achieve the federal air quality standards (also known as the National Ambient Air Quality Standards (NAAQS)).

California Air Resources Board (CARB) staff is proposing to amend the current CHC Regulation (Current Regulation)[1, 2] to further reduce emissions from harbor craft. Staff has prepared this Standardized Regulatory Impact Assessment (SRIA) for the Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft (Proposed Amendments), required of proposed regulations with at least $50 million in annual economic impact, pursuant to the requirements of Senate Bill (SB) 617 and the California Department of Finance (DOF).[3,4] The purpose of a SRIA is to provide a summary of the cost and benefit impacts of the Proposed Amendments, including impacts to economic indicators like employment, gross State product, and output.

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[1] 17 CCR § 93118.5. Amendments to The Regulations to Reduce Emissions From Diesel Engines on Commercial Harbor Craft Operated Within California Waters And 24 Nautical Miles of The California Baseline, "Airborne Toxic Control Measure for Commercial Harbor Craft," *https://ww3.arb.ca.gov/regact/2010/chc10/frochc931185.pdf?_ga=2.78049812.1270712077.1612894570-1636078118.1596670776*.

[2] 13 CCR § 2299.5. Amendments to The Regulations to Reduce Emissions From Diesel Engines on Commercial Harbor Craft Operated Within California Waters And 24 Nautical Miles of The California Baseline, "Low Sulfur Fuel Requirement, Emission Limits and Other Requirements for Commercial harbor Craft," *https://ww3.arb.ca.gov/regact/2010/chc10/frochc22995.pdf?_ga=2.14562743.1270712077.1612894570-1636078118.1596670776.*

[3] California Legislature, Senate Bill 617, signed on October 5, 2011, last accessed June 2020, *http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120SB617*.

[4] Department of Finance, Chapter 1: Standardized regulatory Impact Analysis For Major Regulations - Order of Adoption, last accessed June 2020, *http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Order_of_Adoption-2.pdf*.

2. High-Level Summary of Background and Purpose of Proposed Amendments

CHC operating in Regulated California Waters (RCW), which include waters up to 24 nautical miles of the California baseline) are currently subject to emission-related requirements for both new and in-use diesel engines. In 2008, CARB adopted the initial CHC regulation, which established new and in-use engine emissions limits for both auxiliary and propulsion diesel engines on certain CHC categories. Auxiliary engines are used for electrical power onboard the vessel and propulsion diesel engines provide thrust to propel a CHC forward through the water. The initial CHC regulation led to reductions in NOx and PM emissions by requiring CHC to meet specific marine engine standards established by the United States Environmental Protection Agency (U.S. EPA) (e.g., Tier 1, Tier 2, or Tier 3 standards) for main and auxiliary engines. The initial CHC Regulation[5, 6] was amended in 2010 (becoming the Current Regulation) to include in-use emissions requirements for auxiliary and propulsion engines on additional CHC categories.

The Current Regulation requires harbor craft to:

- Meet "new engine emission standards" which require accelerated turnover to Tier 2 or Tier 3 standards between 2009 and 2022 for new and in-use diesel engines.
- Install a non-resettable hour meter on each engine, if not already installed.
- Use CARB diesel or an approved alternative fuel.
- Submit an initial report to CARB providing vessel and engine information.
- Maintain and update vessel records and keep copies on the vessel or at the homeport office.

The primary purpose of the Proposed Amendments is to further reduce emissions from harbor craft, which would deliver emissions reductions in disadvantaged communities heavily impacted by port operations and help reduce the community health risk. Reducing emissions from harbor craft would also help California attain national and regional air quality standards and to mitigate impacts resulting from climate change. New and expanded recordkeeping and reporting requirements would also improve regulatory compliance and enforcement. The Proposed Amendments would apply more stringent requirements for new and in-use vessels, expand the regulatory requirements to include vessel categories that were previously not subject to regulated in-use vessel requirements, and accelerate the deployment of Zero-Emission and Advanced Technologies (ZEAT) through mandates and voluntary

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[5] California Air Resources Board Final Regulation Order Airborne Toxic Control Measure for Diesel Engines on Commercial Harbor Craft Operated Within California Waters and 24 Nautical Miles of the California Baseline, Section 93118.5, Title 17, California Code of Regulations, November 19, 2008, *https://www.arb.ca.gov/regact/2007/chc07/rev93118.pdf?_ga=2.250235973.234599760.1605638934-1017863673.1605638934*.

[6] California Air Resources Board Final Regulation Order Emission Limits and Requirements for Diesel Engines on Commercial Harbor Craft Operated Within California Waters and 24 Nautical Miles of the California Baseline, Section 2299.5, Title 13, California Code of Regulations, November 19, 2008, *https://www.arb.ca.gov/regact/2007/chc07/chcfro13.pdf*.

provisions. Each of these goals is discussed in more detail in Section A.7 of this chapter.

3. Background on Commercial Harbor Craft

a. Overview of Commercial Harbor Craft Vessel Types

CHC include any private, commercial, government, or military marine vessel including, but not limited to, passenger ferries, barge and dredge vessels, excursion vessels, tugboats, ocean-going tugboats, articulated tug barges, petrochemical tank barges, towboats, push boats, crew and supply vessels, workboats, pilot vessels, supply boats, commercial passenger fishing vessels, fishing vessels, research vessels, U.S. Coast Guard vessels, hovercraft, emergency response harbor craft, and barge vessels that do not otherwise meet the definition of ocean-going vessels (OGV) or recreational vessels. CHC are used throughout California harbors, bays, and other coastal and inland waters but are heavily concentrated at seaports and other major harbors and marinas throughout the State. In 2023 (when the Proposed Amendments would take effect), staff estimates there will be about 3,200 harbor craft operating in California that would be subject to the Proposed Amendments.

b. Basics on Commercial Harbor Craft Operations

This section provides an introduction to harbor craft operations and the various types of CHC that work in and visit California seaports, marinas, and harbors.

i. Barges

Barges are cargo transporting vessels that are generally towed or tugged along with other vessels. Since barges are typically not self-propelled, they require tugboats or towboats to be moved. Barges come in a wide variety of configurations and some barge configurations and vocations may produce significant emissions if they are supporting fuel-bunkering operations. Depending on the type of barge, there may be a number of auxiliary engines aboard for pumping fuel or petrochemicals off the barge, powering hydraulic actuators for mechanical barge dumping, or generating electricity for running lights. In California, as of 2021, there are approximately 160 barges representing about 5 percent of the total CHC population. Figures A-1 through A-4 are images of different types of barges including a(n):

1) Articulated Tug Barge (ATB);
2) Double-Hull Petrochemical Tank Barge;
3) Double-hull fuel bunker barge; and
4) Construction Barge.

Figure A-1. Kirby Corp. ATB Departing the San Francisco Bay Area

Figure A-2. Sause Bros. Ocean Double-Hull Fuel Barge, Alsea Bay

Figure A-3. *Bernie Briere* Double-Hull Fuel Bunker Barge at Port of San Francisco

Figure A-4. Flat Top Construction Barge

ii. Commercial Fishing Vessels

Commercial fishing vessels are used to catch fish in the sea, or on a lake or river, and may operate their engines at the dock while loading supplies. Commercial fishing vessels transit to various offshore locations to collect fish, sometimes with trips lasting a few days. Most of the smaller commercial fishing vessels are powered by one main engine and have an auxiliary generator engine for powering vessel refrigeration, lighting, deck equipment, and some vessels have an icemaker for preserving fish. Vessel propulsion is accomplished by single or twin-screw fixed-pitch propellers but some larger commercial fishing vessels may have more main engines and twin-screw propulsion. In California, as of 2021, there are approximately 1,200 commercial fishing vessels representing 38 percent of the total CHC population. Figures A-5 and A-6 below are images of commercial fishing vessels that are recovering trawl nets.

Figures A-5 and A-6. Commercial Fishing Vessels Recovering Trawl Nets

iii. Commercial Passenger Fishing Vessels

Commercial Passenger Fishing Vessels (CPFV) are any coastal or offshore vessel used for sport fishing, charter fishing, or any other type of fishing activity where individuals other than the owners, operators, or employees of the vessel are onboard the vessel to perform fishing activities. They include but are not limited to operations that provide both day and overnight trips, including those that may voyage periodically in and out of RCW to target migratory species.

These vessels may idle at their docks while warming up and loading passengers and equipment. CPFVs transit at high speed out to the open ocean to locate fishing grounds where they troll at low speeds or maintain their position. In California, as of 2021, there are approximately 350 CPFVs representing approximately 11 percent of the total CHC population. Figure A-7 is an image of the vessel *Freelance,* which is located in San Diego, California.

Figure A-7. CPFV Freelance, Operating out of San Diego, CA

iv. Crew and Supply Vessels

Crew and supply vessels are self-propelled vessels that are used for carrying personnel and/or supplies to and from offshore and in-harbor locations (including, but not limited to, offshore work platforms, construction sites, islands, and other vessels). Ocean-going crew and supply vessels are regularly used to service offshore drilling platforms and assist in towing and repositioning of drilling platforms. They are also frequently used to bring service personnel and parts to repair ships at anchorage. In California, as of 2021, there are approximately 170 crew and supply vessels representing about 5 percent of the total CHC population.

Figures A-8 and A-9 are images of the *Maersk Transporter* and the *NRC Quest* crew and supply vessels, respectively.

Figures A-8 and A-9. Maersk Transporter and NRC Quest Offshore Crew and Supply Vessels

v. Dredges

Dredges are vessels designed to remove earth from the bottom of waterways, by means of a scoop, a series of buckets, or a suction pipe. Dredging vessels excavate underwater debris from shipping channels by utilizing mechanical, hydraulic, or a combination of both methods. Dredging operations are accomplished either by barge-mounted heavy equipment or custom-built harbor craft. A few dredges have propulsion engines but most are positioned and moved by push/tow tugboats. Auxiliary engines are used to power pumps, generators, air compressors, and dredge machinery. In California, as of 2021, there are approximately 50 dredges representing about 1.5 percent of all California CHC. The majority of the dredges are located in the San Francisco Bay Area.

a) Mechanical dredges

Mechanical dredges come in a number of different arrangements including barge-mounted hydraulic excavators with back-hoe or clamshell-type buckets, bucket wheel excavators, and cutter-suction dredges. Figures A-10 through A-12 are images of hydraulic excavator and back-hoe type dredges.

Figures A-10 and A-11. Hydraulic Excavator with Clamshell Bucket and a Cutter-Suction Dredge for Dredging Harder Materials like Rock and Corral

Figure A-12. Barge Mounted Back-Hoe Type Dredge

b) Hydraulic Dredges

Hydraulic dredging vessels utilize large high-volume debris-resistant water pumps to pump a combination of water and debris either to the side of the excavation area, into a self-contained hopper, or dumping hopper barge (called a scow) to transport long distances, or into a pipeline to pump a short distance away. Hydraulic suction dredges are better suited for removing softer debris such as sand and mud. These vessels often employ their main engines at full power through a gearbox power take-off to pump massive quantities of water and debris. Figures A-13 and A-14 below are images of suction hopper-type dredge vessels.

Figures A-13 and A-14. Suction-Hopper Type Dredge Vessels

vi. Excursion Vessels

Excursion vessels are self-propelled vessels that transport passengers for purposes such as harbor, lake, bay, or river sight-seeing tours, dinner cruises, scuba diving expeditions, parasailing, and whale watching tours. In California, as of 2021, there are approximately 420 excursion vessels, representing about 13 percent of the total CHC population. The majority of these vessels are located in the South Coast, San Francisco Bay Area, and San Diego. Figure A-15 below is an image of the Bay Area excursion vessel, *Old Blue*, operated by Blue and Gold Fleet.

Figure A-15. Blue and Gold Fleet Excursion Vessel, Old Blue

Due to the cyclical nature of excursion trips, trip frequencies, and the low-power requirements and transit speeds, excursion vessels are one sector of CHC activity in

California where the application of zero-emission propulsion technologies is a viable option for certain vessels. For example, *Enhydra*, Red and White Fleet's new plug-in hybrid 600-passenger battery/diesel-electric excursion vessel, is capable of running 100 percent zero-emission excursion trips in the San Francisco Bay with adequate charging infrastructure. Figure A-16 below is an image of the Red and White Fleet's *Enhydra* vessel.

Figure A-16. Red and White Fleet's Battery Plug-in/Diesel-Electric Bay Area Excursion Vessel, Enhydra

vii. Ferries

Ferries transport deck passengers or vehicles, operating between two points over a direct water route. Ferries include vessels operated by public or private companies to transport passengers commercially, on both regularly scheduled, and on-demand bases. In California, as of 2021, there are approximately 70 ferries, representing approximately 2 percent of the total CHC population. Ferries are mostly located in the San Francisco Bay Area and South Coast.

a) Short Run Ferries

Short-run ferries are a subset of ferries that operate on shorter runs, which the Proposed Amendments define as less than three nautical miles apart. The Proposed Amendments would require zero-emission operations for short-run ferries; more detail will be provided in section A.7.c of this SRIA.

b) High-Speed Ferries

High-speed ferries utilize powerful engines at high engine loads for extended time intervals while transiting over relatively long distances. High-speed ferries operate the engines at a high load continuously while transiting, which requires larger and/or higher power-density engines. Figure A-17 below is an image of the Water Emergency Transportation Authorities (WETA) high-speed catamaran ferry, *Hydrus*.

Figure A-17. WETA High-Speed Catamaran Ferry, Hydrus.

c) Low-Speed Monohull Ferries

Similar to excursion vessel designs, low-speed monohull ferries are older vessels with single-hull designs. These ferries are typically used for very short distances (e.g., river crossings) or sight-seeing purposes. Figure A-18 below is an image of the Bay Area's Blue and Gold Fleet *Bay Monarch* vessel, which can hold up to 788 passengers.

Figure A-18. Blue and Gold Fleet Low-Speed Monohull Ferry, Bay Monarch

viii. Pilot Vessels

Pilot vessels are designed for transferring and transporting maritime pilots to and from OGVs while such vessels are underway, at anchor, or at dock. In California, as of 2021, there are ten pilot vessels, representing less than 1 percent of the total CHC population. They have home seaports in the San Francisco Bay Area and South Coast. Figure A-19 below is an image of the San Francisco Bar Pilot's run boat, the *P/V Golden Gate*.

Figure A-19. San Francisco Bar Pilots 67' Runboat, P/V Golden Gate

ix. Research Vessels

Research vessels include but are not limited to vessels with highly advanced mobile research stations, and vessels that provide stable platforms from which explorers can deploy equipment, divers, or submersibles.[7] In California, as of 2021, there are 25 research vessels, representing less than 1 percent of the total CHC population. Figure A-20 is an image of the Scripps Institute of Oceanography's *Robert Gordon Sproul* which is a regional general-purpose research vessel that serves research and education missions offshore California and the U.S. West Coast.

Figure A-20. Scripps Research Vessel Robert Gordon Sproul

x. Tugboats

CARB defines tugboats as any self-propelled vessel in the service of pulling, pushing, maneuvering, berthing, or hauling alongside barges or other vessels in harbors, over

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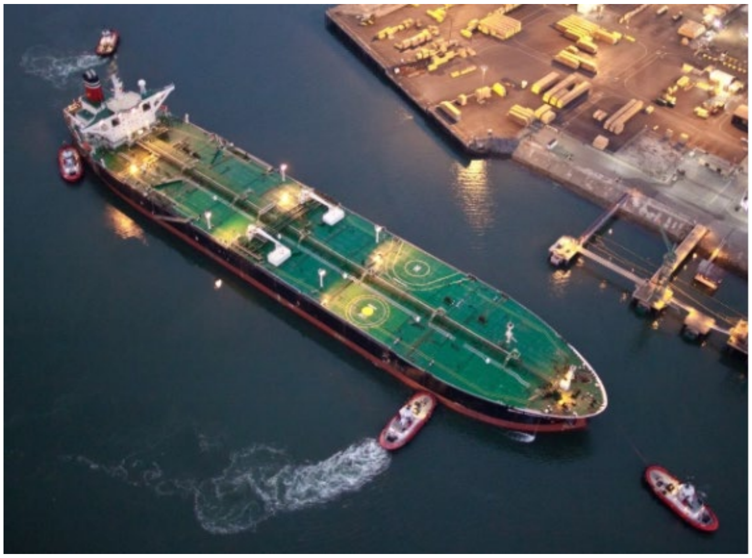
[7] Specifically, Research Vessels are any vessel subject to requirements of 46 CFR Subchapter U, Oceanographic Research Vessels, last accessed January 28, 2021, *https://www.govinfo.gov/content/pkg/CFR-2012-title46-vol7/pdf/CFR-2012-title46-vol7-chapI-subchapU.pdf*.

the open seas, or through rivers and canals. Tugboats generally can be divided into three groups: ship assist/escort tugboats, push/tow tugboats, and ATBs. The term "tugboat" is interchangeable with "towboat" and "push boat" when the vessel is used in conjunction with barges. In California, as of 2021, there are approximately 230 tugboats, representing about 7 percent of the total CHC population.

a) Ship Assist Tugboats

A ship assist tugboat is a highly maneuverable tug that primarily assists ATBs and OGVs while docking and undocking. Ship assist tugs have a highly variable duty cycle. They have powerful main propulsion engines but only operate at maximum load for very brief periods. Commonly, ship assist tugs remain on standby waiting for ships or transit between jobs at lower loads. Figure A-21 is an image of ship assist tugboats maneuvering a ship to a berth.

Figure A-21. Ship Assist Tugboats Maneuvering a Ship to Shore



b) Escort Tugboats

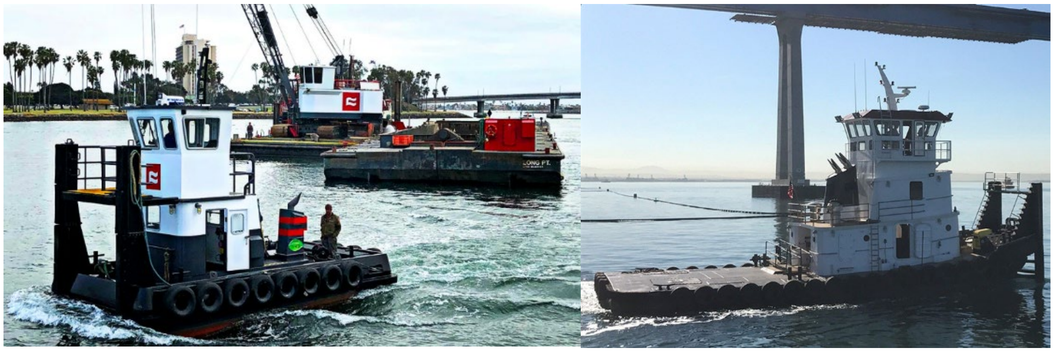
Escort tugboats intercept and escort ATBs, or OGVs entering or departing the regional port area, with the purpose of providing maneuvering or stopping assistance in case of loss of propulsion or steering power while en route to or from docks and terminals. Figures A-22 and A-23 are images of the Bay Area escort tug, *Caden Foss*.

Figures A-22 and A-23. Bay Area Escort Tug, Caden Foss

c) Push/Tow Tugboats

Push and towing tugs are often repurposed older ship assist tugboats. They are used to move and position barges in harbor and inland waterways. Unlike escort and ship assist tugs, push tugs operate their engines at higher loads for extended time intervals. The average load factors for these pushing and towing tugs are estimated to be 40-50 percent (similar to a larger ATB push tug). Figures A-24 and A-25 are images of near-shore pushing vessels.

Figures A-24 and A-25. Near Shore Pushing Vessels



Ocean-going towing vessels are similar to the older near-shore pushing/towing vessels in that they are often decades-old repowered vessels. Like ATBs and near-shore push boats, ocean-going towing vessels operate their main engines at high loads for extended time intervals and have a higher continuous load, similar to ATB tugs. Figure A-26 is an image of the *Pacific Falcon* ocean towing tug.

Figure A-26. Pacific Falcon Ocean Towing Tug

xi. Workboat/Emergency Response Vessels

Workboats and emergency response vessels are self-propelled vessels that are used to perform any duty not specifically listed by another category of CHC, including but not limited to duties such as firefighting/rescue, law enforcement, hydrographic surveys, training, spill response, debris removal, cable laying, construction support (including construction drilling or diving support), and other non-emergency and emergency response operations. Workboats and emergency response vessels can include vessels owned by public, private, and non-profit organizations. In California, as of 2021, there are approximately 480 workboats, representing about 15 percent of the total CHC population. The workboat sector encompasses a wide variety of CHC tasked with supporting various maritime construction or infrastructure development projects. Figure A-27 is an image of a general use workboat.

Figure A-27. General Use Workboat

4. Overview of Emissions from Commercial Harbor Craft

Diesel engines on CHC emit a complex mixture of air pollutants, including TACs, criteria air pollutants, including NOx and PM2.5, and GHGs. An overview of these different types of pollutants is provided below.

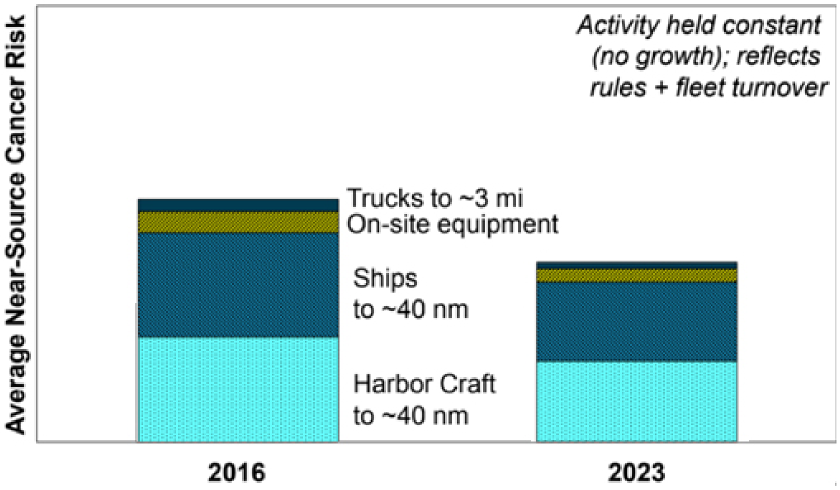
a. Toxic Air Contaminants

Diesel exhaust includes a number of TACs that have health impacts due to near-source exposure, including gaseous TACs, and a mixture of toxics in the particulate phase such as DPM.

Long-term exposure to DPM can increase the risk of developing lung cancer and shares many of the same non-cancer health effects as PM2.5.[8] These effects include premature death, hospitalizations, and emergency department visits for exacerbated chronic heart and lung disease, including asthma, increased respiratory symptoms, and decreased lung function in children.

CHC emissions, from both main and auxiliary engines, at the Port of Los Angeles (POLA) and the Port of Long Beach (POLB), are significant and were the second-largest contributor of near-source cancer risk in 2016, and are anticipated to become the largest contributor of near-source cancer risk in 2023 (Figure A-28).[9] Further, CHC would become the largest seaport emissions source in 2023 at the POLA and POLB as reductions from other sources occur.[10]

Figure A-28. Seaport Contribution to Near-Source Cancer Risk[11]



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[8] CARB, Overview: Diesel Exhaust & Health, last accessed January 29, 2020, https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health.

[9] CARB Board Hearing, Implementation of State SIP Strategy and South Coast AQMP - Concepts to Minimize the Community Health Impacts from Large Freight Facilities, March 22, 2018, last accessed February 21, 2021, https://www.arb.ca.gov/board/books/2018/032218/18-2-5pres.pdf?_ga=2.243242562.1596168673.1607359382-1902767897.1606875431.

[10] Public Workshop for the Draft Proposed Amendments to the Commercial Harbor Craft Regulation, March 16, 2021, https://ww2.arb.ca.gov/sites/default/files/2021-03/March%202021%20Workshop%20Slides%20-%20English.pdf.

[11] Adapted from CARB Board Hearing, Implementation of State SIP Strategy and South Coast AQMD - Concepts to Minimize the Community Health Impacts from Large Freight Facilities, March 22, 2018, last accessed February 21, 2021, https://www.arb.ca.gov/board/books/2018/032218/18-2-5pres.pdf?_ga=2.243242562.1596168673.1607359382-1902767897.1606875431.

b. Criteria Air Pollutants

PM is emitted from a vessel's exhaust stack as a complex mixture of suspended particles and aerosols varying in size, shape, and chemical composition. These particles can either be directly emitted into the atmosphere (primary particles) or formed by chemical reactions of gases (secondary particles) from natural or man-made sources such as sulfur dioxide (SO2), NOx, and certain organic compounds. PM can be inhaled into the upper airways and lungs, creating respiratory ailments leading to public health concerns. Exposure can increase premature mortality, hospital admissions for cardiopulmonary causes, acute and chronic bronchitis, asthma attacks, and respiratory symptoms. These health effects are of particular concern for sensitive groups such as infants, children, the elderly, and those with preexisting heart or lung disease.[12]

NOx consists of highly reactive gases, including nitric oxide (NO) and nitrogen dioxide (NO2). NOx emissions from diesel engines are important because they can react with reactive organic gases in the atmosphere, to then form other criteria pollutants – namely ozone and PM2.5.[13] The majority of NOx emissions from diesel engines are in the form of NO, even in the presence of catalyzed diesel particulate filter (DPF) aftertreatment where NO/NOx ratios have shown to range between 0.67 to 0.82.[14] Both NO and NO2 are formed in significant amounts by diesel engines, which operate at elevated temperatures and pressures that are most conducive to generating emissions of NOx. Short-term exposure to elevated concentrations of NOx is known to irritate the respiratory system and aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing, or difficulty breathing), hospital admissions, and visits to emergency rooms (ER).

CHC operate in several air basins, including the South Coast, the San Francisco Bay Area, and the San Joaquin Valley (primarily at the Port of Stockton). Each of these areas has varying levels of ozone pollution, and none of these areas are in the attainment of the 2008 or 2015 eight-hour ozone health-protective standards. Since the South Coast and San Joaquin Valley are designated as extreme nonattainment areas for the 2008 and 2015 eight-hour ozone standards, it is imperative that NOx emissions are reduced further from CHC since NOx is a precursor to ozone formation.

c. Greenhouse Gases

CHC also emit GHGs and black carbon, a potent short-lived climate pollutant. GHGs contribute to the greenhouse effect by absorbing reflected solar energy and warming

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[12] CARB, Inhalable Particulate Matter and Health (PM2.5 and PM10), August 10, 2017, last accessed November 16, 2020, *https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health*.

[13] U.S. EPA, What is NO2, *https://www.epa.gov/no2-pollution/basic-information-about-no2#*.

[14] Real-World Emissions from Modern Heavy-Duty Diesel, Natural Gas, and Hybrid Diesel Trucks Operating Along Major California Freight Corridors, July 19, 2016, *https://link.springer.com/article/10.1007/s40825-016-0044-0*.

the Earth's atmosphere, contributing to global climate change.[15] Presently, the maritime industry as a whole accounts for around 2 percent of global GHG emissions, but this percentage is projected to increase by up to 250 percent by 2050 due to industry growth associated with increasing global trade demands.[16] California has set a GHG emissions reduction goal of 40 percent below 1990 levels by 2030[17] and this target is expected to enable California to reach its ultimate goal of reducing emissions by 80 percent from 1990 levels by 2050.

Reducing CHC emissions would help to achieve California's goals in reducing both GHG emissions and short-lived climate pollutants. Short-lived climate pollutants are powerful climate forcers that can have an immediate and powerful impact on climate change, compared to longer-lived GHGs such as carbon dioxide (CO2).

5. Background on Current Regulation

On September 2, 2008, CARB adopted the initial Regulation for CHC that established emission-related requirements for new and in-use auxiliary and propulsion diesel engines for CHC, including ferries, excursion vessels, tugboats, and towboats, and crew and supply boats. The initial CHC Regulation became effective on January 1, 2009,[18] and was amended in 2010 (becoming the Current Regulation) to include in-use emission requirements for main and auxiliary engines on crew and supply vessels, barges, and dredges.[19]

a. Requirements of the Current Regulation

The Current Regulation requires that in-use Tier 1 and earlier propulsion and auxiliary diesel engines on a CHC vessel operating as a ferry, excursion vessel, tugboat, towboat, crew and supply vessel, barge, or dredge meet emission limits equal to or cleaner than U.S. EPA standards in effect (Tier 2 or Tier 3) at the time the engine is

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[15] IMO, Greenhouse Gas Emissions, accessed November 16, 2020, *https://www.imo.org/en/OurWork/Environment/Pages/GHG-Emissions.aspx.*

[16] Stefanini, S., Climate Change News, "Countries Inch Towards 'Bare Minimum' Climate Target For Shipping," April 10, 2018, last accessed November 16, 2020 *https://www.climatechangenews.com/2018/04/10/countries-inch-towards-bare-minimum-climate-target-shipping/*.

[17] California Health and Safety Code §38566, Division 25.5, Senate Bill No. 32, September 8, 2016, Accessed November 16, 2020, *https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=38566*

[18] California Air Resources Board Final Regulation Order Airborne Toxic Control Measure for Diesel Engines on Commercial Harbor Craft Operated Within California Waters and 24 Nautical Miles of the California Baseline, Section 93118.5, Title 17, California Code of Regulations, November 19, 2008, *https://www.arb.ca.gov/regact/2007/chc07/rev93118.pdf?_ga=2.250235973.234599760.1605638934-1017863673.1605638934*.

[19] California Air Resources Board Final Regulation Order Amendments to Reduce Emissions from Diesel Engines on Commercial Harbor Craft Operated Within California Waters and 24 Nautical Miles of the California Baseline, Section 93118.5, Title 17, July 20, 2011, *https://www.arb.ca.gov/regact/2010/chc10/frochc931185.pdf?_ga=2.207842769.234599760.1605638934-1017863673.1605638934*.

brought into compliance. The Current Regulation does not impose in-use requirements on workboats, pilot vessels, commercial passenger fishing, and tank barges over 400 feet in length.

The compliance date depends on the engine model year and annual operating hours, and requirements phase-in from December 31, 2009, through December 31, 2022. There are four compliance schedules in the Current Regulation: one for vessels with their home seaports outside of the South Coast Air Quality Management District (SCAQMD), an accelerated schedule for vessels with their home seaports in the SCAQMD, and two other statewide schedules for crew and supply vessels and barges and dredges. All of the compliance schedules are based on the engine model year and hours of operation and are designed to replace the oldest, highest-use engines first. For vessel categories subject to in-use requirements, the Current Regulation contains low-use provisions, which require owners and operators to demonstrate that the engine has not, and would not, operate more than 80 or 300 hours per year, depending on the vessel category.

The Current Regulation also requires owner/operators of all CHC operating in RCW (including those in vessel categories not subject to in-use requirements) to keep records for each vessel, install a non-resettable hour meter on each engine, and use Ultra-low sulfur diesel (ULSD) (15 parts per million (ppm) sulfur)) to fuel their engines. CHC owner/operators are required to submit a report to CARB if they have acquired a CHC vessel or engine or if there is a change in the engine hours of operation.

New ferries carrying 75 passengers or more must meet Tier 4 engine requirements or use Tier 2 or Tier 3 engines in conjunction with the Best Available Control Technology (BACT).

6. Statement of the Need of the Proposed Amendments

In the coming years, California needs to continue to build upon its successful efforts to meet critical risk reduction, air quality, and climate goals. Achieving these goals will provide much needed public health protection for the millions of Californians that still breathe unhealthy air, reduce exposure to air toxics, and help meet State Implementation Plan (SIP) commitments. Additionally, meeting California's GHG emissions reduction targets is an essential part of the global action needed to slow global warming and achieve climate stabilization. Finally, accelerating the adoption of zero-emission technology in the marine sector is a key strategy to achieving these goals, and aligns with policy directives such as Governor Newsom's Executive Order (EO) N-79-20,[20] which directs CARB and other State, local, and federal agencies to develop strategies to achieve 100 percent zero-emission from off-road vehicles and equipment by 2035 where feasible. The Proposed Amendments would achieve

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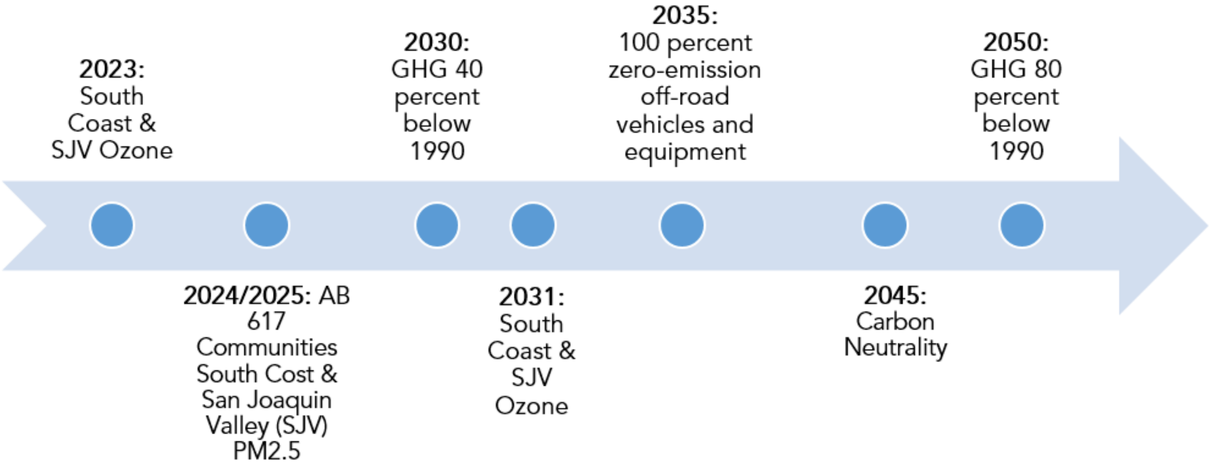
[20] Executive Order N-79-2020. State of California Executive Order signed by Governor Gavin Newsom. September 23, 2020, *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf*.

additional NOx, PM, and GHG emissions reductions from CHC and increase the use of zero-emission technology in the marine sector.

Figure A-29 displays the multitude of standards, targets, and goals the State of California would need to meet over the next 30 years.

Figure A-29. California's Air Quality Targets and GHG Reduction Goals



a. Need to Achieve Public Health and Air Quality Benefits

Staff recognizes that under the Current Regulation, vessel owner/operators have made considerable investments to replace older engines with newer, cleaner engines. Owner/operators have even done so voluntarily with the assistance of funding programs like CARB's Carl Moyer Program, which is administered through local air districts. However, the near-source cancer risk and local pollution contribution from CHC still remains high.[21] CHC continues to impact nearby communities, including those in ozone and PM2.5 nonattainment areas, which include the San Francisco Bay Area, San Joaquin Valley, Ventura County, South Coast, and San Diego. In addition, DPM emissions from CHC impact communities located adjacent to those operations, as well as people living and working miles away. In addition, emissions from CHC engines are expected to become even more significant as emissions from other mobile sources decrease due to more stringent regulations and cleaner technologies. The emissions from CHC impose uncompensated health and environmental costs to the portside communities and it is necessary to reduce this risk as much as possible.

As mentioned above in Section 4.a of this chapter, in 2017, staff conducted a scoping evaluation for POLA and POLB.[22] This scoping evaluation showed that CHC were still the second-highest contributor to near-source cancer risk in 2016 and would

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[21] CARB Board Hearing, Implementation of State SIP Strategy and South Coast AQMP - Concepts to Minimize the Community Health Impacts from Large Freight Facilities, March 22, 2018, last accessed February 21, 2021, *https://www.arb.ca.gov/board/books/2018/032218/18-2-5pres.pdf?_ga=2.243242562.1596168673.1607359382-1902767897.1606875431*.

[22] Ibid.

contribute an even larger proportion in 2023 (Figure A-28). As a result, staff proposed at the March 2018 Board Hearing to develop regulations to further reduce emissions from CHC and other freight sources including OGVs, cargo handling equipment, and drayage trucks. These measures would also achieve emissions reductions needed to help attain ambient air quality standards and combat climate change, which is critical since the South Coast Air Basin is classified as an extreme nonattainment area for the eight-hour ozone standard, and serious nonattainment for the PM2.5 standard. Since the Current Regulation will be fully implemented at the end of 2022, CARB staff is proposing to further reduce emissions from CHC starting in 2023. The Proposed Amendments would have final compliance deadlines in 2032 with the majority of compliance extensions expiring by 2037.

b. Need to Reduce Greenhouse Gas Emissions

CHC engine exhaust contains various GHG emissions that contribute to the greenhouse effect by absorbing reflected solar energy and warming the Earth's atmosphere, contributing to global climate change. Anthropogenic climate change is a significant and growing problem that must be addressed to avoid more serious effects in the near future. Aside from requiring cleaner tiered CHC engines to reduce criteria, toxic, and GHG emissions, Assembly Bill (AB) 32[23] requires California to reduce its GHG emissions to 1990 levels by 2020. In addition, under SB 32,[24] California set a GHG emissions reduction goal of 40 percent below 1990 levels by 2030 and this target is expected to enable California to reach the ultimate goal of reducing emissions by 80 percent under 1990 levels by 2050 per EO S-03-05.

SB 605 (Lara, Chapter 523, Statutes of 2014) requires CARB to develop a plan to reduce emissions of short-lived climate pollutants (SLCP), and SB 1383 (Lara, Chapter 395, Statutes of 2016) requires the Board to approve and begin implementing the plan by January 1, 2018.[25] SB 1383 also sets targets for statewide reductions in SLCP emissions of 40 percent below 2013 levels by 2030 for methane (CH4), and 50 percent below 2013 levels by 2030 for black carbon. Reductions in GHGs, including SLCPs like black carbon, from CHC, are needed to achieve the State's multiple GHG reduction targets and related climate goals.

Strategies to reduce GHG emissions from CHC are included in the Proposed Amendments. The accelerated replacement of older engines with engines meeting Tier 4 standards required by the Proposed Amendments and the voluntary provisions and mandates to accelerate deployment of ZEAT into the CHC sector would all reduce GHG emissions.

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[23] Assembly Bill No. 32, September 27, 2006, *http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf*.

[24] Senate Bill 32, September 8, 2016, *http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_0001-0050/sb_32_bill_20160908_chaptered.html*.

[25] California Health and Safety Code § 39730, Division 26, Senate Bill No. 605, Short-lived climate pollutants, September 21, 2014, last accessed January 29, 2021, *http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201320140SB605*.

c. Need to Address State Policy and Plans Directing CARB to Achieve Further Reductions from CHC

The Proposed Amendments are needed to address the State policies and plans below directing CARB to achieve additional emissions reductions from CHC.

i. State Implementation Plan Commitments

CHC make up a large share of emissions in various Air Basins throughout the State. Some of these areas do not have air quality levels that meet the Federal NAAQS and are designated as nonattainment. U.S. EPA classifies areas of ozone nonattainment (e.g., "extreme," "severe," "serious," "moderate" or "marginal") based on how much an area exceeds the standard. For PM2.5, nonattainment areas can either be designated as moderate or serious, again based on the level of their PM2.5 air quality. This classification affects the required date that such areas need to attain the relevant standard(s). The worse the air quality, the more time is allowed to demonstrate attainment in recognition of the greater challenge involved. However, the areas with higher classifications are also subject to more stringent requirements, such as permitting and pollution control requirements for stationary sources, and transportation control measures.

When U.S. EPA establishes a new NAAQS, areas that do not meet this level of the standard are required to develop SIPs, which identify the emissions control requirements that the Air District and State would rely upon to attain and maintain the NAAQS. If U.S. EPA finds that the State has failed to submit the required SIP or that the air quality standard is not achieved by the date designated by U.S. EPA, nonattainment areas can face sanctions such as the removal of Federal highway funding and 2:1 required emissions offsets for any new or modified stationary sources or emission units that require a permit.

California has five air basins or counties that are directly affected by CHC emissions and are nonattainment for the Federal PM2.5 and ozone NAAQS. For geographical reference, Figure A-30 shows the 35 air districts within California.

Figure A-30. California Air Districts

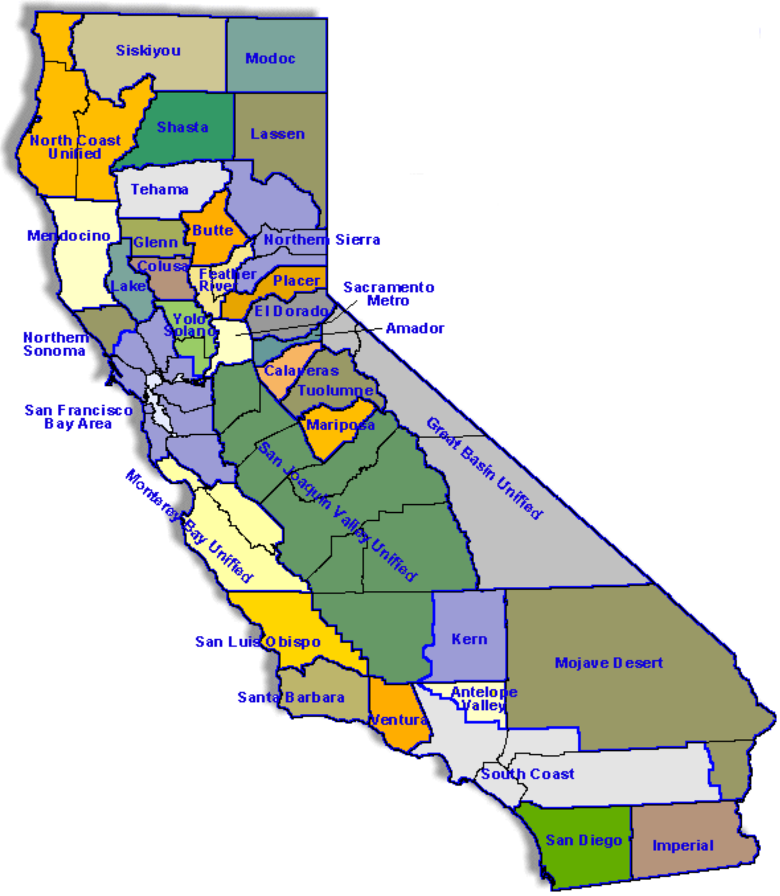

Table A-1 shows the air districts/basins in California that are nonattainment for the various ozone and PM2.5 standards and their designation status. Nonattainment areas in California that are impacted by CHC emissions include the San Francisco Bay Area, San Joaquin Valley, Ventura County, South Coast, and San Diego. In addition, other areas that are in attainment of the ozone and PM2.5 standards would also benefit from the reductions that would be achieved from the Proposed Amendments such as Santa Barbara and Humboldt County.

California has the two areas with the most critical air quality challenges in the nation, the South Coast Air Basin and San Joaquin Valley. Within the San Joaquin Valley, CHC contribute 0.2 percent of NOx and 0.03 percent of PM2.5 when compared to the annual total for the Valley in 2020. Therefore, reductions from the Proposed Amendments are not expected to have as large of a benefit as in other coastal areas. The near-term targets for these areas are a 2023 deadline for attainment of the 80 parts per billion (ppb) eight-hour ozone standard, 2024 for the 35 micrograms per cubic meter (μg/m3) 24-hour PM2.5 standard, and 2025 for the 12 μg/m3 annual PM2.5 standard. There are also mid-term attainment years of 2031 and 2037 for the more recent eight-hour ozone standards of 75 ppb and 70 ppb, respectively.[26] In 2018, U.S. EPA designated the South Coast Air Basin as an extreme nonattainment area for the 2015 eight-hour ozone standard.

Table A-1. California Non-Attainment Area Classifications for the Ozone and PM2.5 NAAQS: National Ambient Air Quality Standard Classifications California Non-Attainment Areas

Nonattainment Area	2008 Ozone	2015 Ozone	2006 PM2.5	2012 PM2.5
San Francisco Bay Area	Marginal	Marginal	Moderate	n/a
San Joaquin Valley	Extreme	Extreme	Serious	Moderate
Ventura County	Serious	Serious	n/a	n/a
South Coast	Extreme	Extreme	Serious	Moderate
San Diego	Serious	Moderate	n/a	n/a

The South Coast Air Basin has implemented many new and more stringent regulations to reduce emissions over the years, but the Basin still exceeds federal NAAQS for both ozone and PM2.5, and still experiences some of the worst air pollution in the nation. To meet the upcoming deadlines for attaining federal ozone standards, significant NOx reductions are necessary (45 percent and 55 percent beyond all existing regulations by 2023 and 2031, respectively). Before the Proposed Amendments, OGVs combined with CHC would be the largest source of NOx emissions in the South Coast Basin in 2023 so it is essential to maximize both early and long-term reductions from these sources. Since CARB and SCAQMD have shown that CHC would continue to be a significant contributor to near-source cancer risk, staff proposed at the March 2018 Board Hearing to develop regulations to further reduce emissions from CHC and other freight sources including OGVs, cargo handling equipment, and drayage trucks.[27]

The CHC rulemaking is one of several actions CARB is undertaking additional to SIP commitments and is intended to collectively reduce community health risk, attain regional air quality standards, and mitigate climate change while pushing forward the adoption of ZEAT.

ii. Emissions Reductions in Assembly Bill 617 Portside Communities

CHC typically operate in areas with a high percentage of low-income and minority populations who are disproportionately impacted by higher levels of diesel emissions. The State of California has recently placed additional emphasis on protecting local communities from the harmful effects of air pollution through the passage of AB 617 (Garcia, Chapter 136, Statutes of 2017). AB 617 is a significant piece of air quality legislation that highlights the need for further emissions reductions in communities with high exposure burdens, like those near seaports. These regulatory efforts would

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[26] California Air Resources Board, Revised Proposed 2016 State Strategy for the State Implementation Plan, March 7, 2017, *https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf*.

[27] Implementation of State SIP Strategy and South Coast AQMP - Concepts to Minimize the Community Health Impacts from Large Freight Facilities, March 22, 2018, last accessed February 21, 2021, *https://www.arb.ca.gov/board/books/2018/032218/18-2-5pres.pdf?_ga=2.243242562.1596168673.1607359382-1902767897.1606875431*.

help achieve needed public health protection for local port communities and reduce exposure to toxic air emissions in disadvantaged communities. To reduce this burden, and in response to AB 617, CARB established the Community Air Protection Program. Through this program, the Board annually considers for selection impacted communities to collaborate with to develop and implement new locally-focused Community Emissions Reduction Plans (CERP).

Emissions generated from CHC are one of the primary areas of concern in a number of portside communities currently developing CERPs due to their substantial toxic and criteria air pollution emissions. Currently, the Stockton, West Oakland, Wilmington/West Long Beach/Carson, and San Diego portside AB 617 communities all have developed or are developing CERPs that include their concerns with the emissions generated from CHC and the effect it has on their health.[28,29,30,31] Since CHC operations in the State largely occur in the vicinity of at-risk communities, these communities would directly benefit from localized reductions of NOx and PM emissions from the Proposed Amendments.

iii. Executive Order N-79-20

In September 2020, Governor Newsom issued EO N-79-20,[32] which directed CARB, in coordination with other State agencies, U.S. EPA, and local air districts, to develop and propose technologically feasible and cost-effective strategies to achieve 100 percent zero-emission from off-road vehicles and equipment operations in the State where feasible. The Proposed Amendments support the directive of the executive order by establishing both voluntary provisions and mandates to accelerate the deployment of ZEAT into the CHC sector. The Proposed Amendments include zero-emission mandates where technology is more feasible and establishes a regulatory incentive framework to encourage innovation and adoption everywhere else.

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[28] San Joaquin Valley Air Pollution Control District, Draft Community Emissions Reduction Program, Stockton, February 3, 2021, last accessed February 21, 2021, *http://community.valleyair.org/media/2301/draft-stockton-cerp_02032021.pdf*.

[29] Bay Area Air Quality Management District, West Oakland Environmental Indicators Projects, The West Oakland Community Action Plan, October 2019, last accessed February 21, 2021, *https://www.baaqmd.gov/~/media/files/ab617-community-health/west-oakland/100219-files/final-plan-vol-1-100219-pdf.pdf?la=en*.

[30] South Coast Air Quality Management District, Draft Community Emissions Reduction Plan Wilmington, Carson, West Long Beach, September 2019, last accessed February 21, 2021, *http://www.aqmd.gov/docs/default-source/ab-617-ab-134/steering-committees/wilmington/cerp/final-cerp-wcwlb.pdf?sfvrsn=8*.

[31] San Diego Air Pollution Control District, Draft Community Emissions Reduction Plan, San Diego Portside Environmental Justice Neighborhoods Community, October 2020, last accessed February 21, 2021, *https://www.sandiegocounty.gov/content/dam/sdc/apcd/PDF/AB_617/Portside%20Environmental%20Justice%20DRAFT%20CERP%20Oct%202020.pdf*.

[32] Executive Order N-79-2020. State of California Executive Order signed by Governor Gavin Newsom. September 23, 2020, *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf*

d. Sustainable Freight Pathways to Zero and Near-Zero Discussion Document

In April 2015, CARB released the "Sustainable Freight Pathways to Zero and Near-Zero Discussion Document (Discussion Document)" in response to Board Resolution 14-2, which directed CARB to engage with stakeholders to identify and prioritize actions to move California toward a sustainable freight transport system.[33,34] The Discussion Document set out CARB's vision of a clean freight system, and included immediate and potential near-term CARB actions to be developed for future Board consideration. The near-term CARB measures identified in the Discussion Document included amending the Current Regulation to achieve additional emissions reductions from CHC.

7. Background on Proposed Amendments

The Proposed Amendments would introduce new requirements into the Current Regulation beginning on January 1, 2023, and would achieve additional emissions reductions by requiring engines to meet a more stringent performance standard for new and in-use vessels and expanding the vessel categories subject to regulation. Staff proposes requiring the use of ZEAT where feasible and reducing emissions from the remaining fleet using the cleanest available combustion technology and emission controls.

a. In-Use and New-Build Vessel Performance Standards

Staff proposes more stringent engine performance standards for NOx and PM. In order to meet the required performance standards, vessel owner/operators could choose to repower and retrofit engines on in-use vessels or obtain a new-build vessel. For engines less than or equal to 600 kilowatts (kW), the Proposed Amendments would require a performance standard equivalent to Tier 3 engine plus a DPF, or Tier 4 plus a DPF if there is an available engine model certified to Tier 4. Engines greater than 600 kW would need to meet a performance standard equivalent to a Tier 4 engine plus a DPF.

b. Expanded Vessel Categories

Subjecting additional CHC vessel categories to in-use requirements would achieve additional emissions reductions that are needed in the areas where CHC operate. Staff is proposing to add the following vessel categories to the in-use requirements of the Proposed Amendments:

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[33] CARB Board Resolution 14-2, Sustainable Freight Strategy Update, January 23, 2014, *https://arb.ca.gov/board/res/2014/res14-2.pdf*.

[34] California Air Resources Board, Sustainable Freight Pathways to Zero and Near-Zero Emissions Discussion Document, April 23, 2015, last accessed January 29, 2021, *https://ww2.arb.ca.gov/resources/documents/sustainable-freight-pathways-zero-and-near-zero-emissions-discussion-document*.

- **Commercial Passenger Fishing Vessels.** The Proposed Amendments would require any CPFVs with Tier 0 and Tier 1 engines to meet performance standards starting in 2023, and any CPFVs with Tier 2, Tier 3, or Tier 4 engines to meet performance standards starting in 2026. The Current Regulation has not required CPFVs to meet Tier 2 or 3 engine standards and does not have any reporting or fuel use requirements for CPFVs that carry six passengers or fewer[35]. However, CARB staff recognizes that all CPFVs, carrying any number of passengers for hire, compete for the same business, may operate in similar locations, and use similar types of vessels and diesel engines. Therefore, staff is proposing changes in the Proposed Amendments that would subject all diesel-powered CPFVs to the regulatory requirements. Vessels capable of carrying more than six passengers, regardless of the fuel used, would also be subject to the proposed performance standards.
- **Commercial Fishing Vessels**. The Proposed Amendments would require commercial fishing vessels to repower with an engine meeting minimum Tier 2 or higher emission standards starting in 2030.
- **All Tank Barges** (the Current Regulation only applies to tank barges under 400 feet and 10,000 gross tons). The Proposed Amendments would require any tank barges with Tier 0 and Tier 1 engines to meet performance standards starting in 2023, and any tank barges with Tier 2, Tier 3, or Tier 4 engines to meet performance standards starting in 2028. In addition, ATB tugs and barges would be required to reduce emissions from the main engines while in transit.
- **Pilot vessels.** The Proposed Amendments would require any pilot vessels with Tier 0 and Tier 1 engines to meet performance standards starting in 2023, and any pilot vessels with Tier 2, Tier 3, or Tier 4 engines to meet performance standards starting in 2025.
- **Workboats.** The Proposed Amendments would require any workboats with Tier 0 and Tier 1 engines to meet performance standards starting in 2023, and any workboats with Tier 2, Tier 3, or Tier 4 engines to meet performance standards starting in 2028.

Approximately 2,200 pilot vessels, tank barges, research vessels, workboats, commercial passenger fishing vessels, and commercial fishing vessels operate in California, and are equipped with approximately 4,400 diesel-fueled engines. Since these vessels make up such a large portion of CHC in California, it is important that emissions from these vessels are regulated. In 2023, under baseline conditions, it is estimated that these engines will emit approximately 113 tons per year of DPM and over eight tons per day of NOx.

Table A-2 below outlines whether each vessel category is subject to in-use requirements under the Current Regulation and whether they would be subject to in-use requirements under the Proposed Amendments.

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[35] In the Current Regulation, CPFVs that carry six passengers or less, even if operated commercially, meet the definition of a recreational vessel. In the CPFV industry, these vessels are commonly called "six pack" or "uninspected" vessels.

Table A-2. Changes to Regulated In-Use Vessel Categories

Vessel Category	In-Use Requirements Under Current Regulation	Regulated Under Proposed Amendments
Ferry	Yes	Yes
Tugboats	Yes	Yes
Barges	Yes	Yes
Dredges	Yes	Yes
Crew & Supply	Yes	Yes
Tugboats on Articulated Tug Barges (ATBs)	Yes	Yes
Excursion	Yes	Yes
Pilot Vessels	No	Yes
Tank Barges	Under 400 feet and 10,000 gross tons only	Yes – all
Research Vessels	No	Yes
Workboats	No	Yes
Commercial Fishing	No	Yes
Commercial Passenger Fishing	No	Yes
Historic	No	No
Coast Guard/ Military	No	No
Temporary Replacement	No	No
Ocean-Going Vessels*	No	No

*Ocean-Going Vessels are regulated under CARB's Control Measure for Ocean-Going Vessels At Berth.

c. Mandates for Zero-Emission and Advanced Technologies (ZEAT)

The Proposed Amendments include ZEAT mandates where technology is more feasible and establish a regulatory incentive framework that would encourage adoption as ZEAT technology advancements are made in the marine sector.

For purposes of the Proposed Amendments, ZEAT technologies are grouped as follows:

- Zero-Emission Capable Hybrid Vessels, which include vessels in certain CHC sectors that can demonstrate that 30 percent or more of combined main propulsion and auxiliary power is derived from a zero-emission tailpipe emission source. Examples include diesel-powered vessels with battery plug-in hybrid propulsion systems capable of being charged from the grid, or vessels with hydrogen fuel cells.
- Zero-Emission Vessels, which include vessels in certain categories that do not and would not use an internal combustion engine to generate propulsion or auxiliary power. Combustion engines may exist for an emergency, safety, or other incidental or unforeseen purposes, but would not be permitted for use during normal operation of the vessel.

The Proposed Amendments would require new excursion vessels to be zero-emission capable by January 1, 2025, and new and in-use short-run ferries to be zero emission by January 1, 2026. If vessel owner/operators adopt ZEAT early or where not otherwise required, additional compliance time could be granted to other engines or vessels within a fleet through one of two alternative compliance pathways described in Section 7.f of this chapter.

d. Low-Use Compliance Pathway

The Current Regulation provides a low-use compliance pathway that exempts engines from in-use requirements as long as engine hours do not exceed an annual threshold of 80 hours for dredges and barges, and 300 hours for all other vessel categories. The Proposed Amendments would change this pathway to reflect the distinctions between engine tiers, in order to provide flexibility to stakeholders who have already upgraded to cleaner engines, while continuing to remove engines with the lowest performance standards. Each fleet would have no more than five vessels eligible for low-use compliance; however, California homeported vessels (where a vessel is registered and permanently based) would not be counted towards this cap. New annual hour thresholds were informed by a vessel/engine replacement cost guideline of approximately $100,000 per weighted ton of emissions reduced, which was selected based on CARB's 2017 Carl Moyer Program Guidelines outlining cost-effectiveness thresholds.[36] The thresholds for each engine tier in Table A-3 would apply equally to all vessel categories.

Table A-3. Proposed Annual Low-Use Hours Limits for Engines on Regulated In-Use Vessels Based on Current Engine Tier

Tier 0	Tier 1	Tier 3	Tier 3 or Tier 4
80 hours/year	300 hours/year	400 hours/year	700 hours/year

e. Proposed Compliance Extensions

Staff is proposing five additional compliance extensions in the Proposed Amendments. A compliance extension for facility infrastructure installation delays would provide a one-year extension, renewable once for a total of two years. The extension is for any vessel or engine technology requiring infrastructure that has unforeseen circumstances, outside of the owner's or operator's control, that prevents the installation or use of dock power or zero-emission charging infrastructure.

A compliance extension for a single vessel having engines with different compliance dates. This extension would provide a one-time one-year extension, for each set of engines on a single regulated in-use vessel with different compliance dates. The extension can be applied to one in-use engine that the applicant chooses.

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[36] CARB, The Carl Moyer Program Guidelines 2017 Revisions, April 27, 2017, last accessed February 25, 2021, *https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2017/2017_cmpgl.pdf*.

A compliance extension for instances where no certified engines or Verified Diesel Emission Control Strategy (VDECS) are available would provide a renewable two-year extension if there are no certified engines or CARB verified DPFs available to meet applicable compliance dates.

A compliance extension for instances where meeting performance standards would not be feasible for in-use harbor craft would provide three additional years, with the ability to renew once for a total of six years, for all vessel categories, if demonstrated that no suitable engines or control technologies could be safely installed in the vessel and purchasing a replacement vessel with compliant engines would not be financially feasible. Workboats are not proposed to be subject to the six-year cap of extensions under this extension.

A compliance extension for vessels that have tier 4 engines and operate limited hours would provide a renewable three-year extension for regulated in-use vessels equipped with Tier 4 marine or Tier 4 off-road engines, where meeting Tier 4 plus DPF performance standards is not technically feasible without replacing the vessel, and the vessel has not and will not operate above the annual hour thresholds listed in Table A-4. This compliance extension would prevent owner/operators from having to replace an entire vessel using Tier 4 engines just to add the DPF, which would lead to high costs relative to the amount of emissions reductions that would be achieved.

Table A-4. Vessel Replacement Thresholds

Vessel Category	Requirement of Tier 4 Only if Operating Below
Ferry, Pilot, Tug	2,000 hours/year
Commercial Passenger Fishing, Excursion, Research	2,500 hours/year
Dredge, Barge, Crew Supply, Workboat	3,500 hours/year

f. Alternative Compliance Pathways

Staff is also proposing two ACPs by which owner/operators could comply with the Proposed Amendments.

The first ACP, or Option 1, would deem an applicant in compliance if the applicant pursues an alternative that includes, but is not limited to, any combination of engine modifications, exhaust treatment control, engine repowers, use of alternative fuels or additives, fleet averaging, or any other measures that sufficiently reduce emissions equivalent to the performance standards identified in the Proposed Amendments. This ACP would allow owner/operators flexibility in choosing their own strategy, while maintaining the same requirements for emission reductions and supporting the development of effective technologies.

The second ACP, or Option 2, would apply to owners/operators that elect to deploy ZEAT in advance of, or in addition to, the requirements of the Proposed Amendments. This ACP would provide additional compliance time for all engines on a single other selected vessel within their fleet operating within the same air district as shown in

Table A-5. Allowing additional compliance time for other engines or vessels through this ACP may incentivize early adoption or further development of ZEAT in the marine market. ACP Option 2 is separate and distinct from compliance extensions that can be granted to vessel operators meeting applicable criteria as outlined in the previous section.

Table A-5. Additional Compliance Time for ZEAT Adoption When Not Required

Marine Technology Type	Additional Compliance Time
Zero-Emission Capable Hybrid	3 Extra Years
Zero-Emission	7 Extra Years

g. Other Vessel Requirements

i. Main Idling and Auxiliary Engine Requirements

Beginning January 1, 2024, vessels subject to the Proposed Amendments would not be able to idle propulsion engines or operate auxiliary generator engines for more than 15 minutes when docked, berthed, or moored. Quick engine accelerations or restarting the engine while otherwise idling in order to circumvent this requirement would still be considered continuous idling. This concept would allow 15 minutes of idling after coming to dock at the end of a work period, and 15 additional minutes prior to initial operation in a subsequent work period after engines are restarted. Staff defines a new work period to begin when main engines have been shut off for four hours or longer.

ii. Opacity Testing

Beginning January 1, 2023, all main propulsion diesel engines, including low-use engines, operating on in-use vessels subject to the Proposed Amendments would be subject to opacity testing biennially and submit results to CARB within 30 days of the completed test, and no later than December 31 of the testing year. Opacity testing can be performed by either the vessel owner or operator, or a third-party. The individual performing opacity testing would need to be certified by the California Council on Diesel Education and Technology, or an equivalent organization approved by CARB.

Engines exceeding the smoke opacity levels outlined in the Proposed Amendments would have to be repaired within 30 calendar days from the date of the failed opacity test or be taken out of service.

iii. Vessel Reporting

The Current Regulation requires vessel information to be reported to CARB only periodically, such as after repowering engines or as compliance deadlines approach. To ensure that CARB's records are current and the regulation can be effectively implemented and enforced, the Proposed Amendments would make changes to information vessel owner/operators are required to report, and would require reporting to be done annually beginning January 1, 2023.

Under the Proposed Amendments, vessel owner/operators would be required to report to CARB the percentage of time a vessel is used in each vessel use category, new owner contact information when a vessel is sold, engine tier and model year, and the quantity of diesel exhaust fluid (DEF) (aqueous solution of urea) consumed if the engine is equipped with a selective catalytic reduction system (SCR).

h. Facility Infrastructure and Reporting Requirements

As advanced and alternative technologies emerge for the CHC sector, the infrastructure needed to support these technologies needs to be made available. There are some vessels operating in California that are capable of zero-emission operation, but limited infrastructure is available to maximize the use of zero-emission operation and reduce emissions. Additionally, the introduction of zero-emission power systems is expanding, from both new and established marine powertrain manufacturers. As of today, there is insufficient infrastructure available to support the widespread deployment of zero-emission and other advanced technologies.

The majority of facilities have docks or slips that are equipped with shore power capabilities that enable harbor craft auxiliary engines to operate using electricity while at dock. However, there are facilities and vessels that do not have shore power capabilities. The Proposed Amendments would require facilities to install shore power infrastructure if more than 50 CHC vessels visit those facilities per year. Vessel owner/operators would be prohibited from idling all propulsion and auxiliary engines for more than 15 consecutive minutes when the vessel is docked, berthed, or moored; however, plugging into shore power is included as a compliance strategy if on-board power from auxiliary engines would be needed for longer than 15 minutes.

In order for vessel owner/operators to effectively operate vessels using ZEAT, charging infrastructure or zero-emission fueling (e.g. hydrogen) is required. The Proposed Amendments would require facilities to allow vessel owner/operators to install charging or fueling infrastructure, such as fast charging equipment, on-site hydrogen fueling tanks, or for hydrogen delivery trucks to come to the dock. Table A-6 outlines the various requirements, and associated responsibilities for facility and owner/operators to comply with the Proposed Amendments.

Table A-6. Proposed Infrastructure Installation and Maintenance Responsible Party

Proposed Requirement	Vessel Owner/Operator Responsible	Facility Responsible
Installation and Maintenance of Infrastructure to Support Shore Power Requirement		X
Installation and Maintenance of Infrastructure to Support the Use of Zero-Emission Vessels (e.g. Hydrogen Fueling Infrastructure)	X	
Installation and Maintenance of Infrastructure to Support the Use of Zero-Emission Capable Hybrid Technology (e.g. Rapid Charging Infrastructure)	X	

In addition, staff estimates that over one-third of subject vessels operating in the State have not satisfied the reporting requirements of the Current Regulation. Without proper reporting, CARB is limited in its ability to locate, identify, and ensure that the vessels are compliant with the Current Regulation and are achieving the intended emissions reductions. To ensure compliance with the Proposed Amendments, starting on January 1, 2023, and applying thereafter quarterly, facility owners and operators would be required to provide recordkeeping and reporting information to CARB that would detail the vessels that visited the facility. This would facilitate staff's ability to identify the vessel and its general operation location in order to perform inspections and more effectively implement the Proposed Amendments. Additional reporting would also be required for facilities with shore power infrastructure.

i. Implementation Timeframe for Current Regulation and Proposed Amendments

Table A-7 below illustrates the compliance dates for each vessel category, engine tier, and engine model year. The compliance dates for the Proposed Amendments range from 2023 to 2032, with lower engine tiers and older model years having earlier compliance dates. If vessel owner/operators choose to apply for and receive compliance extensions due to the lack of feasible technology (a maximum of six years), the implementation timeframe range would extend to 2037.

Any Tier 0 or Tier 1 engines would have a compliance date between 2023 and 2025. Tier 2, Tier 3, and Tier 4 engines for ferries, and tugboats would have compliance dates between 2024 and 2029. Tier 2, Tier 3, and Tier 4 engines for pilot boats would have compliance dates between 2025 and 2029. Tier 2, Tier 3, and Tier 4 engines for research vessels, CPFV, and excursion vessels would have compliance dates between 2026 and 2030. Tier 2, Tier 3, and Tier 4 engines for dredges, barges, crew & supply, and workboats would have compliance dates between 2028 and 2031. Commercial fishing vessels would have a compliance date between 2030 and 2032 and are only required to repower with an engine meeting Tier 2 or higher emission standards. New excursion vessels would be required to be zero-emission capable starting 2025, and new and in-use short-run ferries would be required to be fully zero-emission starting 2026.

Table A-7. Implementation Timeline for Current Regulation and Proposed Amendments

Existing Regulation		Proposed Regulation (Implementation Dates)									
2021 & Earlier	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
IN-USE VESSEL REQUIREMENTS											
Tier 2 or 3 (Tugs, Ferries, Excursion, Crew & Supply, Barge, Dredge)		**Any Tier 0 and 1 → Tier 4*** (generally Workboats, Research, Pilot, Tank Barges, and CPFV)									
		≤ MY 1993	MY 1994-2001	MY 2002-2006							
			Tier 2, 3, 4 → Tier 4*+DPF** Ferries (Except Short Run), Pilot***, All Tugs								
			MY 2007-2009	MY 2010-2012	MY 2013-2015	MY 2016-2019	MY 2020-2021	MY 2022+			
					Tier 2, 3, 4 → Tier 4*+DPF** Research, Charter Fishing, Excursion						
					MY 2007-2010	MY 2011-2012	MY 2013-2014	MY 2015-2017	MY 2018+		
							Tier 2, 3, 4 → Tier 4*+DPF** Dredges, Barges, Crew & Supply, Workboats				
							MY 2007-2009	MY 2010-2013	MY 2014-2017	MY 2018+	
									Any Tier 0 and 1 → Tier 2 or Cleaner *Commercial Fishing*		
									≤ MY 1987	MY 1988-1997	MY 1998+
Other VESSEL REQUIREMENTS											
Tier 2, 3, or 4 All New Vessels Tier 3 + BACT New Ferries Carrying 75+ Passengers			New Excursion: Zero-Emission Capable (e.g. Plug-in Hybrid) 30% or more of power must be derived from a zero-emission tailpipe source								
					New and In-Use Short-Run Ferries: Zero-Emission						

*All engines ≥600 kW would be required to be certified to Tier 4. For engines <600 kW, a Tier 4 certified engine would be required if certified by U.S. EPA or CARB and available by the compliance date.

**Retrofit DPF requirements would apply to all Tier 3 and Tier 4 engines.

***Pilot vessels at Tier 2, 3, or 4 with model year 2007-2009 would not need to comply until December 31, 2025

Note: "Charter Fishing" in Table A-7 refers to CPFV.

8. Major Regulation Determination

The Proposed Amendments have been determined to be a major regulation requiring a SRIA, based on annual estimated direct costs that are projected to exceed $50 million each year starting in the second year of the analysis period, 2024, through the final year of the analysis period, 2038.

9. Baseline Information

To estimate the economic impacts of the Proposed Amendments, staff evaluated the economic and emission impacts of the proposal relative to the baseline (Baseline) scenario for each year of the analysis period from 2023 to 2038. The years of the analysis extend 12 months post full implementation of the Proposed Amendments. The Baseline for the Proposed Amendments reflects compliance with the Current Regulation and incorporates updates to the CHC vessel inventory as described below.

For the SRIA, staff updated the inventory in 2021 using recently available data to estimate emissions under the Baseline and Proposed Amendments, as well as to forecast the number of CHC vessels each year from 2023 to 2038 for which there are direct costs or benefits associated with the Proposed Amendments. CARB's previous CHC inventory was released in 2007,[37] and later updated in 2010 when amending the Original Regulation, which used vessel and engine profile data largely based on a 2004 CARB CHC survey. Updates to the statewide CHC emissions inventory were completed to support health risk assessments near the seaports and the new regulatory amendments efforts, and to support staff's cost analysis. These updates are described within this document. An updated inventory methodology document will be released for public comment prior to the Board hearing as part of the Initial Statement of Reasons (ISOR or "Staff Report") and will contain detailed information on the data sources and methodology used in the statewide CHC emissions inventory.

