This stinks! – NABU's campaign for a cleaner cruise industry

Backgroundpaper

There is hardly any other branch in economy where the gulf between image and reality is as wide as in the cruise industry: With huge marketing budgets and many efforts, cruise companies create a picture of being a bright, clean and environmental friendly tourism sector. But the opposite is the case: The 'swimming hotels' massively contribute to the air pollution that threatens our climate, environment and health. Effective emission abatement technologies like diesel particulate filters or SCR-catalysts are hardly found on a cruise ship. On shore, these techniques are built in trucks or passenger cars as a standard. But cruise companies have a special responsibility: Not only do they transport people - instead of goods as container ships do-, they also anchor in the middle of city centres and an intact, clean nature is the capital for the dream vacation. But currently the growing number of „dream boats" contributes to the threatening of these nature treasures.

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1. The cruise market

Despite the economic crisis, the cruise sector, in particular the German market has experienced a constant growth of almost two-digit percentages in the last years. The number of passengers going on a cruise is constantly growing. In 2014 worldwide 22 million passengers went on an ocean cruise. But as if this growth in quantity wouldn't be enough the industry offers more and more questionable destinations to its customers to show them the last unaffected natural paradises: Alarmingly, the cruise industry expects especially cruises to the highly sensitive Arctic regions to rise sharply.

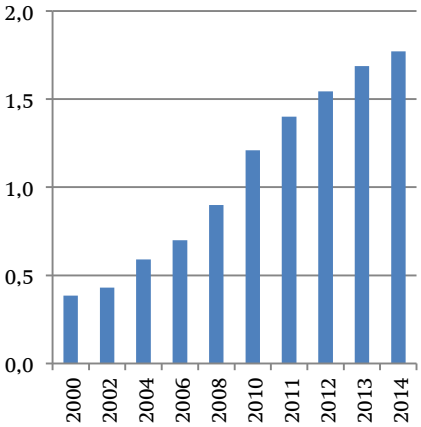
The US corporation *Carnival Cruises* is the market leader in the global cruise business, followed by *Royal Caribbean Cruise Lines* (also from the US), the Italian *Mediterranean Shipping Company (MSC)* and *Norwegian Cruise Lines*. The *Carnival Group* alone has 25 subsidiaries, bringing together a fleet of more than 100 cruise ships in total. The *Carnival Group* includes, among others, the German market leader *AIDA Cruises* (with ten ships at present) as well as the *Holland America Line*, *Costa Cruises* and *Princess Cruises*. On an international level, cruise companies are organised in umbrella organisations: In Europe, the *European Cruise Council* operates from Brussels and the *Cruise Lines International Association*

(CLIA) was established as an international lobby organization in North America. *CLIA* has opened branch offices in Europe and Germany, too.

No other tourism sector in Europe is growing as fast as cruise tourism. The number of cruise ship passengers who started a cruise from a port in Europe has more than doubled over the last decade. This means that no other tourism sector is currently growing so fast. There are more than 35 new cruise ships with a total capacity of around 100,000 passengers that will be introduced to the European market until 2020.

Parallel to the market growth the number of ship calls in popular port cities like Hamburg, Rostock, Kiel and Lübeck has increased in recent years. While Hamburg in 2006 for example had some 60 cruise ships stopovers, there were nearly 200 visits in 2014. But not only the city of Hamburg, even the much smaller city of Warnemünde (near Rostock) has to cope with almost 200 port calls and the corresponding environmental impacts.

