

ENVIRONMENTAL IMPACT OF CRUISE TOURISM: EXPLORING MITIGATION CASE STUDIES IN MAJOR PORTS

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ABSTRACT

Cruise tourism has transformed into a separate industry with unique characteristics and has contributed to developing a new tourism product clearly distinguished from passenger maritime transportation. This new product has led to new economic benefits not only for the operating shipping firms, but also for the local communities at the ports of call along the travel/cruise itinerary driving socio-economic growth. Despite these beneficial effects, cruise tourism has raised many concerns among local communities due to the inflicted environmental pressures on resources and ecosystems. Energy and water consumption, waste management, marine pollution, traffic and noise burden are the main topics of dispute that ports have to consider in their development strategies. To allay these concerns, major ports around the world, mainly in cruise intensive destinations, have implemented strategies, policies, plans and measures to alleviate or pre-empt any negative effects that could impose not only on the natural environment, but also on the well-being of residents. This review explores case studies of the measures undertaken to mitigate environmental impact due to cruise tourism around the ports and highlights some common practices. While ports are still testing measures and technologies more investment is necessary to create a positive impact.

Keywords: cruise tourism, environmental impact, cruise impact mitigation, case studies, ports.

1 INTRODUCTION

An intriguing post at the *Guardian* newspaper arguing that ‘A good cruise is one that doesn’t come: Europe’s ports bear brunt of ship pollution’ [1] has triggered the initiation of this research around the cruise ports realm. It seeks to unveil case studies and best practices that major ports around the world are implementing to offset the negative effects of cruise tourism.

The cruise industry has long been under debate for its positive or negative impacts. Frequently accused of not complying with regulations for environmental protection cruise lines, have often been the subject of related fines. At the same time, local economies may argue that they unfold economic benefits from the cruise operations (direct or indirect economic effects) and the near port economic activity that is being developed through a wide nexus of supporting services.

Today, cruise is an integrated sector that shapes, promotes and delivers a very distinct product: cruise tourism [2]. The sector has managed to bounce back since the COVID era and is expected to reach new heights by 2029 [3]. Fig. 1 shows that in 2023, it has already reached the 107% of the 2019 levels counting over 31 million passengers [4] with a special focus on routes sailing in the Caribbean and the Mediterranean Sea [5].

Most studies in the industry have been mainly concentrated on the impacts of cruise on local and regional economies [6], [7]. Cruising plays an important role in the social and economic growth of both host countries and cruising centres. As ports of call are the centre of the cruise industry, local economies are most affected by its operation. Local economic activity is greatly stimulated by the expenses cruise passengers are producing during land



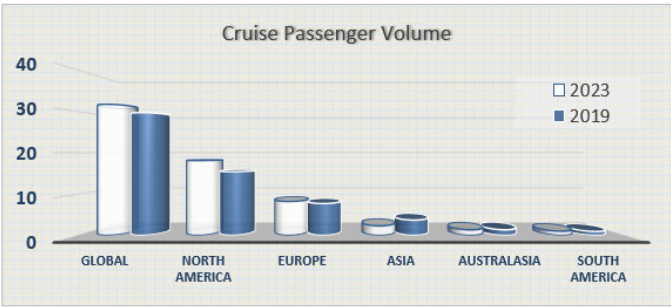


Figure 1: Cruise passenger volume evolution 2019–2023 (in millions of passengers).
(Source: CLIA 2023 Global Passenger Report.)

activities and excursions, shopping, eating, and various complementary services. Klein [8] argues that cruise ports can create value not only to passengers but also to the local communities by leveraging economic advantage for local markets, tourism operators as well as to the wider ecosystem of services that evolves around them. Ports of call benefit from the large numbers of visitors, resulting in the demand and hereafter creation of jobs and expansion of local businesses to supply a wide range of services. As more and more travellers select cruise as their holiday option and cruise ship traffic rises, the industry often acts as a catalyst for infrastructure development in many destinations.

