Attachment 4

Supplemental Environmental Analysis of Potential Impacts From Changes in Southern California Vessel Routing as a Result of the ARB Ocean-going Vessel Fuel Rule

February 2009

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1 Introduction

This document provides additional analysis of environmental impacts that may result from adoption by the Air Resources Board (ARB or Board) of its proposed regulation, *Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline* (OGV Fuel Rule). The OGV Fuel Rule requires ocean-going vessel main (propulsion) diesel engines, auxiliary diesel engines, and auxiliary boilers to operate on cleaner-burning, lower sulfur marine distillate fuels within a 24 nautical mile (nm) zone along the California coastline. This document supplements the environmental analysis contained in the *Staff Report: Initial Statement of Reasons for Proposed Rulemaking* prepared in June 2008 for this rulemaking (staff report or ISOR); the environmental analysis is required by California Code of Regulations, title 17, sections 60005-60007 and by the California Environmental Quality Act, Public Resources Code section 21000 et seq. (CEQA).

The OGV Fuel Rule is implemented in two phases with progressively more stringent fuel sulfur levels. The first phase of the proposal begins on July 1, 2009 for main engines and auxiliary boilers. For auxiliary engines, the first phase begins on the effective date of the proposed regulation. Phase 1 requires vessel operators to use either marine gas oil (MGO), or marine diesel oil (MDO) with a sulfur limit of 0.5% or less. Phase 2 begins on January 1, 2012 for the main engines, auxiliary engines and auxiliary boilers. Phase 2 requires vessel operators to use either MGO or MDO, both meeting a sulfur limit of 0.1% or less. The use of MGO or MDO results in emission reductions of diesel particulate matter (PM), sulfur oxides (SOx), oxides of nitrogen (NOx), and "secondarily" formed PM (PM formed in the atmosphere from NOx and SOx). Additional information about the OGV Fuel Rule and the activities it would regulate are available in the ISOR. (ARB, 2008)

The Board voted to approve the regulation at a hearing on July 24, 2008, directing staff to perform further analysis, make additional modifications and collect additional public comment prior to final adoption of the regulation by the Executive Officer. Among other things, the Board instructed staff to prepare this supplemental environmental analysis and circulate it for public comment. This supplemental environmental analysis focuses specifically on environmental impacts that might result if the proposed regulation results in an unintended shift of shipping traffic out of the Santa Barbara Channel shipping lanes to a new route south of the northernmost Channel Islands.

1.1 Purpose of the Proposed Regulation

The purpose of the proposed regulation is described on pages I-1 and I-2 of the ISOR:

> *The proposed regulation is designed to reduce emissions of diesel PM, PM, NOx, SOx, and "secondarily" formed PM (PM formed in the atmosphere from NOx and SOx emissions). Diesel PM emission reductions are needed to reduce the potential cancer risk. Diesel PM, PM from boilers, and secondarily formed PM reductions are needed to reduce premature mortality and other noncancer*

health impacts from PM exposures to people who live in the vicinity of California's major ports and shipping lanes. Reductions in diesel PM, PM and secondary PM from SOx and NOx will also contribute to regional PM reductions that will assist in California's progress toward achieving State and federal air quality standards. Reductions in NOx, an ingredient in the formation of ozone pollution, will help reduce regional ozone levels and secondary nitrate PM.

1.2 Key Conclusions

ARB staff analyzed the environmental impacts that may occur in the event ocean-going vessel (OGV) operators adopt an avoidance strategy and transit through the Point Mugu Sea Range instead of the normal route through the Santa Barbara Channel. The analysis presented in this report provides an evaluation of the impacts of the avoidance strategy on emissions, air quality, public health, attainment status, marine ecosystems, and cumulative impacts. ARB staff believes most shipping lines or ship operators are not likely to use an avoidance route for reasons described in the ISOR and in this document; staff consequently views impacts associated with extensive use of an avoidance strategy to be speculative. As explained later in this report, there are a number of factors that will impede the wide scale use of an avoidance route and no evidence has been provided by the U.S. Navy or others that OGV may adopt an avoidance strategy. Nevertheless, in response to the Board's direction to assess impacts that might occur as a result of changes in shipping routes and to provide worst-case appraisal of potential environmental impacts, we conducted an analysis of potential impacts. Based on the analysis, we have determined the following potential adverse impacts may result:

- Air quality modeling indicates that there may be small localized areas to the north and east of the Ports of Los Angeles and Long Beach and in San Diego County along the coastline that exhibit small increases in on-shore ozone concentrations. While the increases in concentrations are very small (about 1 percent), we are concluding that even these small increases would represent a significant adverse environmental impact associated with large-scale use of avoidance routing.

- There is a small increase in carbon dioxide (CO_2) greenhouse gas emissions that may result from the avoidance strategy. While this is a very small increase relative to overall CO_2 emissions from shipping, we are concluding that even this small increase represents a significant adverse environmental impact associated with large-scale use of avoidance routing.

However, the overall statewide environmental and public health benefits of the OGV Fuel Rule are very significant, even if an avoidance strategy is adopted by many OGV operators. Statewide, the emissions of PM and SOx are reduced significantly by over 40 percent and 50 percent, respectively. Based on air quality modeling, an avoidance strategy has been shown to also result in decreases in 8-hour ozone concentrations, particularly in the highly populated areas around the Ports of Los Angeles and Long Beach and also result in significant reductions in PM over most of the South Coast Air Basin (SCAB). These ozone and PM reductions will result in more than

500 premature deaths avoided each year in the SCAB. These substantial benefits of the OGV Fuel Rule on PM emissions, on-shore air quality and public health provide overriding considerations to support the regulation. Therefore, staff anticipates that the Executive Officer will adopt a statement of overriding considerations as part of the action approving the regulation.

Given the nature of the proposed action, ARB has not identified a project alternative that would be effective in reducing the level of significance of these impacts while accomplishing statewide environmental and public health benefits that are the purpose of the regulation.

In the unlikely event of large-scale avoidance, mitigation measures for the potentially small increase in ozone are provided in State Implementation Plans (SIPs) that are developed by local air districts and approved by ARB. SIPs include federally enforceable commitments and measures that will ensure California attains the federal air quality standards for ozone and particulate matter. California's SIP was most recently updated in 2007 and includes numerous measures for both stationary and mobile sources that have or will reduce NOx, hydrocarbons (HC), SOx, and PM. It also includes a measure to require the use of cleaner fuels by OGV. In the event avoidance does occur and the commitment in the SIP is compromised, there is already in place a mechanism that will be used to mitigate any loss of expected emission reductions. Under the SIP, in the event a measure does not realize the expected emission reductions, the emission reductions foregone are achieved through another measure or program. Furthermore, on an on-going basis, ARB works with local air districts to refine and update SIPs to ensure aggressive reductions in PM and ozone-forming emissions are achieved and that new and revised measures are defined to ensure the emission reduction commitments are met.

In the unlikely event of large-scale avoidance, mitigation measures for the potentially very small increase in CO_2 will be provided as ARB and others implement the measures outlined in the recently adopted "*Climate Change Proposed Scoping Plan*" (AB 32 Scoping Plan). (AB 32, 2008) The AB 32 Scoping Plan contains numerous measures to significantly reduce California's carbon footprint. These measures, while primarily focused on reducing greenhouse gas (GHG) emissions such as CO_2, will also reduce PM and NOx.

1.3 ARB's Certified Regulatory Program

ARB's rulemaking process is a certified regulatory process under the California Environmental Quality Act, Public Resources Code section 21000 et seq. (See Public Resources Code section 21080.5 and California Code of Regulations, title 14, section 15251.) Provisions in ARB's rulemaking process provide for the review of any potentially significant adverse environmental effects of the regulations it adopts, amends or repeals, and requires that ARB consider feasible mitigation or alternatives if significant effects are identified. This analysis is included in the staff report or ISOR that ARB staff prepares as part of any rulemaking proposal. As provided in California Code of Regulations, title 14, section 15252, the environmental analysis in the ISOR is the equivalent of a negative declaration or environmental impact report prepared under CEQA.

ARB's environmental analysis must comply with ARB's own regulatory requirements at California Code of Regulations, title 17, sections 60005-60007, and with certain CEQA requirements. CEQA requirements for an equivalent document prepared under a certified regulatory program include but are not limited to those in Public Resources Code, section 21080.5, subdivision (d)(3), and California Code of Regulations, title 14, sections 15250 and 15250. In addition, staff is required to respond to all significant environmental issues raised by the public during the public review period or at the Board public hearing in the Final Statement of Reasons for the regulation.

1.4 ISOR Environmental Analysis and Board Action

ARB staff analyzed potential adverse environmental impacts that could result from adoption of the regulation in Chapter VII of the ISOR. That analysis included a discussion of the potential impacts in the areas of water quality, hazardous waste, air quality and greenhouse gas emissions. The ISOR also included an analysis of vessel operators' potential use of alternative overwater routes to avoid requirements of the OGV Fuel Rule. ARB staff discussed the possibility that some vessel operators may use longer alternative routes to minimize the amount of travel within regulated California waters. While some individual vessel operators may decide to change their existing routes to avoid burning as much cleaner fuel as they otherwise might be required to do, ARB staff concluded in the ISOR that there would not be a significant shift to alternative routes by the shipping lines.

When it approved the OGV Fuel Rule on July 24, 2008, the Board concluded that the only potentially significant adverse environmental impact from the regulation was the anticipated net increase of greenhouse gas emissions. The Board found the increase of up to 50,000 metric tons of carbon dioxide emissions "very small" compared to worldwide greenhouse gas emissions, but concluded an increase of this size could nonetheless be considered significant. The Board adopted a finding that public health and air quality benefits of the regulation overrode the potentially significant environmental impact of increased greenhouse gas emissions.

The Board also directed ARB staff to conduct this supplemental environmental analysis in response to comments from the United States Navy (U.S. Navy) for the purpose of further analyzing the potential for significant adverse environmental impacts if vessel traffic to and from ports in Southern California shifts away from the Santa Barbara Channel. In particular, the Board instructed staff to evaluate the possibility that more vessels will avoid the Santa Barbara Channel and whether such a shift would result in significant adverse environmental impacts under CEQA including degradation in air quality. The Board also instructed staff to circulate the supplemental environmental analysis for a public comment period of at least 15 days.

1.5 U.S. Navy Comments

The U.S. Navy and ARB staff met on multiple occasions prior to the start in June 2008 of the formal rulemaking process to discuss the impacts that the regulation may have on naval operations in the Point Mugu Sea Range. Additionally, the U.S. Navy provided both written and oral comments at the July 2008 Board meeting. (U.S. Navy, 2008; and ARB, 2008b)

The U. S. Navy contends that the OGV Fuel Rule requirements, alone or combined with proposed or future efforts to reduce vessel speed in the Santa Barbara Channel will cause commercial shippers to abandon existing transit routes through the Santa Barbara Channel. The U.S. Navy maintains that the shippers may choose, instead, to use a route that is mostly outside the OGV Fuel Rule 24 nm zone and that passes through the U.S. Navy's Point Mugu Sea Range. (This alternative route is referred to in this document as the "avoidance route" since it would be primarily used by shippers to avoid the 24 nm zone in which the rule's fuel use requirements apply until their vessels are relatively close to port.) The U.S. Navy has argued that the additional traffic in the Point Mugu Sea Range will negatively impact operations.

The U.S. Navy contends that the avoidance route would be attractive to shippers for a number of reasons. First, shippers will save fuel costs since they will be outside the OGV Fuel Rule 24 nm zone and therefore, not be required to use the more expensive, cleaner fuel. Second, the avoidance route may be outside any potential future vessel speed reduction zones, allowing the ships to travel faster to reduce shipping time. Third, the U.S. Navy has pointed to efforts to reduce marine mammal strikes in the Santa Barbara Channel which may in the future either impose slower vessel speeds in the channel or move the routes outside the Santa Barbara Channel. In addition, the U.S. Navy contends that if shippers use an avoidance route, on-shore air quality will be negatively impacted.

1.6 Overview of Supplemental Environmental Analysis

As directed by the Board, ARB staff conducted this supplemental environmental analysis to more closely examine the potential adverse environmental impacts that could result from the proposed regulation if shippers use an avoidance route through the Point Mugu Sea Range. The analysis evaluates potential environmental impacts that might result from a shift in vessel traffic from the Santa Barbara Channel shipping lanes to a route further south. As described below, for purposes of this analysis, ARB has alternately assumed that 50 percent and 100 percent of all ocean-going vessel traffic, most of which currently passes through the Santa Barbara Channel, will use an avoidance route to the south. ARB staff analyzed the potential for these large-scale shifts in vessel traffic to cause significant environmental impacts. The assumed avoidance route use rates of 50 percent and 100 percent represent worst-case scenarios for regulation-caused changes in shipping routes and ARB believes actual changes in shipping routes are likely to be much smaller.

This analysis evaluates the following impacts of using an avoidance route to circumvent the OGV Fuel Rule:

- statewide ocean-going vessel emissions,
- on-shore air quality,
- human health impacts,
- impacts to marine mammals,
- other impacts to the marine environment, and
- cumulative impacts.

1.7 Baseline

For purposes of this analysis, the physical environmental conditions that existed at the beginning of ARB's informal rulemaking process and work on the ISOR constitute the environmental setting or "baseline" for purposes of analyzing whether the proposed regulation will result in significant adverse environmental effects. ARB staff's work on the proposed regulation began in 2005 so the environmental baseline for purposes of ARB's analysis are conditions as they existed in 2005. When staff found that the best data available was from an earlier year, or was contained in documentation made available to ARB more recently than the start of the rulemaking process, the best information was utilized in ARB's analysis even if it was not from the baseline year.

The existing environmental setting is described in the ISOR. Existing shipping routes that are especially relevant to the analysis in this document are described in section 2.1, below. Baseline information related to the distribution of whales is described in section 4.1.

2 Environmental Setting/Background Information

2.1 Ocean-going Vessel Activities

In any given year, there are thousands of ocean-going vessel (OGV or vessels) visits to California ports. Over 2,000 OGVs visited California's ports in 2006, and these vessels made nearly 11,000 port calls. Of those 11,000 port calls, approximately 5,500 port calls were to the Ports of Los Angeles and Long Beach (POLA and POLB). In addition, Southern California is home to Ports at Hueneme, El Segundo, Catalina and San Diego. Because of the large number of ports and vessel activity, the traffic patterns are diverse throughout the Southern California region. Figure 1 shows the predominant vessel traffic lanes off the Southern California coast. The solid red lines in Figure 1 represent the most commonly used routes in Southern California.[1] However, it is not uncommon for vessels to travel outside these routes due to such factors as weather conditions,

[1] The designated shipping lanes were determined from three sources of data. The near-port vessel lanes were extracted from the Army Corps of Engineers National Waterway Network. Data from the Ship Traffic, Energy and Environment Model developed by Dr. Chenfeng Wang and Dr. James Corbett (Wang, 2007) were used to define traffic lanes further out at sea. Data from automated instrumentation system telemetry data collected during 2007 was used to define the traffic lanes that connect the near-port routes and routes further out at sea.

individual ship needs, and traffic volumes in a given area. Figure 2 presents data from automated instrumentation telemetry data collected in 2007 that tracks the actual location of ships. As can be seen, OGV are predominately traveling within the traffic routes noted in Figure 1, but that it is not unusual for a small number of ships to be traveling outside of these traffic routes. Figure 2 also shows that the Santa Barbara Channel, which lies between the Channel Islands and the Santa Barbara and Ventura county coastlines, is the predominant route used by vessels approaching the POLA and POLB from the north or traveling northward from Southern California. This is due to the fact that this route is the shortest and most economic route along the great circle route which is used to transit from Asia to America.