Number of passengers on the German cruise market

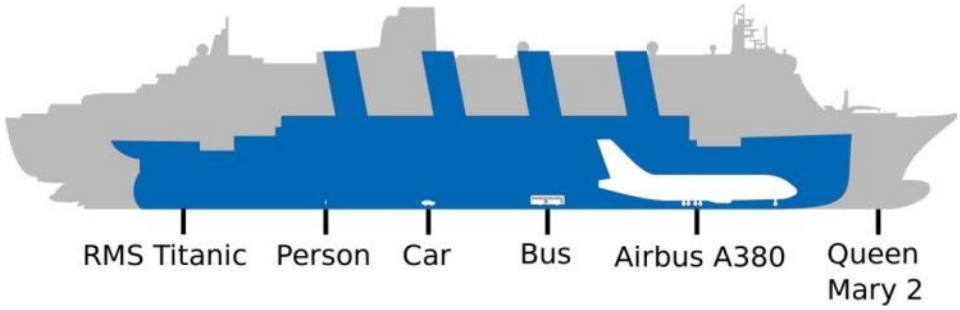


2. The ships

In total, the global fleet is currently made up of approx. 600 cruise liners, but worldwide numerous ships are being planned or are under construction. NABU publishes the planned ship buildings each year within its „cruise ship ranking", assessing the planned emission abatement techniques or alternative fuels.

The size of a cruise ship can vary considerably. The *Queen Mary 2* for instance, one of the most popular cruise liners worldwide, would have exceeded the hull's lengths of the Titanic by almost hundred metres, and an Airbus A 380, currently the biggest passenger airplane, appears tiny in comparison (see figure).

The biggest cruise liner in the world was launched in December 2010: The *Allure of the Seas* has a length of 362 metres, a wide of 47 metres and is able to accommodate 6.296 passengers plus more than 2.165 crew members. By way of comparison: The *Queen Mary 2*, once the biggest ship, "only" measures 345 metres in length and 41 metres in wide, and it can carry a "mere" 2.600 passengers.



3. Ship emissions

As "floating small towns" powered by dirtiest fuels, cruise ships have a huge ecological footprint. The ship engines contribute considerably to global and local emissions of **sulphur dioxides (SO_2), nitrogen oxides (NO_x) and particulate matter (PM)**. The latter includes **soot emissions (black carbon)** which are in particular harmful to climate and health. Therefore, soot emissions need to be strictly controlled. On land fixed permissible limit values exist. However, ocean going vessels have remained insufficiently regu-

lated for too long, especially compared with passenger cars and trucks. Even more, emissions of air pollutants from ocean liners are still increasing globally.

Due to the fuels used and the lax regulations, ships are among the dirtiest emission sources. On the open seas, bunker oils are used almost exclusively, a residual refinery product which contains high amounts of sulphur, ashes, heavy metals and other toxic residues and sediments. On land, this heavy fuel oil would have to be disposed or processed as hazardous waste in a costly manner. It would destroy every vehicle engine operating on land, but it would not be allowed to be used as fuel anyway, because of its high level of contamination and toxic combustion residues.

In addition, most ship emissions occur in immediate vicinity of the coast, from where they are carried far into the hinterland[i]. On a global level, two thirds of all ship emissions are generated within 400 km from the coast. In the North Sea, even up to 90 percent of ship emissions are emitted within 90 km of the coast, and are thus particularly dangerous for people and nature. In this context, scientists from the Danish Centre for Energy, Environment and Health (CEEH) found that in Europe ship emissions are responsible for up to 50,000 premature deaths every year. Currently, there are no comprehensive, precise emission data available with respect to cruise ships. This results on the one hand from the heterogeneity of the fleet and, on the other hand, from the refusal of many cruise companies to provide a detailed emission balance for their fleet.

The specific polluting emissions from a single ship depend on numerous technical, operational and environmental factors such as size and number of engines, exhaust gas treatment, fuel and lubricant used, velocity, etc. If the forecasts of UN's International Maritime Organization (IMO) come true, shipping, including the booming international cruise tourism with its ever larger ships, will continue to cause increasing emissions which are harmful to climate and health. In order to prevent this, ship owners, port operators and politicians must take urgent action on this matter.

a. Sulphur- und Nitrogen Oxide Emissions

Sulphur oxide and sulphur dioxide (SO and SO_2) are toxic gases that are both harmful to plant vegetation and human health. The largest proportion of the sulphur emissions from ships is poisonous sulphur dioxide (95 percent). Sulphur oxide can react to sulphate aerosols (secondary PM). Furthermore concentrated SO_x emissions lead to acid rain.