The updated inventory used the most recent information to update the CHC emissions and future forecasts, including the following items:

- Vessel and engine population and profile data were obtained from POLA, POLB, Port of Oakland, CARB reporting data 2019,[38] and United States Coast Guard (USCG) Merchant Vessel data;[39]
- Population and activity growth factors were estimated based on historical trends in the past decade;
- Survival and purchasing curves were developed from the age distribution of CHC in CARB reporting data from 2010-2019;

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[37] CARB, Emissions Estimation Methodology for Commercial Harbor Craft Operating in California, 2007, accessed February 9, 2021, *https://ww3.arb.ca.gov/regact/2007/chc07/appb.pdf*.

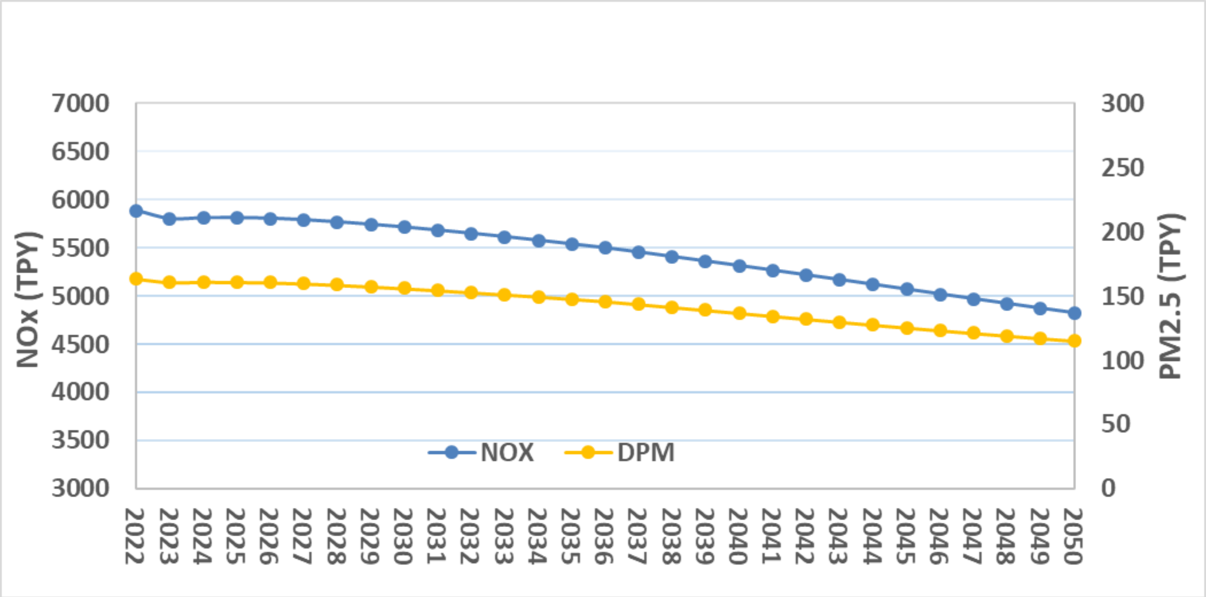
[38] CHC engine data reported to CARB by owners/operators under the CHC Regulation, Feb 2019.

[39] U.S. Coast Guard, Merchant Vessels of the United States. Accessed May 2018, *https://www.dco.uscg.mil/OurOrganization/AssistantCommandantforPreventionPolicy(CG-5P)/InspectionsCompliance(CG-5PC)/OfficeofInvestigationsCasualtyAnalysis/MerchantVesselsoftheUnitedStates.aspx*.

- Load factors were updated using CARB reporting data and Engine Control Module (ECM) data from the industry; and
- Emission factors (EF) were updated using the U.S. EPA marine[40] and off-road[41] engine certification data.

Figure A-31 shows the Baseline statewide RCW PM2.5 and NOx emissions from CHC in tons per year (TPY) from 2022 to 2050. As shown in the figure, there is a gradual emissions reduction from 2022 to 2050. The annual emissions reduction gradients stay relatively constant for both NOx and PM2.5. For the NOx, the average annual emissions reduction is at about 0.7 percent, with a total emissions reduction of 18 percent from 2022 to 2050; For PM2.5, the average annual emission reduction is at about 1.2 percent, with a total emissions reduction of 30 percent from 2022 to 2050. Under the Baseline, there will be no additional compliance requirements after 2023. The emissions reductions after 2023 under the Baseline are mainly due to the natural turnover of the vessels, in which older vessels, with dirtier engines, are replaced with new vessels with cleaner engines.

Figure A-31. Statewide Business-As-Usual Baseline Emissions Estimates (TPY)



Staff is aware that the global situation that occurred in 2020 may have an impact on the trajectory of CHC activity, as there have been changes in human activity which resulted in disruptions to the supply chain and the freight and passenger transportation industries. However, while cargo volumes experienced a decline in the first half of 2020 due to the economic slowdown, the market is already showing signs

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[40] U.S. EPA, Annual Certification Data for Vehicles, Engines, and Equipment: Marine Compression-Ignition (CI) Engines, January 1, 2021, accessed February 9, 2021, *https://www.epa.gov/sites/production/files/2021-01/marine-compression-ignition-2000-present.xlsx*.

[41] U.S. EPA, Annual Certification Data for Vehicles, Engines, and Equipment: Nonroad Compression Ignition (NRCI) Engines, January 1, 2021, accessed February 9, 2021, *https://www.epa.gov/sites/production/files/2021-01/nonroad-compression-ignition-2011-present.xlsx*.

of improvement. For example, the total 2020 POLA volume represented the fourth highest volume in the port's history.[42] The global situation that occurred in 2020 also reduced or restricted certain CHC activities from occurring, with excursion and ferry vessels being key industries affected. However, Staff do not anticipate the global situation that occurred in 2020 will have a significant impact on future activity for the CHC industry. Population and activity growth factors that were developed based on historical trends in the past decade are anticipated to still apply for the following reasons:

1) The first regulatory compliance date that would result in costs to CHC owners and operators to comply with the Proposed Amendments would not begin until January 1, 2023. Staff expects activities of affected industries will revert to normal economic conditions by this time.
2) Staff considered the latest data from the DOF California Economic Forecast that was released with the May revise in 2021.[43] For the labor force and employment numbers in the Trade, Transportation, Warehousing, and Utilities sector[44], the employment numbers (in thousands) in 2023 are estimated to be more than the levels in 2019 (3,053 in 2019 vs. 3,071 in 2023). In addition, the employment numbers from the Trade, Transportation, Warehousing, and Utilities sector are predicted to continue to increase in 2024 over 2023 levels.

To account for impacts from the global situation that occurred in 2020 in the baseline, the Regional Economic Models, Inc. (REMI) model was adjusted to reflect the latest DOF conforming forecasts from the May revise. These adjustments and the macroeconomic impacts of the Proposed Amendments are further described in Chapter E.

10. Public Outreach and Input

During the development of the Proposed Amendments, CARB staff conducted more than 400 meetings as of May 2021 with members of impacted communities, environmental justice advocates, community members, air districts, industry stakeholders (including vessel operators, seaports, industry associations, and manufacturers of emission control systems and ZEAT systems), and public agencies including the USCG, and the California Public Utilities Commission (CPUC). These meetings were conducted to discuss staff's proposal and gather input and information from industry stakeholders, as well as hear concerns from both industry and the impacted communities. Meeting formats included public workshops, workgroup

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[42] Logistics Management, "Port of Los Angeles and Port of Long Beach end 2020 with strong volume gains," January 21, 2021, last accessed February 25, 2021, https://www.logisticsmgmt.com/article/port_of_los_angeles_and_port_of_long_beach_end_2020_with_strong_volume_gain.

[43] State of California, Department of Finance, Economic Forecasts, California Economic Forecast – Annual and Quarterly (.xlsx), April 2021, last accessed June 8, 2021, https://www.dof.ca.gov/Forecasting/Economics/Eco_Forecasts_Us_Ca/documents/California%20Economic%20Forecast%20MR%202021-22.xlsx.

[44] Where most CHC vessels employment activity would fall under.

meetings, community meetings, informal meetings, phone calls, and site visits. These meetings were held in-person at a variety of locations, including at the Cal/EPA headquarters building in Sacramento, California, and in-person visits to seaports/terminals and community forums, and also through webinars and phone calls. Starting in 2020, many meetings were held using remote formats such as webinars and web conferences.

a. Public Workshops, Webinars, and Workgroup Meetings

Since 2018, staff has conducted four public workshop series (five total events, as one workshop, was held on different dates in two locations), one workgroup meeting, and one question and answer session. Staff notified stakeholders of these meetings via email distribution of a public notice at least two weeks prior to their occurrence. These notices were posted to the program's website and sent out to over 4,000 subscribers to the CARB "Harbor Craft (Commercial Harbor Craft Regulatory Activities)" email list. The public workshops and question and answer sessions were open to all members of the public. Meeting materials, including agendas, slide presentations, and draft regulatory documents were posted and available to the public on CARB's CHC Regulation website in advance of the workshops.

- March 16, 2021: This public online workshop was attended primarily by the general public, industry representatives, including vessel owner/operators, and staff from public agencies, including port staff. CARB staff presented and gave a summary of the current regulation, the modifications on the draft proposal, preliminary emission inventory and cost analysis, and the next steps. There were 298 remote registrants for the workshop.
- October 21, 2020: This public online question and answer session was a follow-up session to the September 30 public online workshop. The session was attended primarily by the industry representatives, including vessel owner/operators, marine vessel designers, engine manufacturers, emission control technology developers, and staff from public agencies, including port staff. At this session, staff answered questions about the content presented and discussed during the September 30, 2020 workshop.
- September 30, 2020: This public online workshop was attended primarily by the general public, industry representatives, including vessel owner/operators, and staff from public agencies, including port staff. CARB staff presented updated regulatory concepts which incorporated stakeholder feedback from the March 2020 webinar, draft regulatory language, and a draft cost analysis. This workshop also served as a California Environmental Quality Act (CEQA) scoping meeting to obtain feedback for the environmental impact analysis. Staff also solicited alternatives for this SRIA. There were 199 remote registrants for the workshop.
- March 5, 2020: This public webinar was attended primarily by the general public, industry representatives, including vessel owner/operators, and staff from public agencies, including port staff. CARB staff presented refined regulatory concepts and requested data to support cost and emissions benefit

analyses. Staff also solicited alternatives for this SRIA. There were 117 remote attendees at the webinar.

- May 9, 2019: This facility workgroup meeting was attended by public and private marina, harbor, and port operators to discuss draft regulatory concepts for vessel facilities. CARB staff gathered information from attendees about the types of infrastructure currently available for CHC, typical contractual relationships between CHC and vessel facilities, and presented reporting concepts. There were nine call-in attendees at the workgroup. Materials from the facility workgroup meeting were posted on CARB's CHC Regulation website after the meeting took place.
- December 4, 2018, and December 10, 2018: This public workshop series was held in Long Beach and Sacramento, California, respectively. The Sacramento workshop was webcast to provide an opportunity for broader public participation. Both meetings were attended primarily by the general public, industry representatives, including vessel owner/operators, and staff from public agencies, including port staff. CARB staff discussed regulatory concepts, presented emissions estimates, outlined data collection efforts, and solicited stakeholder input. Staff also solicited alternatives for this SRIA. There were 24 in-person attendees at the Long Beach workshop and 16 in-person attendees at the Sacramento workshop. Those who viewed the Sacramento workshop via webcast were given the opportunity to engage with staff by submitting questions via email during the meeting.

b. Stakeholder Meetings and Engagement

Staff held numerous meetings and teleconferences with industry associations, individual manufacturers, and groups of industry representatives to gather information and receive input on staff's proposal. Among the industry associations represented were American Waterways Operators, Passenger Vessel Association, Sportfishing Association of California, and the Marine Recreation Association. Discussions were held with manufacturers of engine and emissions reductions technologies for vessels, including the Engine Manufacturers Association, and several individual members. Staff engaged with manufacturers of ZEAT and diesel aftertreatment systems (e.g., DPFs), including Manufacturers of Emission Controls Association, and several individual members. Staff consulted with multiple government agencies throughout the development of the Proposed Regulation, including U.S. EPA, USCG, California Office of Spill Prevention and Response, California local air districts, and California Ports.

From 2018 through early 2020, staff visited a number of vessel operators to learn more about their individual business operations and understand the scope of challenges facing their industries and surrounding communities. Staff also made visits to tour multiple vessels including ferry, tugboat, ATB, pilot, and workboat vessels to learn about their unique layout and operational challenges. In-person visits and facility tours were halted in Spring 2020.

Staff conducted outreach to communities and environmental justice advocates by participating in meetings and calls with the California Cleaner Freight Coalition. These calls focused on updating community advocacy groups on the development process of CARB's freight-related regulatory activities.

CARB staff attended and presented at several community meetings of local residents and businesses, to communicate intentions and solicit input. These meetings included independent environmental justice advocacy organizations and formal steering committees in communities that are implementing targeted emissions reduction programs under AB 617. The CHC regulation is highlighted in the Community Air Protection Program Blueprint[45] as one component of helping communities heavily impacted by freight sources achieve their air quality goals. As these meetings were held for specific communities, the content of inquiries and comments staff received was typically limited to specific types of harbor craft operating in that area.

In addition to meeting with a wide range of stakeholders, staff sent a survey in early 2019 to CHC owner/operators, requesting information on vessel activity, capital, labor, and installation costs for engine replacement or repowers, engine and vessel disposal costs, and financial information about the business. Staff sent vessel owner/operators a notification through the CARB's e-mail listserv informing them that surveys would be distributed to either their self-reported email or U.S. mail contact, based on information in CARB's CHC reporting database. Participants were initially given until February 28, 2019, to respond, which was extended to March 22, 2019, in order to solicit additional survey responses. Staff sent 943 surveys directly to vessel owner/operators' self-reported email, and nearly 350 surveys to vessel owner/operators' self-reported U.S. mailing addresses. The information provided by vessel owner/operators was aggregated, combined with other data sources, and used in staff's cost assumptions and estimates. Details on the information CARB received in response to the survey and how the information was used in the SRIA are provided in Appendix A.

B. Benefits

1. Emission Benefits

a. Emission Inventory Methodology

CARB staff estimated emissions for CHC operating within California coastal waters and inland waterways based on the best available information regarding past, current, and projected vessel and engine information and vessel activity. The emission inventory models emissions for future years for each vessel type, engine type (i.e., auxiliary engine or main engine), and pollutant. The baseline inventory reflects compliance with the Current CHC regulation, which applies to specific regulated CHC vessels operating

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[45] CARB Community Air Protection Blueprint, October 2018, last accessed February 10, 2021, *https://ww2.arb.ca.gov/sites/default/files/2020-03/final_community_air_protection_blueprint_october_2018_acc.pdf.*

in RCW. For specific vessel types including ferries, excursion vessels, tugboats, crew and supply vessels, barges, and dredges, all Tier 1 and earlier engines have to meet Tier 2, Tier 3, or Tier 4 standards in effect at the time of compliance. A detailed compliance schedule applies for different vessels, tiers, and model year engines. Staff used data reported to CARB's reporting database in February 2019 as the basis for the baseline emission inventory and assumed a compliance rate of 100 percent. The costs and emission benefits of the Proposed Amendments are both calculated relative to the Current Regulation.

Emissions of PM2.5, DPM, NOx, ROG, and GHGs were estimated for the Proposed Amendments as well as for Alternatives 1 and 2. All three scenarios were compared to the baseline emissions. The two Alternatives to the Proposed Amendments included an analysis of cost impacts and health benefits and are discussed further in Chapter F. The following paragraphs describe the methodology staff used to develop the emissions estimates.

The updated inventory used the most recent information to update the CHC emissions and future forecasts as outlined in Section A.9 of this document. From the updates mentioned in Section A.9, staff calculated the emission reductions that would result from CHC complying with the Proposed Amendments. Equation 1 describes how emissions were quantified for CHC in the Proposed Amendments:

$$\boldsymbol{E = \sum_{i,j,k,l,m} POP_{i,j,k,l,m} * A_{j,k,n} * HP * LF_{j,k} * EF_{j,l,m} * \ FCF_{j,m}}$$

Where:

- E: Estimated CHC emissions (grams/year);
- i, j, k, l, m, n: Location, vessel type, engine type, rated horsepower bin, model year, age;
- POP: Population of engines;
- A: Average activity in annual operating hours (hr);
- HP: Rated brake-horsepower for each equipment type (bhp);
- LF: Load factor (unit-less);
- EF: Emission factor, adjusted for deterioration (grams/bhp-hr); and
- FCF: Fuel correction factor (unit-less).

Emissions benefits from the Proposed Amendments would begin in 2023, when the first emission control requirements would take effect. Staff quantified emissions benefits through 2038, which is consistent with the timeframe used for the cost analysis. The compliance dates in the Proposed Amendments are designed to clean up the fleet's oldest and dirtiest engines first while giving more time for relatively newer engines (Tier 2 or higher) to be upgraded or replaced. Staff developed the statewide emissions estimates for the Proposed Amendments based on the implementation phases below. For all phases, the compliance schedules are grouped by vessel type, location of the vessel's homeport, the engine's model year, and the engine's annual hours of operation:

- Phase 1: Would begin in 2023 and run through 2025. This phase would require any Pre-Tier 1 and Tier 1 certified engines on all regulated in-use vessels to comply with two-step phase-in paths:
  - Step 1: repower with Tier 3 or Tier 4 engines;
  - Step 2: retrofit with DPF based on the engine model year of replacement engine repowered in Step 1.
- Phase 2: Would begin in 2024 and run through 2029. This phase would require any Tier 2, Tier 3, or Tier 4 engines on ferries (except short-run ferries), pilot vessels, all tug/towboats, and push boats to comply with engine standards by replacing the in-use engine with an engine certified to Tier 3 or Tier 4 marine or off-road engine emissions standards plus install a DPF.
- Phase 3: Would require all new and newly acquired excursion vessels to be a zero-emission capable hybrid by January 1, 2025.
- Phase 4: Would require all new and in-use short-run ferries to be zero-emission by January 1, 2026.
- Phase 5: Would begin in 2026 and run through 2030. This phase would require any Tier 2, Tier 3, or Tier 4 engines on research vessels, CPFV, and in-use excursion vessels to comply with engine standards by replacing the in-use engine with an engine certified to Tier 3 or Tier 4 marine or off-road engine emissions standards plus install a DPF.
- Phase 6: Would begin in 2028 and run through 2031. This phase would require any Tier 2, Tier 3, or Tier 4 engines on barges, dredges, crew and supply vessels, and workboats to comply with engine standards by replacing the in-use engine with an engine certified to Tier 3 or Tier 4 marine or off-road engine emissions standards plus install a DPF.
- Phase 7: Would begin in 2030 and run through 2032. This phase would require any Pre-Tier 1 and Tier 1 certified engines on commercial fishing vessels to comply with engine standards by replacing the in-use engine with an engine certified to the Tier 2 or newer marine or off-road engine emissions standards.

b. Anticipated Emissions Reduction Benefits

The Proposed Amendments are expected to reduce emissions of PM2.5, DPM, NOx, ROG, and GHGs beyond levels achieved under the Baseline (Table B-1). Emissions reductions would begin in 2023 when the Proposed Amendments impose new emissions reduction requirements. Staff estimated that from 2023 through 2038, the Proposed Amendments would further reduce cumulative statewide emissions by approximately 1,490 tons of PM2.5, 1,560 tons of DPM, 33,110 tons of NOx, 2,070 tons of ROG, and 375,490 metric tons (MT) of GHG, relative to the Baseline. GHG emissions reductions would be achieved as cleaner tiered engines and ZEAT penetrate the CHC fleet.[46] GHG reductions would occur from zero-emission vessels since GHG produced by the electrical grid are approximately 65 percent lower than those produced from burning fuel in vessel auxiliary engines for the same electrical power. As the Proposed Amendments are implemented, emissions reductions would continue to increase as more vessels upgrade their engines to cleaner tiers, install DPFs, and utilize ZEAT that are available for short-run ferries and excursion vessels.

Table B-1. Projected Annual and Total PM2.5, DPM, NOx, ROG, and GHG Emissions Reductions Resulting from the Proposed Amendments from 2023 through 2038

Year	PM2.5 (Tons)	DPM (Tons)	NOx (Tons)	ROG (Tons)	GHG (MT)
2023	35	36	432	4	-78
2024	44	46	767	25	3,035
2025	53	55	1,096	45	6,247
2026	62	65	1,467	68	14,816
2027	68	72	1,679	80	18,777
2028	75	78	1,826	92	23,391
2029	82	85	1,976	104	27,874
2030	95	99	2,261	137	32,308
2031	109	114	2,519	175	36,933
2032	117	122	2,694	191	36,772
2033	125	130	2,768	197	29,211
2034	125	131	2,770	196	29,538
2035	127	133	2,769	195	28,543
2036	126	132	2,739	191	28,910
2037	125	130	2,700	186	29,337
2038	122	128	2,649	180	29,880
Total	1,490	1,560	33,110	2,070	375,490

2. Benefits to Typical Businesses

The Proposed Amendments may result in financial benefits to the following businesses:

- CHC engine Original Equipment Manufacturers (OEM);
- Battery systems manufacturers;
- Hydrogen fueling system manufacturers;
- Diesel engine repair shops and boatyards;
- California shipyards;

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[46] There would be a slight increase of GHG emissions expected in 2023, mainly because of the slightly higher Brake-specific fuel consumption (BSFC) factors used for some of the higher Tiered engines. In addition, on average DPFs have been shown to result in a 4 percent fuel penalty so that increased fuel results in additional CO2 emissions. However, overall, the Proposed Amendments will reduce the GHG emissions below their baseline levels by requiring new excursion vessels deployed after January 1, 2025 to be zero-emission capable hybrid vessels, and all short-run ferries (new and in-use) to be zero-emission starting on January 1, 2026.

- Opacity testing equipment manufacturers;
- Manufacturers of emission control technologies, including but not limited to DPFs;
- DPF installation, repair, and maintenance centers;
- Electrical suppliers; and
- Design, engineering, and construction firms.

The Proposed Amendments would provide fleets the options to repower older engines and for many vessels install exhaust retrofits as part of their overall strategy to meet performance requirements. These options would provide market opportunities for engine OEMs and VDECS manufacturers to advance and innovate technology to develop compliance strategies. The increase in the production and usage of cleaner tiered marine engines and DPFs could also benefit various businesses related to the component supply chain, including manufacturers of SCR control equipment.

The Proposed Amendments would require ZEAT on all short-run ferries and new excursion vessels. The Proposed Amendments would also provide fleet incentives to adopt ZEAT in the form of additional compliance time on other selected conventional (e.g. diesel-fueled) vessels within their fleets. Therefore, the Proposed Amendments include both requirements, and additional incentives for fleet operators to adopt ZEAT. In turn, the Proposed Amendments could provide multiple pathways and different market opportunities for ZEAT manufacturers, such as a battery system, an electrical charging infrastructure, hydrogen fueling system manufacturers, and the opportunity to develop new technology. ZEAT would require infrastructure to support the electrical demand to allow CHC to plug-in and recharge, which would result in temporary increases in construction materials and jobs in the State. For more detail on projected impacts to jobs, please refer to Chapter E of the SRIA. The Proposed Amendments could also provide benefits in the form of lower fuel costs for vessels that have utilized ZEAT. These are described in more detail in Section C.2.k and cost savings are shown in Tables C-21 and C-22.

The Proposed Amendments would provide opportunities for both larger and smaller engineering, construction, and design firms to redesign and expand existing seaport, harbor, marina, or other dockside infrastructure to accommodate CHC owner/operator compliance strategies. The utilities and electrical infrastructure component OEMs would benefit from the opportunities to expand shore power, hydrogen fuel delivery, and charging services to the seaports. Staff is not anticipating large-scale deployment of new electrical substations by local utilities. However, in the event that such installation is needed, large-scale upstream infrastructure may catalyze further development of local distributed electrical generation networks.

The Proposed Amendments would require vessels to perform opacity testing every other year (biennially). This would benefit the opacity testing equipment manufacturers, and the testing companies who perform pay-for-service opacity testing for operators of diesel fleets. The engines and emission control systems (e.g. DPFs) on vessels that fail to meet opacity test limits would be required to repair the engines and emission control systems. These additional repair activities would provide immediate emission benefits and would also benefit the diesel engine repair shop industry.

The Proposed Amendments would require engines aboard CHC vessels, with the exception of ZEAT or commercial fishing vessels, to be retrofit with DPF aftertreatment devices for compliance. This would provide additional business opportunities for diesel repair shops or other companies that are authorized installers of retrofit DPFs.

3. Benefits to Small Businesses

Businesses, including construction companies, engineers, electricians, parts and components manufacturers, consulting firms, and others involved in designing, installing, and maintaining equipment for engine and aftertreatment technologies may fall into the category of small businesses. The benefits discussed above would also apply to small businesses.

4. Benefits to Individuals

California experiences some of the highest concentrations of PM2.5 in the nation. Individuals who live in, or work in, high-risk areas near seaports, marinas, harbors, and other waters are exposed to higher PM2.5 concentrations from harbor craft than other California residents. These individuals are at a higher risk of developing respiratory impairments as a result of main and auxiliary engine emissions, especially those individuals within sensitive groups such as the young and the elderly. The Proposed Amendments would reduce NOx, PM2.5, and TAC emissions from CHC vessels and result in health benefits for individuals in California. Reductions in both NOx and primary PM2.5 emissions from the Proposed Amendments would result in a greater reduction in PM2.5 air pollution, which would reduce air pollution-related health issues in the community.

The Proposed Amendments would require repower and retrofit of older marine vessels, including passenger vessels, with diesel engines meeting technologically feasible levels of emission control that have been proven in other sectors for more than a decade (e.g. on-road heavy-duty trucks). Overall, the Proposed Amendments would eliminate 33,100 tons of NOx and 1,490 tons of PM2.5 from 2023 to 2038. In turn, passengers and crew on vessels with repowered and retrofit engines would be exposed to substantially less air pollution. In addition, ZEAT requirements would require the use of quieter zero-emission and other advanced technologies on ferry and excursion vessels that would decrease the noise levels that passengers and crew are exposed to on traditional diesel-fueled harbor craft.

The Proposed Amendments would also benefit individuals by reducing incidents of premature death, hospital admissions, and emergency room visits, as well as reduce criteria pollutants and GHGs. The Proposed Amendments would accomplish this by reducing emissions from fuel combustion on board a vessel, including PM2.5, DPM, NOx, and ROG. GHGs would be reduced when short-run ferries and excursion vessels use ZEAT technologies. Staff estimated the statewide value of health benefits from reduced regional NOx and PM2.5, and the value of GHG emissions reductions using the social cost of carbon, as described in section B.4.d.

a. Noncancer Health Impacts and Valuations

Staff evaluated the statewide noncancer health impacts associated with exposure to PM2.5 and NOx emissions from CHC. NOx includes NO2, a potent lung irritant, which can aggravate lung diseases such as asthma when inhaled.[47] However, the most serious quantifiable impacts of NOx emissions occur through the conversion of NOx to fine particles of ammonium nitrate aerosol through chemical processes in the atmosphere. PM2.5 formed in this manner is termed as secondary PM2.5. Both directly emitted PM2.5 and secondary PM2.5 from CHC are associated with adverse health outcomes, such as cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, as well as emergency room visits for asthma. As a result, reductions in PM2.5 and NOx emissions are associated with reductions in these adverse health outcomes.

Staff used two methods to estimate the health benefits of the Proposed Amendments. For regions where air dispersion modeling has been performed (San Francisco Bay Area and South Coast air basins), health benefits from primary PM2.5 were estimated using the results from air dispersion modeling[48] combined with a health model based on U.S. EPA's Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE).[49] For all other air basins where basin-wide air dispersion results were unavailable, staff used the incidence-per-ton (IPT) methodology, which uses 2014 to 2016 baseline scenarios also based on BenMAP-CE's health model. Health benefits from secondary PM2.5 (formed from NOx emissions) for all air basins were calculated using the IPT method and then summed with the primary PM2.5 health benefits to calculate the total health benefits reported in Table B-2. For estimating health outcomes, the baseline incidences for cardiopulmonary mortality were extracted from the Centers for Disease Control and Prevention (CDC) WONDER online database,[50] while the baseline incidences for hospitalizations for cardiovascular illness and respiratory illness, and asthma emergency room visits were acquired from the BenMAP-CE software. The two methodologies (estimation of health outcomes

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[47] United States Environmental Protection Agency, Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-15/068, January 2016, last accessed May 7, 2021, *http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=526855*.

[48] CARB staff use CALPUFF modeling to evaluate the Primary PM2.5 impacts at South Coast Air Basin and San Francisco Bay Area Air Basin. CALPUFF modeling was performed according to the Calpuff User Guide, last accessed May 7, 2021, *http://www.src.com/calpuff/download/calpuff_usersguide.pdf*.

[49] National Institute of Health, The Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP–CE): A tool to estimate the health and economic benefits of reducing air pollution, February 2018, last accessed May 11, 2021, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6022291/*.

[50] Centers for Disease Control and Prevention, CDC WONDER databases, last accessed May 11, 2021, *https://wonder.cdc.gov*.

from air dispersion modeling and the IPT methodology) are summarized in the following sections.

b. Estimation of Health Outcomes

i. Air Dispersion Modeling

For the San Francisco Bay Area and South Coast air basins, staff used air dispersion modeling (CALPUFF) to estimate the changes in primary PM2.5 concentrations resulting from the Proposed Amendments over modeling domains covering the majority of each of these two air basins. The modeling domains were determined to cover a large enough domain to represent both air basins for estimating health outcomes. Using a methodology developed by U.S. EPA[51] and also described in the documentation included on CARB's health analysis methodology webpage,[52] staff used a health model to estimate the impacts of the estimated PM2.5 concentrations in each census tract of the modeling domain, and results were aggregated over the domain.

ii. Incidence-Per-Ton Methodology

CARB uses the IPT methodology to quantify the health benefits of emission reductions in cases where dispersion modeling results are not available. A description of this method is included on CARB's health analysis methodology webpage. CARB's IPT methodology is based on a methodology developed by U.S. EPA.[53, 54, 55]

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 PM2.5 for a baseline scenario using measured ambient concentrations and dividing by the emissions of PM2.5 or a

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[51] National Institute of Health, The Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP–CE): A tool to estimate the health and economic benefits of reducing air pollution, February 2018, last accessed May 11, 2021, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6022291/*.

[52] Estimating Health Benefits Associated with Reductions in PM and NOx Emissions: Detailed Description, last accessed February 9, 2021, *https://ww2.arb.ca.gov/sites/default/files/2019-08/Estimating%20the%20Health%20Benefits%20Associated%20with%20Reductions%20in%20PM%20and%20NOX%20Emissions%20-%20Detailed%20Description.pdf.*

[53] 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, last accessed May 7, 2021, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/.*

[54] 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, last accessed May 7, 2021, *https://www.sciencedirect.com/science/article/pii/S0160412012001985*.

[55] 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, last accessed May 7, 2021, *https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050.*

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 emission reductions from the Proposed Amendments in an air basin by the IPT factor then yields an estimate of the reduction in health outcomes achieved by the Proposed Amendments. For future years, the number of outcomes is adjusted to account for population growth. CARB's current IPT factors are based on a 2014 to 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 PM2.5: primary PM2.5 and secondary PM2.5 of ammonium nitrate aerosol formed from precursors.

c. Reduction in Adverse Health Impacts

Staff quantified the reduction in adverse health impacts including cardiopulmonary mortality, hospitalizations for cardiovascular illness and respiratory illness, as well as emergency room visits for asthma resulting from the Proposed Amendments. The studies that staff used for estimating mortality, hospitalizations, and emergency room visits are the same as used by the U.S. EPA and are listed in CARB's methodology document.[56]

Staff estimates that the total number of cases statewide that would be reduced (from 2023 to 2038) from the implementation of the Proposed Amendments are as follows:

- 501 premature deaths reduced (391 to 613, 95 percent confidence interval (CI)).
- 153 hospital admissions for cardiovascular illness reduced (19 to 282, 95 percent CI).
- 224 emergency room visits reduced (141 to 306, 95 percent CI).

Table B-2 shows the estimated total reductions in health outcomes resulting from reductions in primary and secondary PM2.5 from the Proposed Amendments from 2023 to 2038.

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

Table B-2. Proposed Amendments: Estimated Total Reductions in Health Outcomes from 2023 to 2038*

Air Basin	Cardiopulmonary Mortality	Hospital Admissions	Emergency Room Visits
North Central Coast	2 (1 - 2)	1 (0 - 1)	1 (1 - 1)
North Coast	3 (2 - 3)	1 (0 - 1)	1 (1 - 1)
Sacramento Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
San Diego County	35 (27 - 42)	10 (1 - 19)	14 (9 - 19)
San Francisco Bay Area	158 (123 - 193)	46 (6 - 86)	74 (47 - 102)
San Joaquin Valley	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
South Central Coast	26 (20 - 31)	8 (1 - 15)	11 (7 - 15)
South Coast	276 (216 - 338)	86 (11 - 160)	121 (77 - 165)
TOTAL	501 (391 - 613)	153 (19 - 282)	224 (141 - 306)

*A portion of the cardiopulmonary, hospital admissions, and emergency room visits for the San Francisco Bay Area and the South Coast air basins were calculated by estimation of health outcomes from modeled concentrations; other estimates were obtained using the IPT methodology. The values in parentheses represent the 95 percent confidence intervals of the central estimate. Totals may not add due to rounding. Air basins with zero impacts are not shown, and these are Great Basins Valleys, Lake County, Lake Tahoe, Mojave Desert, Mountain Counties, Northeast Plateau, and the Salton Sea.

In general, health studies have shown that populations with low-income are more susceptible to health problems from exposure to air pollution.[57, 58] However, the methods currently used by U.S. EPA and CARB do not have the granularity to account for this impact.

In accordance with U.S. EPA's practice, health outcomes were monetized by multiplying incidence by a standard value derived from economic studies.[59] The valuation per incident is provided in Table B-3. The valuation for avoided premature mortality is based on willingness to pay to avoid premature mortality.[60] This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year. This is not an estimate of how much any single individual would be willing to pay

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[57] Daniel Krewski et al., Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality, May 2009, Health Effects Institute Research Report 140, last accessed May 7, 2021, *https://ephtracking.cdc.gov/docs/RR140-Krewski.pdf*.

[58] R. Charon Gwynn et al., The burden of air pollution: impacts among racial minorities, August 2001, Environmental Health Perspectives; 109(4):501–6, last accessed May 7, 2021, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240572/.*

[59] National Center for Environmental Economics et al., Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses (EPA 240-R-10-001, Dec. 2010), last accessed May 7, 2021, *https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-22.pdf.*

[60] United States Environmental Protection Agency Science Advisory Board (U.S. EPA-SAB), An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (EPA-SAB-EEAC-00-013), July 2000, last accessed May 7, 2021, *http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf.*

to prevent a certain death of any particular person,[61] nor does it consider any specific costs associated with mortality such as hospital expenditures. While reductions in premature mortality are an important benefit of the Proposed Amendments, the valuation methods used to monetize the benefit do not easily lend themselves to macroeconomic modeling. The monetized benefits associated with avoided premature deaths are reported here but are not included in macroeconomic modeling (Chapter E).

Unlike premature mortality valuation, the valuation for avoided hospitalizations and ER visits are based on a combination of typical costs associated with hospitalization and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, and lost earnings for both individuals and family members, lost recreation value, and lost household protection (e.g., valuation of time-losses from an inability to maintain the household or provide childcare).[62] Since these are most closely associated with specific cost-savings to individuals (and costs to the healthcare system), monetized benefits from avoided hospitalizations and ER visits are included in macroeconomic modeling (Chapter E).

Table B-3. Valuation Per Incident for Avoided Health Outcomes

Outcome	Cost-Savings per Incident (2019$)
Avoided Premature Deaths	$ 9,864,695
Avoided Cardiovascular Hospitalizations	$ 58,288
Avoided Acute Respiratory Hospitalizations	$ 50,842
Avoided ER Department Visits	$ 834

Statewide valuation of health benefits was calculated by multiplying the avoided health outcomes by valuation per incident. The total statewide valuation due to avoided health outcomes between 2023 and 2038 totaled $4.95 billion. These values, by outcome, are summarized in Table B-4. The spatial distribution of these benefits follows the distribution of emissions reductions and avoided adverse health outcomes; therefore, most of the cost savings to individuals would occur in the South Coast and San Francisco air basins.

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[61] United States Environmental Protection Agency, Mortality Risk Valuation – What does it mean the place a value on a life?, last accessed May 7, 2021, *https://www.epa.gov/environmental-economics/mortality-risk-valuation#means*.

[62] Lauraine G. Chestnut et. al., The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations (Contemporary Economic Policy, 24: 127–143. doi: 10.1093/CEP/BYJ007), January 2006, last accessed May 7, 2021, *http://onlinelibrary.wiley.com/doi/10.1093/cep/byj007/full.*

Table B-4. Statewide Valuation from Avoided Adverse Health Outcomes between 2023 and 2038 as a Result of the Proposed Amendments (2019 $)

Year	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits	Total
2023	$64,637,000	$96,000	$3,000	$64,736,000
2024	$102,816,000	$158,000	$4,000	$102,978,000
2025	$141,755,000	$224,000	$6,000	$141,985,000
2026	$185,351,000	$299,000	$8,000	$185,658,000
2027	$215,728,000	$353,000	$9,000	$216,090,000
2028	$241,907,000	$400,000	$10,000	$242,317,000
2029	$269,872,000	$450,000	$11,000	$270,333,000
2030	$314,005,000	$527,000	$12,000	$314,545,000
2031	$358,763,000	$604,000	$14,000	$359,382,000
2032	$393,337,000	$664,000	$15,000	$394,016,000
2033	$422,712,000	$713,000	$16,000	$423,440,000
2034	$432,690,000	$732,000	$16,000	$433,437,000
2035	$445,646,000	$755,000	$16,000	$446,417,000
2036	$450,349,000	$765,000	$16,000	$451,129,000
2037	$451,407,000	$767,000	$16,000	$452,190,000
2038	$450,487,000	$764,000	$16,000	$451,266,000
Total	$4,941,461,000	$8,272,000	$187,000	$4,949,919,000

d. GHG and Black Carbon Emissions Benefits

The Proposed Amendments would result in an estimated cumulative net reduction in GHG emissions between 2023 and 2038 totaling 375,490 MT compared with the Baseline. GHGs from diesel engines commonly include CO2, nitrous oxide (N2O), and CH4, which are the primary climate forcing agents which contribute to global warming, and other shifts in the climate system, as observed over the past century, are caused by human activities. GHGs and the SLCP black carbon (a subset of PM2.5) from CHC contribute to climate change. Climate scientists agree that global warming and other shifts in the climate system observed over the past century are caused by human activities. These recorded changes are occurring at an unprecedented rate. According to new research, unabated GHG emissions could cause sea levels to rise up to 10 feet by the end of this century—an outcome that could devastate coastal communities in California and around the world.

The Proposed Amendments would achieve GHG benefits. This is mainly achieved by reducing fuel consumption through the use of shore power and the requirement for ZEAT. Additionally, the Proposed Amendments require Tier 4 engines for vessels 600 kW and above, which are generally associated with less fuel consumption per unit work relative to older engines such as uncertified engines or those certified to marine Tier 3 emission standards. For a period starting with the first implementation in 2023 through final implementation in 2038, GHG emissions on average are reduced by

4.3 percent by implementing the Proposed Amendments. Therefore, the forecasted GHG emissions reductions for the Proposed Amendments would be a net benefit.

i. Social Cost of Carbon

The benefit of GHG reductions achieved by the Proposed Amendments is estimated using the social cost of carbon (SC-CO2), which provides a dollar valuation of the damages caused by one metric ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future.

The Council of Economic Advisors and the Office of Management and Budget convened an Interagency Working Group (IWG) on the Social Cost of Greenhouse Gases to develop a methodology for estimating the SC-CO2. The methodology relies on a standardized range of assumptions and can be used consistently when estimating the benefits of regulations across agencies and around the world.[63] Staff utilized the current IWG supported SC-CO2 values to consider the social costs of actions taken to reduce GHG emissions. This is consistent with the approach presented in the Revised 2017 Climate Change Scoping Plan, in line with the Office of Management and Budget Circular A-4 of September 17, 2003, and reflects the best available science in the estimation of the socio-economic impacts of carbon.[64, 65]

The IWG describes the SC-CO2 as follows:

> "The social cost of carbon (SC-CO2) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO2 emissions by the same amount in that year. The SC-CO2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts – from global climate change that result from an additional ton of CO2.
>
> These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO2 emissions today will affect economic outcomes throughout the next several centuries."[66]

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[63] Additional technical detail on the IWG process is available in the Technical Updates of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866 (by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government), last accessed May 7, 2021, *https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf*, and *https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf*.

[64] California Air Resources Board, California's 2017 Climate Change Scoping Plan, November 2017, last accessed May 7, 2021, *https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf*.

[65] Office of Management and Budgets, Circular A-4, last accessed May 7, 2021, *https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf*.

[66] National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of Carbon Dioxide, last accessed May 7, 2021, *http://www.nap.edu/24651*.

The SC-CO2 is year-specific and is highly sensitive to the discount rate used to discount the value of the damages in the future due to CO2. The SC-CO2 increases over time as systems become more stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. A higher discount rate decreases the value today of future environmental damages. This analysis uses the IWG standardized range of discount rates from 2.5 to 5 percent to represent a varying valuation of future damages. Table B-5 shows the range of IWG SC-CO2 values used in California's regulatory assessments.[67, 68]

Table B-5. Social Cost of Carbon (2019 $/Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2020	$15	$54	$80
2025	$18	$59	$88
2030	$21	$65	$94
2035	$23	$71	$101
2040	$27	$77	$108
2045	$30	$83	$115
2050	$34	$89	$123

If all of the expected emission reductions projected under the Proposed Amendments are achieved and assumed to be equivalent to CO2 reductions, the avoided SC-CO2 in a given year is the total emission reductions in metric tons CO2-equivalent (MTCO2e) multiplied by the SC-CO2 (in $/MTCO2e) for that year. The annual emission reductions from the Proposed Amendments, in million metric tons of CO2 equivalent (MMTCO2e), and the estimated benefits are shown in Table B-6. The total benefits range between $8 to $37 million from 2023 to 2038, depending on the discount rate.

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[67] The SC-CO2 values are of July 2015 and are available at: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, revised July 2015, last accessed May 7, 2021, *https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf*.

[68] The IWG SC-CO2 values are provided in 2007 dollars. CARB staff adjusted from 2007 to 2019 dollars by using the Consumer Price Index (CPI-U), adjusting from 2007 dollars to 2019 dollars, last accessed May 7, 2021, *https://www.dof.ca.gov/Forecasting/Economics/Indicators/Inflation/documents/CPI_All_Item_CY.xlsx*.

Table B-6. Avoided Social Cost of CO2 from 2023 to 2038 (Million 2019 $)

Year	GHG Emission Reductions (MMTCO2e)	5 % Discount Rate	3 % Discount Rate	2.5 % Discount Rate
2023	0.00	0	0	0
2024	0.00	0	0	0
2025	0.01	0	0	1
2026	0.01	0	1	1
2027	0.02	0	1	2
2028	0.02	0	1	2
2029	0.03	1	2	3
2030	0.03	1	2	3
2031	0.04	1	2	4
2032	0.04	1	2	4
2033	0.03	1	2	3
2034	0.03	1	2	3
2035	0.03	1	2	3
2036	0.03	1	2	3
2037	0.03	1	2	3
2038	0.03	1	2	3
Total	0.38	8	25	37

There is an active discussion within government and academia about the role of SC-CO2 in assessing regulations, quantifying avoided climate damages, and the values themselves. In January 2017, the National Academies of Sciences, Engineering, and Medicine (NASEM) released a report examining potential approaches for a comprehensive update to the SC-CO2 methodology to ensure resulting cost estimates reflect the best available science. The NASEM review did not modify the estimated values of the SC-CO2, but evaluated the models, assumptions, handling of uncertainty, and discounting used in the estimating of the SC-CO2. The report titled, "Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide," recommends near-term improvements to the existing IWG SC-CO2, as well as long-term comprehensive updates. CARB will continue to follow updates to the IWG SC-CO2, outlined in the NASEM report, and incorporate appropriate peer-reviewed modifications to estimates based on the latest available data and science.[69]

It is important to note that the SC-CO2, while intended to be a comprehensive estimate of the damages caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the SC-CO2, including costs associated with changes in co-pollutants, the social cost of other GHGs including CH4 and N2O, and costs that

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[69] National Academies of Sciences, Engineering, and Medicine. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, 2017, last accessed May 7, 2021, *https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of*.

cannot be included due to modeling and data limitations. The Intergovernmental Panel on Climate Change (IPCC) has stated that the IWG SC-CO2 estimates are likely underestimated due to the omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts.[70] CARB will continue engaging with experts to evaluate the comprehensive California-specific impacts of climate change and air pollution.

e. Unquantified Benefits

Under the Proposed Amendments, NOx emissions reductions would occur, which as described above, are essential to cutting regional ozone levels to attain federal and State ambient air quality standards. The reduction in PM2.5 that would result from the Proposed Amendments would also likely result in better visibility throughout regions near seaports, marinas, harbors, and other waterways due to the improved air quality, which is an unquantified benefit to individuals in California. In addition to the monetized health impacts, additional health benefits associated with emission reductions would be achieved by the Proposed Amendments. These additional health benefits, including reductions in elevated vulnerability and impacts in disadvantaged communities, work loss days, school loss days, brain and lung health, cancer risk, and birth outcomes, currently are not monetized. Staff is developing methodologies that will allow these additional benefits to be quantified in the future.

C. Direct Costs

The net direct costs of the Proposed Amendments are estimated to be approximately \$1.8 billion (amortized) and \$2.1 billion (non-amortized) during the implementation period of 2023 through 2038. CARB staff assumed that harbor craft owners and operators would comply with the Proposed Amendments by meeting the performance standards specified for each vessel category, engine year, and engine size by the corresponding compliance year. The direct costs and cost savings of repowering vessel engines and installing DPFs include capital costs, labor and installation costs, operational costs, loss of use costs, and fuel savings from Tier 4 main and auxiliary engines. The direct costs and cost savings for vessel replacements/new-build vessels include capital costs, labor and installation costs, operational costs, and cost savings generated from the resale of the vessel being replaced.

For the ZEAT requirements applicable to certain in-use and new vessel categories, the direct costs and cost savings include electricity costs, charging infrastructure costs, and cost savings from reductions in the quantity of fuel used during the operation of the vessel. Staff assumed voluntary ZEAT deployment, in surplus of mandates, would not have incremental costs beyond direct compliance with the Proposed Amendments. Deploying ZEAT is often associated with lower operational costs, may be funded partially with air quality and other grants, and is associated with ancillary

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[70] Intergovernmental Panel on Climate Change, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Climate Change 2007: Mitigation of Climate Change. 2007, last accessed May 18, 2021, *https://www.ipcc.ch/report/ar4/wg3/*.

brand image benefits for being a green company. In addition, voluntary ZEAT deployment may be eligible for regulatory flexibility, such as additional compliance time on other vessels in the fleet, which would reduce costs during the implementation period of 2023 to 2038.

Additional cost categories include infrastructure costs for shore power, biennial opacity testing, annual compliance fees, vessel labeling costs occurring every five years, costs associated with compliance extension requests for instances where meeting performance standards is not feasible, including costs to provide financial feasibility and Naval Architect reports as supporting documentation, a one-time cost to CHC fleet owner/operators to interpret regulatory requirements in the Proposed Amendments, and recordkeeping and reporting costs.

The parties that would incur direct costs under the Proposed Amendments include public and private CHC fleet owner/operators and owner/operators of vessel facilities where CHC dock or moor. The direct costs in this section include costs to local, State, and federal government agencies, which are also quantified separately in Chapter D: Fiscal Impacts.

Table C-1 provides an overview of the direct cost categories and the parties who would be anticipated to incur the direct net costs. The assumptions underlying the direct costs are detailed in subsequent sections of this chapter.

Table C-1. Direct Net Costs by Category and Responsible Party

Cost Category	Applicable Costs	Parties Anticipated to Incur Costs
Repower and Retrofit	• Capital Costs of Engine and DPF (including California sales tax) • Labor and Installation Costs • Operational Costs • Loss of Use • Fuel Savings	• Private and Public CHC Fleet Owner/Operators
Vessel Replacement	• Capital Costs of Vessel and DPF (including California sales tax) • Labor and Installation Costs • Operational Costs • Vessel Resale Revenue • Fuel Savings	• Private and Public CHC Fleet Owner/Operators
Zero-Emission and Advanced Technology Infrastructure	• Charging Infrastructure Costs • Electricity Costs • Fuel Cost Savings	• Private and Public Owner/Operators of Short Run Ferries and Excursion Vessels • Utility Companies
Shore Power Infrastructure	• Charging Infrastructure Costs • Electricity Costs • Fuel Cost Savings	• Private and Public CHC Fleet Owner/Operators • Private and Public Facility Owner/Operators • Utility Companies
Opacity Testing	• Biennial Opacity Test Costs	• Private and Public CHC Fleet Owner/Operators
Compliance Fees	• Annual Fee Covering CARB's Implementation and Enforcement Costs	• Private and Public CHC Fleet Owner/Operators
Vessel Labeling Cost	• Cost of CARB-issued Vessel Identification	• Private and Public CHC Fleet Owner/Operators
Naval Architect Report Cost (Compliance Extension Requests)	• Cost of Report Identifying Feasibility of Vessel Modifications	• Private and Public CHC Fleet Owner/Operators
Financial Feasibility Report (Compliance Extension Requests)	• Cost of Financial Analysis Demonstrating Lack of Ability to Pay for Vessel Replacement	• Private and Public CHC Fleet Owner/Operators
Regulation Interpretation	• One-time Cost per Fleet to Interpret Proposed Amendments to Regulation	• Private and Public CHC Fleet Owner/Operators
Recordkeeping and Reporting	• Cost of CHC Owner/Operator Recordkeeping and Annual Reporting to CARB • Cost of Facility Recordkeeping and Quarterly Reporting to CARB	• Private and Public CHC Fleet Owner/Operators • Private and Public Facility Owner/Operators
Implementation and Enforcement	• CARB Personnel-Years Costs for Implementation and Enforcement Activities	• CARB, but Reimbursed by a Compliance Fee Applicable to • Private and Public CHC Fleet Owner/Operators

1. Scope of Cost Analysis

a. Cost Analysis Baseline

The requirements of the Current Regulation will be fully implemented by December 31, 2022. Therefore, the baseline for the cost analysis is a full implementation of the Current Regulation, and costs calculated for the Proposed Amendments are incremental to the baseline.

b. Cost Analysis Timeline

Staff assumed that the costs incurred by the regulated parties and CARB would start in 2023, which is the first implementation date, through 2037 when the Proposed Amendments would be fully implemented. The compliance dates for the Proposed Amendments range from 2023 through 2032, with lower engine tiers and older model years having earlier compliance dates. If vessel owner/operators choose to apply for and receive compliance extensions due to lack of feasible technology (a maximum of six years), the compliance timeframe range would extend to 2037.[71] The cost analysis extends through 2038 to capture a full 12 months after the potential 2037 compliance actions.

The anticipated timing of when each cost would begin is summarized in Table C-2.

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[71] Commercial fishing vessels have the latest compliance dates of 2030-2032 and are not eligible for the six-year extension.

Table C-2. Cost Start Dates to Comply with the Proposed Amendments

Year	Costs Beginning in Year
2023	• Engine capital costs, labor and installation costs, operational costs, and vessel replacement/new-build costs for any vessel with Tier 0 or Tier 1 engines, which are generally Workboats, Research Vessels, Pilot Boats, Tank Barges, and Commercial Passenger Fishing Vessels. • Compliance fee costs. • Recordkeeping and Reporting costs. • Facility reporting costs. • Financial feasibility report costs and Naval Architect Report costs due to compliance extension requests for instances where meeting performance standards would not be feasible. • ZEAT and shore power infrastructure costs. • Fuel savings and electricity costs for shore power. • Opacity testing costs. • Vessel labeling costs.
2024	• Engine and DPF capital costs, labor and installation costs, operational costs, and vessel replacement/new-build costs for Ferries and all Tug vessel categories with any Tier 2, 3, or 4 engines.
2025	• Engine and DPF capital costs, labor and installation costs, operational costs, and vessel replacement/new-build costs for Pilot Boats with any Tier 2, 3, or 4 engines. • ZEAT capital costs, labor and installation costs, operational costs, and vessel replacement/new-build costs for new Excursion Vessels. • Fuel savings and electricity costs for Excursion Vessels.
2026	• Engine and DPF capital costs, labor and installation costs, operational costs, and vessel replacement/new-build costs for Research Vessels, Commercial Passenger Fishing Vessels, and Excursion Vessels with any Tier 2, 3, or 4 engines. • ZEAT capital costs, labor and installation costs, and operational costs for new and in-use Short Run Ferries begin. • Fuel savings and electricity costs for Short Run Ferries.
2027	• No costs begin in this year.
2028	• Engine and DPF capital costs, labor and installation costs, operational costs, and vessel replacement/new-build costs for Dredges, Barges, Crew and Supply, and Workboats with any Tier 2, 3, or 4 engines.
2029	• No costs begin in this year.
2030	• Engine capital costs and labor and installation costs for Commercial Fishing Vessels with any Pre-Tier 1 or Tier 1 engines.

c. Key Analysis-wide Assumptions

i. Amortization of Costs Based on Vessel, Engine, and Infrastructure Lifespan

Staff assumed that capital and labor, and installation costs for engine repowers, retrofits, and vessel replacements/new-builds would be amortized over the expected equipment (i.e., engine and DPF) and vessel useful life periods. The useful life period is the point where approximately 50 percent of the engines or vessels retire in the fleet. Staff determined the useful life by developing vessel survival curves using data reported to CARB via the CHC reporting database. Based on feedback from stakeholders about typical financing rates, staff used an interest rate of 4 percent for vessel and engine costs for the capital recovery factor.[72,73] More information about vessel survival curves can be found in Appendix A.

Staff assumed the capital costs for landside and vessel-side shore power and ZEAT infrastructure would be amortized over a 20-year useful life at an interest rate of 5 percent.

Staff assumed that shore power infrastructure costs would also be amortized over a 20-year useful life at an interest rate of 5 percent.

ii. Application of Vessel Population Growth Factors

The costs of the Proposed Amendments are directly proportional to the statewide vessel population. Staff assumed that the growth in the statewide vessel population would be the same as the growth factor used to develop the baseline emissions estimates. Baseline assumptions are described in further detail in section A.9. Under these assumptions, catamaran, monohull, and short-run ferry vessel categories are anticipated to see annual growth that averages approximately 1.5 percent between 2023 to 2038 while all other vessel categories are not anticipated to grow. Staff applied the growth factors, by vessel category, to all costs except for ZEAT charging infrastructure and shore power costs. For ZEAT charging infrastructure, staff assumed a defined number of installations that would not be dependent on vessel population growth. For shore power, staff applied an industrywide growth rate since the shore power requirement would apply to all vessel categories. The industrywide growth factors used for shore power infrastructure are provided in Table C-3. The compounded vessel growth factor percentage is for all CHC vessel categories combined and applies to Shore Power Retrofit Cost inputs.

Table C-3. Industrywide Compound Vessel Growth Factors

Year	Compound Growth Factor	Year	Compound Growth Factor
2023	0.0%	2031	0.07%
2024	0.06%	2032	0.07%
2025	0.06%	2033	0.08%
2026	0.06%	2034	0.08%
2027	0.06%	2035	0.08%
2028	0.07%	2036	0.08%
2029	0.07%	2037	0.08%
2030	0.07%	2038	0.08%

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[72] Staff communications with SWITCH Maritime on November 4, 2020.

[73] R.E. Staite Engineering, INC. comment letter to CARB, Proposed Amendments to the Regulations to Reduce Emissions from Diesel Engines on Commercial Harbor Craft (CHC) operated within California Waters and 24 Nautical Miles of the California Baseline, October 30, 2020.

iii. Application of Compliance Scenario Assumptions

The Proposed Amendments would establish a performance standard equivalent to a Tier 3 marine standard plus a DPF, or a Tier 4 marine standard plus a DPF if there is an available engine model certified to Tier 4. Staff is aware that U.S. EPA only requires Tier 4 engines for engines rated above 600 kW but has certified some Marine Tier 4 engines with power ratings down to 448 kW. For the purposes of the compliance scenarios, staff assumed all engines rated at or below 448 kW would repower or retrofit to Tier 3 marine standards, and engines rated greater than 448 kW would repower or retrofit to Tier 4 marine standards.

The Proposed Amendments contain various compliance pathways, including repowering and retrofitting engines on existing vessels, replacing an existing vessel with a new-build vessel, staying below the low-use hour thresholds, and applying for a compliance extension in instances where it is not technically or financially feasible to meet the performance standards. Staff developed compliance scenario assumptions in order to model the percentage of total vessel horsepower statewide in each vessel category that would:

1) Repower or repower and retrofit by the first compliance deadline.
2) Be replaced with a new-build vessel by the first compliance deadline.
3) Repower or repower and retrofit after receiving one compliance extension.
4) Be replaced with a new-build vessel after receiving one compliance extension.
5) Repower or repower and retrofit after receiving two compliance extensions.
6) Be replaced with a new-build vessel after receiving two compliance extensions.
7) Vessels eligible for low-use exception.
8) Vessels eligible for limited operating hours extension.

iv. Compliance Scenario Assumptions for Repowers, Retrofits, and Vessel Replacements

As discussed in the previous section, there are multiple pathways for CHC owners and operators to comply with the Proposed Amendments. Staff estimates that the majority of vessel owners would comply by repowering or repowering and retrofitting engines, as it would be a technologically feasible pathway for most vessel owners and operators to comply with the requirements and would be less costly than replacing the vessel. Staff estimates a much smaller portion of vessel owners would replace their vessels to comply with the Proposed Amendments by the initial compliance date, as repowering and retrofitting would not be feasible. This section describes the pathways of repowering, retrofitting, and replacing vessels. Staff summarizes the other compliance pathways which include obtaining compliance extensions, low-use extensions, or low-use exemptions, below in sections v - vii.

Staff developed methodologies to determine what percentage of vessels would repower or repower and retrofit by the initial compliance date, after an approved extension, or would ultimately replace their vessels.

For vessel categories with any Tier 0 or Tier 1 engines, which primarily represent vessel categories that are not subject to requirements for regulated in-use vessels under the Current Regulation, the Proposed Amendments would require engine repowers to Tier 3 or Tier 4, depending on the engine size and vessel category, from 2023 to 2025. Staff assumed that 100 percent of vessels with Tier 0 and Tier 1 engines rated at 448 kW or smaller would be repowered to meet Tier 3 performance standards by the initial compliance date. Staff's assumption is based on the wide availability of feasible and proven Tier 3 engines in numerous vessel applications. In addition, Tier 3 engines do not include aftertreatment, and the engine blocks are about the same size as Tier 0 or Tier 1, even if additional cooling or powertrain parts need to be replaced.

For repowers or repowers and retrofits to Tier 4 engines and/or DPF, staff's assumptions regarding what percentage of vessel owners would repower and retrofit or replace vessels are based primarily on information provided in a 2019 evaluation conducted by the California State University Maritime Academy (CSU Maritime Academy or CMA).[74] The CMA report determined the feasibility of repowering or retrofitting a specific in-use CHC within each of the 13 vessel categories with Tier 4 marine engines or retrofit aftertreatment, including assessing the extent of reconfiguration that would be required for repowers and retrofits. It also ranked vessel categories under different feasibility determinations from most to least feasible. The categories were as follows:

1) Feasible Fitment: The addition of the Tier 4 repower or retrofit aftertreatment equipment can be installed with minimal vessel modification and will likely not impact stability beyond the thresholds determined by USCG to require stability evaluation/review;
2) Moderate Reconfiguration: The addition of the Tier 4 repower with ancillary components or aftertreatment retrofit equipment to the existing vessel design may require changes to machinery/component locations, vessel mechanical/electrical subsystems, bulkhead penetrations, and moderate structural reinforcement to the existing vessel design in component hanging/mounting locations;
3) Substantial Reconfiguration: The addition of the Tier 4 repower or aftertreatment retrofit equipment will require most if not all of the alterations described under the "Moderate Reconfiguration" determination plus the addition of more significant or extensive redesign and structural fabrication to accommodate the equipment and/or to overcome apparent stability issues; and
4) No Fitment Identified: This designation indicates that despite thorough analysis of feasibility, the study authors were not able to identify repower or retrofit solutions that would be successful for the combination of vessel design, vessel build material, and physical characteristics of Tier 4 engines and retrofit aftertreatment systems.

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[74] CSU Maritime Academy, Evaluation of the Feasibility and Costs of Installing Tier 4 Engines and Retrofit Exhaust Aftertreatment on In-Use Commercial Harbor Craft, 2019, last accessed February 2021, *https://ww2.arb.ca.gov/resources/documents/commercial-harbor-craft-tier-4-feasibility-report*.

Based on the feasibility determinations from the CMA report, staff developed numerical feasibility fitment factors, which represent the percentage of vessels that staff estimates would be repowered or repowered and retrofitted by the first applicable compliance date. The percentages staff assigned to each category assume that technology improvement and increased product offerings over time will lead to increased feasibility of repowering and retrofitting vessels. The fitment feasibility factors that staff assumed also vary depending on the size of the engine and whether a repower or a repower and retrofit would be required.

For vessels with engines greater than 448 kW (600 hp) that would be repowered to Tier 4, staff relied on the fitment factors developed for each vessel category from the feasibility categorizations in the CMA report, as described above. The fitment feasibility factors are assumed to be the following:

- Feasible Fitment = 95 percent;
- Moderate Reconfiguration = 90 percent;
- Substantial Reconfiguration = 75 percent; and
- No Fitment Identified = 0 percent.

The fitment factors assigned to each vessel category for vessels repowering from Tier 0 and Tier 1 to Tier 4 are provided in Table C-4 as the "Percent Vessel Repowers/Retrofits by Initial Compliance Date" by vessel category.

Table C-4. Compliance Scenario Assumptions for Tier 0 and Tier 1 to Tier 4 Repowers (Engines >600HP/448kW)

Vessel Category	% Vessel Repowers/ Retrofits by Initial Compliance Date	% Vessel Replacements by Initial Compliance Date	% Vessel Repowers /Retrofits after 1st Extension	% Vessel Replacements after 1st Extension	% Vessel Repowers/ Retrofits after 2nd Extension	% Vessel Replacements after 2nd Extension
Ferry, Catamaran	75%	5%	5%	5%	5%	5%
Ferry, Monohull	90%	5%	1.25%	1.25%	1.25%	1.25%
Ferry, Short Run	100%	0%	0%	0%	0%	0%
Pilot Boat	75%	5%	5%	5%	5%	5%
Push/Tow Tug	90%	5%	1.25%	1.25%	1.25%	1.25%
Escort/Ship Assist Tug	95%	5%	0%	0%	0%	0%
ATB Tug	95%	5%	0%	0%	0%	0%
Research Vessel	75%	5%	5%	5%	5%	5%
Commercial Passenger Fishing	50%	5%	11.25%	11.25%	11.25%	11.25%
Excursion	95%	5%	0%	0%	0%	0%
Dredge	90%	5%	1.25%	1.25%	1.25%	1.25%
ATB Barge	95%	5%	0%	0%	0%	0%
Bunker Barge	95%	5%	0%	0%	0%	0%
Other Barge	90%	5%	1.25%	1.25%	1.25%	1.25%
Towed Petrochemical Barge	90%	5%	1.25%	1.25%	1.25%	1.25%
Crew Supply	75%	5%	5%	5%	5%	5%
Workboat	75%	5%	5%	5%	5%	5%

For vessels with any Tier 2, Tier 3, and Tier 4 engines, which primarily represent vessel categories that are subject to the Current Regulation, the Proposed Amendments would require a performance standard equivalent to a Tier 3 or Tier 4 engine repower plus a DPF retrofit, starting in 2024. For these vessels, staff assumed the following feasibility fitment factors, representing the percentage of repowers and retrofits upon the first applicable compliance deadline:

- Feasible Fitment = 90 percent;
- Moderate Reconfiguration = 80 percent;
- Substantial Reconfiguration = 50 percent; and
- No Fitment Identified= 1 percent.

Staff used the above fitment factors for all vessel categories except for commercial passenger fishing vessels. Based on the CMA study and information received from stakeholders[75] that all other CPFVs are constructed of wood and fiberglass, staff assumed almost 100 percent of the vessel of CPFV would be replaced by the initial

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[75] Stakeholder discussion was on Tuesday October 13, 2020, in a meeting with the Sportfishing Association of California Board.

compliance date. Therefore, staff assumed that only 1 percent of vessels would repower/retrofit by the initial compliance date.

Staff also received data from ferry operators about the percentage of vessel repowers and retrofits and vessel replacements that would occur based on the Proposed Amendments, and staff averaged these percentages with the feasibility fitment factor percentages from a study conducted by CMA for catamaran and monohull ferries.[76, 77] Staff considered the likelihood of a vessel owner or operator to repower an in-use vessel that might result in a reduced passenger capacity versus purchasing a new vessel by analyzing vessel routes, existing ridership trends, and availability of additional dock space to run more vessels or existing vessels more frequently.

The fitment factors assigned to each vessel category for vessels repowering/retrofitting from Tier 2, Tier 3, or Tier 4 to Tier 4 plus a DPF are provided in Table C-5 as the "Percent Vessel Repowers/Retrofits by Initial Compliance Date" by vessel category.

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[76] Catamaran ferry vessel replacement percentages were derived using the average of data provided by WETA in a November 13, 2020 email to Melissa Houchin (CARB), and data provided by an industry source who asked to remain unnamed.

[77] Monohull ferry vessel replacement percentages were derived using the average of the compliance percentages derived from feasibility factors in the CSU Maritime Academy Study (September, 2019) and data provided by an industry source who asked to remain unnamed.

Table C-5. Compliance Scenario Assumptions for Percentage of CHC Repowering and Retrofit to Tier 4+DPF (Engines >448 kW)

Vessel Category	% Vessel Repowers/ Retrofits by Initial Compliance Date	% Vessel Replacements by Initial Compliance Date	% Vessel Repowers/ Retrofits after 1st Extension Period	% Vessel Replacements after 1st Extension Period	% Vessel Repowers /Retrofits after 2nd Extension	% Vessel Replacements after 2nd Extension
Ferry, Catamaran	31.5%	5%	15.875%	15.875%	15.875%	15.875%
Ferry, Monohull	42.5%	5%	13.125%	13.125%	13.125%	13.125%
Ferry, Short Run	100%	0%	0%	0%	0%	0%
Pilot Boat	50%	5%	12.5%	12.5%	12.5%	12.5%
Push/Tow Tug	80%	5%	3.75%	3.75%	3.75%	3.75%
Escort/Ship Assist Tug	90%	5%	1.25%	1.25%	1.25%	1.25%
ATB Tug	90%	5%	1.25%	1.25%	1.25%	1.25%
Research Vessel	50%	5%	11.25%	11.25%	11.25%	11.25%
Commercial Passenger Fishing	1%	5%	0%	47%	0%	47%
Excursion	90%	5%	1.25%	1.25%	1.25%	1.25%
Dredge	80%	5%	3.75%	3.75%	3.75%	3.75%
ATB Barge	90%	5%	0%	0%	0%	0%
Bunker Barge	90%	5%	0%	0%	0%	0%
Other Barge	80%	5%	3.75%	3.75%	3.75%	3.75%
Towed Petrochemical Barge	80%	5%	3.75%	3.75%	3.75%	3.75%
Crew Supply	50%	5%	12.5%	12.5%	12.5%	12.5%
Workboat	50%	5%	11.25%	11.25%	11.25%	11.25%

v. Assumptions for Compliance Extensions

For vessels that would not be replaced or engines that would not be repowered or repowered and retrofitted upon the initial compliance date, staff assumed that vessel owner/operators would apply for the “Meeting Performance Standards Is Not Feasible for In-Use Harbor Craft” compliance extension included in the Proposed Amendments. This extension would provide three additional years, with the ability to renew once for a total of six years beyond the initial compliance date, for all vessel categories, if the vessel owner demonstrates that no suitable engines or control technologies could be safely installed in the vessel and purchasing a replacement vessel with compliant engines would not be financially feasible. The percentage of vessels that would receive compliance extensions is equal to one minus the sum of the feasibility fitment factor and the percentage of vessels replaced by the initial compliance date. Staff modeled the percentages of vessels receiving compliance extensions as follows:

- At the end of the first three-year compliance extension period, the vessel owner would have three compliance pathways, and staff assumes the following percentages for each pathway based on feasibility fitment factors from the CMA report:
    1) file for a second extension (50 percent);
    2) repower or retrofit the vessel (25 percent); or
    3) replace the vessel (25 percent).
- At the end of the second three-year compliance extension period, the vessel owner would have two compliance pathways, and staff assumes the following percentages for each pathway based on feasibility fitment factors from the CMA report:
    1) repower or retrofit the vessel (50 percent); or
    2) replace the vessel (50 percent).

vi. Compliance Scenario Assumptions Unique to Short Run Ferries and Commercial Fishing Vessels

Short-run ferries and commercial fishing vessel categories have unique compliance scenario assumptions.