Figure 1. Vessel Traffic Lanes in Southern California

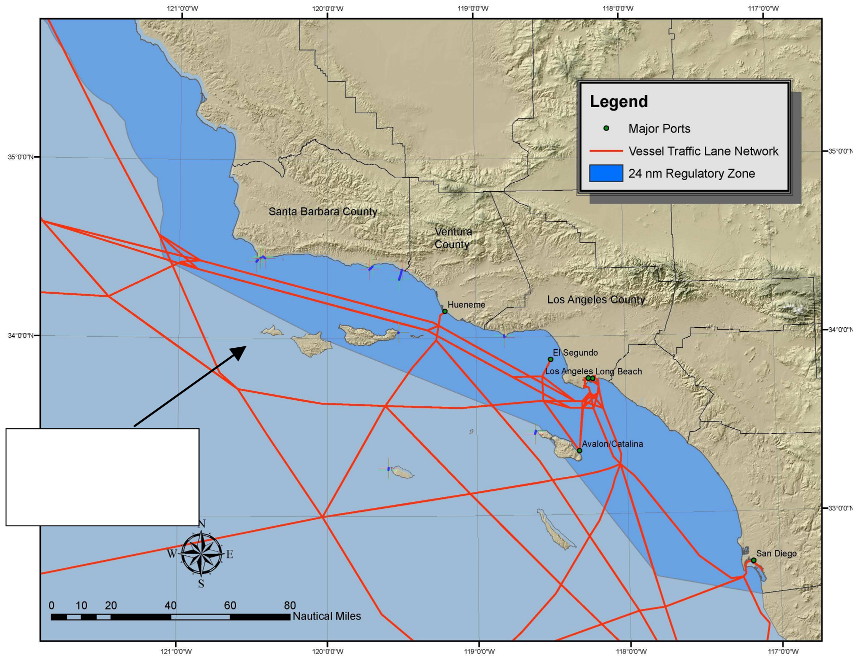
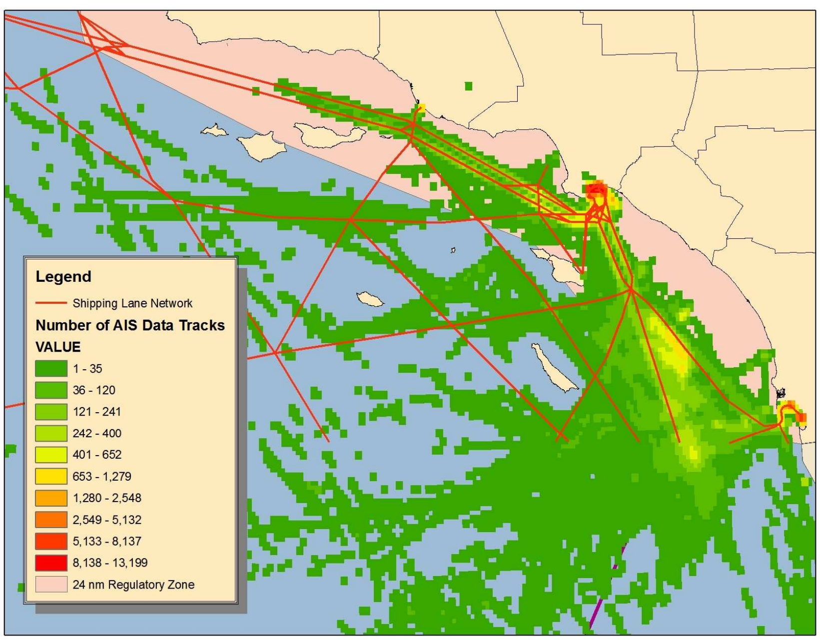


Figure 2. 2007 Automated Information Telemetry Data for Southern California Ocean-going Vessel Traffic



Note: AIS data was compiled for a 3 month period in late 2007 and early 2008. The colored blocks graphically represent the number of ships detected within each block (grid cell) for the 3 month monitoring period. Each stream of blocks represents the travel path of the vessels.

2.2 Regulatory and Other Efforts Potentially Impacting OGV Operations

2.2.1 ARB's OGV Fuel Rule

Emissions from shipping activity off the coast of California and in California ports are a major public health concern at both regional and community levels. As part of a comprehensive effort to reduce OGV emissions, on July 24, 2008, the ARB approved the OGV Fuel Rule. Additional steps are required before the regulation is finalized and becomes effective, but that is expected during the first five months of 2009. As described previously, this regulation requires ocean-going vessel main (propulsion) diesel engines, auxiliary diesel engines, diesel-electric engines, and auxiliary boilers to operate on cleaner-burning, lower sulfur distillate fuels within a 24 nautical mile zone (Regulated California Waters or RCW) along the California coastline. The fuel requirement is implemented in two phases with progressively more stringent fuel sulfur levels. (ARB, 2008) [2]

2.2.2 ARB Vessel Speed Reduction Assessment

In addition to the OGV Fuel Rule, as part of the early actions identified pursuant to the Global Warming Solutions Act of 2006, ARB staff is also currently undertaking a technical assessment of the use of vessel speed reduction (VSR) to achieve emission reduction benefits in California. A voluntary VSR program is currently in place at the POLA and POLB. The purpose of the ARB technical assessment is to investigate potential VSR measures that would expand upon the voluntary program at the POLA and POLB and to evaluate the emission reduction benefits and impacts. The technical assessment will evaluate the emissions and health impacts, timing and geographical range, technical and economic feasibility, and what approaches might be considered such as regulatory or non-regulatory approaches when considering a VSR measure. It is expected that the technical assessment will be completed in Spring 2009.

2.2.3 Whale Strikes and Marine Mammal Protection

Recently, due to blue whale deaths in the Santa Barbara Channel that have been attributed to ship strikes, there are organizations advocating changes to the operation of OGVs off the Southern California coastline. According to the U.S. Navy, because of the concerns over blue whale safety, members of the Channel Islands National Marine Sanctuary Advisory Committee have advocated reducing speeds in the Santa Barbara Channel and moving the shipping lanes. In addition, the Center for Biological Diversity filed a petition under the Endangered Species Act to set a 10 knot speed limit for commercial vessels through the Santa Barbara Channel.

2.3 Point Mugu Sea Range and U.S. Navy Concerns

The Point Mugu Sea Range covers a vast overwater region off the coast of Southern California as shown in Figure 3. It is approximately 200 nautical miles (nm) long (north to south) and extends from 3 nm off the Ventura County coastline to 180 nm offshore. (CCC, 2001) It is adjacent to the Point Mugu Naval Air Station in Ventura County and is

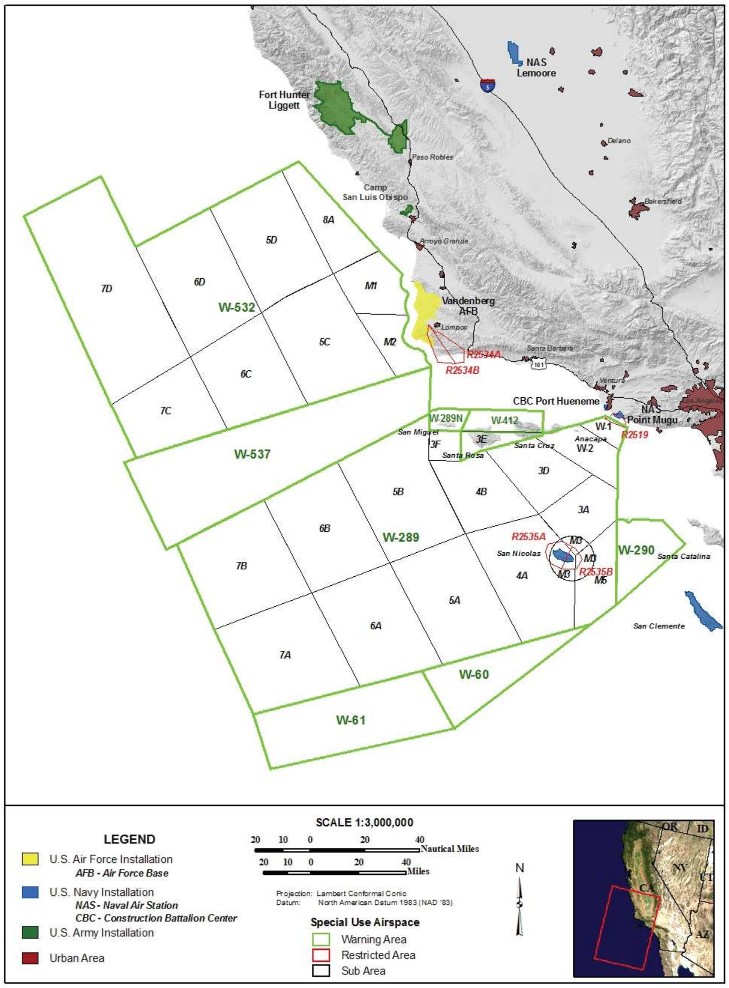
[2] In 2005, the ARB approved a regulation requiring the use of cleaner fuels in OGV auxiliary engines. Due to a successful legal challenge, that regulation was suspended in May 2008 after 14 months of implementation.

comprised of surface and subsurface ocean areas and military air space covering about 27,000 square nautical miles (36,000 square miles). The Point Mugu Sea Range includes sophisticated instrumentation that is utilized for specialized research, development, testing and evaluation (RDT&E) activities. It is the nation's largest and most instrumented RDT&E sea range. While the Point Mugu Sea Range is very large, the U.S. Navy has indicated that there is a critical region of concern, based on operational requirements of the range. Although the Point Mugu Sea Range is close to the shore in many areas and actually comes ashore at Point Mugu, U.S. Navy representatives stated that a vast majority of the operations are conducted south and west of the Northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa), and north and west of San Nicolas Island. This region is the portion that is south-west of the upper Channel Islands, as shown in dark blue in Figure 3.
(U.S. Navy, 2008 and SOIR, 2005)

According to U.S. Navy representatives, the Point Mugu Sea Range is utilized for military activities on a continual basis. The range is used by the Navy, Air Force, Coast Guard and other agencies and has approximately 17,000 events a year (SOIR, 2005). Use is continuous throughout the year, but the intensity of use will vary based on the needs of the users. To ensure that all users meet their RDT&E, training, maintenance and operations requirements, access to the Point Mugu Sea Range must remain available throughout the year.

The U.S. Navy claims it does not have the authority to deny access to ships through the Point Mugu Sea Range. It does, however, have a process in place to inform vessels of Point Mugu Sea Range activities such that operators of commercial and non-commercial vessels can plan for alternative routes or fishing locations to avoid military exercises. U.S. Navy representatives state that they publish a Notice to Mariners (NOTMARS) in the United States Coast Guard "Local Notice to Mariners" publications prior to test and training events and issue advisories to let the operators of tankers and other vessels know if the test range will be "active." For example, ship operators can contact a unit known as "PLEAD Control" if they are planning to enter the Sea Range. If PLEAD Control states that the Point Mugu Sea Range is active, ships have historically delayed their travel or take a longer route circumventing the active area. Oil tankers currently routinely travel through the portion of the Point Mugu Sea Range that is

Figure 3. Point Mugu Sea Range (SOIR, 2005)



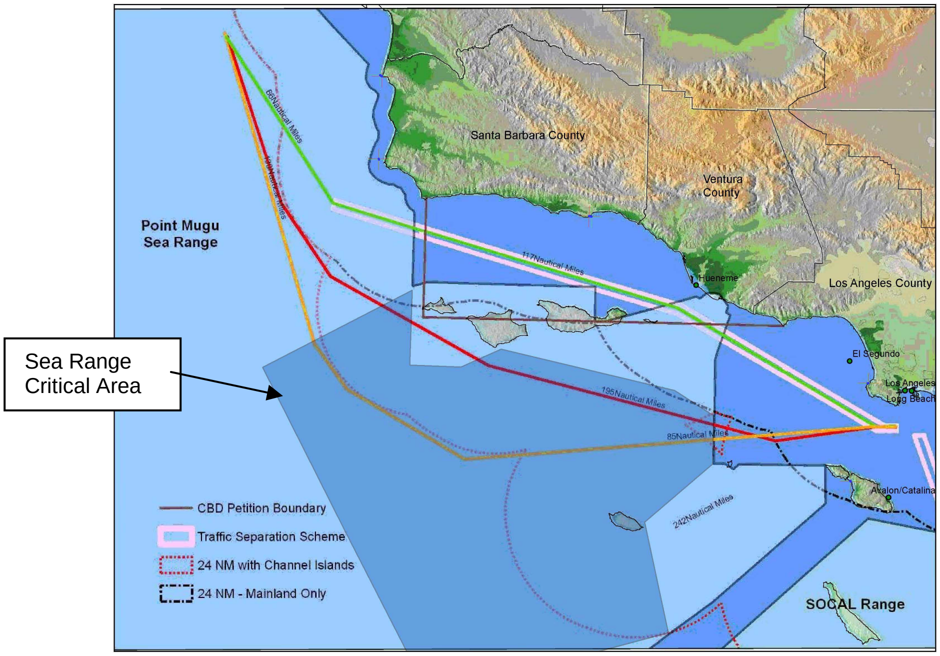
of concern due to an agreement to stay 50 nm off the California coastline to avoid oil spills reaching shore, in response to the Exxon Valdez spill. (West Coast Taskforce, 2002) The U.S. Navy did not have any information to indicate whether tankers or other OGVs have in the past or may in the future travel through an active Sea Range despite warnings. U.S. Navy representatives said problems to date have been mainly with stray pleasure craft or commercial fishing boats.

U.S. Navy representatives contend the ARB OGV Fuel Rule, alone, or combined with other measures such as vessel speed reduction programs, will provide an incentive for some ship operators to avoid using the existing Santa Barbara shipping channel, which is within the OGV Fuel Rule 24 nm zone, and instead use a route outside the regulated zone (avoidance route). If the ships are outside the 24 nm zone, they would save fuel costs by not being required to burn the more expensive, cleaner fuel that complies with the OGV Fuel Rule. To avoid the 24 nm zone, the avoidance route would most likely result in ships traveling through the Point Mugu Sea Range. The U.S. Navy argues that an increase in traffic in the Point Mugu Sea Range would potentially interrupt naval exercises, even if vessels abide by posted advisories. Ship traffic in the Point Mugu Sea Range could result in a temporary halt in exercises, and in the worst case, would create an accident risk that could potentially close the Point Mugu Sea Range.

In documentation provided to ARB staff, the U.S. Navy identified two potential avoidance routes that it claims would be economically better alternatives to transiting through the Santa Barbara Channel for OGV operators. These routes are shown in Figure 4 below as the red route (closer to the northern Channel Islands) and orange route (further offshore to the southwest) that are on the seaward side of the Channel Islands. Both of these routes travel through areas that the U.S. Navy has said are critical regions of the Point Mugu Sea Range, as shown in dark blue in Figure 4. Both avoidance routes would save fuel costs because they are mostly outside the 24 mn zone where the OGV Fuel Rule would require the use of the more expensive, cleaner fuel. The orange route was identified by the U.S. Navy to illustrate a potential avoidance route if the OGV Fuel Rule fuel requirement was extended to 24 nm beyond the Channel Islands instead of as it is defined in the OGV Fuel Rule, at 24 nm from the mainland coastline.

The red avoidance route is the shortest, therefore, uses the least fuel, while still avoiding the 24 nm zone. Because the red avoidance route is the quickest (shortest) and most cost efficient of the two avoidance routes, it is considered the most likely avoidance route and has been used in the analysis presented in this report. According to U.S. Navy representatives, neither avoidance route is a good alternative from the perspective of Point Mugu Sea Range operation. (Parisi, 2008) Furthermore, they claim that any significant increase in the ship traffic in the Point Mugu Sea Range due to shippers using an avoidance route would negatively impact operations, limiting their ability to test weapons systems and train military forces.