The amount of sulphur oxide emissions depends on the sulphur content in the fuel used. Currently, the sulphur content in ship fuel[1] varies between a maximum of 3.5 percent (heavy fuel oil, HFO) and 0.1 percent (marine diesel oil, MDO). For comparison, the maximum permissible sulphur content for conventional diesel fuel for cars and trucks in the EU since January 2009 is 0.001 percent. Thus, the sulphur content in ship fuels exceeds the fuel used onshore 3,500 times. The average sulphur content in ship fuels is 2,700 times dirtier than fuel used onshore.

Nitrogen oxides are formed during the fuel combustion in the engine. Increased burning time and combustion temperatures lead to an increase of NO_x emissions. Nitrogen oxides have a significant eutrophicating effect for freshwater bodies, soils and coastal areas, thereby negatively affecting the functioning of ecosystems. Also, the acidification of soil is stressed by high nitric oxide concentrations (NO_x).

As regulation is still very low ships belong to the most dirty air emission sources.

[1] „ship fuel" in this backgroundpaper refers to fuel for ocean going vessels.

b. Soot emissions

The combustion of fossil fuels (oil or diesel) for ship engines and the energy generation on board produces particulate matter (PM). Depending on the diameter of the particles, emissions are classified as PM10 (10 nanometers), PM2.5 (2.5 nanometers) and PM0.1 (0.1 nanometers). Studies show that particulate emissions are related to the fuel quality respectively the sulphur content of the fuel used. The largest subgroup within the particles from diesel combustion is soot, also called black carbon (BC). Black Carbon are ultra fine particles (UFP) that are very harmful to climate and health. BC belongs to the group of so-called "short lived climate pollutants" (SLCP) and in 2013 was recognized as the second biggest driver of climate warming just behind carbon dioxide. The dark soot particles in the atmosphere absorb solar radiation and lead to heating of the ambient air. BC emissions which take place in Arctic regions or are blown there by wind have a particularly harmful effect on the climate. Since the black particulates are deposited directly on the white ice and snow surfaces, the sun reflection (albedo) of the ice is reduced. In addition, the black particulates warm up themselves. Both effects together cause an increase in temperature and accelerate the melting of the Arctic ice. Against this background, cruise ships in (Ant-)Arctic regions (so-called polar cruises) without any soot reduction system on board pose a particular ecological risk.

Marine diesel with 0.1% sulphur compared (left) to heavy fuel oil (HFO) 2,8% (right)

Studies also investigated the harmful effect of particulate matter on health and found that the ultrafine and respirable particles may trigger heart and lung diseases, chronic bronchitis as well as asthmatic diseases. The World Health Organization (WHO) published a report in July 2012 that confirmed Black Carbon from diesel combustion as cancerogenic. The fine particles in particular are responsible for the aforementioned 50,000 premature deaths, mostly in coastal and harbour regions.

4. Measures for emission reduction

Emission reductions for ships can be achieved in the short and medium term by means of numerous technical and political measures. A mix of both would be the optimum approach, i.e. to promote technological developments and at the same time create political motivation for ecological shipping traffic. The simplest measure causing an immediate effect is the use of low-sulphur fuels. This reduces both sulphur oxide and heavy metal emissions (above all lead and tin) without any technical conversions. This measure should be decided politically and until then taken voluntarily by ship owners.

