Cost analysis of Arctic HFO ban for Cruise shipping

A case study of the MS Rotterdam operations in the Arctic Summer 2018

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Executive Summary

The main purpose of the analysis is to better understand the nature of the likely cost impact of Arctic HFO ban on Cruise industry and passenger ticket prices and in doing so, contribute to informed decision-making at the International Maritime Organisation (IMO). This study has analysed these costs for cruise industry using three summer 2018 trips of MS Rotterdam to the Arctic as case studies.

This study finds that the likely cost impact of Arctic HFO ban will be small for shipowners and/or cruise passenger. Notably, if the ban were already in place in 2018, the price of average cruise passenger ticket would go up by only €7/passenger per day (assuming full costs pass-through). This price increase would be equal to the price of a glass of wine sold on board of MS Rotterdam. If the ban enters into effect in 2021 as proposed by Finland et al. (MEPC 72/11/1) the price increase per passenger ticket would be €5/day (assuming full costs pass-through), which is comparable to a price of burger sold on board. Lower additional costs in 2021 could be explained by the forecasted reduction in price difference between high Sulphur HFO (default fuel) and cleaner marine gas oil (to be switched to in case of HFO ban).

These findings lead us to conclude that Arctic HFO ban can be implemented immediately with limited impact on cruise industry. Considering the luxury nature of cruise shipping, any (small) increase in ticket prices should be acceptable for cruise passengers, especially considering that these costs would serve to the protection of the pristine environment that underpins the very growth in this industry segment.

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1. Description of the policy context

Cruise tourism has grown 62% over 10 years from 2005-2015[1]. Arctic cruising is increasing[2] with, as an example, the Arctic port of Svalbard experiencing an annual growth of 20% per year. Studies show that 86% of the fuel consumed by cruise ships operating in the Arctic is Heavy Fuel Oil (HFO)[3].

The HFO, currently used by the majority of cruise ships, is the dirtiest fuel used in any transport sector. The International Maritime Organization (IMO) has already banned ships from using and carrying HFO in the Antarctic due to the risk to the fragile polar environment.[4] The Arctic experiences higher volumes of shipping and cruise tourism and therefore is arguably at greater risk.

The simplest and the most effective way to protect the Arctic against the risks linked to heavy fuel oil is to mandate vessels to switch away from HFO.

At its 72nd session in April 2018, the International Maritime Organization (IMO)'s Marine Environment Protection Committee (MEPC) approved a scope of work for its Pollution Prevention & Response (PPR) sub-committee, which agreed to "on the basis of an assessment of the impacts, develop a ban on HFO for use and carriage as fuel by ships in Arctic waters, on an appropriate timescale." Parties and international organizations were urged to submit concrete proposals to the next meeting of the MEPC, which will take place in October 2018, on an appropriate impact assessment methodology process.

The aim of this study is to evaluate the possible impact of the Arctic HFO ban on fuel costs and passenger ticket prices for a commercial cruise operator travelling through the Arctic and contribute to informed decision-making process at the IMO.

1.1. Risks from use of Heavy Fuel Oil in the Arctic

The Arctic Council (AC) called HFO "the most significant threat from ships to the Arctic environment".[5] HFO consists of the residues of the oil refinery process. Its combustion is very polluting, resulting in high emissions of Sulphur oxides (SOx), volatile organic compounds, and heavy metals as well as emissions of black carbon particles. Black carbon emissions, in particular, can settle and change the albedo of ice surfaces, thereby retaining heat from sunlight and accelerating ice melt.

The environmental impact of HFO is not limited to air pollution. According to Det Norske Veritas (DNV), using distillates instead of HFO as fuel would achieve significant spill risk reduction.[6] A review of the problems posed by spills of heavy fuel oils, by the International Tanker Owners Pollution Federation (ITOPF) concluded "[w]here the impact and costs of a spill are a concern, it should be recognized that the consequences of heavy fuel oils can be more prolonged because of the persistent nature of the product. The threat to vulnerable marine life such as seabirds as well as economically sensitive resources can therefore on occasions last longer in the event of a heavy fuel oil spill."[7]