Figure 4. Map of Shipping Routes off the Southern California Coast and Potential Avoidance Routes Through the Point Mugu Sea Range (U.S. Navy, 2008)



Note: The Santa Barbara Channel shipping route is shown in green and pink. Two avoidance routes, both traveling through critical regions of the Sea Range are shown in red and orange. The medium blue region shows the critical area of Point Mugu Sea Range operations. Map not to scale.

In addition, the U.S. Navy claims that, if OGVs use either avoidance route, the emissions of GHG (CO_2), NOx, SOx, and PM would increase, resulting in adverse air quality impacts on the South Coast Air Basin (SCAB). Increases would occur because: 1) the red avoidance route is longer than the route through the Santa Barbara Channel and would, therefore, produce more emissions; and 2) since the avoidance route is outside the OGV Fuel Rule 24 nm zone, OGVs would not be required to use the cleaner burning marine distillate fuels while transiting in the avoidance route except when they were fairly close to port, and the added use of dirtier, heavy fuel oil during avoidance would result in greater emissions.

To support their claims of adverse air quality impacts, the U.S. Navy pointed to a study conducted in 2000, *Air Quality Impacts from NOx Emissions of Two Potential Marine Vessel Control Strategies in the South Coast Air Basin*, (Task Force Study) that compared the onshore impact of NOx for two operational strategies – moving the shipping lane and vessel speed reduction. (ARB/SCAQMD, 2000). The scenarios in the Task Force Study included a baseline route, an alternative shipping route located outside the Channel Islands and different speed reduction options using the baseline route. The baseline route characterized ships using the Santa Barbara Channel, which is representative of the predominant shipping route into and out of the POLB and POLA in the northward direction. The alternative shipping lane in the Task Force Study was a relocation of the Santa Barbara Channel shipping lane to a region further offshore and is similar to the red avoidance route shown in Figure 4.

In the Task Force Study, air quality dispersion modeling was performed to evaluate the onshore net mass flux of NOx into the SCAB for two event periods in 1997. The two event periods were August 3-7, 1997 and September 3-5, 1997. The Task Force Study determined that the alternative shipping route outside the Channel Islands resulted in increases in NOx emissions because of the longer travel distance. However, the onshore net mass flux of NOx in the SCAB from ships traveling the alternative route varied from day to day demonstrating the importance of meteorological flow patterns on the resulting onshore flux of NOx.[3] For the two event periods modeled, the alternative route resulted in higher impacts onshore for two of the days and had lower impacts onshore for four of the days, as compared to the baseline route.

The U.S. Navy highlighted the information in the Task Force Study that explained that the two days that had higher onshore NOx flux levels were representative of South Coast meteorological conditions for about 29% of an average South Coast year, whereas the four days with less NOx flux only were representative of conditions for about 18% of an average South Coast year. The U.S. Navy claims that this study supports their contention that if ships use the alternative route through the Point Mugu Sea Range, air quality in the SCAB will be adversely impacted.

ARB staff agrees with the U.S. Navy's characterization of the results from the Task Force Study. However, it is important to note that the Task Force Study had significant limitations in that it did not consider critical photochemical processes which provide information on the conversion of NOx to ozone and it did not consider the impacts of annual emissions. Also, the Task Force Study did not include the evaluation of primary and secondary $PM_{2.5}$ formation, which has significant air quality and public health impacts. As will be described below, this supplemental analysis provides a new more comprehensive evaluation on the air quality impacts due to OGV transiting through the Point Mugu Sea Range.

3 Air Quality and Public Health Impacts

To evaluate the potential environmental impacts of OGVs transiting through the Point Mugu Sea Range to avoid the fuel use requirements of the OGV Fuel Rule, ARB staff evaluated the emissions, air quality, and public health impacts of two potential avoidance scenarios against a baseline of existing vessel traffic patterns and emissions. ARB staff investigated the change in the total mass of statewide OGV emissions for NOx, particulate matter less than 2.5 micrometers ($PM_{2.5}$), SOx, HC, and CO_2 that could occur if OGVs avoided the OGV Fuel Rule. ARB staff also investigated the impacts that any change in emissions would have on air quality and public health in the SCAB.

[3] In the Task Force Study, two high ozone episode periods comprising 8 days were modeled using an Eulerian air quality modeling system. The emissions of NOx from each scenario were simulated without photochemistry and the net onshore mass flux into the SCAB was calculated. However, the first day of each period (August 3rd and September 3rd) were not used in the analysis since they are start-up days for the modeling simulations and may be overly influenced by initial conditions.

This analysis assumes only the impacts from the OGV Fuel Rule, not potential impacts from the possibility of VSR requirements sometime in the future. The cumulative impacts of the OGV Fuel Rule and potential VSR requirements are discussed in section 6 “Cumulative Impacts.” The scenarios evaluated are described below.

3.1 Assumed Avoidance Levels

It is not possible to predict the number of ships that may use an avoidance route as a result of the OGV Fuel Rule; as stated in the ISOR, ARB staff believes that there are a number of issues that will impede the wide scale use of an avoidance route by the shippers instead of continuing to use the established Santa Barbara Channel route. These issues include the following:

- safety concerns associated with traveling through an active test range;
- total fuel costs are only reduced by about 3 percent from using an avoidance route;
- shippers will still need to carry and switch to the cleaner fuel as they enter the OGV Fuel Rule 24 nm zone as they approach POLA and POLB;
- ships will experience possible delays if they must wait for nearby active exercises to be completed; and
- since the avoidance route is longer than the channel route, the transit may take longer, potentially causing scheduling conflicts at port terminals.

Shipping companies are very concerned with the safety of crew, equipment and cargo and have active programs to implement risk reduction strategies. Ships traveling near, or through, an active test range would increase risk, and possibly liability, and this could be in conflict with a company’s risk reduction policy. Although using an avoidance route may reduce fuel costs by about 3 percent for a typical trans-Pacific voyage due to the lower costs of heavy fuel as compared to the cleaner fuel required by the OGV Fuel Rule, the shippers will still be required to switch to the cleaner fuel as they enter the 24 nm zone approaching the POLA and POLB. In addition, the distance traveled will be longer increasing the transit time along the California coastline. If ships do use the avoidance route, they potentially will also be subject to redirection or delays due to test range activity that could impact dockside scheduling and result in increased costs due to unloading delays and manpower rescheduling.

Because of the number of concerns involved with using an avoidance route, ARB staff believes that only a small number of ships will use an avoidance strategy, and, therefore, considers the 50 percent avoidance scenario a worse case. ARB staff is not aware of any shipping company that elected to use an avoidance route while the OGV Auxiliary Engine Rule was actively implemented, even though it would have provided fuel cost savings. Moreover, many of the shipping companies, including one of the world’s largest, A.P. Moller - Maersk, have adopted voluntary, and costlier, cleaner fuel programs within portions of the Santa Barbara Channel shipping lanes. (Maersk, 2007 and PMSA, 2008) The 100 percent avoidance scenario was included in the analysis due to a request by a U.S Navy representative. ARB staff believes a 100% avoidance scenario is highly unlikely.

Baseline Scenario
For the Baseline Scenario, emissions were estimated for 2005 using existing vessel traffic patterns and fuel usage. This scenario corresponds with the CEQA baseline of existing conditions. For air quality analysis, this scenario included all emissions from offshore shipping (e.g. OGVs), on-road mobile sources, biogenic emissions, elevated point sources, and other area sources. In this scenario, the OGV traffic was spatially allocated using existing data on shipping routes.

50% Avoidance Route Scenario
The second scenario, 50% Avoidance Route Scenario, included the same sources as in the Baseline Scenario; however it was assumed the OGV Fuel Rule was being implemented and that a portion of the OGV avoided the OGV Fuel Rule requirements by transiting through the Point Mugu Sea Range. In the 50% Avoidance Route Scenario, all emissions and sources had the same spatial allocation as the baseline with the exception of the OGVs. The 50% Avoidance Route Scenario was developed by relocating 50% of the baseline traffic that was within the Santa Barbara Channel to the red avoidance route, as shown in Figure 4, traveling through the Point Mugu Sea Range. It was assumed that the OGVs transiting through the Santa Barbara Channel in this scenario and any vessel within the OGV Fuel Rule 24 nm zone complied with the OGV Fuel Rule and used cleaner fuels. For vessels using the avoidance route, it was assumed that they only complied with the OGV Fuel Rule while within the 24 nm zone. For any transiting that occurred outside the 24 nm zone, it was assumed that the vessels used heavy fuel oil. Similar to the Baseline Scenario, 2005 year emissions were estimated.

100% Avoidance Route Scenario
The third scenario, 100% Avoidance Route Scenario, included the same sources as in both the Baseline Scenario and 50% Avoidance Route Scenario. Again, 2005 year emissions were estimated. In the 100% Avoidance Route Scenario, all emissions and sources had the same spatial allocation with exception of the OGVs. The 100% Avoidance Route Scenario was developed by relocating 100% of the baseline traffic within the Santa Barbara Channel to the red avoidance route, as shown as the red route in Figure 4, traveling through the Point Mugu Sea Range. Similar to the 50% Avoidance Route Scenario, ships were assumed to comply with the OGV Fuel Rule (using cleaner fuel) anytime they were within 24 nm zone and used heavy fuel when outside the 24 nm zone.

Below we provide a discussion on our analysis and findings.

3.2 Statewide Emissions Impacts

As explained in the OGV Fuel Rule ISOR, the use of heavy fuel oil (HFO) results in much higher emissions of PM and SOx than the use of marine distillate fuels due to the higher levels of sulfur, ash, and nitrogen containing compounds in HFO. Marine distillate fuels (MGO or MDO) on the other hand, are similar to the diesel fuel used by landside sources and result in lower emissions. To estimate the statewide ocean-going vessel emissions of NOx, $PM_{2.5}$, SOx, HC, and CO_2 for the three scenarios, ARB staff followed the methodology previously described in Appendix D of the OGV Fuel Rule

ISOR (ARB, 2008). Emissions were determined for the year 2005. The only difference between the inventory used for this assessment and the one used in the OGV Fuel Rule ISOR was in the base year chosen: 2005 was chosen for this analysis; the fuel rule used 2006. The two years differed in emissions by approximately 10 percent which represents actual emissions growth by ships visiting California.

The estimated statewide emissions for the three scenarios under consideration are shown in Table 1. As shown in Table 1, the statewide emissions of $PM_{2.5}$ and SOx decrease significantly in both of the avoidance scenarios, compared to the Baseline Scenario. For the 50% Avoidance Route Scenario, $PM_{2.5}$ decreases by 47 percent and SOx decreases by 58 percent. In the 100% Avoidance Route Scenario, $PM_{2.5}$ decreases by 36 percent and SOx decreases by 47 percent. This large net decrease is due to the very large statewide decreases in SOx and $PM_{2.5}$ emissions due to the use of the marine distillate fuels required by OGV Fuel Rule.

Table 1. Estimated OGV Statewide Emissions (tons/day) for Three Scenarios (2005 inventory, 100 nm SIP zone)

Pollutant	Baseline Scenario	OGV Fuel Rule with 50% Avoidance	Difference* (50% Avoid vs. Baseline)	% Change* (50% Avoid vs. Baseline)	OGV Fuel Rule with 100% Avoidance	Difference* (100% Avoid vs. Baseline)	% Change* (100% Avoid vs. Baseline)
SOx	147	62	-85	-58%	78	-69	-47%
$PM_{2.5}$	19	10	-9	-47%	12	-7	-36%
NOx	212	216	4	2%	230	17	8%
HC	7.4	7.8	0.4	5%	8.2	0.8	11%
CO_2	9168	9332	164	2%	9834	665	7%

*Positive value indicates an increase in emissions (disbenefit) relative to the baseline. Negative values represent a decrease in emissions (benefit) relative to the baseline.

The overall emissions decreases in SOx and $PM_{2.5}$ due to the OGV Fuel Rule far exceed the small emission reductions in HC and NOx foregone in the event OGV use heavy fuel oil while transiting through the avoidance route. Because there are small reductions in HC and NOx that result from the use of marine distillate fuels compared to heavy fuel oil, the use of the heavy fuel oil by OGV in the avoidance route slightly outweigh any statewide decreases due to OGV using the cleaner marine distillate fuel in the 24 nm zone. This is reflected in the small increases in HC and NOx emissions with the 50% and 100% Avoidance Route Scenarios. As shown in Table 1, the use of the 50% Avoidance Route results in increases of HC and NOx of 5 percent and 2 percent respectively, relative to the Baseline Scenario. The 100% Avoidance Route results in an 11 percent HC increase and an 8 percent NOx increase relative to the Baseline Scenario. While the percent change in HC may seem significant at 11 percent, the magnitude of the increase is very small, at about 1 ton per day or a 0.03 percent increase in the 2005 statewide HC emissions of 2410 tons per day. Likewise, with respect to NOx, the total statewide increase in NOx emissions for the 100% Avoidance Scenario is also very small, at about a 0.5 percent.[4]

[4] Statewide HC emissions were estimated at 2410 tons per day in 2005 and NOx at 3556 tons per day. (ARB, 2007)

Emissions of CO_2 are also impacted by the avoidance route. The magnitude of CO_2 emissions is due in part to the type of fuel used and in part to the distance and speed at which a ship travels. The use of marine distillate fuels in the regulatory zone results in less CO_2 emissions as compared to the use of heavy fuel oil because marine distillate fuels have higher energy content by weight, resulting in lower fuel consumption. The longer travel distance in the avoidance route increases CO_2 emissions. Under both the 50% and 100% Avoidance Scenarios, the increased CO_2 resulting from OGV traveling the longer avoidance route (12 nautical miles longer) through the Point Mugu Sea Range is greater than the reduction in CO_2 from the use of marine distillate fuel by the portion of ships transiting through the Santa Barbara Channel.

Under the 50% Avoidance Route Scenario, there is about an overall 2 percent increase (164 tons/day) in CO_2. Under the 100% Avoidance Route Scenario, there is about an overall 7 percent increase (665 tons/day) in CO_2. However, in reaching conclusions about this increase, it is important to consider this increase in relation to the other environmental and public health benefits associated with the avoidance route scenarios. As discussed in Chapter VII of the ISOR, while an increase in CO_2 emissions may represent a significant adverse environmental impact, the substantial health and environmental benefits from the reductions in PM clearly constitute overriding considerations. This would still be the case even with avoidance as both the 50% and 100% Avoidance Route Scenarios result in significant $PM_{2.5}$ and SOx reductions relative to the Baseline Scenario.

In summary, both the 50% and the 100% Avoidance Route Scenarios result in less $PM_{2.5}$, and SOx emissions statewide and slightly greater NOx, CO_2, and HC than the Baseline Scenario. To better understand the impacts of the emission changes described above on air quality and public health, ARB staff conducted air quality modeling to provide comprehensive data on the impacts of these changes. Because the change in emissions is concentrated in a region off the southern California coast, the modeling, as described below, focuses on the South Coast Air Basin.

3.3 Air Quality and Public Health Impacts

To investigate the air quality and public health impacts, ARB staff used the Community Multi-scale Air Quality (CMAQ) model to simulate annual 2005 concentrations of gaseous and fine particulate matter within the Southern California modeling domain, as described in Appendix 1. Using the CMAQ model provides a more comprehensive evaluation of the impacts of OGV emissions on air quality than the modeling conducted previously for the Task Force Study since that work did not consider atmospheric photochemistry in the analysis or annual emissions.

The CMAQ model produced hourly gaseous and aerosol concentrations for each grid cell within the domain. These results were used to calculate the annual maximum 8-hour ozone (O_3) concentration and the annual average ambient concentrations of total $PM_{2.5}$ for each grid cell in the modeling domain. The percent differences in the model-simulated maximum 8-hour O_3 and annual average concentrations of total $PM_{2.5}$ between the baseline and each avoidance scenario were used to evaluate the air quality impacts of the 50% and 100% Avoidance Route Scenarios.