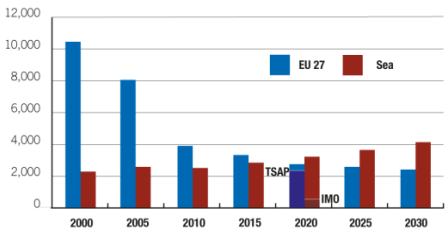


Figure 1: Emissions of SO_2 2000–2030 (ktonnes)

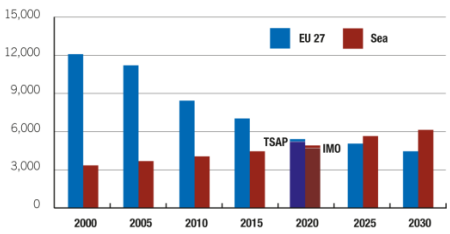


Figure 2: Emissions of NO_x 2000–2030 (ktonnes)

EU27 = Emissions from land-based sources (incl. domestic shipping)
Sea = Emissions from international shipping in European sea areas
TSAP = Target in line with the EU's Thematic Strategy on Air Pollution
IMO = Expected outcome from implementing the revised IMO MARPOL Annex VI

a. Political framework conditions: IMO and EU

The *International Maritime Organisation (IMO)* of the United Nations sets the international framework for the regulation of pollutant reductions in sea shipping traffic. Its International Convention for the Prevention of Pollution from Ships (so-called *MARPOL protocol*) defines in Annex VI the permissible limit values regarding sulphur and nitrogen oxides, and bans the deliberate emission of substances harmful to the ozone layer[ii]. From 2012 onwards, Annex VI specified a maximum value of 3.5 percent sulphur content in ship fuels. On a global average, the sulphur content in fuels at the present time is approximately 2.7 percent. Despite the opposition of many industry groups, the maximum limit shall be reduced to 0.5 percent from 2020 or 2025 onwards. The exact date depends on the results of a revision in 2018.

The *IMO* can work towards a reduction of sulphur dioxide and nitrogen dioxide emissions by establishing so-called *emission control areas (ECAs)*. In the specified areas stricter regulations apply: In **sulphur emission control areas (SECAs)** the permissible maximum value for sulphur content is 0.1 percent (since January 2015)[iii]. Currently there are only three *SECAs* in Europe: in the North Sea, the Baltic Sea and the English Channel. There is strong opposition against *SECAs* all around Europe, but this would mean a change from a 3.5 percent sulphur limit (currently) to a 0.1 percent sulphur limit, leading to further reductions in emissions and by that to great benefits for human health, climate and nature. The use of a cleaner fuel with less sulphur will in parallel lead to a reduction of particulate matter – but ship owners can also keep the limits by installing a scrubber (see below).

Sulphur limits for shipping fuel

	World (IMO)		EU		North America
	2015	2020	2015	2020	2015
Non-SECAs	3,5%	0,5%*	3,5%	0,5%	0,5%
SECAs	0,1%	0,1%	0,1%	0,1%	0,1%

*conditional to revision 2018

Since 2012, the USA and Canada together have a SECA (in combination with a NECA, see below). It is in effect in all coastal waters up to 370 km from the coast: The pacific, Atlantic and gulf coast and the eight main islands of Hawaii. But unfortunately, the highly sensitive Canadian and American arctic areas are not included. Still, the US-American environmental agency EPA estimates that the introduction of the ECAs will save yearly about 320.000 tons NO_x-emissions (-23 per cent), 90.000 tons PM2,5 emissions (-74 per cent) and about 920.000 tons SO_x emissions (-86 per cent). These reductions are supposed to save approximately 14.000 premature deaths and alleviate respiratory diseases and symptoms of about 5 million people.

