



Evaluating the social cost of cruise ships air emissions in major ports of Greece



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ABSTRACT

Detailed NO_x , SO_2 and $\text{PM}_{2.5}$ emissions have been estimated for cruise ships in the five busiest Greek ports (i.e. Piraeus, Santorini, Mykonos, Corfu and Katakolo) for year 2013. The emissions were analyzed in terms of gas species, seasonality and activity. The total in-port inventory of cruise shipping accounted to 2742.7 tons: with NO_x being dominant (1887.5 tons), followed by SO_2 and $\text{PM}_{2.5}$ (760.9 and 94.3 tons respectively). Emissions during hotelling corresponded to 88.5% of total and have significantly outweighed those produced during ships' maneuvering activities (11.5% of total). Seasonality was found to play a major role, as summer emissions and associated impacts were significantly augmented. The anticipated health impacts of ship emissions can reach to €24.3 million or to €5.3 per passenger proving the necessity of control of the emissions produced by cruise ships in port cities or policy and measures towards a more efficient cruise industry.

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Introduction

The future of tourism development is largely dependent on the natural environment and its preservation (Hall and Lew, 1998). Thus environment is not only an important foundation for tourism sustainable development, but it can also be the foundation for unique attractions for tourists (Zi, 2015). Tourism by its very nature is a resource dependent industry and some commentators argue that sustainable tourism is unachievable given the industry's ability to pollute and consume resources (Johnson, 2002). This view has been summarized as follows: "Tourism contains the seed of its own destruction; tourism can kill tourism, destroying the very environmental attractions which visitors come to a location to experience" (Glasson et al., 1995).

Air pollution can be one of the major impacts tourism can impose, causing serious health problems including lung cancer, cardiovascular disease, and birth defects. Particulate matter (PM) emissions from marine vessels are related to increased cardiovascular hospitalizations and have been estimated to be responsible for about 60,000 annual cardiopulmonary and lung cancer deaths mostly along European, East Asian, and South Asian coastal areas (Corbett et al., 2007; Tian et al., 2013). Because of the proximity of ports to urban areas their operations can influence human health, inducing serious health problems such as premature mortality, asthma, bronchitis and heart failure symptoms (IAPH, 2007).

Cruise tourism has experienced rapid growth in recent years, and has become one of the most dynamic and fastest growing segments of touristic sector (Sun et al., 2011). From 2003 to 2013 demand for cruising worldwide has increased from 12.0 to 21.3 million passengers (+77%). Over a similar period, global land-based tourism has risen by around 57% to an estimated

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1.087 billion tourists in 2013, 5.0% up of 2012. Globally in 2014, 410 cruise ships (including river cruise) operated, totaling 21.6 million passengers and contributing almost \$37.1 billion in revenue. In 2013 in Europe, the vast majority of cruise ships visited ports in the Mediterranean and the Baltic, generating 31.2 million passenger visits at a total of around 250 European port cities, an 8.7% increase over 2012. Due to cruise activities direct expenditure of €16.2 billion was generated and it was the first annual increase following three consecutive years in which these expenditures has been decreased (CLIA, 2014). The Mediterranean is the world's second largest cruise shipping market: it represented 21.7% of the annual cruise capacity for 2013 while the anticipated value for 2014 is 18.9% (CLIA, 2014; MedCruise, 2014). In 2013 a total of 166 cruise ships were active in Mediterranean waters, with a capacity of 220,352 beds and an average of 1327 beds per ship (CLIA, 2014; MedCruise, 2014).