In addition, to evaluate the public health impacts, the non-cancer health impacts due to particulate matter and ozone exposures were estimated for each scenario and the differences between the non-cancer health impacts for the Baseline Scenario and each avoidance scenario were determined to provide a quantification of the public health impacts due to the avoidance route relative to the Baseline Scenario. Additional details on the modeling are provided in Appendix 1.

3.3.1 Analysis of 2005 $PM_{2.5}$ and Ozone Air Quality Impacts

To evaluate the impacts of avoidance of the OGV Fuel Rule on ambient $PM_{2.5}$ and ozone levels, the contribution of OGV emissions is quantified by analyzing model predicted ozone and total $PM_{2.5}$ concentrations for the Baseline Scenario and each avoidance scenario. The model-simulated percent change between the avoidance scenario and the Baseline Scenario provides an estimate of the impacts of OGV Fuel Rule avoidance on air quality in the Southern California. The model-simulated percent change in each grid cell (R_i) is calculated by:

$$R_i = \frac{\left(C_{i,avoidance} - C_{i,baseline}\right)}{C_{i,baseline}} x100 \qquad \textbf{(1)}$$

where R_i is the model-simulated percent change in $PM_{2.5}$ and 8 hour ozone levels (a positive value is an increase from baseline, i.e. disbenefit and negative is a decrease from baseline, i.e. benefit). $C_{i,\ baseline}$ and $C_{i,\ avoidance}$ are the pollutant concentrations in grid cell i for the baseline and the avoidance case, respectively.

3.3.1.1 2005 Impacts on Annual Average Ambient $PM_{2.5}$

Figures 5 and 6 present the estimated 2005 impacts from the 50% Avoidance Route Scenario and the 100% Avoidance Route Scenario on the annual averaged total $PM_{2.5}$ (summation of primary and secondary $PM_{2.5}$) in Southern California relative to the Baseline Scenario. Total primary $PM_{2.5}$ includes $PM_{2.5}$ sulfate ($PM_{2.5}SO_4$) plus the non-reactive $PM_{2.5}$ species which includes $PM_{2.5}$ elemental carbon (EC), primary organic carbon, and unspeciated $PM_{2.5}$. The primary $PM_{2.5}$ did not include concentrations of nitrate because it is not feasible to use the model to distinguish between the primary and secondary components of this species. This should not be a significant source of error since there are no significant amounts of primary nitrates in the SCAB emissions inventory (based on the ARB speciation profile, about 0.01 percent of direct PM is assumed to be nitrate). The total secondary $PM_{2.5}$ includes $PM_{2.5}$ nitrate ($PM_{2.5}NO_3$), $PM_{2.5}$ ammonia ($PM_{2.5}NH_4$), secondary $PM_{2.5}SO_4$ and organic carbon.

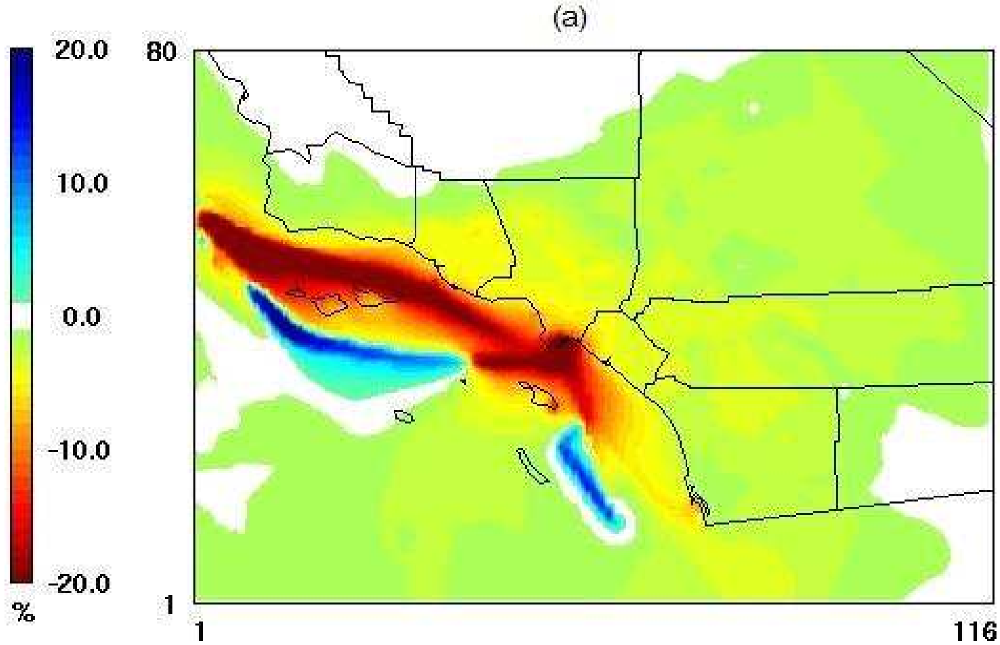
The impacts of the avoidance route scenarios were determined by calculating the relative change of the annual averaged $PM_{2.5}$ concentration between the Baseline Scenario and each avoidance route scenario within each grid cell [see Eq. (1)]. A positive value means there is an increase in total $PM_{2.5}$ concentrations relative to the

Baseline Scenario and a negative value indicates a decrease in concentrations. In other words, a positive value indicates a net air quality disbenefit and a negative value, a benefit.

In Figures 5 and 6, the green, yellow, orange and red colors represent decreases, a positive benefit and the blue colors represent increases, a disbenefit. As can be seen in Figure 5, for $PM_{2.5}$, the 50% Avoidance Scenario overall provides on-shore $PM_{2.5}$ air quality benefits relative to the Baseline Scenario. The 50% Avoidance Route Scenario has a 1 to 20 percent decrease in $PM_{2.5}$ concentration, depending on the location.

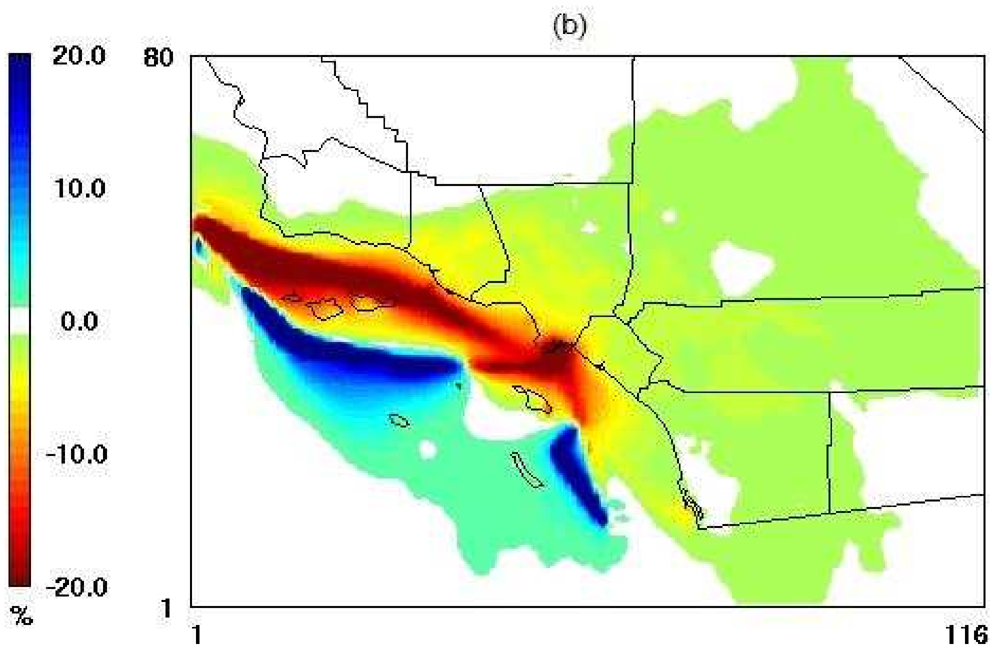
For the 100% Avoidance Route Scenario, there is again an on-shore $PM_{2.5}$ air quality benefit relative to the Baseline Scenario with a similar 1 to 20 percent decrease in concentration. However, for the 100% Avoidance Route Scenario, the affected on-shore area that has decreased concentrations (air quality benefits) is smaller than for the 50% Avoidance Route Scenario.

Figure 5. 2005 Model-Simulated Percent Change* in Annual Average Ambient $PM_{2.5}$ Due to 50% Avoidance Route Scenario
(Only percent changes > 1% and < -1% shown)



* Positive value indicates an increase in emissions (disbenefit) relative to the baseline. Negative values represent a decrease in emissions (benefit) relative to the baseline.

Figure 6. 2005 Model-Simulated Percent Change* in Annual Average Ambient $PM_{2.5}$ Due to 100% Avoidance Route Scenario
(Only percent changes > 1% and < -1% shown)



* Positive value indicates an increase in emissions (disbenefit) relative to the baseline. Negative values represent a decrease in emissions (benefit) relative to the baseline.

Another approach to evaluate the $PM_{2.5}$ air quality impacts due to the Avoidance Route Scenarios is to compare the difference between spatial average $PM_{2.5}$ concentrations and population-weighted average $PM_{2.5}$ concentrations under the Baseline and Avoidance Route Scenarios. The $PM_{2.5}$ spatial average is determined by averaging the annual $PM_{2.5}$ concentration levels in each grid cell where people live.

The population-weighted average reflects the actual exposures to people and is determined by the following equation:

$$C_{pop-wt} = \frac{\sum_{i=1}^{n} C_i \, x \, P_i}{\sum_{i=1}^{n} P_i} \quad \textbf{(2)}$$

$C_{pop\text{-}wt}$ is the population weighted average $PM_{2.5}$ concentration in the SCAB modeling domain in areas where people live, C_i is the concentration in grid cell i, P_i is the population in the grid cell i, and n is the number of grid cells within the modeling domain. The numbers of population in each grid cell were derived using GIS tools and the year 2000 U.S. Census data.

For the 50% Avoidance Route Scenario, both the spatial average and population-weighted average $PM_{2.5}$ concentrations show improvements (decrease in onshore concentrations or exposures to $PM_{2.5}$) as compared to the Baseline Scenario. For the spatial average, there is a 2.3 percent decrease in the onshore concentrations of $PM_{2.5}$ in the SCAB. The population-weighted average showed about a 4.1 percent decrease in exposure compared to the Baseline Scenario.

For the 100% Avoidance Route Scenario, similar results were found with the spatial average having a 1.6 percent decrease in the onshore concentrations of $PM_{2.5}$ relative to the Baseline Scenario and 3.4 percent decrease in exposure compared to the Baseline Scenario.

3.3.1.2 Impacts on Ambient Maximum 8-Hour Ozone

Figures 7 and 8 provide the impacts on annual maximum 8-hour ozone concentrations due to the 50% and 100% Avoidance Route Scenarios relative to the Baseline Scenario. In each case, the impacts of the avoidance scenario were determined by calculating the relative change of the annual maximum 8-hour ozone concentration between the Baseline Scenario and the avoidance scenario within each grid cell [see Eq. (1)]. A positive value means there is an increase in concentrations relative to the Baseline Scenario with the avoidance route and a negative value indicates an decrease in concentrations. Similar to the figures for ambient $PM_{2.5}$ above, in Figures 7 and 8, the green, yellow, orange and red colors represent positive benefits (decreases in concentrations) and the blue colors a disbenefit (increases in concentrations) relative to the baseline.

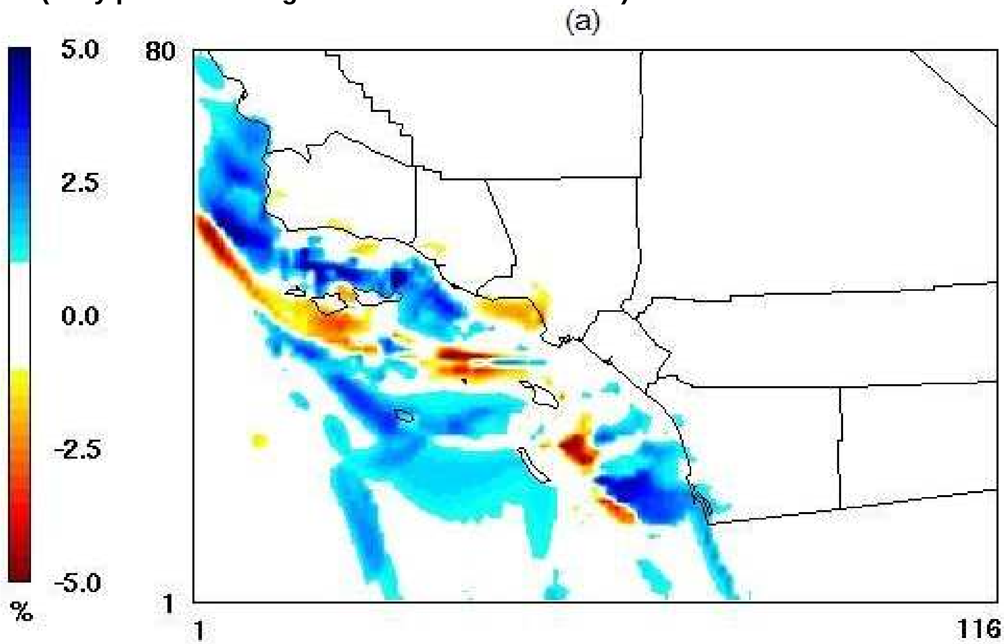
As can be seen in Figure 7, for ozone, the 50% Avoidance Route Scenario results in on-shore air quality improvements (decrease in on-shore ozone concentrations) in coastal regions to the north of the POLA and POLB. These areas show about a 1 to 2 percent decrease in ozone relative to the Baseline Scenario. However, there are other areas directly to the east of the POLA and POLB and in San Diego County where there are small increases in concentration, about 1 percent, due to the 50% Avoidance Route Scenario.[5]

For the 100% Avoidance Route Scenario, similar to the 50% Avoidance Route Scenario there are on-shore air quality benefits in coastal regions to the north of the POLA and POLB. In these regions the benefits are slightly greater than that seen in the 50% Avoidance Route Scenario, having 1 to 3 percent decreases in ozone relative to the Baseline Scenario. The decreases also occur over a broader area than the 50% Avoidance Route Scenario results. There are also areas north and to the east of the POLA and POLB [6] and in San Diego County that exhibit small increases in on-shore ozone concentrations. In these areas, the ozone concentrations are increased by about 1 percent relative to the Baseline Scenario. For the 100% Avoidance Route Scenario, the magnitude of the concentration changes is slightly less than those seen with the 50% avoidance scenario, and the affected areas are larger in the 100% Avoidance Route Scenario.

[5] The area directly to the east of the POLA and POLB is not shown in Figure 7 due to the 1% display resolution. While this area is not displayed, all percentage changes are accounted for in the calculations.