Nitrogen Oxide Emission Control Areas (NECAs) can, as SECAs, be applied for by the neighbouring states of a sea at the *IMO*, who will introduce them once agreed. The stricter limit values can currently be kept either by equipping the ship with a modern engine (TIER III) or by using a *selective catalytic reduction system (SCR, below)* that cleans the fumes. Both possibilities are technically mature and on the market – even more, more than 500 ships today have an SCR already built in. But not only the current number of NECAs, also their specification is by far not sufficient in order to achieve the urgently needed drastic reductions of NO_x: Currently, there is only one *NECA* and this will only be in place as of 2016. Also, the stricter limits apply only for new built ships from a

date on that hast to be picked. In the USA/Canada *NECA* it's the year 2016. This means, that only in 2016 and only ships travelling to the USA/Canada *NECA* will undertake measures. Therefore, the *IM0* urgently has to take action to reduce the harmful NO_x emissions from shipping, especially from the existing fleet. Measures could be the implementation of an emission's fee (similar to the Norwegian NOx fund) or to require SCRs on all ships in all waters.

b. Technical measures

The use of low sulphur fuels is the most simple and quickest measure to reduce the emissions of sulphur oxides and heavy metals (mainly lead and tin). Although this leads to a reduction in sulphur oxide emissions and also to a measurable reduction in particulate matter, soot emissions are not sufficiently reduced that way.

The consequent measure is the installation of a **diesel particulate filter (DPF)**, which is already common for passenger cars and trucks and reduces their soot emissions almost completely. The precondition for fitting such a filter on a ship is the use of fuel with a maximum sulphur content of 0.5 percent. So the general switch to low sulphur fuels (0.5% and below) actually enables the use of soot abatement technologies. Particulate filters can clean up to 99.9 percent of the particles from exhaust gas. Even though the producers are ready to retrofit the filters, the industry is hesitant to use the (for ships new) technology. However, some cruise companies announced to retrofit their fleet with a DPF as part of an emission abatement technology package (see below). Recently there have been subsidy projects for the retrofitting of smaller vessels with particulate filters which have been carried out successful.

Selective catalytic reduction systems (SCRs) can eliminate most of the NO_x from ships exhaust fumes. They are already utilized in about 600 ocean going vessels. Recently some cruise ships were equipped with this technology. Besides two exemptions (below), most cruise companies have signaled little preparedness for action in this respect so far, in spite of their special responsibility to protect the health of their passengers and the environment.

A further technical measure is the so-called **seawater scrubbing**. In a subsequent treatment process the ship's exhaust gases are washed with water and thus cleaned from harmful particles and residues. Depending on the system and the fuel used, the sulphur emissions can be reduced by 70 to 95 percent. Almost all scrubbing systems also reduce PM emissions but not the number of ultra fine particles which are the most harmful. This procedure has, however, the disadvantage that the wastewater is often drained into the sea with essential parts of the exhaust residues and a changed pH value, and that huge amounts of contaminated sludge or even dry granulate must be disposed off on land.

Liquefied natural gas (LNG) can be used as a fuel for ships. It reduces the emissions of SO2 and PM emissions by up to 99% and of NOx by up to 80% for some ships. Also, the green house gas (GHG) emissions are about 20% lower than with heavy fuel oil (HFO). But the positive effect of LNG on the climate is discussed controversial because of the higher energy demand throughout the supply chain: LNG has to be kept cool (–162 °C). The other factor is the so called "methane slip": methane is a greenhouse gas, about 25 times more harmful for the climate than CO2 (time frame: 100 years) that gets emitted to some extent when LNG is explored, handled or combusted. If a lot of methane gets emitted, LNG is more destructive for the climate than conventional fuel. A study conducted by the ICCT concluded that on an average over various pathways LNG shows an advantage of 10% lower climate emissions. The best practices offer a reduction of

greenhouse gases of up to 18%. Currently, the infrastructure for LNG bunkering in ports is not much developed and safety matters are still in discussion.