In port cities, cruise tourism is a fast-growing part of the tourism industry with significant benefits, including economic, environmental and social challenges for both the city and the surrounding area. During a cruise, tourists spend both on board and ashore. Total spending on land is often closely linked to the time spent on land and the attractions of the port city. Tourist resources in port cities are the main factor determining the attractiveness of cruise ports. Cruise tourists add value to economies before, during and after their cruise. On a typical 7-day cruise, guests spend an average of €660 in port towns and 24 cruise guests help create a full-time equivalent job. Forecasts for the total cruise industry revenue are quite optimistic (Fig. 2) as there seems to be a positive trend until 2029 (last year of forecast).

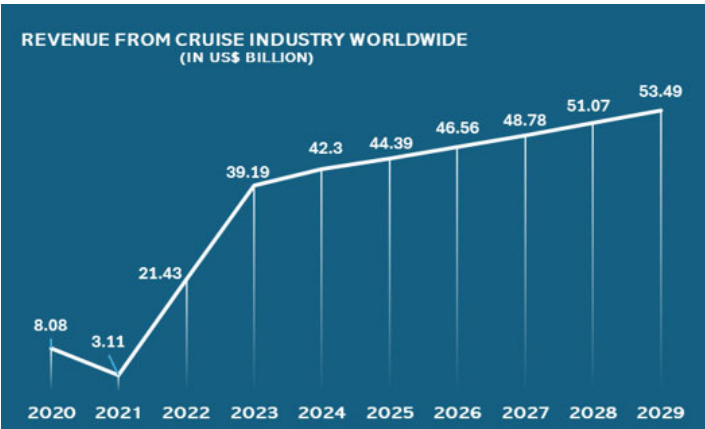


Figure 2: Cruise industry revenue 2020–2029 (in billion US\$) [3].



These benefits do not stop there, as 60% of people who have cruised admit returning to a destination which have visited during a cruise in the past, thus multiplying the economic benefit for the host communities [9], [10].

Brida and Zapata-Aguirre [11] argue that cruising represents the paradigm of globalisation: physical mobility, international capital that can be moved anywhere and anytime, multi-national crews on a single ship, no national or international regulations, optimal ship registries.

The growth of the cruise tourism industry has been accompanied by the development of new cruise passenger terminals in many port cities to support the goals of land use planning and urban regeneration [12]. Although, local benefits fail to materialise when cruise tourism is undertaken without investment in, and involvement of, destination communities [13].

Concerns arise as cruise ships are now larger and perform most of the functions of a small resort: accommodation, catering, transport and tourism activities, and recreation, reducing in-destination spending.

The most valued economic benefits are now under scrutiny whether the income generated exceeds direct and indirect costs (including environmental costs) and whether income distribution is responsible. As the popularity and geographical reach of cruising grows so does its environmental, social and economic impacts.

2 IMPACT OF THE CRUISE TOURISM ON THE ENVIRONMENT

Port development is a driver for economic growth from local to national and regional scale but has been proved to raise significant challenges for the environment. Focusing on sustainability, several strategies can be used to help ensure that port development is environmentally sound. Responsible tourism has three broad areas of concern: (a) tourism's impact on the environment; (b) the equitable distribution of economic benefits to all segments of a tourist destination; and (c) minimising negative sociocultural impacts [8]. This review explores only the environmental pillar and, in particular, focuses on the mitigation efforts trialled and/or adopted by large cruise ports around the world.

Cruise tourism can have adverse environmental impacts, including increased air and water pollution, habitat destruction and disruption of marine ecosystems. These environmental risks can have socio-economic consequences, such as negative impacts on public health, reduced attractiveness for tourism and damage to local industries dependent on natural resources.

In their research, Lloret et al. [14] summarise the effects cruise tourism can have both on the environment and human health: 'cruising, despite technical advances and some surveillance programmes, remains a major source of air, water (fresh and marine) and land pollution affecting fragile habitats, areas and species, and a potential source of physical and mental human health risks'. Estimating the impact of the entire life cycle of a cruise ship on both the environment and human health is a really challenging task.

In this point we should state that all shipping traffic produces environmental impacts, but the cruise ships create disproportionate impacts because they carry thousands of passengers who produce their own personal waste streams [15].