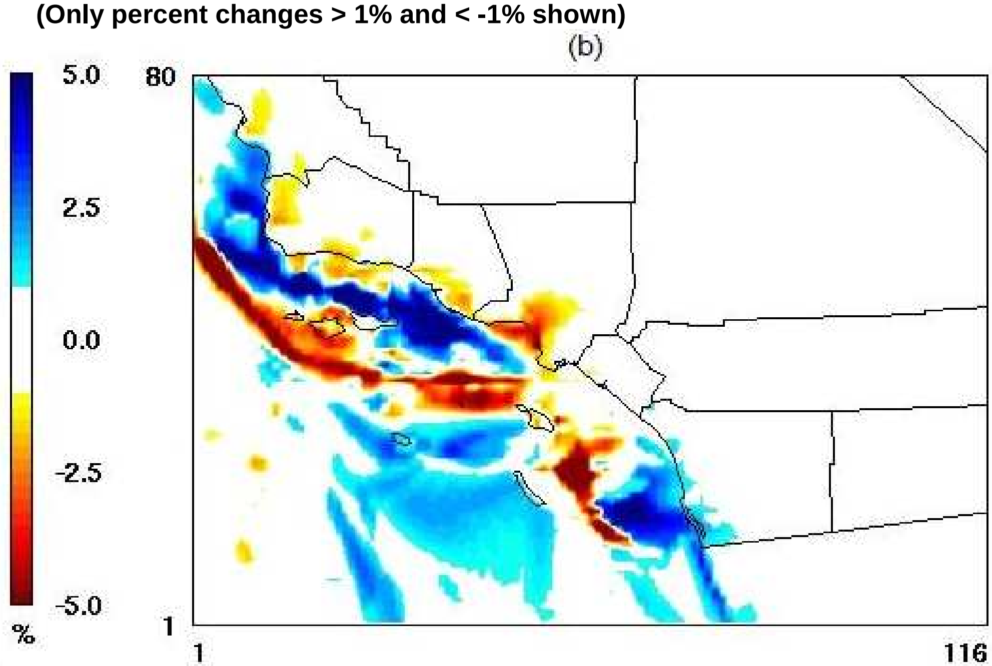
[6] Similar to footnote 5, some of the areas with ozone increases are not shown in Figure 8 due to the display resolution of 1%.

Figure 7. 2005 Model-Simulated Percent Change* in Annual Maximum 8-Hour Ozone Concentration Due to 50% Avoidance Route Scenario
(Only percent changes > 1% and < -1% shown)



*Positive value indicates an increase in emissions (disbenefit) relative to the baseline.
Negative values represent a decrease in emissions (benefit) relative to the baseline.

Figure 8. 2005 Model-Simulated Percent Change* Annual Maximum 8-Hour Ozone Concentration Due to 100% Avoidance Route Scenario
(Only percent changes > 1% and < -1% shown)



* Positive value indicates an increase in emissions (disbenefit) relative to the baseline. Negative values represent a decrease in emissions (benefit) relative to the baseline.

With respect to the spatial average and population weighted average maximum 8-hour ozone concentration, the 50% Avoidance Route Scenario results in an overall small disbenefit (meaning higher ozone ambient levels and exposures with the avoidance route). For the spatial average ozone concentration, the 50% Avoidance Route Scenario results in about a 0.04 percent (0.037 ppb ozone) increase in the onshore ozone concentrations relative to the Baseline Scenario. The population-weighted average maximum 8-hour ozone concentration showed about a 0.02 percent (0.024 ppb) increase in exposure relative to the Baseline Scenario. As shown in Figure 7, these increases are predominately in the San Diego County region.

The 100% Avoidance Route Scenario results in about a 0.04 percent (0.0354 ppb ozone) decrease in the spatial average maximum 8-hour ozone concentration and about a 0.34 percent (0.244 ppb ozone) decrease in the population weighted average relative to the Baseline Scenario. As mentioned earlier, small increases are seen predominately in the San Diego County region and the border between Los Angeles County and Kern County. However, there are greater benefits seen in the areas of Los Angeles County and to the north that are offsetting these increases resulting in an overall improvement in ozone with the avoidance route.

ARB staff also evaluated the impact of the small increases in ozone on attainment or non-attainment status for the new federal 8-hour ozone standard (75 ppb) or State 8-hour ozone standard (70 ppb). For those areas with modeled increases in ozone in San Diego, Los Angeles, Kern, and San Bernardino Counties, we compared the increase in the maximum 8-hour ozone concentrations due to the 50% and 100% Avoidance Route Scenarios to the measured values of ozone with the design values for the air monitoring stations used to assess attainment with the national 8-hour ozone standard. In each case, the small increase in ozone, less than 1 percent will not significantly impact the attainment or non-attainment status in the regions that potentially could experience increases in the event ships use the avoidance routes.

3.4 Analysis of Non-Cancer Health Impacts

A substantial number of epidemiologic studies have found a strong association between exposure to ozone and ambient particulate matter (PM) and adverse health effects. (ARB, 2002, 2005, 2006, 2008a) As part of this supplemental EIR, ARB staff conducted an analysis of the difference between the potential non-cancer health impacts associated with exposures to the model-predicted ambient levels of $PM_{2.5}$ (primary and secondary PM from SOx and NOx) and ozone in Southern California for the avoidance scenarios and the Baseline Scenario. The non-cancer health effects evaluated include premature death, hospital admissions, asthma-related and other lower respiratory symptoms, work loss days, and minor restricted activity days.

To estimate the potential non-cancer health impacts, staff developed population exposure estimates using the model-predicted concentrations of total $PM_{2.5}$, and ozone within each modeling grid cell and the population within the grid cell. The populations within each grid cell were determined from U.S. Census Bureau year 2000 census data.

ARB staff used the same PM-mortality relationship as were used in the ISOR and the Ports and Goods Movement Emission Reduction Plan. The methodology for estimating these health impacts is described in Appendix A of the Emission Reduction Plan for Ports and Goods Movement in California. (ARB, 2006)

For ozone, ARB staff used the same methodology for estimating health impacts from exposure to short-term (1-hour maximum) ozone concentration. (ARB, 2005, 2006) The health endpoints, including mortality, hospital admissions for all respiratory diseases, school absences, minor restricted activity days, were calculated using the U.S. EPA BENMAP. (ABT, 2008) To convert modeled 8-hour maximum ozone concentration to 1-hour maximum ozone concentration used in calculating short-term health impacts, a factor of 1.33 was used. (ARB, 2006) We calculated the estimated number of annual premature death and other health effects associated with exposure to the ozone and $PM_{2.5}$ concentration modeled for each of the grid cells. The totals for each health effect over the entire modeling area were then calculated. For each grid cell, each health effect was estimated based on concentration-response functions derived from published epidemiological studies relating changes in ambient concentrations to changes in health endpoints, the population affected, and the baseline incidence rates. The selection of the concentration-response functions was based on the latest epidemiologic literature, as described in Emission Reduction Plan for Ports and Goods Movement in California. (ARB, 2006)

For each health effect, we estimated the average numbers of cases per year in Southern California for the baseline and each avoidance scenario. The difference between the baseline and each avoidance scenario were then determined to provide an estimate of the change in non-cancer health impacts due to each avoidance scenario. For simplicity, the results and discussion below will focus on premature deaths. In Appendix 2, additional data on the other non-cancer health endpoints are provided.

Table 2 provides a summary of the estimated premature deaths due to the difference in $PM_{2.5}$ and ozone concentrations between the Baseline Scenario and the 50% and 100% Avoidance Route Scenarios. As shown, due to the decreases in $PM_{2.5}$ concentrations, there are significantly greater public health benefits for the avoidance scenarios relative to the baseline. This is the case for the 50% Avoidance Route Scenario as well even with the small disbenefit due to the increase in ozone. Similar results are seen for the other non-cancer health endpoints which are provided in Appendix 2.

Table 2. Estimated Impacts of Avoidance Route Scenarios

	50% Avoidance Route Scenario		100% Avoidance Route Scenario	
	$PM_{2.5}$	Ozone	$PM_{2.5}$	Ozone
Exposure	**Decreases**	**Increases**	**Decreases**	**Decreases**
Result	600 premature deaths avoided per year	10 more premature deaths per year	500 premature deaths avoided per year	12 premature deaths avoided per year
Combined Impacts	590 premature deaths avoided per year		512 premature deaths avoided per year	

Note: The values listed in Table 2 are the mean values. The values and associated 95% confidence intervals are provided in Appendix 2. In addition, the values for ozone represent the upper bound or worse case as it was assumed that the exposures occurred every day of the year.

In October 2008, ARB approved a methodology for estimating premature deaths associated with long-term exposures to fine airborne particulate matter in California that increased the relative risk factor from 6 percent to 10 percent increase in premature death per 10 $\mu g/m^3$ increase in $PM_{2.5}$ exposures (ARB, 2008a). To be consistent with the OGV Fuel Rule ISOR, the premature deaths estimated listed above were calculated using the 6 percent value[7]. If the 10 percent value are used the estimates of premature deaths would increase by about 70 percent.

3.5 Mitigation of Effects on Air Quality and Public Health

Mitigation measures for ozone are provided in State Implementation Plans (SIPs) that are developed by local air districts and approved by ARB. SIPs include federally enforceable commitments and measures that will ensure California attains the federal air quality standards for ozone and particulate matter. California's SIP was most recently updated in 2007 and includes several measures to reduce emissions of NOx and HC, ozone precursor emissions, statewide including the SCAB. These measures include controls for both stationary and mobile sources and are designed to significantly reduce emissions of NOx and HC over the next several years. These mitigation measures are incorporated by reference. (ARB, 2007a and ARB, 2007b)

It is important to note that the total emission reduction tonnage commitment in the SIP is an enforceable State commitment. While the SIP contains estimates of emission reductions expected from each measure, it is the total emission reductions in the aggregate of all existing and proposed new measures combined necessary to attain the federal standards that represents the SIP commitment. As such, in the event a measure does not realize the expected or planned emission reductions, the emission reductions foregone are achieved through another measure or program. As applied to the OGV Fuel Rule, in the event avoidance does occur and the commitment for this measure in the SIP is compromised, there is already in place a mechanism that will be used to mitigate any loss of expected emission reductions. Furthermore, on an on-going basis, ARB works with local air districts to refine and update SIPs to ensure aggressive reductions in PM and ozone-forming emissions are achieved and that new

[7] To be consistent with the non-cancer health impacts in the OGV Fuel Rule ISOR, ARB staff estimated the non-cancer health impacts in this study with the same methodology used in the ISOR. (ARB, 2008)

and revised measures are defined to ensure the emission reduction commitments are met.

CO_2 mitigation measures will be provided as ARB and others implement the measures outlined in the recently adopted AB 32 Scoping Plan. (AB 32, 2008) The AB 32 Scoping Plan contains numerous measures representing a variety of strategies including market mechanisms, regulatory and voluntary measures and fees designed to significantly reduce California's carbon footprint. These measures, while primarily focused on reducing GHG emissions such as CO_2, will also reduce PM and NOx. This is discussed further in the ISOR and the AB 32 Scoping Plan.

Despite the fact the ozone and CO_2 impacts identified in ARB's analysis will be addressed and mitigated through the SIP process and AB 32 Scoping Plan implementation, respectively, ARB still concludes that these impacts will be significant because neither of these impacts will be mitigated to a level less than significant though measures included in the OGV Fuel Rule. However, the substantial health and environmental benefits from the proposed OGV Fuel Rule constitute strong, overriding considerations that amply justify adoption of the rule notwithstanding these significant effects. For this reason, the Executive Officer is expected to consider the adoption of findings that include a CEQA statement of overriding considerations for the significant impacts identified above as part of any final action to approve the OGV Fuel Rule.

4 Biological Impacts

The Southern California Bight (SCB) is a coastal region of unique oceanographic conditions, marine ecosystems and biodiversity. The SCB extends from Point Conception in Southern California to Cabo Colonett and Bahia de San Quintin in Baja California. Habitats within Southern California's ocean ecosystem contain some of the most biologically diverse natural communities in the world. The National Ocean and Atmospheric Administration (NOAA) and other marine groups have carefully assessed the population of marine wildlife in Southern California.

The impacts to the marine ecosystem from commercial, recreational and military activity in the area of the Santa Barbara Channel and the Point Mugu Sea Range is receiving considerable study, in part due to the presence of the Channel Islands Marine Sanctuary and the fact that several endangered and threatened species can be found in the region. In preparing this supplemental environmental analysis, ARB staff considered a wide range of possible areas of concern such as habitat or feeding ground disruption or destruction and harm to marine plant life, (e.g. kelp beds), marine birds or marine fish. Based on the available research and literature and on consultations with NOAA staff, ARB staff determined that in most areas, the small, localized impact from the ships using the open water avoidance route through the Point Mugu Sea Range should not pose a significant adverse environmental impact. (Vetter, 2009 and NOAA, 2008b) However, ARB staff did identify potential effects of ship traffic through the Point Sea Range that could potentially pose a risk and that merited further investigation. These include:

- physical injury or death to marine mammals due to a collision with a ship,

- acoustic impacts of vessels on marine mammals, and
- the changes in risks of oil spills.

Our analysis of these effects is presented below. It is important to note that the use of an avoidance route to avoid the regulatory requirements will not change the number of ships visiting California. However, it would result in a redistribution of ship traffic and emissions from the Santa Barbara Channel to outside the Channel Islands. Because there is no overall increase in traffic, this redistribution should not increase the total risk of ship strikes, oil spills or vessel noise. It will, however, change the location of the possible occurrences of any of these three types of events. Since the risk of these environmental impacts is related to ship traffic density, relocating the traffic to the larger, less geographically constrained area outside the Santa Barbara Channel, will decrease vessel traffic density in the channel. This is a beneficial environmental impact, which contributes to mitigating any small potential adverse impacts in the Point Mugu Sea Range.

4.1 Risk of Marine Mammal Ship Strikes

At certain times of the year, hundreds of thousands of marine mammals may be present along the coast of central and southern California. At least 34 species of cetaceans (marine mammals) have been identified from sightings or stranding the Southern California Bight (SCB). (Forney, 2007) The marine mammal population off California includes baleen whale species, species of porpoises, dolphins, and other toothed whales, pinnipeds (fin-footed semi-aquatic marine mammals such as eared seals, sea lions and fur seals) and the southern sea otter. Some species are purely migrants that pass through southern California waters on their way to calving or feeding ground elsewhere, some are seasonal visitors that remain for a few weeks or months, and others are resident for much or all of the year.

The National Marine Fisheries Services has determined that collisions with vessels can injure or kill protected species (e.g. endangered and threatened species, and marine mammals). (NOAA, 2008) During the fall of 2007, there were four confirmed blue whale fatalities in the Santa Barbara Channel. Of the whales that were examined, all were determined to be struck by ships. Previously, the greatest number of blue whale fatalities in one year off of California was three (in each of the years 1988 and 2002), and these fatalities were separated by hundreds of miles (Marin to San Diego County in 2002) and occurred over a period of several months.

According to NOAA, the most significant effect of shipping on cetaceans is likely to be ship strikes with the larger species of whales with the potential for strikes being a function of the density of the whales, their behavior, and the speed of the ship. (NOAA, 2008b) The most common large whales found within this region are blue, fin, humpback, gray, and sperm whales. All these species except the gray whales are listed as Endangered under the U.S. Endangered Species Act (ESA) (16 U.S.C S 1531). In addition to the ESA, all marine mammals are protected by the Marine Mammal Protection Act (MMPA 1972, amended 1994, 16 U.S.C. S 1431).

These whales typically show feeding or migrating behaviors in the Southern California region. Recent data collected by NOAA on the densities of blue, fin, humpback and sperm whales show that the densities of these species are either similar or less in the regions south of the northern Channel Islands (in the Point Mugu Sea Range) compared to the areas within the Santa Barbara Channel. Based on this data, NOAA staff predicts that the likelihood of ship strikes for blue, fin, humpback and sperm whales would be similar or lower if ships used alternative routes that took them south of the northern Channel Islands. NOAA does not have similar density data for gray whales. However, because the red avoidance route and the existing shipping lane through the Santa Barbara Channel intercept both inshore and offshore gray whale migration routes, NOAA staff did not believe the likelihood of ship strikes would be different for the two routes. (NOAA, 2008b)

4.2 Effects of Vessel Noise on Marine Mammals

Shipping noise, from container ships, tankers and other large ocean going vessels, is low frequency and pervasive in areas of high ship traffic. While it is unlikely to cause acute physical harm, it could cause disruption in diving patterns or cause hearing loss, and it may interfere with important communication signals from marine mammals whose vocalizations are in the low frequency range. (EDC, 2004, NOAA, 2008a) The impacts are not clearly understood and research is ongoing, but the impacts could result in stress or behavior pattern changes in the animals. However, NOAA staff believes that if there are impacts from vessel noise, it is likely to be related to cetacean densities. Since, as shown earlier, the densities for the larger cetaceans is similar or less in regions south of the northern Channel Islands as compared to the Santa Barbara Channel, the impacts from vessel noise would be similar or lower if more ships used the alternative “avoidance” route. (NOAA, 2008b)

4.3 Oil Spills Due to Ship Collisions or Groundings

Substantial volumes of petroleum products are transported off the California Coast from Alaska, foreign countries and between California production sources. POLA and POLB include some of the highest volume oil transfer facilities in the United States. Collisions or ship groundings can occur as a result of these operations. Over the years, several close calls have occurred in the waters off Southern California. A variety of measures, such as traffic separation schemes, safety commissions, and precautionary zones have been established to help reduce the risk of vessel collisions or groundings off the coast or within California Ports.