In general, the cruise industry is hesitant to invest in emission abatement technologies or cleaner fuels unless legal requirements force them to do so - and legal requirements at this point are not sufficient to protect health, biodiversity and climate. Still, in the last years there were some announcements of cruise companies to act on the matter:

SCR-catalysts are installed at one *Hapag-Lloyd Kreuzfahrten* and two *TUI Cruises* ships. The *TUI Cruises* ships also have scrubbers on board. In 2014, *AIDA Cruises* announced to equip the entire fleet with a comprehensive exhaust gas aftertreament system that includes scrubber, particulate filters and SCR catalysts. The mother company, *Carnival Cruises* announced a little bit later, to equip 32 ships of it daughter enterprises with an "innovative scrubber technology" that cleans sulphur, PM and BC of the emissions[iv]. Under the roof of *Carnival Cruises, AIDA cruises and Costa* cruises announced in 2015 to build two ships each that will run on LNG only. Unfortunately, all cruise lines have planned the emission aftertreatment systems in a way so they can keep on sailing their ships on the poisonous HFO.

c. Infrastructural measures

The cruise liners of major shipping companies are more or less swimming hotels and concerning their energy consumption, some of them resemble small towns. Even when

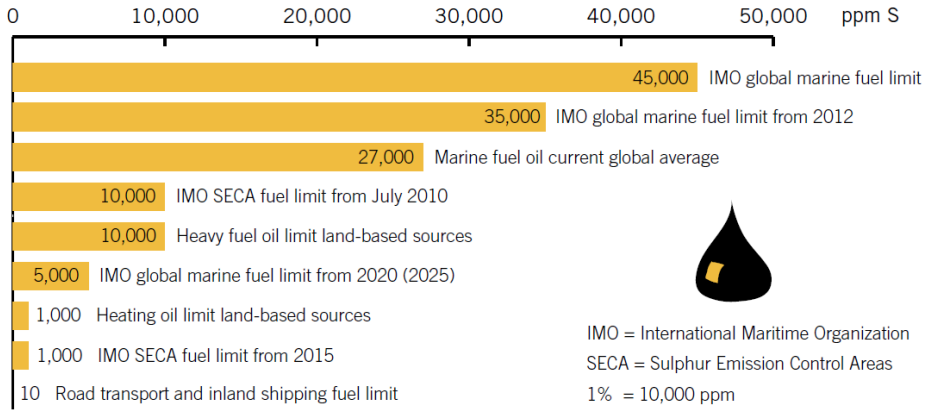


Figure 1: Fuel Sulphur Content. Source: AirClim 2011

at berth, these ships requires enormous amounts of energy because not only the propulsion and ship technology need energy, but also all the other facilities a cruise ship has: lifts, lighting, air conditioning, sauna, spa, swimming and sports facilities, restaurants and other entertainment facilities such as cinemas, theatres, ballrooms and casinos, and on some ships even an ice rink and a golf course. The *Oasis of the Seas* for example needs an uninterrupted power supply of 2,000 kVA and an overall power supply of 97,000 kW. In most cases, the energy supply is provided by the cruise liners' engines which can be powered by residual oil, marine diesel or gas. Which fuel is used depends on the engines of the ship and the local regulations) In European ports, ships have to burn a fuel with a maximum sulphur content of 0.1 per cent when at berth for tow hour or more.

There are various technical solutions and emission free alternatives to the use of oil in ports, which are currently being discussed or have already been implemented. The power supply from land ("cold ironing" or "onshore power supply, OPS") is one possibility to provide cruise ships with electricity at berth. The cruise ships must then be

connected to a kind of socket at the marine terminal (on land). However, depending on their construction type, cruise ships need different electrical voltage. In 2013, a standardisation of shore-side power connections and board-side installations was published, but that does not solve the problem that many ports and ships already have a plug or a socket respectively, so it's not guaranteed that a ship with a plug fits the socket in the port. For new ships and ports, it's still a dilemma which voltage to choose.
Another problem that has to be considered when thinking about the land based infrastructure is that even a single cruise ship has the power demand of a small town. This implies that not only that the power supply from shore must provide an enormous demand of electricity without fluctuation but also that this energy must absolutely be produced from renewable energy sources in order to generate a real environmental benefit. According to the World Ports Climate Initiative (WPCI) there were 10 ports that offered shore power to cruise lines in 2013: For example, the Gothenburg harbor operates four small-scale shore power connections without technical problems since 2005.v, vi and even has a converter, so ships can use either 50 or 60 Hertz voltage. Ship emissions at berth can also be reduced by shore-side gas supply with LNG. The technical infrastructure for this energy supply is simpler compared to shore-side electrical power and already implemented in some places.