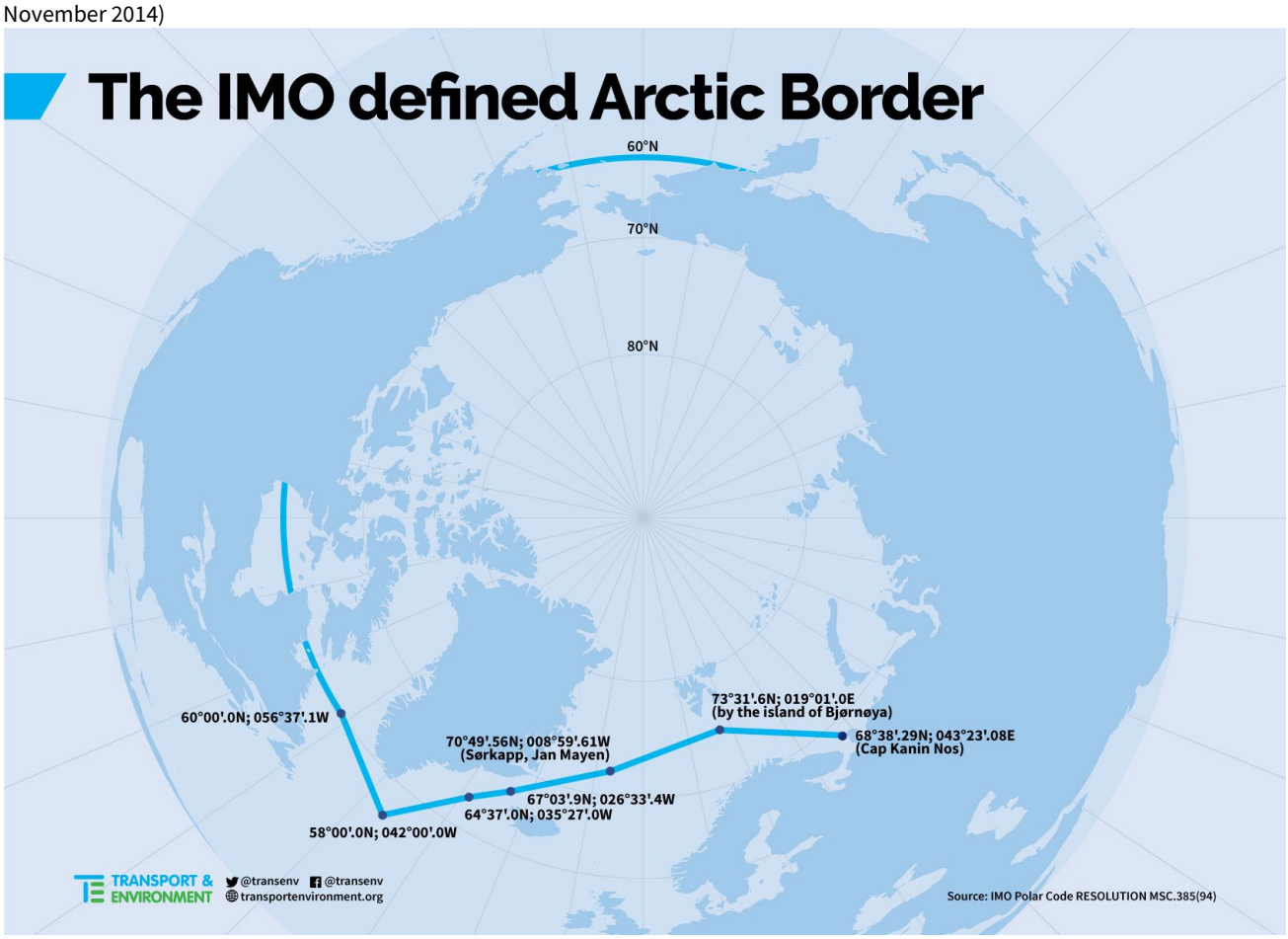
The discharge of HFO into the world's oceans due to oil spills is well-documented and has had devastating effects on ecosystems and the marine environment. The consequences of such spills in the Arctic would be many times more serious due to the remoteness of the region, the extreme temperatures, the weather, the

[1] https://www.cruising.org/docs/default-source/research/clia-2017-state-of-the-industry.pdf?sfvrsn=0
[2] https://thebarentsobserver.com/en/arctic/2017/06/bigger-cruise-ships-more-tourists-sail-svalbard-waters
[3] https://www.theicct.org/publications/prevalence-heavy-fuel-oil-and-black-carbon-arctic-shipping-2015-2025
[4] http://www.imo.org/en/MediaCentre/PressBriefings/Pages/44-MARPOL-amends.aspx#.W6s4OGj7Q2w
[5] Arctic Marine Shipping Assessment 2009 Report (AMSA, 2009). Arctic Council, April
[6] Det Norske Veritas, *Heavy fuel in the Arctic (Phase 1)*,Report No./DNV Reg No.: 2011-0053/ 12RJ7IW-4 Rev 00, 2011-01-18, (2011).
[7] Ansell D.V. et. al., A Review of the Problems Posed by Spills of Heavy Fuel Oils, The International Tanker Owners Pollution Federation Ltd. (2001).

