Next Challenge on the Horizon:
Air Pollution Emissions from Ships

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INTRODUCTION

The Santa Barbara Channel, with its sparkling blue water and wild, rugged islands, is one of the most beautiful and picturesque stretches of water in the world. It is also the location of a significant and growing source of air pollution. Currently, ocean-going vessels traversing the Santa Barbara Channel produce over 40 percent of the nitrogen oxides (NOx) emissions generated in Santa Barbara County. This is even more amazing given the fact that Santa Barbara does not even have a port. If trade volumes increase as forecasted, by 2020 marine vessel traffic in the Channel will produce nearly 75 percent of the NOx emissions in Santa Barbara County. This growing air quality problem is not unique to the Santa Barbara Channel, but is becoming a concern for coastal areas everywhere.

As the International Maritime Organization notes in their "*Study of Greenhouse Emissions from Ships*", there is an increasing awareness of the impacts of shipping emissions on onshore air quality. An estimated 85 percent of international shipping traffic occurs in the northern hemisphere, and 70 percent of that is within 400 km (240 miles) of land. Much of the shipping activity and associated emissions occur near major urban areas, many of which are already struggling with air quality problems (IMO 2000).

In this article we will discuss the air quality management issues associated with air pollution emissions produced by ocean-going vessels, using Santa Barbara County as a case study. We will begin by describing some of the geographical and economic factors that contribute to this unique problem. We will then provide context and perspective in a discussion of air quality and emissions inventory trends and also discuss management challenges associated with marine vessel emissions. Finally, we will explore strategies that could lead to solutions to this looming air quality management challenge.

GEOGRAPHY & ECONOMICS

There are unique geographic and economic factors that contribute to the growth of air pollution emissions from ocean-going vessels near coastal communities in California. The eastern terminus of one of the primary great circle routes between Asia and Southern California is a point offshore the northern border of Santa Barbara County (See Figure 1). At this point, vessel traffic from Asia turns south, navigating the entire western coast of the County and then, at the western edge of the California bight, turns east into the Channel traveling on along the coast until reaching ports in San Pedro and Long Beach. Ships returning from Southern California ports to Asia retrace this route.

The north and southbound shipping lanes range from five to twenty miles from the shore (See Figure 1); the ships travel through the Channel and down the coast at cruising speeds, emitting pollutants in greater amounts than when the vessels are in port. Most marine vessels transiting between Southern Californian and Asian ports use this route, traversing the coastlines of Los Angeles, Ventura and Santa Barbara Counties before heading out to sea.

The dramatic increase in the number and size of the vessels transiting the Southern California coast is a direct result of California's role as the major point of entry and departure for trade between the US and Asia. A 2004 report ("California's Global Gateways: Trends and Issues") by Economists John Haveman and David Hummels found that in 2000, an estimated $297 billion worth of goods entered California with an ultimate destination outside the state. The study also showed that about 86% of the 2002 international maritime trade, by value, through California was with countries in Asia (Haveman 2004). Due to the continued economic development in Asia, combined with large and growing populations, an increasing need for raw materials, and an expanding production capacity economists are predicting two to four fold increases in trade with the US. This increase in trade volumes will result in larger ships (UNCTD 2005), more frequent transits, and therefore greater quantities of emissions generated along the California's coast.

AIR QUALITY

Historically, most of Southern California has exceeded both the state and federal health standards for ozone. On August 8, 2003 Santa Barbara County was designated attainment for all federal health standards. We still exceed the state ozone and particulate standards, which are more

stringent and more health protective than the federal standards. However, to the south, Ventura County and the South Coast Air Basin still exceed both the state and federal ozone standards.

Not only must all Southern California jurisdictions continue to address those health standards that they fail to attain, but also, in Santa Barbara, our attainment status with regard to the federal ozone standard remains fragile. Significant increases in ozone precursor emissions could threaten our ability to attain the state standard and remain in attainment with the federal standard. Increases in emissions are of more of concern to Ventura County and the South Coast Air Basin, which have even greater air quality challenges, as both areas strive to attain both the state and federal health standards.