The environmental impacts from the cruise industry can be upstream (concerning the ship construction phase) or downstream (pollution generated by the operation of cruise tourism). In this paper we only examine the downstream impacts which are more relevant to the operations of the cruise ships, the mere service of cruise tourism. A brief overview of the main impacts of cruising involves the following.



2.1 Air pollution

The shipping sector is one of the leading sources of greenhouse gas (GHG) emissions, air and water pollution. The sector still relies almost entirely on fossil fuels full of toxic substances including sulphur [16].

Port operations and logistics activities are often accompanied by an increase in energy demand and subsequently pollutant emissions [17], they bring a certain degree of impact on the surrounding environment, especially carbon dioxide (CO₂), a GHG that has a significant impact on the ecosystem [18]. Even though all ship types have an environmental and climate impact, air pollution from cruise ships is particularly worrying [16], [19].

2.2 Water/sea pollution

Wastewaters, including 'blackwater' (contaminated wastewater from toilets) and 'grey water' (greywater is wastewater generated from domestic, non-industrial processes, including drainage from dishwasher, galley taps, laundry facilities, showers, bath and washbasin drains, etc.), are a growing problem for sea pollution. Wastewater can result in a decrease of available dissolved oxygen in the marine ecosystem and can potentially cause algae bloom especially in shallow or enclosed waters [20]. Greywater is usually kept separate from blackwater to reduce the amount of water that gets heavily polluted and represents the greater percentage liquid waste produced by a cruise ship (50%–80%).

The discharge of bilge water (i.e. the water that collects in the bilges of a vessel that contains fluids from machinery spaces and internal drainage systems, among other sources) is a source of hydrocarbon discharge, even when treated to reduce the oil content to levels meeting international regulations for release into the environment [14]. Ballast water (used for the ships stability and manoeuvrability during a voyage) can contain wastewaters, oil and other hydrocarbons, microbes, microplastics and invasive species [14], [20], [21].

2.3 Solid waste

Cruise ships are bound to answer to a multitude of needs and desires and provide respective services like 24-hour food service, living accommodations, transport and leisure activities [22]. Cruise liners generate large amounts of non-hazardous solid waste (plastic, paper, wood, cardboard, food waste, cans, glass) and other waste discarded by passengers. [8]. In particular, they produce large amounts of food- and cabin-related waste, contributing 25% of waste from ships despite only making up <1% of the global shipping fleet [23].

2.4 Biodiversity

Cruise ships and maritime transport in general, have been associated with the transfer of alien species from one part of the world to another. This has often resulted in the introduction of vector borne diseases in new regions where they were not previously endemic [24]. The introduction of invasive aquatic species to new environments is a major threat to the world's oceans and to the conservation of biodiversity. Carried either in ships' ballast water or on ships' hulls, many transported species may establish a reproductive population in the host environment, becoming invasive, out-competing native species and multiplying into pest proportions thus threatening local biodiversity [25].



2.5 Traffic, noise and visual pollution

When a cruise port is located near a city and port traffic mixes with city traffic, road traffic, especially cars/coaches and lorries, may increase. Local negative effects include increased travel time, reduced efficiency and additional pollution from increased travel [26].

Noise from cruise ships is also considered as a pollutant. Noise pollution in the marine environment is a significant issue that is often neglected in marine pollution assessments, yet low frequency noise has doubled every decade since 1950 [27]. Research by Caric et al. [28] found noise can displace both fish and predators. Noise sensitive marine organisms are more prone to suffer adverse effects.

Seldom does visual pollution get accounted for when researching about cruise tourism impacts on the environment. Especially in large ports of call the aesthetic impact of cruise ships can have a toll for the residents in the vicinity.

2.6 Dredging (during port development)

While cruise ships come in all sizes, there is an eminent trend towards larger vessels, which may require ports to increase the frequency and depth of dredging projects in order to accommodate them, which can destroy local (marine) habitats. Even without dredging, the passage of cruise ships can affect bottom dwellers and cause severe turbidity by stirring up sediment.