- Short-run ferries would be subject to zero-emission requirements, and staff assumes 100 percent of such ferries would be repowered instead of replaced due to the large cost difference between a vessel replacement vs. retrofit/repower, which is estimated to be nearly $1,000 per horsepower unit higher for vessel replacements. Staff assumes no compliance extension requests for this category due to a later regulatory phase-in date of 2026.
- Commercial fishing vessels would be required to repower engines to at least a Tier 2 standard from 2030 to 2032, depending on the existing engine model year. Staff assumes 100 percent of commercial fishing vessels would repower to Tier 3 since staff assumes in 2030 Tier 3 engines would be widely available, and that there would be no compliance extensions for this category due to the later regulatory phase-in date. Staff is assuming commercial fishing vessels would not upgrade to Tier 4 engines due to lack of feasibility, engines are typically being rated less than 448 kW, and engine manufacturers being able to sell engines certified to non-current emission standards, such as Tier 3, as allowed by U.S. EPA replacement engine provisions.

vii. Application of Low-Use Exception and Limited Operating Hours Extensions

In this section, staff summarizes the assumed percentage of total statewide CHC vessel horsepower that staff expects would be either:

1) Granted a low-use exception; or
2) Represents Tier 4 engines that would receive extensions for the installation of DPF due to technical infeasibilities. The percentages in this section are

independent of the percentages calculated in sections C.1.c.iv., C.1.c.v, and C.1.c.vi).[78]

a) Low-Use Exception

The Proposed Amendments contain a low-use compliance pathway that would provide an exception to engines from meeting in-use requirements as long as the engine's hours do not exceed an annual threshold, which is based on the current engine tier. Table C-6 displays the threshold values that would be applicable to each engine tier.

Table C-6. Annual Low-Use Hours Limits for Engines on Regulated In-Use Vessels Based on Current Engine Tier

Tier 0	Tier 1	Tier 2	Tier 3 or Tier 4
80 hours/year	300 hours/year	400 hours/year	700 hours/year

Staff analyzed data in the emission inventory, which also included information from the CHC reporting database, and developed assumptions for the percentage of total statewide CHC horsepower that would receive a low-use exception in each vessel category, and therefore would not incur repower, repower, and retrofit, or vessel replacement costs. Table C-7 lists the percentage of total statewide CHC horsepower by vessel category that staff assumes would be eligible for the low-use exception.

Table C-7. Percentage of Total Statewide CHC Horsepower Eligible for Low-Use Exception

Vessel Category	Percentage of Total Statewide CHC Horsepower Receiving Low-use Exception	Vessel Category	Percentage of Total Statewide CHC Horsepower Receiving Low-use Exception
Ferry, Catamaran	4%	Excursion	29%
Ferry, Monohull	4%	Dredge	3%
Ferry, Short Run	4%	ATB Barge	0%
Pilot Boat	0%	Bunker Barge	28%
Push/Tow Tug	7%	Other Barge	28%
Escort/Ship Assist Tug	25%	Towed Petrochemical Barge	28%
ATB Tug	0%	Crew Supply	10%
Research Vessel	16%	Workboat	10%
Commercial Passenger Fishing	4%	Commercial Fishing	5%

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[78] For example, 4 percent of total Statewide Ferry Catamarans horsepower, is assumed to be eligible for low-use exception. Hence, 96 percent of the total Statewide Ferry Catamarans horsepower will either be repowered, repowered and retrofitted, or vessels will be replaced. The percentages in tables C-4, and C-5 thus apply to the 96 percent of the total Statewide Ferry Catamarans horsepower.

b) Extensions for Vessels with Tier 4 Engines and Limited Operating Hours

The Proposed Amendments would provide a renewable three-year extension period for vessels that are equipped with Tier 4 engines, where meeting Tier 4 plus DPF performance standards would not be technically feasible without replacing the vessel and the vessel had not and would not operate above annual hour thresholds listed in Table C-8.

Table C-8. Vessel Replacement Thresholds

Vessel Category	Tier 4 Only Required if Operating Below
Ferry, Pilot, Tug	2,000 hours/year
Passenger Fishing, Excursion, Research	2,500 hours/year
Dredge, Barge, Crew Supply, Workboat	3,500 hours/year

Staff analyzed the most recently reported activity data from the CHC reporting database to determine the percentage of engines above 448 kW in each vessel category that would operate below or above the proposed thresholds. Staff multiplied these values by the percentage of engine repowers expected in each vessel category, based on the feasibility fitment factors in the CMA Report, to get a final percentage of CHC that would receive a limited operating hours extension, and therefore would not incur DPF retrofit or replacement costs (Table C-9). Table I-G in Appendix A describes how these percentages were applied in greater detail.

Table C-9. Percentage of Total Statewide CHC Horsepower Above 448 kW Eligible for Limited Operating Hours Extension

Vessel Category	Percentage of Total Statewide CHC Horsepower Receiving Limited Operating Hours Extension	Vessel Category	Percentage of Total Statewide CHC Horsepower Receiving Limited Operating Hours Extension
Ferry, Catamaran	15%	Excursion	10%
Ferry, Monohull	6%	Dredge	20%
Ferry, Short Run	0%	ATB Barge	10%
Pilot Boat	0%	Bunker Barge	20%
Push/Tow Tug	9%	Other Barge	20%
Escort/Ship Assist Tug	7%	Towed Petrochemical Barge	20%
ATB Tug	3%	Crew Supply	36%
Research Vessel	29%	Workboat	45%
Commercial Passenger Fishing	70%	N/A	N/A

2. Direct Cost Inputs

a. Main and Auxiliary Engine Horsepower for Repower/Retrofit and Vessel Replacement/New-Build

Using cost data received from stakeholders and the CMA Report,[79] staff developed $/horsepower unit values for key cost categories, including engine repower and retrofits and vessel replacements/new-builds. For these categories specifically, staff multiplied the $/horsepower unit values by the total amount of main and auxiliary engine horsepower by year for each vessel category, starting in 2023. The horsepower values are based on the CHC engine inventory,[80] which factors in engine type (main or auxiliary), engine model year, average engine horsepower, and natural turnover populations.

Tables C-10 and C-11 below show the total horsepower within each CHC category for repowers and retrofits, and vessel replacements/new-builds, respectively for the odd years (2023 to 2037). The cost analysis document provided in Appendix A describes these calculations in additional detail.

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[79] See Cost Analysis Document provided in Appendix A for more information about the sources of the cost data.

[80] Public Workshop for the Draft Proposed Amendments to the Commercial Harbor Craft Regulation, March 16, 2021, *https://ww2.arb.ca.gov/resources/documents/public-workshop-presentation-english-march-16-2021.*

Table C-10. Total Repower/Retrofit Horsepower by CHC Category

Vessel Category	2023	2025	2027	2029	2031	2033	2035	2037	Average HP (All Years)	Number of Vessels (All Years)
Ferry (Catamaran)	0	4,808	14,892	3,329	2,423	7,505	1,678	0	5,018	18
Ferry (Monohull)	0	829	2,617	749	256	808	231	0	1,281	9
Ferry (Short Run)	0	2,356	618	775	0	0	0	0	405	10
Pilot Boat	0	2,919	34	36	730	8	4	0	305	3
Push/Tow Tug	0	21,713	8,550	1,409	1,018	334	28	0	5,682	60
Escort/Ship Assist Tug	0	43,384	11,434	467	603	151	0	0	8,643	26
ATB Tug	0	38,938	1,790	408	541	16	0	0	7,809	13
Research Vessel	0	0	112	1,812	145	25	386	0	313	4
Commercial Passenger Fishing	0	0	274	78	0	0	0	0	53	1
Excursion	0	0	27,169	4,723	178	377	61	0	4,746	91
Dredge	0	0	0	0	41	185	0	0	352	7
ATB Barge	0	0	0	0	0	0	0	0	895	6
Bunker Barge	0	0	0	0	0	0	0	0	20	1
Other Barge	0	0	0	0	158	52	0	0	327	11
Towed Petrochemical Barge	0	0	0	0	24	12	0	0	55	1
Crew Supply	0	0	0	0	4,392	2,194	0	0	2,634	36
Workboat	0	0	0	0	4,351	1,355	0	0	2,452	43

Table C-11. Total Vessel Replacement Horsepower by CHC Category

Vessel Category	2023	2025	2027	2029	2031	2033	2035	2037	Average HP (All Years)	Number of Vessels (All Years)
Ferry (Catamaran)	0	938	9,665	3,766	3,212	9,010	2,519	0	3,518	13
Ferry (Monohull)	0	384	2,513	838	586	1,216	323	0	764	5
Ferry (Short Run)	0	0	0	0	0	0	0	0	0	0
Pilot Boat	0	395	195	150	858	25	14	0	207	2
Push/Tow Tug	1,200	1,601	1,946	1,787	1,320	1,031	389	0	1,222	13
Escort/Ship Assist Tug	91	2,635	1,931	1,520	786	532	273	0	1,047	3
ATB Tug	451	2,329	801	450	592	110	5	0	760	1
Research Vessel	253	0	158	357	7	215	290	0	179	2
Commercial Passenger Fishing	501	474	2,487	22,596	4,292	16,386	2,447	0	7,525	155
Excursion	684	8	1,567	500	167	482	397	0	463	9
Dredge	0	84	0	0	62	422	0	0	108	2
ATB Barge	0	128	0	0	0	0	0	0	84	1
Bunker Barge	0	0	0	0	0	0	0	0	4	0
Other Barge	143	2	0	36	161	200	0	0	94	3
Towed Petrochemical Barge	0	3	0	0	25	213	0	0	53	1
Crew Supply	91	34	661	91	4,663	4,525	0	0	1,611	22
Workboat	1,676	2,737	1,513	1,676	7,093	5,471	0	0	2,781	49

b. Vessel Facility Population

Facility owner/operators are private or public entities that accept payment for allowing CHC to dock or moor at their facilities. These entities include ports, terminals, marinas, harbors, and land with docks. Facility owner/operators would incur direct costs for recordkeeping and reporting requirements, and for costs to install shore power infrastructure if the facility receives more than 50 vessel visits per year.

In order to estimate the number of facilities that would be subject to the Proposed Amendments, staff identified facilities statewide using publicly available information contained on the Division of Boating and Waterways' website.[81] Staff searched for CHC facilities by city and analyzed satellite imagery and/or information listed on the facility website to determine whether the facility conducted or was capable of conducting business with CHC owners and operators. Staff further refined this list by contacting the facilities by phone or electronic mail and removing any that confirmed that they do not conduct business with CHC. Based on this analysis, staff estimates that there are 276 facilities that could be subject to the requirements in the Proposed Amendments.[82]

c. Repower and Retrofit Costs for In-Use Vessels

As stated previously, the Proposed Amendments would establish a performance standard equivalent to Tier 3 plus a DPF, or Tier 4 plus a DPF if there is an available engine model certified to Tier 4, for engines less than or equal to 600 kW. Staff expects that the majority of engines rated at or below 448 kW would repower to Tier 3 marine standards, and for the purposes of the cost analysis, cost values for repowering to Tier 3 were applied to all engine horsepower less than or equal to 448 kW. Engines greater than 448 kW would likely be able to meet a performance standard equivalent to a Tier 4 engine plus a DPF; therefore, staff applied cost values for repowering to Tier 4 plus a DPF to all engine horsepower greater than 448 kW.

Vessel owner/operators would incur the following repower and retrofit costs.

- Capital costs: The costs resulting from equipment purchased to comply with the Proposed Amendments—i.e., Tier 3 or Tier 4 engines, DPFs, or zero-emission propulsion systems (short run ferries). The capital costs for repower and retrofits range between $141 and $692 per horsepower, depending on the vessel category and engine tier. Tables II-A through II-Q in Appendix A provides further details on the engine capital costs.
- Labor and installation costs: The costs resulting from labor and vessel modifications required to install the equipment, including structural and mechanical alternations, accessing the engine room, testing and commissioning, and shipyard costs. Labor and installation costs range between $41 and $512

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[81] California Division of Boating and Waterways, Find a Boating Facility, last accessed January 2021, *http://www.dbw.ca.gov/BoatingFacilities*.

[82] Copy of Facility Contact Sheet, 2019.

per horsepower, depending on the vessel category and engine tier. Tables II-A through II-Q in Appendix A provides further details on the labor and installation costs.

- Operational costs:
    - Tier 3 repower: Incremental costs would be due to differences in fuel consumption. However, staff assumes no incremental differences in fuel consumption by repowering to Tier 3, and therefore assigned no operational costs to this scenario.
    - Tier 4 repower: Maintenance costs of SCR aftertreatment systems resulting from Tier 4 engine repowers, the cost of DEF (used as a reductant) commonly used in Tier 4 engines, and fuel savings resulting from more thermodynamically efficient Tier 4 main engines.[83]
    - DPF Retrofit: Cost of fuel used during the DPF regeneration process, and annual maintenance costs.[84]
- Loss of use costs: Costs incurred due to vessel downtime during the repower and retrofit process.

For short-run ferries, ZEAT requirements starting on January 1, 2026, would apply to both in-use and new-build vessels. In addition to the repower costs, vessel owner/operators would also incur zero-emission infrastructure costs, costs for electricity, and cost savings from reductions in fuel usage. These costs are described in 2.g. of this chapter and Appendix A.

For commercial fishing vessels, the Proposed Amendments would require all engines to meet U.S. EPA-certified Tier 2 or higher emissions standards, which would result in engine repower costs to vessel owners/operators. For the purposes of the cost analysis, staff applied Tier 3 repower cost values to all commercial fishing vessel horsepower due to the advancements of engine technology and the high probability that Tier 3 engines will be the standard engine in 2030 to 2032. It is possible an operator could remove an existing Tier 2 engine from one vessel and newly install it in their commercial fishing vessel; however, most commercial fishing vessel operators do not operate vessels in regulated in-use vessel categories that might be having Tier 2 engines removed to comply with the Proposed Amendments. Additionally, U.S. EPA requirements on engine manufacturers no longer allow for the sale of Tier 2 marine engines in most circumstances, and the Proposed Amendments would not allow for an operator to newly purchase a used Tier 2 engine.

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[83] Staff assumed no hydrodynamic drag penalty for the extra weight from the heavier engine. Fuel consumption is impacted by a variety of factors including vessel speed, water currents, meteorological conditions, and other operational considerations. Staff assumed that for cases where vessel weight would substantially impact vessel drag, operator compliance outcomes would favor new build vessels, which are already incorporated in the compliance outcome percentages identified in the CMA report and reported in Tables C-4 and C-5 above. New build vessels would be designed with shapes, sizes, and densities to maximize operational utility and hydrodynamic efficiencies, and therefore would not be associated with increased drag even if required to operate with heavier engines.

[84] Staff assumed no hydrodynamic drag penalty for the extra weight from the aftertreatment devices. See detail in footnote 83 above for justification.

Staff compiled three different cost summaries for repower and retrofit costs during the analysis timeframe. The first summary amortized engine repower and DPF retrofit capital, labor and installation, sales tax, and loss of use costs over the lifetime of the engine, based on survival curves for each vessel category (see Appendix A for more detail). These costs are summarized in Table C-12.

The second summary presents non-amortized repower and retrofit costs. Under this scenario, vessel owner/operators would incur the entire capital, sales tax, labor, and installation costs up-front based on the compliance year. These costs are summarized in Table C-13.

The third cost scenario is a cash flow analysis that factors in financing of up-front capital costs to show how costs are spread during the analysis period. Based on feedback from stakeholders, [85,86] staff assumed that 70 percent of the non-amortized cost would be financed with a 15-year loan at an interest rate of 4 percent, and that 30 percent of the non-amortized capital cost would be required as an up-front cost. These costs are summarized in Table C-14.

During the regulatory development process, staff received limited stakeholder cost information[87] about the revenue generated from scrapping existing engines. This data was not comprehensive across all vessel categories. Because there were not enough data to support assuming scrapping or reselling engines provided monetary value, staff did not include these cost savings in this SRIA document. Note that resale cost savings were included when vessel replacement was required, as discussed in the next subsection.

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[85] Staff communications with SWITCH Maritime on November 4, 2020.

[86] R.E. Staite Engineering, INC. comment letter to CARB, Proposed Amendments to the Regulations to Reduce Emissions from Diesel Engines on Commercial Harbor Craft (CHC) operated within California Waters and 24 Nautical Miles of the California Baseline, October 30, 2019.

[87] Scrapped Disposal Costs per Vessel Category.xlsx

Table C-12. Amortized Repower and Retrofit Costs by Cost Type (2019 $)

Year	Repower Capital Costs	Repower Labor and Installation Costs	Retrofit Capital Costs	Retrofit Labor and Installation Costs	Repower and Retrofit Operational Costs	Sales Tax	Fuel Savings Costs	Loss of Use	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$4,682,904	$2,432,604	$0	$0	$720,632	$402,730	-$697,939	$1,061,261	$8,897,400	-$697,939	$8,199,461
2024	$14,750,659	$7,732,455	$710,718	$1,687,576	$3,456,225	$1,329,678	-$3,341,502	$3,147,134	$31,484,767	-$3,341,502	$28,143,265
2025	$22,139,167	$11,414,069	$1,282,097	$2,708,805	$5,661,975	$2,014,229	-$5,396,119	$4,479,121	$47,685,234	-$5,396,119	$42,289,114
2026	$26,720,461	$14,196,272	$2,034,911	$4,266,253	$7,207,698	$2,472,962	-$6,717,246	$5,197,037	$59,622,632	-$6,717,246	$52,905,386
2027	$29,219,941	$15,763,094	$2,917,034	$6,521,017	$8,145,851	$2,763,780	-$7,257,211	$5,950,221	$68,517,159	-$7,257,211	$61,259,948
2028	$31,240,943	$17,017,964	$3,571,322	$7,627,956	$8,794,331	$2,993,855	-$7,503,733	$6,827,577	$75,080,093	-$7,503,733	$67,576,360
2029	$31,773,750	$17,656,474	$4,096,398	$8,989,774	$9,177,801	$3,084,833	-$7,654,693	$7,375,775	$79,069,971	-$7,654,693	$71,415,279
2030	$33,872,605	$19,053,150	$4,780,927	$10,700,533	$9,934,389	$3,324,204	-$8,076,138	$8,891,486	$87,233,089	-$8,076,138	$79,156,951
2031	$35,336,852	$19,807,591	$4,868,931	$10,935,896	$10,102,094	$3,457,697	-$8,192,892	$9,596,567	$90,647,930	-$8,192,892	$82,455,038
2032	$36,512,336	$20,428,240	$4,908,655	$11,163,371	$10,204,725	$3,562,205	-$8,280,472	$10,172,430	$93,389,757	-$8,280,472	$85,109,285
2033	$36,900,282	$20,883,341	$5,005,856	$11,644,278	$10,424,079	$3,603,928	-$8,444,538	$10,352,827	$95,210,662	-$8,444,538	$86,766,124
2034	$37,117,172	$21,033,204	$5,072,768	$11,790,970	$10,499,948	$3,628,335	-$8,477,694	$10,466,989	$95,981,051	-$8,477,694	$87,503,357
2035	$37,190,206	$21,132,720	$5,169,246	$12,163,960	$10,593,931	$3,642,913	-$8,511,939	$10,637,747	$96,887,810	-$8,511,939	$88,375,871
2036	$37,278,741	$21,202,489	$5,239,097	$12,291,157	$10,665,341	$3,656,534	-$8,539,991	$10,759,508	$97,436,334	-$8,539,991	$88,896,343
2037	$37,278,741	$21,202,489	$5,239,097	$12,291,157	$10,665,341	$3,656,534	-$8,539,991	$10,759,508	$97,436,334	-$8,539,991	$88,896,343
2038	$37,278,741	$21,202,489	$5,239,097	$12,291,157	$10,665,341	$3,656,534	-$8,539,991	$10,759,508	$97,436,334	-$8,539,991	$88,896,343
Total	$489,293,503	$272,158,645	$60,136,152	$137,073,860	$136,919,700	$47,250,950	-$114,172,090	$126,434,695	$1,222,016,555	-$114,172,090	$1,107,844,465

Table C-13. Non-Amortized Repower and Retrofit Costs by Cost Type (2019 $)

Year	Repower Capital Costs	Repower Labor and Installation Costs	Retrofit Capital Costs	Retrofit Labor and Installation Costs	Repower and Retrofit Operational Costs	Sales Tax	Fuel Savings Costs	Loss of Use Costs	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$55,587,745	$40,742,436	$0	$0	$720,632	$4,780,546	-$697,939	$11,945,209	$108,996,021	-$697,939	$108,298,082
2024	$112,926,448	$82,464,017	$7,568,768	$18,285,641	$3,456,225	$10,362,589	-$3,341,502	$16,913,295	$241,614,394	-$3,341,502	$238,272,891
2025	$84,326,113	$56,749,858	$6,057,307	$10,986,813	$5,661,975	$7,772,974	-$5,396,119	$10,537,142	$174,319,208	-$5,396,119	$168,923,088
2026	$49,413,162	$37,764,046	$8,110,394	$17,466,122	$7,207,698	$4,947,026	-$6,717,246	$2,969,562	$122,930,984	-$6,717,246	$116,213,738
2027	$27,413,836	$22,982,409	$9,571,568	$27,273,409	$8,145,851	$3,180,745	-$7,257,211	$5,564,227	$100,951,299	-$7,257,211	$93,694,089
2028	$23,190,676	$22,014,377	$7,115,537	$13,321,833	$8,794,331	$2,606,334	-$7,503,733	$6,709,073	$81,145,825	-$7,503,733	$73,642,093
2029	$6,111,961	$8,690,105	$5,759,628	$19,761,136	$9,177,801	$1,020,957	-$7,654,693	$5,013,128	$54,513,758	-$7,654,693	$46,859,066
2030	$28,538,366	$29,427,364	$7,659,370	$26,268,287	$9,934,389	$3,113,005	-$8,076,138	$15,556,693	$117,384,469	-$8,076,138	$109,308,331
2031	$23,189,363	$22,462,789	$964,032	$2,697,741	$10,102,094	$2,077,192	-$8,192,892	$10,979,817	$70,395,836	-$8,192,892	$62,202,944
2032	$19,222,186	$19,148,612	$433,172	$2,661,508	$10,204,725	$1,690,361	-$8,280,472	$9,382,013	$61,052,216	-$8,280,472	$52,771,744
2033	$4,335,045	$6,240,115	$1,090,472	$6,022,714	$10,424,079	$466,594	-$8,444,538	$847,709	$28,960,133	-$8,444,538	$20,515,594
2034	$2,607,916	$2,756,462	$736,223	$1,727,385	$10,499,948	$287,596	-$8,477,694	$1,030,059	$19,357,993	-$8,477,694	$10,880,299
2035	$833,937	$1,356,017	$1,116,287	$6,048,709	$10,593,931	$167,719	-$8,511,939	$1,782,273	$21,731,154	-$8,511,939	$13,219,215
2036	$1,025,474	$1,201,727	$805,250	$2,267,997	$10,665,341	$157,442	-$8,539,991	$869,071	$16,834,861	-$8,539,991	$8,294,870
2037	$0	$0	$0	$0	$10,665,341	$0	-$8,539,991	$0	$10,665,341	-$8,539,991	$2,125,349
2038	$0	$0	$0	$0	$10,665,341	$0	-$8,539,991	$0	$10,665,341	-$8,539,991	$2,125,349
Total	$438,722,227	$354,000,334	$56,988,008	$154,789,295	$136,919,700	$42,631,080	-$114,172,090	$100,099,270	$1,241,518,832	-$114,172,090	$1,127,346,742

Table C-14. Cash Flow Analysis of Repower and Retrofit Costs by Cost Type (2019 $)

Year	Repower and Retrofit Capital Costs	Repower and Retrofit Labor and Installation Costs	Repower and Retrofit Operational Costs	Repower and Retrofit Loss of Use Costs
2023	$20,176,059	$2,432,604	$720,632	$1,061,261
2024	$47,234,531	$9,420,031	$3,456,225	$3,147,134
2025	$43,891,422	$14,122,874	$5,661,975	$4,479,121
2026	$37,655,075	$18,462,525	$7,207,698	$5,197,037
2027	$33,822,185	$22,284,111	$8,145,851	$5,950,221
2028	$33,726,469	$24,645,920	$8,794,331	$6,827,577
2029	$28,943,502	$26,646,248	$9,177,801	$7,375,775
2030	$38,520,312	$29,753,683	$9,934,389	$8,891,486
2031	$36,427,678	$30,743,487	$10,102,094	$9,596,567
2032	$36,315,744	$31,591,611	$10,204,725	$10,172,430
2033	$32,388,375	$32,527,618	$10,424,079	$10,352,827
2034	$31,974,505	$32,824,174	$10,499,948	$10,466,989
2035	$31,679,114	$33,296,680	$10,593,931	$10,637,747
2036	$31,758,524	$33,493,647	$10,665,341	$10,759,508
2037	$31,209,307	$33,493,647	$10,665,341	$10,759,508
2038	$27,709,571	$33,493,647	$10,665,341	$10,759,508
Total Cost	$543,432,371	$409,232,505	$136,919,700	$126,434,695

d. Vessel Replacement/New-Build Vessel Costs

Due to a variety of factors, including technical feasibility issues with repowering and/or retrofitting in-use engines, staff expects that some vessels would need to be replaced in order to meet performance standards in the Proposed Amendments. Engines greater than or equal to 600 kW on new-build vessels would be required to meet Tier 4 standards plus a DPF, and engines below 600 kW on new-build vessels would be required to meet Tier 3 standards plus a DPF, or Tier 4 if there is an available engine certified to this standard. For the purposes of the cost analysis, staff derived $/horsepower unit values based on the total cost of the vessel replacement and used Tier 4 capital plus DPF cost values from the applicable vessel category to determine the split between capital and labor and installation unit $/horsepower values.

Staff expects that vessel owner/operators would incur the following costs, which apply to all vessel categories except for short-run ferries and excursion vessels, which are described in more detail further in this section.

- Capital costs: The costs resulting from purchasing a new-build vessel and DPFs, ranging from $191 to $692 per HP (see Table II-A to Table II-Q in Appendix A, for details).
- Labor and installation costs: The costs resulting from designing and constructing a new vessel, and installing the DPFs, ranging from $1,559 to $18,088 per HP (see Table II-A to Table II-Q in Appendix A, for details).
- Operational costs:
  - Tier 3 engine: Incremental costs would be due to differences in fuel consumption; however, staff assumed no incremental differences in fuel consumption by purchasing a new vessel with Tier 3 engines, and therefore assigned no operational costs to this scenario. (see Table II-A to Table II-Q in Appendix A, for details)
  - Tier 4 engine: Maintenance costs of SCR aftertreatment systems resulting from purchasing a new vessel with Tier 4 engines, the cost of DEF (used as a reductant) on Tier 4 engines, and fuel savings resulting from more efficient Tier 4 main engines, ranging from -$11.5 to $5.2 per HP (see Table II-A to Table II-Q in Appendix A, for details).
  - DPF Retrofit: Cost of fuel used during the DPF regeneration process, and annual maintenance costs, ranging from $2.1 to $7.9 per HP (see Table II-A to Table II-Q in Appendix A, for details).
- Vessel resale revenue: Cost savings due to revenue from reselling the old vessel. Staff assumed that existing vessels would be sold outside of California, ranging from $335 to $3,819 per HP (see Table VI in Appendix A, for details).

ZEAT requirements for short-run ferries, would apply to both in-use and new-build vessels starting on January 1, 2026. However, staff assumes 100 percent of new and in-use short-run ferries vessels would be repowered with zero-emission powertrains instead of being replaced with a new-build vessel due to the large cost difference between a new-build vessel and a repower, which is estimated to be nearly

$1,000 per horsepower unit. Therefore, staff assumed there would be no new-build costs for in-use short-run ferries resulting from the Proposed Amendments.

New excursion vessels would be required to be zero-emission capable by January 1, 2025, meaning that one or more on-board power sources would be required to provide a minimum of 30 percent vessel power with zero-tailpipe emissions in a given calendar year. In addition to the new-build costs for excursion vessels, which include capital, labor and installation, and operational costs, owner/operators would also incur charging infrastructure costs, costs for electricity, and cost savings from reductions in fuel usage. These costs are described in Section C.2.h.

Staff compiled three different cost summaries for new-build vessel costs during the analysis timeframe. The first summary amortizes new-build and DPF retrofit capital, sales tax, labor and installation, and vessel resale revenue over the lifetime of the vessel, based on survival curves for each vessel category (see Appendix A for more detail). After the end of the useful life period, staff assumed that a new DPF would need to be purchased, and that this cost is attributable to the Proposed Amendments (i.e., incremental to baseline). Staff assumed that the DPF capital and labor and installation costs would be amortized over the engine lifetime. Tier 3 and Tier 4 engine repower capital, labor, and installation costs are amortized over the engine's useful life. The amortized vessel replacement costs are summarized in Table C-15.

The second summary presents non-amortized new-build costs. Under this scenario, vessel owner/operators would incur the entire capital, sales tax, labor, and installation costs up-front based on the compliance year. These costs are summarized in Table C-16.

The third cost scenario is a cash flow analysis that factors in financing of up-front capital costs to show how costs are spread during the analysis period. Based on feedback from stakeholders,[88, 89] staff assumed that 70 percent of the non-amortized cost would be financed with a 15-year loan at an interest rate of 4 percent, and that 30 percent of the non-amortized capital cost would be required as an up-front cost. These costs are summarized in Table C-17.

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[88] Staff communications with SWITCH Maritime on November 4, 2020.

[89] R.E. Staite Engineering, INC. comment letter to CARB, Proposed Amendments to the Regulations to Reduce Emissions from Diesel Engines on Commercial Harbor Craft (CHC) operated within California Waters and 24 Nautical Miles of the California Baseline, October 30, 2020.

Table C-15. Amortized Vessel Replacement Costs by Cost Type (2019 $)

Year	Vessel Replacement Cost	Retrofit Capital Costs	Retrofit Labor and Installation Costs	Retrofit Operational Costs	Sales Tax	Vessel Resale Revenue	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$903,470	$12,319	$29,221	$14,426	$7,614	-$199,203	$959,435	-$199,203	$760,232
2024	$3,332,456	$47,307	$167,312	$82,082	$33,825	-$684,366	$3,629,157	-$684,366	$2,944,791
2025	$5,403,963	$72,939	$239,826	$129,222	$53,605	-$1,088,268	$5,845,950	-$1,088,268	$4,757,683
2026	$7,839,165	$100,976	$327,796	$173,190	$77,911	-$1,517,769	$8,441,127	-$1,517,769	$6,923,359
2027	$12,276,914	$151,601	$643,325	$263,567	$122,440	-$2,373,452	$13,335,406	-$2,373,452	$10,961,954
2028	$15,813,217	$187,027	$782,688	$315,990	$150,137	-$3,071,614	$17,098,922	-$3,071,614	$14,027,308
2029	$20,790,913	$233,824	$982,929	$381,681	$195,430	-$3,966,438	$22,389,348	-$3,966,438	$18,422,910
2030	$28,455,600	$307,294	$1,374,110	$495,152	$260,432	-$5,440,326	$30,632,156	-$5,440,326	$25,191,830
2031	$32,588,498	$351,619	$1,538,767	$556,573	$294,263	-$6,247,908	$35,035,458	-$6,247,908	$28,787,549
2032	$36,844,856	$391,176	$1,737,099	$615,573	$333,493	-$7,011,129	$39,588,704	-$7,011,129	$32,577,575
2033	$43,467,288	$451,591	$2,065,210	$710,503	$387,875	-$8,278,747	$46,694,592	-$8,278,747	$38,415,844
2034	$48,185,345	$495,196	$2,209,521	$763,178	$427,063	-$9,132,165	$51,653,241	-$9,132,165	$42,521,075
2035	$49,376,908	$506,513	$2,291,732	$783,467	$438,023	-$9,355,791	$52,958,620	-$9,355,791	$43,602,828
2036	$51,394,980	$526,835	$2,324,044	$805,204	$451,456	-$9,756,845	$55,051,063	-$9,756,845	$45,294,218
2037	$51,394,980	$526,835	$2,324,044	$805,204	$451,456	-$9,756,845	$55,051,063	-$9,756,845	$45,294,218
2038	$51,394,980	$526,835	$2,324,044	$805,204	$451,456	-$9,756,845	$55,051,063	-$9,756,845	$45,294,218
Total	$459,463,533	$4,889,886	$21,361,667	$7,700,216	$4,136,480	-$87,637,710	$493,415,303	-$87,637,710	$405,777,593

Table C-16. Non-Amortized Vessel Replacement Costs by Cost Type (2019 $)

Year	Vessel Replacement Cost	Retrofit Capital Costs	Retrofit Labor and Installation Costs	Retrofit Operational Costs	Sales Tax	Vessel Resale Revenue	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$14,317,627	$12,319	$29,221	$14,426	$127,225	-$3,028,349	$14,373,593	-$3,028,349	$11,345,243
2024	$36,496,051	$34,988	$138,091	$82,082	$386,768	-$9,389,358	$36,751,213	-$9,389,358	$27,361,855
2025	$41,084,228	$25,632	$72,514	$129,222	$505,705	-$6,165,996	$41,311,596	-$6,165,996	$35,145,600
2026	$43,300,328	$28,037	$87,970	$173,190	$476,709	-$7,983,423	$43,589,525	-$7,983,423	$35,606,102
2027	$75,057,327	$50,625	$315,529	$263,567	$847,782	-$16,914,961	$75,687,048	-$16,914,961	$58,772,087
2028	$59,560,954	$35,427	$139,363	$315,990	$523,979	-$10,473,429	$60,051,734	-$10,473,429	$49,578,305
2029	$87,820,870	$46,797	$200,241	$381,681	$892,328	-$17,916,689	$88,449,589	-$17,916,689	$70,532,900
2030	$130,256,179	$73,469	$391,182	$495,152	$1,243,628	-$27,531,097	$131,215,982	-$27,531,097	$103,684,885
2031	$70,353,731	$44,325	$164,657	$556,573	$640,791	-$13,478,494	$71,119,286	-$13,478,494	$57,640,793
2032	$75,056,429	$39,557	$198,331	$615,573	$772,806	-$16,321,052	$75,909,891	-$16,321,052	$59,588,840
2033	$113,193,109	$60,415	$328,111	$710,503	$1,047,231	-$24,244,748	$114,292,138	-$24,244,748	$90,047,390
2034	$83,126,362	$43,605	$144,311	$763,178	$767,867	-$16,833,812	$84,077,456	-$16,833,812	$67,243,645
2035	$20,399,847	$11,317	$82,210	$783,467	$211,934	-$4,678,263	$21,276,842	-$4,678,263	$16,598,579
2036	$34,155,340	$20,322	$32,312	$805,204	$250,365	-$6,038,390	$35,013,179	-$6,038,390	$28,974,788
2037	$0	$0	$0	$805,204	$0	$0	$805,204	$0	$805,204
2038	$0	$0	$0	$805,204	$0	$0	$805,204	$0	$805,204
Total	$884,178,385	$526,835	$2,324,044	$7,700,216	$8,695,117	-$180,998,059	$894,729,480	-$180,998,059	$713,731,420

Table C-17. Cash Flow Analysis of New-Build Vessel Costs by Cost Type (2019 $)

Year	Vessel Replacement Capital Costs	Vessel Replacement Labor and Installation Costs	Vessel Resale Revenue
2023	$536,946	$827,257	-$199,203
2024	$1,725,474	$2,986,451	-$684,366
2025	$2,510,587	$4,853,589	-$1,088,268
2026	$2,758,425	$7,034,198	-$1,517,769
2027	$4,673,509	$11,004,789	-$2,373,452
2028	$3,927,557	$14,254,470	-$3,071,614
2029	$5,865,752	$18,752,291	-$3,966,438
2030	$8,001,651	$25,734,615	-$5,440,326
2031	$6,367,838	$29,518,453	-$6,247,908
2032	$7,394,111	$33,358,202	-$7,011,129
2033	$9,118,063	$39,408,706	-$8,278,747
2034	$8,705,675	$43,714,689	-$9,132,165
2035	$6,921,527	$44,790,133	-$9,355,791
2036	$7,238,875	$46,672,326	-$9,756,845
2037	$6,365,510	$46,672,326	-$9,756,845
2038	$6,272,371	$46,672,326	-$9,756,845
Total Cost	$88,383,872	$416,254,819	-$87,637,710

e. Sales Tax

Sales tax is an additional cost levied on top of the purchase price of an engine, a DPF, and a new vessel. The sales tax varies across the state from a minimum of 7.25 percent up to 10.5 percent in some municipalities. A value of 8.6 percent was used for staff's analysis based on a weighted average based on county-level output.[90]

Staff applied this sales tax percentage to the capital cost values of engines and retrofit devices, and new-build vessels. In order to ensure sales tax costs were properly accounted for, staff deducted sales tax line items in new-build vessel costs estimates that were provided by stakeholders (See Table II-A through Table II-P in Appendix A for the new-build vessel costs estimates). Staff also assumed that the insured vessel replacement values in the CSU Maritime Academy Report[91] included sales tax. Because a specific sales tax value was not provided in the CSU Maritime Academy Report, staff assumed a statewide sales tax value of 8.6 percent.

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[90] California Department of Tax and Fee Administration, "California City & County Sales & Use Tax Rates, October 1, 2020, last accessed February 10, 2021, *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm*.

[91] CSU Maritime Academy, "Evaluation of the Feasibility and Costs of Installing Tier 4 Engines and Retrofit Exhaust Aftertreatment on In-Use Commercial Harbor Craft, 2019, last accessed February 2021, *https://ww2.arb.ca.gov/sites/default/filesf/2019-10/cmafeasibilityreport09302019.pdf*.

f. Facility Shore Power Infrastructure

The Proposed Amendments contain an idling provision that would prohibit all propulsion engines from idling, and auxiliary engines from operating for more than 15 consecutive minutes when the vessel is docked, berthed, or moored. Shore power is included as a compliance strategy if on-board power from auxiliary engines would be needed in excess of the 15-minute threshold. Facility owner/operators receiving more than 50 vessel visits per year would be required to install and maintain shore power infrastructure. Staff assumed that facility owners/operators would comply with the requirements in the Proposed Amendments by installing infrastructure powered by the electric utility.

Both vessel owner/operators and facility owner/operators would incur costs as a result of the infrastructure required to enable a shore power connection and permit vessel owners/operators to shut down all on-board auxiliary generators.

- Vessel owners/operators would incur costs to ensure the necessary infrastructure is present on the vessel to enable the connection to shore power and would incur costs from the use of electricity for shore power, which would be mostly offset by costs savings as a result of reductions in diesel fuel used to power auxiliary engines.
- Facility owners/operators would incur costs to purchase and install charging infrastructure, and the direct costs of electricity supplied to vessels, which staff assumes would be passed through to the end-user.

g. Infrastructure Equipment Costs

Staff derived $/horsepower unit values for the costs of the equipment and installation, engineering costs, and utility-related costs to bring power to the facility. Staff assumed shore power costs would include the following costs: upstream utility costs ($45 per HP), charging station costs $194 per HP) engineering costs (($14 per HP), installation costs ($26 per HP), and vessel-side infrastructure costs ($53 per HP). (See Table VIII-A and Table VIII-B in Appendix A for detailed calculations). Staff applied these unit costs to the total auxiliary engine horsepower that staff assumed would incur costs as a result of the Proposed Amendments. In order to derive this auxiliary engine horsepower value, staff used data from a 2019 survey of commercial harbor craft owners.[92] Results from the survey showed that 24 percent of vessels were not equipped with the capability to establish a shore power connection. Staff assumed that of this 24 percent, 50 percent would comply by limiting the vessel's idling and operating time to under 15 minutes, and 50 percent would comply by connecting to shore power, and therefore incur shore power costs. Staff applied this percentage to the total auxiliary engine horsepower from the inventory. Staff applied both vessel-side infrastructure costs and facility-side infrastructure costs to this horsepower value.

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[92] 2019 Master Survey for Cost Analysis.

Staff assumed that the purchase and installation of shore power would be amortized over a period of 20 years at an interest rate of 5 percent.[93]

h. Electricity Costs and Diesel Fuel Savings

The California Energy Commission (CEC) provides diesel and electricity fuel price forecasts as part of the Integrated Energy Policy Report (IEPR) process. The forecast includes three demand cases designed to capture a reasonable range of demand outcomes over the next 10 years. The "high-energy demand case" incorporates relatively high economic/demographic growth, relatively low electricity and natural gas rates, and relatively low committed efficiency program, self-generation, and climate change impacts. The "low-energy demand case" includes lower economic/demographic growth, higher assumed rates, and higher committed efficiency program and self-generation impacts. The "mid" case uses input assumptions at levels between the "high" and "low" cases.[94]

For this analysis, the average California diesel ($/DGE, diesel gallon equivalency) and electricity fuel prices ($/GGE, gasoline gallon equivalency) to 2031 were taken from CEC's "Transportation Energy Demand Forecast 2020 IEPR Update".[95] Fuel prices past 2031 were calculated using the Energy Information Administration's (EIA) 2020 Annual Energy Outlook for the Pacific region.[96] The annual percentage change in EIA diesel and electricity fuel prices past 2031 was applied to the 2031 CEC diesel and electricity prices to estimate price changes past 2031. The electricity price projections represent commercial electricity prices in the mid-case scenario. Table C-18 lists the Diesel and Electricity Price Projections from 2023 to 2038. Staff used these prices to derive electricity costs and fuel savings costs.

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[93] CARB staff assumption, which aligns with expected lifetime data and assumptions presented in the California Air Resources Board, Standardized Regulatory Impact Assessment for the Proposed Control Measure for Ocean-Going Vessels At Berth, August 2019, last accessed June 2021, *https://ww3.arb.ca.gov/regact/2019/ogvatberth2019/appc-1.pdf*.

[94] California Energy Commission, Final 2019 Integrated Energy Policy Report, February 2020, last accessed January 2021, *https://efiling.energy.ca.gov/getdocument.aspx?tn=232922*.

[95] California Energy Commission, Transportation Energy Demand Forecast 2020 IEPR Update, December 3, 2020, last accessed January 2021), *https://efiling.energy.ca.gov/GetDocument.aspx?tn=235841&DocumentContentId=68785*.

[96] Energy Information Administration, Annual Energy Outlook 2020, last accessed January 2021, *https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2020&region=1-9&cases=ref2020&start=2018&end=2050&f=A&linechart=ref2020-d112119a.3-3-AEO2020.1-9&map=ref2020-d112119a.4-3-AEO2020.1-9&sourcekey=0*.

Table C-18. Diesel and Electricity Price Projections from 2023 to 2038 (2019 $)

Year	Diesel ($/gal)	Electricity ($/kWh)
2023	$2.38	$0.23
2024	$2.38	$0.23
2025	$2.35	$0.24
2026	$2.34	$0.24
2027	$2.28	$0.25
2028	$2.25	$0.25
2029	$2.19	$0.26
2030	$2.15	$0.26
2031	$2.15	$0.27
2032	$2.16	$0.27
2033	$2.20	$0.27
2034	$2.21	$0.27
2035	$2.23	$0.26
2036	$2.26	$0.26
2037	$2.27	$0.26
2038	$2.29	$0.26

The total amortized and non-amortized shore power infrastructure costs and fuel savings are summarized in Table C-19 and Table C-20.

Table C-19. Amortized Shore Power Infrastructure Costs (2019 $)

Year	Upstream Utility Cost	Charging Station Cost	Installation Cost	Dock Construction Cost	Vessel-Side Infrastructure Cost	Engineering Cost	Fuel Savings	Electricity Costs	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$186,692	$804,692	$107,119	$0	$219,946	$57,808	-$441,744	$442,085	$1,818,343	-$441,744	$1,376,599
2024	$186,790	$805,116	$107,175	$0	$220,062	$57,839	-$442,325	$442,283	$1,819,265	-$442,325	$1,376,940
2025	$186,793	$805,128	$107,177	$0	$220,065	$57,840	-$436,203	$454,661	$1,831,663	-$436,203	$1,395,460
2026	$186,796	$805,140	$107,179	$0	$220,069	$57,841	-$434,715	$464,247	$1,841,271	-$434,715	$1,406,555
2027	$186,799	$805,153	$107,180	$0	$220,072	$57,841	-$424,353	$471,663	$1,848,709	-$424,353	$1,424,356
2028	$186,802	$805,166	$107,182	$0	$220,076	$57,842	-$418,430	$480,787	$1,857,855	-$418,430	$1,439,425
2029	$186,805	$805,180	$107,184	$0	$220,080	$57,843	-$407,729	$489,178	$1,866,270	-$407,729	$1,458,541
2030	$186,808	$805,194	$107,186	$0	$220,083	$57,844	-$400,450	$498,318	$1,875,433	-$400,450	$1,474,983
2031	$186,812	$805,208	$107,188	$0	$220,087	$57,845	-$399,215	$507,628	$1,884,768	-$399,215	$1,485,553
2032	$186,815	$805,223	$107,189	$0	$220,091	$57,846	-$402,111	$506,612	$1,883,777	-$402,111	$1,481,666
2033	$186,819	$805,238	$107,192	$0	$220,095	$57,848	-$408,580	$505,726	$1,882,917	-$408,580	$1,474,337
2034	$186,822	$805,253	$107,194	$0	$220,100	$57,849	-$411,877	$506,050	$1,883,267	-$411,877	$1,471,390
2035	$186,826	$805,269	$107,196	$0	$220,104	$57,850	-$415,568	$502,508	$1,879,753	-$415,568	$1,464,185
2036	$186,830	$805,286	$107,198	$0	$220,109	$57,851	-$419,787	$498,204	$1,875,477	-$419,787	$1,455,690
2037	$186,834	$805,303	$107,200	$0	$220,113	$57,852	-$422,640	$496,150	$1,873,452	-$422,640	$1,450,813
2038	$186,838	$805,320	$107,202	$0	$220,118	$57,853	-$426,211	$493,665	$1,870,997	-$426,211	$1,444,785
Total	$2,988,881	$12,882,869	$1,714,939	$0	$3,521,271	$925,493	-$6,711,939	$7,759,764	$29,793,218	-$6,711,939	$23,081,279

Table C-20. Non-Amortized Shore Power Infrastructure Costs (2019 $)

Year	Upstream Utility Cost	Charging Station Cost	Installation Cost	Dock Construction Cost	Vessel-Side Infrastructure Cost	Engineering Costs	Fuel Savings	Electricity Costs	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$1,163,298	$5,014,124	$667,469	$0	$1,370,509	$360,210	-$441,744	$442,085	$9,017,695	-$441,744	$8,575,951
2024	$1,163,910	$5,016,760	$667,820	$0	$1,371,230	$360,399	-$442,325	$442,283	$9,022,403	-$442,325	$8,580,078
2025	$0	$0	$0	$0	$0	$0	-$436,203	$454,661	$454,661	-$436,203	$18,458
2026	$0	$0	$0	$0	$0	$0	-$434,715	$464,247	$464,247	-$434,715	$29,531
2027	$0	$0	$0	$0	$0	$0	-$424,353	$471,663	$471,663	-$424,353	$47,310
2028	$0	$0	$0	$0	$0	$0	-$418,430	$480,787	$480,787	-$418,430	$62,357
2029	$0	$0	$0	$0	$0	$0	-$407,729	$489,178	$489,178	-$407,729	$81,450
2030	$0	$0	$0	$0	$0	$0	-$400,450	$498,318	$498,318	-$400,450	$97,868
2031	$0	$0	$0	$0	$0	$0	-$399,215	$507,628	$507,628	-$399,215	$108,413
2032	$0	$0	$0	$0	$0	$0	-$402,111	$506,612	$506,612	-$402,111	$104,501
2033	$0	$0	$0	$0	$0	$0	-$408,580	$505,726	$505,726	-$408,580	$97,146
2034	$0	$0	$0	$0	$0	$0	-$411,877	$506,050	$506,050	-$411,877	$94,173
2035	$0	$0	$0	$0	$0	$0	-$415,568	$502,508	$502,508	-$415,568	$86,940
2036	$0	$0	$0	$0	$0	$0	-$419,787	$498,204	$498,204	-$419,787	$78,417
2037	$0	$0	$0	$0	$0	$0	-$422,640	$496,150	$496,150	-$422,640	$73,511
2038	$0	$0	$0	$0	$0	$0	-$426,211	$493,665	$493,665	-$426,211	$67,454
Total	$2,327,208	$10,030,884	$1,335,289	$0	$2,741,739	$720,609	-$6,711,939	$7,759,764	$24,915,494	-$6,711,939	$18,203,555

i. Zero-Emission Infrastructure

The Proposed Amendments would require owner/operators of Short Run Ferries and Excursion Vessels to adopt zero-emission and zero-emission capable hybrid technologies. In order to meet these ZEAT requirements, staff expects that installation of charging infrastructure would be required.

Vessel owner/operators would incur costs for the installation and maintenance of all zero-emission infrastructure on both the vessel and the facility, including infrastructure for electric charging, hydrogen or other alternative refueling, or other advanced technologies. However, the share of charging infrastructure costs that vessel owners/operators and facility owners/operators would bear is not fully understood as the passage of AB 841 in September 2020 changed the way these costs are allocated. AB 841 was passed with the goal of accelerating emission reductions and meeting the State's climate goals. To meet these goals, more zero-emission vehicles and electric charging would need to be made available throughout the State. A large hurdle to achieving these goals is due to the cost of installing charging infrastructure. AB 841 places charging infrastructure costs on the utility side of the meter at no-cost to the customer. The CPUC requested that utilities submit letters to suggest new tariffs and rules, for the commission to approve or deny. Multiple utility companies submitted letters proposing the establishment of a tariff that would place responsibility for the design and deployment of electrical distribution infrastructure necessary on the utility side of the customer meter on the utility, and all installation and maintenance of infrastructure on the customer side of the meter to be the customer's responsibility. The CPUC is scheduled to approve or deny the request for these tariffs at the end of June 2021.

For the cost analysis, staff assumed that the charging infrastructure would be powered by grid electricity. Although hydrogen-powered vessels and associated infrastructure is expected to some degree under the Proposed Amendments, based on the cost data that staff received from stakeholders and the current state of the technology, staff assumed that all zero-emission and advanced technologies would be powered by battery-electric technology[97]. However, staff acknowledges that hydrogen fuel cell electric technologies, at some point in the future, may represent some of the market share of ZEAT deployments in the marine harbor craft sector.

Staff assumed the following Zero-Emission Infrastructure costs for an individual facility:

- Upstream Utility Costs: $2,096,885;
- Charging Station Cost: $2,748,070;

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[97] As of May 21, 2021, staff is aware of five vessels operating in revenue service in the United States that operate with fuel derived from zero-emission tailpipe fuels. All of these vessels use lithium-ion batteries for on-board energy storage, and there is no hydrogen fuel cell vessel currently operated in normal revenue service. There are hydrogen fuel cell vessels that are constructed and still undergoing final U.S. Coast Guard approvals, and would need to undergo sea trials before being able to enter revenue service. An updated and more detailed overview of these technologies will be provided as part of the staff report in the Initial Statement of Reasons in support of the Proposed Amendments.

- Installation Cost: $365,817;
- Vessel-Side Infrastructure: $751,129; and
- Dock Construction Cost: $0.

See Table VIII-B of Appendix A for a description of the infrastructure cost inputs for short-run ferry and excursion charging infrastructure.

j. Infrastructure Equipment Costs

Staff estimated that 17 charging facilities would need to be installed throughout the State in order to meet the charging demands resulting from ZEAT requirements. There are 16 short run ferries in the State, and staff assumed that 8 charging installations would be needed to support zero-emission requirements. There are fewer charging infrastructure installations than vessels because most fleets operate multiple vessels over the same routes and terminals. Staff assumed that 9 short run ferries would be replaced with zero-emission vessels, and that each vessel would need its own charging infrastructure installation.

Staff assumed that the purchase and installation of charging infrastructure would be amortized over a period of 20 years at an interest rate of 5 percent.[98] After the initial 20-year period, staff assumed a reduction of 50 percent in infrastructure costs, which represents repairs and replacement of infrastructure components.[99]

k. Electricity Costs and Diesel Fuel Savings

Staff assumed the same cost inputs for electricity and diesel fuel as listed in Section C.2.h. above.

Tables C-21 and C-22 summarize the amortized and non-amortized direct costs for zero-emission infrastructure that staff assumes would be incurred by vessel owner/operators as a result of the Proposed Amendments.

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[98] CARB staff assumption, which aligns with expected lifetime data and assumptions presented in the California Air Resources Board, Standardized Regulatory Impact Assessment for the Proposed Control Measure for Ocean-Going Vessels At Berth, August 2019, last accessed June 2021, *https://ww3.arb.ca.gov/regact/2019/ogvatberth2019/appc-1.pdf*.

[99] Ibid.

Table C-21. Amortized Zero-Emission and Advanced Technology Infrastructure Costs (2019 $)

Year	Upstream Utility Cost	Charging Station Cost	Installation Cost	Dock Construction Cost	Vessel-Side Infrastructure Cost	Fuel Savings	Electricity Costs	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	$0	$0	$8,096,743	$0	$8,096,743
2024	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	$0	$0	$8,096,743	$0	$8,096,743
2025	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$18,443	$19,223	$8,115,966	-$18,443	$8,097,523
2026	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$941,980	$1,005,498	$9,102,241	-$941,980	$8,160,262
2027	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,356,063	$1,465,746	$9,562,489	-$1,356,063	$8,206,426
2028	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,431,604	$1,552,545	$9,649,288	-$1,431,604	$8,217,684
2029	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,650,191	$1,814,798	$9,911,540	-$1,650,191	$8,261,350
2030	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,661,806	$1,829,251	$9,925,994	-$1,661,806	$8,264,188
2031	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,664,613	$1,832,820	$9,929,563	-$1,664,613	$8,264,950
2032	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,670,269	$1,839,946	$9,936,689	-$1,670,269	$8,266,420
2033	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,678,560	$1,850,209	$9,946,952	-$1,678,560	$8,268,392
2034	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,686,874	$1,860,423	$9,957,166	-$1,686,874	$8,270,293
2035	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,693,816	$1,868,818	$9,965,561	-$1,693,816	$8,271,745
2036	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,693,816	$1,868,818	$9,965,561	-$1,693,816	$8,271,745
2037	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,693,816	$1,868,818	$9,965,561	-$1,693,816	$8,271,745
2038	$2,847,739	$3,732,101	$496,809	$0	$1,020,094	-$1,693,816	$1,868,818	$9,965,561	-$1,693,816	$8,271,745
Total	$45,563,818	$59,713,614	$7,948,946	$0	$16,321,507	-$20,535,663	$22,545,731	$152,093,616	-$20,535,663	$131,557,953

Table C-22. Non-Amortized Zero-Emission and Advanced Technology Infrastructure Costs (2019 $)

Year	Upstream Utility Cost	Charging Station Cost	Installation Cost	Dock Construction Cost	Vessel-Side Infrastructure Cost	Fuel Savings	Electricity Costs	Total Direct Costs	Total Cost Savings	Total Net Costs
2023	$11,829,706	$15,503,409	$2,063,780	$0	$4,237,543	$0	$0	$33,634,437	$0	$33,634,437
2024	$11,829,706	$15,503,409	$2,063,780	$0	$4,237,543	$0	$0	$33,634,437	$0	$33,634,437
2025	$11,829,706	$15,503,409	$2,063,780	$0	$4,237,543	$0	$0	$33,634,437	$0	$33,634,437
2026	$0	$0	$0	$0	$0	-$941,980	$1,005,498	$1,005,498	-$941,980	$63,519
2027	$0	$0	$0	$0	$0	-$1,356,063	$1,465,746	$1,465,746	-$1,356,063	$109,683
2028	$0	$0	$0	$0	$0	-$1,431,604	$1,552,545	$1,552,545	-$1,431,604	$120,941
2029	$0	$0	$0	$0	$0	-$1,650,191	$1,814,798	$1,814,798	-$1,650,191	$164,607
2030	$0	$0	$0	$0	$0	-$1,661,806	$1,829,251	$1,829,251	-$1,661,806	$167,445
2031	$0	$0	$0	$0	$0	-$1,664,613	$1,832,820	$1,832,820	-$1,664,613	$168,208
2032	$0	$0	$0	$0	$0	-$1,670,269	$1,839,946	$1,839,946	-$1,670,269	$169,678
2033	$0	$0	$0	$0	$0	-$1,678,560	$1,850,209	$1,850,209	-$1,678,560	$171,649
2034	$0	$0	$0	$0	$0	-$1,686,874	$1,860,423	$1,860,423	-$1,686,874	$173,550
2035	$0	$0	$0	$0	$0	-$1,693,816	$1,868,818	$1,868,818	-$1,693,816	$175,002
2036	$0	$0	$0	$0	$0	-$1,693,816	$1,868,818	$1,868,818	-$1,693,816	$175,002
2037	$0	$0	$0	$0	$0	-$1,693,816	$1,868,818	$1,868,818	-$1,693,816	$175,002
2038	$0	$0	$0	$0	$0	-$1,693,816	$1,868,818	$1,868,818	-$1,693,816	$175,002
Total	$35,489,118	$46,510,226	$6,191,340	$0	$12,712,628	-$20,517,220	$22,526,507	$123,429,820	-$20,517,220	$102,912,600

l. Administrative Costs

Vessel owners/operators, vessel facility owners/operators, and State agencies would all incur administrative costs as a result of the Proposed Amendments. Administrative costs to State and local agencies are also separately identified in sections D.1 and D.2 of this SRIA. Administrative costs described in this section include:

- Opacity Testing
- Compliance Fees
- Vessel Labeling
- Naval Architect and Financial Feasibility Reports (Compliance Extensions)
- Recordkeeping and Reporting
- Facility Reporting
- Regulation Interpretation Costs

m. Opacity Testing

Beginning January 1, 2023, all main propulsion diesel engines, including swing engines and low-use engines, operating on in-use vessels subject to the Proposed Amendments would need to perform opacity testing biennially and submit results to CARB within 30 days of the completed test, and no later than December 31 of the testing year. Based on stakeholder data,[100] staff assumes a per-vessel opacity testing cost of $2,205 for catamaran and monohull ferries. For other vessel categories, staff assumes a per engine opacity testing cost of $200. Staff assumed higher costs would apply for CHC vessels to conduct opacity testing due to extra travel costs, time to test a smaller volume of engines at various in-field locations, and costs to transit the vessel out into open water. Opacity testing costs would occur biennially starting in 2023.

n. Compliance Fees

The Proposed Amendments include annual compliance fees that would impose a direct, on-going cost to vessel owner/operators. The proposed compliance fees would help to offset staff costs of implementing and enforcing the Proposed Amendments, which would involve activities such as receiving and processing vessel owner/operator and facility reports, including outreach and follow-up with regulated parties, reviewing and approving compliance extension requests, and statewide enforcement of the regulation. Collectively, these implementation and enforcement activities are required for CARB to assess the compliance of off-road marine engines and emissions control components sold in the State.

Staff developed a preliminary proposed fee schedule[101] based on estimated costs of personnel, equipment, and administration for implementation and enforcement

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[100] Email between Lauren Duran Gularte (WETA) and Tracy Haynes (CARB) dated November 17, 2020.

[101] Revised Draft Regulatory Language, Table 19–Annual Fees for Owners or Operators of Regulated In-Use Vessels, April 1, 2021, *https://ww2.arb.ca.gov/sites/default/files/2021-04/Revised%20Draft%20CHC%20Regulatory%20Language.pdf*.

equaling $1.9 million per year. This fee structure is located in the Draft Regulation Order and could potentially change prior to the Final Regulation Order being approved. Using projected vessel and engine populations for 2023, the fee amounts in Table C-23 were calculated to fully recover implementation and enforcement costs, while providing a 25 percent lower fee for fleets operating only one vessel and assessing a 50 percent higher fee for low-use compliance engines due to additional staff time to review demonstrations and applications. Fees are assessed based on the number of main engines and vessels in the fleet. No fees are assessed for auxiliary engines operating on CHC. Fees would be payable to CARB by January 1 of each calendar year beginning in 2023.

Table C-23. Annual Fees for Owners or Operators of Regulated In-Use Vessels

Category	Fee Amount
Per vessel, for single-vessel fleets	$349
Per vessel, for all other fleets	$466
Per engine, for single-vessel fleets	$145
Per engine, for all other fleets	$193
Per engine, if complying by low-use pathway	$290

o. Vessel Labeling

To increase reporting compliance, the Proposed Amendments would require the use of Unique Vessel Identifiers (UVI). All CHC would need to have their identifier affixed to the vessel by January 1, 2024.

Staff assumed that the cost of a UVI would be $150 per vessel, and that these costs would recur every five years beginning in 2023.[102] Staff assumed that vessel owners/operators would incur this cost during the year prior to the compliance deadline.

p. Naval Architect and Financial Feasibility Reports (Compliance Extensions)

Vessel owner/operators seeking the compliance extension “Meeting Performance Standards Is Not Feasible for In-Use Harbor Craft” would need to demonstrate that Tier 4 + DPF is not feasible on their vessel, and that purchasing a replacement vessel with compliant engines would not be financially feasible. In order to do so, staff assumes that vessel owner/operators would incur costs of obtaining a technical feasibility analysis from a third-party Naval Architect and providing financial data that staff would use to evaluate the ability to pay.

- Staff assumed that the cost of a Naval Architect Report would be approximately $61,000, and the cost of a Financial Feasibility Report would be $400.[103] Staff

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[102] Staff assume the labeling costs would recur every 5 years due to labeling degradation.

[103] CARB staff assume it would take 8 personnel hours to prepare each Financial Feasibility Report. At $50 per personnel hour, this results in a total of $400 per report.

averaged per vessel costs from four sources to derive the $61,000 Naval Architect Costs:

- WETA provided $1.05 million Naval Architect cost for its fleet of 9 vessels, which averages $116,667 per vessel.
- Based on results from a 2019 CARB survey of CHC owner/operators, the average Naval Architect Report cost is $27,250 per vessel.
- Golden Gate Bridge provided a cost of $216,900 for 7 vessels, which averages to $30,986 per vessel.
- A confidential source requesting non-attribution provided a cost of $201,000 for 3 vessels, which is $67,000 per vessel. The average cost from these four sources is $60,476 per vessel.

The total percentage of vessels in each category that incurs the Financial Feasibility Report expense is based on the percentage of vessels that receive a compliance extension by their initial compliance date. Staff assumed it would take 8 personnel hours to prepare each Financial Feasibility Report. At $50 per personnel hour, this results in a total of $400 per report. See Table I-E of Appendix A for more information about compliance scenario assumptions.

q. Recordkeeping and Reporting

The Current Regulation requires vessels to report to CARB only periodically, such as after repowering engines or as compliance deadlines approach. To ensure that CARB's records are current and the regulation can be effectively implemented, the Proposed Amendments would make changes to the information vessel owner/operators are required to report, and would require annual reporting.

Vessel owner/operators would be required to report to CARB the percentage of time a vessel is used in each vessel use category, new owner contact information when a vessel is sold, engine tier and model year, and the quantity of DEF consumed if the engine is equipped with an SCR.

Staff assumes that requirements to maintain vessel and engine records and submit annual reporting to CARB would cost $200 per vessel, representing four personnel hours. These costs would occur annually beginning in 2023.

r. Facility Reporting

To further increase reporting compliance, the Proposed Amendments require facilities to report to CARB quarterly, starting January 1, 2023. Facilities would be required to provide facility and vessel owner/operator contact information, information about the facility use agreement, and dock, berth or slip location number of vessel tenants. Facilities with shore power infrastructure would be required to provide information about the equipment, such as installation date, type of equipment supported, and the number of plugs. Staff assumes that the facility reporting to CARB would cost $100 per vessel, representing two personnel hours. These costs would occur annually beginning in 2023.

s. Regulation Interpretation Costs

Staff received stakeholder input regarding the amount of time required to interpret CARB Regulations.[104]

Staff assumes this would be a one-time cost per fleet occurring in 2023, and represents administrative time needed to understand the regulation during the first year the Proposed Amendments would be in effect. Staff assumed a per-fleet cost of $7,500 which represents 100 personnel hours with a personnel hour cost of $75. This cost is multiplied by 1,305 fleets, which is based on data in the emission inventory.

Administrative costs and the parties expected to incur each type of cost are summarized in Table C-24, which includes costs to CARB and local, State, and federal agencies. These are fiscal impacts, therefore, they are described in further detail in Chapter D, but are included in Table C-24 because they are included in the total cost of the Proposed Amendments.

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[104] Email between Alex Brodie (Island Packers) and David Quiros (CARB) dated October 1, 2020.

Table C-24. Administrative Costs for the Proposed Regulation (2019 $)

Year	Compliance Extension Costs	Recordkeeping and Reporting	Regulation Interpretation	Vessel Labeling	Opacity Testing	Compliance Fees	Facility Reporting	Total Costs
2023	$7,551,463	$631,800	$9,787,500	$473,850	$757,222	$2,586,517	$315,900	$22,104,252
2024	$7,555,796	$632,022	$0	$0	$758,228	$2,577,517	$316,011	$11,839,575
2025	$7,555,838	$632,025	$0	$0	$759,264	$2,577,517	$316,012	$11,840,657
2026	$7,555,880	$632,028	$0	$0	$760,330	$2,577,517	$316,014	$11,841,769
2027	$7,555,922	$632,030	$0	$0	$761,427	$2,577,517	$316,015	$11,842,912
2028	$7,555,963	$632,208	$0	$473,850	$762,556	$2,577,517	$316,017	$12,318,111
2029	$3,778,002	$632,036	$0	$0	$763,718	$2,577,517	$316,018	$8,067,291
2030	$3,778,022	$632,039	$0	$0	$764,914	$2,577,517	$316,019	$8,068,512
2031	$3,778,042	$632,041	$0	$0	$766,145	$2,577,517	$316,021	$8,069,766
2032	$3,778,062	$632,044	$0	$0	$767,412	$2,577,517	$316,022	$8,071,057
2033	$3,778,081	$632,232	$0	$473,850	$768,716	$2,577,517	$316,023	$8,546,420
2034	$3,778,100	$632,049	$0	$0	$770,058	$2,577,517	$316,025	$8,073,750
2035	$0	$632,052	$0	$0	$771,439	$2,577,517	$316,026	$4,297,034
2036	$0	$632,055	$0	$0	$772,860	$2,577,517	$316,027	$4,298,460
2037	$0	$632,057	$0	$0	$774,323	$2,577,517	$316,029	$4,299,927
2038	$0	$632,255	$0	$473,850	$775,829	$2,577,517	$316,030	$4,775,481
Total	$67,999,171	$10,112,973	$9,787,500	$1,895,400	$12,254,441	$41,249,279	$5,056,209	$148,354,973

3. Total Net Costs

The total amortized net costs of the Proposed Amendments calculated from all of the direct cost inputs described above are summarized in Table C-25. The total non-amortized net costs of the Proposed Amendments calculated from all of the direct cost inputs described above are summarized in Table C-26. The total amortized and non-amortized net costs include all capital costs, as well as infrastructure costs, administrative costs for registration and reporting, and cost savings.