AIR POLLUTION EMISSIONS

The Santa Barbara District's 2005 marine shipping emissions inventory showed that the 7,086 transits along the 130 mile coastline of Santa Barbara County produced 14,918 tons of NOx, which was over 40% of the total NOx emitted in the County that year. The draft *"San Pedro Bay Ports Clean Air Action Plan Technical Report,"* issued in June 2006, estimates emissions from ocean-going vessels in the Los Angeles area to 12,834 tons per year of NOx. The relatively large magnitude of a marine vessel air pollution emissions profile is a function of the design and size of the engines and quality of the fuel it burns. It is interesting to note that 10 percent of the vessels in Santa Barbara's 2005 inventory produced 50 percent of the emissions and 92 percent of the marine vessel NOx emissions come from foreign flagged ships. A single category of marine vessels, container ships, are responsible for 83 percent of the NOx emissions and over 60 percent of the transits. We project that by 2020 the total number of transits will swell to over 13,000 which, when combine with the expected increase in power required to accommodate growing vessel sizes, would produce over 30,000 tons of NOx (over 80 tons per day!) and represent over 70% of the Santa Barbara County NOx emissions inventory if the ships remain uncontrolled.

By 2020, we project that, while emissions from onshore mobile and stationary sources will be shrinking, increased emissions from ocean-going vessels will have cancelled the emission reductions that we achieved from onshore emission control strategies in Santa Barbara County (See Figure 2). The efforts of Southern California air quality management agencies to attain and

maintain air quality health standards would be severely hampered if the projected marine vessel emissions increases come to pass.

MARINE VESSEL EMISSION CONTROL CHALLENGES

Several factors, some technical and some geopolitical, preclude traditional approaches to managing the air pollution emissions emitted by ocean-going vessels. The technical problems are related to the availability and proven effectiveness of control technologies and the application of control technologies to existing vessels. The geopolitical issues are associated with the fact that most of the vessels are foreign-flagged, and many operate under "flags of convenience." The international nature of the industry along with frequently changing routes results in emissions sources that are not easily regulated by local, state, and federal laws.

Notwithstanding new technologies currently being developed and incorporated into new ships, most large ocean going vessels with engines rated between 10,000 kW and 70,000 kW are equipped with two-stroke engines that burn #6 bunker fuel oil. The design of these engines results in high levels of NOx, Sulfur Oxides (SOx) and Particulate Matter (PM) emissions. There are two standard methods for controlling NOx; primary control methods, which reduce NOx by altering the combustion process, and secondary control methods, which control NOx by treating the exhaust gas stream. As with all air pollution control technologies, the most efficient and effective application of controls for a marine vessel engine would be at the design phase. Application of either of these methods as retrofit controls can present both engineering and economic challenges. While providing relatively low control efficiencies, the most promising control technologies from both the engineering and economic perspective appear to be primary control method retrofit strategies such as upgrading fuel injectors and introducing water into the combustion process through either the combustion air or in a fuel/water emulsion.

Marine vessel emissions of sulfur compounds occur primarily from the combustion of the bunker fuel that contains high sulfur concentrations. Marine fuels have a worldwide average sulfur content of about 2.7% (Entec 2005), which is much greater than the 0.0015% sulfur content of on-road diesel fuel sold in California. The sulfur in the fuel is oxidized to sulfur dioxide (SO2) during the combustion process and converted to sulfate compounds in the atmosphere. In addition to health

impacts at high concentrations and acidic deposition sulfur emissions contribute to the secondary formation of PM. SO2 emissions from marine vessels can be controlled by operating the engines on fuels with lower sulfur content or possible using a scrubbing technology to remove the SO2 from the exhaust gas.