3 METHODOLOGY

This literature review is based on internationally published studies on the effects of cruises on both the environment and human health. Our study used the following resources: peer-reviewed journals and books in scientific databases related to the research field (e.g. Science Direct, PubMed, Web of Science) and grey literature (e.g. papers, reports, technical notes and congress contributions). Online sources were also exploited, especially information provided by the selected port authorities' websites.

This study should not be considered a systematic review given that only key documents providing examples of the issues identified were selected. This kind of exploratory analysis allowed us to address the specifics of the cruise industry and study these particular examples/case studies. The aim of this review was to improve the understanding of cruise tourism in coastal areas, to present practices that enhance the environmental footprint of cruise tourism and to look forward to future research directions. Therefore, it only focuses on the environmental effects' mitigation measures in cruise ports.

4 MITIGATION MEASURES FROM THE CRUISE LINES

Greening of the cruise tourism industry is an endeavour that requires all stakeholders aboard a common cause. The major stakeholders are the cruise lines and the port that host the cruise ships. Both have an equal responsibility to design, adopt and implement integrated strategies to soften their environmental footprint.

Some of the promoted measures to be undertaken by the cruise ships companies are the following.

4.1 Onshore power supply (OPS)

OPS or cold ironing – in maritime jargon – involves using shoreside electricity that allows ship engines to be switched off at birth. This infrastructure can help reduce emissions by up to 98%, depending on the mix of energy sources used to produce this electricity. Under the



Fit for 55 package, from January 2030 ships staying for more than 2 hours in a port would have to connect to OPS, unless they used another zero-emission technology.

In Europe most OPS are situated in ports in northern Europe while Mediterranean ports are funded to incorporate such facilities in the immediate future. Fig. 3 illustrates OPS geographical distribution around the world and stage of implementation. A study conducted with data from 714 major ports in the European Economic Area and the UK showed that significant annual reductions in local air pollution can be achieved by using OPS amounting to 86,431t NO_x, 4,130t SO_x, 1,596t PM₁₀, 4,333t CO, 94t CH₄, 4,818t NMVOC, and 235t N₂O [29].

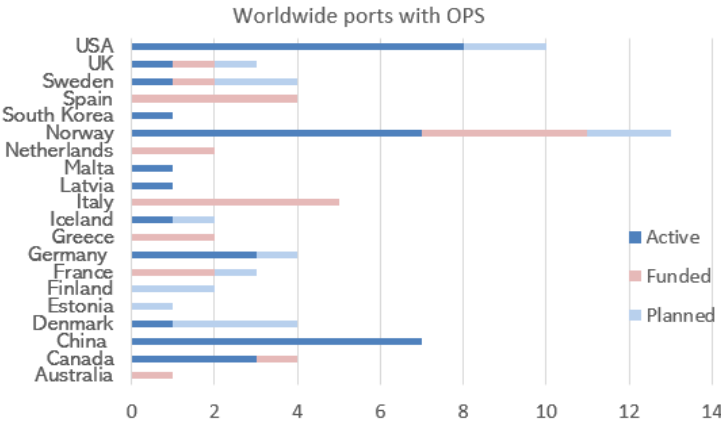


Figure 3: World ports with at least one cruise berth with OPS [9].

4.2 Wastewater management

Many technological advances have been applied to cruise ships to help with the management of the wastewater produced during voyage or in port. As part of their overarching sustainability focus, cruise lines have committed to not discharging untreated sewage anywhere in the world, during normal operations and are bound to incorporate advanced treatment systems.

4.3 Solid waste management

A cruise ship produces a large volume of non-hazardous solid waste, including huge volumes of plastic, paper, wood, cardboard, food waste, cans, glass, and the variety of other wastes disposed of by passengers [8]. A CLIA report [30] states that some ships are able to repurpose 100% of waste, transfer surplus heat from machinery to heat water for showers and pools, and significantly reduce food waste by using bio-digesters.

4.4 Use of renewable fuels and alternative energy sources

Various cruise lines are testing and using into new ships the capability to run on renewable fuels, including biofuels and synthetic carbon fuels [30]. Ships designed with LNG engines and fuel supply systems are able to switch to bio or synthetic LNG in the future, with little or no modifications. Zhang et al. (2023) have estimated that the use of alternative fuels in



cruise ships will reach economic competitiveness comparable to conventional fossil fuels by 2040.