Table C-25. Annual Amortized Direct Costs of the Proposed Amendments (2019 $)

Year	Repower and Retrofit Costs	Vessel Replacement Costs	Infrastructure Costs	Administrative Costs	Cost Savings	Total Costs
2023	$8,897,400	$959,435	$9,915,086	$22,104,252	-$1,338,886	$40,537,287
2024	$31,484,767	$3,629,157	$9,916,008	$11,839,575	-$4,468,193	$52,401,313
2025	$47,685,234	$5,845,950	$9,947,629	$11,840,657	-$6,939,033	$68,380,437
2026	$59,622,632	$8,441,127	$10,943,512	$11,841,769	-$9,611,710	$81,237,330
2027	$68,517,159	$13,335,406	$11,411,197	$11,842,912	-$11,411,079	$93,695,595
2028	$75,080,093	$17,098,922	$11,507,143	$12,318,111	-$12,425,380	$103,578,889
2029	$79,069,971	$22,389,348	$11,777,811	$8,067,291	-$13,679,050	$107,625,371
2030	$87,233,089	$30,632,156	$11,801,427	$8,068,512	-$15,578,719	$122,156,464
2031	$90,647,930	$35,035,458	$11,814,331	$8,069,766	-$16,504,628	$129,062,857
2032	$93,389,757	$39,588,704	$11,820,466	$8,071,057	-$17,363,980	$135,506,004
2033	$95,210,662	$46,694,592	$11,829,869	$8,546,420	-$18,810,426	$143,471,116
2034	$95,981,051	$51,653,241	$11,840,434	$8,073,750	-$19,708,610	$147,839,864
2035	$96,887,810	$52,958,620	$11,845,313	$4,297,034	-$19,977,114	$146,011,663
2036	$97,436,334	$55,051,063	$11,841,038	$4,298,460	-$20,410,439	$148,216,455
2037	$97,436,334	$55,051,063	$11,839,013	$4,299,927	-$20,413,291	$148,213,045
2038	$97,436,334	$55,051,063	$11,836,557	$4,775,481	-$20,416,863	$148,682,572
Total	$1,222,016,555	$493,415,303	$181,886,834	$148,354,973	-$229,057,402	$1,816,616,263

Table C-26. Annual Non-Amortized Direct Costs of the Proposed Amendments (2019 $)

Year	Repower and Retrofit Costs	Vessel Replacement Costs	Infrastructure Costs	Administrative Costs	Cost Savings	Total Costs
2023	$108,996,021	$14,373,593	$42,652,132	$22,104,252	-$4,168,032	$183,957,625
2024	$241,614,394	$36,751,213	$42,656,840	$11,839,575	-$13,173,185	$319,688,878
2025	$174,319,208	$41,311,596	$34,089,098	$11,840,657	-$12,016,761	$249,543,798
2026	$122,930,984	$43,589,525	$1,469,745	$11,841,769	-$16,077,364	$163,754,659
2027	$100,951,299	$75,687,048	$1,937,409	$11,842,912	-$25,952,588	$164,466,080
2028	$81,145,825	$60,051,734	$2,033,332	$12,318,111	-$19,827,195	$135,721,807
2029	$54,513,758	$88,449,589	$2,303,976	$8,067,291	-$27,629,301	$125,705,313
2030	$117,384,469	$131,215,982	$2,327,569	$8,068,512	-$37,669,490	$221,327,041
2031	$70,395,836	$71,119,286	$2,340,448	$8,069,766	-$23,735,213	$128,190,124
2032	$61,052,216	$75,909,891	$2,346,558	$8,071,057	-$26,673,903	$120,705,820
2033	$28,960,133	$114,292,138	$2,355,935	$8,546,420	-$34,776,427	$119,378,199
2034	$19,357,993	$84,077,456	$2,366,473	$8,073,750	-$27,410,257	$86,465,415
2035	$21,731,154	$21,276,842	$2,371,326	$4,297,034	-$15,299,585	$34,376,770
2036	$16,834,861	$35,013,179	$2,367,022	$4,298,460	-$16,691,985	$41,821,536
2037	$10,665,341	$805,204	$2,364,968	$4,299,927	-$10,656,447	$7,478,993
2038	$10,665,341	$805,204	$2,362,483	$4,775,481	-$10,660,018	$7,948,491
Total	$1,241,518,832	$894,729,480	$148,345,314	$148,354,973	-$322,417,751	$2,110,530,549

a. Direct Costs on Typical Businesses

The typical business that would be impacted by the Proposed Amendments is a vessel owner/operator or a facility owner/operator. Staff derived the number of businesses operating or owning vessels that would be subject to the Proposed Amendments by extracting the number of vessels and businesses within each CHC category from the CARB CHC reporting database. To account for vessels subject to the Current Regulation that are currently not reporting to CARB, staff applied a vessel scaling factor to the number of businesses, which is based on the number of vessels in each category in the reporting database divided by the number of vessels in each category from CARB's CHC emission inventory. The vessels that are required to report, but have not reported to the CHC reporting database, are reflected in the emission inventory. Staff divided the total costs within each CHC category and year by the number of businesses to calculate an average cost per business operating or owning CHC.

The total facility owner/operator costs are made up of shore power infrastructure capital, maintenance costs, electricity costs, and recordkeeping and reporting costs. Staff estimate that 12.2 percent of all CHC vessels would comply using shore power rather than staying under auxiliary engine idling limits (see Table VIII-A in Appendix A for detail). There are 3,159 CHC vessels in the State (see Table VII-A in Appendix A); therefore, staff estimate that 386 vessels (3,159 multiplied by 12.2 percent)[105] would comply with the requirement to use shore power. Assuming the same number of shore power facilities would be needed and they are evenly distributed among the total of 276 statewide facilities, staff estimate that there 1 or 2 new shore power (386 vessels divided by 276 facilities) installs per facility. These costs were divided by the total number of facilities to calculate an average cost per facility. The number of facility businesses was derived using the methodology described in Section C.2.b.

The total vessel owner/operator costs are made up of repower costs, retrofit costs, vessel replacement/new-build vessel costs, ZEAT infrastructure costs, shore power related costs for vessel-side infrastructure, and administrative costs as detailed in Section C.2 excluding facility recordkeeping and reporting. Table C-27 displays the amortized costs and the average vessel number per business within each vessel category while Table C-28 displays the non-amortized costs. Costs to vessel owners and operators would vary widely depending on the number of vessels owned and the specific compliance pathways that are taken. As described earlier in the chapter, some businesses may take immediate compliance actions, while others may take advantage of multiple compliance extensions or low use exceptions.

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[105] Due to rounding, the estimated number may not equal exactly to the product of the two separate numbers.

Table C-27. Direct Amortized Costs for Typical Business Vessel Owner/Operators of CHC (2019 $)

Vessel Category	Total Businesses	Average Vessel# per Business	2023	2025	2027	2029	2031	2033	2035	2037
Ferry (Catamaran)	6	6	$52,546	$720,959	$1,571,871	$1,932,216	$2,652,741	$3,348,725	$3,557,063	$3,557,069
Ferry (Monohull)	8	3	$35,103	$260,865	$379,706	$412,518	$496,919	$550,382	$560,426	$560,429
Ferry (Short Run)	6	3	$23,813	$15,147	$435,821	$527,394	$527,397	$527,799	$522,261	$522,263
Pilot Boat	3	3	$29,767	$256,818	$287,645	$360,517	$441,428	$453,896	$449,008	$449,011
Push/Tow Tug	51	3	$59,953	$167,745	$240,461	$262,273	$275,539	$285,527	$282,552	$282,555
Escort/Ship Assist Tug	17	4	$39,598	$429,950	$654,748	$694,042	$706,879	$716,646	$711,578	$711,582
ATB Tug	4	5	$137,788	$1,506,398	$2,035,351	$2,104,317	$2,165,980	$2,193,072	$2,185,680	$2,185,684
Research Vessel	14	2	$45,801	$55,443	$63,998	$77,264	$87,177	$91,929	$98,539	$99,517
Commercial Passenger Fishing	292	1	$14,025	$22,044	$24,789	$32,633	$41,297	$55,706	$62,808	$63,100
Excursion	214	2	$28,268	$30,207	$53,853	$64,854	$73,054	$75,121	$72,866	$72,957
Dredge	22	2	$19,078	$19,769	$19,771	$18,418	$36,308	$42,299	$38,480	$44,155
ATB Barge	4	5	$42,418	$290,484	$290,488	$669,935	$958,353	$959,070	$949,205	$949,210
Bunker Barge	11	3	$25,167	$18,371	$18,373	$14,599	$17,561	$17,986	$12,133	$12,136
Other Barge	24	4	$45,542	$40,496	$40,796	$43,663	$52,752	$54,847	$48,638	$50,192
Towed Petrochemical Barge	10	2	$21,498	$21,012	$21,014	$20,530	$39,981	$44,236	$40,191	$44,156
Crew Supply	65	3	$30,697	$44,425	$46,185	$63,214	$95,809	$106,273	$111,686	$121,923
Workboat	190	3	$33,668	$49,844	$53,814	$59,833	$75,356	$82,175	$82,453	$88,916
Commercial Fishing	1035	1	$4,353	$591	$592	$593	$4,013	$6,008	$5,835	$5,836

Table C-28. Direct Non-Amortized Costs for Vessel Owner/Operators of CHC

Vessel Category	Total Businesses	Average Vessel # per Business	2023	2025	2027	2029	2031	2033	2035	2037
Ferry (Catamaran)	6	6	$71,053	$1,991,260	$7,935,743	$2,606,060	$2,060,390	$5,753,105	$1,608,603	$75,763
Ferry (Monohull)	8	3	$193,305	$1,098,422	$939,113	$290,293	$166,900	$367,878	$100,868	$3,045
Ferry (Short Run)	6	3	$2,680,117	$2,665,929	$1,456,569	$820,282	$8,997	$9,392	$3,848	$3,840
Pilot Boat	3	3	$37,248	$1,891,894	$197,045	$132,050	$785,353	$24,470	$9,430	-$1,848
Push/Tow Tug	51	3	$420,443	$542,442	$366,664	$174,026	$92,189	$72,360	$31,974	$13,218
Escort/Ship Assist Tug	17	4	$116,123	$2,367,506	$925,286	$383,873	$144,561	$111,123	$77,198	$54,195
ATB Tug	4	5	$1,502,056	$7,236,095	$981,098	$230,356	$317,748	-$37,289	-$116,016	-$119,145
Research Vessel	14	2	$517,589	$76,498	$51,289	$199,288	$19,868	$45,483	$76,630	$4,988
Commercial Passenger Fishing	292	1	$59,983	$104,382	$25,875	$150,804	$34,439	$108,102	$41,751	$2,402
Excursion	214	2	$238,498	$108,272	$183,033	$124,399	$15,276	$26,883	$19,635	$5,247
Dredge	22	2	$23,872	$87,298	$11,030	$7,167	$21,240	$91,417	$4,343	$4,463
ATB Barge	4	5	$53,078	$1,222,338	$28,240	$30,498	$39,636	$40,341	$30,466	$30,450
Bunker Barge	11	3	$31,491	$59,354	$14,829	$9,581	$9,901	$10,319	$4,461	$4,451
Other Barge	24	4	$198,443	$97,969	$19,787	$17,401	$32,932	$35,937	$7,024	$7,055
Towed Petrochemical Barge	10	2	$48,245	$97,010	$11,555	$7,646	$17,209	$64,739	$5,932	$6,115
Crew Supply	65	3	$133,849	$60,559	$31,398	$12,370	$133,242	$120,166	$7,029	$7,383
Workboat	190	3	$193,475	$206,450	$49,341	$48,713	$174,229	$130,959	$6,527	$6,652
Commercial Fishing	1035	1	$8,482	$1,578	$1,630	$1,663	$45,012	$1,847	$1,672	$1,668

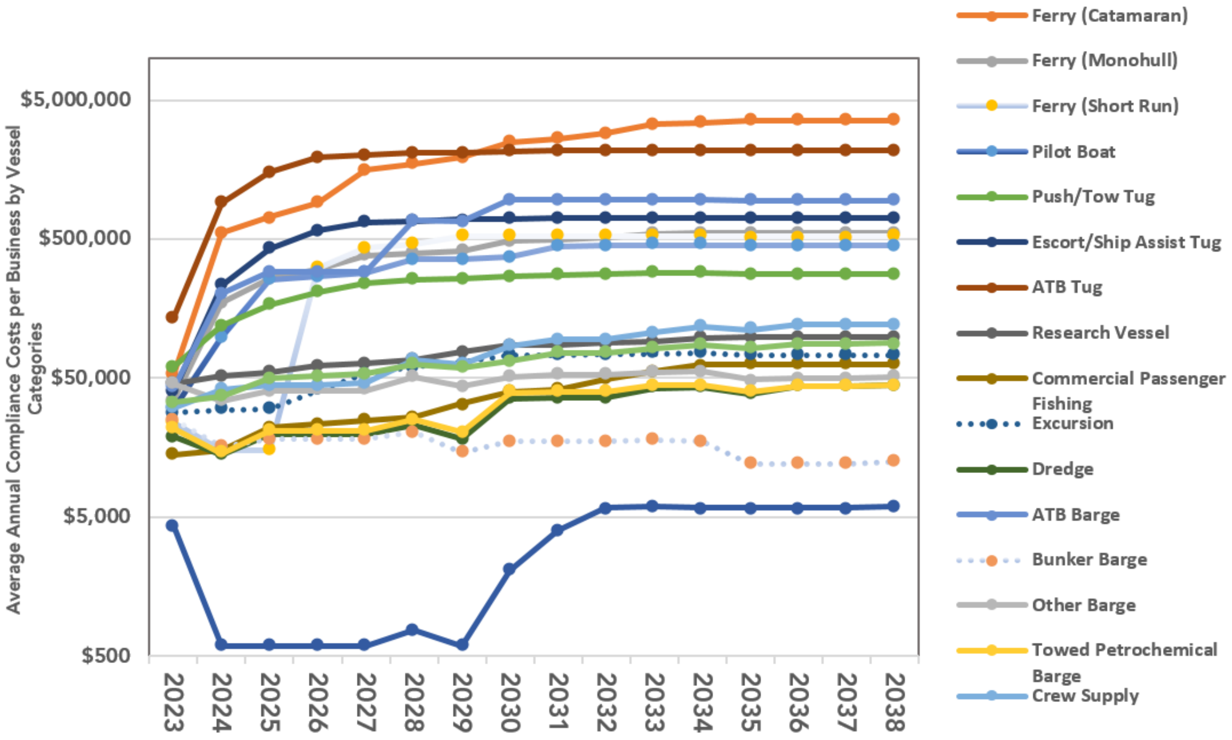
Table C-29 presents the average costs per business for vessel facility owners and operators, estimated by dividing the total facility owner/operator costs by the total number of vessel facilities.

Table C-29. Average Costs per Business for Vessel Facility Owners and Operators

Year	Total Facility Owner/Operator Costs	Average Cost Per Facility
2023	$1,472,212	$5,334
2024	$1,472,931	$5,337
2025	$1,472,950	$5,337
2026	$1,472,969	$5,337
2027	$1,472,989	$5,337
2028	$1,473,009	$5,337
2029	$1,473,030	$5,337
2030	$1,473,051	$5,337
2031	$1,473,073	$5,337
2032	$1,473,096	$5,337
2033	$1,473,119	$5,337
2034	$1,473,143	$5,337
2035	$1,473,167	$5,338
2036	$1,473,192	$5,338
2037	$1,473,217	$5,338
2038	$1,473,244	$5,338

Figure C-1 presents the annual average costs per business for vessel owner/operators from 2023 through 2038, estimated by dividing the total costs in each vessel category by the number of businesses that own vessels within that category.

Figure C-1. Annual Average Costs Per Business for Vessel Owner/Operators of CHC from 2023 to 2038



To further illustrate the anticipated cost for a specific business, CARB staff constructed two example typical businesses and analyzed the costs to comply with the Proposed Amendments. All cost input assumptions are the same as discussed in the previous sub-sections. In these examples, staff assumed that the typical businesses comply without the use of any compliance extensions or low-use extensions.

High speed ferry (catamaran) and Escort/Ship Assist Tugs account for about 20 percent of total CHC emissions. Staff selected these two vessel categories to represent a typical business within all CHC sectors.

The first typical business example is a high-speed ferry (catamaran) operator with four vessels and a total engine horsepower of 16,531 hp. Staff analyzed a scenario in which this ferry operator would have compliance deadlines for two vessels in 2025 and the other two vessels in 2026. For the vessels with a compliance deadline in 2025, staff assumed the vessel operator would comply with the Proposed Amendments by replacing the two vessels; for the vessels with a compliance deadline in 2026, staff assumed the vessel operator would comply with the Proposed Amendments by repowering the two vessels to Tier 4 engines and retrofit with DPFs. In addition, the ferry operator would face other costs associated with the Proposed Amendments starting in 2023 such as recordkeeping and reporting, vessel labeling, facility reporting, regulation interpretation, implementation, and enforcement costs borne by the vessel operator through fees, and opacity testing costs.

Table C-30 shows the annual costs for this typical ferry operator to comply with the Proposed Amendments from 2023 through 2038, presenting both the non-amortized costs, where vessel replacement for two vessels are occurring in 2025, and repower and retrofit for two vessels are occurring in 2026, along with a presentation of costs amortized over the lifetime of the equipment. The total non-amortized costs for this typical business to comply with the Proposed Amendments is estimated to be $46 million and ranges between approximately $25,000 to $32.4 million per year. The total amortized costs for this typical business to comply with the Proposed Amendments is estimated to be $38 million and ranges between approximately $25,000 to $2.8 million per year.

Staff compared these costs to the annual revenue of a typical business in the water transportation industry, which is $375 million.[106] The maximum non-amortized costs for this typical business is 8.6 percent of the average annual revenue for businesses within the same industry, while the maximum amortized costs for this typical business is 0.7 percent of the average annual revenue for businesses in the industry.

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[106] United States Census Bureau, 2012 SUSB Annual Datasets by Establishment Industry, 2015, last accessed May 4, 2021, *https://www.census.gov/data/datasets/2012/econ/susb/2012-susb.html*.

Table C-30. Compliance Cost Analysis for a Typical Business, Ferry (Catamaran)

Year	Other Costs	Operation Costs	Major Costs, Non-Amortized Costs	Major Costs, Amortized Costs	Total Non-Amortized Costs	Total Amortized Costs
2023	$37,584	$0	$0	$0	$37,584	$37,584
2024	$24,584	$0	$0	$0	$24,584	$24,584
2025*	$24,586	$47,776	$32,327,253	$1,601,499	$32,399,615	$1,673,861
2026*	$24,587	$70,031	$12,151,967	$2,694,460	$12,246,585	$2,789,078
2027	$24,589	$70,031	$0	$2,694,460	$94,620	$2,789,080
2028	$25,190	$70,031	$0	$2,694,460	$95,222	$2,789,682
2029	$16,882	$70,031	$0	$2,694,460	$86,913	$2,781,373
2030	$16,883	$70,031	$0	$2,694,460	$86,914	$2,781,374
2031	$16,885	$70,031	$0	$2,694,460	$86,916	$2,781,376
2032	$16,887	$70,031	$0	$2,694,460	$86,918	$2,781,378
2033	$17,489	$70,031	$0	$2,694,460	$87,520	$2,781,980
2034	$16,890	$70,031	$0	$2,694,460	$86,921	$2,781,381
2035	$9,181	$70,031	$0	$2,694,460	$79,213	$2,773,672
2036	$9,183	$70,031	$0	$2,694,460	$79,214	$2,773,674
2037	$9,185	$70,031	$0	$2,694,460	$79,216	$2,773,676
2038	$9,787	$70,031	$0	$2,694,460	$79,819	$2,774,278
Total	$300,373	$958,181	$44,479,220	$36,629,477	$45,737,774	$37,888,031

Notes: Major Costs include Vessel Replacement and Repower and retrofit costs, which include capital, labor, and installation costs for vessel replacement, engine repower, and DPF retrofits. Other costs include recordkeeping and reporting, vessel labeling, facility reporting, regulation interpretation, implementation and enforcement borne by the vessel operator through fees, and opacity testing costs.

*For the vessels with a compliance deadline in 2025, Staff assume the vessel operator would comply with the Proposed Amendments by replacing the two vessels. The Major Costs and Operation Costs in 2025 reflected the Vessel Replacement Costs for replacing the two vessels. For the vessels with a compliance deadline in 2026, Staff assumed the vessel operator would comply with the Proposed Amendments by repowering the two vessels to Tier 4 engines and retrofit with DPFs. The Non-Amortized Major Costs in 2026 reflect the Costs for Repowering and Retrofitting two vessels, the Amortized Major Costs and Operation Costs in 2026 reflect the cumulative costs for both the Vessel Replacement occurring in 2025 and the Repowering and Retrofitting costs starting in 2026.

The second typical business example considered by staff is a business-owning Escort/Ship Assist Tugs. Staff considered a business with four Escort/Ship Assist Tugs with a total engine horsepower of 19,663 hp. Staff analyzed a scenario in which this tug operator would have compliance deadlines for two vessels in 2025 and the other two vessels in 2026 where the tug operator would repower the tugs to a Tier 4 Engine and perform a DPF retrofit. Engine repower and DPF retrofit costs include capital, labor, and installation. In addition, the tug operator would face other costs such as recordkeeping and reporting, vessel labeling, regulation interpretation, implementation, and enforcement borne by the vessel operator through fees, and opacity testing costs.

Table C-31 shows the annual costs for this typical tug operator to comply with the Proposed Amendments from 2023 through 2038, presenting both the non-amortized costs, where repower and retrofit costs are represented as occurring fully within 2025 and 2026, along with a presentation of costs amortized over the lifetime of the equipment. The total non-amortized costs for this typical business to comply with the Proposed Amendments is estimated to be approximately $15 million and ranges between $25,000 to $6.8 million per year. The total amortized costs for this typical business to comply with the Proposed Amendments is estimated to be approximately $18 million and ranges between $25,000 to $1.4 million per year.

Staff compared these costs to the annual revenue of a typical business in the water transportation industry, which is $375 million.[107] The maximum non-amortized costs for this typical business is 1.8 percent of the average annual revenue for businesses in the same industry, and the maximum amortized cost is 0.4 of the average annual revenue for businesses in the same industry.

Table C-31. Compliance Cost Analysis for a Typical Business, Escort/Ship Assist Tug

Year	Other Costs	Operation Costs	Repower, Non-Amortized Costs	Repower Costs, Amortized Costs	Total Non-Amortized Costs	Total Amortized Costs
2023	$37,584	$0	$0	$0	$37,584	$37,584
2024	$24,584	$0	$0	$0	$24,584	$24,584
2025	$24,586	$46,088	$6,643,354	$528,731	$6,714,028	$599,405
2026	$24,587	$92,176	$6,643,354	$1,257,839	$6,760,118	$1,374,602
2027	$24,589	$92,176	$0	$1,257,839	$116,765	$1,374,604
2028	$25,190	$92,176	$0	$1,257,839	$117,367	$1,375,206
2029	$16,882	$92,176	$0	$1,257,839	$109,058	$1,366,897
2030	$16,883	$92,176	$0	$1,257,839	$109,059	$1,366,898
2031	$16,885	$92,176	$0	$1,257,839	$109,061	$1,366,900
2032	$16,887	$92,176	$0	$1,257,839	$109,063	$1,366,902
2033	$17,489	$92,176	$0	$1,257,839	$109,665	$1,367,504
2034	$16,890	$92,176	$0	$1,257,839	$109,066	$1,366,905

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[107] United States Census Bureau, 2012 SUSB Annual Datasets by Establishment Industry, 2015, last accessed May 4, 2021, *https://www.census.gov/data/datasets/2012/econ/susb/2012-susb.html*.

Year	Other Costs	Operation Costs	Repower, Non-Amortized Costs	Repower Costs, Amortized Costs	Total Non-Amortized Costs	Total Amortized Costs
2035	$9,181	$92,176	$0	$1,257,839	$101,357	$1,359,197
2036	$9,183	$92,176	$0	$1,257,839	$101,359	$1,359,198
2037	$9,185	$92,176	$0	$1,257,839	$101,361	$1,359,200
2038	$9,787	$92,176	$0	$1,257,839	$101,963	$1,359,802
Total	$300,373	$1,244,377	$13,286,709	$16,880,639	$14,831,458	$18,425,388

Notes: Repower and retrofit costs include capital, labor, and installation costs for engine repower and DPF retrofits. Other costs include recordkeeping and reporting, vessel labeling, regulation interpretation, implementation, and enforcement borne by the vessel operator through fees and opacity testing costs.

b. Direct Costs on Small Businesses

For the purposes of the cost analysis for this SRIA, companies with 100 or fewer employees are considered small businesses.[108] Meeting the small business criteria would not relieve vessel or facility owners/operators of any requirements in the Proposed Amendments, rather, staff used the small business criteria for analysis purposes only. To illustrate the costs and cost-savings to a small business owning or operating vessels or vessel facilities, staff completed a similar analysis as presented in section C.3.a for direct costs on typical businesses.

To determine the number of companies that would be defined as a small business, staff completed an analysis of the current vessel fleets reported to CARB pursuant to the Current Regulation. Staff compared vessel companies reported to CARB with the Dun and Bradstreet database[109] to determine the percentage of companies with 100 or fewer employees. For fleets where employee information was not available, staff used other criteria to make a small business determination, such as whether the company appeared to be a single-vessel fleet owned and/or operated by an individual. Based on this information, 70 percent of vessel fleets are considered small businesses.

The compliance costs for a small business will vary depending on the compliance option and the number of vessels owned/operated. However, the per-vessel costs to vessel and facility owners/operators that are considered small businesses are not expected to be different from the compliance costs experienced by typical vessel and facility owners/operators (see Section C.2).

To illustrate the anticipated cost for a typical small business, staff constructed two small business examples and analyzed the costs to comply with the Proposed Amendments. All cost input assumptions are the same as discussed previously in this

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[108] California Government Code, Title 2, Division 3, Part 5.5, Chapter 6.5, §14837, last accessed May 27, 2021, *https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=14837.&lawCode=GOV*.

[109] Dun and Bradstreet Database, 2020. Annual gross income data for vessel companies.

chapter. Specifically, staff chose to illustrate the costs to a single vessel CPFV owner and the costs to a single vessel commercial fishing vessel operator. These two vessel categories comprise the majority of the businesses within the entire CHC vessel sector, with the majority of them being businesses with a single vessel. Staff estimates there are approximately 295 commercial passenger fishing businesses and 1,049 commercial fishing businesses in the State, accounting for about 18 percent and 57 percent of the businesses within the entire CHC sector, respectively.

The first small business example is a CPFV business with one vessel with total engine horsepower of 730 hp. Staff analyzed a scenario in which this vessel would have a compliance deadline in 2026 which would require replacement of the existing vessel with a new-build vessel. Vessel replacement would result in costs for capital, labor, and installation costs and cost savings from the old vessel resale value. In addition, the commercial passenger fishing business would face other costs such as recordkeeping and reporting, vessel labeling, regulation interpretation, implementation and enforcement, and opacity testing costs.

Table C-32 shows the annual costs for this typical CPFV operator to comply with the Proposed Amendments from 2023 through 2038, presenting both the non-amortized costs, where vessel replacement costs occur in 2026, along with a presentation of costs amortized over the lifetime of the equipment. The total non-amortized costs for this typical small business to comply with the Proposed Amendments is estimated to be approximately $1.96 million and ranges between $2,600 to $1.9 million per year. The total amortized costs for this typical small business to comply with the Proposed Amendments is estimated to be approximately $1.2 million and ranges between $2,600 to $92,000 per year.

Staff compared these costs to the annual revenue of a typical small business in the scenic and sightseeing transportation industry, which is $978,000.[110] The maximum non-amortized costs for this typical small business is 1.9 times of their annual revenue, while the maximum amortized costs for this typical business is 9.3 percent of the average annual revenue for businesses in the industry.

Based on staff's discussions with owners and operators of CPFVs,[111] resale of used vessels is common in California, and new vessel purchases would require financing to incur capital expenditures. If an entity does not have sufficient capital for a down payment on a loan, the Proposed Amendments include compliance extensions of up to 6 years to acquire sufficient additional funds. Because vessel replacement is a likely compliance outcome, and loans would be required to finance the capital expenditures, the percentage of amortized costs to annual revenue (9.3 percent) is likely more appropriate than the percentage of non-amortized costs (1.9 times) for this category. Additionally, staff has received information that the CPFV industry has operated for several years in the past with a 35 percent taxation and fees for using local docks, harbors, and facilities. These charges may vary by region throughout the State, but are

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[110] United States Census Bureau, 2012 SUSB Annual Datasets by Establishment Industry, 2015, last accessed May 4, 2021, *https://www.census.gov/data/datasets/2012/econ/susb/2012-susb.html*.

[111] Small Business CPFV Cost Assumption notes from 13OCT2020 meeting with SAC Board.pdf.

unique to this vessel sector, and vessel operators pass the cost onto customers.[112] Following this model, the increased direct costs for compliance with the Proposed Amendments, although possibly absorbable within most CPFV businesses' profit margins, would most likely be passed onto the customer. However, staff cannot rule out the possibility of some business elimination if costs cannot be passed on to the customer or if passing through costs would result in a significant decrease in demand. Staff estimated the cost impacts to CPFV customers as direct costs to individuals, which is presented in Section C.3.c.

Table C-32. Compliance Cost Analysis for Small Business, Commercial Passenger Fishing Vessel

Year	Other Costs	Operation Costs	Vessel Replacement Costs, Non-Amortized Costs	Vessel Replacement Costs, Amortized Costs	Total Non-Amortized Costs	Total Amortized Costs
2023	$6,374	$0	$0	$0	$6,374	$6,374
2024	$2,632	$0	$0	$0	$2,632	$2,632
2025	$2,633	$0	$0	$0	$2,633	$2,633
2026	$2,633	$2,660	$1,883,524	$86,113	$1,888,816	$91,406
2027	$2,634	$2,660	$0	$86,113	$5,293	$91,406
2028	$2,823	$2,660	$0	$86,113	$5,483	$91,596
2029	$2,532	$2,660	$0	$86,113	$5,192	$91,305
2030	$2,533	$2,660	$0	$86,113	$5,192	$91,305
2031	$2,533	$2,660	$0	$86,113	$5,193	$91,306
2032	$2,534	$2,660	$0	$86,113	$5,193	$91,306
2033	$2,708	$2,660	$0	$86,113	$5,367	$91,480
2034	$2,535	$2,660	$0	$86,113	$5,194	$91,307
2035	$2,295	$2,660	$0	$86,113	$4,955	$91,068
2036	$2,296	$2,660	$0	$86,113	$4,955	$91,069
2037	$2,296	$2,660	$0	$86,113	$4,956	$91,069
2038	$2,447	$2,660	$0	$86,113	$5,107	$91,220
Total	$44,437	$34,576	$1,883,524	$1,119,470	$1,962,537	$1,198,483

Note: Replacement costs include capital, labor, and installation costs net of resale value. Other costs include recordkeeping and reporting, vessel labeling, regulation interpretation, implementation, and enforcement borne by the vessel operator through fees, and opacity testing costs.

The second small business example is a commercial fishing business that owns a single vessel with total engine horsepower of 362 hp. Staff considered an example where this vessel would repower the engine to Tier 3 in 2030, the first compliance date for the commercial fishing vessel category. Repower costs include capital, labor, and installation costs. In addition, this business would face other costs such as recordkeeping and reporting, vessel labeling, regulation interpretation,

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[112] Email from Ken Franke, President of Sportfishing Association of California, October 14, 2020, SAC CPFV Profit Loss Formula.pdf.

implementation, and enforcement borne by the vessel operator through fees, and opacity testing costs.

Table C-33 shows the annual costs for this typical commercial passenger fishing vessel operator to comply with the Proposed Amendments from 2023 through 2038, presenting both the non-amortized costs, where repower costs occur in 2030, along with a presentation of costs amortized over the lifetime of the equipment. The total non-amortized costs for this typical business to comply with the Proposed Amendments is estimated to be approximately $163,000 and ranges between $976 to $144,000 per year. The total amortized costs for this typical business to comply with the Proposed Amendments is estimated to be approximately $93,000 and ranges between $976 to approximately $9,000 per year.

Staff compared these costs to the annual revenue of a typical small business in the Fishing, Hunting, and Trapping Industry, which is $1.3 million.[113] The maximum non-amortized cost for this small business is 11.5 percent of their annual revenue; however, the maximum amortized costs for this small business is 0.7 percent of the average annual revenue for businesses in the industry. Note that these costs do not account for the use of any public grants or air quality incentive funding, which has typically been widely used by the commercial fishing industry. Staff established later compliance deadlines for the commercial fishing vessel sector to enable them to maximize public funding opportunities. Staff acknowledges that to the extent the typical commercial fishing small business incurs costs, they may not be able to pass on costs to the consumer of the seafood product due to market pricing, and costs may be absorbed by the business. Staff cannot rule out the possibility of some business elimination if costs cannot be passed on to the customer or if passing through costs would result in a significant decrease in demand.

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[113] United States Census Bureau, 2012 SUSB Annual Datasets by Establishment Industry, 2015, last accessed May 4, 2021, *https://www.census.gov/data/datasets/2012/econ/susb/2012-susb.html.*

Table C-33. Compliance Cost Analysis for Small Business, Commercial Fishing Vessel

Year	Other Costs	Operation Costs	Repower Costs, Non-Amortized Costs	Repower Costs, Amortized Costs	Total Non-Amortized Costs	Total Amortized Costs
2023	$4,224	$0	$0	$0	$4,224	$4,224
2024	$976	$0	$0	$0	$976	$976
2025	$976	$0	$0	$0	$976	$976
2026	$977	$0	$0	$0	$977	$977
2027	$977	$0	$0	$0	$977	$977
2028	$1,127	$0	$0	$0	$1,127	$1,127
2029	$978	$0	$0	$0	$978	$978
2030	$978	$0	$143,396	$8,153	$144,374	$9,131
2031	$979	$0	$0	$8,153	$979	$9,131
2032	$979	$0	$0	$8,153	$979	$9,132
2033	$1,129	$0	$0	$8,153	$1,129	$9,282
2034	$980	$0	$0	$8,153	$980	$9,133
2035	$980	$0	$0	$8,153	$980	$9,133
2036	$981	$0	$0	$8,153	$981	$9,134
2037	$981	$0	$0	$8,153	$981	$9,134
2038	$1,132	$0	$0	$8,153	$1,132	$9,285
Total	$19,354	$0	$143,396	$73,375	$162,750	$92,729

Note: Repower costs include capital, labor, and installation. Other costs include recordkeeping and reporting, vessel labeling, regulation interpretation, implementation and enforcement, and opacity testing costs.

c. Direct Costs on Individuals

The Proposed Amendments would not result in any direct costs to individuals. However, staff anticipates the Proposed Amendments would result in indirect costs to individuals to the extent that compliance costs are passed through ultimately to consumers of services and cargo (Table C-34).

To estimate these indirect costs to consumers, staff calculated cost ratios in metrics of:

- Increased cost per passenger for a one-way trip on a high-speed ferry;
- Increased cost per passenger for a one-way trip on a short-run ferry;
- Increased cost per passenger for an excursion vessel trip;
- Increased cost per Twenty-Foot-Equivalent-Unit resulting from costs on ship assist and escort tug and pilot vessels only;
- Increased cost per pound of fish for commercial fishing vessels; and
- Increased cost per passenger/day for one-day and multi-day CPFVs.

Staff performed this analysis using the average cost of compliance over the full implementation period from 2023 to 2037. More information on the methodologies that were used to calculate each cost metric are detailed in Appendix C.

Table C-34. Calculated Cost Metrics and Cost Impacts to Individuals

Cost Metric	Average Amortized Cost Increase
Cost Per Passenger – High-Speed Ferry, One-Way Trip	$1.81
Cost Per Passenger – Short-Run Ferry, One-Way Trip	$0.97
Cost Per Passenger – Excursion Vessels	$1.04
Cost Increase Per Twenty-Foot-Equivalent Unit – Tug Vessels	$0.38
Cost Per Pound of Fish – Commercial Fishing Vessels	$0.04
Cost Per Passenger/day – Commercial Passenger Fishing Vessels, One-Day Trip	$28.02
Cost Per Passenger/day – Commercial Passenger Fishing Vessels, Multi-Day Trip	$26.09
Cost Per Passenger/day – Commercial Passenger Fishing Vessels, “6-pack” Vessel*	$93.51

*6-pack vessels are uninspected passenger vessels that can carry up to 6 passengers (in addition to 2 crew). Due to the smaller passenger capacity and market segment, the costs to individual passengers aboard these vessels were calculated separately.

d. Regional Analysis

The Proposed Amendments apply across California. However, as CHC are necessarily located near bodies of water, the direct costs of the Proposed Amendments on businesses will first be felt in regions where vessels and vessel facilities are located before being passed through to the rest of the economy.

To illustrate the regional distribution of direct costs of the Proposed Amendments, staff proportioned the compliance costs of the Proposed Amendments within California based on vessel categories and the distribution of vessel horsepower in regions across the State. Tables C-35 and C-36 illustrate these costs, showing both the annual amortized and non-amortized costs.[114]

The counties with the greatest share of costs are Alameda, Los Angeles, Orange, San Diego, and San Francisco counties; approximately 75 percent of the compliance costs, based on vessel horsepower. While these counties may face the largest initial direct costs, these costs are generally a small percentage of these counties’ Gross Domestic Product (GDP).[115] Table C-37 illustrates the year of the greatest non-amortized cost in each county along with the cost as a percentage of the county’s GDP. On average, non-amortized costs are less than 0.02 percent of county-level GDP in the years of greatest impact. This includes four of the five counties with the largest share of costs; for San Francisco, direct costs may be up to 0.05 percent of county-level GDP in 2024. Amortized costs average less than 0.01 percent of county-level GDP.

The county with the greatest cost as a percentage of county level GDP is Del Norte County, a smaller county that has a significant number of commercial fishing vessels.

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[114] Napa, San Bernardino, and Tehama counties were excluded from the table as all costs, including the totals, were $0 million with rounding.

[115] The total value of goods produced and services provided in a country during one year.

Del Norte County has lower than average total compliance costs compared with other counties, $8 million over the lifetime of the regulation, but the non-amortized compliance costs in 2031 may be up to 0.17 percent of the county's GDP. As discussed above, staff anticipate that the majority of these costs will be able to be passed on to consumers.

Table C-35. Summary of Amortized Compliance Costs by County (Millions of 2019 $)

County	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	Total
Alameda	$2	$4	$5	$7	$8	$9	$9	$10	$10	$10	$11	$11	$11	$11	$11	$11	$137
Contra Costa	$1	$2	$2	$3	$3	$3	$3	$4	$4	$4	$4	$4	$4	$4	$4	$4	$51
Del Norte	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$4
El Dorado	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$16
Humboldt	$0	$0	$0	$0	$0	$0	$0	$0	$1	$1	$1	$1	$1	$1	$1	$1	$8
Los Angeles	$9	$13	$17	$20	$23	$25	$26	$30	$31	$33	$34	$35	$35	$36	$36	$36	$438
Marin	$0	$1	$2	$2	$4	$4	$4	$5	$5	$6	$7	$7	$7	$7	$7	$7	$76
Mendocino	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1	$1	$1	$1	$1	$1	$6
Monterey	$2	$1	$1	$1	$2	$2	$2	$2	$3	$3	$3	$3	$3	$3	$3	$3	$36
Orange	$4	$4	$4	$5	$6	$6	$7	$8	$8	$9	$9	$10	$10	$10	$10	$10	$118
Sacramento	$1	$1	$1	$1	$2	$2	$2	$2	$2	$2	$2	$2	$2	$2	$2	$2	$28
San Diego	$7	$7	$9	$11	$12	$13	$14	$15	$16	$17	$18	$19	$19	$19	$19	$19	$235
San Francisco	$8	$13	$17	$22	$25	$27	$28	$32	$33	$34	$35	$36	$36	$36	$36	$36	$453
San Joaquin	$0	$0	$0	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$10
San Luis Obispo	$1	$0	$0	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$13
San Mateo	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1	$1	$1	$1	$1	$1	$1	$7
Santa Barbara	$1	$1	$1	$1	$1	$2	$2	$2	$2	$2	$3	$3	$3	$3	$3	$3	$32
Santa Clara	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2
Santa Cruz	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5
Solano	$1	$1	$2	$2	$3	$3	$3	$4	$4	$4	$5	$5	$5	$5	$5	$5	$59
Sonoma	$0	$0	$0	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$1	$12
Ventura	$2	$2	$3	$3	$3	$4	$4	$4	$5	$5	$6	$6	$6	$6	$6	$6	$70
Total	$41	$52	$68	$81	$94	$104	$108	$122	$129	$136	$143	$148	$146	$148	$148	$149	$1,817

Table C-36. Summary of Non-Amortized Compliance Costs by County (Millions of 2019 $)

County	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	Total
Alameda	$8	$24	$24	$16	$14	$7	$9	$10	$5	$6	$7	$5	$2	$2	$1	$1	$143
Contra Costa	$5	$10	$10	$6	$4	$3	$2	$3	$3	$1	$2	$2	$1	$2	$0	$0	$54
Del Norte	$1	$0	$0	$0	$0	$0	$0	$2	$2	$2	$0	$0	$0	$0	$0	$0	$8
El Dorado	$3	$2	$2	$2	$2	$1	$2	$2	$0	$1	$1	$1	$0	$0	$0	$0	$18
Humboldt	$1	$1	$1	$0	$0	$1	$0	$3	$4	$3	$1	$1	$0	$0	$0	$0	$16
Los Angeles	$45	$80	$61	$38	$38	$39	$28	$53	$28	$23	$27	$20	$7	$11	$2	$2	$501
Marin	$2	$14	$7	$5	$14	$4	$6	$13	$4	$6	$10	$3	$3	$0	$0	$0	$88
Mendocino	$1	$1	$0	$0	$0	$0	$0	$2	$2	$2	$0	$0	$0	$0	$0	$0	$10
Monterey	$6	$5	$3	$3	$3	$2	$4	$8	$7	$7	$2	$2	$1	$1	$0	$0	$54
Orange	$17	$17	$13	$10	$12	$7	$15	$15	$6	$10	$9	$9	$3	$2	$0	$1	$145
Sacramento	$4	$5	$4	$2	$2	$3	$1	$2	$3	$1	$2	$2	$0	$2	$0	$0	$34
San Diego	$33	$37	$31	$19	$17	$17	$22	$28	$19	$20	$17	$17	$5	$7	$1	$1	$292
San Francisco	$36	$91	$69	$50	$41	$32	$22	$45	$17	$16	$21	$10	$6	$5	$1	$1	$463
San Joaquin	$1	$2	$1	$1	$1	$1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$10
San Luis Obispo	$2	$2	$1	$1	$1	$1	$1	$3	$3	$2	$1	$1	$0	$1	$0	$0	$19
San Mateo	$1	$1	$1	$0	$1	$0	$1	$2	$2	$2	$0	$0	$0	$0	$0	$0	$11
Santa Barbara	$5	$5	$5	$1	$1	$4	$2	$6	$6	$4	$3	$3	$1	$2	$0	$0	$49
Santa Clara	$0	$0	$0	$0	$0	$0	$0	$1	$0	$0	$0	$0	$0	$0	$0	$0	$3
Santa Cruz	$1	$1	$1	$0	$0	$0	$1	$1	$1	$1	$0	$1	$0	$0	$0	$0	$8
Solano	$4	$10	$5	$4	$9	$5	$3	$9	$4	$3	$7	$3	$2	$2	$0	$0	$69
Sonoma	$1	$2	$1	$1	$1	$1	$1	$2	$2	$2	$1	$1	$0	$0	$0	$0	$16
Ventura	$8	$12	$9	$4	$4	$8	$5	$12	$10	$8	$7	$6	$2	$4	$0	$0	$99
Total	$184	$320	$250	$164	$164	$136	$126	$221	$128	$121	$119	$86	$34	$42	$7	$8	$2,111

Table C-37. Summary of Non-Amortized Costs as a Percentage of County GDP by County and Year of Greatest Impact

County	Year of Greatest Impact	Non-Amortized Cost as a Percentage of County GDP
Alameda	2024	0.02%
Contra Costa	2024	0.01%
Del Norte	2031	0.17%
El Dorado	2023	0.03%
Humboldt	2031	0.04%
Los Angeles	2024	0.01%
Marin	2024	0.04%
Mendocino	2031	0.04%
Monterey	2030	0.02%
Napa	2031	0.00%
Orange	2023	0.01%
Sacramento	2024	0.00%
San Bernardino	2031	0.00%
San Diego	2024	0.01%
San Francisco	2024	0.05%
San Joaquin	2024	0.01%
San Luis Obispo	2031	0.01%
San Mateo	2032	0.00%
Santa Barbara	2031	0.02%
Santa Clara	2030	0.00%
Santa Cruz	2030	0.01%
Solano	2024	0.03%
Sonoma	2031	0.01%
Tehama	2031	0.00%
Ventura	2024	0.02%

D. Fiscal Impacts

This chapter describes costs and benefits that would be incurred by local, State, and federal agencies due to the Proposed Amendments. Local government agencies that own or operate CHC or facilities would be subject to the same direct costs and benefits described in Chapter C, as well as experience changes in revenue from utility user taxes, diesel fuel taxes, and local sales taxes. State government agencies that own or operate CHC or facilities would be subject to the same direct costs and benefits described in Chapter C, as well as experience changes in revenue from diesel fuel taxes, energy resource fees, and State sales taxes. Federal government agencies that own or operate CHC or facilities would be subject to the same direct costs outlined in Chapter C. Costs to CARB would include staffing and resources needed to implement and enforce the Proposed Amendments, as well as third-party costs that would provide vessel activity data to CARB to ensure compliance with reporting requirements. In addition, the Proposed Amendments would result in health benefits to individuals in California. These benefits may translate to cost savings for local and State healthcare providers.

Staff determined the percentage of CHC fleets that are owned/operated by local, State, and federal government agencies by analyzing a list of fleets reported to CARB to comply with the Current Regulation. Staff categorized fleet ownership as private, local, State, or federal government.[116]

Staff determined the percentage of CHC facilities that are owned/operated by local, State, and federal agencies by using the CHC facility list identified in reference 812, and determining private, local, State, or federal government ownership.[117] These entities include ports, harbor districts, cities, counties, and other government agencies.

Table D-1 provides the percentage of CHC fleets and facilities owned/operated by local, State, and federal government agencies. Privately owned fleets and facilities are also shown to illustrate the relative numbers of total fleets and facilities that are privately owned/operated versus government-owned/operated. Staff used the numbers in this table to calculate the direct costs to local, State, and federal government agencies.

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[116] CARB staff performed the vessel fleets business classification based on vessel reporting data. Federal government fleets included ownership or operation by a National Park, a Federal agency, the U.S. Army Corps of Engineers, or the U.S. Military. State government fleets were either associated with the University of California, California State University, or a State agency. Local government fleets included any fleet owned or operated by a city, county, or regional public transit agency, which includes many port authorities in the State. Private ownership attributed to any other fleet not meeting an aforementioned public fleet criterion.

[117] CARB staff performed the vessel facility classification based on staff collected vessel facility data. Federal facilities included those operated by the U.S. Army Corps of Engineers. State facilities included those operated by a State Park or a designated subdivision of the State of California. Local facilities included any owned or operated by a city or county, and the port authorities. Private facilities included any other facility not meeting an aforementioned public facility criterion or facilities owned or operated by a California Tribal Community.

Table D-1. The number of CHC Fleets and Facilities Breakout by Privately Owned, Local, State, and Federal Government in 2020

Ownership	Total Number of CHC Fleets Analyzed* (2020)	% of Total Fleets	Total Number of CHC Facilities (2020)	% of Total Facilities
Privately Owned	1,263	96.9%	221	80.1%
Local Government Owned	23	1.8%	49	17.8%
State Government Owned	9	0.7%	5	1.8%
Federal Government Owned	8	0.6%	1	0.4%
Total	1,303	100%	276	100%

*Total number of fleets analyzed was based on numbers of fleets reported to CARB for compliance with the Current Regulation. The numbers of fleets in each category have not been scaled up to match the total number of fleets operating CHC in California. Because the majority, but not all fleets, have been reported, staff assume the percentages listed apply to the Statewide population.

1. Local government

a. Direct Costs to Vessel Fleet and Facility Owner/Operators

The Proposed Amendments would have a small fiscal impact on local government agencies that own/operate fleets or vessel facilities, relative to the total estimated cost of the Proposed Amendments. Using 2020 data from the CHC reporting database, staff determined that 1.8 percent of total vessel fleets (as a percentage of vessel-owning companies, rather than as a percentage of vessel population) were owned/operated by local governments, and 18.2 percent of vessel facilities were owned/operated by local governments.

The assumptions underlying the direct costs to local government agencies are identical to those identified in Chapter C of this document. Staff applied the local government fleet and facility percentages to the total direct costs in Table C-25 to estimate the costs incurred by local government vessel owner/operators and facility owners/operators. Infrastructure and administrative costs would be borne by both vessel fleets and vessel facilities; staff applied the fleet and facility local government percentages to all costs within these categories that would be incurred by the specific party. Sections C.2.f. through C.2.l contain more information about the types of infrastructure and administrative costs that would be incurred by either fleet or facility owner/operators.

The estimated direct costs to local government equipment and facility owners are summarized in Table D-2.

Table D-2. Total Direct Costs of the Proposed Amendments to Local Governments from 2023 through 2038 (2019 $)

Year	Repower and Retrofit Costs	Vessel Replacement Costs	Infrastructure Costs[1]	Administrative Costs[2]	Cost Savings	Total Direct Costs
2023	$1,911,632	$200,261	$1,897,059	$440,682	-$65,775	$4,383,859
2024	$4,205,891	$482,980	$1,897,744	$259,512	-$224,720	$6,621,408
2025	$2,981,758	$620,375	$674,419	$259,532	-$211,789	$4,324,295
2026	$2,051,355	$628,504	$100,169	$259,552	-$267,163	$2,772,417
2027	$1,653,848	$1,037,420	$109,610	$259,572	-$434,167	$2,626,282
2028	$1,299,899	$875,135	$112,762	$267,960	-$324,711	$2,231,045
2029	$827,136	$1,245,017	$118,881	$192,927	-$458,572	$1,925,388
2030	$1,929,464	$1,830,201	$120,759	$192,949	-$635,592	$3,437,780
2031	$1,097,980	$1,017,451	$122,474	$192,971	-$389,581	$2,041,295
2032	$931,504	$1,051,837	$122,420	$192,994	-$441,353	$1,857,401
2033	$362,133	$1,589,478	$122,444	$201,385	-$584,229	$1,691,210
2034	$192,054	$1,186,956	$122,682	$193,042	-$454,058	$1,240,676
2035	$233,340	$292,991	$122,201	$126,377	-$240,163	$534,746
2036	$146,418	$511,451	$121,437	$126,403	-$264,741	$640,966
2037	$37,516	$14,213	$121,072	$126,429	-$158,205	$141,025
2038	$37,516	$14,213	$120,631	$134,823	-$158,268	$148,915
Total	$19,899,444	$12,598,482	$6,006,764	$3,427,109	-$5,313,089	$36,618,711

b. Utility User Tax

Several cities and counties in California levy a Utility User Tax on electricity usage. This tax varies from city to city and ranges from no tax to 11 percent. A value of 3.53 percent was used in this analysis representing a population-weighted average.[118] By increasing the amount of electricity used, there would be an increase in the amount of the utility user tax revenue collected by cities and counties, as shown in Table D-3.

c. Diesel Fuel Tax

When used off-road, Dyed Diesel is taxed at the combined statewide sales tax rate, plus applicable district taxes. Displacing diesel with electricity would decrease the total amount of diesel fuel dispensed in the State, resulting in a reduction in tax revenue collected by local governments, as shown in Table D-3. A combined State and local sales tax value of 8.6 percent[119] was used for staff's analysis based on a weighted

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[118] California State Controller's Office, User Utility Tax Revenue and Rates, last accessed January 2021, *https://www.sco.ca.gov/Files-ARD-Local/LocRep/2017-18_Cities_UUT.pdf.*

[119] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October 1, 2020, last accessed February 10, 2021. *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm*.

average based on county-level output. Staff assumed 4.67 percent would go towards local sales tax, and 3.94 percent would go towards State sales tax.[120]

d. Local Sales Tax

Sales taxes are levied in California to fund a variety of programs at the local and State levels. The Proposed Amendments would result in additional sales of vessels and vessel equipment relative to baseline conditions, which would result in a direct increase in sales tax revenue collected by local governments, as shown in Table D-3. A combined State and local sales tax value of 8.6 percent[121] was used for staff's analysis based on a weighted average based on county-level output. Staff assumed 4.67 percent would go towards local sales tax, and 3.94 percent would go towards State sales tax.[122]

e. Fiscal Impact on Local Governments

Table D-3 shows the estimated fiscal cost to local governments due to the Proposed Amendments relative to baseline conditions. The fiscal impact to local governments is estimated to be approximately $12 million over the regulatory implementation period, from 2023 to 2038.

Table D-3. Estimated Fiscal Impacts to Local Governments from 2023 through 2038 (2019 $)

Year	Utility User Tax Revenue	Local Diesel Fuel Tax	Local sales Tax	Total Direct Costs	Total Costs
2023	-$15,606	$11,964	-$2,661,938	$4,383,859	$1,718,280
2024	-$15,613	$135,392	-$5,830,371	$6,621,408	$910,816
2025	-$16,728	$230,767	-$4,490,294	$4,324,295	$48,040
2026	-$51,882	$249,404	-$2,941,793	$2,772,417	$28,145
2027	-$68,391	$255,766	-$2,185,043	$2,626,282	$628,615
2028	-$71,777	$264,028	-$1,697,858	$2,231,045	$725,438
2029	-$81,330	$261,369	-$1,037,752	$1,925,388	$1,067,676
2030	-$82,163	$280,848	-$2,363,006	$3,437,780	$1,273,460
2031	-$82,618	$286,227	-$1,474,214	$2,041,295	$770,691
2032	-$82,834	$289,918	-$1,336,003	$1,857,401	$728,483
2033	-$83,165	$296,890	-$821,088	$1,691,210	$1,083,848
2034	-$83,537	$297,897	-$572,475	$1,240,676	$882,561
2035	-$83,708	$298,999	-$205,921	$534,746	$544,116
2036	-$83,556	$300,112	-$221,192	$640,966	$636,331

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[120] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate, last accessed May 18, 2021, *https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm*.

[121] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, October 1, 2020, last accessed February 10, 2021. *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm*.

[122] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate, last accessed May 18, 2021. *https://www.cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm*.

Year	Utility User Tax Revenue	Local Diesel Fuel Tax	Local sales Tax	Total Direct Costs	Total Costs
2037	-$83,483	$299,979	$0	$141,025	$357,521
2038	-$83,396	$299,812	$0	$148,915	$365,332
Total	-$1,069,784	$4,059,374	-$27,838,948	$36,618,711	$11,769,353

f. Cost-Savings from Avoided Health Impacts

With the reduction in DPM (a TAC), plus PM2.5 and NOx emissions resulting in improved air quality, it is expected that local governments would benefit from fewer employee sick days and a reduction in ER and public hospital visits. The Proposed Amendments would lead to some cost savings, but the share of cost savings attributable to the local government is not easily quantified. Based on the spatial distribution of emissions reductions and associated health benefits (Table B-2), most avoided hospitalizations and ER visit cost savings would occur in the South Coast and San Francisco Bay air basins. Local governments would also benefit from a greater ability to attain regional air quality goals.

Passengers that rely on CHC for transportation or recreation, communities that are located near where CHC operate, and occupational workers at ports, terminals, and other vessel facilities would especially benefit from reduced exposure to DPM, PM2.5, and NOx emissions. Staff did not specifically quantify the reduction in passenger or occupational exposure; however, to the extent that port and some terminal workers are local government employees, the Proposed Amendments would further reduce health care costs associated with air pollution from regulated vessels.

2. State Government

a. Direct Costs to Vessel Fleet and Facility Owner/Operators

The Proposed Amendments would have a small fiscal impact on State government agencies that own/operate fleet or vessel facilities, relative to the total estimated cost of the Proposed Amendments. Using 2020 data from the CHC reporting database, staff determined that 0.7 percent of total vessel fleets were owned/operated by State governments, and 0.7 percent of vessel facilities were owned/operated by State governments.

The assumptions underlying the direct costs to State government agencies are identical to those identified in Section C of this document. Staff applied the state government fleet and facility percentages to the total direct costs in Table C-25 to estimate the costs incurred by State government vessels and facility owner/operators. Infrastructure and administrative costs would be borne by both vessel fleets and vessel facilities; staff applied the fleet and facility State government percentages to all costs within these categories that would be incurred by the specific party. Sections C.2.f through C.2.l contain more information about the types of infrastructure and administrative costs that would be incurred by either fleet or facility owner/operators.

The estimated direct costs to State government equipment and facility owners are summarized in Table D-4.

Table D-4. Total Direct Costs of the Proposed Amendments to State Governments from 2023 through 2038 (2019 $)

Year	Repower and Retrofit Costs	Vessel Replacement Costs	Infrastructure Costs[1]	Administrative Costs[2]	Cost Savings	Total Direct Costs
2023	$748,030	$78,363	$372,311	$156,218	-$25,738	$1,329,184
2024	$1,645,784	$188,992	$372,385	$85,320	-$87,934	$2,204,546
2025	$1,166,775	$242,755	$240,554	$85,327	-$82,874	$1,652,538
2026	$802,704	$245,936	$15,355	$85,335	-$104,542	$1,044,789
2027	$647,158	$405,947	$18,669	$85,343	-$169,892	$987,225
2028	$508,656	$342,444	$19,434	$88,625	-$127,061	$832,098
2029	$323,662	$487,180	$21,397	$59,264	-$179,441	$712,062
2030	$755,008	$716,166	$21,662	$59,273	-$248,710	$1,303,398
2031	$429,644	$398,133	$21,856	$59,281	-$152,445	$756,469
2032	$364,502	$411,588	$21,887	$59,290	-$172,704	$684,563
2033	$141,704	$621,970	$21,941	$62,574	-$228,612	$619,577
2034	$75,152	$464,461	$22,018	$59,309	-$177,675	$443,264
2035	$91,307	$114,649	$22,012	$33,222	-$93,977	$167,213
2036	$57,294	$200,133	$21,934	$33,232	-$103,594	$208,998
2037	$14,680	$5,562	$21,896	$33,242	-$61,906	$13,475
2038	$14,680	$5,562	$21,851	$36,527	-$61,931	$16,690
Total	$7,786,739	$4,929,841	$1,257,162	$1,081,382	-$2,079,035	$12,976,089

b. Diesel Fuel Tax

When used off-road, Dyed Diesel is taxed at the combined statewide sales tax rate, plus applicable district taxes. Displacing diesel with electricity would decrease the total amount of diesel fuel dispensed in the State, resulting in a reduction in tax revenue collected by State governments, as shown in Table D-8. The State tax on diesel fuel used in this analysis was 3.94 percent.

c. Energy Resource Fee

The Energy Resource Fee is a $0.0003/kWh surcharge levied on consumers of electricity purchased from electrical utilities.[123] The revenue collected is deposited into the Energy Resources Programs Account of the General Fund which is used for ongoing energy programs and projects deemed appropriate by the Legislature, including but not limited to, activities of the California Energy Commission. The annual estimated energy resource fee revenue is quantified in Table D-8.

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[123] California Department of Tax and Fee Administration, 2020 Electrical Energy Surcharge Rate, last accessed July 2020, *https://www.cdtfa.ca.gov/formspubs/l725.pdf*.

d. State Sales Tax

Sales taxes are levied in California to fund a variety of programs at the local and State levels. The Proposed Amendments would result in additional sales of vessels and vessel equipment relative to baseline conditions, which would result in a direct increase in sales tax revenue collected by the State government, as shown in Table D-8. A combined State and local sales tax value of 8.6 percent was used for staff's analysis based on a weighted average based on county-level output. Staff assumed 3.94 percent would go towards State sales tax.[124]

e. Costs to CARB

Existing CARB staff have been working to implement and enforce the Current Regulation and additional staff will be necessary to augment implementation and enforcement of the Proposed Amendments. The following information and Tables D-6a and D-6b describe the existing and new CARB staff positions required to implement and enforce the Current Regulation and the Proposed Amendments:

- CARB's Transportation and Toxics Division (TTD) currently has one Air Pollution Specialist (APS) position, one Air Resources Technician (ART) II position, and 0.33 Air Resources Supervisor (ARS) I position devoted to the implementation of the Current Regulation. Beginning in fiscal year (FY) 2022 – 2023, one additional Air Resources Engineer (ARE) and one additional ART II position would be needed to perform implementation functions once the Proposed Amendments are effective, including preparing guidance documents, assisting regulated entities with compliance, reviewing and accepting reporting data, and processing requests for low-use exceptions and compliance extension requests. The total number of personnel years (PY) for TTD to implement functions of the Proposed Amendments would be 4.33 beginning in FY 2022-2023.
- CARB's Enforcement Division (ED) currently has one APS position and 0.33 ARS I position devoted to the implementation of the Current Regulation. Beginning in FY 2022 – 2023, three additional APS positions, four new ART II positions, and 0.33 new SSM I positions would be needed to conduct enforcement activities, including analyzing vessel activity data reports, and issuing and processing citations. The need for increased enforcement would result from newly regulated vessel categories and new facility requirements under the Proposed Amendments. The total number of PYs for ED to conduct enforcement activities for the Proposed Amendments would be 8.66 beginning in FY 2022 – 2023.

Tables D-6a and D-6b show the needed PYs and their associated costs for implementing and enforcing the Current Regulation. The total PY costs include a

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[124] California Department of Tax and Fee Administration, California City & County Sales & Use Tax Rates, last accessed February 2021, *https://www.cdtfa.ca.gov/taxes-and-fees/sales-use-tax-rates.htm.*

26 percent indirect labor cost. This cost was calculated to provide the incremental cost basis for implementing and enforcing the Proposed Amendments.

Table D-5. CARB Positions and Costs per Year for Implementing and Enforcing the Current Regulation

CARB Division	Position	PY	Cost Per PY	Direct Costs	Indirect Costs (26%)	Total PY Cost
TTD (Implementation)	ARS I	0.33	$234,051	$78,017	$20,284	$98,301
TTD (Implementation)	APS	1	$191,764	$191,764	$49,859	$241,623
TTD (Implementation)	ART II	1	$99,324	$99,324	$25,824	$125,148
ED (Enforcement)	ARS I	0.33	$234,051	$78,017	$20,284	$98,301
ED (Enforcement)	APS	1	$191,764	$191,764	$49,859	$241,623

1. **Grand Total**: $804,996
2. CARB would also need additional resources in order to implement the Proposed Amendments. Staff estimated an annual travel cost of $61,290 starting in FY 2022-2023 in order to perform enforcement-related activities such as inspections, and an annual cost of $50,000 starting in FY 2022-2023 for third-party contract(s) to gather vessel operational activity and visit data in order to support reporting and enforcement.

The FY 2021 to 2022 budget does not include any resources specifically for implementation or enforcement of the Proposed Amendments (the additional functions described above), because the Proposed Amendments have not yet been adopted. CARB will seek authorization to use fees collected to augment staff once the Board acts on the Proposed Amendment. Tables D-6a and D-6b summarize the number of PYs needed by CARB and their associated costs for implementing and enforcing the Proposed Amendments. The total PY costs include a 26 percent indirect labor cost referenced in a mobile source certification and compliance fee workshop.[125] The enforcement fees would be based on these costs. Table D-7 summarizes the estimated annual staffing and resource costs expected to be incurred by CARB from 2023 to 2038 but reimbursed through the collection of compliance fees.

Table D-6a. CARB PY and Costs per Year for TTD to implement the Proposed Amendments

Position	ARE	ART II	ARS I	APS	ART II
PY	1	1	0.333	1	1
Cost Per PY	$202,582	$99,324	$234,051	$191,764	$99,324
Direct Costs	$202,582	$99,324	$78,017	$191,764	$99,324
Indirect Costs (26%)	$52,671	$25,824	$20,284	$49,859	$25,824
Total PY Cost	$255,253	$125,148	$98,301	$241,623	$125,148

1. Contracts: $50,000; Contract with an external entity that will help with reporting vessels to CARB.
2. **Grand Total**: $895,473

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[125] Mobile Source Certification and Compliance Fee Workshop, Aftermarket Parts, Evaporative Components, and Retrofits, July 30, 2020, last accessed May 19, 2021, *https://ww2.arb.ca.gov/sites/default/files/2020-07/July%2030%2C%202020%201PM%20AMP-EvapComp-Retrofit%20workshop%20ver.2_R.pdf*.

Table D-6b. CARB PY and Costs per Year for ED to enforce the Proposed Amendments

Position	APS	ART II	ARS I	SSM I
PY	4	4	0.333	0.333
Cost Per PY	$191,764	$99,324	$234,051	$153,412
Direct Costs	$767,056	$397,296	$78,017	$51,086
Indirect Costs (26%)	$199,435	$103,297	$20,284	$13,282
Total PY Cost	$966,491	$500,593	$98,301	$64,369

1. Travel: $61,290; Travel costs estimated by ED.
2. **Grand Total**: $1,691,044

Table D-7. Estimated Annual Staffing and Resource Costs Incurred by CARB from 2023 through 2038

Year	PY Costs	Travel Costs	Contracting	Total
2023	$2,475,727	$61,290	$50,000	$2,587,017
2024	$2,466,727	$61,290	$50,000	$2,578,017
2025	$2,466,727	$61,290	$50,000	$2,578,017
2026	$2,466,727	$61,290	$50,000	$2,578,017
2027	$2,466,727	$61,290	$50,000	$2,578,017
2028	$2,466,727	$61,290	$50,000	$2,578,017
2029	$2,466,727	$61,290	$50,000	$2,578,017
2030	$2,466,727	$61,290	$50,000	$2,578,017
2031	$2,466,727	$61,290	$50,000	$2,578,017
2032	$2,466,727	$61,290	$50,000	$2,578,017
2033	$2,466,727	$61,290	$50,000	$2,578,017
2034	$2,466,727	$61,290	$50,000	$2,578,017
2035	$2,466,727	$61,290	$50,000	$2,578,017
2036	$2,466,727	$61,290	$50,000	$2,578,017
2037	$2,466,727	$61,290	$50,000	$2,578,017
2038	$2,466,727	$61,290	$50,000	$2,578,017
Total	$39,476,632	$980,640	$800,000	$41,257,272

f. Fiscal Impact on State Government

Table D-8 shows the estimated fiscal impacts to the State government from 2023 through 2038. During this period, the State government would experience a positive fiscal impact of approximately $20 million from the Proposed Amendments, relative to the baseline conditions of the Current Regulation. This includes a $3 million decrease in fuel tax revenue, $23.5 million in increased energy resources fee and sales tax revenue, $28 million in new CARB implementation costs, $13 million in direct compliance costs, and additional revenue from compliance fees of $41 million. The compliance fee has been calibrated so that it will cover the incremental costs to CARB ($28 million) and baseline costs with continuing to implement requirements of the Current Regulation.

Table D-8. Estimated Fiscal Impacts to State Governments from 2023 through 2038 (2019 $)

Year	Costs to CARB	State Fuel Tax Revenue	Energy Resources Fee	State Sales Tax	Total Direct Costs	Collected Compliance Fees	Total Fiscal Impact
2023	$1,781,521	$10,094	-$569	-$2,245,832	$1,329,184	-$2,586,517	-$1,712,120
2024	$1,772,521	$114,228	-$569	-$4,918,985	$2,204,546	-$2,577,517	-$3,405,777
2025	$1,772,521	$194,694	-$593	-$3,788,385	$1,652,538	-$2,577,517	-$2,746,743
2026	$1,772,521	$210,418	-$1,802	-$2,481,941	$1,044,789	-$2,577,517	-$2,033,533
2027	$1,772,521	$215,786	-$2,338	-$1,843,484	$987,225	-$2,577,517	-$1,447,808
2028	$1,772,521	$222,756	-$2,407	-$1,432,454	$832,098	-$2,577,517	-$1,185,005
2029	$1,772,521	$220,513	-$2,681	-$875,533	$712,062	-$2,577,517	-$750,636
2030	$1,772,521	$236,947	-$2,659	-$1,993,628	$1,303,398	-$2,577,517	-$1,260,938
2031	$1,772,521	$241,485	-$2,625	-$1,243,769	$756,469	-$2,577,517	-$1,053,435
2032	$1,772,521	$244,599	-$2,637	-$1,127,163	$684,563	-$2,577,517	-$1,005,634
2033	$1,772,521	$250,481	-$2,652	-$692,738	$619,577	-$2,577,517	-$630,327
2034	$1,772,521	$251,330	-$2,662	-$482,988	$443,264	-$2,577,517	-$596,051
2035	$1,772,521	$252,261	-$2,686	-$173,732	$167,213	-$2,577,517	-$561,941
2036	$1,772,521	$253,200	-$2,705	-$186,616	$208,998	-$2,577,517	-$532,119
2037	$1,772,521	$253,087	-$2,713	$0	$13,475	-$2,577,517	-$541,148
2038	$1,772,521	$252,947	-$2,724	$0	$16,690	-$2,577,517	-$538,084
Total	$28,369,337	$3,424,825	-$35,023	-$23,487,249	$12,976,089	-$41,249,279	-$20,001,300

3. Federal Government

a. Direct Costs to Vessel Fleet and Facility Owners/Operators

The Proposed Amendments would have a small fiscal impact on federal government agencies that own/operate fleets or vessel facilities, relative to the total estimated cost of the Proposed Amendments. Using 2020 data from the CHC reporting database, staff determined that 0.6 percent of total vessel fleets (as a percentage of vessel-owning companies, rather than as a percentage of vessel population) were owned/operated by federal governments, and 0.4 percent of vessel facilities were owned/operated by federal governments.

The assumptions underlying the direct costs to federal government agencies are identical to those identified in Chapter C of this document. Staff applied the federal government fleet and facility percentages to the total direct costs in Table C-25 to estimate the costs incurred by federal government vessel and facility owner/operators. Infrastructure and administrative costs would be borne by both vessel fleets and vessel facilities; staff applied the fleet and facility local government percentages to all costs within these categories that would be incurred by the specific party. Sections C.2.f. and C.2.l contain more information about the types of infrastructure and administrative costs that would be incurred by either fleet or facility owner/operators.

The estimated direct costs to federal government equipment and facility owners are summarized in Table D-9.

Table D-9. Total Direct Costs of the Proposed Amendments to Federal Governments from 2023 through 2038

Year	Repower and Retrofit Costs	Vessel Replacement Costs	Infrastructure Costs	Administrative Costs	Cost Savings	Total Direct Costs
2023	$664,915	$69,656	$241,025	$134,918	-$22,878	$1,087,636
2024	$1,462,919	$167,993	$241,043	$71,896	-$78,163	$1,865,687
2025	$1,037,133	$215,783	$208,152	$71,903	-$73,666	$1,459,305
2026	$713,515	$218,610	$7,855	$71,909	-$92,926	$918,963
2027	$575,252	$360,842	$10,708	$71,916	-$151,015	$867,703
2028	$452,139	$304,395	$11,274	$74,834	-$112,943	$729,699
2029	$287,700	$433,049	$12,915	$48,735	-$159,503	$622,895
2030	$671,118	$636,592	$13,037	$48,743	-$221,076	$1,148,413
2031	$381,906	$353,896	$13,092	$48,751	-$135,506	$662,138
2032	$324,001	$365,856	$13,132	$48,758	-$153,514	$598,234
2033	$125,959	$552,862	$13,192	$51,677	-$203,210	$540,480
2034	$66,802	$412,854	$13,256	$48,775	-$157,933	$383,753
2035	$81,162	$101,910	$13,295	$25,587	-$83,535	$138,418
2036	$50,928	$177,896	$13,279	$25,596	-$92,084	$175,615
2037	$13,049	$4,944	$13,272	$25,605	-$55,028	$1,841
2038	$13,049	$4,944	$13,263	$28,525	-$55,050	$4,730
Total	$6,921,546	$4,382,081	$851,788	$898,128	-$1,848,031	$11,205,512

E. Macroeconomic Impacts

1. Methods for Determining Economic Impacts

This section describes the estimated impact of the Proposed Amendments on the California economy. The Proposed Amendments would result in changes in costs to numerous CHC sectors in order to comply with the in-use and new-build vessel performance standards, ZEAT requirements, and other vessel requirements. These changes in costs would affect employment, output, and investment in the CHC sectors and also impact the industries that may see changes in demand to support the CHC sector, such as engine manufacturers and manufacturers of ZEAT.