Annex VI

MARPOL 73/78 is the International Maritime Organization's (IMO) International Convention for the Prevention of Pollution from Ships. Annex VI, was adopted by the Parties to MARPOL in 1997 and contains NOx standards for engines built (or significantly modified) after January 1, 2000, and sets a global cap on bunker fuel sulfur concentrations at 4.5% (45,000 ppm). Annex VI also allows for the designation of SOx Emission Control Areas (SECA) within which all vessels would be required to operate on fuel with a maximum sulfur content of 1.5% (15,000 ppm) or utilize after-treatment technologies that would reduce their SOx emission rate to 6.0 g/ kWh or less. Annex VI was ratified by the required minimum number of member countries in May 2004 and entered into force in May of 2005. As of May 31, 2006 Annex VI has been ratified by 35 nations representing over 70% of the world's shipping tonnage. Noticeably absent from the ratification list are the US, Canada and Mexico.

The US Coast Guard has been issuing statements of voluntary compliance with Annex VI for ships and the US EPA has been issuing voluntary compliance statements for engines since 2000. The current EPA Category 3 marine engine standards which have been in effect since February 2003 are equivalent to those set in Annex VI. The EPA is also evaluating the possibility of applying for a North American SECA designation under Annex VI with Canada and Mexico. On May 15, 2003, the US treaty (108-7) for ratification of Annex VI was received by the Senate from the White House and then forwarded to the Senate Foreign Relations Committee for review, and advice towards ratification. On April 7, 2006 the Senate Committee on Foreign Relations provided its advice and consent for ratification and now US ratification is pending the approval of the national implementation language.

Despite the politically difficult nature and excruciatingly slow approval procedures of the treaty process, most engine manufacturers are currently building engines to meet these standards and have

acknowledged that further emission reductions are possible with the current state of technology. However, due to the high cost of building ships and since large ocean-going vessels are typically in service for many years, the turnover rate in vessels is very slow. Therefore, it could be several decades before we realize significant emission reductions through the current regulations and treaty process.

SOLUTIONS

Daunting challenges to reducing this significant source of air pollution remain; however, we believe there exist viable strategies that can achieve emission reductions over time. Several California agencies, air districts, and ports authorities have realized the connection between increasing trade volumes and air quality and have been involved in collaborative partnerships that work towards addressing the issue. There have also been some economic mechanisms that have been employed to provide incentives for ship operators to operate the cleanest vessels possible.

Cooperative Action

California. The Maritime Air Quality Working Group, led by the California Air Resources Board, is an assembly of stakeholders, which includes air quality management agencies, environmental advocacy groups, and shipping industry representatives. The group's goal is to engage the shipping industry in discussions regarding air quality issues, identify potential control technologies than can reduce air pollution emissions from ship engines, and determine how to make the technologies cost-effective for the vessel owners. The U.S. Transportation Maritime Administration (MARAD) is pursuing similar goals on a parallel track. MARAD is investigating incentive programs to encourage the installation of control technology on coastal vessels. The Working Group is currently involved in a program to apply multi-agency funding to an emissions control retrofit demonstration project on a major cargo carrier.

US West Coast. As part of the EPA Clean Diesel Campaign the West Coast Collaborative was created in June 2004 with the objective of reducing diesel emissions along the west coast of the US. The collaborative consists of international (Canada and Mexico), federal, state and local governments, private companies, and environmental groups working together to reduce diesel emissions from the following source categories: Agriculture, construction, locomotives, marine

vessels and ports, and trucking. California air districts have participated in the collaborative as part of the marine vessel and ports working group. The working group has evolved into a forum for sharing information regarding emissions, projects and research being conducted throughout the region. This collaborative has been an important tool in addressing this regional problem, and has allowed partners learn from each other and work together to make progress towards common goals.