5 MITIGATION ACTIVITIES FROM PORTS

Fit for 55 provides ports with a unique opportunity to implement key mitigation measures and create infrastructure for shore power or zero-emission technologies. Failure to comply with the new will become a factor contributing to loss of competitiveness for some. Cruise ports around the world are on the frontline in supporting and promoting the sustainability of the industry. They act as the critical interface between cruise ships, ports and port cities.

5.1 Europe

5.1.1 Port of Barcelona, Spain

Barcelona is a principal cruise port in Europe, with numerous marinas and ferry terminals. In 2023, the Barcelona Cruise Port handled 3.6 million passengers, but Barcelona was the most sulphur polluted cruise port in Europe in 2022, with cruise ships emitting 18,277 kg of sulphur dioxide (SO_x) [31]. In their research, Ruiz-Guerra et al. [32] observed a linear relationship between passenger volume and air pollution in Barcelona port while Perdiguero and Sanz's [33] simulations showed that the effect of one cruise entering, staying or leaving the port affects the air quality even as far as 7–10 km away. This implies that the whole city of Barcelona, and some localities around the city are affected by it. To mitigate the impact of air pollution, the port of Barcelona has created an Air Quality Improvement Plan with the aim to reduce emissions as much as possible, specifically of particulate matter (PM₁₀), nitrogen oxides (NO_x) and other polluting gases resulting from the Port's activity. The measures to achieve this goal include among others environmental discounts for vessels with good environmental performance. The Port is also working on bringing about a change in legislation so that such environmental discounts can be increased up to 40% of the boat's fee, in order to attract cleaner boats and reduce emissions.

5.1.2 Port of Venice, Italy

Venice, one of Europe's most overcrowded cities from tourists, was also Europe's most polluted cruise port in 2019. To alleviate this impact, in 2021, Italian law banned cruise ships and other large vessels from the Venice Lagoon [34]. This had an impressive result as it led air pollutants' concentrations from cruise ships in Venice to fall roughly by 80% (SO_x) between 2019 and 2022.

5.1.3 Port of Le Havre, France

Since 1993 the port of Le Havre, has claimed to be one the most environmentally conscious cruise port [35]. Today, France's leading eco-responsible port, has defined a range of ecological services that may be technological or technical in nature, for provision of clean ship reception services at ports. Among other initiatives, the Port has joined SEREP in a common effort to develop a collection and treatment of scrubber waste industry to offer concrete solutions to shipping companies that choose to use scrubbers. Furthermore, has decided to cover 30% of the cost of the waste collection and disposal with the aim to encourage ship lines to deposit their liquid waste and scrubber residues on site.

5.1.4 Port of Dubrovnik

In 2019, Dubrovnik signed a Memorandum of Understanding with Cruise Lines International Association (CLIA) to promote sustainable tourism management. The number of visitors in Dubrovnik's Old Town – a UNESCO World Heritage site – in a relatively limited city area,



had a great toll not only for the pleasure of the tourists but for the local community as well. It was deemed important to improve communications with cruise companies and introduce more efficient organisation. Adopted measures included careful planning of cruise arrivals and departures resulting in better tourism flows for the benefit of residents and visitors and the protection of the heritage site [4].

5.1.5 Port of Stockholm

A leading port in environmental initiatives, Stockholm has developed a closed-loop system to manage greywater and blackwater from cruise ships. Wastewater from cruise ships is collected, treated, and then reused or safely discharged. The port also connects to the city's central sewage treatment facility, allowing ships to pump their waste directly to the plant for treatment, preventing the dumping of untreated sewage into the Baltic Sea [36].