The direct impacts of the Proposed Amendments would lead to additional indirect and induced effects, like changes in personal income that affect consumer expenditures across other spending categories. The incremental total economic impacts of the Proposed Amendments are simulated relative to the baseline using cost data described in Chapter C of the SRIA. The analysis focuses on incremental change in major macroeconomic indicators from 2023 to 2038 including employment, output growth, and Gross State Product (GSP). The years of the analysis are used to simulate the Proposed Amendments through 12 months post full implementation.

REMI Policy Insight Plus Version 2.5.0 is used to estimate the macroeconomic impacts of the Proposed Regulation on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.[126] REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the Proposed Regulation, pursuant to the requirements of SB 617 and the California DOF. Staff used the REMI single region, 160 sector model with the model reference case adjusted to reflect California DOF's most current publicly-available economic and demographic projections.[127, 128]

Specifically, REMI model's National and Regional Control was updated to conform to the most recent California DOF economic forecasts which include U.S. Real GDP, income, and employment, as well as California population and civilian employment by industry, released with the May Revision budget on May 14, 2021.[129, 130, 131, 132] After the DOF forecasts end in 2024, CARB staff made assumptions that post-2024, economic variables would continue to grow at the same rate projected in the REMI baseline forecasts.

2. Inputs of the Assessment

The estimated economic impact of the Proposed Amendments is sensitive to modeling assumptions. This section provides a summary of the assumptions and inputs used to determine the suite of policy variables that best reflect the macroeconomic impacts of the Proposed Amendments. The direct costs estimated in Chapter C and

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[126] For further information and model documentation see: *https://www.remi.com/model/pi/*

[127] California Legislature, Senate Bill 617. October 2011, last accessed June 4, 2021, *https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120SB617*

[128] California Department of Finance, Chapter 1: Standardized Regulatory Impact Analysis for Major Regulations - Order of Adoption. December 2013, last accessed June 4, 2021, *https://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/documents/Order_of_Adoption-12012013.pdf*

[129] California Department of Finance. Economic Research Unit. National Economic Forecast – Annual & Quarterly. Sacramento: California. April 2021, last accessed May 14, 2021, *https://www.dof.ca.gov/Forecasting/Economics/Eco_Forecasts_Us_Ca/documents/United%20States%20Economic%20Forecast%20MR%202021-22.xlsx*.

[130] California Department of Finance. Economic Research Unit. California Economic Forecast – Annual & Quarterly. Sacramento: California. April 2021, last accessed May 26, 2021, *https://www.dof.ca.gov/Forecasting/Economics/Eco_Forecasts_Us_Ca/documents/California%20Economic%20Forecast%20MR%202021-22.xlsx*.

[131] California Department of Finance. Economic Research Unit. National Deflators: Calendar Year averages: from 1929, April 2021. Sacramento: California. April 2021, last accessed May 25, 2021, *https://www.dof.ca.gov/Forecasting/Economics/Indicators/Inflation/documents/Implicit%20Price%20Deflators%20CY.xlsx*.

[132] California Department of Finance. Demographic Research Unit. Report P-3: Population Projections, California, 2010-2060 (Baseline 2019 Population Projections; Vintage 2020 Release). Sacramento: California. April 2021, last accessed May 28, 2021, *https://www.dof.ca.gov/Forecasting/Demographics/Projections/documents/P3_Complete.zip*.

the non-mortality health benefits estimated in Chapter B are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[133]

The direct costs of the Proposed Amendments are described in Chapter C of the SRIA, and include capital costs for repower, retrofit, vessel replacements, and electric equipment, construction costs for infrastructure installations, and administrative costs associated with financial review, naval architect reports, and recordkeeping and reporting from vessels and facilities. Equipment, operational, and administrative costs and savings for vessels are input into the economic model as a change in production costs based on the vessel categories North American Industry Classification System (NAICS). Table E-1 provides the vessel category and associated NAICS code that was used:

Table E-1. Vessel Category and Associated NAICS Code

Vessel Category	Industry (NAICS Code)
Ferry (Catamaran)	Water Transportation (483)
Ferry (Monohull)	Water Transportation (483)
Ferry (Short Run)	Water Transportation (483)
Pilot Boat	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
Push/Tow Tug	Water Transportation (483)
Escort/Ship Assist Tug	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
ATB Tug	Water Transportation (483)
Research Vessel	Water Transportation (483)
Commercial Passenger Fishing	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
Excursion	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
Dredge	Construction (23)
ATB Barge	Water Transportation (483)
Bunker Barge	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
Other Barge	Construction (23)
Towed Petrochemical Barge	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
Crew Supply	Water Transportation (483)
Workboat	Scenic and Sightseeing Transportation and Support Activities for Transportation (487,488)
Commercial Fishing	Fishing, Hunting, and Trapping (114)

Costs borne by facilities such as seaports, terminals, marinas, harbors, and land with docks are also input into the economic model as increases in production costs in the scenic and sightseeing transportation and support activities for the transportation industry (NAICS 487, 488).

Costs and savings incurred by vessels and facilities would result in corresponding changes in final demand for industries supplying those particular services or

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[133] Refer to Technical Appendix: Macroeconomic Modeling Inputs for a full list of REMI inputs for this analysis.

equipment. Increased demand associated with new engines and more stringent in-use engine requirements are assumed to be met by businesses in the engine, turbine, and power transmission equipment manufacturing industry (NAICS 3336). Demand for electric equipment on vessels is modeled as increased demand for businesses in the electrical equipment manufacturing industry (NAICS 3353). Infrastructure-related demand for utilities, installation of dock power, dock construction, and other engineering costs are modeled as increased demand in the construction industry (NAICS 23). Additional demand for labor and installation of vessel-side equipment is modeled as increased demand in the ship and boat building industry (NAICS 3366). Staff assumed that 80 percent of this work would occur at California facilities based on discussions with shipyards, marine service facilities, boat repair shops, and fleet owners. Additional demand for opacity testing is expected to be met by businesses that currently perform opacity testing on vehicles and is modeled as increased demand for businesses within the automotive repair and maintenance industry (NAICS 8111).

The additional demand for financial review is modeled as increased demand in the accounting, tax preparation, bookkeeping, and payroll services industry (NAICS 5412). Naval architect reports are modeled as increased demand in the architectural, engineering, and related services industry (NAICS 5413). Recordkeeping and reporting for vessels and facilities are modeled as increased demand in the office and administrative services and facilities support services industry (NAICS 5611, 5612).

As a result of the Proposed Amendments, there would also be changes in diesel and electricity fuel use. These changes are modeled as changes in demand in the petroleum and coal products manufacturing industry (NAICS 324) and the electric power generation, transmission, and distribution industry (NAICS 2211), respectively.

Table E-2 illustrates the sources of changes in production costs for vessel owners, vessel operators, and vessel facilities and corresponding changes in final demand by the industry as described above.

Table E-2. Sources of Changes in Production Cost and Final Demand by Industry

Source of Cost or Savings	Industries with changes in production costs*	Industries with changes in final demand (NAICS)
Repower, Retrofit, and Vessel Replacement Costs	Vessel Owner/Operators	Engine, turbine, and power transmission equipment manufacturing (3336), Ship and boat building (3366)
Shore Power Infrastructure	Vessel Owner/Operators and Vessel Facilities (487, 488)	Construction (23), Electrical equipment manufacturing (3353), Ship and boat building (3366)
Financial Review	Vessel Owner/Operators	Accounting, tax preparation, bookkeeping, and payroll services (5412)
Naval Architect Report	Vessel Owner/Operators	Architectural, engineering, and related services (5413)
Recordkeeping and Reporting, Vessel Labeling, Facility Report, and Regulation Interpretation Cost	Vessel Owner/Operators and Vessel Facilities (487, 488)	Office administrative services; facilities support services (5611, 5612)
Compliance Fees	Vessel Owner/Operators	**n/a
Opacity Tests	Vessel Owner/Operators	Automotive repair and maintenance (8111)
Electricity Costs	Vessel Owner/Operators	Electric power generation, transmission, and distribution (2211)
Diesel Fuel Savings	Vessel Owner/Operators	Petroleum and coal products manufacturing (324)

*Costs to Vessel Owner/Operators are applied to NAICS categories as represented in Table E-2.
**Since the compliance fees would be paid to CARB, and would offset implementation costs of the Proposed Amendments, this would not result in a change in final demand for any industry.

In addition to these changes in production costs and final demand for businesses, there would be economic impacts as a result of fiscal effects. The Proposed Amendments would result in changes in diesel, electricity, and sales tax revenues. The changes in tax revenue are modeled as changes in State and local government spending, assuming that this revenue is not offset elsewhere. The additional CARB staff to implement the Proposed Amendments is modeled as an increase in government employment. The fees collected through Proposed Amendments would be expected to offset all employment and implementation costs of the regulation and are not anticipated to result in additional economic impacts through increased government spending. For this reason, the increased fee revenue collected through the Proposed Amendments was not added to the REMI modeling as an increase in State government spending, nor was government spending decreased to reflect the opportunity costs of additional hires.

The health benefits resulting from emission reductions of the Proposed Amendments would reduce health care costs for individuals on average. The reduction in healthcare cost is modeled as a decrease in spending for hospitals, with a reallocation of the spending towards other freight and increased savings. The GHG emission reduction benefits as valued through the SC-CO2 represent the avoided damage from climate change worldwide per MT of CO2-equivalent. These benefits fall outside the scope of the economic model and are not evaluated here.

3. Results of the Assessment

The results from the REMI model provide estimates of the impact of the Proposed Amendments on California's economy. These results represent the annual incremental change from the implementation of the Proposed Amendments relative to the baseline scenario. California's economy is anticipated to grow through 2038; therefore, negative statewide impacts reported here should be interpreted as a slowing of growth and positive statewide impacts as an acceleration of growth resulting from the Proposed Amendments.

a. California Employment Impacts

Table E-3 presents the impacts of the Proposed Amendments on total employment in California and for the primary and secondary industries impacted by the Proposed Amendments, for all of the odd years of the assessment.[134] The Proposed Amendments are anticipated to have a slightly positive impact on employment growth in 2023 through 2030, corresponding with demand for cleaner technology and ZEAT engines and demand for labor and installation of new engines that would likely occur at California-based shipyards. From 2031 through 2038, the Proposed Amendments are estimated to result in slightly slower employment growth as the overall costs of the Proposed Amendments offset the positive impacts of additional in-state demand. The changes in statewide employment never represent more than a 0.01 percent change relative to baseline California employment.

The overall trend in employment growth by major sectors are illustrated in Figure E-1. The major sectors that are estimated to have increased demand are estimated to experience employment growth. In particular, the manufacturing sector is estimated to see employment growth in most years of the assessment. Sectors that are estimated to face direct costs are estimated to have decreased employment growth because of the Proposed Amendments. In particular, the majority of CHC fall within the transportation and public utilities sector, which is estimated to experience decreases in employment growth in most years of the assessment.

Industries that are estimated to have net costs, decreases in demand, or revenue loss are anticipated to have decreases in employment growth. This includes the industries that operate CHC equipment. The water transportation industry, scenic and sightseeing transportation, and support activities for the transportation industry, and the fishing industry are all estimated to have decreases in employment growth relative to the baseline. These range from an impact on employment of less than 0.01 percent in the early years of the assessment to 0.8 percent and 1.1 percent for the fishing, hunting and trapping industry, and water transportation industry, respectively.

Some industries contain businesses that will see both increases in demand and increased direct costs. Costs to dredges were modeled as increased costs in the

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[134] In 2038, the impacts are similar in magnitude to the impacts in 2037 as evidenced in the figures that are also presented in this section.

construction industry. However, the construction industry will also see increases in demand in the early years of the assessment for landside infrastructure. As a result, the construction industry is estimated to see slight increases in employment growth in the early years of the assessment, followed by slight decreases in employment growth in later years. Within the construction industry, the Proposed Amendments are not estimated to increase or decrease employment by more than 0.01 percent relative to baseline levels.

Industries that are estimated to have increased demand may see employment growth. California shipyards are expected to perform a significant amount of the installation and retrofits on CHC. As a result, the ship and boat building industry is estimated to see increases in employment up to 9 percent above baseline levels, depending on the year of the assessment and the number of retrofits or installations that are performed.

Figure E-1. Changes in Employment Growth by Major Sector

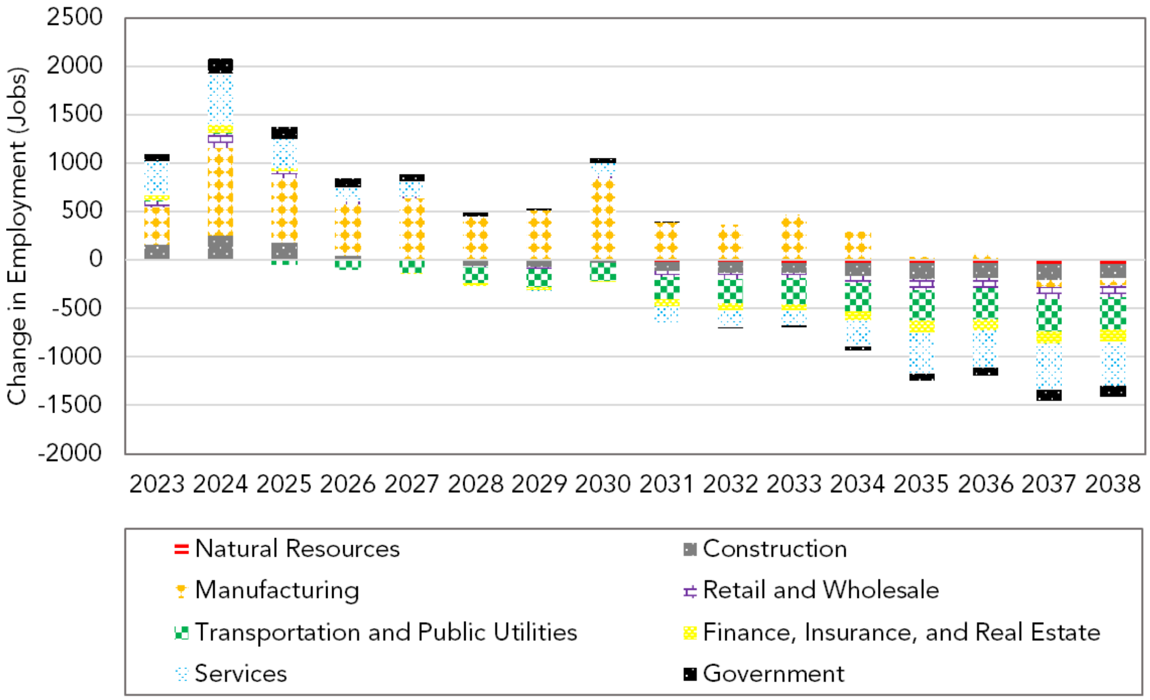

Table E-3. Summary of Employment Growth Impacts Associated with the Proposed Amendments

Industry	Units	2023	2025	2027	2029	2031	2033	2035	2037
CA statewide	Total Employment (millions)	24.9	25.4	25.5	25.5	25.5	25.6	25.7	25.9
CA statewide	Percent change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
CA statewide	Change in jobs	1,090	1,330	750	200	-260	-220	-1,210	-1,450
Water transportation	Percent change	-0.06%	-0.23%	-0.41%	-0.57%	-0.76%	-0.91%	-1.01%	-1.05%
Water transportation	Change in jobs	0	-10	-30	-40	-50	-60	-60	-70
Scenic and sightseeing trans. and support activities for trans.	Percent change	-0.01%	-0.03%	-0.05%	-0.06%	-0.08%	-0.09%	-0.10%	-0.10%
Scenic and sightseeing trans. and support activities for trans.	Change in jobs	-10	-40	-70	-90	-110	-130	-140	-140
Construction	Percent change	0.01%	0.01%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
Construction	Change in jobs	160	180	10	-60	-100	-110	-170	-170
Fishing, hunting, and trapping	Percent change	-0.18%	-0.17%	-0.16%	-0.16%	-0.30%	-0.55%	-0.70%	-0.81%
Fishing, hunting, and trapping	Change in jobs	-10	-10	-10	-10	-10	-20	-30	-30
Engine, turbine, and power transmission equipment manufacturing	Percent change	0.27%	0.43%	0.22%	0.11%	0.14%	0.08%	0.02%	0.00%
Engine, turbine, and power transmission equipment manufacturing	Change in jobs	30	50	30	10	20	10	0	0
Ship and boat building	Percent change	4.59%	8.55%	9.45%	8.49%	6.94%	8.92%	1.85%	-0.13%
Ship and boat building	Change in jobs	300	560	600	520	410	500	100	-10
Electrical equipment manufacturing	Percent change	0.11%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Electrical equipment manufacturing	Change in jobs	10	10	0	0	0	0	0	0

Industry	Units	2023	2025	2027	2029	2031	2033	2035	2037
Accounting, tax preparation, bookkeeping, and payroll services	Percent change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
Accounting, tax preparation, bookkeeping, and payroll services	Change in jobs	10	10	0	0	0	0	-10	-10
Architectural, engineering, and related services	Percent change	0.02%	0.02%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%
Architectural, engineering, and related services	Change in jobs	50	50	40	20	10	10	-10	-10
Office administrative services; facilities support services	Percent change	0.06%	0.01%	0.01%	0.01%	0.00%	0.01%	0.00%	0.00%
Office administrative services; facilities support services	Change in jobs	70	10	10	10	0	10	0	0
Automotive repair and maintenance	Percent change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Automotive repair and maintenance	Change in jobs	10	10	0	0	-10	-10	-10	-10
Electric power generation, transmission, and distribution	Percent change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Electric power generation, transmission, and distribution	Change in jobs	0	0	0	0	0	0	0	0
Petroleum and coal products manufacturing	Percent change	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
Petroleum and coal products manufacturing	Change in jobs	0	0	0	0	0	0	0	0

b. California Business Impacts

Gross output is used as a measure for business impacts because it represents an industry's sales or receipts and tracks the quantity of freight or services produced in a given time period. Output is the sum of output for each private industry, state, and local government as it contributes to the State's GDP, and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decrease or demand increases, industries would likely experience growth.

As illustrated in Table E-4 and Figure E-2, the Proposed Amendments are estimated to result in an increase in statewide output from 2023 through 2030. During the latter portion of the analysis, the Proposed Amendments are estimated to lead to a slight decrease in statewide output. The changes in statewide output are no larger than 0.01 percent of baseline levels.

Figure E-2 illustrates the impacts to output by major sectors. Similar to the employment impacts, sectors and industries that are anticipated to face production cost increases, decreases in demand or revenue are anticipated to have corresponding decreases in output growth, while industries that are anticipated to see increases in demand are estimated to have increases in output growth.

The trends in output impacts by industry are also similar to the trends in the changes in employment by industry. The industries that face direct costs to comply with the Proposed Amendments are estimated to see a decrease in output of up to 1 percent, relative to the baseline, in the years with the greatest impact. Conversely, industries such as ship and boat building and engine, turbine, and power transmission equipment manufacturing are estimated to see increases in output, relative to baseline levels, of 9 percent and 0.4 percent in the years of greatest impact.

Figure E-2. Changes in Output Growth by Major Sector

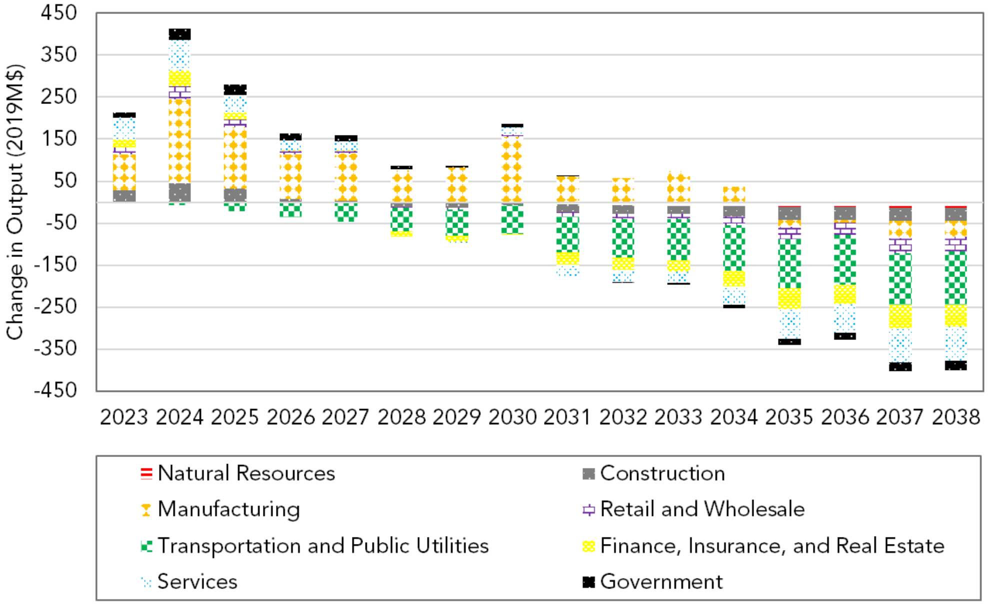

Table E-4. Summary of Output Growth Impacts Associated with the Proposed Amendments

Industry	Units	2023	2025	2027	2029	2031	2033	2035	2037
CA statewide	Total Output (2019B$)	5,341.4	5,582.6	5,710.4	5,855.1	5,991.3	6,156.0	6,339.1	6,548.0
CA statewide	Percent change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
CA statewide	Change (2019M$)	210	258	113	-13	-112	-124	-340	-403
Water transportation	Percent change	-0.06%	-0.24%	-0.41%	-0.58%	-0.77%	-0.93%	-1.03%	-1.07%
Water transportation	Change (2019M$)	-3	-13	-23	-32	-42	-50	-56	-61
Scenic and sightseeing trans. and support activities for trans.	Percent change	-0.01%	-0.03%	-0.05%	-0.07%	-0.08%	-0.09%	-0.10%	-0.10%
Scenic and sightseeing trans. and support activities for trans.	Change (2019M$)	-2	-8	-15	-21	-26	-31	-35	-37
Construction	Percent change	0.01%	0.01%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
Construction	Change (2019M$)	27	33	3	-11	-18	-20	-32	-32
Fishing, hunting, and trapping	Percent change	-0.18%	-0.17%	-0.16%	-0.16%	-0.30%	-0.55%	-0.71%	-0.82%
Fishing, hunting, and trapping	Change (2019M$)	-2	-2	-2	-2	-4	-7	-10	-11
Engine, turbine, and power Transmission equipment manufacturing	Percent change	0.27%	0.44%	0.22%	0.11%	0.15%	0.09%	0.02%	0.00%
Engine, turbine, and power transmission equipment manufacturing	Change (2019M$)	29	48	24	12	15	9	2	0
Ship and boat building	Percent change	4.63%	8.69%	9.66%	8.72%	7.21%	9.20%	2.06%	0.02%
Ship and boat building	Change (2019M$)	39	79	88	81	68	87	20	0
Electrical equipment manufacturing	Percent change	0.11%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Electrical equipment manufacturing	Change (2019M$)	2	2	0	0	0	0	0	0
Accounting, tax preparation, bookkeeping, and payroll services	Percent change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%

Industry	Units	2023	2025	2027	2029	2031	2033	2035	2037
Accounting, tax preparation, bookkeeping, and payroll services	Change (2019M$)	1	1	1	0	-1	-1	-2	-2
Architectural, engineering, and related services	Percent change	0.02%	0.02%	0.01%	0.01%	0.01%	0.01%	0.00%	0.00%
Architectural, engineering, and related services	Change (2019M$)	10	10	9	4	3	4	-2	-3
Office administrative services; facilities support services	Percent change	0.06%	0.01%	0.01%	0.01%	0.00%	0.01%	0.00%	0.00%
Office administrative services; facilities support services	Change (2019M$)	10	1	1	1	1	1	0	0
Automotive repair and maintenance	Percent change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Automotive repair and maintenance	Change (2019M$)	1	1	0	0	-1	-1	-1	-2
Electric power generation, transmission, and distribution	Percent change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Electric power generation, transmission, and distribution	Change (2019M$)	1	1	2	1	1	1	0	-1
Petroleum and coal products manufacturing	Percent change	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
Petroleum and coal products manufacturing	Change (2019M$)	1	0	-3	-5	-7	-8	-10	-10

c. Impacts on Investments in California

Gross domestic private investment consists of purchases of residential and non-residential structures and equipment and software by private businesses and non-profit institutions. It is used as a proxy for impacts on investments in California because it provides an indicator of the future productive capacity of the economy.

The changes in private investment for the Proposed Amendments, relative to the baseline, are shown in Table E-5 and show increases in private investment as great as $34 million in 2025 and a decrease as large as $46 million in 2037, relative to baseline levels. In any given year these impacts represent changes of less than 0.01 percent of baseline investment.

Table E-5. Changes in Gross Domestic Private Investment Growth

Units	2023	2025	2027	2029	2031	2033	2035	2037
Private Investment (2019B$)	467	500	511	523	534	549	565	583
Percent Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Change (2019M$)	18	34	12	-8	-16	-21	-40	-46

d. Impacts on Individuals in California

As modeled, the Proposed Amendments do not impose direct costs on individuals in California. However, the costs incurred by affected businesses and the public sector would cascade through the economy and affect individuals. One measure of the statewide impact is the change in real personal income.

Table E-6 shows the annual change in real personal income across all individuals in California. Total personal income increases by $59 million in 2023, followed by a gradual decrease, ending with a decrease of $205 million in 2037. The change in personal income can also be divided by the California population to show the average or per capita impact on personal income. Personal income initially increases by approximately $1 per person in 2023 and decreases by about $5 per person in 2037, the year with the greatest impact.

Table E-6. Change in Personal Income Growth

Units	2023	2025	2027	2029	2031	2033	2035	2037
Personal Income (2019B$)	2,777	2,914	3,002	3,100	3,225	3,320	3,423	3,534
Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Change (2019M$)	59	49	12	-35	-100	-97	-181	-205
Per Capita Change (2019$)	1.46	1.21	0.29	-0.85	-2.39	-2.28	-4.23	-4.77

e. Impacts on Gross State Product

Gross State Product is the market value of all freight and services produced in California and is one of the primary indicators used to gauge the health of the economy. Table E-7 shows the annual change in GSP as estimated as a result of the Proposed Amendments. Under the Proposed Amendments, GSP is anticipated to experience a slight increase in growth from 2023 through 2027. This primarily reflects the initial increase in demand for more expensive engines and demand for installations and construction services within California. After this initial demand has been met, the ongoing increased costs to the CHC sector results in a slight decrease in GSP growth. In 2037, GSP is estimated to be $213 million lower than baseline levels, a 0.01 percent decrease.

Table E-7. Change in Gross State Product Growth

Units	2023	2025	2027	2029	2031	2033	2035	2037
Gross State Product (2019B$)	3,178	3,325	3,410	3,512	3,616	3,735	3,861	3,995
Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Change (2019M$)	110	132	59	-7	-61	-65	-180	-213

f. Creation or Elimination of Businesses

The Proposed Amendments do not directly result in business creation or elimination and the REMI model cannot directly estimate the creation or elimination of businesses. However, changes in the jobs and output for California can be used to understand some of the potential impacts. The overall jobs and output growth impacts are small relative to the total California economy, about 0.01 percent in the years of greatest impact. However, impacts in some sectors are larger or occur at different times, as described in previous sections.

Reductions in output growth could indicate the elimination of businesses, relative to the baseline. Conversely, increased output within an industry could signal the potential for additional business creation if existing businesses cannot accommodate all future demands. There is no threshold that identifies the creation or elimination of businesses. Based on the modeling of output changes, the ship and boat building industry, and in particular shipyards that may be providing services to install equipment on CHC, may see an increased output in several years. Increased demand for services at California shipyards would also benefit ancillary businesses within the supply chain.

As discussed in Chapter B, the Proposed Amendments would also provide opportunities for design, engineering, construction, and project management to design and install expanded infrastructure at docks. This is reflected in the increased output and employment impacts in the construction industry and may result in a short-run expansion of or creation of businesses.

Industries that operate CHC would face costs and see net decreases in output growth and employment. Some of these businesses are large and would not be anticipated to face business elimination. However, many are small businesses and would face significant compliance costs. The water transportation industry and the fishing, hunting, and trapping industry are estimated to face decreases in output of up to 1 percent in the years of greatest impact. Also, as discussed in Chapter C, the direct cost on small businesses such as CPFVs is also significant. If these businesses are unable to pass on the costs of the Proposed Amendments to customers or if there is a significant change in demand for services, it is possible that some businesses would be eliminated. Chapter C describes the impact of the regulation on typical and small businesses and describes the potential impacts on customers if the costs of the Proposed Regulation were to be passed on.

g. Incentives for Innovation

The Proposed Amendments would provide a strong signal for the development of zero-emission technologies in the off-road sector and help in building a robust market for advanced technologies. Growth in the industries that manufacture ZEAT will also strengthen the supply chain and promote technology improvements that may not have happened otherwise. The Proposed Amendments would result in deploying ZEAT into the marine sector in California, which responds to Governor Newsom’s EO N-79-20 by establishing a strategy to achieve zero-emission off-road equipment operations, where feasible and cost effective, by 2035.

h. Competitive Advantage or Disadvantage

The Proposed Amendments would impose requirements on nearly all CHC owners and operators, regulated in-use vessels, and commercial fishing vessel engines. Most of the regulated in-use vessels that would be subject to the Proposed Amendments, including ferries, excursion vessels, tugboats, crew and supply vessels, barges and dredges, workboats, pilot vessels, CPFV, and research vessels conduct the majority or all of their operations within RCW. Regardless of whether vessels are homeported in or outside of California, vessel operators still need to comply with the same requirements when operated in RCW. Therefore, the Proposed Amendments would not create a competitive advantage or disadvantage for in-state versus out-of-state vessels or fleets in these vessel categories for operations in RCW. Stakeholders have brought up concerns regarding commercial fishing vessels, which compete with fishing operations from outside California and the United States. ATBs, and other towing vessels and petrochemical tank barges, would also be subject to costs not specifically imposed on the OGV tanker vessels with which they compete.

The Proposed Amendments would increase costs for many commercial fishing vessels operating in RCW, and in some cases, could potentially make them less competitive against out of state or international fleets. CARB staff expects that commercial fishing vessel operators that harvest fish species that can only be caught in California would not face a competitive advantage or disadvantage relative to fishing operations outside of California. Conversely, fishing operations that harvest species that can also be harvested outside of California may face a slight competitive disadvantage compared with out-of-state and international fleets. As provided in Chapter C.3.c., staff expects the average cost increase due to the Proposed Amendments per pound of fish harvested in California (assuming all costs of compliance would be passed onto the consumer) would be an estimated $0.04 per pound. A cost increase of $0.04 per pound is approximately 3 to 4 percent of the ex-vessel (which is the cost paid to the angler at the time of first sale) dollar value of landings.[135] However, commercial fishing vessels would not face in-use requirements until 2030; therefore, vessel owners who choose to comply early would have the option of applying for incentive programs such as the Carl Moyer Program, which provides funding for cleaner engines if emissions reductions are achieved ahead of regulatory requirements.

ATBs that operate in RCW would face the same compliance requirements whether they are homeported inside or outside of California, therefore the Proposed Amendments would not cause a competitive advantage or disadvantage for vessel fleets based within versus outside the State. Stakeholders have raised concerns that the ATBs that compete with some classes of OGV tankers in the movement of refinery feedstock and products may face costs not specifically incurred by the OGV tankers with which they compete. However, ATBs and other towing vessels will continue to have certain operational advantages over OGV tankers, such as operating with a smaller crew. While ATBs would face costs in response to the Proposed Amendments, OGV tankers will also face compliance costs due to the recently adopted Control Measure for Ocean-Going Vessels At-Berth, which will impose requirements for tanker vessels to reduce emissions at berth starting in 2025.

Staff also recognizes the Proposed Amendments could create a competitive advantage or disadvantage for specific businesses within each vessel category, depending on how individual businesses are impacted by the requirements. This would depend on the compliance costs for individual vessels, which depend on factors such as the timing of compliance deadlines based on engine model year and tier, vessel layout and construction, as well as the availability of technology options for each vessel. Additionally, businesses with vessels that would not be required to meet the performance standard because they operate just under the proposed low-use thresholds may face a competitive advantage compared to businesses that operate above the low-use thresholds. Finally, vessels that operate within RCW near the Oregon or Mexico borders may face a competitive disadvantage compared with similar vessel operations in Oregon or Mexico because tourism-related activities, such as commercial passenger fishing, could potentially shift to those operations conducted exclusively outside of RCW.

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[135] Office for Coastal Management Commercial Fish Landings, 2021, last accessed June 16, 2021, *https://www.fisheries.noaa.gov/foss/f?p=215:200:9224158526384::NO*.

i. Summary of Agency Interpretation of the Assessment Results

As modeled, CARB estimates the Proposed Amendments are unlikely to have a significant impact on the overall California economy. Table E-8 summarizes the major economic indicators in California for the odd years of the analysis. Overall, the change in the growth of jobs, GSP, and output is projected to not exceed 0.01 percent of the baseline. Certain industries would face significant costs.

Table E-8. Summary of Macroeconomic Impacts of the Proposed Amendments

Economic Indicator	Units	2023	2025	2027	2029	2031	2033	2035	2037
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
GSP	Change (2019M$)	110	132	59	-7	-61	-65	-180	-213
Personal Income	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Personal Income	Change (2019M$)	59	49	12	-35	-100	-97	-181	-205
Employment	Percent Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Employment	Change (jobs)	1,090	1,330	750	200	-260	-220	-1,210	-1,450
Output	Percent Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Output	Change (2019M$)	210	258	113	-13	-112	-124	-340	-403
Private Investment	Percent Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Private Investment	Change (2019M$)	18	34	12	-7	-16	-21	-40	-46

F. Evaluation of Regulatory Alternatives

1. Alternative 1: No Low-Use Exception and No Extension for Vessels with Tier 4 Engines and Limited Operating Hours

Alternative 1 would require all vessels to meet the performance standards specified in the Proposed Amendments for the appropriate vessel category, engine year, and engine size. Unlike the Proposed Amendments, there would be no low-use exception and no compliance extensions for vessels with Tier 4 engines and limited operating hours. This alternative provides less flexibility for a regulated party to select the best control option to fit their unique operations. Vessel owners and operators would not have the option to choose how to comply–vessels with limited operating hours and vessels operating a greater number of hours per year would both be required to install the same controls. Vessels with even a few operational hours per year would be required to install new control technology, and in some cases replace their vessels to accommodate the emission control systems. Compliance costs would be the same for vessels regardless of operating hours, but operational revenue could differ substantially.

a. Costs

The total cost to vessel owners and operators is the summation of the cost of amortized engine repower costs, engine retrofit costs, vessel replacement costs, infrastructure costs, recordkeeping and reporting costs, vessel labeling costs, facility report and regulation interpretation costs, implementation and enforcement costs, opacity testing costs, shore power costs, zero-emission vessel infrastructure costs, and marginal energy costs due to electrification and cost savings. Alternative 1 would be estimated to cost **$237 million** more than the Proposed Amendments from 2023 to 2038. Under Alternative 1, more vessels would need to be repowered, retrofit, and replaced to comply, including vessels that only operate occasionally. Under this scenario, approximately **328** more vessels operating in RCW, homeported at several California seaports, harbors, and marinas, would be subject to emission control requirements compared with the Proposed Amendments. Therefore, there would be higher costs for repowering and retrofitting additional vessels. A detailed breakdown of Alternative 1 costs and how they compare to the costs in the Proposed Amendments can be found in Tables F-1 and F-2. Repower and retrofit and vessel replacement costs include capital, labor and installation, and operation costs.

Table F-1. Proposed Amendments Summary of Costs by Cost Items

Year	Repower and Retrofit – Capital Costs	Repower and Retrofit - Financial Review	Repower and Retrofit - Naval Architect Report	Vessel Replacement	Other Costs*	Total Costs
2023	$8,199,461	$49,619	$7,501,844	$760,232	$24,026,131	$40,537,287
2024	$28,143,265	$49,647	$7,506,149	$2,944,791	$13,757,462	$52,401,313
2025	$42,289,114	$49,647	$7,506,191	$4,757,683	$13,777,802	$68,380,437
2026	$52,905,386	$49,648	$7,506,233	$6,923,359	$13,852,706	$81,237,330
2027	$61,259,948	$49,648	$7,506,274	$10,961,954	$13,917,772	$93,695,595
2028	$67,576,360	$49,648	$7,506,315	$14,027,308	$14,419,257	$103,578,889
2029	$71,415,279	$24,824	$3,753,178	$18,422,910	$14,009,180	$107,625,371
2030	$79,156,951	$24,824	$3,753,198	$25,191,830	$14,029,661	$122,156,464
2031	$82,455,038	$24,825	$3,753,218	$28,787,549	$14,042,228	$129,062,857
2032	$85,109,285	$24,825	$3,753,237	$32,577,575	$14,041,082	$135,506,004
2033	$86,766,124	$24,825	$3,753,256	$38,415,844	$14,511,067	$143,471,116
2034	$87,503,357	$24,825	$3,753,276	$42,521,075	$14,037,332	$147,839,864
2035	$88,375,871	$0	$0	$43,602,828	$14,032,964	$146,011,663
2036	$88,896,343	$0	$0	$45,294,218	$14,025,895	$148,216,455
2037	$88,896,343	$0	$0	$45,294,218	$14,022,484	$148,213,045
2038	$88,896,343	$0	$0	$45,294,218	$14,492,011	$148,682,572
Total	$1,107,844,465	$446,804	$67,552,367	$405,777,593	$234,995,034	$1,816,616,263

*Other Costs include: Recordkeeping and Reporting, Vessel Labeling, Facility Reporting, and Regulation Interpretation Cost, Implementation and Enforcement Cost, Opacity Testing, Shore Power, Zero-Emission Vessel Infrastructure, and Marginal Energy Cost Due to Electrification.

Table F-2. Alternative 1 Summary of Costs by Cost Item

Year	Repower and Retrofit – Capital Costs	Repower and Retrofit - Financial Review	Repower and Retrofit - Naval Architect Report	Vessel Replacement	Other Costs	Total Costs
2023	$9,750,504	$49,619	$7,501,844	$872,056	$24,026,131	$42,200,154
2024	$32,577,875	$49,647	$7,506,149	$3,283,770	$13,757,462	$57,174,902
2025	$48,665,514	$49,647	$7,506,191	$5,293,103	$13,777,802	$75,292,257
2026	$61,279,544	$49,648	$7,506,233	$7,863,895	$13,852,706	$90,552,025
2027	$71,428,993	$49,648	$7,506,274	$12,477,019	$13,917,772	$105,379,706
2028	$78,882,899	$49,648	$7,506,315	$15,873,365	$14,419,257	$116,731,484
2029	$83,769,033	$24,824	$3,753,178	$20,897,211	$14,009,180	$122,453,426
2030	$92,825,614	$24,824	$3,753,198	$28,467,677	$14,029,661	$139,100,974
2031	$96,373,569	$24,825	$3,753,218	$32,523,737	$14,042,228	$146,717,576
2032	$99,216,058	$24,825	$3,753,237	$36,817,944	$14,041,082	$153,853,146
2033	$101,098,216	$24,825	$3,753,256	$43,412,637	$14,511,067	$162,800,002
2034	$101,937,729	$24,825	$3,753,276	$48,146,870	$14,037,332	$167,900,032
2035	$102,909,768	$0	$0	$49,390,823	$14,032,964	$166,333,555
2036	$103,520,236	$0	$0	$51,332,335	$14,025,895	$168,878,466
2037	$103,520,236	$0	$0	$51,332,335	$14,022,484	$168,875,056
2038	$103,520,236	$0	$0	$51,332,335	$14,492,011	$169,344,583
Total	$1,291,276,025	$446,804	$67,552,367	$459,317,114	$234,995,034	$2,053,587,345

*Other Costs include: Recordkeeping and Reporting, Vessel Labeling, Facility Reporting, and Regulation Interpretation Cost, Implementation and Enforcement Cost, Opacity Testing, Shore Power, Zero-Emission Vessel Infrastructure, and Marginal Energy Cost Due to Electrification.

Table F-3 summarizes amortized costs to CHC owners and operators by vessel category for Alternative 1 for the odd years (2023 to 2037) and Table F-4 shows the cost differential between Alternative 1 and the Proposed Amendments for the same time period.

Table F-3. Amortized Costs for Alternative 1 from 2023 – 2037

Vessels	2023	2025	2027	2029	2031	2033	2035	2037
Ferry (Catamaran)	$331,695	$4,732,298	$10,320,808	$12,685,148	$17,377,392	$21,912,393	$23,278,559	$23,278,591
Ferry (Monohull)	$294,302	$2,191,646	$3,192,901	$3,471,981	$4,182,753	$4,632,754	$4,719,733	$4,719,752
Ferry (Short Run)	$3,977,686	$3,934,624	$6,626,530	$7,241,688	$7,256,148	$7,254,864	$7,218,396	$7,212,063
Pilot Boat	$93,961	$775,116	$867,598	$1,086,214	$1,328,947	$1,366,351	$1,351,689	$1,351,698
Push/Tow Tug	$3,255,806	$9,329,792	$13,428,116	$14,696,832	$15,436,888	$15,992,621	$15,855,815	$15,855,952
Escort/Ship Assist Tug	$740,188	$9,793,478	$14,994,722	$15,965,422	$16,260,713	$16,482,182	$16,411,980	$16,412,039
ATB Tug	$560,191	$6,087,593	$8,225,626	$8,504,401	$8,752,267	$8,861,134	$8,831,614	$8,831,632
Research Vessel	$735,879	$913,902	$1,059,712	$1,310,018	$1,485,472	$1,566,643	$1,695,259	$1,713,057
Commercial Passenger Fishing	$4,303,442	$6,795,523	$7,697,899	$10,408,091	$13,293,280	$18,108,239	$20,561,349	$20,649,918
Excursion	$11,450,627	$12,590,068	$19,821,629	$23,579,606	$26,086,939	$26,681,186	$26,353,505	$26,373,933
Dredge	$441,616	$462,663	$462,698	$435,030	$854,319	$991,769	$908,306	$1,038,798
ATB Barge	$178,526	$1,171,033	$1,171,047	$2,702,718	$3,866,176	$3,869,043	$3,829,585	$3,829,603
Bunker Barge	$291,279	$226,472	$226,496	$192,027	$237,281	$241,960	$177,580	$177,609
Other Barge	$1,251,830	$1,193,796	$1,203,823	$1,367,837	$1,674,519	$1,739,672	$1,604,128	$1,656,397
Towed Petrochemical Barge	$232,315	$252,952	$252,969	$262,588	$533,650	$591,975	$553,616	$609,204
Crew Supply	$2,127,836	$3,179,496	$3,310,647	$4,582,550	$7,056,793	$7,855,528	$8,310,110	$9,095,361
Workboat	$6,868,809	$10,491,157	$11,344,997	$12,788,898	$16,152,034	$17,615,200	$17,814,705	$19,210,703
Commercial Fishing	$5,064,164	$1,170,649	$1,171,490	$1,172,380	$4,882,004	$7,036,489	$6,857,626	$6,858,745
Total Cost	$42,200,154	$75,292,257	$105,379,706	$122,453,426	$146,717,576	$162,800,002	$166,333,555	$168,875,056

Table F-4. Differential in Amortized Costs for Alternative 1 Compared to the Proposed Amendments from 2023 to 2037

Vessels	2023	2025	2027	2029	2031	2033	2035	2037
Ferry (Catamaran)	$111	$390,226	$873,259	$1,075,530	$1,444,627	$1,803,722	$1,919,857	$1,919,857
Ferry (Monohull)	$4,161	$95,400	$145,928	$162,513	$198,075	$220,371	$226,995	$226,995
Ferry (Short Run)	$0	$0	$102,746	$126,367	$126,367	$126,367	$126,367	$126,367
Pilot Boat	$0	$0	$0	$0	$0	$0	$0	$0
Push/Tow Tug	$129,679	$706,272	$1,096,064	$1,252,349	$1,315,841	$1,362,191	$1,377,094	$1,377,094
Escort/Ship Assist Tug	$37,660	$2,454,957	$3,834,632	$4,137,336	$4,214,390	$4,269,818	$4,285,770	$4,285,770
ATB Tug	$186	$53,141	$75,363	$78,275	$79,487	$79,985	$80,033	$80,033
Research Vessel	$83,008	$126,037	$152,089	$216,666	$253,334	$267,985	$304,056	$308,161
Commercial Passenger Fishing	$44,009	$194,611	$295,238	$715,238	$1,070,502	$1,677,796	$2,057,263	$2,060,657
Excursion	$936,986	$1,651,439	$3,750,014	$5,106,995	$5,843,356	$5,999,416	$6,157,747	$6,165,796
Dredge	$0	$5,823	$5,823	$7,910	$33,636	$39,274	$39,820	$45,475
ATB Barge	$0	$235	$235	$14,120	$23,902	$23,902	$23,902	$23,902
Bunker Barge	$0	$9,938	$9,938	$16,981	$29,658	$29,658	$29,658	$29,658
Other Barge	$117,818	$180,864	$183,689	$278,885	$367,438	$382,305	$395,789	$410,745
Towed Petrochemical Barge	$7,081	$32,571	$32,571	$47,032	$123,586	$139,359	$141,446	$157,379
Crew Supply	$54,526	$213,763	$230,534	$395,573	$751,133	$869,712	$972,419	$1,092,299
Workboat	$247,644	$796,541	$895,986	$1,196,287	$1,610,041	$1,777,560	$1,924,211	$2,092,360
Commercial Fishing	$0	$0	$0	$0	$169,346	$259,463	$259,463	$259,463
Total Cost Differential	$1,662,868	$6,911,820	$11,684,111	$14,828,056	$17,654,719	$19,328,885	$20,321,891	$20,662,011

b. Benefits

For Alternative 1, emission reduction estimates were developed based on the assumption that all vessels would need to comply with the requirements of the Proposed Amendments regardless of hours of operation. Figures F-1 through F-4 show the emissions benefits from Alternative 1 compared to the Proposed Amendments and the Current Regulation. Alternative 1 would be projected to result in greater NOx, DPM, PM2.5, and ROG emissions reductions compared to the Proposed Amendments and the Current Regulation. Alternative 1 would provide slightly lower GHG emissions reductions compared to the Proposed Amendments (Figure F-5). The slight increase in GHG emissions is mainly due to the DPF fuel penalty, which has been shown to result in a 4 percent fuel penalty so that increased fuel results in additional CO2 emissions. Alternative 1 supports NOx, DPM, PM2.5, and ROG emissions reduction objectives.

As shown in Tables F-1 and F-2, Alternative 1 would cost more, would be less cost-effective to implement than the Proposed Amendments, and would provide less flexibility to CHC owners. Alternative 1 would increase the overall cost of the Proposed Amendments by 13 percent, while achieving 2 percent more reductions of NOx, and 3 percent more reductions of DPM and PM2.5 from 2023 to 2038. For these reasons, CARB staff believes that under Alternative 1, the additional burden on owners of vessels that operate infrequently would be greater than the emission reductions achieved.

Figure F-1. Alternative 1 - NOx Emissions Estimates

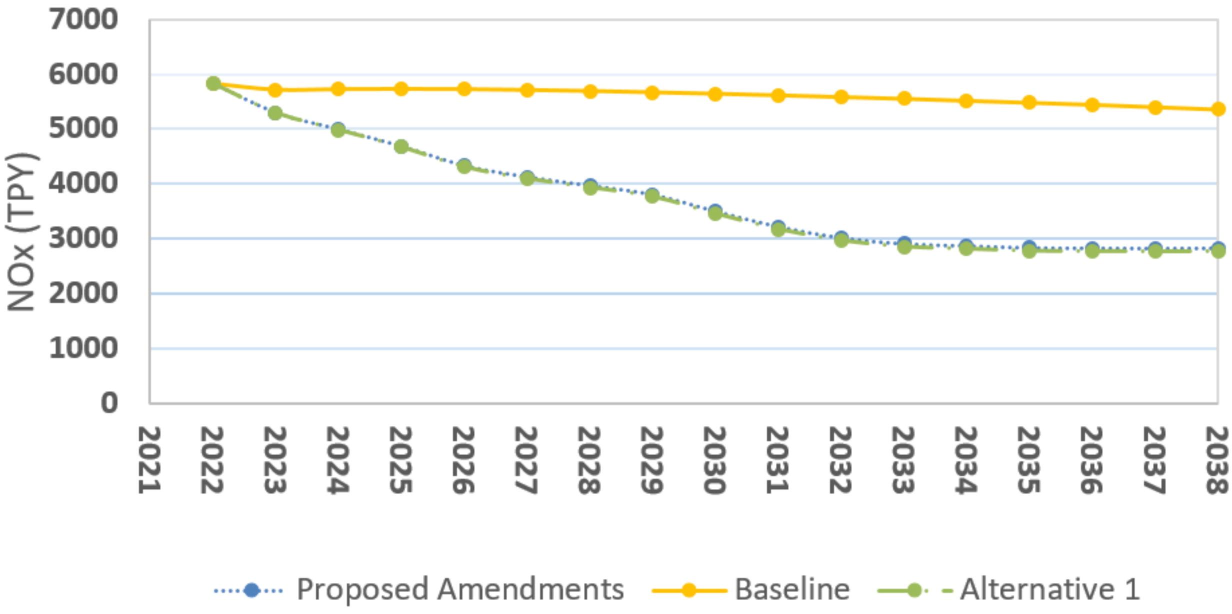


Figure F-2. Alternative 1 - DPM Emissions Estimates

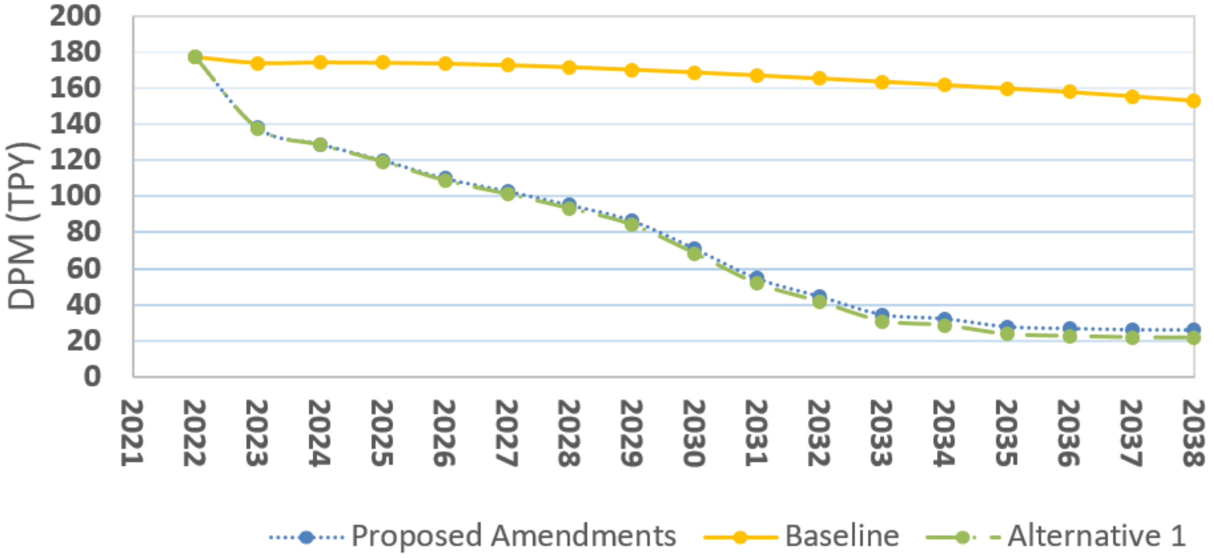


Figure F-3. Alternative 1 – PM2.5 Emissions Estimates

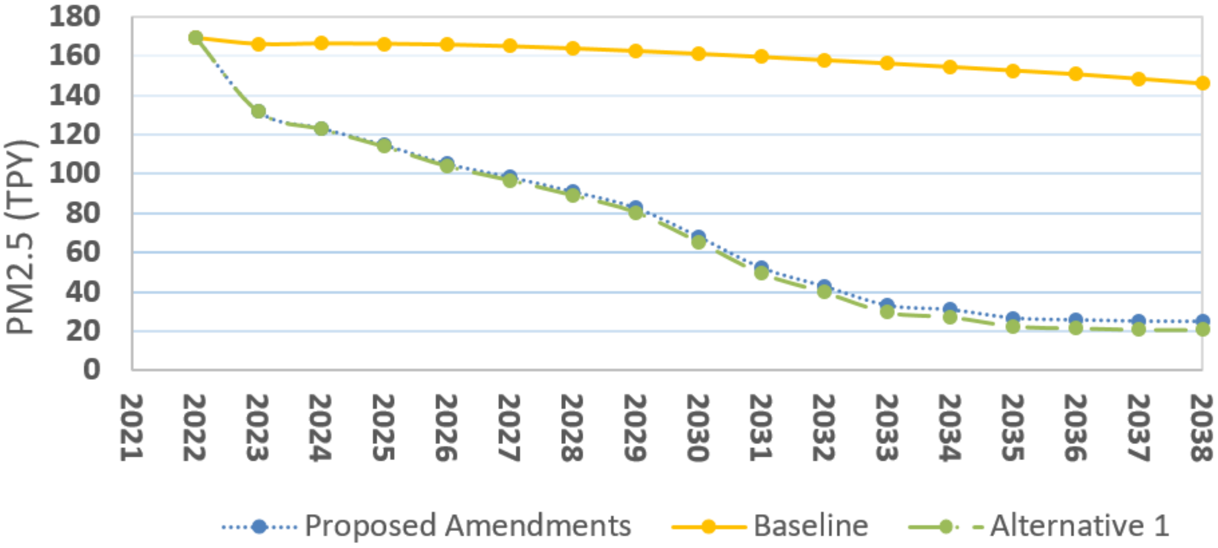


Figure F-4. Alternative 1 – ROG Emissions Estimates

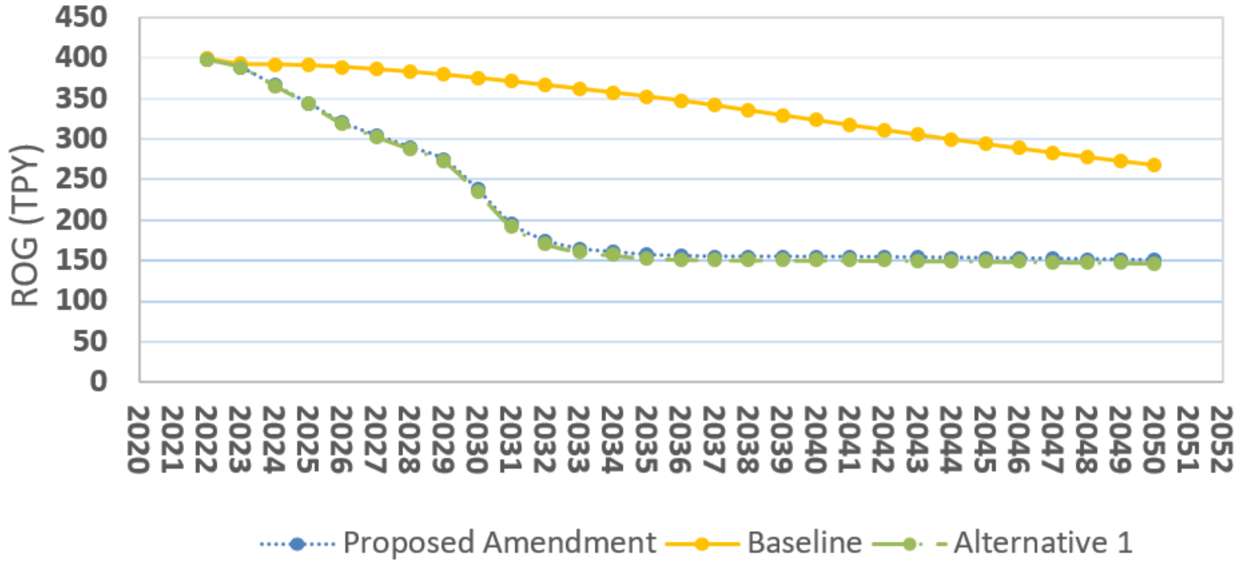
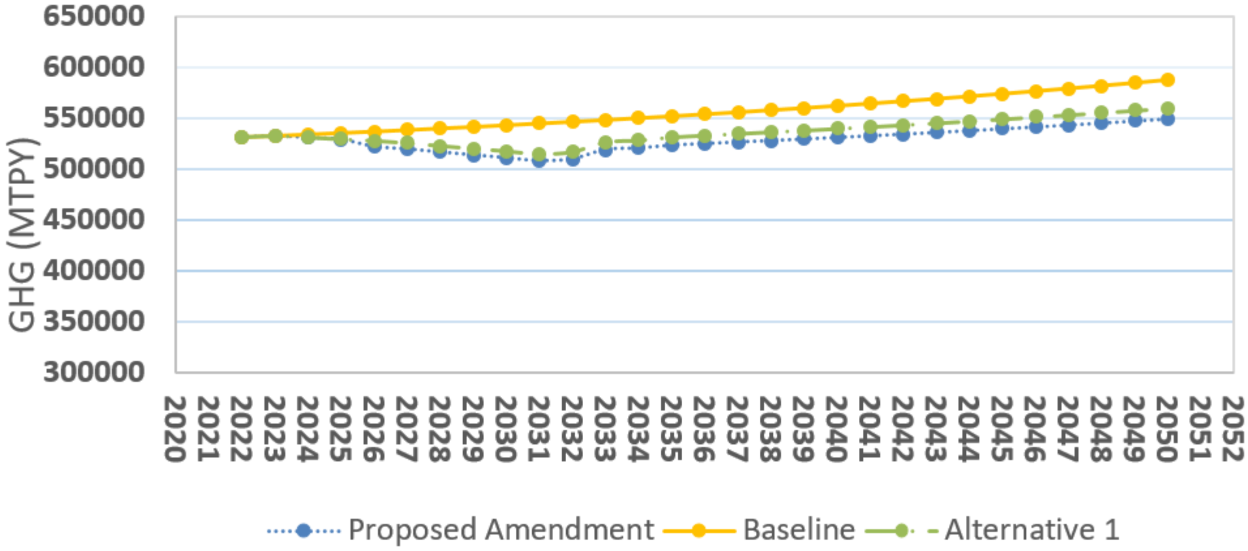


Figure F-5. Alternative 1 – GHG Emissions Estimates



Alternative 1 was also evaluated to determine the resulting health benefits that would be achieved by removing the low-use exemption from the Proposed Amendments. The estimated total reductions in health outcomes that would result from Alternative 1 from 2023 to 2038 are presented in Table F-5. Chapter B of the SRIA (Benefits) discusses the total reductions in health outcomes for the Proposed Amendments. Alternative 1 would provide increased avoided cardiopulmonary mortality (513 v. 501), hospital admissions (156 v. 153), and emergency room visits (229 v. 224) when compared to the Proposed Amendments.

Table F-5. Estimated Total Reductions in Health Outcomes from 2023 to 2038 Under Alternative 1

Air Basin	Cardiopulmonary Mortality	Hospital Admissions	Emergency Room Visits
North Central Coast	2 (1 - 2)	1 (0 - 1)	1 (1 - 1)
North Coast	3 (2 - 3)	1 (0 - 1)	1 (1 - 1)
Sacramento Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
San Diego County	35 (27 - 43)	10 (1 - 19)	14 (9 - 20)
San Francisco Bay Area	162 (126 - 199)	47 (6 - 88)	76 (48 - 105)
San Joaquin Valley	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
South Central Coast	26 (21 - 32)	8 (1 - 16)	12 (7 - 16)
South Coast	282 (221 - 345)	88 (11 - 163)	123 (78 - 169)
TOTAL	513 (400 - 628)	156 (20 - 289)	229 (145 - 313)

Health benefits under Alternative 1 were valued using the same methodology as under the Proposed Amendments. The total value of health benefits under Alternative 1 is included in Table F-6. Alternative 1 provides a higher valuation of health benefits at $5.10 billion, relative to the Proposed Amendments at $4.95 billion.

Table F-6. Statewide Valuation of Avoided Health Outcomes between 2023 and 2038 as a Result of Alternative 1

Year	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits	Total
2023	$64,859,000	$97,000	$3,000	$64,959,000
2024	$103,919,000	$160,000	$4,000	$104,083,000
2025	$143,801,000	$227,000	$6,000	$144,034,000
2026	$188,621,000	$304,000	$8,000	$188,933,000
2027	$219,973,000	$360,000	$9,000	$220,342,000
2028	$246,947,000	$408,000	$10,000	$247,365,000
2029	$275,845,000	$460,000	$11,000	$276,316,000
2030	$321,083,000	$539,000	$13,000	$321,635,000
2031	$366,642,000	$617,000	$14,000	$367,273,000
2032	$401,983,000	$678,000	$15,000	$402,677,000
2033	$432,860,000	$729,000	$16,000	$433,605,000
2034	$443,457,000	$749,000	$16,000	$444,222,000
2035	$457,593,000	$775,000	$16,000	$458,384,000
2036	$462,801,000	$785,000	$16,000	$463,602,000
2037	$464,244,000	$787,000	$16,000	$465,047,000
2038	$463,555,000	$785,000	$16,000	$464,356,000
Total	$5,058,182,000	$8,460,000	$191,000	$5,066,833,000

c. Economic Impacts

The impacts described in Section F.1 were input into REMI to assess the macroeconomic impact of Alternative 1 and are summarized, for the odd years of the analysis, in Table F-7. As discussed in Section F.1, Staff anticipates that Alternative 1 would result in higher costs to CHC vessel owners overall. Alternative 1 would be more stringent compared to the Proposed Amendments, as it does not contain a low-use exemption and no extension for vessels with Tier 4 engines with limited operating hours. This results in higher incremental costs relative to the Proposed Amendments.

As shown in Table F-7, from 2023 through 2027, Alternative 1 is estimated to result in a slight increase in the growth of most of the economic indicators such as GSP, employment, output, and private investment. Similar to the Proposed Amendments, this corresponds with demand for cleaner technology and ZEAT engines and demand for labor and installation of new engines that would likely occur at California-based shipyards. From 2029 through 2037, Alternative 1 is estimated to result in a slight decrease in all of the economic indicators, excepting for employment, reflecting broader impacts of the costs of the regulation as they are spread across California's economy. The impacts, both positive and negative, are never estimated to change GSP, personal income, employment, or output more than 0.01 percent from baseline levels. Relative to the Proposed Amendments, these impacts average 17 to 19 percent greater, both for the positive and negative impacts towards the economic indicators.

Table F-7. Summary of Macroeconomic Impacts of Alternative 1

Economic Indicator	Units	2023	2025	2027	2029	2031	2033	2035	2037
GSP	Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
GSP	Change (2019M$)	125	147	71	-8	-75	-80	-205	-241
Personal Income	Percent Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Personal Income	Change (2019M$)	69	55	16	-41	-117	-113	-206	-233
Employment	Percent Change	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Employment	Change (jobs)	1,230	1,470	890	220	-350	-310	-1,380	-1,640
Output	Percent Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Output	Change (2019M$)	239	287	138	-14	-137	-150	-384	-455
Private Investment	Percent Change	0.00%	0.01%	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.01%
Private Investment	Change (2019M$)	20	37	15	-9	-21	-26	-46	-52

Figures F-6 and Figure F-7 illustrate the changes in employment and output by major sectors associated with Alternative 1, respectively. Similar to the Proposed Amendments, the largest positive impacts are estimated to occur in the manufacturing sector while the largest negative impacts are estimated to occur in sectors with the greatest direct cost impacts, such as the transportation and public utilities sector and the services sector.

Figure F-6. Changes in Employment Growth by Major Sector Associated with Alternative 1

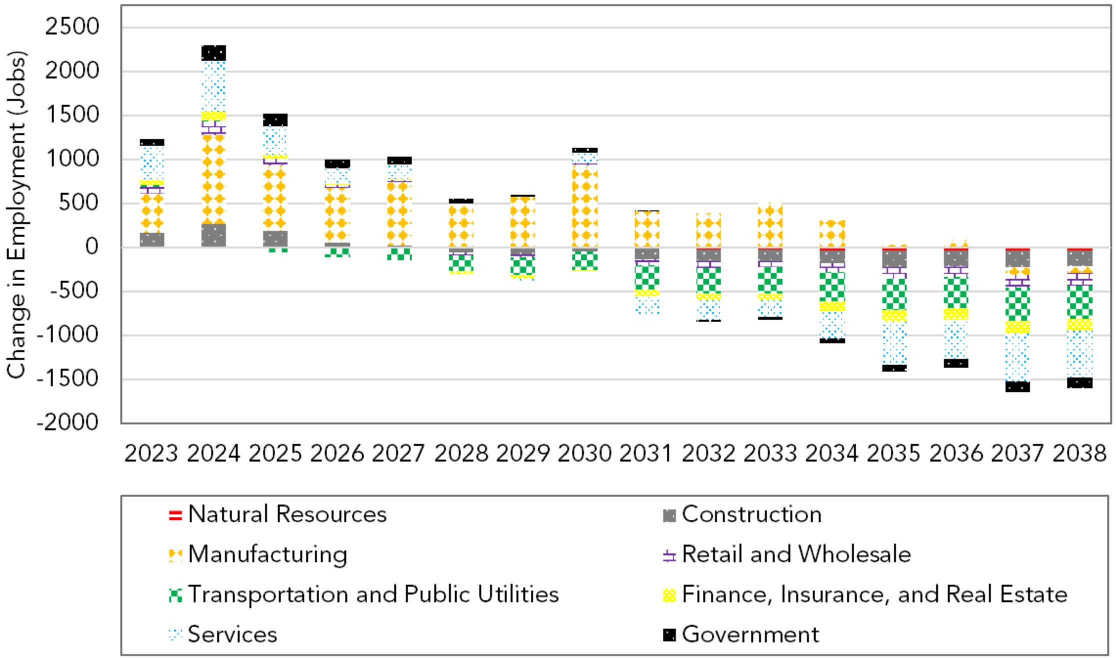
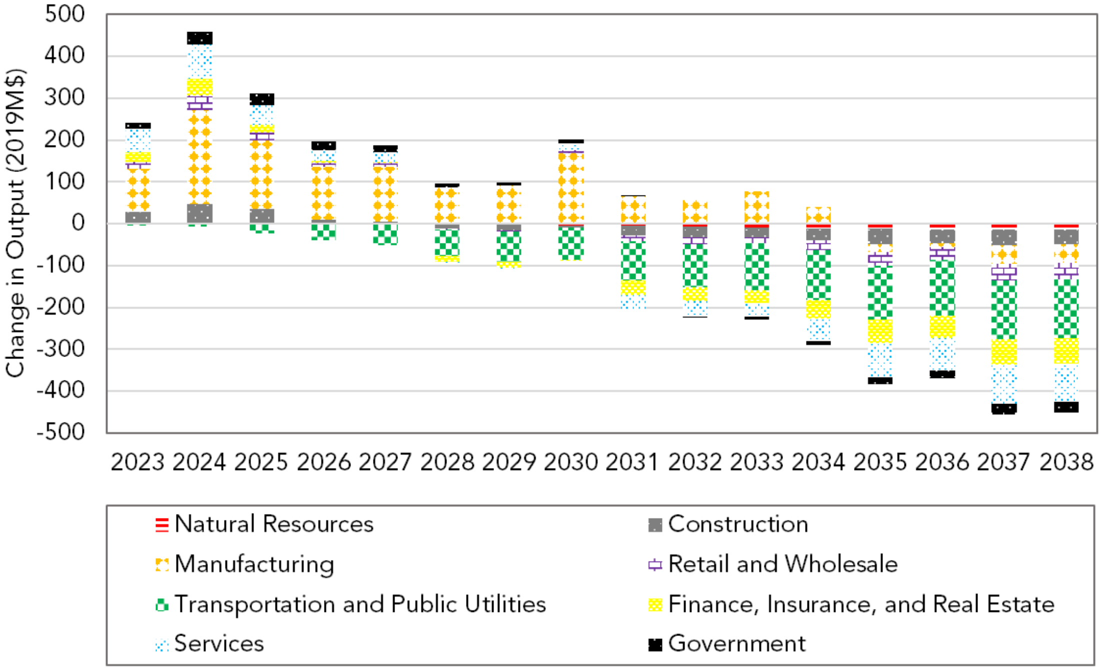


Figure F-7. Changes in Output Growth by Major Sector Associated with Alternative 1



d. Cost-Effectiveness

Cost-effectiveness is a measure of the cost of an emissions reduction project or program per ton of expected emissions reduction. There are multiple approaches to calculating cost-effectiveness. For the Proposed Amendments and Alternatives, Staff used a cost-effectiveness method provided in the Carl Moyer Guidelines Appendices.[136] The Carl Moyer cost-effectiveness metric is useful because it is widely used, and therefore, straightforward to compare between programs, and reflects the emissions reductions of multiple pollutants (NOx, PM2.5, and ROG). The cost-effectiveness (in $/weighted ton) is calculated by dividing the cost over a period of time by the weighed emissions reductions (in TPY) over the same period of time using the following equation.

$$Cost - Effectiveness = \frac{Net\ Direct\ Costs}{[NOx\ (TPY) + (20 * PM2.5)(TPY) + ROG\ (TPY)]}$$

$Where:$

$Net\ Direct\ Costs\ =\ Direct\ Costs - Cost\ Savings$

$NOx\ =\ Cumulative\ tons\ of\ NOx\ emission\ reductions$

$ROG\ =\ Cumulative\ tons\ of\ ROG\ emission\ reductions$

$PM2.5\ =\ Cumulative\ tons\ of\ PM2.5\ emission\ reductions$

Cost-effectiveness of the Proposed Amendments and Alternative 1 was calculated using the metric described above and is summarized in Table F-8. Staff estimated that Alternative 1 would be less cost-effective than the Proposed Amendments due to the higher direct costs to industry and the low impact to emission reductions from repower, retrofit, or replacement of engines or vessels that are infrequently operated.