Multi-Modal Emission Reduction Plans. The challenge of reducing emissions from marine vessels has been identified in several California multi-modal (e.g., trucks, locomotives and ships) emission reduction plans targeting goods movement activities. On January 27, 2005 California Governor Arnold Schwarzenegger released a policy statement identifying the improvement of goods movement as a high priority issue that has a significant impact on the economy and quality of life of Californians. This led to an initiative directed by the California EPA and the California Business, Transportation and Housing Agency is responsible for developing a goods movement action plan. A part of the plan will include mitigation measures that will reduce the environmental impact of proposed goods movement related infrastructure and the expected increase in trade volumes. Other multi-modal emission reduction plans in California include the Port of Los Angeles' No Net Increase plan, the Green Port Program at the Port of Long Beach, and the California Air Resources Board Emission Reduction Plan for Ports and Goods Movement in California, adopted in April 2006. In June 2006, the Port of Los Angeles and the Port of Long Beach jointly issued a draft *"San Pedro Bay Ports Clean Air Action Plan Technical Report,"* which outlines multi-modal emission reduction strategies for the ports complex.

Incentives and Market-Based Approaches

Financial Incentives: Sweden. A Swedish incentive program created in 1996 and implemented in 1998 has successfully reduced emissions from marine vessels by linking existing fairway dues to ship engine emission profiles. While the emission reductions from this program did not have a direct impact on the air quality in Southern California this program was the first of its kind and serves as an example of a successful, innovative, incentive based-approach to controlling shipping emissions. By charging higher fees to ships that have greater air pollution emissions, the Swedish ports create an incentive for vessel operators to investigate and install emission control retrofit technologies as a way to reduce their fairway dues. Vessel owners can reduce NOx emissions by

installing control technologies and reduce SOx emissions either through after-treatment or by reducing the sulfur content of their fuel.

The fairway dues, which existed before the program began, are charged by the gross tonnage per vessel, and are used for ice breaking and other maritime services. The competitive nature of the ferry systems operating in Swedish ports has made it financially difficult for operators not to participate in the program and the individual vessel operators have taken great pride in their commitment to reducing emissions. This program benefited from a large captive fleet of vessels and an existing fee structure that could be differentiated as environmental incentives without taking away from the original purpose of the fee. The success of this innovative program is in many ways responsible for the development of emission reduction technologies for marine vessels and introduced the idea of using incentive programs to reduce emissions from marine vessels around the world.

Financial Incentives: Port of Long Beach. On February 27, 2006, the Port of Long Beach Board of Harbor Commissioners approved a $2.2 million initiative to offer vessel operators that participate in the voluntary Vessel Speed Reduction Program (VSRP) for one year a 15% discount rate on their dockage fees. The VSRP began in 2001 as a collaborative effort (Port of LA, Port of Long Beach, US EPA, ARB, South Coast AQMD, Marine Exchange and the Pacific Merchant Shipping Association) and calls for vessels to reduce their speed to 12 knots or less within 20 miles of the Port. Vessel speed is directly related to the engine power required by the propulsion engines of ocean-going vessels and engine power is directly coupled to engine exhaust emissions; therefore, a reduction in vessel speed will result in a reduction of exhaust emissions. Dockage fees are assessed to a vessel based on overall length and accrue each 24 hour period a vessel spends at berth. Port officials hope that the reduction in dockage fees will offer enough of an incentive to achieve 100% compliance. Unfortunately, this measure would not result in reductions of ship emissions in coastal communities more than 20 miles from the Port.

Emissions Trading: North Sea. An emission trading program developed by SEAaT (Shipping Emissions Abatement and Trading) for marine vessels went through a trial demonstration from April to December 2005 in the North Sea. The program was the first trial emissions trading

program involving ships and may open the door for similar programs around the world. The program primarily focused on reducing SOx emissions from about 40 vessels of varying sizes, types, companies and routes in a region that will become a SECA under Annex VI in 2007. Vessel operators reduced SOx emissions by either switching to cleaner fuels or installing after-treatment SOx reduction technologies. The pilot program was designed with the understanding that an emissions trading scheme for shipping will encourage innovation and stimulate investment in the lowest cost techniques for reducing SOx emissions.