In 1992, major oil companies, members of the Western States Petroleum Association (WSPA), entered into a voluntary, non-binding agreement, with the guidance of Office of Spill Prevention and Response (OSPR) and the U.S. Coast Guard, to route all tankers carrying crude oil from Alaska to California ports at least 50 nm offshore. This agreement has resulted in approximately 90 percent of all tanker traffic to transit at least 25 nm of the coast and approximately 50 percent at least 50 nm offshore. (Resources, 1995) This results in many of the tankers transiting through the Point Mugu Sea Range in Southern California. More recently, in 2002, a taskforce sponsored in part by the U.S. Coast Guard and OSPR issued recommendations to reduce the risk of vessel collisions or drift groundings off the U.S. West Coast. (West Coast Taskforce, 2002) The project addressed four risk factors most amenable to change, including vessel distance offshore. The recommendations regarding the distance offshore risk factor indicated that higher risks were generally within 25 miles from land along the West Coast of California. The workgroup found that vessels transiting within the higher risk areas have a greater potential for grounding than if they transited further offshore. The workgroup also found that for consistency with existing agreements, where there are not other prevention agreements, tank ships laden with crude oil or other petroleum cargo, transiting coastwise should voluntarily stay within a minimum distance of 50 nm offshore. This recommendation mirrors the WSPA agreement. Based on this assessment for tankers, it can be concluded that for ships adopting an avoidance route, which is further offshore, there should be a decrease in risk of grounding related spills and does not represent an adverse environmental impact.

4.4 Summary of Impacts to Biological Resources

Based on the best available information regarding distribution of large whales in the SCAB, vessel noise impacts and oil spill risks, ARB concludes that shippers' extensive use of an avoidance route would not have a significant adverse effect on biological resources.

5 Other Impacts - *OGV Increased* Speeds Through the Point Mugu Sea Range

The U.S. Navy has also argued that ships using an avoidance route may increase vessel speed to make up time lost to having to travel the additional distance. Below we provide a brief analysis of the impact of increased speed on the results from our analysis of the avoidance route scenarios and explain why ARB did not include increased speed in its air quality and biological resources analysis.

In open waters, ships speeds typically operate at about 80 percent of the maximum continuous rating of the engine (MCR), about 20 knots. (ARB, 2008) Increasing the speed by 1 knot, to about 21 knots, will increase the engine load to about 90 percent of MCR. While this is operationally feasible, ARB staff does not believe OGV operators will choose to increase speeds to a great extent. This is because engine manufacturers do not recommend using higher loads. (MANBW) Furthermore, increasing ship speed decreases fuel efficiency and, therefore, has economic disbenefits. As shown in Table 3, in the event ships do increase their speed through the Point Mugu Sea Range, the emissions will not change significantly from those previously presented in Table 1. Increasing vessel speeds in the avoidance route will increase emissions from about 1 to 3%, depending on the pollutant and have negligible impacts on the air quality and public health findings discussed previously.

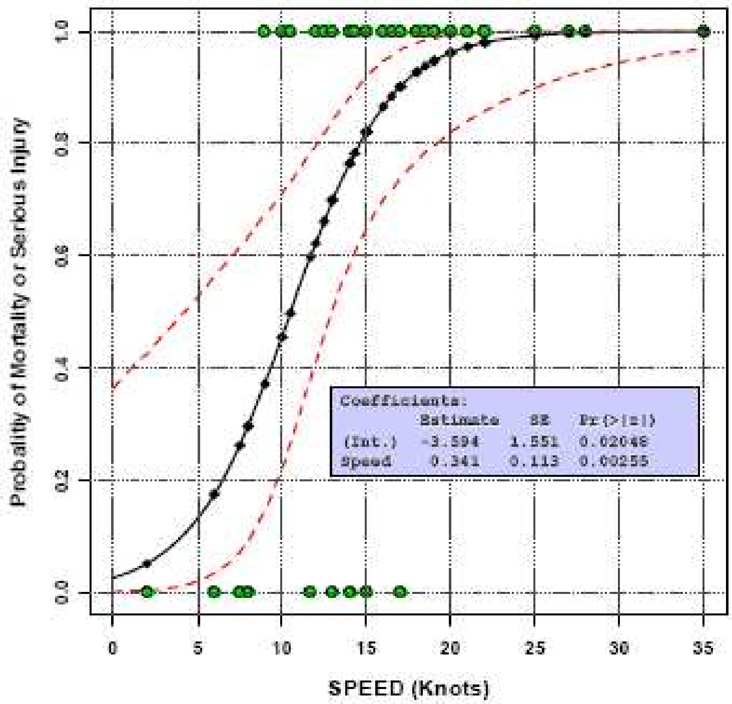
Table 3. Estimated OGV Statewide Emissions (tons/day) Comparing Impacts due to Increasing Vessel Speed from the Default Speed (S_{20}) of 20 knots to an Increased Speed (S_{21}) 21 Knots in Avoidance Route

Pollutant	Baseline (No Avoidance/No Regulation) Default Speed S_{20}	OGV Fuel Rule with 50% Avoidance S_{20}	OGV Fuel Rule with 50% Avoidance S_{21}	Percent Change* OGV Fuel Rule with 50% Avoidance (S_{21} vs. S_{20})	OGV Fuel Rule with 100% Avoidance Default Speed (S_{20})	OGV Fuel Rule with 100% Avoidance Increased Speed (S_{21})	Percent Change* OGV Fuel Rule with 100% Avoidance (S_{21} vs. S_{20})
SOx	147	62	63	2%	78	80	3%
$PM_{2.5}$	19	10	10	2%	12	12	3%
NOx	212	216	218	1%	230	234	2%
HC	7.4	7.8	7.8	1%	8.2	8.3	2%
CO_2	9168	9332	9417	1%	9834	9989	2%

*Positive value indicates an increase in emissions (disbenefit) relative to the baseline. Negative values represent a decrease in emissions (benefit) relative to the baseline.

With respect to marine mammal strikes, a small increase in speed should also not result in increased likelihood of ship strikes relative to the scenarios previously evaluated. Increased speed has been shown to increase the likelihood of ship strikes for some large marine mammals, especially when ships are going faster than about 10 to 13 knots. (Pace and NOAA World, 2008) However, as shown in Figure 9, increasing the speed from 20 knots to 21 knots would not likely have any appreciable increase in risk to marine mammals.

Figure 9. Relationship Between Vessel Speed and Probability of Mortality for Whale Strikes (Pace).



ARB staff concludes that an increase in speed of vessels using an avoidance route is both unlikely and speculative. Even if vessels were to utilize the slightly faster speeds that they are capable of while on an avoidance route, the faster speed would not substantially alter ARB's analysis of emissions and air quality impacts or the analysis of impacts to biological resources, for the reasons described above.

6 Cumulative Impacts

6.1 Cumulative Impact Analysis Requirements

The cumulative impacts analysis considers whether the cumulative environmental effects of the project combined with the effects of other past, present, or reasonably foreseeable future activities are significant. In addition, the analysis considers whether the proposed regulation's effects are cumulatively considerable when viewed in connection with the effects of the other projects. The U.S. Navy has pointed to voluntary and mandatory speed reduction programs to reduce emissions or protect endangered or protected species that in combination with the OGV Fuel Rule could increase the likelihood that ships will adopt an avoidance route. The U.S. Navy contends that when ships adopt an avoidance route, it could adversely affect air quality and marine mammals.

As discussed earlier, a number of agencies or organizations have implemented or are proposing vessel speed reduction programs. These programs are described in more detail below.

6.2 Past, Present, and Reasonably Foreseeable Activities

6.2.1 Potential ARB Vessel Speed Reduction Program

ARB is in the process of developing a technical assessment report for the purpose of evaluating impacts of a VSR program on vessel emissions. Vessel speed reduction is an effective strategy to reduce emissions by reducing the energy output of the main propulsion engine. Speed reduction is an operational change that all vessels can make to reduce both NOx and PM emissions, and it doesn't require any modifications to the vessel. Emissions from vessels are directly related to the energy required to move the vessel through water. Since energy output is proportional to the cube of the speed, moderate reductions in speed result in large reductions in energy output of the engine, thus reducing emissions significantly. The technical assessment will evaluate the emissions and health impacts, timing and geographical range, technical and economic feasibility, and what approaches ARB may consider taking, such as regulatory or non-regulatory measures in considering a VSR measure.

There are two types of approaches currently under consideration, voluntary or regulatory. In addition, ARB is considering two types of VSR operational zones. The first type of zone is a bubble zone with the POLA and POLB, or other ports under consideration, located at the center of the circular bubble. This approach is similar to the type of VSR zone used in the POLA and POLB VSR programs. The second is similar to the OGV Fuel Rule, is a coastal reduction zone that extends from the coastline from 24 to 40 nm. Currently, ARB is evaluating a bubble zone with either a 24 nm or 40 nm radius. For either the coastal zone or the bubble zone approach, the vessel speed limit currently under consideration is 12 knots.

6.2.2 Existing Voluntary POLA and POLB VSR Program

Since 2001, the POLA and POLB have implemented a voluntary VSR program to reduce emissions. Since 2005, the POLB has promoted voluntary compliance by offering the Green Flag program. Under the program, the POLB offers Green Flag environmental awards to individual ships and awards and discounted dockage fees to vessel operators who consistently slow down ship speeds to reduce air pollution. The program is voluntary, and relies on the co-operation of vessel operators and ship captains.

The initiative provides incentives and reduced dockage fees for vessels to slow down to 12 knots when 20 nautical miles from Point Fermin. Under a recent change approved by Commissioners during the program's annual review, the program was expanded to offer incentives to slow down to 12 knots when 40 nautical miles from Point Fermin.

Additionally, in 2008, the POLB and POLA enacted an incentive program that pays the cost differential for using the more expensive, cleaner fuel out to a distance of either

20 nm or 40 nm as ships visit the Port. The shippers select either the 20 nm zone or 40 nm zone and must also comply with VSR within the selected zone.

6.2.3 *Pending Center for* **Biological Diversity Litigation**

In 2008, the Center for Biological Diversity filed suit against the U.S. Department of Homeland Security and the United States Coast Guard. The suit is seeking an order compelling the Coast Guard to consult with the National Marine Fisheries Service (NMFS) regarding the effects of ship traffic on endangered and threatened species in the waters off the California coast, including the Santa Barbara Channel. In a letter to the Secretary of Commerce and the Assistant Administrator for Fisheries, the Center for Biological Diversity formally requested the NMFS promulgate emergency regulations that impose a 10 knot speed limit in the Santa Barbara Channel for all vessels over 65 feet in length. (Cummings, 2007)

6.3 Cumulative Impacts Analysis

In assessing the potential for cumulative environmental effects, ARB must determine whether the projects described above will have significant cumulative impacts and whether the effects of the proposed regulation are cumulatively considerable. In this analysis, ARB has identified actual and potential VSR projects that will possibly influence the number of ships adopting an avoidance route, and therefore potentially increase the severity of any adverse environmental impacts resulting from such routing.

The POLA and POLB VSR programs are based on a circular speed reduction zone that extends out in all overwater directions (circular bubble) centered at the ports. This type of zone does not substantially favor either a near-shore route through the Santa Barbara Channel or the avoidance route, outside the channel. Furthermore, the POLA and POLB VSR measures are incentive-based voluntary programs to reduce speed, so vessel operators have no reason to take a longer route if they elect not to follow the voluntary speed limit. Therefore, the POLA and POLB VSR programs will not influence the number of ships that will adopt an avoidance route and, therefore, are not included in further cumulative effects analysis.

Similarly, one of the approaches in the VSR proposal under study by ARB would use an overwater circular bubble speed zone and would not affect the level of avoidance since the shape of the zone does not favor one route over another route. A second approach under consideration by ARB would establish a zone that extends out either 24 or 40 nm from the coastline, with a proposed vessel speed limit of 12 knots. If this approach is enacted within the Santa Barbara Channel, it may influence the number of ships that adopt an avoidance route and is included in the cumulative effects analysis. However, the lawsuit and petition filed by the Center for Biological Diversity seeks a mandatory 10 knot speed limit within the Santa Barbara Channel, which is more restrictive than the 12 knot speed limit being studied by ARB. Therefore, the cumulative impacts analysis presented here focuses on the impacts of the ARB Fuel Rule combined with the additional impacts resulting from the more restrictive 10 knot speed limit in the Santa Barbara Channel, proposed by the Center of Biological Diversity to protect endangered and threatened species.

The potential environmental effects of VSR in the Santa Barbara Channel are similar to the effects discussed in this analysis for the OGV Fuel Rule when compared to the Baseline Scenario. Since VSR requirements would add to the transit time for ships within the Santa Barbara Channel, some vessel operators may elect to use a route south of the channel if they believe the lack of a speed limit offsets the longer travel distance and other factors militating against a route outside the channel shipping lanes (see discussion in section 3.1, above). Ships that remain in the channel and subject to VSR would have reduced emissions and pose a reduced threat to whales compared to the baseline because lower speeds result in reduced emissions for every mile traveled and a lower risk of whale strikes. Ships that use the avoidance route would produce emissions and whale strike risks more in line with baseline emissions and the baseline whale strike threats, as discussed in the preceding sections of this report.

The combined adverse environmental effects of the OGV Fuel Rule and VSR cannot be greater than the environmental effects identified for the OGV Fuel Rule alone under the 100% avoidance scenario. This is because the combined influence of VSR and the regulation on decisions by vessel operators to use an avoidance route cannot result in an avoidance rate greater than the 100% analyzed under that scenario.

6.3.1 Emissions and Air Quality

Since the avoidance rate is not likely to reach 100% under the OGV Fuel Rule, the rule combined with VSR in the Santa Barbara Channel may produce a higher avoidance rate than the OGV Fuel Rule alone. Ignoring other variables, a comparison of the 50% and 100% avoidance scenarios in this document's environmental assessment would suggest that higher avoidance levels are associated with a slightly higher NOx, CO_2 and HC emissions than under the baseline of existing conditions, but are also associated with lower levels of $PM_{2.5}$ and ozone and $PM_{2.5}$ and ozone-related public health impacts than with lower diversion rates. The potential for slightly higher NOx, CO_2 and HC emissions with a higher avoidance rate associated with cumulative impacts would tend to be offset by lower emissions and the significant reductions in $PM_{2.5}$ and SOx from vessels that continue to transit the Santa Barbara Channel.

To evaluate the cumulative emissions impacts associated with combining VSR with the OGV Fuel Rule, ARB staff estimated the Statewide ocean-going vessel emissions of NOx, $PM_{2.5}$, SOx, HC, and CO_2 assuming both the ARB Fuel Rule and a 10 knot speed limit in the Santa Barbara Channel were implemented and contrasted that against the Baseline Scenario. Emissions were estimated as previously described in Section 4; however it was assumed that any vessel transiting in the Santa Barbara Channel would operate at 10 knots per hour. Emissions were estimated for the 2005 baseline, a 50% avoidance route cumulative impacts scenario (50% avoidance and VSR) and a 100% avoidance route cumulative impacts scenario (100% avoidance and VSR).