5.2 The Americas

5.2.1 Port of Miami, USA

The Port of Miami in Florida is the busiest port in the world based on cruise passenger traffic. Miami claims to be the cruise capital of the World and welcomes the biggest passenger ships on its nine modern cruise terminal – in 2023, the port received 7.3 million cruise passengers [37]. Miami has taken a big step to reduce pollution from cruise ships. It spent \$125 million to build and launch a shore power program. That allows cruise ships to turn off their engines and plug into the grid while docked, reducing emissions by more than 95%. Onshore electricity capacity covers three cruise ships simultaneously plugged in.

5.2.2 Nassau Cruise Port, Bahamas

Nassau Port is situated on New Providence Island near the coast of Florida. It is the main seaport of the Bahamas, and in 2023, it handled 4.49 million passengers. Nassau has developed an integrated Environmental Management Plan to ensure minimum adverse impacts to the environment. A major measure to safeguard the marine environment concerns a coral relocation plan. These marine organisms are very sensitive to the changes of their environment. To protect the local population for the cruise port development, 500 corals will be moved. The proposed site for translocation is the western tip of Paradise Island and was selected in order to meet the environmental requirements of the coral, ensuring they are outside of any impact from construction activities at the Port.

5.3 Australasia

5.3.1 Port of Shanghai, China

Situated at the estuary of the Yangtze River in eastern China, the port of Shanghai is famous for being the busiest in the world. But it also has the sixth largest cruise terminal in the world. In 2023, Shanghai Cruise Terminal welcomed 1.2 million cruise guests. The Port of Shanghai has the ambition to become carbon neutral by 2060. The government of the city has outlined incentives to promote the use of land-based power. Some of the proposed incentives include subsidising construction fees, setting minimum usage requirements for vessels to be connected to the power, subsidising the cost of electricity for users, and ensuring that costs are affordable in line with international oil prices.

5.3.2 Port of Sydney, Australia

Sydney has two dedicated cruise passenger terminals – the Overseas Passenger Terminal and the White Bay Cruise Terminal, where smaller ships typically berth. The two terminals



collectively house four berths. To mitigate possible environmental effects due to air pollution from incoming cruise ships, the Australian Maritime Safety issued a Direction to use either low sulphur (maximum 0.10% m/m) fuel or an alternative measure that achieves an equivalent outcome. Cruise ships are required to changeover to low sulphur fuel or an alternative measure within one hour of arrival and changeover back to heavy fuel oil is only permitted up to one hour prior to departure of the vessel.

6 LIMITATIONS AND CHALLENGES TO OVERCOME

Aware of their impact on the environment, cruise ports are beginning to try and adopt a series of measures to help mitigate this impact. Up to now, these efforts are promising but not yet sufficient as only large ports have the capacity to implement such breakthrough measures. Ports are experimenting with new technologies and try to incorporate them in their daily operation.

As ports are starting to move towards sustainability, they are encountering a series of challenges that might hinder their transition in becoming green ports. A major challenge is the need for substantial infrastructure upgrades. Extensive investments will be required to both refurbish their already existing facilities and to build new clean energy infrastructure. Another major challenge for EU ports is overcoming technological barriers to the adoption of green technologies. A great percentage of ports still relies on equipment powered by fossil fuels. All this equipment will need to be replaced sooner or later and the technological transition path is not yet obvious.

EU ports must adopt a more proactive approach to guarantee that adequate regulatory frameworks are in place to lift all the limitations and that all competent stakeholders (ports, cities, local community, cruise operators) are aligned and work together for a 'greener' cruise industry. Incentives and funding will also be required to accelerate action especially because there is an urgency in confronting the environmental impacts of cruise tourism. To this end, cooperation with the cruise lines is also a prerequisite for an integrated solution to environmental protection.

7 CONCLUSION

This review only focuses on the environmental effects of mitigation measures in cruise ports presenting diverse case studies and the efforts ports are making towards environmental sustainability. The cases presented in this review reveal that although many efforts are being implemented there is still a great amount of work to be done. The environmental challenges to cruise tourism are multiple and pose great limitations in the transition of the cruise industry to sustainability. Ports around the world are faced with the same dilemma: economic benefits vs environmental costs. Nevertheless, common issues do not mean common solutions. Each port initiates, promotes and supports different measures, different solutions considering its unique characteristics or problems that is confronting.

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