Table F-8. Cost-Effectiveness of the Proposed Amendments and Alternative 1 From 2023 to 2038

Metric	Carl Moyer Methodology ($/weighted tons)
Proposed Amendments	$28,878
Alternative 1	$31,881
Difference in Cost-Effectiveness	$3,003

e. Reason for Rejection

Alternative 1 was rejected because it imposes higher costs and low additional emission reductions; therefore, would be less cost-effective to implement than the Proposed Amendments. Lastly, for CHC that visit California seaports infrequently, making expensive vessel modifications, even for a single vessel visit, would not be economical.

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[136] The Carl Moyer Program Guidelines, Appendix C: Cost-Effectiveness Calculation Methodology and Appendix D: Tables for Emission Reduction and Cost-Effectiveness Calculations, last accessed June 2021, *https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2017/2017_cmpgl.pdf*.

2. Alternative 2: No Requirements for Commercial Fishing Vessels

Alternative 2 would include all of the requirements of the Proposed Amendments, with the exception that it does not include emission control requirements for commercial fishing vessels. The Proposed Amendments would require commercial fishing vessels to install engines certified to Tier 2 or newer levels by 2030 to 2032. Under Alternative 2, commercial fishing vessels would still have requirements and associated costs with other requirements in the Proposed Amendments such as for recordkeeping and reporting, fuel use, vessel labeling, and opacity testing.

a. Costs

The total cost to vessel owners and operators is the summation of the cost of amortized engine repower costs, engine retrofit costs, vessel replacement costs, infrastructure costs, recordkeeping and reporting costs, vessel labeling costs, facility report and regulation interpretation costs, implementation and enforcement costs, opacity testing costs, shore power costs, zero-emission vessel infrastructure costs, and marginal energy costs due to electrification and cost savings. Alternative 2 would be estimated to cost **$43 million less** than the Proposed Amendments from 2023 to 2038.

Under Alternative 2, vessel owners and operators for other regulated in-use vessels (non-commercial fishing vessels) would still be required to meet performance standards equivalent to using Tier 3 or Tier 4 engines plus a DPF, which would be achieved through repowering engines, retrofitting engines, replacing vessels, or using other methods to reduce the emissions, subject to CARB approval. However, under Alternative 2, approximately **665 fewer** commercial fishing vessels operating in RCW would be subject to emission control requirements of using Tier 2 or cleaner engines, compared with the Proposed Amendments. Therefore, there would be no costs for repowering and retrofitting commercial fishing vessels. A more detailed breakdown of Alternative 2 costs and how they compare to the costs in the Proposed Amendments can be found in Table F-9 and Table F-10. Table F-11 summarizes amortized costs to CHC owners and operators by vessel category for Alternative 2 for the odd years (2023 to 2037) and Table F-12 shows the cost differential between Alternative 2 and the Proposed Amendments for the same time period.

Table F-9. Proposed Amendments Summary of Costs by Cost Items

Year	Repower and Retrofit	Financial Review	Naval Architect Report	Vessel Replacement	Other Costs	Total Costs
2023	$8,199,461	$49,619	$7,501,844	$760,232	$24,026,131	$40,537,287
2024	$28,143,265	$49,647	$7,506,149	$2,944,791	$13,757,462	$52,401,313
2025	$42,289,114	$49,647	$7,506,191	$4,757,683	$13,777,802	$68,380,437
2026	$52,905,386	$49,648	$7,506,233	$6,923,359	$13,852,706	$81,237,330
2027	$61,259,948	$49,648	$7,506,274	$10,961,954	$13,917,772	$93,695,595
2028	$67,576,360	$49,648	$7,506,315	$14,027,308	$14,419,257	$103,578,889
2029	$71,415,279	$24,824	$3,753,178	$18,422,910	$14,009,180	$107,625,371
2030	$79,156,951	$24,824	$3,753,198	$25,191,830	$14,029,661	$122,156,464
2031	$82,455,038	$24,825	$3,753,218	$28,787,549	$14,042,228	$129,062,857
2032	$85,109,285	$24,825	$3,753,237	$32,577,575	$14,041,082	$135,506,004
2033	$86,766,124	$24,825	$3,753,256	$38,415,844	$14,511,067	$143,471,116
2034	$87,503,357	$24,825	$3,753,276	$42,521,075	$14,037,332	$147,839,864
2035	$88,375,871	$0	$0	$43,602,828	$14,032,964	$146,011,663
2036	$88,896,343	$0	$0	$45,294,218	$14,025,895	$148,216,455
2037	$88,896,343	$0	$0	$45,294,218	$14,022,484	$148,213,045
2038	$88,896,343	$0	$0	$45,294,218	$14,492,011	$148,682,572
Total	$1,107,844,465	$446,804	$67,552,367	$405,777,593	$234,995,034	$1,816,616,263

*Other Costs include: Recordkeeping and Reporting, Vessel Labeling, Facility Reporting, and Regulation Interpretation Cost, Implementation and Enforcement Cost, Opacity Testing, Shore Power, Zero-Emission Vessel Infrastructure, and Marginal Energy Cost Due to Electrification.

Table F-10. Alternative 2 Summary of Costs by Cost Items

Year	Repower and Retrofit	Financial Review	Naval Architect Report	Vessel Replacement	Other Costs	Total Costs
2023	$8,199,461	$49,619	$7,501,844	$760,232	$24,026,131	$40,537,287
2024	$28,143,265	$49,647	$7,506,149	$2,944,791	$13,757,462	$52,401,313
2025	$42,289,114	$49,647	$7,506,191	$4,757,683	$13,777,802	$68,380,437
2026	$52,905,386	$49,648	$7,506,233	$6,923,359	$13,852,706	$81,237,330
2027	$61,259,948	$49,648	$7,506,274	$10,961,954	$13,917,772	$93,695,595
2028	$67,576,360	$49,648	$7,506,315	$14,027,308	$14,419,257	$103,578,889
2029	$71,415,279	$24,824	$3,753,178	$18,422,910	$14,009,180	$107,625,371
2030	$77,615,113	$24,824	$3,753,198	$25,191,830	$14,029,661	$120,614,626
2031	$78,915,703	$24,825	$3,753,218	$28,787,549	$14,042,228	$125,523,522
2032	$79,686,500	$24,825	$3,753,237	$32,577,575	$14,041,082	$130,083,219
2033	$81,343,339	$24,825	$3,753,256	$38,415,844	$14,511,067	$138,048,331
2034	$82,080,571	$24,825	$3,753,276	$42,521,075	$14,037,332	$142,417,079
2035	$82,953,086	$0	$0	$43,602,828	$14,032,964	$140,588,878
2036	$83,473,558	$0	$0	$45,294,218	$14,025,895	$142,793,670
2037	$83,473,558	$0	$0	$45,294,218	$14,022,484	$142,790,260
2038	$83,473,558	$0	$0	$45,294,218	$14,492,011	$143,259,787
Total	$1,064,803,796	$446,804	$67,552,367	$405,777,593	$234,995,034	$1,773,575,594

[*] Other Costs include: Recordkeeping and Reporting, Vessel Labeling, Facility Reporting, and Regulation Interpretation Cost, Implementation and Enforcement Cost, Opacity Testing, Shore Power, Zero-Emission Vessel Infrastructure, and Marginal Energy Cost Due to Electrification.

Table F-11. Amortized Costs for Alternative 2 from 2023 to 2038

Vessels	2023	2025	2027	2029	2031	2033	2035	2037
Ferry (Catamaran)	$331,585	$4,342,072	$9,447,549	$11,609,618	$15,932,765	$20,108,670	$21,358,702	$21,358,735
Ferry (Monohull)	$290,141	$2,096,246	$3,046,973	$3,309,468	$3,984,678	$4,412,383	$4,492,738	$4,492,757
Ferry (Short Run)	$3,977,686	$3,934,624	$6,523,784	$7,115,321	$7,129,781	$7,128,497	$7,092,029	$7,085,696
Pilot Boat	$93,961	$775,116	$867,598	$1,086,214	$1,328,947	$1,366,351	$1,351,689	$1,351,698
Push/Tow Tug	$3,126,128	$8,623,520	$12,332,052	$13,444,482	$14,121,047	$14,630,429	$14,478,721	$14,478,858
Escort/Ship Assist Tug	$702,528	$7,338,521	$11,160,090	$11,828,086	$12,046,323	$12,212,365	$12,126,210	$12,126,269
ATB Tug	$560,005	$6,034,453	$8,150,263	$8,426,126	$8,672,780	$8,781,149	$8,751,581	$8,751,599
Research Vessel	$652,871	$787,864	$907,623	$1,093,352	$1,232,138	$1,298,658	$1,391,203	$1,404,896
Commercial Passenger Fishing	$4,259,433	$6,600,912	$7,402,661	$9,692,853	$12,222,778	$16,430,443	$18,504,086	$18,589,261
Excursion	$10,513,642	$10,938,629	$16,071,615	$18,472,611	$20,243,583	$20,681,771	$20,195,758	$20,208,137
Dredge	$441,616	$456,840	$456,875	$427,120	$820,683	$952,495	$868,486	$993,324
ATB Barge	$178,526	$1,170,797	$1,170,811	$2,688,599	$3,842,274	$3,845,141	$3,805,682	$3,805,700
Bunker Barge	$291,279	$216,534	$216,557	$175,047	$207,623	$212,302	$147,922	$147,951
Other Barge	$1,134,012	$1,012,931	$1,020,134	$1,088,952	$1,307,081	$1,357,367	$1,208,339	$1,245,652
Towed Petrochemical Barge	$225,234	$220,381	$220,398	$215,556	$410,064	$452,615	$412,170	$451,825
Crew Supply	$2,073,310	$2,965,733	$3,080,113	$4,186,976	$6,305,660	$6,985,815	$7,337,691	$8,003,063
Workboat	$6,621,165	$9,694,616	$10,449,010	$11,592,610	$14,541,993	$15,837,641	$15,890,494	$17,118,344
Commercial Fishing	$5,064,164	$1,170,649	$1,171,490	$1,172,380	$1,173,322	$1,354,241	$1,175,377	$1,176,497
Total	$40,537,287	$68,380,437	$93,695,595	$107,625,371	$125,523,522	$138,048,331	$140,588,878	$142,790,260

Table F-12. Differential in Amortized Costs for Alternative 2 Compared to the Proposed Amendments from 2023 to 2038

Vessels	2023	2025	2027	2029	2031	2033	2035	2037
Ferry (Catamaran)	$0	$0	$0	$0	$0	$0	$0	$0
Ferry (Monohull)	$0	$0	$0	$0	$0	$0	$0	$0
Ferry (Short Run)	$0	$0	$0	$0	$0	$0	$0	$0
Pilot Boat	$0	$0	$0	$0	$0	$0	$0	$0
Push/Tow Tug	$0	$0	$0	$0	$0	$0	$0	$0
Escort/Ship Assist Tug	$0	$0	$0	$0	$0	$0	$0	$0
ATB Tug	$0	$0	$0	$0	$0	$0	$0	$0
Research Vessel	$0	$0	$0	$0	$0	$0	$0	$0
Commercial Passenger Fishing	$0	$0	$0	$0	$0	$0	$0	$0
Excursion	$0	$0	$0	$0	$0	$0	$0	$0
Dredge	$0	$0	$0	$0	$0	$0	$0	$0
ATB Barge	$0	$0	$0	$0	$0	$0	$0	$0
Bunker Barge	$0	$0	$0	$0	$0	$0	$0	$0
Other Barge	$0	$0	$0	$0	$0	$0	$0	$0
Towed Petrochemical Barge	$0	$0	$0	$0	$0	$0	$0	$0
Crew Supply	$0	$0	$0	$0	$0	$0	$0	$0
Workboat	$0	$0	$0	$0	$0	$0	$0	$0
Commercial Fishing	$0	$0	$0	$0	-$3,539,335	-$5,422,785	-$5,422,785	-$5,422,785
Total Cost Differential	$0	$0	$0	$0	-$3,539,335	-$5,422,785	-$5,422,785	-$5,422,785

b. Benefits

Emission reduction estimates for Alternative 2 were developed based on the assumption that all vessels would need to comply with the emission control requirements of the Proposed Amendments except for commercial fishing vessels. Figures F-8 through F-12 show the emissions benefits from Alternative 2 compared to the Proposed Amendments and the Current Regulation for NOx, DPM, PM2.5, ROG, and GHG respectively. Alternative 2 would provide fewer NOx, PM2.5, DPM, and ROG emissions reductions compared to the Proposed Amendments due to commercial fishing vessels not having to comply with emission control requirements. Alternative 2 would provide similar GHG emissions reductions compared to the Proposed Amendments because similar BSFC factors were used for Tier 0, Tier 1, Tier 2, and Tier 2 engines. Alternative 2 would decrease the overall cost of the Proposed Amendments by 2 percent and achieve 7 percent fewer reductions of NOx and 8 percent fewer emission reductions of DPM and PM2.5.

Figure F-8. Alternative 2 - NOx Emissions Estimates

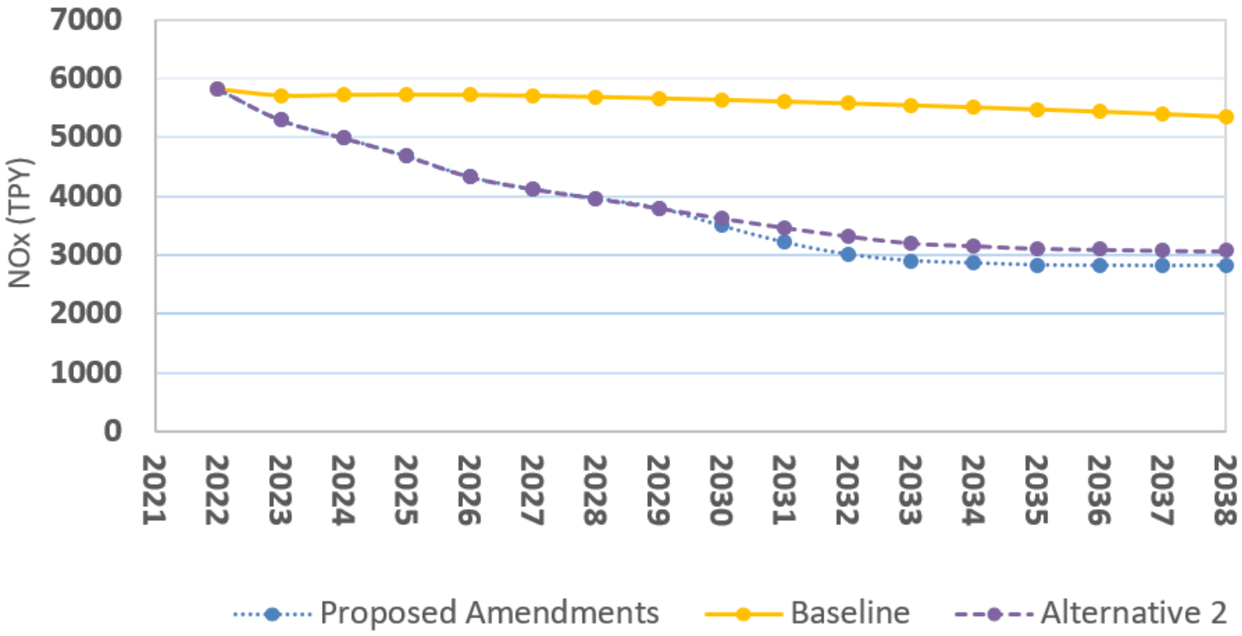


Figure F-9. Alternative 2 - DPM Emissions Estimates

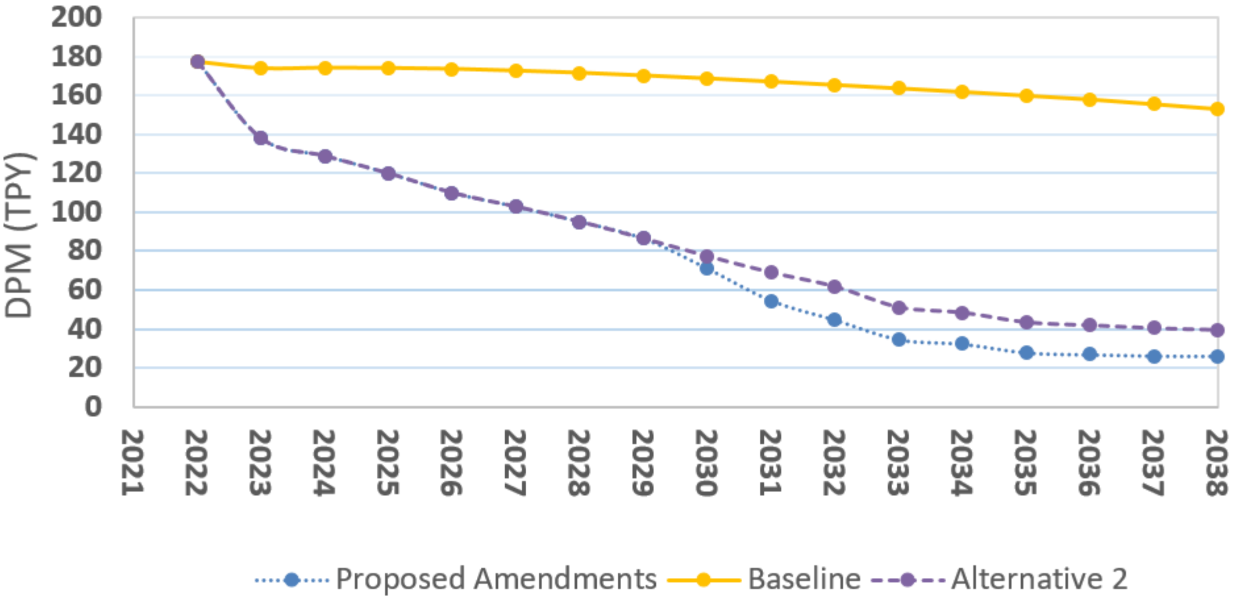


Figure F-10. Alternative 2 – PM2.5 Emissions Estimates

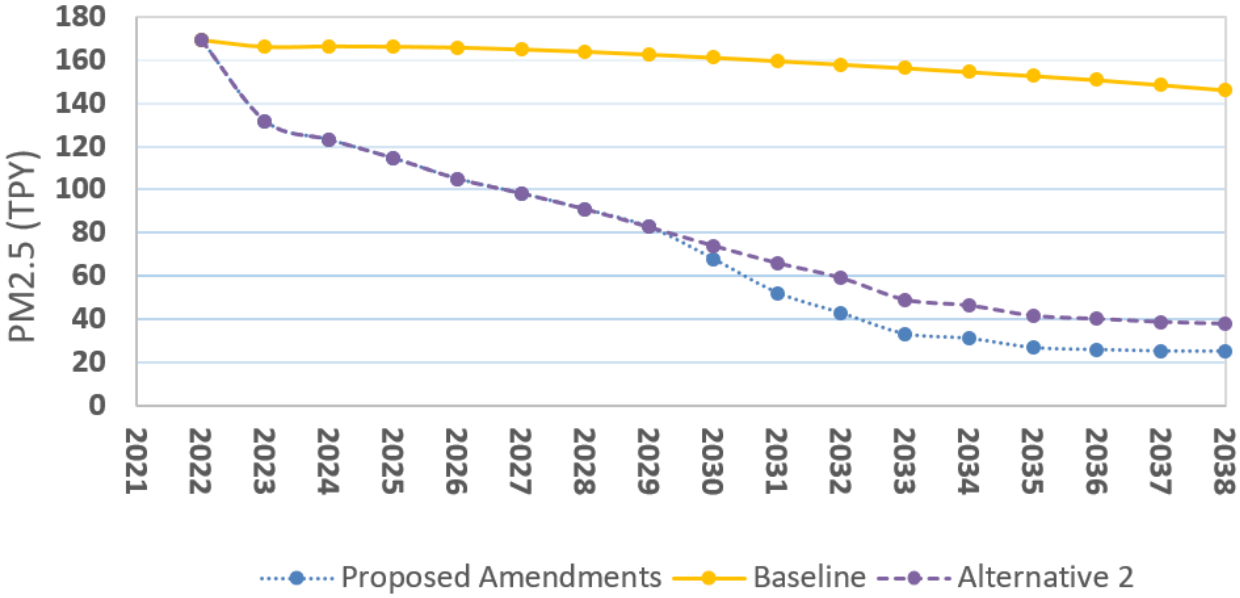


Figure F-11. Alternative 2 – ROG Emissions Estimates

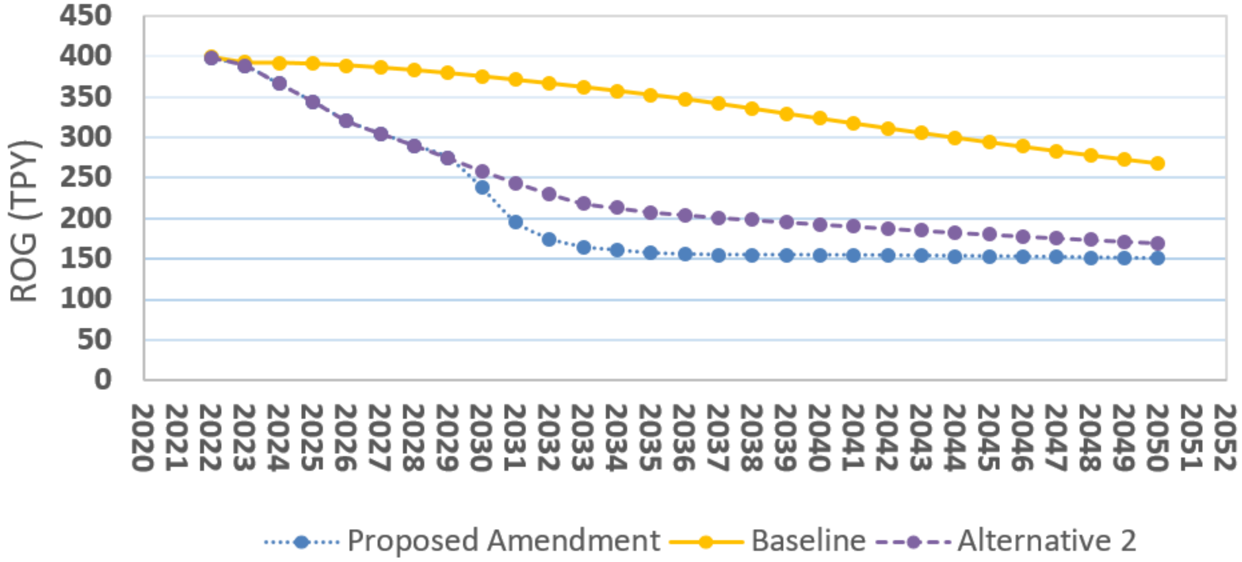
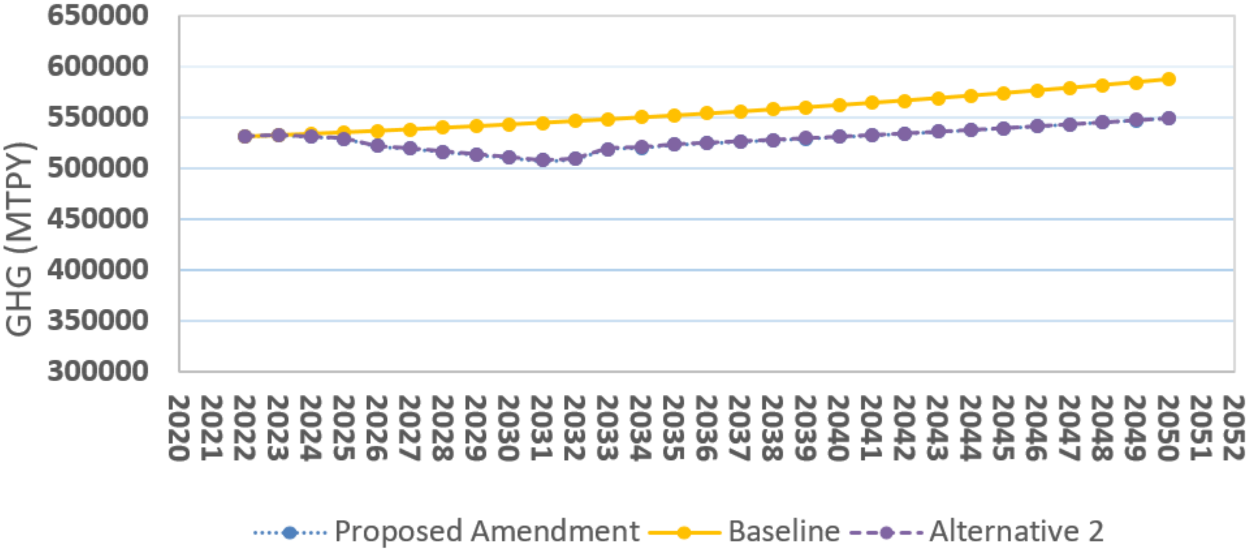


Figure F-12. Alternative 2 – GHG Emissions Estimates



Alternative 2 was also evaluated to determine the resulting health benefits that would be achieved if commercial fishing vessels' emission control requirements were excluded from the Proposed Amendments. The estimated total reductions in health outcomes that would result from Alternative 2 from 2023 to 2038 are presented in Table F-13. Chapter B (Benefits) discusses the total reductions in health outcomes for the Proposed Amendments. Alternative 2 would result in fewer reductions for cardiopulmonary mortality (475 v. 501), hospital admissions (144 v. 153), and emergency room visits (212 v. 224) when compared to the Proposed Amendments. This demonstrates that Alternative 2 would be less health-protective than the Proposed Amendments.

Table F-13. Estimated Total Reductions in Health Outcomes from 2023 to 2038 under Alternative 2

Air Basin	Cardiopulmonary Mortality	Hospital Admissions	Emergency Room Visits
North Central Coast	1 (1 - 2)	1 (0 - 1)	1 (1 - 1)
North Coast	2 (2 - 3)	0 (0 - 1)	1 (1 - 1)
Sacramento Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
San Diego County	31 (24 - 38)	9 (1 - 17)	13 (8 - 17)
San Francisco Bay Area	155 (121 - 190)	45 (6 - 84)	73 (46 - 100)
San Joaquin Valley	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
South Central Coast	24 (19 - 29)	8 (1 - 14)	10 (7 - 14)
South Coast	260 (203 - 318)	81 (10 - 150)	114 (72 - 156)
Total	475 (371 - 582)	144 (18 - 268)	212 (134 - 291)

Health benefits under Alternative 2 were valued using the same methodology as under the Proposed Amendments. The total value of health benefits under Alternative 2 is provided in Table F-14. Alternative 2 provides a lower valuation of health benefits at $4.70 billion, relative to the Proposed Amendments at $4.95 billion.

Table F-14. Statewide Valuation of Avoided Health Outcomes between 2023 and 2038 as a Result of Alternative 2

Year	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits	Total
2023	$64,649,000	$96,000	$3,000	$64,748,000
2024	$102,841,000	$158,000	$4,000	$103,004,000
2025	$141,792,000	$224,000	$6,000	$142,022,000
2026	$185,433,000	$299,000	$8,000	$185,740,000
2027	$215,845,000	$353,000	$9,000	$216,207,000
2028	$242,075,000	$400,000	$10,000	$242,485,000
2029	$270,106,000	$450,000	$11,000	$270,567,000
2030	$301,525,000	$506,000	$12,000	$302,043,000
2031	$332,670,000	$560,000	$13,000	$333,243,000
2032	$360,768,000	$608,000	$14,000	$361,390,000
2033	$390,641,000	$657,000	$15,000	$391,313,000
2034	$401,093,000	$677,000	$15,000	$401,784,000
2035	$414,671,000	$701,000	$15,000	$415,387,000
2036	$420,038,000	$711,000	$15,000	$420,764,000
2037	$422,398,000	$715,000	$15,000	$423,128,000
2038	$422,763,000	$715,000	$15,000	$423,493,000
Total	$4,689,308,000	$7,834,000	$177,000	$4,697,319,000

c. Economic Impacts

The impacts described in Section F.2 were input into REMI to assess the macroeconomic impact of Alternative 2 and are summarized, for the odd years of the analysis, in Table F-15. As discussed previously, Staff anticipates that Alternative 2 would result in lower costs to commercial fishing vessel owners and is less stringent compared to the requirements in the Proposed Amendments. Alternative 2 does not contain emission control requirements for commercial fishing vessels, which would result in a decrease in direct costs from 2023 to 2038.

The macroeconomic impact analysis results are shown in Table F-15. Impacts on employment growth by major sector are shown in Figure F-13 and impacts on output growth by major sector are shown in Figure F-14. Overall, the impacts are similar to those under the Proposed Amendments with slight increases in economic growth in the early years of the assessment followed by decreases in growth for all economic indicators by the end of the assessment. Relative to the Proposed Amendments, the positive impacts to economic indicators under Alternative 2 are on average 2 to 5 percent smaller. The negative impacts to the economic indicators under Alternative 2 are approximately 7 percent smaller than the Proposed Amendments in 2037.

Table F-15: Summary of Macroeconomic Impacts of Alternative 2

Economic Indicator	Unit	2023	2025	2027	2029	2031	2033	2035	2037
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
GSP	Change (2019M$)	104	132	58	-8	-83	-53	-165	-196
Personal Income	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Personal Income	Change (2019M$)	55	48	11	-36	-111	-83	-169	-192
Employment	% Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
Employment	Change (jobs)	1,030	1,320	750	200	-450	-130	-1,110	-1,340
Output	% Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Output	Change (2019M$)	200	256	112	-14	-156	-104	-315	-376
Private Investment	% Change	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%
Private Investment	Change (2019M$)	17	33	12	-8	-21	-20	-36	-42

Figure F-13. Impacts on Employment Growth by Major Sector Associated with Alternative 2

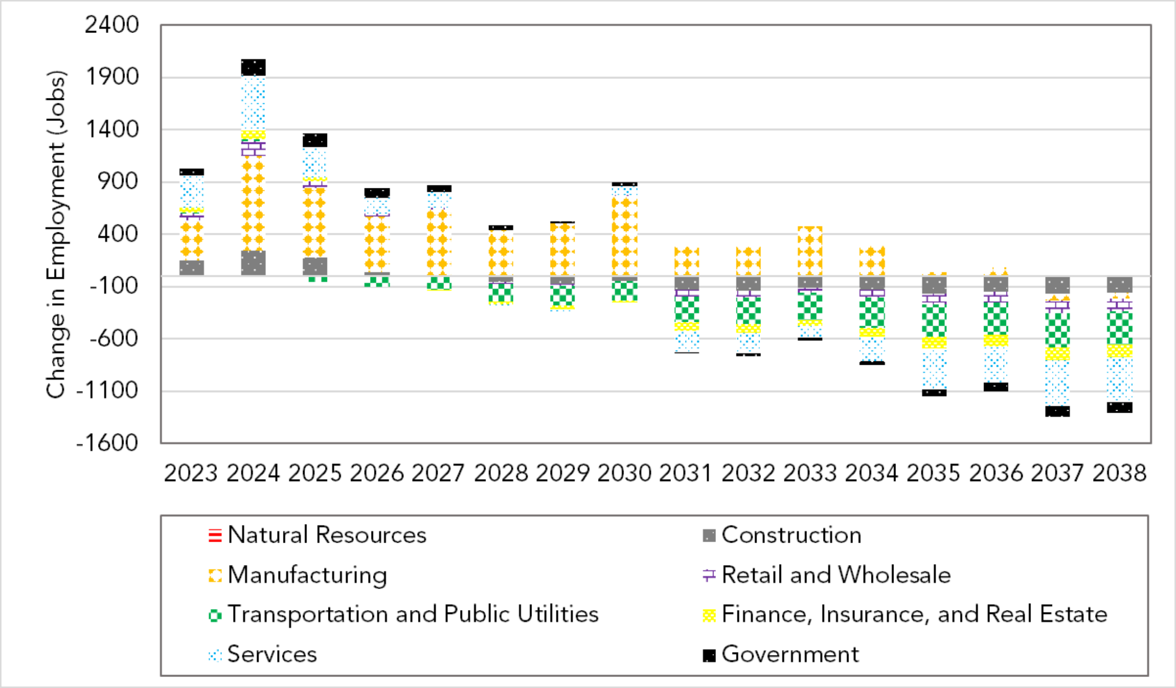
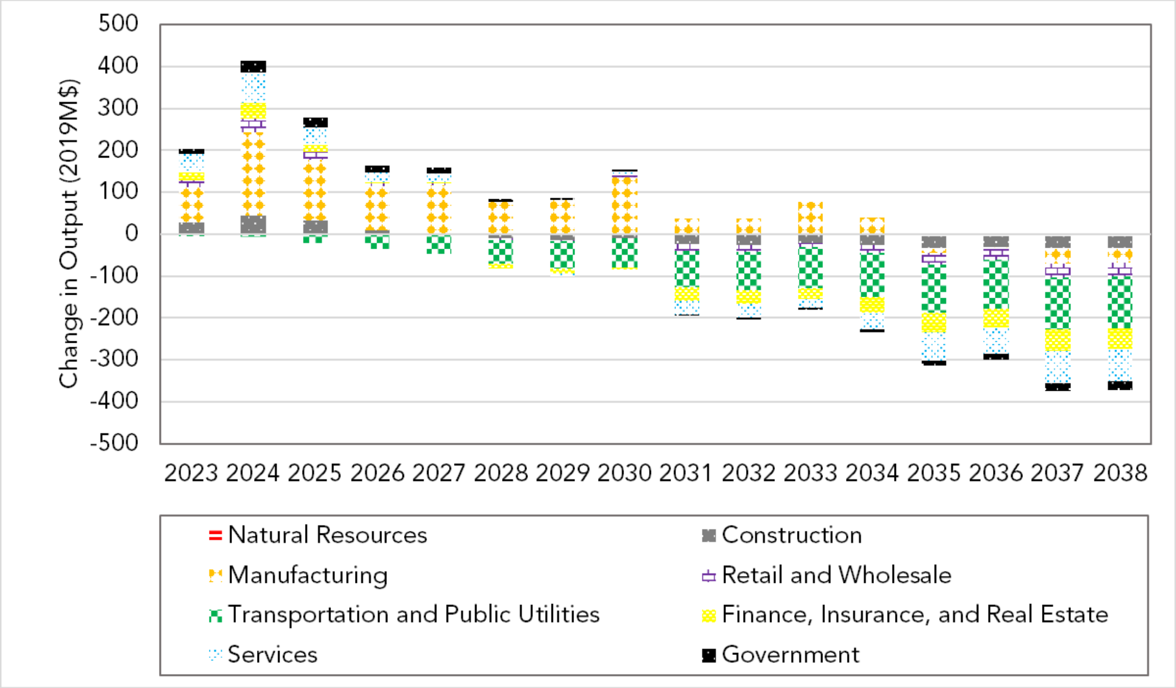


Figure F-14. Changes in Output Growth by Major Sector Associated with Alternative 2



d. Cost-Effectiveness

The Cost-effectiveness methodology used for Alternative 2 followed the same analysis as described in Section F.1.d.

Cost-effectiveness for the Proposed Amendments and Alternative 2 were calculated using the metric described in Section F.1.d and is summarized in Table F-16. Staff estimated that Alternative 2 would be less cost-effective than the Proposed Amendments because the cost to repower Tier 0 or Tier 1 engines to Tier 2 or Tier 3 engines is lower relative to the significant emission reductions achieved.

Table F-16. Cost-Effectiveness of the Proposed Amendments and Alternative 2 From 2023 – 2038

Metric	Carl Moyer Methodology ($/weighted tons)
Proposed Amendments	$28,878
Alternative 2	$30,757
Difference in Cost-Effectiveness	$1,879

e. Reason for Rejection

Alternative 2 was rejected because excluding emission control requirements for commercial fishing vessels would forgo feasible emission reductions and result in fewer health benefits to the local communities, compared with the Proposed Amendments. Alternative 2 would result in fewer reductions of health outcomes such as cardiopulmonary mortality, hospital admissions, and emergency room visits when compared to the Proposed Amendments. As a result, Alternative 2 would fail to provide additional public health and air quality benefits for California's residents, especially communities adjacent to seaports and terminals. For these reasons, Alternative 2 would not meet CARB's goals and objectives for the Proposed Amendments.

G. List of Appendices

Appendix A: Table of Contents

Appendix A: List of Tables

1. Appendix A: Cost Analysis Inputs and Assumptions for Standardized Regulatory Impact Assessment

This document was prepared by California Air Resources Board (CARB) staff to document the inputs used to calculate cost estimates for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft (hereinafter Proposed Amendments). Staff has developed cost estimates for the Standardized Regulatory Impact Assessment (SRIA), which is required by Senate Bill (SB) 617 for proposed regulations that have an economic impact exceeding $50 million. Any additional changes made to the cost estimates as a result of staff refinements or new information from stakeholders will be reflected in the staff report as part of the Initial Statement of Reasons (ISOR).

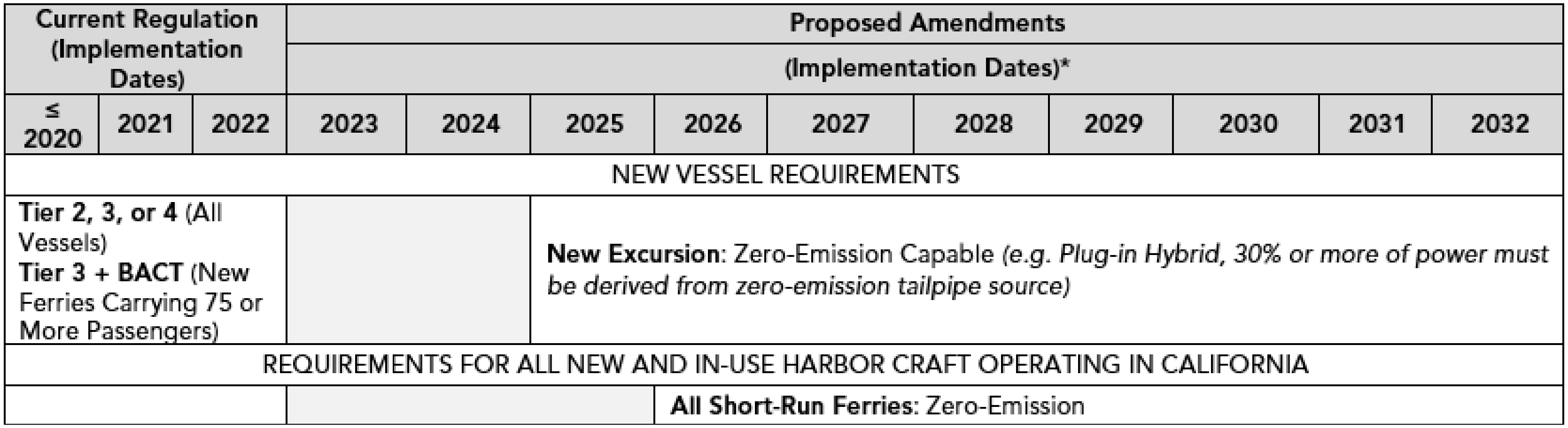
Table I: Scope, Timing, and Cost Assumptions of the Analysis

<table>
<tr><th></th><th>2023 through 2038</th></tr>
<tr><td>Proposed Timeline of Major Compliance Requirements for Current Regulation and Proposed Amendments</td><td>

Table I-A: Implementation Timeline for Current Regulation and Proposed Amendments

<table>
<tr><th colspan="3" rowspan="2">Current Regulation (Implementation Dates)</th><th colspan="10">Proposed Amendments</th></tr>
<tr><th colspan="10">(Implementation Dates)*</th></tr>
<tr><th>≤ 2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031</th><th>2032</th></tr>
<tr><td colspan="13">IN-USE VESSEL REQUIREMENTS*</td></tr>
<tr><td colspan="3" rowspan="10">**Tier 2 or 3** (Tugs, Ferries, Excursion, Crew & Supply, Barge, Dredge)</td><td colspan="3">**Any Tier 0 and 1 to Tier 3 or 4****</td><td colspan="7" rowspan="2"></td></tr>
<tr><td>≤ MY 1993</td><td>MY 1994-2001</td><td>MY 2002-2006</td></tr>
<tr><td rowspan="2"></td><td colspan="6">**Tier 2, 3, 4 to Tier 3+DPF & Tier 4+DPF** (Ferry, Pilot, All Tugs)</td><td colspan="3" rowspan="2"></td></tr>
<tr><td>MY 2007-2009***</td><td>MY 2010-2012***</td><td>MY 2013-2015</td><td>MY 2016-2019</td><td>MY 2020-2021</td><td>MY 2022+</td></tr>
<tr><td colspan="3" rowspan="2"></td><td colspan="5">**Tier 2, 3, 4 to Tier 3+DPF & Tier 4+DPF** (Research, Commercial Passenger Fishing, Excursion)</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>MY 2007-2010</td><td>MY 2011-2012</td><td>MY 2013-2014</td><td>MY 2015-2017</td><td>MY 2017+</td></tr>
<tr><td colspan="5" rowspan="2"></td><td colspan="4">**Tier 2, 3, 4 to Tier 3+DPF & Tier 4+DPF** (Dredges, Barges, Crew & Supply, Workboats)</td><td rowspan="2"></td></tr>
<tr><td>MY 2007-2009</td><td>MY 2010-2013</td><td>MY 2014-2017</td><td>MY 2017+</td></tr>
<tr><td colspan="5" rowspan="2"></td><td colspan="2" rowspan="2"></td><td colspan="3">**Pre-Tier 1 and Tier 1 to Tier 2 and above** (Commercial Fishing)</td></tr>
<tr><td>≤ MY 1987</td><td>MY 1988-1997</td><td>MY 1998+</td></tr>
</table>

</td></tr>
</table>

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>Proposed Timeline of Major Compliance Requirements for Current Regulation and Proposed Amendments (continued)</td><td>

<table>
<tr><th colspan="3" rowspan="2">Current Regulation (Implementation Dates)</th><th colspan="10">Proposed Amendments</th></tr>
<tr><th colspan="10">(Implementation Dates)*</th></tr>
<tr><th>≤ 2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031</th><th>2032</th></tr>
<tr><td colspan="13">NEW VESSEL REQUIREMENTS</td></tr>
<tr><td colspan="3">Tier 2, 3, or 4 (All Vessels)
Tier 3 + BACT (New Ferries Carrying 75 or More Passengers)</td><td colspan="2"></td><td colspan="8">New Excursion: Zero-Emission Capable <i>(e.g. Plug-in Hybrid, 30% or more of power must be derived from zero-emission tailpipe source)</i></td></tr>
<tr><td colspan="13">REQUIREMENTS FOR ALL NEW AND IN-USE HARBOR CRAFT OPERATING IN CALIFORNIA</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td><td colspan="7">All Short-Run Ferries: Zero-Emission</td></tr>
</table>
*Tier 3 + DPF requirements apply to engines <600 HP, and Tier 4 + DPF requirements apply to engines >=600 HP.
**Generally Workboats, Research, Pilot, Tank Barges, and Commercial Passenger Fishing
***Pilot boats with Tier 2, 3, and 4 engines that are MY 2009 and earlier would have a compliance date beginning in 2025.

For the purpose of the cost analysis, Tier 3 + diesel particulate filter (DPF) requirements apply to engines <600 HP, and Tier 4 + DPF requirements apply to engines >=600 HP.

Table I-B: Regulation Timeline: Mandates for Zero-Emission and Advanced Technologies
<table>
<tr><th>Marine Technology Type</th><th>Vessel Category Requirement</th><th>Mandate Phase-In Date</th></tr>
<tr><td>Zero-Emission Capable Hybrid</td><td>New Excursion Vessels</td><td>January 1, 2025</td></tr>
<tr><td>Zero-Emission</td><td>New and In-Use Short Run (<3 nautical miles [nm]) Ferries</td><td>January 1, 2026</td></tr>
</table>
</td></tr>
</table>

	2023 through 2038
Assumptions Regarding Timing of Costs	Major Costs • Capital, Labor, and Installation Costs (including Redundant Labor and Installation Costs) would begin on the vessel compliance year as outlined in Tables I-A and I-B and are amortized according to the Engine Capital Recovery Factor Table I-J. o Non-amortized scenarios assumed that the Capital, Labor, and Installation Costs would be incurred during the vessel compliance year as outlined in Tables I-A and I-B. • Operational Costs would begin on the vessel compliance year as outlined in Tables I-A and I-B. • Loss of Use Costs result from downtime during the retrofit and/or repower process, and as such, apply to repower and retrofit scenarios only. These costs would begin on the vessel compliance year as outlined in Tables I-A and I-B and are amortized according to the Engine Capital Recovery Factor Table I-J. o Non-amortized scenarios assumed that Loss of Use Costs would be incurred during the vessel compliance year as outlined in Tables I-A and I-B. • Vessel Replacement Costs would begin on the vessel compliance year as outlined in Tables I-A and I-B. and are amortized according to the Vessel Capital Recovery Factor Table I-I. o Non-amortized scenarios assumed that Vessel Replacement Costs would be incurred during the vessel compliance year as outlined in Tables I-A and I-B. • Vessel Residual/Resale Value Before Replacement applies to vessel replacements only. These values would begin on the vessel compliance year as outlined in Tables I-A and I-B and are amortized according to the Vessel Capital Recovery Factor Table I-I. o Non-amortized scenarios assumed that Residual/Resale Value Before Replacement values would be applied during the vessel compliance year as outlined in Tables I-A and I-B. • Low Use Exemption Costs would begin on the vessel compliance year as outlined in Tables I-A and I-B. Administrative Costs • Recordkeeping and Reporting and Facility Report Costs would occur annually beginning in 2023. • Vessel Labeling Cost ($ per vessel) would occur every five years beginning in 2023. • Opacity Testing Cost ($ per vessel) would occur bi-annually starting in 2023. • Personnel Years (PY) Costs for Implementation and Enforcement of Regulation would occur annually starting in 2023. • Compliance Extension Costs o Financial Feasibility Report Cost: CARB staff assumed the Financial Feasibility Report Cost would occur from 2023 to 2034, based on the regulation's phase-in compliance dates and the available three-year extension periods. o Naval Architect Report Cost: CARB staff assumed the Naval Architect Report Cost would occur from 2023 to 2034, based on the regulation's phase-in compliance dates and the available three-year extension periods.

Years of Cost Analysis	**2023 through 2038**

Assumptions Regarding Timing of Costs (continued)	Infrastructure Costs
	• Shore Power Infrastructure Costs would occur starting in 2023 and are amortized according to a capital recovery factor of 0.08, which was calculated using a 5 percent interest rate and a 20-year infrastructure useful life. CARB staff is exploring the option of using a lower interest rate in future analyses for public entities (e.g., ports) based on their lower cost of debt compared to industry.
	  ○ Non-amortized scenario assumed that the Shore Power Infrastructure Costs would occur from 2023-2024, and would be evenly distributed over the two-year construction period.
	• Short Run Ferry and Excursion Vessel Charging Infrastructure Costs would occur two years before the Excursion Vessel initial compliance date and are amortized according to a capital recovery factor of 0.08, which was calculated using a 5 percent interest rate and a 20 year infrastructure useful life. CARB staff is exploring the option of using a lower interest rate in future analyses for public entities (e.g., ports) based on their lower cost of debt compared to industry.
	  ○ Non-amortized scenario assumed that the Charging Infrastructure Costs would occur starting in 2023 (two years before the Excursion Vessel initial compliance date) through 2025, and would be evenly distributed over the three-year construction period.

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>CARB Staff Assumptions Regarding Compliance Scenarios</td><td>

Table I-C: Compliance Scenario Assumptions for Tier 0 and Tier 1 to Tier 3 Repowers (Engines <600HP)

<table>
<tr><th>Vessel Category</th><th>% Vessel Repowers by Initial Compliance Date</th></tr>
<tr><td>Ferry, Catamaran</td><td>100%</td></tr>
<tr><td>Ferry, Monohull</td><td>100%</td></tr>
<tr><td>Ferry, Short Run</td><td>100%</td></tr>
<tr><td>Pilot Boat</td><td>100%</td></tr>
<tr><td>Push/Tow Tug</td><td>100%</td></tr>
<tr><td>Escort/Ship Assist Tug</td><td>100%</td></tr>
<tr><td>ATB Tug</td><td>100%</td></tr>
<tr><td>Research Vessel</td><td>100%</td></tr>
<tr><td>Commercial Passenger Fishing</td><td>100%</td></tr>
<tr><td>Excursion</td><td>100%</td></tr>
<tr><td>Dredge</td><td>100%</td></tr>
<tr><td>ATB Barge</td><td>100%</td></tr>
<tr><td>Bunker Barge</td><td>100%</td></tr>
<tr><td>Other Barge</td><td>100%</td></tr>
<tr><td>Towed Petrochemical Barge</td><td>100%</td></tr>
<tr><td>Crew Supply</td><td>100%</td></tr>
<tr><td>Workboat</td><td>100%</td></tr>
<tr><td>Commercial Fishing</td><td>100%</td></tr>
</table>

CARB staff assumed 100 percent of vessels with Tier 0 and Tier 1 engines <600HP would be able to repower by the initial compliance date.
</td></tr>
</table>

Years of Cost Analysis	2023 through 2038
CARB Staff Assumptions Regarding Compliance Scenarios (continued)	**Table I-D: Compliance Scenario Assumptions for Tier 0 and Tier 1 to Tier 4 Repowers (Engines >=600HP)**

Vessel Category	% Vessel Retrofits or Repowers by Initial Compliance Date	% Vessel Replacements by Initial Compliance Date	% Vessels Granted 1st Extension	% Vessel Retrofits or Repowers after 1st Extension	% Vessel Replacements after 1st Extension	% Vessel Repowers or Retrofits after 2nd Extension	% Vessel Replacements after 2nd Extension
Ferry, Catamaran	75%	5%	20%	5.00%	5.00%	5.00%	5.00%
Ferry, Monohull	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Ferry, Short Run	100%	0%	0%	0.00%	0.00%	0.00%	0.00%
Pilot Boat	75%	5%	20%	5.00%	5.00%	5.00%	5.00%
Push/Tow Tug	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Escort/Ship Assist Tug	95%	5%	0%	0.00%	0.00%	0.00%	0.00%
ATB Tug	95%	5%	0%	0.00%	0.00%	0.00%	0.00%
Research Vessel	75%	5%	20%	5.00%	5.00%	5.00%	5.00%
Commercial Passenger Fishing	50%	5%	45%	11.25%	11.25%	11.25%	11.25%
Excursion	95%	5%	0%	0.00%	0.00%	0.00%	0.00%
Dredge	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
ATB Barge	95%	5%	0%	0.00%	0.00%	0.00%	0.00%
Bunker Barge	95%	5%	0%	0.00%	0.00%	0.00%	0.00%
Other Barge	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Towed Petrochemical Barge	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Crew Supply	75%	5%	20%	5.00%	5.00%	5.00%	5.00%
Workboat	75%	5%	20%	5.00%	5.00%	5.00%	5.00%

Years of Cost Analysis	
CARB Staff Assumptions Regarding Compliance Scenarios (continued)	The compliance scenarios listed in the table are based on the following CARB staff assumptions: • There are various reasons, including technical feasibility issues, which would prevent all vessels from being retrofit or repowered by their initial compliance date. Rather than apply for an extension, CARB staff assumed that 5 percent of vessels (except for Short Run Ferries) would be replaced by their initial compliance date due to the owners' ability to incur the cost of a vessel replacement. • For Short Run Ferries, CARB staff assumed 100 percent would be repowered to zero-emission operations instead of replaced due to the large cost difference between a vessel replacement vs. retrofit/repower. Additionally, CARB staff have identified Short Run ferries being repowered with zero-emission powertrains in other regions of the United States. CARB staff assumed no compliance extension requests for this category due to a later regulatory phase-in date of 2026. • The percentage of vessels that would repower or retrofit by the first compliance date is based on vessel repower and retrofit feasibility fitment factors reported in the *"Evaluation of the Feasibility and Costs of Installing Tier 4 Engines and Retrofit Exhaust Aftertreatment on In-Use Commercial Harbor Craft"*[1] conducted by California State University Maritime Academy, September 2019 (Cal Maritime Study): ○ Feasible fitment for most options = 95 percent; ○ Moderate reconfiguration for most options = 90 percent; ○ Substantial reconfiguration = 75 percent; ○ No fitment = 50 percent. • The percentage of vessels that would receive compliance extensions is equal to one minus the sum of the feasibility fitment factor and the percentage of vessels replaced by the initial compliance date. • At the end of the first compliance extension period, the vessel owner would have three compliance pathways, and CARB staff assumed the following percentages for each pathway: 1) file for a second extension (50 percent); 2) repower or retrofit the vessel (25 percent), or; 3) replace the vessel (25 percent). • At the end of the second compliance extension period, the vessel owner would have two compliance pathways, and CARB staff assumed the following percentages for each pathway: 1) repower or retrofit the vessel (50 percent), or; 2) replace the vessel (50 percent). Although Workboats would not have compliance extension limitations, the cost workbook treats this vessel category the same as other vessel categories for modeling simplicity.

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[1] CSU Maritime Academy, "Evaluation of the Feasibility and Costs of Installing Tier 4 Engines and Retrofit Exhaust Aftertreatment on In-Use Commercial Harbor Craft, 2019, last accessed February 2021, *https://ww2.arb.ca.gov/sites/default/filesf/2019-10/cmafeasibilityreport09302019.pdf*.

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>CARB Staff Assumptions Regarding Compliance Scenarios (continued)</td><td>
Table I-E: Compliance Scenario Assumptions for Tier 2 and Tier 3 to Tier 3 + DPF (Engines <600HP) and Tier 2, Tier 3, and Tier 4 to Tier 4+DPF (Engines >=600HP)
<table>
<tr><th>Vessel Category</th><th>% Vessel Retrofits or Repowers by Initial Compliance Date</th><th>% Vessel Replacements by Initial Compliance Date</th><th>% Vessels Granted 1st Extension</th><th>% Vessel Repowers or Retrofits after 1st Extension Period</th><th>% Vessel Replacements after 1st Extension Period</th><th>% Vessel Repowers or Retrofits after 2nd Extension</th><th>% Vessel Replacements after 2nd Extension</th></tr>
<tr><td>Ferry, Catamaran</td><td>31.5%</td><td>5%</td><td>63.5%</td><td>15.875%</td><td>15.875%</td><td>15.875%</td><td>15.875%</td></tr>
<tr><td>Ferry, Monohull</td><td>42.5%</td><td>5%</td><td>52.5%</td><td>13.125%</td><td>13.125%</td><td>13.125%</td><td>13.125%</td></tr>
<tr><td>Ferry, Short Run</td><td>100%</td><td>0%</td><td>0%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>Pilot Boat</td><td>50%</td><td>5%</td><td>45%</td><td>12.50%</td><td>12.50%</td><td>12.50%</td><td>12.50%</td></tr>
<tr><td>Push/Tow Tug</td><td>80%</td><td>5%</td><td>15%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td></tr>
<tr><td>Escort/Ship Assist Tug</td><td>90%</td><td>5%</td><td>5%</td><td>1.25%</td><td>1.25%</td><td>1.25%</td><td>1.25%</td></tr>
<tr><td>ATB Tug</td><td>90%</td><td>5%</td><td>5%</td><td>1.25%</td><td>1.25%</td><td>1.25%</td><td>1.25%</td></tr>
<tr><td>Research Vessel</td><td>50%</td><td>5%</td><td>45%</td><td>11.25%</td><td>11.25%</td><td>11.25%</td><td>11.25%</td></tr>
<tr><td>Commercial Passenger Fishing</td><td>1%</td><td>5%</td><td>94%</td><td>0.00%</td><td>47.00%</td><td>0.00%</td><td>47.00%</td></tr>
<tr><td>Excursion</td><td>90%</td><td>5%</td><td>5%</td><td>1.25%</td><td>1.25%</td><td>1.25%</td><td>1.25%</td></tr>
<tr><td>Dredge</td><td>80%</td><td>5%</td><td>15%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td></tr>
<tr><td>ATB Barge</td><td>90%</td><td>5%</td><td>5%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>Bunker Barge</td><td>90%</td><td>5%</td><td>5%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>Other Barge</td><td>80%</td><td>5%</td><td>15%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td></tr>
<tr><td>Towed Petrochemical Barge</td><td>80%</td><td>5%</td><td>15%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td><td>3.75%</td></tr>
<tr><td>Crew Supply</td><td>50%</td><td>5%</td><td>45%</td><td>12.50%</td><td>12.50%</td><td>12.50%</td><td>12.50%</td></tr>
<tr><td>Workboat</td><td>50%</td><td>5%</td><td>45%</td><td>11.25%</td><td>11.25%</td><td>11.25%</td><td>11.25%</td></tr>
</table>
</td></tr>
</table>

Years of Cost Analysis	
CARB Staff Assumptions Regarding Compliance Scenarios (continued)	The compliance scenarios listed in the table are based on the following staff assumptions: • There are various reasons, including technical feasibility issues, which would prevent all vessels from being retrofit or repowered by their initial compliance date. Rather than apply for an extension, staff assumed that 5 percent of vessels (except for Short Run Ferries) would be replaced by their initial compliance date due to the owners' ability to incur the cost of a vessel replacement. • For Short Run Ferries, staff assumed 100 percent would be retrofit/repowered instead of replaced due to the large cost difference between a vessel replacement vs. retrofit/repower. Additionally, staff has identified Short Run ferries being repowered with zero-emission powertrains in other regions of the United States. Staff assumed no compliance extension requests for this category due to a later regulatory phase-in date of 2026. • The percentage of vessels that would repower or retrofit by the first compliance date is based on vessel repower and retrofit feasibility fitment factors reported in the Cal Maritime Study: o Feasible fitment for most options = 90 percent; o Moderate reconfiguration for most options = 80 percent; o Substantial reconfiguration = 50 percent; o No fitment = 30 percent. • The percentage of vessels that would receive compliance extensions is equal to one minus the sum of the feasibility fitment factor and the percentage of vessels replaced by the initial compliance date. • At the end of the <u>first</u> compliance extension period, the vessel owner would have three compliance pathways, and staff assumed the following percentages for each pathway: 1) file for a second extension (50 percent); 2) repower or retrofit the vessel (25 percent), or; 3) replace the vessel (25 percent). • At the end of the <u>second</u> compliance extension period, the vessel owner would have two compliance pathways, and staff assumed the following percentages for each pathway: 1) repower or retrofit the vessel (50 percent), or; 2) replace the vessel (50 percent). Although Workboats would not have compliance extension limitations, the cost workbook treats this vessel category the same as other vessel categories for modeling simplicity.

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>Assumptions Regarding Vessel Horsepower Qualifying for Low Use Exemption</td><td>
Table I-F: Low Use Percentages of Vessel Horsepower by CHC Category
<table>
<tr><th>Vessel Category</th><th>Percentage of HP that is Low Use</th><th>Basis</th></tr>
<tr><td>Ferry, Catamaran</td><td>4%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Ferry, Monohull</td><td>4%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Ferry, Short Run</td><td>4%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Pilot Boat</td><td>0%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Push/Tow Tug</td><td>7%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Escort/Ship Assist Tug</td><td>25%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>ATB Tug</td><td>0%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Research Vessel</td><td>16%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Commercial Passenger Fishing</td><td>4%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Excursion</td><td>29%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Dredge</td><td>3%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>ATB Barge</td><td>0%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Bunker Barge</td><td>28%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Other Barge</td><td>28%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Towed Petrochemical Barge</td><td>28%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Crew Supply</td><td>10%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Workboat</td><td>10%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
<tr><td>Commercial Fishing</td><td>5%</td><td>The percentage is based on data from CARB’s CHC Reporting Database.</td></tr>
</table>
</td></tr>
</table>

Years of Cost Analysis	**2023 through 2038**
Assumptions Regarding Vessel Horsepower Qualifying for Limited Operating Hours Extension	**Table I-G: Percentage of Vessel Horsepower Qualifying for Limited Operating Hours Extension**

Vessel Category	**Percentage of HP with limited Operating Hours**	**Basis**
Ferry, Catamaran	15%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Ferry, Monohull	6%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Ferry, Short Run	0%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Pilot Boat	0%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Push/Tow Tug	9%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Escort/Ship Assist Tug	7%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
ATB Tug	3%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Research Vessel	29%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Commercial Passenger Fishing	70%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Excursion	10%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Dredge	20%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
ATB Barge	10%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Bunker Barge	20%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Other Barge	20%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Towed Petrochemical Barge	20%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Crew Supply	36%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.
Workboat	45%	The percentage is based on data from CARB’s CHC Reporting Database and feasibility fitment factors from the Cal Maritime Study.

Years of Cost Analysis	2023 through 2038
Constant Values used in Cost Calculations	Staff multiplied the DPF retrofit capital and labor and installation costs by these limited operating hours extension percentages for all engine horsepower above and equal 600 HP that would be required to repower and retrofit to Tier 4 and a DPF. • **DPF Fuel Penalty:** 4.15 percent was derived by taking the average of six different DPF fuel penalty percentages from the CARB DPF verification database. In order to select the six values, staff analyzed seven verification applications to CARB (confidential data source that requested non-attribution) for DPF products used in TRU, Stationary, and Marine applications with various regeneration strategies, and determined that one application for a passive DPF system was not applicable due to its passive regeneration strategy. • **Diesel Exhaust Fluid (DEF) Consumption Rate:** 3.75 percent was derived by taking the average of the values from the following sources: ○ Caterpillar, which reported a DEF consumption rate of 3-8 percent (the average value of 5.5 percent was used in the calculation).[2] ○ Cummins, which reported a DEF consumption rate of 2 percent.[3] • **DPF Cleaning Cost ($/horsepower [hp]):** $1.6/HP was calculated based on a phone call with Caitlin Bowles with Diesel Emissions Service on February 19, 2021. The unit cost is calculated based on: A total of $1,300 per DPF Cleaning, with 402 average horse power per engine, assumed cleaning every two years. • **DEF Cost ($/gallon):** $1.75 is taken from the Cal Maritime Study. • **DPF Drag Penalty ($/gallon):** $0 is based on CARB staff's assumption that there would be no functional increase in drag, given that other measures would be taken to maintain existing vessel weight, like passenger count reductions, and that the weight of the fuel in the vessel is significantly larger than the heavier engines and aftertreatment devices. • **Diesel Fuel Cost ($/gallon):** $2.38 is based on a 2023 fuel price, Fuel Price Forecasts by Transportation Energy Forecasting Unit, Demand Analysis Office, Energy Assessments Division, California Energy Commission. • **Electricity and Diesel Cost Inputs ($/kWh):** Price inputs from 2023 to 2031 were taken from CEC's "Transportation Energy Demand Forecast 2020 IEPR Update.[4] Fuel prices past 2031 were calculated using the Energy Information Administration's (EIA) 2020 Annual Energy Outlook for the Pacific region.[5] The annual percentage change in EIA diesel and electricity fuel prices past 2031 was applied to the 2031 CEC diesel and electricity prices to estimate price changes past 2031. The electricity price projections represent commercial electricity prices in the mid-case scenario.

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[2] Caterpillar, "Your U.S. EPA Tier 4 Final Marine Engine Questions Answered," last accessed July 2020, *https://www.cat.com/en_US/by-industry/marine/tier-four/your-questions-answered/def-faqs.html*.

[3] Cummins, "Diesel Exhaust Fluid (DEF) Q&A," last accessed April 2020, *https://www.cumminsfiltration.com/sites/default/files/MB10033.pdf.*

[4] California Energy Commission, Transportation Energy Demand Forecast 2020 IEPR Update, December 3, 2020, last accessed January 2021, *https://efiling.energy.ca.gov/GetDocument.aspx?tn=235841&DocumentContentId=68785*.

[5] Energy Information Administration, Annual Energy Outlook 2020, last accessed January 2021, *https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2020&region=1-9&cases=ref2020&start=2018&end=2050&f=A&linechart=ref2020-d112119a.3-3-AEO2020.1-9&map=ref2020-d112119a.4-3-AEO2020.1-9&sourcekey=0*.

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>Constant Values used in Cost Calculations (continued)</td><td>

Table I-H: Diesel and Electricity Price Projections from 2023 to 2038 (2019 $)

<table>
<tr><th>Year</th><th>Electricity ($/kWh)</th><th>Diesel ($/gal)</th></tr>
<tr><td>2023</td><td>$0.23</td><td>$2.38</td></tr>
<tr><td>2024</td><td>$0.23</td><td>$2.38</td></tr>
<tr><td>2025</td><td>$0.24</td><td>$2.35</td></tr>
<tr><td>2026</td><td>$0.24</td><td>$2.34</td></tr>
<tr><td>2027</td><td>$0.25</td><td>$2.28</td></tr>
<tr><td>2028</td><td>$0.25</td><td>$2.25</td></tr>
<tr><td>2029</td><td>$0.26</td><td>$2.19</td></tr>
<tr><td>2030</td><td>$0.26</td><td>$2.15</td></tr>
<tr><td>2031</td><td>$0.27</td><td>$2.15</td></tr>
<tr><td>2032</td><td>$0.27</td><td>$2.16</td></tr>
<tr><td>2033</td><td>$0.27</td><td>$2.20</td></tr>
<tr><td>2034</td><td>$0.27</td><td>$2.21</td></tr>
<tr><td>2035</td><td>$0.26</td><td>$2.23</td></tr>
<tr><td>2036</td><td>$0.26</td><td>$2.26</td></tr>
<tr><td>2037</td><td>$0.26</td><td>$2.27</td></tr>
<tr><td>2038</td><td>$0.26</td><td>$2.29</td></tr>
</table>

</td></tr>
</table>

Years of Cost Analysis	**2023 through 2038**
Vessel Growth Factors	**Table I-H-i: Vessel Growth Factors by CHC Category**

Vessel Category	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Ferry-Catamaran	0.0%	1.9%	1.9%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.1%	2.1%	2.1%	2.1%	2.1%	2.2%	2.2%
Ferry-Monohull	0.0%	1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%	1.5%	1.5%	1.6%	1.6%	1.6%	1.6%
Ferry-Short Run	0.0%	1.1%	1.1%	1.1%	1.1%	1.1%	1.2%	1.2%	1.2%	1.2%	1.2%	1.3%	1.3%	1.3%	1.3%	1.4%
Pilot Boat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Push/Tow Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Escort/Ship Assist Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ATB Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Research Vessel	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Commercial Passenger Fishing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Excursion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Dredge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ATB Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bunker Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Towed Petrochemical Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crew Supply	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Workboat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Commercial Fishing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>Vessel Growth Factors (continued)</td><td>
<p>Staff analyzed reported inventories of CHC from the Ports of Los Angeles and Long Beach, and reporting data to CARB from the past decade to generate estimated vessel growth factors. Based on relatively flat historical growth trends, staff assumed zero population growth for all vessel categories except Ferries. Staff used a Statewide compound growth factor that assumed zero population growth for the State with the exception of the Bay Area, where Ferry growth assumptions were based on the San Francisco Bay Area Water Emergency Transportation Authority (WETA) 2016 Strategic Plan.[6] ,. . The Ferry growth percentages apply to Catamaran, Monohull, and Short-Run Ferry categories.</p>
<p>The vessel growth factor percentage is applied to each cost input within a vessel category to account for changes in vessel population.</p>
<p>Table I-H-ii: Compounded Vessel Growth Factors</p>
<table>
<tr><th></th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031</th><th>2032</th><th>2033</th><th>2034</th><th>2035</th><th>2036</th><th>2037</th><th>2038</th></tr>
<tr><td>Compound Growth Factor</td><td>0.0%</td><td>0.06%</td><td>0.06%</td><td>0.06%</td><td>0.06%</td><td>0.07%</td><td>0.07%</td><td>0.07%</td><td>0.07%</td><td>0.07%</td><td>0.08%</td><td>0.08%</td><td>0.08%</td><td>0.08%</td><td>0.08%</td><td>0.08%</td></tr>
</table>
<p>The compounded vessel growth factor percentage is for all CHC vessel categories combined, and applies to Shore Power Retrofit Cost inputs.</p>
</td></tr>
</table>

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[6] San Francisco Bay Area Water Emergency Transportation Authority, “2016 Strategic Plan,” last accessed March 2021, *https://weta.sanfranciscobayferry.com/sites/default/files/weta/strategicplan/WETAStrategicPlanFinal.pdf*.