Table 4. Estimated OGV Statewide Emissions (tons/day) Comparing Impacts Due To Cumulative Impacts Of 10 Knot Vessel Speed Limit In The Santa Barbara Channel Combined With Avoidance

Pollutant	Baseline Scenario	OGV Fuel Rule with 50% Avoidance and 10 knot VSR in Santa Barbara Channel	% Change* (50% Avoidance +VSR vs. Baseline)	OGV Fuel Rule with 100% Avoidance and 10 knot VSR in Santa Barbara Channel	% Change* (100% Avoidance + VSR vs. Baseline)
SOx	147	62	-58%	78	-47%
$PM_{2.5}$	19	10	-47%	12	-36%
NOx	212	211	-1%	229	8%
HC	7.4	7.6	3%	8.2	11%
CO_2	9168	9130	-0.4%	9829	7%

*Positive value indicates an increase in emissions (disbenefit) relative to the baseline. Negative values represent a decrease in emissions (benefit) relative to the baseline.

As shown in Table 4, for 100% avoidance combined with VSR, the change in emissions is very similar to that estimated for the OGV Fuel Rule with 100% avoidance (see Table 1). There are significant reductions in SOx, $PM_{2.5}$, and increases in NOx, HC and CO_2. For the 50% Avoidance Route Scenario combined with VSR there are significant decreases in SOx, $PM_{2.5}$, small decreases in NOx and CO_2 and a small increase in HC, as compared to the baseline. At 50% avoidance, the decreases in emissions with VSR are greater than those estimated for the OGV Fuel Rule alone (50% Avoidance Route Scenario). This is because greater reductions in these pollutants result when ships transiting the Santa Barbara Channel use cleaner low sulfur fuel required by the OGV Fuel Rule and travel at a reduced speed, as required by VSR. This reduced speed also helps to increase the reductions in HC from ships such that there is a benefit when using the cleaner fuel and operating at a reduced speed as compared to just using the cleaner fuel.

Based on these emission estimates we conclude that the impacts on air quality and public health should be similar to those if only the OGV Fuel Rule is implemented. That is, regardless of the rate of avoidance, there will be a significant decrease in PM and PM-related health impacts if both the OGV Fuel Rule and a VSR requirement are implemented in the Santa Barbara Channel. At higher rates of avoidance there could be slight increases in the CO_2 emissions, so that cumulative CO_2 emissions from both the OGV Fuel Rule and VSR program would exceed the baseline ship CO_2 emissions and the increased CO_2 emissions attributable to the OGV Fuel Rule alone. In addition, because combined, the VSR and the OGV Fuel Rule would result in less NOx emissions for avoidance rates less than 100%, we would expect in most cases lower overall ozone levels than with the OGV Fuel Rule alone (without VSR). However, given the complex relationships between atmospheric chemistry and ozone formation, there is a potential to have cumulative effects similar to those seen for the OGV Fuel Rule alone, i.e. there may be localized areas that have increases in ozone levels depending on the level of avoidance routing by shippers. However, we would not expect these localized increases to be greater than those already discussed above regarding implementation of the OGV Fuel Rule alone.

As stated in preceding sections, shippers' use of avoidance routing is uncertain and speculative. But if a high avoidance rate is assumed (50% or 100%, under ARB's modeling), use of avoidance routes could result in increased cumulative CO_2 emissions and might also result in higher ozone levels for certain areas along the coast when compared to the baseline.

For these reasons, we conclude that the OGV Fuel Rule and VSR requirement may result in significant cumulative effects in the areas of air quality, specifically in the form of increased CO_2 emissions and increased levels of ozone in localized onshore areas, and on public health as a result of localized ozone impacts. While there is a very small increase in CO_2 emissions, less than 0.03 percent,[8] (50,000 tons per year as reported in the ISOR due to the net change in fuel-cycle CO_2 emissions from the OGV Fuel Rule and a maximum of 243,000 tons per year from avoidance) relative to the overall CO_2 emissions from shipping is very small, we believe this may represent a significant adverse environmental impact. In addition, to be conservative the potential for small localized increases in ozone may also constitute a significant adverse cumulative impact resulting from vessel avoidance routing.

Given our determination that the adverse cumulative effects of localized increases in ozone and overall increases in GHG emissions are significant, we must also conclude that the OGV Fuel Rule's contribution to these effects is cumulatively considerable. As noted previously, ARB believes shippers' use of an avoidance route and any resulting environmental impacts are speculative. But the OGV Fuel Rule is one of just two foreseeable projects that have been identified as potentially contributing to use of an alternate route by vessel operators, and the rule's contribution to any changes in vessel routing and resulting environmental effects is likely to be cumulatively considerable.

6.3.2 Marine Mammals

The analysis elsewhere in this document on the OGV Fuel Rule's impacts on marine mammals concluded that even under the 100% Avoidance Route Scenario, ships are not likely to strike a greater number of whales when compared to the baseline and might strike fewer whales than if ships remain in the Santa Barbara Channel. This conclusion was based on the fact that the best available data indicates that whale species in the area are likely to be present in the Santa Barbara Channel at densities that are equal to or greater than the expected densities south of the northern Channel Islands.

The addition of VSR requirements in the Santa Barbara Channel does not change the conclusions that a shift of some or all vessel traffic to a route south of the channel will not have an adverse effect on large marine mammals that are at risk of death or injury from vessel strikes. The OGV Fuel Rule combined with VSR measures will therefore not have a significant adverse cumulative effect on marine mammals.

ARB staff notes that if VSR were implemented in the Santa Barbara Channel and a significant number of ships use an avoidance route outside the Channel, the benefit of

[8] The Marine Environment Protection Committee of the International Maritime Organization estimates the 2007 CO2 emissions from international shipping to be approximately 843 million tonnes or about 2.7% of global CO2 emissions. (IMO, 2008)

slower vessel speeds in protecting whales would be diminished. But in that event, the continuing risk to whales from ships traveling at faster speeds is not a cumulative effect for purposes of ARB's analysis, since faster speeds are part of the environmental setting and would not result from either a VSR requirement or the OGV Fuel Rule.

6.3.3 Mitigation of Cumulative Effects on Air Quality and Public Health

Mitigation measures for ozone are provided in State Implementation Plans (SIPs) that are developed by local air districts and approved by ARB. SIPs include federally enforceable commitments and measures that will ensure California attains the federal air quality standards for ozone and particulate matter. California's SIP was most recently updated in 2007 and includes several measures to reduce emissions of NOx and HC, ozone precursor emissions, statewide including the SCAB. These measures include controls for both stationary and mobile sources and are designed to significantly reduce emissions of NOx and HC over the next several years. These mitigation measures are incorporated by reference. (ARB, 2007a and ARB, 2007b) It is important to note that the total emission reduction tonnage commitment in the SIP is an enforceable State commitment. While the SIP contains estimates of emission reductions expected from each measure, it is the total emission reductions in the aggregate of all existing and proposed new measures combined necessary to attain the federal standards that represents the SIP commitment. As such, in the event a measure does not realize the expected or planned emission reductions, the emission reductions foregone are achieved through another measure or program. As applied to the OGV Fuel Rule, in the event avoidance does occur and the commitment for this measure in the SIP is compromised, there is already in place a mechanism that will be used to mitigate any loss of expected emission reductions. Furthermore, on an on-going basis, ARB works with local air districts to refine and update SIPs to ensure aggressive reductions in PM and ozone-forming emissions are achieved and that new and revised measures are defined to ensure the emission reduction commitments are met.

CO_2 mitigation measures will be provided as ARB and others implement the measures outlined in the recently adopted AB 32 Scoping Plan. (AB 32, 2008) The AB 32 Scoping Plan contains numerous measures representing a variety of strategies including market mechanisms, regulatory and voluntary measures and fees designed to significantly reduce California's carbon footprint. These measures, while primarily focused on reducing greenhouse gas (GHG) emissions such as CO_2, will also reduce PM and NOx. This is discussed further in the ISOR and the AB 32 Scoping Plan.

Therefore, the project's contributions to cumulative impacts of increased ozone and GHG emissions will be mitigated through the existing SIP process and AB 32 Scoping Plan implementation, respectively. ARB concludes that these cumulative impacts will nonetheless be significant because they will not be mitigated to a level less than significant though measures included in the OGV Fuel Rule. However, the substantial health and environmental benefits from the proposed OGV Fuel Rule constitute strong, overriding considerations that amply justify adoption of the rule notwithstanding the significant cumulative effects. For this reason, the Executive Officer is expected to consider the adoption of findings that include a CEQA statement of overriding considerations for the significant cumulative impacts identified above as part of any final action to approve the OGV Fuel Rule.

7 Analysis of Alternatives

This section evaluates a reasonable range of alternatives to the OGV Fuel Rule to determine whether any feasible alternative would attain the objectives of the OGV Fuel Rule while avoiding or substantially lessening one or more of the significant environmental effects. The ISOR, chapter V, for the OGV Fuel Rule identified four regulatory alternatives to the proposed regulation (ARB, 2008). These alternatives are summarized below and also represent a reasonable range of potentially feasible alternatives to the proposed regulation.

Three of the alternatives (Alternatives 1, 2 and 4, below) would lessen the environmental impacts discussed above that may result from ship owners and operators adopting avoidance routes outside the 24 nm zone. Because these three alternatives would not regulate ships traveling in the Santa Barbara Channel differently from those using an avoidance route, they would not provide shippers with any incentive for using avoidance routes and are considered to be “route neutral”. Since there is no benefit to using the avoidance route, the ship operators and owners would likely stay in the established Santa Barbara Channel route under each of these alternatives. Therefore, these three alternatives would lessen one or more of the significant environmental impacts that would result from OGV Fuel Rule avoidance. However, none of these three alternatives would accomplish the purpose for which ARB proposed the OGV Fuel Rule. Air quality improvements and associated public health benefit would not be realized under any of these three alternatives within the time frame of the planned rule. Only Alternative 2 has the potential for eventually achieving benefits comparable or superior to the proposed rule, but this benefit would be deferred for several years and depends on future actions by national and international bodies.

The fourth alternative, Alternative 3 below, could result in shippers using an avoidance route and would not achieve the same benefit to air quality and public health as the proposed regulation. Therefore, ARB anticipates this alternative would not reduce significant environmental effects and would not achieve the purpose of the regulation.

<u>Alternative 1: Do Nothing</u>

The first alternative, the “Do Nothing” option, clearly does not accomplish the purpose of the regulation. Namely, this alternative would not achieve the substantial emission reductions and associated health benefits to residents of coastal communities.

Alternative 2: Rely on U.S. Environmental Protection Agency (EPA) and International Maritime Organization (IMO) Regulations

The second alternative, "Rely on U.S. EPA and IMO regulations, is similar to the first option but anticipates subsequent benefits of federal and international rules. As discussed in detail in the staff report, the benefits of existing and expected regulations are only expected to achieve comparable health benefits to the ARB regulation beginning in 2015 at the earliest. However, prior to 2015 (as shown in Figure V-2 of the staff report) these rules do not achieve nearly the same level of benefits in terms of avoided premature deaths. In addition, there is no guarantee that comparable benefits will be achieved in 2015. Comparable benefits will only be achieved if the U.S. EPA's application to the IMO to create an "Emission Control Area" (including California) is expeditiously approved.

Alternative 3: Implement the Regulation as Proposed, Except Without the Lower Sulfur Limit of 0.1 Percent in 2012

The third alternative, "Implement the Regulation as Proposed, Except Without the Lower Sulfur Limit of 0.1 Percent in 2012," neither fully achieves the purpose of the regulation, nor is it expected to substantially mitigate the potential environmental impacts of the regulation. As discussed in the staff report, the alternative results in about 10% less particulate matter (PM) emission reductions beginning in 2012 when the "Phase II" 0.1% sulfur distillate fuel is required (see Table V-4 in the staff report). In addition, vessels would still be required to use the more expensive distillate fuel, so there would not be a significant change in the incentive for ships to reroute to avoid the use of this fuel. Specifically, while the 0.1% sulfur distillate is expected to be somewhat more expensive than the higher sulfur "Phase I" distillate, the more significant price differential is the increase from standard heavy fuel oil to distillate. This differential was estimated in the staff report to be $373/tonne (see Table VIII-6 in the staff report). The jump to Phase II distillate fuel is expected to increase the differential by an extra $60/tonne to $433/tonne.

Alternative 4: Implement the Regulation Within 24 nm of California's Major Ports Rather than within 24 nm of the California Coastline

The fourth alternative, "Implement the Regulation Within 24 nm of California's Major Ports Rather than Within 24 nm of the California Coastline," may mitigate the small localized increases in ozone and the increases in CO_2 that could potentially occur if the OGV Fuel were implemented and OGV used the avoidance route. However, the emission reductions and public health benefits for Alternative 4 would be much less than those from the OGV Fuel Rule even with avoidance and clearly would not be as effective in reducing emissions.

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Appendix 1

Air Quality Modeling to Determine the Impacts of Potential OGV Avoidance Routes on South Coast Air Basin Air Quality

Regional Air Quality Modeling Section
Modeling and Meteorology Branch
Planning and Technical Support Division
Air Resources Board
California Environmental Protection Agency
Sacramento, California 95814

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1.1 *Introduction*

To investigate the impact of ocean going vessels (OGVs) evading the fuel use requirements in the regulation "Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline" (OGV Fuel Rule) by transiting through the Point Mugu Sea Range on onshore gaseous and fine particulate matter ($PM_{2.5}$) concentrations, a regional air quality model was used to simulate annual concentrations for Southern California. Three scenarios were simulated: 1) a baseline, do nothing scenario, where the ships travel in the established Santa Barbara Channel, without OGV Fuel Rule regulatory requirements, 2) a scenario where the regulatory requirements were applied within the RCW and 50 percent of the vessels used an avoidance route and 3) a scenario where the regulatory requirements were applied within the RCW and 100 percent of the vessels used an avoidance route. The impact of OGVs avoiding the OGV Fuel Rule on inland air quality and public health was estimated from the difference between each evasion scenario and the Baseline Scenario.

1.2 *Model Application*

1.2.1 Model configuration

To simulate gaseous and $PM_{2.5}$ concentrations, the Community Multi-scale Air Quality (CMAQ) model version 4.6 was exercised for the year 2005 (http://www.cmaq-model.org/). The CMAQ model was developed by the U.S. EPA, and has been used by ARB in previous regional air quality modeling analyses. The year 2005 was selected because it was also used as the base year for the South Coast Air Quality Management District's $PM_{2.5}$ State Implementation Plan (SIP) development (SCAQMD, 2007).

For the analysis described herein, the emissions inventory and atmospheric chemistry were described using the Carbon Bond V (CB05) gas-phase chemical mechanism and the AERO4 aerosol modules. Within the CMAQ model, particulate matter were grouped into three log-normal modes that correspond to the ultrafine (aerodynamic diameter (D_p) < 0.1 μm), fine (0.1 μm $< D_p < 2.5$ μm), and coarse ($D_p > 2.5$ μm) particles sizes. Concentrations of $PM_{2.5}$ were the sum of all particulate matter concentrations with D_p less than 2.5 μm.

1.2.2 Domain setup

The modeling domain covers the South Coast Air Basin with 116 by 80 horizontal grid cells of 5 km (Figure 1). The vertical structure of the air quality modeling domain was determined by the layer structure of the meteorological model. In this analysis, there are nine layers extending to the top of the meteorological domain. The lowest eight layers extend to approximately 5 kilometers above surface.

The meteorological input fields required by the air quality model were generated using the MM5 prognostic meteorological model (Grell *et al.*, 1994). The MM5 model is recommended by the U.S. EPA (EPA, 2007) for air quality modeling applications and has been used for preparing ozone and PM SIP analyses in Central and Southern California. The MM5 model was used to generate hourly meteorological fields for the year 2005. The Meteorology-Chemistry Interface Processor (MCIP) version 3.2, which is part of the CMAQ software package, was used to generate model-ready meteorological inputs for CMAQ model from the MM5 output files (http://www.cmascenter.org).