ice conditions, and long periods of darkness. All of which could seriously hinder search and rescue and conventional clean-up operations for up to six months of the year. Therefore, the damage from an oil spill in the Arctic is likely to be far more persistent and extensive than in other waters. A study commissioned by the Arctic Council to demonstrate the different behaviors of HFO and diesel spills in cold water environments resulted in 90 percent of HFO remaining in the ocean after 20 days, while marine diesel took three days to nearly disappear from the surface.[8] The cost of cleaning up an HFO spill in the Arctic would also be very high. A recent 3,000-gallon (around 1 tonnes) HFO spill on the southern end of Shuyak Island, Alaska (south of the IMO defined Arctic) cost approximately $9 million to clean up.[9]

The IMO polar code came into effect in 2017 which toughens demands on ship safety and pollution. It banned the use of heavy fuel oil in the Antarctic, for instance, but merely encourages ships not to use it in the Arctic.

Figure 1: The maximum extent of the IMO Arctic as defined in the Polar Code RESOLUTION MSC.385 (94) (adopted on 21 November 2014)



The phasing out the use of HFO as a marine fuel is considered the most effective mitigation strategy to protect arctic from these risks. The International Maritime Organization (IMO) is an appropriate international body to regulate the use and carriage of HFO, to adopt a legally binding instrument to phase out the use of HFO as marine fuel in Arctic waters by 2020. In April 2018 at the Marine Environment Protection Committee (MEPC 73), the IMO agreed to, on the basis of an assessment of the impacts, develop a ban on HFO for use and carriage as fuel by ships in Arctic waters, on an appropriate timescale.

[8] Ibid. Det Norske Veritas (2011).

[9] Desroches, Kayla, Response Wraps Up on Shuyak Island Oil Spill (2018). Available at: https://www.alaskapublic.org/2018/04/25/response-wraps-up-on-shuyak-island-oil-spill/.

1.2. Cost analysis of an Arctic HFO ban for a typical cruise

The purpose of this study is to evaluate the cost per passenger resulting from the switch from HFO to distillate fuel for a cruise ship travelling through the IMO designated Arctic. The analysis is based on the case study of the MS Rotterdam, IMO registration number 9122552, which visited the Arctic for 3 separate voyages during the summer cruise season in 2018 for the period of June until end of August 2018.

2. Methodology

In order to evaluate the possible costs of Arctic HFO ban on the analysed journeys, this report uses the methodology followed by the IMO 3rd GHG Study (2014) and ICCT GHG inventory (Olmer et al., 2017)[10] to estimate the fuel consumption of the ship. This required both technical specifications of the ship in question – the MS Rotterdam – as well as its real operational profile over the analysed period. Technical specifications of MS Rotterdam have been found online and is described in table 1 below.

Table 1: Technical specifications of the cruise ship MS Rotterdam (source: online research)

Ship name	MS Rotterdam	Units
IMO num	9122552	
Ship type	Cruise	
DWT	6,351	tonnes
Gross Tonnage	61,849	tonnes
Maximum speed	25	knots
Total ME Power	37,500	kW
ME Type	electric propulsion motor	
Total AE Power	58,590	kW
AE Type	ICE	
AE average SFOC	210	g/kWh
AE speed	500	rpm
Year of production	1997	
Capacity	1404	passengers
Length	238	metres

The operational profile of the ship over the summer of 2018 was obtained via AIS (with 30 min intervals between each data point) from MarineTraffic. Fuel consumption and associated emissions of CO_2, SO_x, NO_x, and PM were estimated separately for each data point and summed to derive total figures.

The analysed operational profile of the ship spans from 30-June to 25-August 2018 and includes 3 voyages through the IMO Arctic[11]:

I. Rotterdam to Boston (30/June-18/July),
II. Boston to Rotterdam (18/July-05/August), and
III. Rotterdam to Boston (05/August-25/August).