<table>
<tr><th>Years of Cost Analysis</th><th>2023 through 2038</th></tr>
<tr><td>Vessel Capital Recovery Factor</td><td>

Table I-I: Vessel Capital Recovery Factors by CHC Category

<table>
<tr><th>Vessel Category</th><th>Interest Rate</th><th>Useful Life (Years)</th><th>Capital Recovery Factor</th></tr>
<tr><td>Ferry (Catamaran)</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Ferry (Monohull)</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Ferry (Short Run)</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Pilot Boat</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Push/Tow Tug</td><td>4%</td><td>54</td><td>0.0455</td></tr>
<tr><td>Escort/Ship Assist Tug</td><td>4%</td><td>54</td><td>0.0455</td></tr>
<tr><td>ATB Tug</td><td>4%</td><td>54</td><td>0.0455</td></tr>
<tr><td>Research Vessel</td><td>4%</td><td>47</td><td>0.0475</td></tr>
<tr><td>Commercial Passenger Fishing</td><td>4%</td><td>53</td><td>0.0457</td></tr>
<tr><td>Excursion</td><td>4%</td><td>54</td><td>0.0455</td></tr>
<tr><td>Dredge</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>ATB Barge</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Bunker Barge</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Other Barge</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Towed Petrochemical Barge</td><td>4%</td><td>42</td><td>0.0495</td></tr>
<tr><td>Crew Supply</td><td>4%</td><td>53</td><td>0.0495</td></tr>
<tr><td>Workboat</td><td>4%</td><td>47</td><td>0.0457</td></tr>
</table>

The Vessel Capital Recovery Factor (CRF) is calculated using the following equation:

$$CRF = i * \frac{(1+i)^n}{(1+i)^n - 1}$$

Where, CRF is Capital Recovery Factor, i is the interest rate, and n is the useful financial period. Staff assumed the useful financial period is equal to the vessel's useful life, which is the age when 50 percent of the vessels retire in the fleet. The useful life period for each vessel category is determined using survival curves developed from CARB reporting data. Based on feedback from stakeholders about typical financing rates, staff used an interest rate of 4 percent for the capital recovery factor.[7,8]

The Vessel Capital Recovery Factor is applied to the Unit Vessel Replacement Cost in the Vessel Replacement scenario.

</td></tr>
</table>

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[7] Staff communications with SWITCH Maritime on November 4, 2020.

[8] R.E. Staite Engineering, INC. comment letter to CARB, Proposed Amendments to the Regulations to Reduce Emissions from Diesel Engines on Commercial Harbor Craft (CHC) operated within California Waters and 24 Nautical Miles of the California Baseline, October 30, 2019.

<table>
<tr><th>Years of Cost</th><th>2023 through 2038</th></tr>
<tr><td>Engine Capital Recovery Factor</td><td>

Table I-J: Engine Capital Recovery Factors by CHC Category

<table>
<tr><th>Vessel Category</th><th>Interest Rate</th><th>Useful Life (Years)</th><th>Capital Recovery Factor</th></tr>
<tr><td>Ferry (Catamaran)</td><td>4%</td><td>15</td><td>0.0899</td></tr>
<tr><td>Ferry (Monohull)</td><td>4%</td><td>15</td><td>0.0899</td></tr>
<tr><td>Ferry (Short Run)</td><td>4%</td><td>15</td><td>0.0899</td></tr>
<tr><td>Pilot Boat</td><td>4%</td><td>15</td><td>0.0899</td></tr>
<tr><td>Push/Tow Tug</td><td>4%</td><td>14</td><td>0.0947</td></tr>
<tr><td>Escort/Ship Assist Tug</td><td>4%</td><td>14</td><td>0.0947</td></tr>
<tr><td>ATB Tug</td><td>4%</td><td>14</td><td>0.0947</td></tr>
<tr><td>Research Vessel</td><td>4%</td><td>22</td><td>0.0692</td></tr>
<tr><td>Commercial Passenger Fishing</td><td>4%</td><td>16</td><td>0.0858</td></tr>
<tr><td>Excursion</td><td>4%</td><td>15</td><td>0.0899</td></tr>
<tr><td>Dredge</td><td>4%</td><td>15</td><td>0.0899</td></tr>
<tr><td>ATB Barge</td><td>4%</td><td>14</td><td>0.0947</td></tr>
<tr><td>Bunker Barge</td><td>4%</td><td>25</td><td>0.0640</td></tr>
<tr><td>Other Barge</td><td>4%</td><td>14</td><td>0.0947</td></tr>
<tr><td>Towed Petrochemical Barge</td><td>4%</td><td>14</td><td>0.0947</td></tr>
<tr><td>Crew Supply</td><td>4%</td><td>13</td><td>0.0947</td></tr>
<tr><td>Workboat</td><td>4%</td><td>22</td><td>0.1001</td></tr>
<tr><td>Commercial Fishing</td><td>4%</td><td>31</td><td>0.0692</td></tr>
</table>

The Engine Capital Recovery Factor is calculated using the following equation:

$$CRF = i * \frac{(1+i)^n}{(1+i)^n - 1}$$

Where, CRF is Capital Recovery Factor, i is the interest rate, and n is the useful financial period. Staff assumed the useful financial period is equal to the engine's useful life, which is the age when 50 percent of the engines are retired in the fleet. Main engines are used to represent all vessel categories, except for Articulated Tug Barge (ATB) and Other Barge, where the useful life for auxiliary engines is used.

The Engine Capital Recovery Factor is applied to the Total Engine Capital, Labor and Installation Cost, and the Loss of Use Cost in the Retrofit and Repower scenarios.

</td></tr>
</table>

Years of Cost Analysis	2023 through 2038
Engine and Vessel Population	The cost workbook multiplies $/hp cost values for each compliance pathway by a total hp amount per year, starting in 2023. Staff used the CHC engine inventory to determine the total hp values, which are determined based on the engine type (main or auxiliary), engine model year, average engine hp, and natural turnover populations. This total hp is broken down by vessel category. • For example, to calculate the total number of "Push/Tow Tug" hp that would be subject to the Repower Tier 4 compliance pathway in 2023, staff used the CHC engine inventory to identify all Push/Tow Tug Tier 0 and Tier 1 main and auxiliary engines greater than 600 hp with model years equal to or older than 1993 (based on the phase-in compliance date). A vessel survival percentage based on the engine's age was applied to each engine's average hp, and the values were added together to get the total hp per year. The following provides information about the methodology and staff assumptions for the CHC engine inventory and vessel population: • Vessel population: CHCs operating in Regulated California Waters are required to report to CARB per 17 California Code of Regulations (CCR) § 93118.5, the Airborne Toxic Control Measure for Commercial Harbor Craft. CARB's CHC inventory is largely built around this reporting data. In order to check the total population, CARB cross-referenced reporting with the U.S. Coast Guard (USCG) Merchant Vessel Database for vessels with a hailing port in California. The CHC vessel population from CARB reporting as of February 2019 (1,908 vessels) is only about 50 percent of that reported by U.S. Coast Guard (USCG) (3,692 vessels), initially indicating that half of the operating CHCs are not reported to CARB. Using the 3692 vessels as the starting number, to account for the larger population of CHC in the USCG data, CARB staff began to develop statewide population by scaling up reporting data as described below. This maintains the specificity of the reporting data information (e.g. number of engines, horsepower, activity) while providing a more comprehensive population total than the CARB reporting data alone. o For CHC at the port of Oakland and Richmond, all ferries, ATB tugs, and pilot boats, the reported population is unchanged from CARB's reporting data or from data received directly from stakeholders. o For vessel types that could be matched between the two sources (barges, commercial fishing, tugs, and Research Vessels), the reported population is scaled up by vessel type. o For all other vessels, the reported population is scaled up by location. ▪ For the following seven ports with the highest vessel population (>100), the vessel population scaled at the port level from CARB database to Coast Guard data record. • San Francisco, Los Angeles/Long Beach, San Diego, Eureka, Fort Bragg, Newport Beach, Santa Barbara ▪ For all other ports, the vessel population is scaled to match the remaining USCG reports. o CARB staff also refined the engine and vessel population: ▪ Refine the Push/Tow Tug and Escort/Ship Assist Tug population based on information provided by industry stakeholders. ▪ Adjust the vessel population downward about 10 percent from baseline levels based on stakeholder information that vessels without a valid Certificate of Documentation are not in operation. ▪ Add Commercial Passenger Fishing Vessels carrying six passengers of less based on California Department of Fish and Wildlife permits, to make the population for Commercial Passenger Fishing Vessels at 352. ▪ Total CHC Population: 3159. ▪ Vessel survival: The vessel survival percentages are based on vessel survival curves that staff developed using the age distribution of reported vessels for the year 2015-2018. Survival curves of vessels, rather than engines, are used based on discussions with industry stakeholders[9], which show a trend towards rebuilding engines indefinitely instead of repowering. • Engine population: Vessel scaling factors for each CHC category are applied to the applicable engine data that is reported to the CARB CHC Reporting Database.

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[9] CARB Staff's assumption based on phone call discussions with: 1. American Waterway Operation (AWO) on May 8, 2019 and Sport fishing Association on October 19, 2020.

Table II-A: Major Cost Inputs by CHC Category—Ferry (Catamaran)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$291	$323	$28	$323	**Repower to Tier 3:** Value derived by dividing the Capital Cost of $780,000 with engine hp of 2,680 to get $291/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. Staff added together all main and auxiliary Engine Capital Costs that respondents provided for this category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for this category. The Ferry survey response category was not sub-categorized into Catamaran, Monohull, or Short Run. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources. The $/hp values were derived by dividing the Engine Capital Cost with the engine hp in each source, and the $/hp values were averaged, resulting in a value of $323/hp. • Cal Maritime Study: o Average Engine Capital Cost: $2,500,000 (Table 50, page 86) o HP: 6,860 (Table 46, page 81, 3,430 hp per main engine * 2 main engines) • *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District, December 2019. o Engine Capital Cost: $3,978,000 (pages 47-48) o HP: (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) • *"VDECS Feasibility Study for AMD Class Vessels,"* Aurora Marine Design for Golden Gate Bridge, Highway and Transportation District, February 2020. o Engine Capital Cost: CARB staff subtracted the Labor and Installation Cost ($2,732,889) from the total cost of the vessel ($11,652,463, with 9% sales tax deducted) to provide a value of $8,919,574 (page 307 of pdf). o HP: 8,000 (pdf page 8, 4 engines * 2000 hp) o Engine Capital Cost: CARB staff subtracted the Labor and Installation Cost ($2,146,169) from the total cost of the vessel ($8,898,615, with 9% sales tax deducted) to provide a value of $6,752,446 (page 308 of pdf). o HP: 8,000 (pdf page 9, 4 engines * 2000hp)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp) (continued)	$291	$323	$28	$323	**DPF:** DPF Cost and engine hp data were taken from the following sources. The $/hp values were derived by dividing the DPF Cost with the engine hp in each source, and the $/hp values were averaged, resulting in a value of $28/hp: • *Cal* Maritime Study. Average Capital Cost of $350,000 (Table 52, page 87) with hp of 6,860. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); Capital Cost of $176,142 with hp of 4,224. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); Capital Cost of $176,142 with hp of 4,074. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); Capital Cost of $132,107 with hp of 7,356. WETA's fleet includes 3 Catamarans with the same inputs, CARB staff included all three when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); Capital Cost of $132,107 with hp of 4,324. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); Capital Cost of $16,513 with hp of 6,124. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. **Vessel Replacement:** See "Repower to Tier 4" basis.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$512	$571	$3,896	**Repower Tier 3**: Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged, resulting in a value of $512/HP: • Cal Maritime Study: o Average Labor and Installation Costs: $7,000,000 (Table 50, page 86) o HP: 6,860 (Table 46, page 81, 3,430 hp per main engine * 2 main engines). • "*EPA Tier 4 Feasibility for Existing Vessels*," Incat Crowther for Golden Gate Bridge, Highway and Transportation District o Labor and Installation Cost: $2,232,048, all costs except Equipment Cost and Loss of Revenue in the reference (page 47) o HP: 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) • *"VDECS Feasibility Study for AMD Class Vessels,"* Aurora Marine Design for Golden Gate Bridge Highway and Transportation District, February 2020. o Labor and Installation Cost: $2,732,889 (page 307 of pdf). o HP: 8,000 (pdf page 8, 4 engines * 2000 hp) o Labor and Installation Cost: $2,146,169 (page 308 of pdf). o HP: 8,000 (pdf page 9, 4 engines * 2000hp)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$150	$512	$571	$3,896	**DPF:** DPF Cost and engine hp data were taken from the following sources. The $/hp values were derived by dividing the DPF Cost with the engine hp in each source, and the $/hp values were averaged, resulting in a value of $571/HP: • *Cal* Maritime Study. Labor and Installation Cost of $7,000,000 (Table 52, page 87) with hp of 6,860. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); CARB staff split the total costs by applying the same cost breakdown percentages as the Cal Maritime Study, resulting in Labor and Installation Cost of $3,552,849 with hp of 4,224. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); CARB staff split the total costs by applying the same cost breakdown percentages as the Cal Maritime Study, resulting in Labor and Installation Cost of $3,552,849 with hp of 4,074. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); CARB staff split the total costs by applying the same cost breakdown percentages as the Cal Maritime Study, resulting in Labor and Installation Cost of $2,642,136 with hp of 7,356. WETA's fleet includes 3 Catamarans with the same inputs, CARB staff included all three when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); CARB staff split the total costs by applying the same cost breakdown percentages as the Cal Maritime Study, resulting in Labor and Installation Cost of $2,642,136 with hp of 4,324. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table. • WETA in a November 13, 2020 email to Melissa Houchin (CARB); CARB staff split the total costs by applying the same cost breakdown percentages as the Cal Maritime Study, resulting in Labor and Installation Cost of $330,267 with hp of 6,124. WETA's fleet includes 2 Catamarans with the same inputs, CARB staff included both when deriving the average values, but only 1 entry for this vessel is listed in the table.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$150	$512	$571	$3,896	**Vessel Replacement:** Value derived using the following information: • Value derived using information in Cal Maritime Study. Vessel Replacement Cost of $18,280,000 (Table 48, page 85, sales tax of 8.6% removed) divided by vessel hp of 6,860 (Table 46, page 81, 3,430 p per main engine * 2 main engines). • WETA in a November 17, 2020 email to CARB Staff provided total cost of $15,164,392 for 4900 hp. • WETA in a November 17, 2020 email to CARB Staff provided total cost of $23,872,500 for 6919 hp. • WETA in a November 13, 2020 email to CARB Staff provided total cost of $15,211,000 for 5070 hp. • WETA in a November 13, 2020 email to CARB Staff provided total cost of $15,211,000 for 5070 hp. • WETA in a November 13, 2020 email to CARB Staff provided total cost of $15,211,000 for 5070 hp. • WETA in a November 13, 2020 email to CARB Staff provided total cost of $15,211,000 for 5070 hp. CARB staff calculated the average total cost of $4,219/hp. The labor and installation cost was calculated by subtracting the engine capital cost calculated above from the total cost, resulting in Labor and Installation Cost of $3,896/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	-$3.1	$5.8	$5.8	**Repower Tier 3:** CARB staff defined this in terms of fuel costs, and assumed similar costs for pre-Tier 1, Tier 1, 2, and 3 engines. **Repower Tier 4:** Operational Cost and engine hp data were taken from the following sources. The -3.1$/hp values for each source were derived by adding maintenance costs, DEF costs, and engine fuel savings adjustments together. The resulting $/hp Operational Cost values from each source were averaged. • *Cal Maritime Study:* o Annual Maintenance Cost: HP:$6.7/hp, $45,917 annual maintenance cost (Table 49, page 86) divided by 6,860 hp (Table 46, page 81, 3,430 hp per main engine * 2 main engines). o Annual DEF Cost: HP:($3.8/HP), 42.4 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon). o Annual Main Engine Fuel Savings Cost: -$15.8/hp, Total fuel savings cost of -$142,502 (page 17) divided by hp of 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) to get the $/hp value. • *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District, December 2019: -$0.8/hp o Annual Maintenance Cost: $15/HP: $135,106 (page 17) divided by 9,005 hp (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used). o Annual DEF Cost: N/A o Annual Main Engine Fuel Savings Cost: -$15.8/hp. Total fuel savings cost of -$142,502 (page 17) divided by hp of 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) to get the $/hp value. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $5.8/hp. CARB staff calculated the DPF Regen Fuel Cost of $3.8/hp by multiplying an average fuel consumption of 42.4 gal/hp/year by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-B: Major Cost Inputs by CHC Category—Ferry (Monohull)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$291	$652	$104	$652	**Repower to Tier 3:** Value derived using Engine Capital Cost of $780,000 with engine hp of 2,680 to get $291/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators by adding together all main and auxiliary Engine Capital Costs that respondents provided for this category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for this category. The ferry survey response category was not sub-categorized into Catamaran, Monohull, or Short Run. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $652/HP: • Cal Maritime Study: o Average Engine Capital Cost: $625,000 (Table 41, page 79) o HP: 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines). • *"M.S. SONOMA CARB Study Tier 4 Feasibility Report,"* BMT Designers and Planners Inc. for Golden Gate Bridge, Highway, and Transportation District, November 2019. o Engine Capital Cost: The total cost of $6,003,669 (Capital, Labor, and Installation) was provided for this vessel (pdf page 26). To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Engine Capital Cost and Labor and Installation Cost of the Monohull Ferry in the Cal Maritime Study and applied it to the total cost in the Golden Gate Ferry Report in order to derive a value of $3,718,842 o HP: 3,750 (pdf page 7, 2 engines * 1,875hp) **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $208,000 (Table 43, page 80) divided by hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) to get $104/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$401	$140	$1,633	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $401/hp values were averaged: • Cal Maritime Study: o Average Labor and Installation Cost: $384,000 (Table 41, page 79) o HP: 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) • *"M.S. SONOMA CARB Study Tier 4 Feasibility Report,"* BMT Designers and Planners Inc. for Golden Gate Bridge, Highway, and Transportation District, November 2019. o Labor and Installation Cost: The total cost of $6,003,669 (Capital, Labor, and Installation) was provided for this vessel (pdf page 26). To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Costs of the Monohull Ferry in the Cal Maritime Study and applied it to the total cost in the Golden Gate Ferry Report in order to derive a value of $2,284,857. o HP: 3,750 (pdf page 7, 2 engines * 1,875hp) **DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $280,000 (Table 43, page 80) divided by vessel hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) to get $140/hp. **Vessel Replacement:** Value derived using information in Cal Maritime Study. Vessel Replacement Cost of $4,513,500 (Table 39, page 78, sales tax of 8.6% removed) divided by vessel hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) to get a Unit Vessel Replacement Cost of $2,500 .The Unit Engine Capital Cost was subtracted from the Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $1,633.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	-$6.1	$5.0	$5.0	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The -$6.1/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together from Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: $13,387 annual maintenance cost (Table 41, page 79) divided by 2,000 hp (Table 37, page 71, 1,000 hp per main engine * 2 main engines). o Annual DEF Cost: $3.0/HP: 34.1 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$15.8/hp. Value is taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District, as this information was not available in the Cal Maritime Study. Total fuel savings cost of -$142,502 (page 17) was divided by hp of 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) to get the $/hp value. **DPF:** Operational Costs include DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $3.3/hp by multiplying an average fuel consumption of 34.1 gal/hp/year (extracted from the engine inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-C: Major Cost Inputs by CHC Category—Pilot Boat

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$366	$76	$366	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived the Unit Engine Capital Cost by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get a value of $366/HP: • Cal Maritime Study: o Average Engine Capital Cost: $624,500 (Table 84, page 118) o HP: 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines). • Port of Los Angeles' comment letter to Tracy Haynes (CARB) dated April 30, 2020. o Engine Capital Cost: The total cost (Capital, Labor, and Installation, vessel lengthening, purchasing the equipment to lengthen the vessels, extending existing piers) was provided for this vessel. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Pilot Boat in the Cal Maritime Study and applied it to the total cost in the comment letter in order to derive a value of $592,451. o HP: 1,628 **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $130,000 (Table 86, page 119) divided by hp of 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines) to get $76/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$444	$369	$2,366	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged for a value of $444/HP: • Cal Maritime Study: o Average Labor and Installation Cost: $759,000 (Table 84, page 118) o HP: 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines). • Port of Los Angeles' comment letter to Tracy Haynes (CARB) dated April 30, 2020. o Labor and Installation Cost: The total cost (Capital, Labor, and Installation, vessel lengthening, purchasing the equipment to lengthen the vessels, extending existing piers) was provided for this vessel. To separate the Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Pilot Boat in the Cal Maritime Study and applied it to the total cost in the comment letter in order to derive a value of $720,049. o HP: 1,628

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$150	$444	$369	$2,366	**DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $628,000 (Table 86, page 119) divided by hp of 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines) to get $369/hp. **Vessel Replacement:** The Unit Vessel Replacement Cost and hp data were taken from the following sources, and the $/hp values were derived by dividing the Vessel Replacement Cost with the engine hp in each source, and the $/hp values were averaged, resulting in a value of $2366/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost. • Cal Maritime Study Vessel Replacement Cost of $3,069,180 (Table 82, page 118, sales tax of 8.6% removed) divided by vessel hp of 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines). • Port of Los Angeles' comment letter to Tracy Haynes (CARB) dated April 30, 2020. Vessel Replacement Cost of $3,364,462 divided by vessel hp of 1,628 to get $2,076/hp. • San Francisco Bar Pilot Association comment letter to David Quiros dated April 30, 2020. Values are for ocean station vessels, and exclude the DPF retrofit cost. Vessel Replacement Cost of $12,000,000 divided by vessel hp of 2,200 to get $5,009/hp. • San Francisco Bar Pilot Association comment letter to David Quiros dated April 30, 2020. Values are for high-speed Pilot Vessels, and exclude the DPF retrofit cost. Vessel Replacement Cost of $6,500,000 divided by vessel hp of 1,700 to get $3,378/hp. • San Francisco Bar Pilot Association comment letter to David Quiros dated April 30, 2020. Values are for high-speed Pilot Vessels, and exclude the DPF retrofit cost. Vessel Replacement Cost of $1,000,000 divided by vessel hp of 330 to get $2,584/hp. • Jacobsen Pilot Service, Inc. comment letter to David Quiros (CARB) dated April 30, 2020. Vessel Replacement Cost of $4,300,000 divided by vessel hp of 1,930 (extracted from the CARB CHC Reporting Database) to get $2,228/hp. Port of San Diego email to David Quiros dated October 31, 2020. A Vessel Replacement Cost range of $650,000 to $850,000 was provided; CARB staff used the midpoint of $750,000 and divided by a hp of 370, which was extracted from CARB's CHC reporting database, to get $2,072/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	-$9.8	$7.3	$7.3	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The -$9.8/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: Cal Maritime Study, $11,379 annual maintenance cost (Table 83, page 118) divided by 1,700 hp (Table 80, page 113, 850 hp per main engine * 2 main engines). o Annual DEF Cost: $5.2/HP: Cal Maritime Study, 58.2 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon). o Annual Main Engine Fuel Savings Cost: -$21.7/hp. CARB staff assumed the fuel-saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational Costs include DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $5.7hp by multiplying an average fuel consumption of 58.2 gal/hp/year by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-D: Major Cost Inputs by CHC Category— Push/Tow Tug

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$170	$440	$110	$440	**Repower to Tier 3:** Value derived using Engine Capital Cost of $574,000 with engine hp of 3,380 to get $170/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Push/Tow Tug Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Push/Tow Tug Vessels. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $440/HP: • Cal Maritime Study: o Average Engine Capital Cost: $625,000 (Table 66, page 102) o HP: 2,000 (Table 82, page 95, 1000 hp per main engine * 2 main engines). • R.E. Staite Engineering Inc., R.E. Staite provided the total costs for Engine and DPF Capital cost in email communication to CARB Staff on December 18, 2020. CARB Staff broke down the Engine Capital and DPF Capital Cost by assuming the same Engine Capital Cost and DPF Capital Cost percentages as the other Push/Tow Tugs, resulting: o Engine Capital Cost: $2,666,501, of HP:3,301; o Engine Capital Cost: $707,104 of HP:2,324; o Engine Capital Cost: $1,083,568, of HP:2,307; • HP: Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. o Engine Capital Cost: CARB staff averaged the Replacement (Incidental) costs provided for Ocean Going Tug vessels to get $2,237,420. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Push/Tow Tug in the R.E. Staite Engineering Inc. comment letter and applied it to the total cost in the Sause Bros. Inc. comment letter in order to derive a value of $2,075,193. o HP: The average hp provided from the Ocean Going Tug vessels is used—4,439.

	Repowerto Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

Unit Engine Capital Cost ($/hp) (continued)	$170	$440	$110	$440	**DPF:** DPF Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $110/HP:
					• Cal Maritime Study:
					  o Average DPF Capital Cost: $208,000, HP: 2,000 (Table 82, page 95, 1000 hp per main engine * 2 main engines).
					• R.E. Staite Engineering Inc., R.E. Staite provided the total costs for Engine and DPF Capital cost in email communication to CARB Staff of December 18, 2020. CARB Staff broke down the Engine Capital and DPF Capital Cost by assuming the same Engine Capital Cost and DPF Capital Cost percentages as the other Push/Tow Tugs, resulting:
					  o DPF Capital Cost: $565,622, of HP:3,310;
					  o DPF Capital Cost: $149,992 of HP:2,324;
					  o DPF Capital Cost: $229,848, of HP:2,307;
					
					Vessel Replacement: See “Repower to Tier 4” basis above

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$204	$208	$254	$2,767	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $691,100 with engine hp of 3,380 to get $204/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Push/Tow Tug Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Push/Tow Tug Vessels. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $208/HP: • Cal Maritime Study: o Average Labor and Installation Cost: $396,000 (Table 66, page 102) o HP: 2,000 (Table 82, page 95, 1000 hp per main engine * 2 main engines). • R.E. Staite Engineering Inc., R.E. Staite provided the total costs for Engine and DPF Labor and Installation cost in email communication to CARB Staff on December 18, 2020. CARB Staff broke down the Engine and DPF Labor and Installation Cost by assuming the same Engine Labor and Installation Cost percentages as the other Push/Tow Tugs, resulting in: o Engine Labor and Installation Cost: $861,834, of HP:3,301; o Engine Labor and Installation Cost: $586,683 of HP:2,324; o Engine Labor and Installation Cost: $306,387, of HP:2,307; • HP:Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. o Labor and Installation Cost: CARB staff averaged the total vessel costs for the Ocean Going Tug Vessels to get $2,237,420. To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Push/Tow Tug in the R.E. Staite Engineering Inc. comment letter and applied it to the total cost in the Sause Bros Inc. comment letter in order to derive a value of $162,227. o HP: The average hp provided from the Ocean Going Tug vessels is used—4,439.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp (continued))	$204	$208	$254	$2,767	**DPF:** Average Value of $254/ HP calculated using the following information. • Cal Maritime Study: Average Labor and Installation Cost of $264,000 with HP of 2,000. • R.E. Staite Engineering Inc., R.E. Staite provided the total costs for Engine and DPF Labor and Installation cost in email communication to CARB Staff on December 18, 2020. CARB Staff broke down the Engine and DPF Labor and Installation Cost by assuming the same Engine Labor and Installation Cost percentages as the other Push/Tow Tugs, resulting in: o DPF Installation Cost: $1,180,426, of HP:3,301; o DPF Installation Cost: $803,562 of HP:2,324; and o DPF Installation Cost: $419,648, of HP:2,307; **Vessel Replacement:** The Unit Vessel Replacement Cost and hp data were taken from the following sources, and $/hp values were averaged. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $2,767/hp. • Cal Maritime Study Vessel Replacement Cost of $5,416,200 (Table 84, page 101, sales tax of 8.6% removed) divided by vessel hp of 2,000 (Table 82, page 95, 1,000 hp per main engine * 2 main engines) to get $2,708/hp. Sause Bros. Inc. attachment to comment letter to David Quiros (CARB) dated April 30, 2020. Vessel Replacement Cost of $16,300,000 divided by vessel hp of 4,439.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	-$0.8	$4.2	$4.2	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The -$0.8/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: Cal Maritime Study , $13,387 annual maintenance cost (Table 65, page 101) divided by 2,000 hp (Table 62, page 95, 1,000 hp per main engine * 2 main engines). o Annual DEF Cost: $2.3/HP: Cal Maritime Study 26.2 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$9.8/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational Costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $4.2/hp. CARB staff calculated the DPF Regen Fuel Cost of $2.6/hp by multiplying an average fuel consumption of 26.2 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-E: Major Cost Inputs by CHC Category—Escort/Ship Assist Tug

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$443	$51	$443	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $443/HP: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. o Engine Capital Cost: $3,800,000 o HP: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided (Table 53, page 88, 3,425 hp per main engine * 2 main engines). • The American Waterways Operators comment letter to David Quiros (CARB) dated April 30, 2020. o Engine Capital Cost: The total cost was provided for the whole vessel. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Escort/Ship Assist Tug in the emails from Daniel Smith (Crowley Maritime) and applied it to the total cost in The American Waterways Operators comment letter in order to derive a value of $2,901,961. o HP: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided (Table 53, page 88, 3,425 hp per main engine * 2 main engines). • Cal Maritime Study: o Average Engine Capital Cost: $2,400,000 (Table 57, page 93) o HP: 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines).

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp) (continued)	$263	$443	$51	$443	**DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $350,000 (Table 59, page 94) divided by hp of 6,850 (Table 53, page 88, 3425 hp per main engine * 2 main engines) to get $51/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$150	$110	$39	$1,559	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $110/HP: • Emails from Daniel Smith at Crowley to David Quiros (April 29, 2020, and May 6, 2020) o Labor and Installation Cost: $1,045,000 o HP: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided. • The American Waterways Operators comment letter to David Quiros (CARB) dated April 30, 2020. o Labor and Installation Cost: The total cost was provided for the whole vessel. To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Escort/Ship Assist Tug in the Daniel Smith (Crowley Maritime) and applied it to the total cost in The American Waterways Operators comment letter in order to derive a value of $798,039. o HP: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided (Table 53, page 88, 3,425 hp per main engine * 2 main engines). • Cal Maritime Study: o Average Labor and Installation Cost: $412,000 (Table 57, page 93) o HP: 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines).

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$150	$110	$39	$1,559	**DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $264,000 (Table 59, page 94) divided by hp of 6,850 (Table 53, page 88, 3425 hp per main engine * 2 main engines) to get $39/hp. **Vessel Replacement:** CARB staff derived the average Unit Vessel Replacement Cost from the following source, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $1,559/hp. • Cal Maritime Study: Vessel Replacement Cost of $13,540,500 (Table 55, page 92, sales tax of 8.6% removed) divided by hp of 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines).
Unit Operational Cost ($/hp)	$0	$1.2	$3.5	$3.5	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $1.2/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: Cal Maritime Study ,$45,850 annual maintenance cost (Table 56, page 93) divided by 6,850 hp (Table 53 page 88, 3,425 hp per main engine * 2 main engines). o Annual DEF Cost: $1.7/HP: Cal Maritime Study,19.4 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$7.3/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost, for a total of $3.5/hp. CARB staff calculated the DPF Regen Fuel Cost of $1.9/hp by multiplying an average fuel consumption of 19.4 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-F: Major Cost Inputs by CHC Category—ATB Tug

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$328	$31	$328	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived the Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following source: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. Cost information for two ATB Tug repowers was provided, and the information was averaged to derive the $/hp value. The Engine Capital Cost information included the cost of the DPF retrofit; CARB staff deducted the DPF retrofit cost to get the costs as follows: o Engine Capital Cost: $3,605,725 o HP: 10,963 o Engine Capital Cost: $3,969,957 o HP: 12,102 **DPF:** Cost information for a single-engine was provided by Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. CARB staff multiplied the DPF Capital Cost of $160,000 by the number of engines (2) to get $320,000, and divided by 10,190 hp to get $31/hp. **Vessel Replacement:** See “Repower to Tier 4” basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$96	$108	$3,328	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp was derived. **Repower to Tier 4:** Labor and Installation Costs and engine hp data were taken from the following source: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. Cost information for two ATB Tug repowers was provided, and the information was averaged to derive the $/hp value. o Labor and Installation Cost: $1,100,000 o HP: 10,963 o Labor and Installation Cost: $1,100,000 o HP: 12,102 **DPF:** CARB staff assumed the same Labor and Installation Cost as the "Repower to Tier 4" scenario above, and divided $1,100,000 by 10,190 hp to get $108/hp. **Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,219), Ferry (Monohull, $2,285), Pilot Boat ($2,731), Push/Tow Tug ($3,207), Commercial Passenger Fishing ($2,769), Dredge ($6,715), ATB Barge ($18,781), Crew Supply ($1,934), and Workboat ($5,394) vessels to get $3,657/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $3,328.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	-$11.5	$7.9	$7.9	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The -$11.5/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $5.7/HP: 63.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$23.9/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $7.9/hp. CARB staff calculated the DPF Regen Fuel Cost of $6.3/hp by multiplying an average fuel consumption of 63.9 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-G: Major Cost Inputs by CHC Category— Research Vessel

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$254	$66	$254	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $835/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($252/hp), Crew Supply ($499/hp) and Workboat ($354/hp) to get $605/hp. Staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $254/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $600/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($364/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($112/hp) to get $276/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $66/hp. **Vessel Replacement:** See “Repower to Tier 4” basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$351	$208	$3,403	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp was derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $835/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($252/hp), Crew Supply ($499/hp) and Workboat ($354/hp) to get $605/hp. Staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $351/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $600/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($364/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($112/hp) to get $276/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $208/hp. **Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,219), Ferry (Monohull, $2,285), Pilot Boat ($2,731), Push/Tow Tug ($3,207), Commercial Passenger Fishing ($2,769), Dredge ($6,715), ATB Barge ($18,781), Crew Supply ($1,934), and Workboat ($5,394) vessels to get $3,657/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $3,403.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	$1.3	$3.5	$3.5	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $1.3/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $1.7/HP: 19.0 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$7.1/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *“EPA Tier 4 Feasibility for Existing Vessels,”* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost, for a total of $3.5/hp. CARB staff calculated the DPF Regen Fuel Cost of $1.9/hp by multiplying an average fuel consumption of 19.0 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 “Constant Values used in Cost Calculations” for more information. **Vessel Replacement:** See “Unit Operational Cost ($/hp)” for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-H: Major Cost Inputs by CHC Category—Commercial Passenger Fishing

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$141	$254	$66	$254	**Repower to Tier 3:** Value derived using Engine Capital Cost of $60,000 with engine hp of 425 to get $141/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Commercial Passenger Fishing, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Passenger Fishing. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $835/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($252/hp), Crew Supply ($499/hp) and Workboat ($354/hp) to get $605/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $254/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $600/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($364/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($112/hp) to get $276/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $66/hp. **Vessel Replacement:** See “Repower to Tier 4” basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$188	$351	$208	$2,516	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $80,000 with engine hp of 425 to get $188/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Commercial Passenger Fishing, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Passenger Fishing. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $835/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($252/hp), Crew Supply ($499/hp) and Workboat ($354/hp) to get $605/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $351/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $600/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($364/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($112/hp) to get $276/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the Excursion Vessel to get $208/hp. **Vessel Replacement:** CARB staff derived the average Unit Vessel Replacement Cost from the following sources, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $2,516. • Cal Maritime Study: Vessel Replacement Cost of $1,173,510 (page 61, sales tax of 8.6% removed) divided by hp of 1,000 (Table 26, page 57, 500 hp per main engine * 2 main engines) to get $1,174/hp. • Ken Franke (Sportfishing Association of California) to David Quiros (CARB) in an attachment to an email dated June 29, 2020. CARB staff averaged Vessel Replacement Cost and engine hp information for 101 vessels. Vessel Replacement Costs ranged from $180,000 to $8,000,000, and hp per engine ranged from 200 to 1100.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	$0.8	$3.6	$3.6	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $0.8/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $1.8/HP: 20.7 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$7.7/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *“EPA Tier 4 Feasibility for Existing Vessels,”* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $3.6/hp. CARB staff calculated the DPF Regen Fuel Cost of $2.0/hp by multiplying an average fuel consumption of 20.7 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 “Constant Values used in Cost Calculations” for more information. **Vessel Replacement:** See “Unit Operational Cost ($/hp)” for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-I: Major Cost Inputs by CHC Category—Excursion

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$381	$262	$83	See Table III	**Repower to Tier 3:** Value derived using Engine Capital Cost of $2,281,556 with engine hp of 5994 to get $381/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Excursion Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Excursion Vessels. **Repower to Tier 4:** Value derived using information in Cal Maritime Study. Average Engine Capital Cost of $301,000 (Table 32, page 69) divided by hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $262/hp. **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $96,000 (Table 34, page 70) divided by main engine hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $83/hp. **Vessel Replacement:** See "Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Short Run Ferry and Excursion)."
Unit Labor and Installation Cost ($/hp)	$41	$363	$264	See Table III	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $248,500 with engine hp of 5994 to get $41/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Excursion Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Excursion Vessels. **Repower to Tier 4:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $417,000 (Table 32, page 69) divided by main engine hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $363/hp. **DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $304,000 (Table 34, page 70) divided by main engine hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $264/hp. **Vessel Replacement:** See "Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Shor Run Ferry and Excursion)."

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	$2.9	$2.9	See Table III	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $2.9/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: $7,697 annual maintenance cost (Table 31, page 68) divided by 1,150 hp (Table 28 page 63, 575 hp per main engine * 2 main engines). o Annual DEF Cost: $1.2/HP: 13.2 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$4.9 /hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *“EPA Tier 4 Feasibility for Existing Vessels,”* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational Costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $2.9/hp. CARB staff calculated the DPF Regen Fuel Cost of $1.3/hp by multiplying an average fuel consumption of 13.1 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 “Constant Values used in Cost Calculations” for more information. **Vessel Replacement:** See “Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Shor Run Ferry and Excursion).”

Table II-J: Major Cost Inputs by CHC Category—Dredge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$261	$191	$70	$191	**Repower to Tier 3:** Value derived using Engine Capital Cost of $560,850 with engine hp of 2150 to get $261/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Dredge Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Dredge Vessels. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $191/HP: • Cal Maritime Study: o Average Engine Capital Cost: $516,000 (HP: 2,314). • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB broke down the engine capital and DPF Capital cost by assuming the same Engine capital Cost and DPF Capital cost percentages as the **other** Dredges, resulting in: o Engine Capital Cost: $116,229, of HP:1,754; o Engine Capital Cost: $71,592 of HP:1,448; o Engine Capital Cost: $97,679 of HP:1,246; o Engine Capital Cost: $15,942 of HP:170; o Engine Capital Cost: $15,942 of HP:300; **DPF:** DPF Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $70/HP: • Cal Maritime Study: o Value derived using information in Cal Maritime Study. Average Capital Cost of $189,500 (Table 21, page 50) divided by vessel hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp) . • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. by assuming the same Engine capital Cost and DPF Capital cost percentages as the other Dredges, resulting: o DPF Capital Cost: $316,281, of HP:1,754; o DPF Capital Cost: $194,817 of HP:1,448; o DPF Capital Cost: $265,802, of HP:1,246; o DPF Capital Cost: $43,381 of HP:170; o DPF Capital Cost: $43,381 of HP:300; **Vessel Replacement:** See "Repower to Tier 4" basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$270	$61	$47	$6,524	**Repower to Tier 3:** Value derived using engine Labor and Installation Cost of $581,000 with engine hp of 2150 to get $270/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Dredge Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Dredge Vessels. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $61/HP: • Cal Maritime Study: Value derived using information in the Cal Maritime Study. Average Labor and Installation Cost of $581,000 (Table 19, page 49) divided by main engine hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp) R.E. • R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB broke down the engine and DPF Labor and Installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the other Dredge vessels, resulting in: o Engine Labor and Installation Cost: $16,920, of HP:1,754; o Engine Labor and Installation Cost: $16,920 of HP:1,448; o Engine Labor and Installation Cost: $16,920, of HP:1,246; o Engine Labor and Installation Cost: $8,460 of HP:170; o Engine Labor and Installation Cost: $8,460 of HP:300. **DPF:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $47/HP: • Cal Maritime Study: Value derived using information in the Cal Maritime Study. Average Labor and Installation Cost of $449,000 (Table 21, page 50) divided by vessel hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp). • R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB staff broke down the engine and DPF Labor and Installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the other Dredge vessels, resulting: o DPF Labor and Installation Cost: $13,080, of HP:1,754; o DPF Labor and Installation Cost: $13,080 of HP:1,448; o DPF Labor and Installation Cost: $13,080, of HP:1,246; o DPF Labor and Installation Cost: $6,540 of HP:170; o DPF Labor and Installation Cost: $6,540 of HP:300.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$270	$61	$47	$6,524	**Vessel Replacement:** CARB staff derived the average Unit Vessel Replacement Cost from the following source, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $6,524/hp. • Cal Maritime Study: Vessel Replacement Cost of $15,345,900 (Table 17, page 48, sales tax of 8.6% removed) divided by hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp).
Unit Operational Cost ($/hp)	$0	-$3.3	$5.1	$5.1	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The -$3.3/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: $10,040 annual maintenance cost (Table 18, page 49) divided by 2,314 hp (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kW=256 hp, and 155kW=208 hp). o Annual DEF Cost: $3.1/HP: 35.1 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$13.1/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. o **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $5.1/hp. CARB staff calculated the DPF Regen Fuel Cost of $3.5/hp by multiplying an average fuel consumption of 35.1 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-K: Major Cost Inputs by CHC Category—ATB Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$421	$692	$103	$692	**Repower to Tier 3:** Value derived by taking an average of the $/hp from the following two sources to get $421/HP: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. CARB staff took the average cost of the Crowley 550 barges with engines <600HP, and subtracted the DPF retrofit cost of $405,000 (see DPF explanation below for more information) to get an Engine Capital Cost of $1,395,900, divided by engine hp of 2,419. • Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. Engine Capital Cost of $617,364 divided by engine hp of 2,320. The average horsepower and average costs from the provided vessels are used to calculate the unit costs. The Tank Barges in the letter are categorized as ATB Barges in the cost analysis. Total cost was provided for the whole vessel. CARB staff assumed the same split of Engine Capital and Labor and Installation Cost as the Crowley Maritime ATB Barges. **Repower to Tier 4:** Engine Capital Cost and engine hp data were provided in emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. The average hp for the Crowley 650 barges and the average cost are used to calculate the unit cost for engines >=600HP. The total cost for the engine repower included the DPF retrofit cost of $135,000, which CARB staff deducted to get the Engine Capital Cost. • Engine Capital Cost: $2,665,000 • HP: 3,849 **DPF:** Value derived by taking an average of the $/hp from the following sources to get $103/hp. • Cal Maritime Study. Capital Cost of $308,000 (Table 13, Page 38) divided by hp of 2,920 (Table 9, page 29, sum of 4 engines * 460hp, 2 engines * 270 hp, and 1 engine * 80hp). • Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. The Capital Cost for a single engine was provided; CARB staff multiplied this by the total number of engines (9 for 550 ATB Barges) to get $405,000, divided by hp of 2,419. • Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. The Capital Cost for a single engine was provided; CARB staff multiplied this by the total number of engines (3 for 650 ATB Barges) to get $135,000, divided by hp of 3,849 **Vessel Replacement:** See "Repower to Tier 4" basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$91	$130	$225	$18,088	**Repower to Tier 3:** Value derived by taking an average of the $/hp from the following two sources to get $91/HP: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. CARB staff took the average Labor and Installation Cost of Crowley 550 barges with engines <600Hp to get $300,000, divided by the average hp of 2,419. • Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. Labor and Installation Cost of $132,766 divided by hp of 2,320. The average hp and average costs from the provided vessels are used to calculate the unit costs. The Tank Barges in the letter are categorized as ATB Barges in the cost analysis. Total cost was provided for the whole vessel. CARB staff assumed the same split of Engine Capital and Labor and Installation Cost as the Crowley Maritime ATB Barges. **Repower to Tier 4:** Labor and Installation Cost and hp data were provided in emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 29, 2020, and May 6, 2020. The average hp for the Crowley 650 barges and average Labor and Installation Costs are used to calculate the unit cost for Engine >=600HP. • Labor and Installation: $500,000 • HP: 3,849 **DPF:** Value derived by taking an average of the $/hp from the following sources to get $225/hp. • Cal Maritime Study. Labor and Installation Cost of $666,000 (Table 13, Page 38) divided by hp of 2,920 (Table 9, page 29, sum of 4 engines * 460hp, 2 engines * 270 hp, and 1 engine * 80hp). • Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. The Labor and Installation Cost of $666,000 from the Cal Maritime study was used divided by hp of 2,419. • The Labor and Installation Cost of $666,000 from the Cal Maritime study was used, and divided by the average hp of 3,849 for the Crowley 650 barges (see "Repower to Tier 4" for reference). **Vessel Replacement:** CARB staff derived the average Unit Vessel Replacement Cost from the following source, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $17,856/hp. Cal Maritime Study: Vessel Replacement Cost of $54,162,000 (Table 11, page 37, sales tax of 8.6% removed) divided by hp of 2,920 (Table 9, page 29, sum of 4 engines * 460hp, 2 engines * 270 hp, and 1 engine * 80hp)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	$5.2	$2.1	$2.1	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $5.2/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study. o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $0.5/HP: 5.1 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$1.9/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $2.1/hp. CARB staff calculated the DPF Regen Fuel Cost of $0.5/hp by multiplying an average fuel consumption of 5.1 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-L: Major Cost Inputs by CHC Category—Bunker Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$509	$85	$509	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $835/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($252/hp), Crew Supply ($499/hp) and Workboat ($354/hp) to get $605/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the ATB Barge to get $509/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $600/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($364/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($112/hp) to get $276/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the ATB Barge to get $85/hp. **Vessel Replacement:** See “Repower to Tier 4” basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$96	$188	$3,147	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Labor and Installation information was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp was derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs Ferry (Catamaran, $835/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($252/hp), Crew Supply ($499/hp) and Workboat ($354/hp) to get $605/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the ATB Barge to get $96/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $600/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($364/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($112/hp) to get $276/hp. CARB staff assumed the same split of Capital and Labor and Installation costs as the ATB Barge to get $188/hp. **Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,915), Ferry (Monohull, $2,500), Pilot Boat ($2,878), Push/Tow Tug ($3,336), Commercial Passenger Fishing ($2,770), Dredge ($7,347), ATB Barge ($20,548), Crew Supply ($2,116), and Workboat ($5,902) vessels to get $5,590/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $3,147.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	$0.7	$3.7	$3.7	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $0.7/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $1.9/HP: 20.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$7.8/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *“EPA Tier 4 Feasibility for Existing Vessels,”* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $3.7/hp. CARB staff calculated the DPF Regen Fuel Cost of $2.1/hp by multiplying an average fuel consumption of 20.9 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1.6 “Constant Values used in Cost Calculations” for more information. **Vessel Replacement:** See “Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-M: Major Cost Inputs by CHC Category—Other Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$320	$54	$320	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $320/HP: • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB broke down the engine capital and DPF capital cost by assuming the same Engine and DPF capital cost percentages as the Bunker Budges vessels, resulting in: o Engine Capital Cost: $41,506, of HP:139; o Engine Capital Cost: $41,506 of HP:111; o Engine Capital Cost: $$41,506, of HP:111; o Engine Capital Cost: $$55,340, of HP:235; **DPF:** DPF Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $54/HP: • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB staff broke down the engine capital and DPF capital cost by assuming the same Engine and DPF capital cost percentages as the Bunker Budge vessels, resulting in: o DPF Capital Cost: $6,982, of HP:139; o DPF Capital Cost: $6,982, of HP:111; o DPF Capital Cost: $6,982, of HP:111; o DPF Capital Cost: $9,310, of HP:235; **Vessel Replacement:** See "Repower to Tier 4" basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$150	$48	$94	$3,336	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $48/HP: • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB staff broke down the engine labor and installation and DPF labor and installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the Bunker Budge vessels, resulting: • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB staff broke down the engine labor and installation and DPF labor and installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the Bunker Budge vessels, resulting: o Engine Labor and Installation Cost: $6,720, of HP:139; o Engine Labor and Installation Cost: $6,720of HP:111; o Engine Labor and Installation Cost: $6,720, of HP:111; o Engine Labor and Installation Cost: $5,040, of HP:235; **DPF:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $94/HP: • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB staff broke down the engine labor and installation and DPF labor and installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the Bunker Budge vessels, resulting: o DPF Labor and Installation Cost: $13,280, of HP:139; o DPF Labor and Installation Cost: $13,280, of HP:111; o DPF Labor and Installation Cost: $13,280, of HP:111; o DPF Labor and Installation Cost: $9,960, of HP:235.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$150	$48	$94	$3,336	**Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,219), Ferry (Monohull, $2,285), Pilot Boat ($2,731), Push/Tow Tug ($3,207), Commercial Passenger Fishing ($2,769), Dredge ($6,715), ATB Barge ($18,781), Crew Supply ($1,934), and Workboat ($5,394) vessels to get $3,657/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $3,336.
Unit Operational Cost ($/hp)	$0	$4.4	$2.4	$2.4	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $4.4 /hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, in Cal Maritime Study: o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $0.7/HP: 8.2 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$3.1/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *“EPA Tier 4 Feasibility for Existing Vessels,”* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $2.4/hp. CARB staff calculated the DPF Regen Fuel Cost of $0.8/hp by multiplying an average fuel consumption of 8.2 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 “Constant Values used in Cost Calculations” for more information. **Vessel Replacement:** See “Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-N: Major Cost Inputs by CHC Category—Towed Petrochemical Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$320	$54	$320	**Repower to Tier 3:** Staff assumed the cost to be the same as Other Barge, in Table II-M. **Repower to Tier 4:** Staff assumed the cost to be the same as Other Barge, in Table II-M. **DPF:** Staff assumed the cost to be the same as Other Barge, in Table II-M. **Vessel Replacement:** Staff assumed the cost to be the same as Other Barge, in Table II-M.
Unit Labor and Installation Cost ($/hp)	$150	$48	$94	$3,336	**Repower to Tier 3:** Staff assumed the cost to be the same as Other Barge, in Table II-M. **Repower to Tier 4:** Staff assumed the cost to be the same as Other Barge, in Table II-M. **DPF:** Staff assumed the cost to be the same as Other Barge, in Table II-M. **Vessel Replacement:** Staff assumed the cost to be the same as Other Barge, in Table II-M.
Unit Operational Cost ($/hp)	$0	-$3.6	$5.2	$5.2	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The -$3.6 /hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, in Cal Maritime Study: o Annual Maintenance Cost: $6.7/HP: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $3.2/HP: 36.2 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$15.7/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	-$3.6	$5.2	$5.2	**DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $5.2/hp. CARB staff calculated the DPF Regen Fuel Cost of $3.6/hp by multiplying an average fuel consumption of 36.2 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 “Constant Values used in Cost Calculations” for more information. **Vessel Replacement:** Staff assumed the cost to be the same as Other Barge, in Table II-M.

Table II-O: Major Cost Inputs by CHC Category—Crew Supply

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$176	$237	$85	$237	**Repower to Tier 3:** Value derived using Engine Capital Cost of $1,016,145 with engine hp of 5,783 to get $176/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Crew Supply Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Crew Supply Vessels. **Repower to Tier 4: Engine** Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $237/HP: • Cal Maritime Study: o Average Engine Capital Cost: $451,500 (Table 75, page 110) o HP: 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). • Email from Tom Croft (C&C Boats, Inc.) to Tracy Haynes (CARB) dated March 12, 2020. o Engine Capital Cost: The total cost was provided for the whole vessel. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Engine Capital Cost and Labor and Installation Cost of the Crew Supply vessel in the Cal Maritime Study and applied it to the total cost in the C&C Boats, Inc. email in order to derive a value of $415,637. o HP: 1,996. CARB staff took an average of the hp values provided from C&C Boats, Inc. **DPF:** Value derived using information in Cal Maritime Study. Average capital cost of $144,000 (Table 77, page 111) divided by main engine hp of 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). **Vessel Replacement:** See "Repower to Tier 4" basis above.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp)	$107	$262	$159	$1,698	**Repower to Tier 3:** Value derived using engine capital cost of $620,000 with engine hp of 5,783. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Crew Supply Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Crew Supply Vessels. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged: • Cal Maritime Study: o Average Labor and Installation Cost: $499,000 (Table 75, page 110) o HP: 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). • Email from Tom Croft (C&C Boats, Inc.) to Tracy Haynes (CARB) dated March 12, 2020. o Labor and Installation Cost: The total cost was provided for the whole vessel. To separate the Labor and Installation costs, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Crew Supply vessel in the Cal Maritime Study and applied it to the total cost from C&C Boats, Inc. in order to derive a value of $459,363. o HP: 1,996. CARB staff took an average of the hp values provided from C&C Boats, Inc. **DPF:** Value derived using information in Cal Maritime Study. Average capital cost of $271,000 (Table 77, page 111) divided by main engine hp of 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). **Vessel Replacement:** Value derived using information in the Cal Maritime Study. Combined costs for Workboat and Special Use are used to represent the Workboat. Vessel Replacement Cost of $3,249,720 (Table 73, page 109, sales tax of 8.6% removed) divided by hp of 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $1,698/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	0.6	$3.7	$3.7	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $0.6/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from the Cal Maritime Study o Annual Maintenance Cost: $6.7/HP: $11,385 annual maintenance cost (Table 74, page 110) divided by 1,701 hp (Table 71, page 104, 567 hp per main engine * 3 main engines). o Annual DEF Cost: $1.9/HP: 21.3 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$7.9/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $2.1/hp by multiplying an average fuel consumption of 21.3 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-P: Major Cost Inputs by CHC Category—Workboat

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$294	$49	$294	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $294/HP: CARB staff used the Special Use Vessel category to represent the Workboat vessel category. • Cal Maritime Study, Capital Cost: $575,000 (Table 99, page 132), HP: 1,500 (Table 95, page 127, 750 hp per main engine * 2 main engines) • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB broke down the engine capital and DPF capital cost by assuming the same Engine capital Cost and DPF capital cost percentages as the other workboats, resulting in: o Engine Capital Cost: $48,239, of HP:180; o Engine Capital Cost: $116,597 of HP:440; o Engine Capital Cost: $$51,580, of HP:200;

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp) (continued)	$263	$294	$49	$294	**DPF:** DPF Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $49/HP: CARB staff used the Special Use Vessel category to represent the Workboat vessel category. • Cal Maritime Study, DPF Capital Cost: $196,500, HP: 1,500 (Table 95, page 127, 750 hp per main engine * 2 main engines) • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB broke down the engine capital and DPF capital cost by assuming the same Engine capital Cost and DPF capital cost percentages as the other workboats, resulting in: o DPF Capital Cost: $8,108, of HP:180; o DPF Capital Cost: $19,596 of HP:440; o DPF Capital Cost: $$8,669, of HP:200; **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$150	$60	$62	$5,101	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Labor and Installation was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $60/HP: CARB staff used the Special Use Vessel category to represent the Workboat vessel category. • Cal Maritime Study, Capital Cost: 294,000 (Table 99, page 132), HP: 1,500 (Table 95, page 127, 750 hp per main engine * 2 main engines) • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB broke down the engine Labor and Installation and DPF Labor and Installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the other workboats, resulting: o Engine Labor and Installation Cost: $3,196, of HP:180; o Engine Labor and Installation Cost: $4,769 of HP:440; o Engine Labor and Installation Cost: $$3,196, of HP:200;

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Labor and Installation Cost ($/hp) (continued)	$150	$60	$62	$5,101	**DPF:** DPF Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $62/HP: CARB staff used the Special Use Vessel category to represent the Workboat vessel category. • Average labor and Installation Cost of $618,000 (Workboat: Table 93, page 126. Special Use: Table 101, page 133) divided by main engine hp of 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp). • R.E. Staite Engineering Inc., R.E. Staite, in email communication to CARB Staff on December 18, 2020. CARB staff broke down the engine Labor and Installation and DPF Labor and Installation cost by assuming the same Engine and DPF Labor and Installation cost percentages as the other workboats, resulting: o DPF Labor and Installation Cost: $3,304, of HP:180; o DPF Labor and Installation Cost: $4,931 of HP:440; o DPF Labor and Installation Cost: $$3,304, of HP:200; **Vessel Replacement:** Value derived using information in the Cal Maritime Study. Combined costs for Workboat and Special Use are used to represent the Workboat. Vessel Replacement Cost of $16,248,600 (Workboat: Table 91, page 125. Special Use: Table 97, page 131, sales tax of 8.6% removed) divided by main engine hp of 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp). The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $5,101/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Operational Cost ($/hp)	$0	$3.0	$2.9	$2.9	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The Special Use Vessel category is used to represent the Workboat category. The $3.0/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together, from Cal Maritime Study o Annual Maintenance Cost: $6.7/HP: $10,040 annual maintenance cost (Table 98, page 132) divided by 1,500 hp (Table 95, page 127, 750 hp per main engine * 2 main engines). o Annual DEF Cost: $1.1/HP: 12.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $2.38 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$4.8/hp. CARB staff assumed the fuel saving costs for Tier 4 repower are similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs include DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $1.3/hp by multiplying an average fuel consumption of 12.9 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1.6/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-Q: Major Cost Inputs by CHC Category—Commercial Fishing

	Repower to Tier 3	Basis
Unit Engine Capital Cost ($/hp)	$201	**Repower to Tier 3:** Value derived using Engine Capital Cost of $94,000 divided by hp of 468 to get $201/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Commercial Fishing Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Fishing Vessels.
Unit Labor and Installation Cost ($/hp)	$85	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $40,000 divided by hp of 468 to get $85/hp. Numbers come from the results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Commercial Fishing Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Fishing Vessels.
Unit Operational Cost ($/hp)	$0	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.

Table III: Major Cost Inputs—Cost Inputs for Zero-Emissions and Advanced Technology (Short Run Ferry and Excursion)

Vessel Category	Unit Operational Cost ($/hp)	Unit Engine Capital Cost ($/hp)	Unit Labor and Installation Cost ($/hp)	Basis
Ferry (Short Run) Repower	-$53.3	$1,020	$2,380	The Capital, Labor, and Installation Cost information is from a PowerPoint presentation, *"Gee's Bend Ferry Battery Conversion*", for retrofitting the ferry to zero-emission electric ferry, presented by Tim Aguirre at HMS Ferry on June 7th, 2019. • Operational Cost was derived based on a constant value of -$0.07/hp-hr cost savings from Diesel to Electric multiplied by the total number of hours taken from the engine inventory. • CARB staff assumed 30% of the total cost is Capital Cost, and 70% is the Labor and Installation Cost. • Engine Capital Cost was derived based on a total cost of $1,700,000 divided by engine hp of 500, multiplied by 30%, to get $1,020/hp. • Labor and Installation Cost was derived based on a total cost of $1,700,000 divided by engine hp of 500, multiplied by 70%, to get $2,380/hp.
Ferry (Short Run) New	-$53.3	$1,020	$3,293	Cost information provided by WETA in an internet conference on July 23, 2020, discussing the proposed regulation. The cost information is provided for one vessel with a total hp of 830kW, 1113hp.
Excursion, New	-$13.5	$262	$2,126	Cost information was provided by Joe Burgard (Red and White Fleet) to David Quiros (CARB) in an email dated August 19, 2020. Cost information pertains to replacing the vessel "Enhydra" with a zero-emission capable hybrid vessel. • Operational Cost was derived by taking the average Excursion Vessel fuel consumption (gallon per hp per year) multiplied by the 30% zero-emission power requirement in the proposed regulation multiplied by the constant value of $0.07/hphr cost savings from diesel to electric. • Engine Capital Cost: CARB staff assumed the same Engine Capital Cost as the Repower to Tier 4 scenario, which was taken from the Cal Maritime Study. Average Engine Capital Cost of $301,000 (Table 32, page 69) divided by hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $262/hp. • Labor and Installation Cost: CARB staff derived this value by taking a Total Vessel Cost of $1,910,00 divided by hp of 800 to get $2,388/hp, and subtracting the Engine Capital Cost of $262/hp to get a Labor and Installation Cost of $2,126/hp.

Table IV: Major Cost Inputs—Redundant Labor and Installation Costs for DPF Retrofit

Vessel Category	Unit Redundant Labor and Installation Costs ($/hp)	Basis
Ferry (Catamaran)	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Ferry (Monohull)	$46	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $46/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $30,000 (Table 45, page 80) • Haul Out/Shipyard Cost: $91,000 (Table 45, page 80) • HP: 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines)
Pilot Boat	$60	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $60/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $95,000 (Table 87, page 119) • Haul Out/Shipyard Cost: $102,000 (Table 87, page 119) • HP: 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines).
Push/Tow Tug	$46	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $46/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $65,000 (Table 70, page 103) • Haul Out/Shipyard Cost: $91,000 (Table 70, page 103) • HP: 2,000 (Table 62, page 95, 1,000 hp per main engine * 2 main engines)
Escort/Ship Assist Tug	$13	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $13/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $65,000 (Table 61, page 94) • Haul Out/Shipyard Cost: $91,000 (Table 61, page 94) • HP: 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines)
ATB Tug	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Research Vessel	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.

Vessel Category	Unit Redundant Labor and Installation Costs ($/hp)	Basis
Commercial Passenger Fishing	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Excursion	$79	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $79/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $30,000 (Table 36, page 70) • Haul Out/Shipyard Cost: $91,000 (Table 36, page 70) • HP: 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines)
Dredge	$50	Value derived dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $50/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $65,000 (Table 21, page 50) • Haul Out/Shipyard Cost: $115,000 (Table 21, page 50) • HP: 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp)
ATB Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Bunker Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Other Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Towed Petrochemical Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Crew Supply	$53	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $53/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $30,000 (Table 77, page 111) • Haul Out/Shipyard Cost: $91,000 (Table 77, page 111) • HP: 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines).

Vessel Category	Unit Redundant Labor and Installation Costs ($/hp)	Basis
Workboat	$60	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $60/hp. Values come from the Cal Maritime Study. The combined DPF Retrofit cost for Workboat and Special Use is used to represent the Workboat. • Engine Room Access Cost: $65,000 for Workboat (Table 94 page 126) and $65,000 for Special Use Table 103, page 133) to get $130,000. • Haul Out/Shipyard Cost: $91,000 for Workboat (Table 94 page 126) and $91,000 for Special Use Table 103, page 133) to get $182,000. • HP: 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp).

1. CARB staff assumed that engine repower and DPF retrofits will occur at the same time, and therefore some of the Labor and Installation (which the cost workbook applies separately to engine repower and DPF retrofit scenarios) are redundant. CARB staff assumed the Engine Room Access and Haul Out/Shipyard Costs are redundant Labor and Installation Costs, and removed them from the final $/hp Labor and Installation Cost values.

Table V: Major Cost Inputs—Loss of Use

Vessel Category	Unit Cost ($/hp)	Basis
Ferry (Catamaran)	$87	The cost information was taken from "*EPA Tier 4 Feasibility for Existing Vessels*," Incat Crowther for Golden Gate Bridge, Highway and Transportation District, December 2019. • Loss of Use Cost: $780,000 • HP: 9,005
Ferry (Monohull)	$87	CARB staff assumed the Loss of Use Cost is the same as the Ferry (Catamaran).
Ferry (Short Run)	$87	CARB staff assumed the Loss of Use Cost is the same as the Ferry (Catamaran).
Pilot Boat	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Push/Tow Tug	$17	The cost information was based on information provided by R.E. Staite, in email communication to CARB Staff on December 18, 2020. Average of three Push/Tow Tug vessels: • Loss of Use Cost: $55,440, of HP: 3,310; • Loss of Use Cost: $27,000, of HP: 2,324; and • Loss of Use Cost: $50,400, of HP: 2,307.
Escort/Ship Assist Tug	$47	The cost information comes from an email from Daniel Smith at Crowley Maritime to David Quiros (CARB) on April 29, 2020. • Loss of Use Cost: $320,000 • HP: 6,850

Vessel Category	Unit Cost ($/hp)	Basis
ATB Tug	$52	The cost information comes from an email from Daniel Smith at Crowley Maritime to David Quiros (CARB) on April 29, 2020. • Loss of Use Cost: $600,000 • HP: 11,532.5. The hp is an average of two types of ATB Tugs reported by Crowley that are used to represent this category: 10,926hp and 12,102hp.
Research Vessel	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Commercial Passenger Fishing	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Excursion	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Dredge	$46	The cost information was based on information provided by R.E. Staite, in email communication to CARB Staff on December 18, 2020. Average of five Dredge vessels: • Loss of Use Cost: $79,688, of HP: 1,754; • Loss of Use Cost: $59,500, of HP: 1,448; • Loss of Use Cost: $89,250, of HP: 1,246; • Loss of Use Cost: $9,450, of HP: 173; • Loss of Use Cost: $4,725, of HP: 300;
ATB Barge	$174	The cost information comes from an email from Daniel Smith at Crowley Maritime to David Quiros (CARB) on April 29, 2020. • Loss of Use Cost: $600,000 • HP: 3,441 The hp was reported by Crowley Maritime to CARB by way of the CARB CHC Reporting Database. CARB staff averaged both 650 and 550 barge vessel hp to get a value of 3441.
Bunker Barge	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Other Barge	$94	The cost information was based on information provided by R.E. Staite, in email communication to CARB Staff on December 18, 2020. Average of three Barge Vessels: • Loss of Use Cost: $22,500, of HP: 139; • Loss of Use Cost: $6,750, of HP: 111; • Loss of Use Cost: $6,750, of HP: 111.
Crew Supply	$188	The cost information was provided by Tom Croft (C&C Boats, Inc.) in an email to Tracy Haynes (CARB) dated March 12, 2020: • Loss of Use Cost: $375,000 • HP: 1,996. The average hp from C&C Boats is used to represent the vessel.
Workboat	$8	The cost information was based on information provided by R.E. Staite, in email communication to CARB Staff on December 18, 2020. Average of three Workboat Vessels: • Loss of Use Cost: $1,575, of HP: 180; • Loss of Use Cost: $3,712, of HP: 440; • Loss of Use Cost: $1,125, of HP: 200.
Commercial Fishing	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Staff derived the $/hp by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels.

Table VI: Major Cost Inputs— Vessel Residual/Resale Value Before Replacement (Benefit)

Vessel Category	Unit Cost ($/hp)	Basis
Ferry (Catamaran)	$907	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-A times the fraction of New Vessel Cost value when disposed of. The fraction of New Cost from the used vessel is calculated as 22% by an average of: • 17%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Ferry useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Ferry (Monohull)	$491	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-B times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 22% by an average of: • 17%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Ferry useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Pilot Boat	$596	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-C times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 22% by an average of: • 17%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Pilot Boat useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Push/Tow Tug	$572	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-D times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 18% by an average of: • 9%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Push/Tow Tug useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.

Vessel Category	Unit Cost ($/hp)	Basis
Escort/Ship Assist Tug	$370	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-E times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 18% by an average of: • 10%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Escort/Ship Assist Tug useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
ATB Tug	$652	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-F times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 18% by an average of: • 9%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and ATB Tug useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Research Vessel	$720	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-G times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 20% by an average of: • 13%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Research Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Commercial Passenger Fishing	$465	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-H times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 17% by an average of: • 7%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Commercial Passenger Fishing vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.

Vessel Category	Unit Cost ($/hp)	Basis
Excursion	$1,264	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-I times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 18% by an average of: • 9%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Excursion Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Dredge	$1,424	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-J times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 21% by an average of: • 16%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Dredge Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
ATB Barge	$3,819	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-K times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 20% by an average of: • 14%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and ATB Barge Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Bunker Barge	$744	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-L times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 20% by an average of: • 14%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Bunker Barge Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.

Vessel Category	Unit Cost ($/hp)	Basis
Other Barge	$744	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-M times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 20% by an average of: • 14%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Other Barge Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Towed Petrochemical Barge	$744	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-N times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 20% by an average of: • 14%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Towed Petrochemical Barge Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Crew Supply	$335	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-O times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 17% by an average of: • 8%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Crew Supply Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.
Workboat	$1,103	CARB staff calculated the Vessel Residual/Resale value using the vessel replacement cost value in Table II-P times the fraction of New Vessel Cost value when disposed. The fraction of New Cost from the used vessel is calculated as 20% by an average of: • 14%, The Fraction of New Cost is calculated based on Diesel Yachts Resale values and Workboat Vessel useful life; • 27%, The Fraction of New Cost is based on resale value of a used Ferry, Ferry Solano provided by WETA in an email from Timothy Hanners to David Quiros dated November 4th, 2020. The resale value is listed as 6.5 million, the new vessel value is listed as 15.75 million. CARB Staff assumed the average Fraction of New Cost from used Diesel Yachts and used ferry can be used to represent the resale values for other vessel categories.