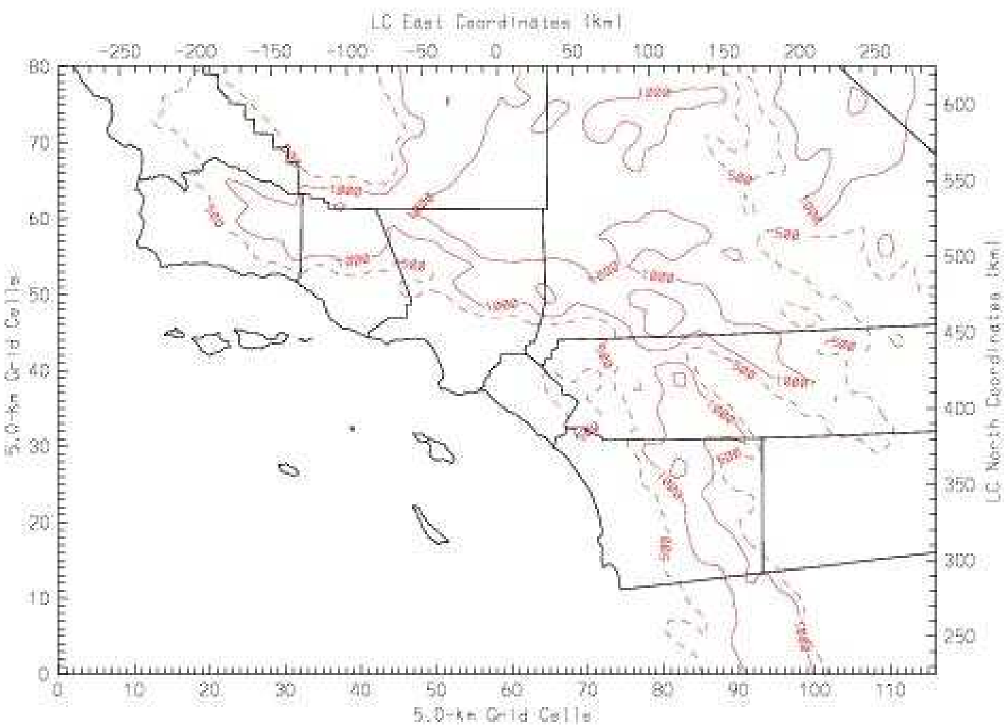

Figure 1. The Southern California Ozone Study (SCOS) modeling domain showing terrain contours.

1.2.3 Initial and boundary conditions

The boundary and initial gaseous and PM concentrations required for the air quality simulations were based on the U.S. EPA definition of "clean air" (EPA, 1991). Since the area of concern, the Santa Barbara Shipping Channel and Point Mugu Sea Range, is near the center of the simulation domain, as shown in Figure 1, the impact of boundary condition (BC) should be minimal. Each simulation included a 10-day spin-up period to minimize the influence of the initial conditions.

1.2.4 Emissions Inventory

Emissions for all sources (e.g. stationary, area-wide, off-road, on-road, biogenic, and OGV) in the modeling domain are considered in the CMAQ air quality model simulations, since the model takes into account the chemical interactions of all pollutants in the airshed on the production of pollutants of interest (ozone, total $PM_{2.5}$, $PM_{2.5}$ nitrates, and $PM_{2.5}$ sulfates). For non-OGV emissions, the year 2005 emission inventory that is used in this modeling analysis is based on the same California Emissions Inventory Forecast System (CEFS) version (1.06) of ARB's Emissions Inventory as was used by the SCAQMD in the preparation of their $PM_{2.5}$ SIP.

The emissions for each OGV avoidance scenario are estimated by making adjustments to the baseline OGV Fuel Rule inventory. The avoidance scenarios were estimated by determining likely avoidance routes around the Channel Islands north of San Pedro Bay and outside of the 24 nautical mile regulatory zone from the south. Two scenario inventories were calculated, the first assuming that half of the ship traffic avoided the regulatory zone ("50% avoidance scenario"), and the second assuming that all of the ship traffic avoided the regulatory zone ("100% avoidance scenario"). It was assumed that ships avoiding the regulatory zone in the two scenarios emitted pollutants at the same rate and at the same speed as they would travel inside of the regulatory zone without vessel speed restrictions nor fuel sulfur restrictions. For those OGV transiting within the regulatory zone it was assumed they used the fuels required by the OGV Furl Rule. A comparison between OGV emissions for each of the two scenarios, the baseline emissions, and the total emissions for the South Coast Air Basin is shown in Table 1.

The emissions inventory was gridded into a 4 km by 4 km statewide domain, then mapped into the 5-km modeling domain described in the previous section with mass conservation. OGV emissions are treated as an area-wide emission source, thus all the OGV emissions are limited to the surface layer. The impact of OGV emission height on air quality model performance is considered to be negligible, as was discussed previously in appendix E-2 of the OGV Fuel Rule Initial Statement of Reasons (ARB, 2008).

Table 1. **Comparison Between OGV Emissions for Each Scenario and Total Emissions from all Sources in the South Coast Air Basin.**

Emission Species	OGV Emissions (tons/day)			SCAB Total Emission (tons/day)
	Base Case	50% Evasion	100% Evasion	
NO_x	123.8	125.3	133.7	1208.0
SO_x	89.1	45.6	56.3	156.8
VOC	4.5	4.6	4.9	2461.4
$PM_{2.5}$ SO_4	1.6	1.0	1.2	18.7
$PM_{2.5}$ EC	0.4	0.3	0.3	19.9
Other PM2.5	8.5	5.4	6.4	134.8

1.3 *Simulation Results*

The CMAQ air quality model was run for the year 2005 for each scenario. Hourly gaseous and aerosol concentrations for each grid cell within the domain were calculated. The results from each simulation were used to calculate, by grid cell, the annual maximum 8-hour ozone (O_3) concentration, and the annual average concentrations of $PM_{2.5}$ total, $PM_{2.5}$ sulfate (SO_4), and $PM_{2.5}$ nitrate (NO_3).

The differences in gaseous and particulate concentrations between the Baseline Scenario and each of the avoidance scenarios were used to illustrate the impact of avoidance on air quality.

Figures 2 and 3 provide a summary of the modeling results in the form of percentage decreases (i.e. positive values indicate concentration decreases and negative values indicate increases). In Figure 2, the percent change in maximum 8-hour ozone concentrations that can be attributed to the two evasion scenarios is shown. In Figure 3, the percent changes in the annual average concentrations of $PM_{2.5}$ are provided.

The air quality model performance was discussed previously in appendix E-2 of the OGV Fuel Rule Initial Statement of Reasons. (ARB, 2008)

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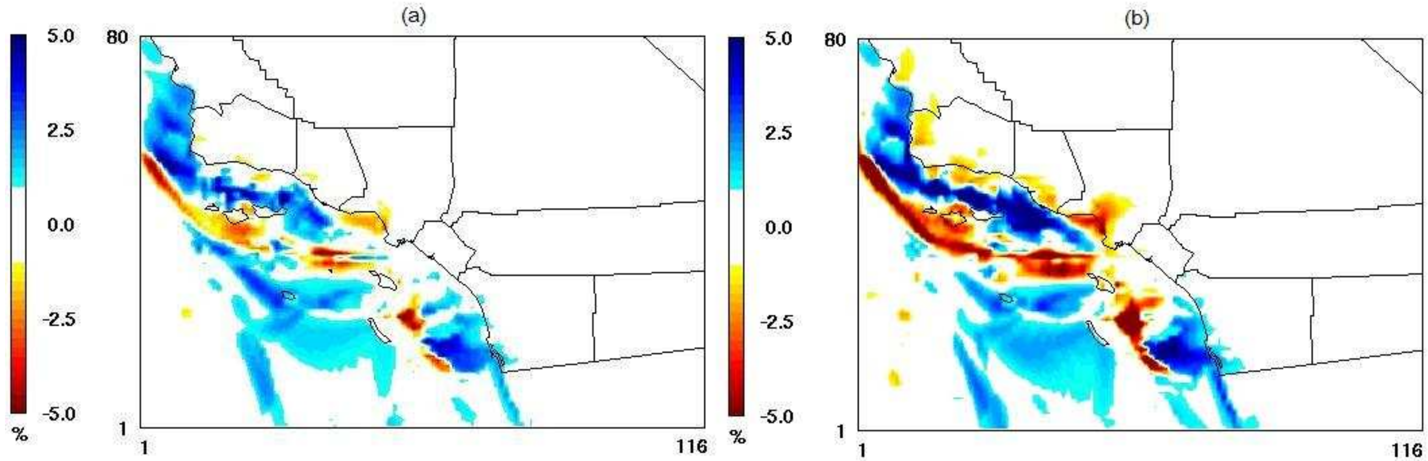

Figure 2. The figures above show the benefit in the form of percentage decrease (i.e. a negative value is a decrease) in annual maximum 8-hour O3 concentration due to (a) 50% avoidance of OGV with fuel regulation, (b) 100% advoidance of OGV with fuel regulation. Only changes > 1% and < -1% are shown in the plot.

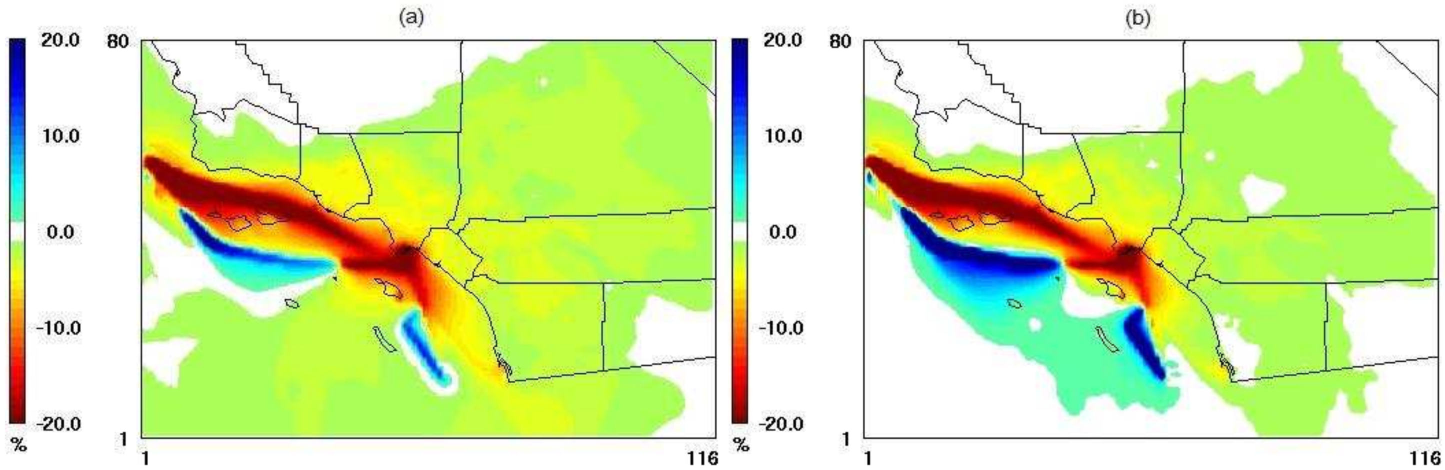

Figure 3. The figures above show the benefit in the form of percentage decrease (i.e. a negative value is a decrease) in annual averaged $PM_{2.5}$ concentration due to (a) 50% avoidance of OGV with fuel regulation, (b) 100% advoidance of OGV with fuel regulation. Only changes > 1% and < -1% are shown in the plot.

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Appendix 2

Summary of Annual 2005 PM and Ozone Health Effects Associated with 50% and 100% Avoidance Route Scenarios

Total $PM_{2.5}$

50% Avoidance Scenario

The estimated non-cancer health impacts from total $PM_{2.5}$ (primary and secondary) resulting from **difference** between the Baseline Scenario and the 50% Avoidance Scenario for 2005 emissions are as follows:

- 600 premature deaths per year (160 to 1,000, 95% Confidence Interval (CI)I)
- 17,000 asthma attacks per year (6,600 to 28,000, 95% CI)
- 200 hospital admissions per year – respiratory (50 to 350, 95% CI)
- 230 hospital admissions per year – cardiovascular (130 to 340, 95% CI)
- 1,500 acute bronchitis per year (0 to 3,200, 95% CI)
- 105,000 work loss days per year(89,000 to 122,000, 95% CI)
- 613,000 minor restricted activity days per year (500,000 to 726,000, 95% CI)

In each case, the values reported represent increased benefits (less adverse health effects) relative to the Baseline Scenario.

100% Avoidance Scenario:

The estimated non-cancer health impacts from total $PM_{2.5}$ (primary and secondary) resulting from **difference** between the Baseline Scenario and the 100% Avoidance Scenario for 2005 emissions are as follows:

- 500 premature deaths per year (140 to 850, 95% CI)
- 14,500 asthma attacks per year (5,600 to 23,400, 95% CI)
- 165 hospital admissions per year – respiratory (40 to 290, 95% CI)
- 195 hospital admissions per year – cardiovascular (110 to 280, 95% CI)
- 1,200 acute bronchitis per year (0 to 2,700, 95% CI)
- 89,000 work loss days per year(75,000 to 102,000, 95% CI)
- 516,000 minor restricted activity days per year (421,000 to 611,000, 95% CI)

In each case, the values reported represent increased benefits (less adverse health effects) relative to the Baseline Scenario.

Ozone

50% Avoidance Scenario

The estimated non-cancer health impacts from ozone resulting from **difference** between the Baseline Scenario and the 50% Avoidance Scenario for 2005 emissions are as follows:

- Premature Deaths
  0.032 per ozone day (0.023 to 0.042, 95% CI)
  7 per year (5 to 9, 95% CI, April to October for ozone days)
  11 per year (8 to 15, 95% CI, whole year for ozone days)

- Hospital Admissions, All Respiratory
  0.252 per ozone day (0.086 to 0.416, 95% CI)
  54 per year (18 to 90, 95% CI, April to October for ozone days)
  92 per year (31 to 150, 95% CI, whole year for ozone days)

- School Loss Days
  55 per ozone day (14 to 96, 95% CI)
  12,000 per year (3,100 to 20,500, 95% CI, April to October for ozone days)
  20,000 per year (5,300 to 35,000, 95% CI, whole year for ozone days)

- Minor Restricted Activity Days
  150 per ozone day (60 to 240, 95% CI)
  32,000 per year (13,000 to 51,000, 95% CI, April to October for ozone days)
  55,000 per year (22,000 to 87,000, 95% CI, whole year for ozone days)

In each case, the values reported represent decreased benefits (more adverse health effects) relative to the Baseline Scenario.

100% Avoidance Scenario

- Premature Deaths
  0.033 per ozone day (0.024 to 0.042, 95% CI)
  7 per year (5 to 9, 95% CI, April to October for ozone days)
  12 per year (9 to 15, 95% CI, whole year for ozone days)

- Hospital Admissions, All Respiratory
  0.255 per ozone day (0.087 to 0.418, 95% CI)
  54 per year (18 to 90, 95% CI, April to October for ozone days)
  93 per year (32 to 150, 95% CI, whole year for ozone days)

- School Loss Days
  54 per ozone day (14 to 94, 95% CI)
  11,500 per year (3,000 to 20,000, 95% CI, April to October for ozone days)
  19,000 per year (5,200 to 34,000, 95% CI, whole year for ozone days)

- Minor Restricted Activity Days
  152 per ozone day (63 to 240, 95% CI)
  37,000 per year (13,500 to 52,000, 95% CI, April to October for ozone days)
  55,700 per year (23,000 to 88,000, 95% CI, whole year for ozone days)

In each case the values reported represent increased benefits (less adverse health effects) relative to the Baseline Scenario.