Another way to reduce emissions from ships at berth are so-called LNG barges, floating gas power plants. The first barge has been launched in Hamburg in 2014. It feeds electricity and heat to the grid when there are no ships at berth. In terms of air pollution is LNG a good solution, since sulphur and soot emissions are almost completely diminished and nitrogen oxides are reduced by around 80 percent. However, the positive balance in terms of air pollution can be counteracted by escaping methane (methane slip, see above). As for the barges, it is only ~8% GHG reduction. Finally, LNG is not only a fossil fuel, also it's environmental and carbon footprint is far worse than that from a land-based electricity supply from renewable sources - not at least through production techniques such as fracking.

d. Voluntary measures ports and ship owners can take

Each port authority can take further air pollution reduction measures that go beyond the measures decreed, such as the introduction of so-called ecological port fees. This means that incoming (cruise) ships pay their port fees depending on their environmental performance, including their respective emission balance, where cleaner ships pay less port fees. In order to prevent a distortion of competition between those ports granting ecological port fees and those not, ports should coordinate with one another and agree on comparable fee arrangements. Ecological port fees should motivate ship operators to invest more quickly in clean technologies. Often, the ecological port fees work with an index or rating that classifies if a ship is more and how much more doing for the environment than required. One of these indices is the *"Environmental Ship Index" (ESI)*, which is for example used by the ports of Bremen/Bremerhaven, Hamburg, Amsterdam, Rotterdam and Oslo. Another index is the *Clean Shipping Index*.
Also, several ports have their own incentive programs for ships that go beyond the legal requirements, such as the Port of Long Beach with its "*Green Ship Program*" that rewards ships with cleaner engines per call.

5. NABU claims

In view of the growth in the cruise sector and the corresponding increase of Black Carbon, sulphur and nitrogen oxide emissions, the campaign “This stinks! Clean up cruise ships” demands that politicians, industry and port operators take effective climate and health protection measures to reduce emissions from cruise ships comparable to those of transportation on land.

NABU demands that….

- Cruise ship companies voluntarily switch from HFO to a cleaner fuel, for example low sulphur fuel (50 ppm) or LNG
- Cruise ship companies equip all their ships with effective emission abatement techniques. Currently, this can only be DPFs and SCRs, scrubbers are no solution
- All ports introduce ecological port fees that include PM and Black Carbon emissions, too.
- All ports build OPS’ for cruise ships
- The stricter sulphur limits in the European SECAs are monitored and violations sanctioned in a way that makes it unattractive to violate
- All territorial waters around the EU become SECAs and NECAs
- Particle- (PM) and Black Carbon limits become part of all treaties and directives of the IMO and the EU regarding the emissions from shipping sector.
- The IMO bans the use of the poisonous HFO
- The IMO makes completely all arctic regions SECAs and NECAs

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[i] See also the study by Hassellöv (2009): *Die Umweltauswirkungen des Schiffsverkehrs (the environmental impact of shipping),* available online at: http://www2.michael-cramer.de/uploads/die umweltauswirkungen des schiffsverkehrs.pdf, as well as by the EU Commission (2001): *The Influence of shipping traffic emissions on the air concentrations of particulate matter*

[ii] See http://www.imo.org (Document: International Convention for the Prevention of Pollution from Ships)

[iii] http://www.imo.org/Environment/mainframe.asp7topic id=233

[iv] https://help.carnival.com/app/answers/detail/a_id/1182/~/scrubber-technology

[v] http://www.ship-technology.com/features/feature-shore-power-green-answer-costly-berthing-emissions/

[vi] http://www.portofgothenburg.com/About-the-port/Sustainable-port/Onshore-power-supply-for-vessels-at-berth/