It is assumed that, under the HFO ban scenario, MS Rotterdam would switch to distillate fuel – marine gas oil (MGO) as, to the best of our knowledge, the ship is not equipped with dual fuel LNG engines. Since MS

[10] Olmer, N., Comer, B., Roy, B., Mao, X., and Rutherford, D. (2017). *Greenhouse gas emissions from global shipping, 2013-2015*. The International Council on Clean Transportation. Available at: https://www.theicct.org/publications/GHG-emissions-global-shipping-2013-2015

[11] It is important to note that the actual dates on the tickets could be slightly different (+-1 day). The current split of voyages were determined on the basis of the ship's port calls between Europe and North America via the IMO Arctic.

Rotterdam is equipped with scrubbers (EGCS), it is assumed that the ship currently uses them to comply with the European and North American SECA requirements and will in the future use them to comply with the 2020 global 0.5% Sulphur cap. Therefore, we have used high Sulphur heavy fuel oil (HSHFO)[12] as our baseline fuel. Estimations were done for 2 fuel price scenarios: 2018 and 2021 (table 2). The latter is the first year of the proposed Arctic HFO ban.

Table 2: fuel price assumption for calculations ($/tonne)

	2018[13]	**2021**[14]
HSHFO	430	466
MGO	660	616
Price difference	230	150

Table 3 presents the passenger ticket prices that were used in our estimations for each separate Arctic voyage with the cruise ship MS Rotterdam.

	# days	**Ticket type**	**Price** ($)[15]
Voyage Rotterdam to Boston (30/June-18/July),	19	interior	3699
Voyage Boston to Rotterdam (18/July-05/August)	19	interior	2719
Voyage Rotterdam to Boston (05/August-25/August)	21	interior	3899

3. Case study findings

3.1. Voyage Rotterdam to Boston (30/June-18/July)

Table 4 presents the results of estimations of fuel consumption and associated emissions of CO_2, NOx, SOx and PM by the cruise ship MS Rotterdam on its Arctic voyage between 30/June-18/July (Figure 2).

Table 4: Fuel consumption and associated emissions by MS Rotterdam (Voyage Rotterdam to Boston (30/June-18/July))

	outside IMO Arctic			**Total**
	ECA	**Non-ECA**	**IMO Arctic**	
Fuel consumption (tonnes)	795	676	228	**1,699**
CO2 (tonnes)	2,461	2,118	710	**5,289**
NOx (tonnes)	50	45	15	**110**
SOx (tonnes)	2	33	11	**46**
PM (tonnes)	0.70	4.39	1.48	**7**