Cruise ships constitute one of the most energy intense forms of touristic activities (Eijgelaar et al., 2010). This is due to the fact that cruise ships act as luxurious resort hotels throughout their journeys and this so called “hotelling” function is mainly responsible for the excessive energy demand. On the other hand, significant proportion of the total energy spent is used for the onboard activities of the crew, thus being a part of the operating cost of the vessel and significantly increasing the emissions per passenger. IMO has estimated that the global fuel consumption in 2007, for passenger ferries and cruise ships was 31.3 million tons (Mt), resulting to a production of 96 Mt of carbon dioxide (Buhaug et al., 2009). There has been extremely limited research to date for calculating emissions and creating relevant inventories for individual sectors of the maritime transport industry, such as cruise ships. Howitt et al. used data for 84 cruise ships moving in journeys to and from New Zealand and calculated carbon emissions per passenger-kilometer (p-km), confirming that cruises emit significantly more carbon emissions and use more fuel per p-km than economy class aviation. The operation of a cruise ship (mainly due to the “hotelling” amenities included) is still about five times higher than the average energy use for the most luxurious of hotels per visitor night, which would include many of the same comforts, such as swimming pools, casinos, gyms and restaurants (Howitt et al., 2010).

Ports play an important role being the vital links of land and sea, acting as gateways and linking transport corridors, thus enhancing trade and communication. The environmental effects of ports to the atmosphere and human health (due to their proximity in densely populated areas) are extremely important and these effects are typically assessed through measured emissions of pollutants to air. Ports are influenced by maritime emissions contributing particularly to local air pollution (Cooper, 2003; Isakson et al., 2001). In harbor cities, maritime activity creates a problem of great acuteness for urban pollution, causing environmental problems affecting both human health and ecosystems (Miola et al., 2009).

Cruise ships can be an important parameter for deteriorating air pollution in ports. This paper presents a comprehensive quantitative case study for cruise ships emissions (NO_x, SO₂ and PM_{2.5}) during vessels' activities (moving–maneuvering and hotelling) in the five busiest cruise ports of Greece (i.e. Piraeus, Santorini, Mykonos, Corfu and Katakolo) for year 2013. No such detailed previous work on cruise ship emissions has been detected in the literature, apart from a similar inventory which has been created only for the port of Piraeus for one year, i.e. mid 2008–mid 2009 (Tzannatos, 2010). Furthermore, an evaluation of the total external cost due to estimated air emissions in port areas is presented. Thus, the current study provides a unique inventory allowing a detailed approach in addressing the issue of air pollution generated by cruise ships at one of the busiest touristic areas in the Mediterranean and the world.

Cruise tourism in Greece

In 2013 Greece was the third most popular destination in Europe following Italy and Spain (keeping a 14.8% share of the total cruise passengers), while the direct annual expenditures from the cruise industry for Greece was €574 million. 5,661,867 cruise passengers visited Greek ports, while for Italy and Spain the numbers were 6,970,000 and 5,236,000 respectively (CLIA, 2014). It is estimated that 11,215 workers were employed in the Greek cruise industry in 2013 (SETE, 2014). Port of Piraeus was ranked 4th in 2013 in respect of passengers numbers in the lists of leading European cruise ports and principal home ports, while Santorini, Corfu and Mykonos were also included in the top-10 list. For the year 2013, 139 cruise ships (83.7% of the total cruise ship fleet in the Mediterranean) visited 42 Greek ports (related to cruise sector) which handled 4288 cruise ship calls. The current study contains data for the five busiest Greek cruise ports, which received 2565 calls from 134 cruise ships that stayed more than 26,500 h in ports and moved almost 4.2 million passengers. These values represent a share of 59.8% and 73.8% in ship calls and total passengers respectively, for the cruise industry in Greece during 2013 (HPA, 2014). In Table 1 and Figure detailed cruise statistics (year 2013) for the studied Greek ports are presented.

Table 1
Detailed cruise statistics for the studied Greek ports.

Ports	Ships visiting	Ship calls	Revenue passengers
Piraeus	113	711	1,302,581
Santorini	62	582	778,057
Mykonos	67	485	587,501
Corfu	76	480	744,651
Katakolo	51	307	763,966
Total	369	2565	4,176,756

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