CONCLUSION

Shipping traffic in Southern California is a growing source of air pollution emissions impacting port and coastal communities. Within the next 15 years, the growth in marine vessel air pollution emissions could cancel all the emission reductions that have been achieved in the last 30 years from onshore emission control programs in California. This presents a serious threat to the air quality and public health. Furthermore, due to the requirements of the federal and California Clean Air Acts, if we fail to attain and maintain the health standards we would be required to further control onshore sources, increasing the regulatory burden on our local businesses and industries.

Solutions are available and are a matter of combining adequate financial resources with political will to create a synergistic matrix of regulatory measures and economic incentives to ensure that new vessels are built with best available control technology and existing vessels are retrofitted with technically sound and cost effective controls.

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5. (UNCTD 2005) United Nations Conference on Trade and Development (UNCTD) Secretariat. *Review of Marine Transport (ISBN 92-1-112674-6; ISSN 0566-7682)*. Geneva, Switzerland. 2005. More information can be found at: http://www.unctad.org/en/docs/rmt2005_en.pdf

6. Additional information on the Santa Barbara County Air Pollution Control District efforts to reduce emissions in the Santa Barbara Channel can be found at: http://www.sbcapcd.org/itg/shipemissions.htm.

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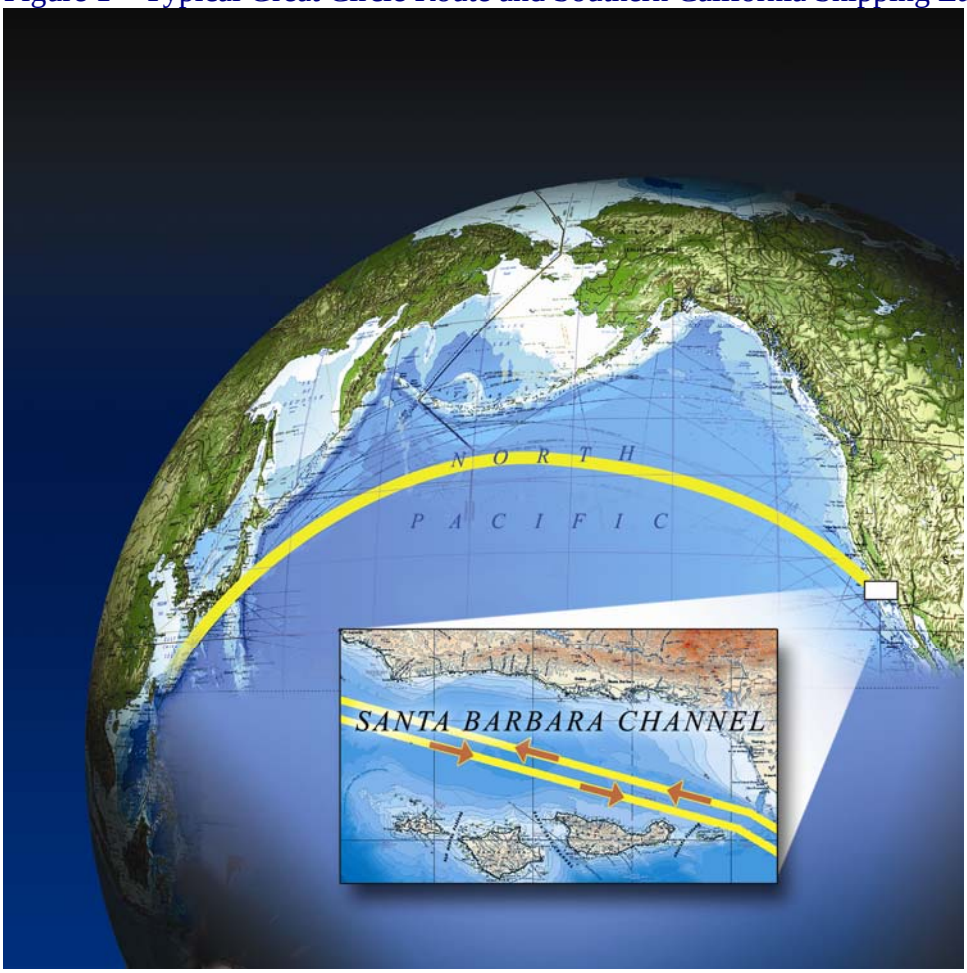
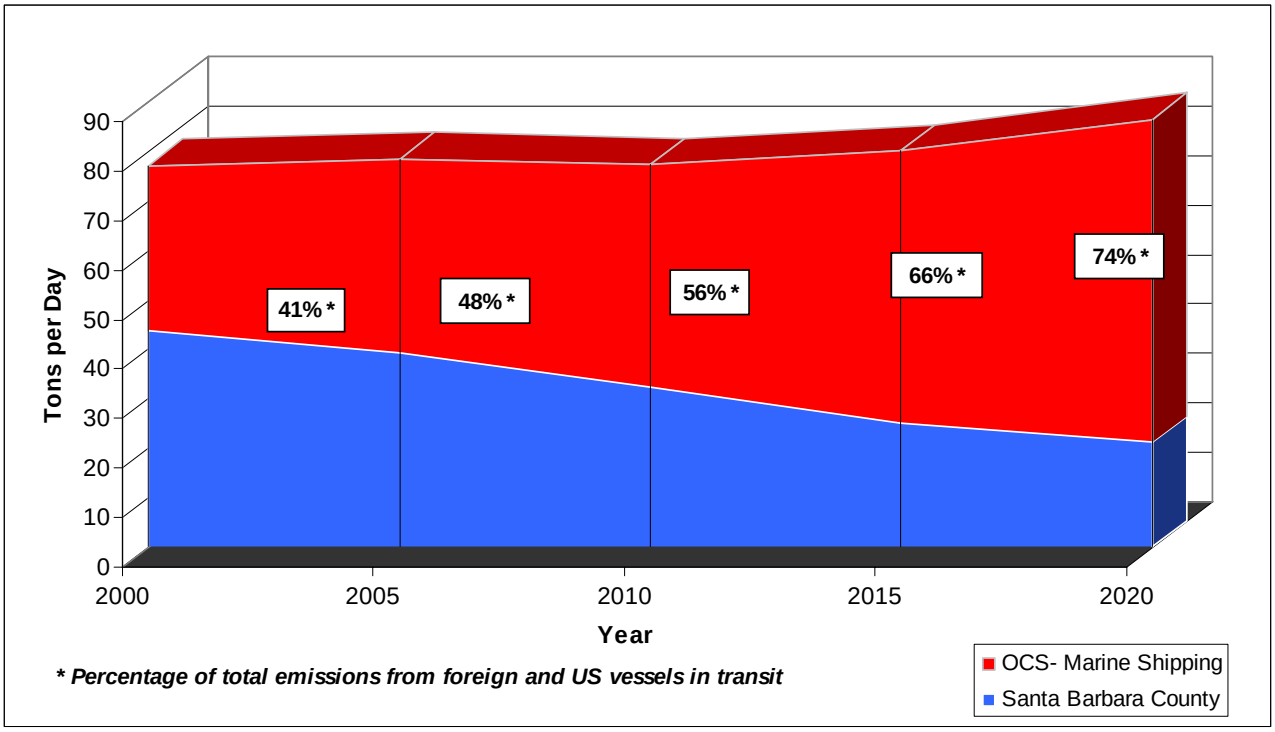
Figure 1 – Typical Great Circle Route and Southern California Shipping Lanes



Mr. Fred Gamble, Channel Crossings Press

Figure 2 - Santa Barbara County NOx Emissions Forecast



Source: 2004 SBCAPCD Clean Air Plan