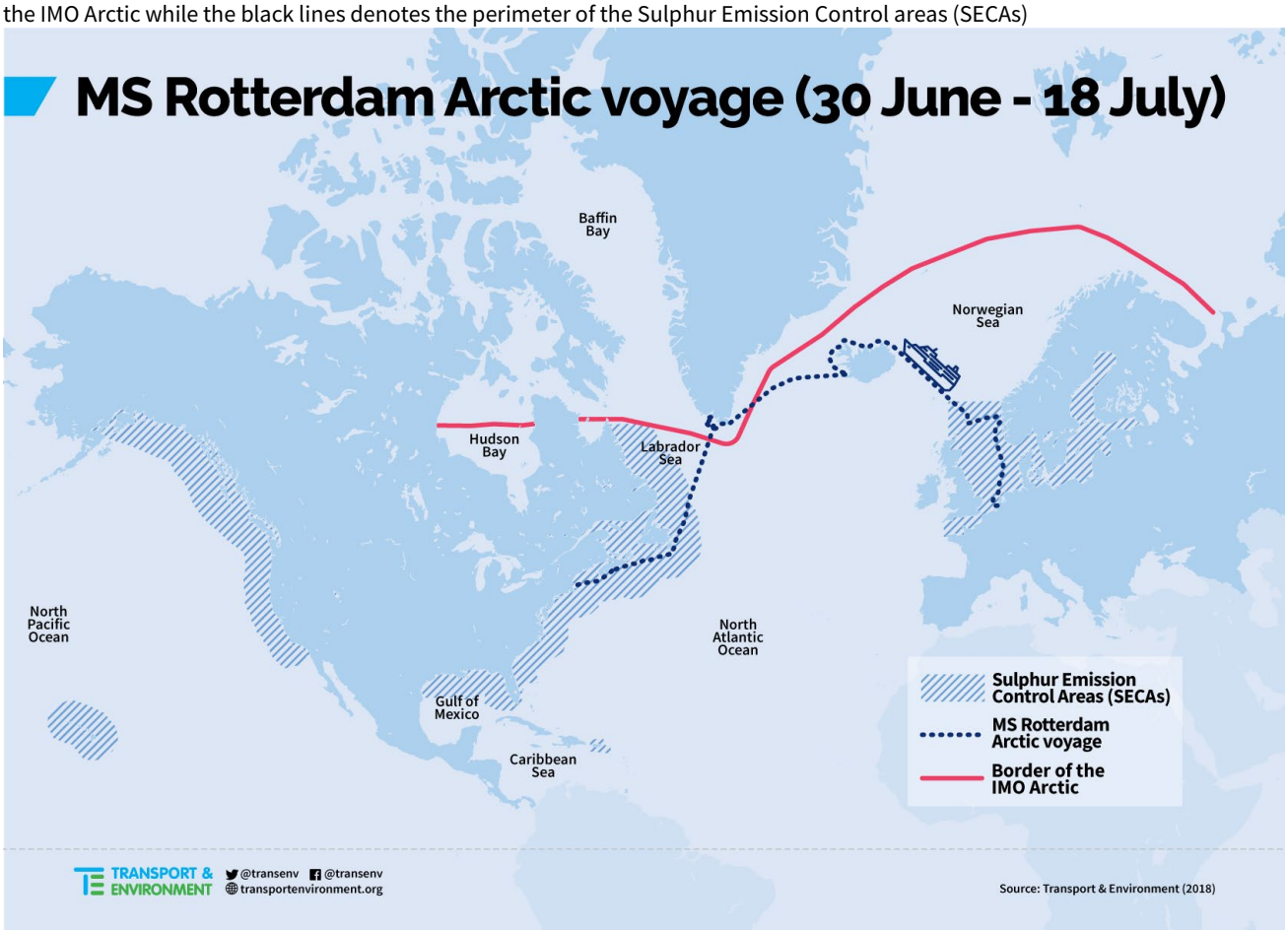
[12] Both 2018 and 2020 scenario assumes that MS Rotterdam uses HSHFO with a Sulphur content of 2.5%.

[13] https://shipandbunker.com/prices/emea/nwe/nl-rtm-rotterdam#ULSFO, accessed on 14/Sep/2018

[14] CE Delft, 2018, https://www.cedelft.eu/en/publications/2165/residuals-bunker-fuel-ban-in-the-imo-arctic-waters.

[15] An exchange rate of 0.87 $/€ was used for price conversion to EURO in the analysis.

Figure 2: Arctic voyage of MS Rotterdam (30/June-18/July) indicated by the blue line. The red line indicates the perimeter of the IMO Arctic while the black lines denotes the perimeter of the Sulphur Emission Control areas (SECAs)



Even though the figures in table 5 indicate the real fuel consumption by MS Rotterdam within and outside the IMO Arctic, the use of these figures is not appropriate for policy analysis. This is because the HFO ban proposal covers both the ban on the use of HFO in the Arctic, as well as carriage of HFO in the Arctic. This means that under the HFO ban scenario, a ship will be able to use and carry HFO up until the IMO Arctic border (i.e. the inbound leg), but the carried HFO must be exhausted before the ship crosses the boundary of the IMO Arctic. Beyond this boundary, the ship will have to switch to non-residual fuels. This also means that on the outbound leg of the voyage - i.e. from IMO Arctic to the next port of call outside the IMO Arctic, the ship will have to use and carry only non-residual fuels. Table 5 presents fuel consumption by MS Rotterdam classified as inbound as well as within and outbound legs of the journey in relation to the IMO Arctic.

Table 5: Fuel consumption by MS Rotterdam on the inbound, within Arctic and outbound legs of the journey (tonnes)

Fuel consumption (tonnes)	**outside-Arctic** (inbound)		**Arctic & post-Arctic** (outbound)
	ECA	**Non-ECA**	
	344	551	804
Total	**1699**		

Table 6 presents total fuel costs for MS Rotterdam during the entire voyage under the business as usual (BAU) and Arctic HFO ban scenarios for the years 2018 and 2021. As it can be seen, an HFO ban would increase fuel costs/per voyage of the ship 15-25% depending on the year of analysis.