Table VII-A: Administrative Cost Inputs—Recordkeeping and Reporting, Vessel Labeling, Facility Report

Vessel Category	Recordkeeping and Reporting ($ Per Vessel Per Year)	Vessel Labeling Cost ($ Per Vessel)	Facility Report Cost ($ Per Vessel Per Year)	Vessel Numbers in 2023
Ferry (Catamaran)	$200	$150	$100	35
Ferry (Monohull)	$200	$150	$100	20
Ferry (Shortrun)	$200	$150	$100	16
Pilot Boat	$200	$150	$100	10
Push/Tow Tug	$200	$150	$100	147
Escort/Ship Assist Tug	$200	$150	$100	63
ATB Tug	$200	$150	$100	19
Research Vessel	$200	$150	$100	25
Commercial Passenger Fishing	$200	$150	$100	352
Excursion	$200	$150	$100	417
Dredge	$200	$150	$100	47
ATB Barge	$200	$150	$100	19
Bunker Barge	$200	$150	$100	31
Other Barge	$200	$150	$100	88
Towed Petrochemical Barge	$200	$150	$100	22
Crew Supply	$200	$150	$100	167
Workboat	$200	$150	$100	481
Commercial Fishing	$200	$150	$100	1199

1. Basis
    - CARB staff assumed the recordkeeping and reporting would take 4 personnel hours to prepare, with a personnel hour cost of $50, resulting in $200 per vessel per year.
    - CARB staff assumed the vessel labeling would take 2 personnel hours, with a personal hour cost of $50, resulting in $100 per vessel per year, combined with a $50 materials cost, for a total of $150 per vessel.
    - CARB staff assumed the facilities reporting cost is half of the cost of the vessel Recordkeeping and Reporting Costs, resulting in $100 per vessel per year.
    - See Table I "Engine and Vessel Population" for more information about the vessel population methodology.

Table VII-B: Administrative Cost Inputs—Opacity Testing

Vessel Category	Opacity Cost ($ Per Engine)	Number of Engines	Opacity Testing Frequency (per year)
Ferry (Catamaran)	$551	143	0.5
Ferry (Monohull)	$551	68	0.5
Pilot Boat	$200	30	0.5
Push/Tow Tug	$200	507	0.5
Escort/Ship Assist Tug	$200	260	0.5
ATB Tug	$200	97	0.5
Research Vessel	$200	70	0.5
Commercial Passenger Fishing	$200	877	0.5
Excursion	$200	1143	0.5
Dredge	$200	101	0.5
ATB Barge	$200	118	0.5
Bunker Barge	$200	81	0.5
Other Barge	$200	187	0.5
Towed Petrochemical Barge	$200	78	0.5
Crew Supply	$200	522	0.5
Workboat	$200	1041	0.5
Commercial Fishing	$200	1879	0.5

1. Basics

- For Ferries, estimated costs of $2205 per vessel for opacity testing and vessel reporting were provided by WETA from an email communication on November 17, 2020. On average, each ferry has 4 engines. The opacity cost per engine for ferry is at $551, which will therefore be applied to Catamaran and Monohull.
- The cost of an opacity test for a diesel truck is $65, based on a call CARB staff held with CA Diesel Compliance, Inc. on June 24, 2020. CARB staff assumed the opacity test cost of a CHC engine would be three times that of a diesel truck engine, for all other vessels.

- See Table I “Engine and Vessel Population” for more information about the engine population methodology.

Table VII-C: Administrative Cost Inputs—Costs for Implementation and Enforcement of Proposed Regulation

Position	Number of Positions	Total PY Cost Year 1	Total PY Cost Subsequent Years
Air Resources Engineer (Range D) - TTD	1	$255,253	$254,253
Air Resources Technician II - TTD	2	$250,296	$249,296
Air Pollution Specialist (Range C) - TTD	1	$241,623	$240,623
Air Resources Supervisor I - TTD	0.33	$98,301	$97,301
Air Pollution Specialist (Range C) - Enforcement	4	$966,491	$965,491
Air Resources Technician II - Enforcement	4	$500,593	$480,593
Staff Services Manager (SSM I) - Enforcement	0.33	$64,369	$63,369
Air Resources Supervisor I - Enforcement	0.33	$98,301	$97,301

1. Basics
    - PY cost sheet provided by CARB’s Administrative Services Division.
    - Total PY cost includes 26% indirect labor cost.
2. Travel Cost
    - $61,290 annual Travel Costs based on CARB staff assumption that travel expenses would be needed to implement the regulation.
3. Ongoing Contracts
    - $50,000 Ongoing Contracts cost based on CARB staff assumption that external entity would be contracted to assist with monitoring vessel activity within Regulated California Water to CARB.
4. Notes: The Cost for implementing and enforcing the proposed regulation was to calculate the total costs for implementing the proposed amendments and calculate the compliance fees for vessel owners.

Table VII-D: Administrative Cost Inputs—Costs for Implementation and Enforcement of the Current Regulation

Position	Number of Positions	Total PY Cost Year 1
Air Resources Technician II- TTD	1	$125,148
Air Pollution Specialist (Range C) - TTD	1	$241,623
Air Resources Supervisor I - TTD	0.33	$98,301
Air Pollution Specialist (Range C) - Enforcement	1	$241,623
Air Resources Supervisor I - Enforcement	0.33	$98,301

1. Basics:
    - PY cost sheet provided by CARB’s Administrative Services Division.
    - Total PY cost includes 26% indirect labor cost.
2. Notes: The Cost for implementing and enforcing the current regulation was calculated to identify the incremental costs from implementing the current regulation to the proposed amendments.

Table VII-E: Administrative Cost Inputs—Financial Feasibility Report (Compliance Extensions)

Vessel Category	Cost per Vessel	Percentage of Vessels for Financial Review Report	Vessel Numbers in 2023
Ferry, Catamaran	$400	64%	35
Ferry, Monohull	$400	53%	20
Ferry, Short Run	$400	0%	16
Pilot Boat	$400	45%	10
Push/Tow Tug	$400	15%	147
Escort/Ship Assist Tug	$400	5%	63
ATB Tug	$400	5%	19
Research Vessel	$400	45%	25
Commercial Passenger Fishing	$400	94%	352
Excursion	$400	5%	417
Dredge	$400	15%	47
ATB Barge	$400	5%	19
Bunker Barge	$400	5%	31
Other Barge	$400	15%	88
Towed Petrochemical Barge	$400	15%	22
Crew Supply	$400	45%	167
Workboat	$400	45%	481

1. Basis
    - CARB staff assumed it will take 8 personnel hours to prepare each Financial Feasibility Report. At $50 per personnel hour, this results in a total of $400 per report.
    - The total percentage of vessels in each category that incurs the Financial Feasibility Report expense is based on the percentage of vessels that receive a compliance extension by their initial compliance date. See Table I-E for more information about compliance scenario assumptions.
    - See Table I “Engine and Vessel Population” for more information about the vessel population methodology.

Table VII-F: Administrative Cost Inputs—Naval Architect Report (Compliance Extensions)

Vessel Category	Cost ($ per report)	Percentage of Vessels for Naval Architect Report	Vessel Numbers in 2023
Ferry, Catamaran	$60,476	64%	35
Ferry, Monohull	$60,476	53%	20
Ferry, Short Run	$60,476	0%	16
Pilot Boat	$60,476	45%	10
Push/Tow Tug	$60,476	15%	147
Escort/Ship Assist Tug	$60,476	5%	63
ATB Tug	$60,476	5%	19
Research Vessel	$60,476	45%	25
Commercial Passenger Fishing	$60,476	94%	352
Excursion	$60,476	5%	417
Dredge	$60,476	15%	47
ATB Barge	$60,476	5%	19
Bunker Barge	$60,476	5%	31
Other Barge	$60,476	15%	88
Towed Petrochemical Barge	$60,476	15%	22
Crew Supply	$60,476	45%	167
Workboat	$60,476	45%	481

1. Basis
   - CARB staff averaged per vessel costs from four sources of Naval Architect Costs:
     - WETA provided $1.05 million Naval Architect cost for its fleet of 9 vessels, which averages $116,667 per vessel.
     - Based on results from a 2019 CARB survey of CHC owners/operators, the average Naval Architect Report cost is $27,250 per vessel.
     - Golden Gate Bridge provided a cost of $216,900 for 7 vessels, which averages to $30,986 per vessel.
     - A confidential source requesting non-attribution provided a cost of $201,000 for 3 vessels, which is $67,000 per vessel. The average cost from these three sources is $60,944 per vessel.
   - The total percentage of vessels in each category that incurs the Naval Architect Report expense is based on the percentage of vessels that receive a compliance extension by their initial compliance date. See Table I-E for more information about compliance scenario assumptions.
   - See Table I "Engine and Vessel Population" for more information about the vessel population methodology.

Table VIII-A: Infrastructure Cost Inputs—Shore Power Infrastructure

Shore Power Infrastructure, Maintenance and Labor Costs	Unit Cost ($/hp)	Basis
Upstream Utility Cost	$45	Value defined as the cost to bring power to the charging station. The cost is the average cost from the Port of San Diego (provided by David Yow from the Port of San Diego in an email dated October 31, 2020), and the cost from SDAPCD Carl Moyer Project (Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program). For SDAPCD Carl Moyer Project, the $/hp value is at $53/hp, derived by dividing line-item cost of $64,590 by hp of 1,228.50. For the Port of San Diego, the $/hp is at $37.5/hp, derived by dividing the project cost by the average auxiliary engine horsepower in Port of San Diego.
Charging Station Cost	$194	Value defined as the cost to bring power to the charging station. The cost is the average cost from the Port of San Diego (provided by David Yow from the Port of San Diego in an email dated October 31, 2020), and the cost from SDAPCD Carl Moyer Project (Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program). For SDAPCD Carl Moyer Project, the $/hp value is at $227/hp, derived by dividing line-item cost of $278,400 by hp of 1,228.50. For the Port of San Diego, the $/hp is at $162/hp, derived by dividing the project cost by the average aux engine horsepower in Port of San Diego.
Engineer Cost	$14	Value defined as the cost to bring power to the charging station. The cost is the average cost from the Port of San Diego (provided by David Yow from the Port of San Diego in an email dated October 31, 2020), and the cost from SDAPCD Carl Moyer Project (Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program). For SDAPCD Carl Moyer Project, the $/hp value is at $16/hp, derived by dividing line-item cost of $20,000 by hp of 1,228.50. For the Port of San Diego, the $/hp is at $12/hp, derived by dividing the project cost by the average aux engine horsepower in Port of San Diego.
Installation Cost	$26	Value defined as the cost to bring power to the charging station. The cost is the average cost from the Port of San Diego (provided by David Yow from the Port of San Diego in an email dated October 31, 2020), and the cost from SDAPCD Carl Moyer Project (Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program). For SDAPCD Carl Moyer Project, the $/hp value is at $30/hp, derived by dividing line-item cost of $37,060 by hp of 1,228.50. For the Port of San Diego, the $/hp is at $22/hp, derived by dividing the project cost by the average aux engine horsepower in Port of San Diego.

Shore Power Infrastructure, Maintenance and Labor Costs	Unit Cost ($/hp)	Basis
Vessel-Side Infrastructure Cost	$53	The cost is the average cost from the Port of San Diego (provided by David Yow from the Port of San Diego in an email dated October 31, 2020), and the cost from SDAPCD Carl Moyer Project (Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program). For SDAPCD Carl Moyer Project, the $/hp value is at $62/hp, derived by dividing line-item cost of $76,090 by hp of 1,228.50. For the Port of San Diego, the $/hp is at $44/hp, derived by dividing the project cost by the average aux engine horsepower in Port of San Diego.
Dock Construction Cost	$0	Value is the cost to construct the dock for the charging. Because these vessels are already operating and have existing docks, and there is no evidence suggesting new docks will need to be constructed to convert existing ferry operations, CARB staff assumed this cost is $0.
Total Project Cost	$332	Value is the sum of the following costs ($/hp): Upstream Utility Cost, Charging Station Cost, Installation Cost, Charging Equipment Cost, and Dock Construction Cost. These values were taken from a 2014 San Diego Air Pollution Control District (SDAPCD) Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program.
Percentage of Vessels Without Shore Power Capability	24%	Percentage is based on a 2019 CARB survey of CHC owners/operators.
Percentage of Vessels Without Shore Power Capability who would Use Shore Power	12%	CARB staff estimate that of the percentage of vessels without shore power capability, half will comply using shore power. CARB staff assumed that the other half will not exceed auxiliary engine idling limits in the proposed regulation, and therefore will be in compliance.
Total Aux Engine hp	422,304	CARB staff took the total auxiliary hp of all the engines in the engine inventory, except for the “Commercial Fishing” vessel category. See Table I “Engine and Vessel Population” for more information about the engine population methodology.
CRF (5%, 20 years) for Infrastructure	0.08	The 20-year berth equipment useful life is based on staff’s assumptions used in the At Berth rulemaking that indicated equipment life for shore power at OGV berths ranging from 15 to 20 years. CARB staff assumed a similar equipment life would apply to properly maintained shore power infrastructure for commercial harbor craft.

Table VIII-B: Infrastructure Cost Inputs—Short Run Ferry and Excursion Charging Infrastructure

Cost Item	Cost	Basis
Upstream Utility Cost	$2,096,885	Upstream Utility Cost is the cost to bring the power to the charging station. CARB used the average costs of the following two items as the upstream utility costs: 1. CARB staff initially assumed three times the Shore power cost; 2. Caltrans provided upstream Utility costs of $4 million for PG&E - Real McCoy Costs.
Charging Station Cost	$2,748,070	Cost Information provided by WETA to CARB staff during a conference call on July 23, 2020. WETA provided a total Short Run infrastructure cost of $4.7 million, which represents one 99-passenger vessel operating a limited schedule; CARB staff took the split of the Charging Station Cost, Installation Cost, and Charging Equipment Cost for Shore Power and applied it to this value to get this cost.
Installation Cost	$365,817	Cost Information provided by WETA to staff during a conference call on July 23, 2020. WETA provided a total Short Run infrastructure cost of $4.7 million, which represents one 99-passenger vessel operating a limited schedule; CARB staff took the split of the Charging Station Cost, Installation Cost, and Charging Equipment Cost for Shore Power and applied it to this value to get this cost.
Vessel-Side Infrastructure Cost	$751,129	Cost Information provided by WETA to CARB staff during a conference call on July 23, 2020. WETA provided a total Short Run infrastructure cost of $4.7 million, which represents one 99-passenger vessel operating a limited schedule; CARB staff took the split of the Charging Station Cost, Installation Cost, and Charging Equipment Cost for Shore Power and applied it to this value to get this cost.
Dock Construction Cost	$0	Value is the cost to construct the dock for the charging. Because these vessels are already operating and have existing docks, and there is no evidence suggesting new docks will need to be constructed to convert existing ferry operations, staff assumed this cost is $0.
Number of Facilities, Short-Run Ferry	8	There are 16 Short Run ferries in the State. Staff assumed 8 charging facilities are needed to charge these ferries.
Number of Facilities, Excursion	9	Staff derived the number of Excursion Vessel facilities by dividing 7,053 hp, which is the sum of the Excursion Vessel replacement hp from 2023 to 2037, by 786, which is the average Excursion Vessel hp calculated from the engine inventory. See Table I "Engine and Vessel Population" for more information about the engine population methodology.
Total Number of Facilities	17	The sum of the Short Run Ferry and Excursion Vessel facilities.
CRF (5%, 20 years) for Infrastructure	0.08	The 20-year berth equipment useful life is based on staff's assumptions used in the At Berth rulemaking that indicated equipment life for shore power at OGV berths ranging from 15 to 20 years. CARB staff assumed a similar equipment life would apply to properly maintained shore power infrastructure for commercial harbor craft.
Excursion, Average hp	779	CARB staff took the average hp of the Excursion engines in the engine inventory. See Table I "Engine and Vessel Population" for more information about the engine population methodology.
Excursion, Total Vessel Replacement hp	6,951	CARB staff added the total Excursion Vessel replacement hp from 2023 to 2037.

Appendix B: Table of Contents

Appendix B: List of Tables

2. Appendix B: Cost Analysis Equations

This document was prepared by California Air Resources Board (CARB) staff to document equations used in the development of cost estimates for the Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft (Proposed Amendments).

Staff developed the cost estimates for the Standardized Regulatory Impact Assessment (SRIA), which is required by Senate Bill (SB) 617 for proposed regulations that have an economic impact exceeding $50 million.

a. Cost Analysis Equations

Total estimated costs are the sum of compliance costs from 2023 to 2038 for the Proposed Amendments, including:

i. Major compliance costs (Capital, Labor, and Installation costs for Repowering, Retrofitting and Replacing the vessels);

ii. Administrative costs (Recordkeeping and Reporting, Vessel Labeling, Facility Reporting, Regulation Interpretation, Implementation and Enforcement, and Opacity Testing costs);

iii. Infrastructure costs (Shore power and Zero-Emission Infrastructure costs).

The following sections describe the equations CARB staff used to calculate costs for each compliance cost category. Note that the term “Total Vessel Horsepower” refers to the total statewide horsepower (HP) of all vessels that would be subject to requirements.

i. Major Compliance Costs

a) Repower Costs

Table B-I. Equations to Calculate Repower Cost

Calculated Value ($)	Equation
Engine Capital Cost (Repower) – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x Unit Engine Capital Cost ($/Horsepower (HP)) x [1 + Vessel Growth Factor [fraction]]
Labor and Installation Cost (Repower) – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Labor and Installation Cost + Loss of Use Cost] ($/HP) x [1 + Vessel Growth Factor [fraction]]
Capital, Labor and Installation Cost (Repower) – Amortized	[Total Vessel Horsepower x (1-Low use percentage)] x Unit Capital, Labor and Installation Cost ($/HP) x (Capital Recovery Factor (CRF)) [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated amortization from previous years
Loss of Use Cost – Amortized	[Total Vessel Horsepower x (1-Low use percentage)] x Loss of Use Cost ($/HP) x CRF [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated amortization from previous years.

Calculated Value ($)	Equation
Operational Cost – Repower to Tier 3	[Total Vessel Horsepower x (1-Low use percentage)] x Unit Operational Cost ($/HP) x CRF [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated amortization from previous years.
Operational Cost – Repower to Tier 4	[Total Vessel Horsepower x (1-Low use percentage e)] x [Unit Maintenance Cost of Tier 4 Selective Catalytic Reduction (SCR)+ SCR fluid cost scaled by fuel cost+ Unit Main Engine Fuel Savings] ($/HP) x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.
Engine and Diesel Particulate Filter (DPF) Capital Cost (Repower to Tier 3 and Retrofit) – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Tier 3 Engine Capital Cost +Unit Tier 3 Labor and Installation Cost] ($/HP) x [1 + Vessel Growth Factor [fraction]]
Engine and DPF Labor and Installation Cost (Repower and Retrofit) – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Tier 3 Labor and Installation Cost+ Unit DPF Labor and Installation Cos+ Loss of Use] ($/HP) x [1 + Vessel Growth Factor [fraction]]
Operational Cost (Tier 2 Repower and Retrofit to Tier 3 +DPF)	[Total Vessel Horsepower x (1-Low use percentage)] x [DPF Regen Fuel Cost scaled by fuel cost + DPF Cleaning Cost] ($/HP) x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.
Engine DPF Capital Cost (Repower to Tier 4 and Retrofit)-No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Tier 4 Engine Capital Cost +Unit Tier 4 Labor and Installation Cost x Tier4 plus DPF Low Use Percentage] ($/HP) x [1 + Vessel Growth Factor [fraction]]
Engine and DPF Labor and Installation Cost (Repower and Retrofit) – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Tier 4 Labor and Installation Cost+ Unit DPF Labor and Installation Cos x Tier4 plus DPF Low Use Percentage + Loss of Use] ($/HP) x [1 + Vessel Growth Factor [fraction]]
Operational Cost (Tier 3 and Pre-Tier 3 Repower and Retrofit to Tier 4 +DPF	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Maintenance Cost of Tier 4 SCR+ SCR fluid cost scaled by fuel cost x Tier 4 plus DPF Low Use Percentage + Unit Main Engine Fuel Savings + (DPF Regen Fuel Cost scaled by fuel cost + DPF Cleaning Cost)] ($/HP) x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.

b) Retrofit Costs

Table B-II. Equations to Calculate Retrofit Costs

Calculated Value	Equation
DPF Capital Cost- Retrofit to Tier 3 +DPF- No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x Unit DPF Capital cost ($/HP) x [1 + Vessel Growth Factor [fraction]]
DPF Labor and Installation Cost – Retrofit to Tier 3 +DPF – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit DPF Labor and Installation Cost + Loss of Use Cost] ($/HP) x [1 + Vessel Growth Factor [fraction]]
DPF Capital and Installation Cost Retrofit to Tier 3 +DPF – Amortized	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit DPF Capital, Labor and Installation Cost+ Loss of Use Cost] ($/HP) x CRF [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.
Operational Cost – Retrofit to Tier 3	[Total Vessel Horsepower x (1-Low use percentage)] x [DPF Regen Fuel Cost scaled by fuel cost + DPF Cleaning Cost] ($/HP) x [1 + Vessel Growth Factor [fractio6n]], accumulated from previous years.

Calculated Value	Equation
DPF Capital Cost – Retrofit to Tier 4 +DPF – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit DPF Capital cost x Tier4 DPF Low Use Percentage] ($/HP) x [1 + Vessel Growth Factor [fraction]]
DPF Labor and Installation Cost – Retrofit to Tier 4 + DPF – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit DPF Labor and Installation Cost x Tier4 DPF Low Use Percentage + Loss of Use Cost] ($/HP) x [1 + Vessel Growth Factor [fraction]]
DPF Capital and Installation Cost Retrofit to Tier 4 +DPF – Amortized	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit DPF Capital, Labor and Installation Cost x Tier4 DPF Low Use Percentage + Loss of Use Cost] ($/HP) x CRF [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.
Operational Cost – Retrofit to Tier 4	[Total Vessel Horsepower x (1-Low use percentage)] x [DPF Regen Fuel Cost scaled by fuel cost + DPF Cleaning Cost] ($/HP) x Tier4 DPF Low Use Percentage x [1 + Vessel Growth Factor [fractio6n]], accumulated from previous years.

c) Replacement Costs

Table B-III. Equations to Calculate Replacement Costs

Calculated Value	Equation
Vessel Replacement Engine Capital Cost – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x Unit Engine Capital Cost ($/HP) x [1 + Vessel Growth Factor [fraction]]
Vessel Replacement Labor and Installation Capital Cost – No Amortization	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit Installation and Other Cost- Vessel Disposal Values] ($/HP) x [1 + Vessel Growth Factor [fraction]]
Total Vessel Replacement Cost, Amortized Costs	Vessel Replacement Engine Cost + Vessel Replacement DPF Retrofit Capital and Installation Cost+ Vessel Replacement DPF Retrofit Operation Cost
Vessel Replacement Engine Capital Cost, Amortized Costs	[Total Vessel Horsepower x (1-Low use percentage)] x [(Unit Vessel Replacement Cost- Vessel Disposal Values)] ($/HP) x CRF [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.
Vessel Replacement DPF Retrofit Capital and Installation Cost	[Total Vessel Horsepower x (1-Low use percentage)] x [Unit DPF Capital, Labor and Installation Cost x Tier4 plus DPF Low Use Percentage] ($/HP) x CRF [fraction] x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.
Vessel Replacement DPF Retrofit Operation Cost	[Total Vessel Horsepower x (1-Low use percentage)] x [DPF Cleaning Cost x Tier4 plus DPF Low Use Percentage] ($/HP) x [1 + Vessel Growth Factor [fraction]], accumulated from previous years.

ii. Administrative Costs

a) Recordkeeping and Reporting

CARB staff assumed the Recordkeeping Report and Facility Report Cost would recur every year and the Vessel Labeling Cost would recur every five years.

Table B-IV. Equation to Calculate Recordkeeping and Reporting

Calculated Value	Equation
Recordkeeping and Reporting, Vessel Labeling, Facility Report	Number of vessels x (Recordkeeping and Reporting Unit Cost+ Vessel Labeling Unit Cost+ Facility Report Cost) [$] x [1 + Vessel Growth Factor [fraction]]

b) Regulation Interpretation Costs

CARB staff assumed there will be one-time cost per fleet in 2023 to interpret and understand the regulation during the start of the new regulation.

Table B-V. Equation to Calculate Regulation Interpretation Costs

Calculated Value	Equation
Regulation Interpretation Cost	Regulation Interpretation Cost [$] x Number of Fleets in 2023

c) Implementation and Enforcement Costs

Table B-VI. Equation to Calculate Implementation and Enforcement Costs

Calculated Value	Equation
Implementation and Enforcement Cost	Total CARB Personnel Year Cost [$] + Travel cost [$] + Ongoing Contract cost [$]

d) Opacity Testing Costs

Table B-VII. Equation to Calculate Opacity Testing Costs

Calculated Value	Equation
Opacity Testing Cost	Number of Engines x Opacity Testing Unit Cost [$] x [1 + Vessel Growth Factor [fraction]] x Opacity Testing Frequency

e) Financial/Naval Architect Costs

CARB staff assumed the Financial Feasibility Report Cost would occur from 2023 to 2034. The number of vessels that would need to file extensions is calculated as the total number of vessels times the percentage file for extensions.

Table B-VIII. Equations to Calculate Financial/Naval Architect Costs

Calculated Value	Equation
Financial Review Cost	Number of Vessels x Financial Review Report Cost per Vessel [$] x [1 + Vessel Growth Factor [fraction]].
Naval Architect Report Cost	Number of Vessels x Naval Architect Report Cost per Vessel [$] x [1 + Vessel Growth Factor [fraction]].

iii. Infrastructure Costs

a) Shore power

Table B-IX. Equations to Calculate Shore Power Costs

Calculated Value	Equation
Shore Retrofit Costs, Amortized Costs	Total Auxiliary Horsepower x Percentage of Auxiliary Engine need Shore Power x Unit Cost per Horsepower [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
Shore Retrofit Cost Calculations, No Amortization	Total Auxiliary Horsepower x Percentage of Auxiliary Engine need Shore Power x Vessel Unit Cost per Horsepower [$] x [1 + Compounded Growth Factor [fraction]]

b) Zero-Emission Infrastructure Costs

CARB staff assumed the infrastructure costs would start in 2023, two years before the Excursion Vessel compliance date of 2025, and it would take three years to finish the construction process. The costs would evenly be distributed among these three years.

Table B-X. Equations to Calculate Zero-Emission Infrastructure Costs

Calculated Value	Equation
Short Run Ferry and Excursion Charging Infrastructure Cost – No Amortization	Upstream Utility Cost [$] x Number of Facilities / 3
Short Run Ferry and Excursion Charging Infrastructure Cost – Amortized	Upstream Utility Cost [$] x Number of Facilities x CRF [fraction]

Appendix C: Table of Contents

Appendix C: List of Tables

1. Appendix C: Development of Industry-Specific Cost Metrics and Cost Impacts to Individuals for Standardized Regulatory Impact Assessment

This document was prepared by California Air Resources Board (CARB) staff to document the methodology used in the development of industry-specific cost metrics and cost impacts to individuals that would result from proposed amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft (Proposed Amendments). Staff developed these cost metrics for the Standardized Regulatory Impact Assessment (SRIA), which, is required by Senate Bill (SB) 617 for proposed regulations that have an economic impact exceeding $50 million.

a. Summary of Cost Metrics

Staff calculated cost metrics to evaluate the impacts to individuals of the Proposed Amendments. These cost metrics are based on the calculated annual average compliance costs of the Proposed Amendments for the implementation period of 2023 to 2037. Amortized average annual compliance costs for this time period are summarized below in Table C-I (See Chapter C for details on the methodology staff used to calculate compliance costs.)

Table C-I. Annual Average Amortized Compliance Cost from 2023 to 2037

Vessel Types	Labor and Installation cost [1]	Engine and Vessel Capital Costs.[2]	Other Costs[3]	Total Costs
Ferry (Catamaran + Monohull)	$18,781,171	$4,627,711	$267,348	$23,675,252
Ferry (Short Run)	$1,627,841	$678,494	$3,993,682	$6,299,732
Escort/Ship Assist Tug	$3,334,719	$5,853,409	$306,235	$9,494,363
Commercial Passenger Fishing	$18,262,312	$2,823,476	$1,704,768	$22,790,556
Excursion	$7,781,793	$4,660,079	$6,390,222	$18,832,094
Commercial Fishing	$3,132,219	$2,377,002	$1,456,580	$6,965,802
Pilot Boat	$818,668	$343,676	$48,609	$1,210,953

1. Annual average (2023-2037) non-amortized labor and installation cost;
2. Annual average (2023-2037) engine and vessel capital costs in non-amortized analysis; and
3. Annual average "other" costs from 2023 to 2037. "Other" costs include: Recordkeeping and Reporting, Vessel Labeling, Facility Reporting, Regulation Interpretation, Implementation and Enforcement, Opacity Testing, Shore Power, Zero-Emission Vessel Infrastructure, and Marginal Energy Cost Due to Electrification.

Table C-II summarizes the cost metrics staff calculated for selected vessel categories. The cost metrics (shown here) reflect the average amortized cost increase calculated for each vessel category from 2023 to 2037. The amortized costs include down payments and monthly payments on loans to finance equipment. Loan terms were assumed to be 15 years at 4 percent interest, with a 30 percent down payment. In most cases, capital expenditures such as for new engines, emission control systems, and new vessels have an expected equipment lifetime longer than loan periods and extend beyond 2037. Therefore, staff expects the annual average costs to individuals after 2037 would be lower than during the time period covered by this analysis.

The methodologies staff used to calculate each cost metric are described in Table C-II.

Table C-II. Calculated Cost Metrics and Cost Impacts to Individuals

Cost Metric	Average Amortized Cost Increase
Cost Per Passenger – High-Speed Ferry, One-Way Trip	$1.81
Cost Per Passenger – Short-Run Ferry, One-Way Trip	$0.97
Cost Per Passenger – Excursion Vessels	$1.04
Cost Increase Per 20-Foot-Equivalent Unit – Tug Vessels	$0.38
Cost Per Pound of Fish – Commercial Fishing Vessels	$0.04
Cost Per Passenger/day – Commercial Passenger Fishing Vessels, One-Day Trip	$28.02
Cost Per Passenger/day – Commercial Passenger Fishing Vessels, Multi-Day Trip	$26.09
Cost Per Passenger/day – Commercial Passenger Fishing Vessels, 6 passenger (6 pack) Vessel	$93.51

b. Calculation of One-Way Trip Cost Per Passenger for High-Speed Ferry Vessels

Staff calculated the estimated cost increase for a passenger taking a one-way trip on a high-speed ferry that would occur due to the Proposed Amendments by using an average annual compliance cost from 2023 - 2037. This estimate is based on ridership specific to high-speed ferries provided from three large operators: Golden Gate Bridge, Highway and Transportation District, San Francisco Bay Area Water Emergency Transportation Authority (WETA), and a confidential ferry operator that requested non-attribution.

This cost per passenger estimate is inclusive of different types of operation. In addition to considering the longer commuter routes operated by all three operators, WETA and Golden Gate both operate single trips to and from sporting events or concerts at Oracle Park and Chase Center. These shorter, single trips were considered in the cost per passenger estimate as well. Staff believes that the cost increase per passenger for smaller operators would likely be similar to the cost estimated using data from these three larger operators with varying run types and lengths.

Staff estimated total passenger count using data directly from ferry operators, when available. When actual passenger inventories were not available, staff estimated passenger count using the number of trips, and an assumed 45 percent capacity of vessels. This capacity estimation was calculated from available passenger inventory information for high-speed ferries in 2019 and applied to operators for whom the passenger inventory was not available. Due to 2020 schedule changes caused by the global situation, 2019 schedules were used when possible to reflect normal activity.

For operators that provide services to Oracle Park[1] and events at Chase Center[2], staff used the 2019 game and event schedules to estimate the number of trips. For some operators, schedules from early 2020 were used when 2019 schedules were not available. The 2020 schedules used appear to mimic typical trends from pre-2020, and therefore staff expects the ridership estimation to represent pre-2020 activity, and therefore not underestimate ridership. The total passenger counts are provided in Table C-III.

Table C-III. Total Passengers in Data Year (pre-2020)

Operator	Total Passengers pre-2020
Confidential Source	1,171,266
Golden Gate[3]	1,416,663
WETA[4]	3,215,195
Total	5,803,124

These three operators currently have a combined fleet of 28 high-speed vessels, including both Catamaran and Monohull ferries. Staff's estimate of high-speed vessel population in 2023 is 55 vessels.[5] These two vessel populations were used to scale the ridership calculations for these three operators to the projected total high-speed ferry passenger estimation of 11,398,994 in 2023 as shown in the following calculation:

55/28 * 5,803,124 = 11,398,994 passengers in 2023

This passenger estimation for 2023 was then scaled for the year 2037 by using a growth factor of 1.29[6], resulting in a passenger estimate of 14,704,702 passengers, as shown in the following calculation:

11,398,994 * 1.29 = 14,704,702 passengers in 2037

In order to compare costs and ridership for the same time period, CARB staff calculated the average annual ridership between 2023 and 2037 as follows:

(11,398,994 + 14,704,702) / 2 = 13,051,848 annual average passengers

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[1] San Francisco Giants 2019 Season Schedule, last accessed May 13th, 2021, *https://www.mlb.com/giants/schedule/printable-schedule-2019*.

[2] Chase Center Event Schedule, last accessed August 25th, 2020, *https://www.chasecenter.com/events*.

[3] Golden Gate Bridge Highway & Transportation District Website: "Golden Gate Ferry Schedules," last accessed August 14th, 2020, *https://www.goldengate.org/ferry/schedules-maps/*.

[4] Email from WETA to Tracy Haynes on November 17th, 2020.

[5] CARB Staff's Ferry Classification Analysis.

[6] For Ferries, Staff used a Statewide compound growth factor that assumed zero population growth for the State with the exception of the Bay Area, where Ferry growth assumptions were based on the San Francisco Bay Area Water Emergency Transportation Authority (WETA) 2016 Strategic Plan (*https://weta.sanfranciscobayferry.com/sites/default/files/weta/strategicplan/WETAStrategicPlanFinal.pdf*, last accessed March 2021). The Ferry growth percentages apply to Catamaran, Monohull, and Short Run Ferry categories.

Finally, the estimated average annual compliance cost[7] from 2023 - 2037 for high-speed ferry categories was divided by the average ridership from 2023 - 2037 to obtain the cost per passenger (per one-way trip):

$23,675,252 / 13,051,848 = $1.81 per passenger per one-way trip

c. Calculation of Cost Per Passenger for Short-Run Ferry Vessels

Staff calculated the estimated cost increase for a passenger taking a one-way trip on a short-run ferry that would occur due to the Proposed Amendments by using an average annual compliance cost from 2023 to 2037. This estimate is based on information from three short-run ferry operators with fleets of varying sizes: Hornblower Cruises, Flagship Cruises, and Angel Island Tiburon Ferry.

Staff estimated total passenger count (Table C-IV) using data from short-run ferry operators, when available. When actual passenger inventories were not available, staff estimated passenger count using the number of trips, and assumed vessels operate at 19 percent capacity. This capacity estimation was a calculated average of the available passenger capacity data from operators that were able to share ridership information. Due to 2020 schedule changes caused by the global situation of 2020, 2019 schedules and ridership data were used to reflect normal activity.

Table C-IV. Total Passengers in Data Year (2019)

Operator	Total Passengers in 2019
Hornblower[8]	1,515,242
Flagship[9]	969,933
Angel Island[10]	124,642
Total	2,609,817

These three operators currently have a combined fleet of seven short-run ferry vessels. Staff's estimate of the short-run ferry vessel population in 2023 is 16 vessels.[11] These two vessel populations were used to scale the ridership calculations for these three operators to the projected total short-run ferry passenger estimation of 5,965,296 in 2023 as shown in the following calculation:

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[7] CARB Draft Cost Analysis for Standardized Regulatory Impact Assessment for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft, June 25, 2021 version, "Cost Metrics" tab.

[8] Hornblower Cruises Alcatraz Departure Schedule, last accessed April 22, 2021, *https://www.cityexperiences.com/san-francisco/city-cruises/alcatraz/departure-schedule/*.

[9] Email from Flagship Cruises to Melissa Houchin on December 1, 2020.

[10] Angel Island Ridership Data emailed to Melissa Houchin on December 14, 2020.

[11] CARB Draft Cost Analysis for Standardized Regulatory Impact Assessment for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft, April 2021 version, "Major Cost Inputs" tab, Table 23.

16/7 * 2,609,817 = 5,965,296 passengers in 2023

This passenger estimate for 2023 was then scaled for the year 2037 by using a growth factor of 1.181[12], resulting in a passenger estimate of 7,045,015 passengers, as shown in the following calculation:

5,965,296 * 1.181 = 7,045,015 passengers in 2037

The average ridership between 2023 and 2037 was then calculated to be 6,505,156, as shown in the following calculation:

(5,965,296 + 7,045,015) / 2 = 6,505,156 annual average passengers

Finally, the estimated average annual compliance cost[13] from 2023 - 2037 for short-run ferry categories was divided by the total passenger estimation for 2037 to obtain the cost per passenger (per one-way trip):

$6,299,732 / 6,505,156 = $0.97 per passenger per one-way trip

d. Calculation of Cost per Passenger for Excursion Vessels

Staff calculated the estimated increased cost per excursion passenger that would occur due to the average compliance costs from 2023 to 2037 for excursion vessels using the following methodology.

First, staff calculated the average number of excursion vessel passengers per vessel trip or excursion. Staff identified four excursion vessels, obtained capacity data on each vessel from the web[14], and retrieved the total horsepower (hp) of all engines from the CHC emission inventory using methods as discussed in Chapter B. Using data from these four vessels, staff then calculated an average vessel capacity per hp as shown in Table C-V below. Staff then used the average capacity per hp value of 0.118 and multiplied it by the statewide average excursion vessel hp of 869 from the CHC Reporting Database to calculate an overall average vessel capacity of 102 passengers for excursion vessels statewide. Then, assuming excursion vessel ridership is 60 percent of vessel capacity, staff calculated an average of 61 passengers per trip for excursion vessels.

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[12] For Ferries, Staff used a Statewide compound growth factor that assumed zero population growth for the State with the exception of the Bay Area, where Ferry growth assumptions were based on the San Francisco Bay Area Water Emergency Transportation Authority (WETA) 2016 Strategic Plan (*https://weta.sanfranciscobayferry.com/sites/default/files/weta/strategicplan/WETAStrategicPlanFinal.pdf*, last accessed March 2021). The Ferry growth percentages apply to Catamaran, Monohull, and Short Run Ferry categories.

[13] CARB Draft Cost Analysis for Standardized Regulatory Impact Assessment for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft, June 25, 2021 version, "Cost Metrics" tab.

[14] CARB, Excursion Websites Data, September 2020.

Table C-V. Excursion Vessel Capacity Per Horsepower

Vessel Name	Capacity	Horsepower*	Capacity per hp
Safari Rose	50	760	0.065
Princess Monterey	150	1100	0.136
Atlantis Monterey	80	800	0.100
Condor Express	127	740	0.171
Average capacity per hp:	-	-	0.118

*Main propulsion hp only.

869 = average excursion vessel hp statewide

869 hp x 0.118 capacity/hp = 102 average capacity for excursion vessel

102 average capacity x 60% ridership = 61 passengers per trip

Staff calculated the number of annual excursion vessel trips, as shown in Table C-VI from online excursion website data.

Table C-VI. Number of Excursion Vessel Trips per Year

Vessel	Trips per Year
Old Blue	469
The Privateer	730
Condor Express	508
Safari Rose	820
Princess Monterey	1,095
Average Excursion Vessel	724.4

Staff multiplied the average 61 passengers per vessel trip with the average number of vessel trips an excursion vessel makes per year to estimate the annual total number of passengers for a vessel.

724.4 annual trips * 61 passengers per trip = 44,188 annual passengers per vessel

Then staff multiplied the number of annual passengers per vessel by the projected number of excursion vessels[15] to get the total estimated number of annual passengers taking excursions on vessels that staff expects would be subject to emission control requirements under the Proposed Amendments.

44,188 annual passengers per vessel * 408 vessels = 18,028,704 passengers

Finally, staff divided the estimated total annual average compliance costs from 2023 to 2037 for excursion vessels by the estimated number of passengers to calculate the estimated cost per passenger.

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[15] CARB, Emission Inventory, March 2020, *https://ww2.arb.ca.gov/sites/default/files/2020-03/CHC%20Webinar%20Presentation%20March%202020_1.pdf*

$18,832,094/18,028,704 passengers = **$1.04 per passenger**

e. Harbor Tug and Pilot Vessel Average Amortized Compliance Cost Increase Per Twenty-foot Equivalent Unit (TEU)

Table C-VII summarizes the estimated compliance cost increase per container ship TEU that staff expects would result from increased compliance costs to harbor tug and pilot vessels due to the proposed Amendments to the Airborne Toxics Control Measure for Commercial Harbor Craft.

Table C-VII. Estimated Total Cost Increase per Container TEU (Dollars)

Cost Increase Per Container TEU
$0.38

f. Methodology Summary

Staff projects no growth in activity or population of harbor tugs or pilot vessels between 2023 and 2037. Because harbor tugs primarily function in direct support of assisting and escorting ocean-going vessels (OGV) to anchoring and berthing locations, and some amount of growth in cargo throughput is expected from OGVs during this time period, staff used data between 2016 and 2018 in order to calculate a normalized and accurate ratio of harbor tug activity to TEU throughput.

Staff calculated the estimate in Table C-VII by first estimating total OGV visits to California in 2016 by utilizing Information Handling Services (IHS) Markit baseline OGV vessel visit data combined with Southern California Marine Exchange data. Staff utilized statewide actual TEU throughput from 2017 for the Ports of San Diego and Hueneme and 2018 data for the Ports of Los Angeles (POLA), Long Beach (POLB), and Oakland. Staff then estimated the corresponding number of ship assists and tug escorts that would occur annually at this level of TEU throughput by assuming that each OGV visit would require a certain number of ship assist tugs and escort tugs based on OGV type, 2020 industry harbor pilot service guidelines, and 2020 regulatory requirements related to California Department of Fish and Wildlife (CDFW) Office of Spill Prevention and Response (OSPR).

To determine the estimated compliance cost increases per ship assist or escort, staff used the vessel visit counts and the average 2020 Bay Area cost-per-assist and cost-per-escort advertised rate sheet values to determine the annual average ship assist, ship escort, and total ship assist + escort revenue. Staff then divided the fractions of the total ship assist + escort sector annual compliance cost attributed to ship assists and escorts, respectively, by the total number of annual ship assists and the total number of annual escorts.

To determine estimated cost increases per TEU, staff divided the annual average ship assist and harbor pilot sector compliance cost increases attributed to container/reefer ships by the total number of actual baseline statewide TEU throughput to obtain the per TEU annual cost increase. Further detail on each calculation is provided in the next section.

i. Calculation of Total Number of Annual OGV Ship Assists and Escorts

To obtain the estimated number of ship assists and escorts, staff quantified the number of OGV visits from 2016 baseline data then applied assumptions based on industry guidelines to quantify the ship assists and escorts required for each vessel visit as described below.

To obtain baseline vessel 2016 visit counts for all OGV types, staff utilized data,[16] compiled from the updated 2016 IHS-Markit information and the 2016 Southern California Marine Exchange vessel visit counts according to port and vessel type. Note that for POLA and POLB, staff utilized data from Southern California Marine Exchange data, while IHS-Markit data was used for all other ports.

To determine the total number of ship escorts for all OGV tankers, articulated tug barge (ATB) combinations, and line-towed tank barges, staff obtained San Francisco Marine Exchange (SFME) baseline vessel visit data for Port of Richmond for OGV visits in 2016.[17] This data included the total number of distinct tanker berth visits for ATBs, line-towed tank barges (OTB), and seven OGV tanker subcategories including crude oil tanker (TCR), chemical tanker (TCH), chemical/oil tanker (TCO), product tanker (TPD), asphalt tanker (TAS), acid tanker (TAC) and non-specific tanker (TTA) vessel types defined in SFME data.[18] The analysis by staff found 918 distinct Port of Richmond berth visits for 2016. To include the ATBs and OTB port calls, staff then scaled up the 400 Port of Richmond tanker visits listed in the 2016 IHS-Markit data by a tanker berth visit correction factor of 2.295 to reflect the combined total of ATBs, OTBs, and the seven OGV tanker types.

918 Berth Visits/400 IHS-Markit Richmond tanker visits = 2.295 Tanker Berth Visit Correction Factor

Staff applied the 2.295 tanker berth visit correction factor to the 1,628 California OGV tanker visits that occurred in 2016 to obtain 3,736 distinct statewide annual tanker berth visits. Other than scaling to add the ATB and OTB port calls to those from OGV tankers in the 2016 IHS Markit baseline data, no other industry growth factors were used.

For container/refrigerated (reefer), roll-on-roll-off (ro-ro)/auto, cruise, and general/bulk vessel visits from 2016, staff assumed no industry growth would occur for their

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[16] Staff Report: Initial Statement of Reasons (ISOR) Appendix H: 2019 Update to Inventory for Ocean-Going Vessels At Berth: Methodology and Results, Page H-15, *https://ww3.arb.ca.gov/regact/2019/ogvatberth2019/apph.pdf.*

[17] 2016 Port of Richmond Data obtained from the San Francisco Marine Exchange *https://www.sfmx.org/.*

[18] SFMX-Vessel-Type-Codes, last accessed September 9, 2020, *https://www.sfmx.org/wp-content/uploads/2017/10/Vessel-Type-Codes.pdf*

respective sectors and used the baseline vessel port call numbers in the 2016 IHS Markit data.

Table C-VIII. Quantification of OGV Visits Requiring Ship Assists and Escorts

Vessel Type	2016 Vessel Visits	Scaling Factor	Effective 2016 Annual Vessel Visits
Container/Reefer	3,914	1	3,914
Cruise	483	1	483
Ro-Ro/Auto	1010	1	1,010
Tanker	1,628	2.295*	3,736
Bulk/General	795	1	795
Total	7,830	---	9,938

*Tanker scaling factor provides the correction factor for statewide tanker port calls to account for additional tanker vessel types including ATBs and OTBs, which also require escort and ship assist services from harbor tugs.

Staff assumed that every OGV tanker type, ATB, or OTB underway would be carrying more than 5,000 long tons of either crude oil, fuel, or other refinery products, requiring a certified ship-escort tug to comply with the tanker escort requirements of the CDFW OSPR Regulation[19].

To calculate the average annual number of tanker ship assists and ship escorts occurring, staff assumed that due to shipping channel and tanker vessel size restrictions, each OGV tanker, ATB, or OTB would use only one escort tug per escort event and require only one tug per ship assist event. This assumption resulted in each tanker, ATB, or OTB berth visit requiring a total of two ship assists (docking and undocking) and two escorts (to and from the dock) per distinct berth visit.

Staff assumed that typical container ship berth visits to Port of Oakland would require an average of two assist tugs per docking event for a total of four ship assists per distinct berth visit (two for docking and two for undocking). Staff based this assumption on the average number of ship assist tugs required per container vessel according to the current San Francisco Bar Pilot guidelines utilized for the Port of Oakland[20]. Staff assumed all other vessel types that are not container/reefer ships would require a single ship assist tug per ship assist event (a single assist tug for docking and a single assist tug for undocking) for a total of two ship assists per distinct berth visit.

Total average annual ship assists and escorts are shown below in Table C-IX. To calculate the number of statewide ship assists, staff applied four assist tugs per container ship visit and two ship assist tugs to every other OGV-type, ATB, or OTB

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[19] Title 14, California Code of Regulations, Subdivision 4. Office of Spill Prevention and Response, Chapter 4. Vessel Requirements, Subchapter 1. Tank Vessel Escort Regulations for the San Francisco Bay Region Sections 851.1 through 851.10.1, last accessed September 9, 2020,*https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=22000&inline*.

[20] San Francisco Bar Pilots Operations Guidelines for the Movement of Vessels on San Francisco Bay and Tributaries, Page 10. Last accessed September 9, 2020, *http://sfbarpilots.com/wp-content/uploads/2016/04/GuidelinesHighlighted.pdf*

berth visit. To calculate total escorts at two per tanker, ATB, and OTB berth visit (one escort to the berth and one exiting the berth), staff multiplied the number of distinct statewide OGV tanker, ATBs, and OTB visits by two tug escorts. Staff assumed that tug escorts are not required for other OGV types.

To calculate the number of statewide harbor pilot services required, CARB Staff assumed every OGV berth visit would require two harbor pilots, one inbound and one outbound.

Table C-IX. Quantification of Average Annual Ship Assists, Escorts, and Harbor Pilot Services

Vessel Type	Projected Annual Vessel Visits	Tug Assists per Vessel Visit	Tug Escorts per Vessel Visit	Total Annual Tug Assists	Total Annual Tug Escorts	Total Annual Harbor Pilot Services
Container/Reefer	3,914	4	0	15,656	0	7,828
Cruise	483	2	0	966	0	966
Ro-Ro*	1,010	2	0	2,020	0	2,020
Tanker**	3,736	2	2	7,472	7,472	7,472
Bulk/General	795	2	0	1,590	0	1,590
Total	9,938	---	---	27,704	7,472	19,876

*Includes Ro-Ro and Auto Carrier Vessels

**Includes Tanker vessels, ATB barges, and OTB barges

ii. Calculation of Average Ship Assist and Escort Costs

Staff calculated the cost of an average Bay Area ship assist or ship escort using the advertised 2020 rate sheets of two large Bay Area tug fleet operators[21]. The rate sheets included cost detail on tanker escorts to/from Zone 1 outside of the Golden Gate Bridge boundary to San Francisco anchorages and refinery terminal locations in the Port of Richmond, Hercules, Rodeo/Crockett, Selby/ Zone 6 to Martinez and Benicia. The rate sheets provided cost detail on ship assists occurring in San Francisco, Port of Oakland Inner/Outer harbors, Alameda, Redwood City, Richmond, Hercules, Rodeo/Crockett, Martinez, Benicia, and Antioch/Pittsburg. Note that the costs of long-distance escorts/ship-assists to Port of Stockton and Port of Sacramento were not factored into the average ship assist or escort costs used in this analysis due to lack of posted cost data for assist services in those locations or escorts to/from those locations and due to a lack of data on the relatively low frequency of tug escorts to those port locations. The average Bay Area 2020 ship assist cost calculated in this

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[21] Crowley Tug Rate Sheet 2018_SF *https://www.crowley.com/wp-content/uploads/2018/10/2018_SF_SAE_Rate_Sheet.pdf*, Last accessed September 9, 2020. Foss Tug SF Rate Sheet 2020 *https://www.foss.com/wp-content/uploads/Foss-SF-Rate-Sheet-2020.pdf* Last accessed September 9, 2020.

analysis from the two Bay Area tug fleet operators is $7,373.50. The average Bay Area 2020 tanker escort cost calculated is $13,473.75.

iii. Calculation of Average Annual Ship Assist Revenue, Escort Revenue, Total Revenue, Ship Assist, and Escort Revenue Fractions

Staff calculated the average annual ship assist revenue, escort revenue, and total revenue using the 2020 average ship assist and escort costs multiplied by the total number of ship assists and ship escorts projected to occur annually Statewide based on the requirements of the baseline OGV, ATB, and OTB vessel visit data in 2017-2018 from IHS Markit and Southern California Marine Exchange (detailed in Section f):

$7,373.50/ship assist * 27,704 ship assists = $204,275,444 Ship Assist Revenue

$13,473.75/ship escort * 7,472 ship escorts = $100,675,860 Ship Escort Revenue

$204,275,444 + $100,675,860 = $304,951,304 Total Combined Ship Assist/Escort Revenue

Staff divided the average amortized ship assist revenue by the total average amortized haror tug revenue to calculate the ship-assist revenue fraction:

$204,275,444 / $304,951,304 = 0.67 Ship-Assist Revenue Fraction

Staff divided the average amortized escort revenue by the total average amortized harbor tug revenue to calculate the ship-escort revenue fraction:

$100,675,860 / $304,951,304 = 0.33 Ship-Escort Revenue Fraction

Table C-X. Average Annual Ship-Assist and Ship-Escort Revenue

Ship Assist Revenue (Dollars)	Ship Escort Revenue (Dollars)	Total Revenue (Dollars)	Fraction of Revenue Ship-Assists	Fraction of Revenue Ship-Escorts
$204,275,444	$100,675,860	$304,951,304	0.67	0.33

iv. Calculation of Cost of Ship Assist/Escort Tug and Pilot Vessel Average Annual Compliance

Staff calculated the average amortized ship assist/escort tug sector compliance cost to be $9,493,243 and harbor pilot vessel sector average amortized compliance costs to be $1,210,775 in the cost analysis for the Proposed Amendments.[22]

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[22] CHC_Implementation_Cost_V0.22 2023 to 2038.xlsx. CARB Draft Cost Analysis for Standardized Regulatory Impact Assessment for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft, April 2021 version, “Cost Metrics” tab.

v. Calculation of Per-Ship Assist, Per-Escort, and Per-Pilot Service Compliance Cost Increases

The ship assist/escort tug sector amortized compliance cost (see section e. above) was then multiplied by the ship assist revenue fraction of 0.67 and divided by the total number of average amortized statewide ship assists to obtain the average amortized compliance cost increase per average ship assist of $230.

$9,493,243*0.67 / 27,704 ship assists = $230/ ship-assist cost average annual increase

The ship assist/escort tug sector average amortized compliance cost was then multiplied by the average amortized ship-escort revenue fraction of 0.33 and divided by the total number of statewide escorts to obtain the average amortized compliance cost increase per ship escort of $418.

$9,493,243*0.33 / 7,472 ship assists = $419/average annual cost increase per ship-escort .

The harbor pilot vessel sector average amortized compliance cost was then multiplied by the ratio of container/reefer vessel visits to the number of total annual OGV visits statewide (3,914 out of 9,938) then divided by the total number of harbor pilot services required for all statewide vessel visits (19,876) to obtain the average amortized cost increase per harbor pilot service of $24.

$1,210,775 * (3,914/9,938) / (19,876) = $24 average cost increase per harbor pilot service

vi. Calculation of Amortized Cost Increase Per TEU

To calculate the amortized cost increase per container TEU, staff applied the average ship assist cost increase of $230 to the number of statewide ship assists allocated to container ships using the average of four ship assist tugs per container ship berth visit (two tugs assisting per docking event and per undocking event). Staff divided the ship assist cost allocated to container vessels by the total number of statewide TEU throughput calculated by staff[23] to estimate the cost increase per TEU.

15,656 container and reefer ship assists * $230 ship assist / 10,053,568 TEUs = **$0.36 average cost increase per TEU**.

CARB staff then applied the same methodology to pilot service cost increases on container/reefer vessels to calculate the per TEU cost increase due to annual pilot vessel sector compliance cost increases.

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[23] Proposed Control Measure for Ocean-Going Vessels At Berth, ISOR Appendix C-1: Standardized Regulatory Impact Assessment, Page 283, *https://ww3.arb.ca.gov/regact/2019/ogvatberth2019/appc-1.pdf*.

3,914 container/reefer vessel visits * 2 pilots per visit * $24 pilot service cost increase/ (10,053,568 TEUs) = **$0.02 average cost increase per TEU**

Total average annual TEU cost increase:

$0.36/TEU + $0.02/TEU = $0.38 average cost increase per TEU

g. Calculation of Cost per Pound of Fish for Commercial Fishing Vessels

Staff calculated the estimated increased cost per pound of fish that would occur due to the average compliance costs from 2023 to 2037 for commercial fishing vessels, using the following methodology.

First, staff calculated the average annual poundage of fish from California waters reported by CDFW as coming into Commercial Fishing Landings in California as shown in the table below using annual fish data from the CDFW's website, specifically, the origin and poundage of Commercial Fish Landings into California During 2017[24], 2018[25], and 2019[26]. CARB staff assumes that all vessels using landings in California would be subject to the Proposed Amendments because of presumed operation in RCW as defined by the Proposed Amendments

Table C-XI. Total Annual Poundage by Year from California Waters

Year	Total Poundage
2017	206,008,975
2018	176,150,608
2019	107,306,573
Average	163,155,385

Then, staff divided the estimated total annual average compliance costs from 2023 to 2037 for fishing vessels by the average annual poundage of fish to calculate the estimated cost per pound of fish.

$ 6,965,802 / 163,155,385 pounds = **$0.04 per pound**

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[24] California Department Fish and Wildlife, Table 7 - Origin and Poundage of Commercial Fish Landings into California During 2017, Last accessed April 14, 2021. *https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=159547&inline.*

[25] California Department Fish and Wildlife, Table 7 - Origin and Poundage of Commercial Fish Landings into California During 2018, Last accessed April 13, 2021. *https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=171059&inline.*

[26] California Department Fish and Wildlife, Table 7 - Origin and Poundage of Commercial Fish Landings into California During 2019, Last accessed April 13, 2021. *https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178009&inline.*

h. Calculation of Cost per Passenger for Commercial Passenger Fishing Vessels

Staff calculated cost metrics as outlined below for three Commercial Passenger Fishing Vessels (CPFV) categories: inspected CPFVs that made trips that were one day or less, inspected CPFVs that made trips that were longer than one day (overnight and multiple day trips), and 6-passenger or less (6-pack) vessels. Inspected vessels are defined as vessels of 7 or more passengers that are inspected by the United States Coast Guard (USCG) for safety requirements, as opposed to uninspected vessels carrying 6 passengers or less that are not subject to the same requirements by USCG.

Table C-XII. Summary of Cost metrics for CPFV categories

Metric	$/passenger-day	percent increase from average $/passenger-day
Typical Inspected vessel (1 day or less trip category)	$28.02	19 %
Typical Inspected vessel (more than 1 day trip category)	$26.09	14 %
Typical 6-pack vessel	$93.51	%

i. Calculation of Cost per Passenger for CPFVs for Inspected Vessels

Staff calculated the estimated increased cost per vessel passenger that would occur due to the Proposed Amendments.

First, staff randomly selected and researched online 33 fishing charter vessels[27] and separated them into two categories, vessels (16) that made mostly trips that were one day or less, and vessels (17) that made mostly trips that were more than one day. Then using the most recent 2020 angler data for the 33 vessels, which was available online at Sportfishing Report[28], staff calculated the average number of CPFV passengers per vessel trip for each category. This resulted in an average of 19 passengers per trip for the CPFV category of one day or less, and an average of 21 passengers per trip for the CPFV category of more than one-day trips.

Note that staff obtained angler data from CPFV trips taken in late 2020, during a time when restrictions were in place by multiple counties in California related to the global situation. Staff was not able to locate the same resolution of vessel-level angler data prior to late 2020, and therefore used available data on vessel capacity in this analysis. In the potential future absence of the global situation that occurred in 2020, and a greater number of anglers ride on CPFVs, the cost to individual passengers would decrease relative to the numbers presented in this analysis.

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[27] CARB, CPFV Trips & Pricing Data, February 2021.

[28] CARB, CPFV Angler Data References, Last accessed February 19, 2021. *https://www.sportfishingreport.com/*.

Next, to calculate the number of annual passengers for each category, staff multiplied the average number of passengers per trip by the number of annual trips a vessel makes and then multiplied that number by the total number of vessels.

In June 2020, the Sportfishing Association of California (SAC) provided staff vessel data through a SAC survey[29]. This information included vessel engine information, service days per year, and vessel replacement costs.

For the one day or less category, staff calculated the number of annual vessel trips a one day or less CPFV makes using the number of service days a vessel makes per year given by SAC data and the average days per trip for the vessel category.

187 service days / average 1 day per trip = 187 annual trips

Staff then multiplied the average 19 passengers per vessel trip with the 187 annual vessel trips to estimate the total annual number of passengers per vessel.

187 annual trips x 19 passengers per trip = 3,553 annual passengers per vessel

Staff then multiplied the number of inspected CPFV vessels from CARB emissions inventory by the number of annual CPFV passengers per vessel to calculate the total passengers per year in the situation where all inspected CPFVs operate under a model of single-day trips.

3,553 annual passengers per vessel x 174 vessels = 618,222 total passengers per year

For the more than one-day category, staff calculated the number of annual vessel trips a more than one-day CPFV makes using the number of service days a vessel makes per year given by the SAC survey and the average days per trip from the online website data for the vessel category.

187 service days / average 3 days per trip = 61 annual trips

Staff then multiplied the average 21 passengers per vessel trip with the 61 annual vessel trips to estimate the total annual number of passengers for a more than one-day vessel.

61 annual trips x 21 passengers per trip = 1,272 annual passengers per vessel

Staff then multiplied the number of inspected CPFV vessels from CARB emissions inventory by the number of annual CPFV passengers per vessel to calculate the total passengers per year in the situation where all inspected CPFVs operate under a model of multi-day trips.

1,272 annual passengers per vessel x 174 vessels = 221,258 total passengers per year

Staff divided the inspected number of 174 CPFVs by the estimated number of 352 inspected and uninspected CPFVs operating in the state to calculate the fraction of

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[29] Sportfishing Association of California, Engine Survey, June 2020.

inspected vessels. Then staff multiplied this fraction by the estimated annual average compliance costs from 2023 - 2037 for CPFVs to calculate the estimated amortized cost for inspected CPFVs.

SAC informed CARB that approximately 35 percent of gross revenues are subject to local taxation, which is a tax that is almost exclusively applied to the CPFV industry. To account for taxation on additional gross revenue generated to comply with CARB rules, CARB divided fare increases by (1-0.35), which resulted in a 54 percent increase relative to fare increases before taxation.

174 inspected vessels / 352 uninspected and inspected = 0.494

$22,790,556 x 0.494 = $ 11,258,535

This amortized cost was then divided by the number of passengers per year for each category to calculate the estimated cost per passenger for a one-day or less trip and for a more than one-day fishing trip.

For the one day or less category:

$11,258,535 / 618,222 passengers = $18.21 per passenger

$18.21 per passenger / (1-0.35) = $28.02 per passenger/day (one day or less fishing trip)

Staff divided the cost per passenger of $28.02 for one day or less of fishing by the average cost per passenger of $147.50, which was calculated by averaging the advertised costs per day of fishing from the 16 randomly selected one day or less CPFVs operating in the state, and then multiplied by 100 to calculate a percentage increase in price.

$28.02 per passenger / $147.50 per passenger = 0.1900

0.1900 x 100 percent = 19 percent increase in price

For the more than one-day category:

$11,258,535/ 221,258 passengers = $50.88 per passenger

$50.88 per passenger / (1-0.35) = $78.28 per passenger (more than one-day fishing trip) and $26.09 per passenger/day

Staff divided the cost per passenger for a more than one-day fishing trip by the average cost per passenger of $572.96, which was calculated by averaging the advertised costs per day of fishing from the 17 randomly selected more than one-day CPFVs operating in the state, and then multiplied by 100 to calculate a percentage increase in price.

$78.28 per passenger / $572.96 per passenger = 0.1366

0.1366 x 100 percent = 14 percent increase in price

ii. Calculation of Cost per Passenger for CPFVs with Six Passengers or Less

Staff calculated the estimated increased cost per passenger on a six-pack vessel that would occur due to the Proposed Amendments.

First, staff calculated the average cost per day of fishing per passenger for 17 randomly selected vessels. Using vessel cost data from CPFV websites[30] and hp data reported to CARB as required by the existing CHC regulation, the average cost was $335.11 per day of fishing per passenger.

Using the 2020 recent angler data from the Sportfishing Report website[31] staff averaged the 17 selected 6-pack vessel's anglers counts to calculate the average of 5.7 passengers per vessel trip. Staff multiplied the average passengers per vessel trip (5.7) with the average number of vessel trips a CPFV makes per year from SAC to estimate the annual total number of passengers for a vessel. Staff then subtracted the number of SAC vessels from the total the estimated number of 352 inspected and uninspected CPFV's operating in the state to calculate an estimated number of 6-pack vessels.

5.7 passengers x 187 annual number of trips = 1,066 passengers per year

352 estimated vessels - 174 CPFV vessels = 178, 6-pack vessels

Staff multiplied the number of 6-pack vessels by the number of annual passengers per vessel to calculate the total passengers per year.

1,066 passengers per year x 178 6-pack vessels = 189,748 passengers per year

Staff divided the number of 6-pack vessels by the estimated number of 352 inspected and uninspected CPFVs operating in the state to calculate the fraction of inspected vessels. Then staff multiplied this fraction by the estimated annual average compliance costs from 2023 – 2037 for CPFVs to calculate the estimated amortized cost for inspected CPFVs. This amortized cost was then divided by the number of passengers per year to calculate the estimated cost per passenger. This value was then divided by 65 percent to account for a 35 percent profit loss given by the SAC.

178 6-pack vessels / 352 uninspected and inspected = 0.506

$22,790,556 x 0.506 = $11,532,021

$11,532,021 / 189,748 passengers = $60.78 per passenger

$60.78 per passenger / 65 percent = **$93.51 per passenger-day increase**

Finally, staff divided the cost per passenger by the average cost per passenger of $335.11, which was calculated by averaging the cost per day of fishing from 17

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[30] CARB, CPFV Trips & Pricing Data, February 2021.

[31] CARB, CPFV Angler Data References, Last accessed February 19, 2021, *https://www.sportfishingreport.com/*

randomly selected 6-pack vessels operating in the state, and then multiplied by 100 to calculate a percentage increase in price.

$93.51 per passenger / $335.11 per passenger = 0.28

0.28 * 100 percent = 28 percent increase in price

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4. Appendix D: Macroeconomic Inputs

This document was prepared by California Air Resources Board (CARB) staff to document the inputs used to calculate cost estimates for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft (hereinafter Proposed Amendments). Staff has developed cost estimates for the Standardized Regulatory Impact Assessment (SRIA), which is required by Senate Bill (SB) 617 for proposed regulations that have an economic impact exceeding $50 million. Any additional changes made to the cost estimates as a result of staff refinements or new information from stakeholders will be reflected in the staff report as part of the Initial Statement of Reasons (ISOR).

Table D-I presents the specific inputs used in the Regional Economic Models, Inc. (REMI) modeling for the Proposed Amendments. REMI version 2.5.0 accepts inputs in 2020 dollars. Costs were adjusted from 2019 to 2020 dollars when input into the REMI model.

Table D-I: REMI Inputs (Million 2020 dollars)

REMI Policy Variable	Industry	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Production Cost	483 - Water Transportation	10.90	22.66	29.98	37.26	44.92	50.25	52.38	59.63	61.88	63.84	67.96	69.40	69.64	70.33	70.33	70.40
Production Cost	487,488 - Scenic and Sightseeing Transportation and Support Activities for Transportation	23.30	27.96	36.61	42.39	47.40	51.61	53.89	59.28	61.97	64.65	68.27	71.43	69.43	70.82	70.81	71.02
Production Cost	23 - Construction	1.19	0.80	1.09	1.09	1.09	1.41	1.29	1.86	1.92	1.92	2.10	2.13	2.02	2.19	2.19	2.21
Production Cost	114 - Fishing, Hunting and Trapping	4.89	0.93	0.93	0.93	0.94	1.12	0.94	2.52	4.55	6.46	6.64	6.46	6.46	6.46	6.46	6.64
Exogenous Final Demand	Engine, Turbine, and Power Transmission Equipment Manufacturing (3336)	58.03	127.10	97.89	64.13	47.63	37.01	22.62	51.51	32.14	29.12	17.90	12.48	4.49	4.82	0.00	0.00
Industry Sales	3366 - Ship and Boat Building	41.28	102.32	79.31	71.67	89.15	68.49	81.70	132.36	67.95	67.83	87.50	60.71	19.58	26.76	0.00	0.00
Exogenous Final Demand	3366 - Ship and Boat Building	13.25	32.85	25.46	23.01	28.62	21.99	26.23	42.49	21.81	21.78	28.09	19.49	6.29	8.59	0.00	0.00
Exogenous Final Demand	23 - Construction	16.36	16.36	14.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exogenous Final Demand	3353 - Electric Equipment Manufacturing	26.57	26.57	20.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exogenous Final Demand	5412 - Accounting, Tax Preparation, Bookkeeping, And Payroll Services	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.00	0.00

REMI Policy Variable	**Industry**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**
Exogenous Final Demand	5413 - Architectural, Engineering, And Related Services	7.63	7.63	7.63	7.63	7.63	7.63	3.82	3.82	3.82	3.82	3.82	3.82	0.00	0.00	0.00	0.00
Exogenous Final Demand	5611, 5612 - Office Administrative Services; Facilities Support Services	11.40	0.96	0.96	0.96	0.96	1.45	0.96	0.96	0.96	0.96	1.45	0.96	0.96	0.96	0.96	1.45
Exogenous Final Demand	8111- Automotive Repair and Maintenance	0.77	0.77	0.77	0.77	0.77	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.79	0.79	0.79
Exogenous Final Demand	2211 - Electric Power Generation, Transmission and Distribution	0.51	0.51	0.55	1.56	2.04	2.13	2.41	2.44	2.45	2.46	2.47	2.48	2.48	2.48	2.47	2.47
Exogenous Final Demand	324 - Petroleum and Coal Products Manufacturing	-0.45	-0.45	-0.46	-1.40	-1.81	-1.88	-2.09	-2.10	-2.10	-2.11	-2.12	-2.13	-2.14	-2.15	-2.15	-2.16
State and Local Government Spending	State Government Spending	0.46	3.08	1.85	0.51	-0.14	-0.57	-1.13	-0.01	-0.78	-0.90	-1.35	-1.56	-1.88	-1.87	-2.06	-2.06
State and Local Government Spending	Local Government Spending	2.71	5.81	4.35	2.79	2.03	1.53	0.87	2.20	1.29	1.15	0.62	0.36	-0.01	0.00	-0.22	-0.22
State and Local Government Employment	State Government Employment (Units = Jobs)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Consumer Spending	Reallocate Consumption: Hospitals	-0.10	-0.17	-0.23	-0.31	-0.37	-0.42	-0.47	-0.55	-0.63	-0.69	-0.74	-0.76	-0.78	-0.79	-0.80	-0.79