Table 6: Fuel costs for the ship/voyage

	2018	2021
BAU (HFO)	€635,596	€688,809
Arctic HFO ban	€796,476	€793,731
delta	*€160,880*	*€104,922*
change in %	*25%*	*15%*

However, voyage cost increase does not provide a holistic picture from the policy impact viewpoint; because if fully passed on, these costs increase would be spread among the 1400+ passenger tickets and per passenger ticket price increase will be much smaller. Table 7 summarizes the estimated impact of additional fuel costs (due to Arctic HFO) ban on the cruise passenger tickets. As it can be seen, ticket prices would increase €4-6 per day if the additional costs resulting from HFO ban are fully passed on to the passengers. If the costs are shared between the cruise operator and the passengers, these already small ticket price increase would be much smaller.

Table 7: Additional costs of Arctic HFO ban on cruise passenger tickets

	2018	2021
Original ticket prices (€)	3218	3218
Price increase per ticket	€115	€75
New ticket price (€)	3333	3293
Hike on ticket prices per journey/passenger	4%	2%
Ticket price increase per day/passenger	€6	€4

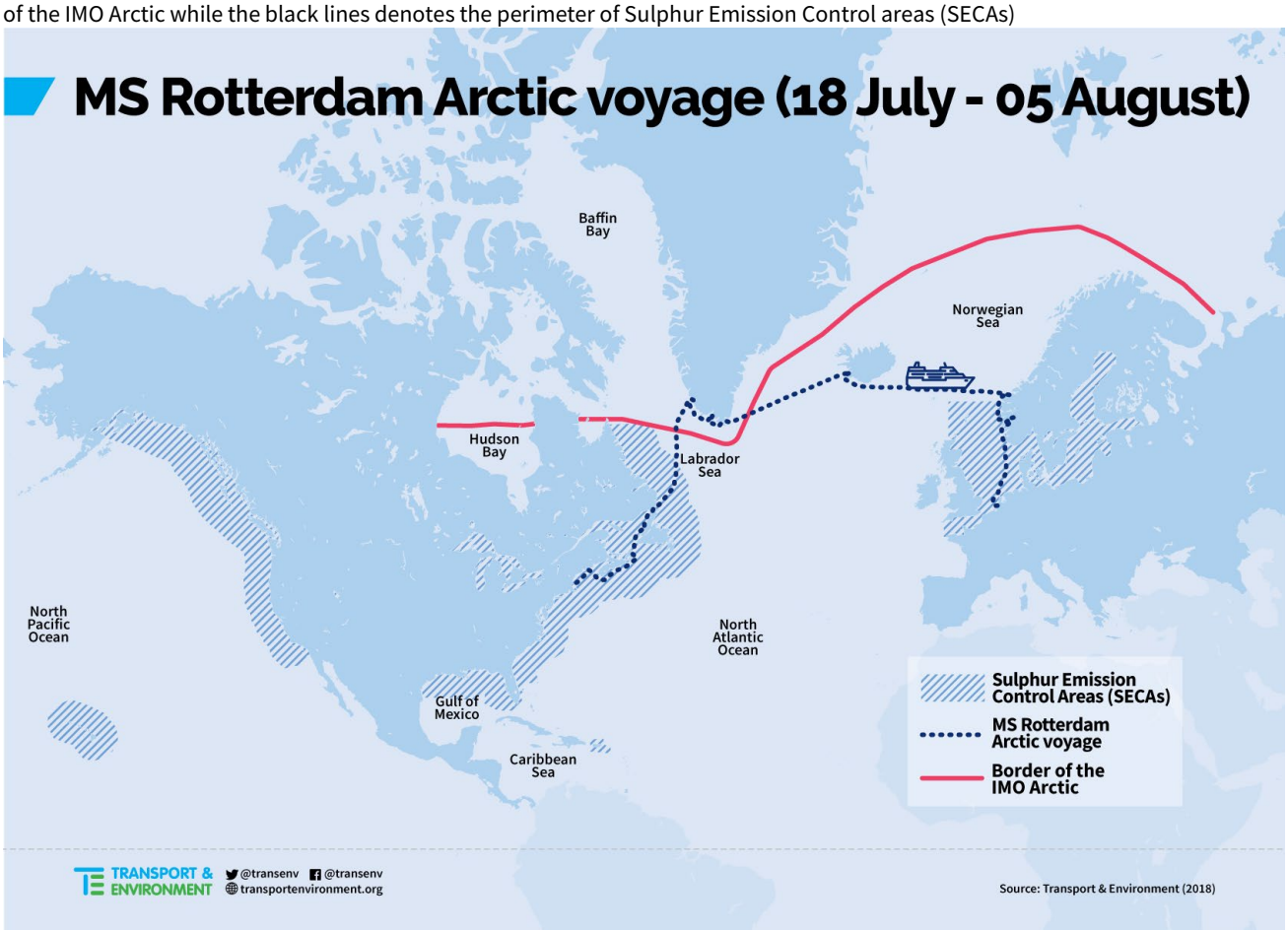
3.2. Voyage Boston to Rotterdam (18/July-05/August)

Table 8 presents the results of estimations of fuel consumption and associated emissions of CO2, NOx, SOx and PM by the cruise ship MS Rotterdam on its Arctic voyage between 18/July-05/August (Figure 3).

Table 8: Fuel consumption and associated emissions by MS Rotterdam (voyage Boston to Rotterdam (18/July-05/August))

	outside IMO Arctic		IMO Arctic	Total
	ECA	Non-ECA		
Fuel consumption (tonnes)	865	597	285	**1,747**
CO2 (tonnes)	2694	1860	886	**5,440**
NOx (tonnes)	54.206	39.811	18.976	**113**
SOx (tonnes)	1.691	29.188	13.912	**45**
PM (tonnes)	0.757	3.877	1.848	**6**

Figure 3: Arctic voyage of MS Rotterdam (18/July-05/August) indicated by the green line. The red line indicates the perimeter of the IMO Arctic while the black lines denotes the perimeter of Sulphur Emission Control areas (SECAs)



In addition, Table 9 presents fuel consumption by MS Rotterdam classified as inbound as well as within and outbound legs of the journey in relation to the IMO Arctic, which was used as the basis for cost analysis in this study.

Table 9: Fuel consumption by MS Rotterdam on the inbound, within Arctic and outbound legs of the journey (tonnes)

	outside-Arctic (inbound)		**Arctic & post-Arctic** (outbound)
	ECA	**Non-ECA**	
Fuel consumption (tonnes)	573	46	1128
Total	**1747**		

Table 10 presents total fuel costs for MS Rotterdam during the entire voyage under the business as usual (BAU) and Arctic HFO ban scenarios for the years 2018 and 2021. As it can be seen HFO ban would increase fuel costs/per voyage of the ship 21-35% depending on the year of analysis.

Table 10: Fuel costs for the ship/voyage

	2018	**2021**
BAU (HFO)	€ 653,553	€ 708,269
Arctic HFO ban	€ 879,266	€ 855,473
delta	€ 225,713	€ 147,204
change in %	*35%*	*21%*

Table 11 summarizes the estimated impact of additional fuel costs (due to Arctic HFO ban) on the cruise passenger tickets. As it can be seen, ticket prices would increase by only €6-8 per day if the additional costs resulting from HFO ban are fully passed on to the passengers. If the costs are shared between the cruise operator and the passengers, these already small ticket price increase would be much smaller.

Table 11: Additional costs of Arctic HFO ban on cruise passenger tickets

	2018	2021
Original ticket prices (€)	2366	2366
Price increase per ticket	€ 161	€ 105
New ticket price (€)	2526	2470
Hike on ticket prices per journey/passenger	7%	4%
Ticket price increase per day/passenger	€ 8	€ 6

3.3. Voyage Rotterdam to Boston (05/August-25/August)

Table 12 presents the results of estimations of fuel consumption and associated emissions of CO2, NOx, SOx and PM by the cruise ship MS Rotterdam on its Arctic voyage between 05/Aug-25/Aug (Figure 4).

Table 12: Fuel consumption and associated emissions by MS Rotterdam (voyage Rotterdam to Boston (05/Aug-25/Aug))

	outside IMO Arctic		IMO Arctic	Total
	ECA	Non-ECA		
Fuel consumption (tonnes)	745	980	187	**1,912**
CO2 (tonnes)	2358	3015	584	**5,957**
NOx (tonnes)	47.444	64.555	12.495	**124**
SOx (tonnes)	1.48	47.328	9.161	**58**
PM (tonnes)	1.48	47.328	9.161	**58**

Figure 4: Arctic voyage of MS Rotterdam (05/Aug-25/Aug) indicated by the yellow line. Red line indicates the perimeter of the IMO Arctic. The black lines indicate Emission Control Areas.

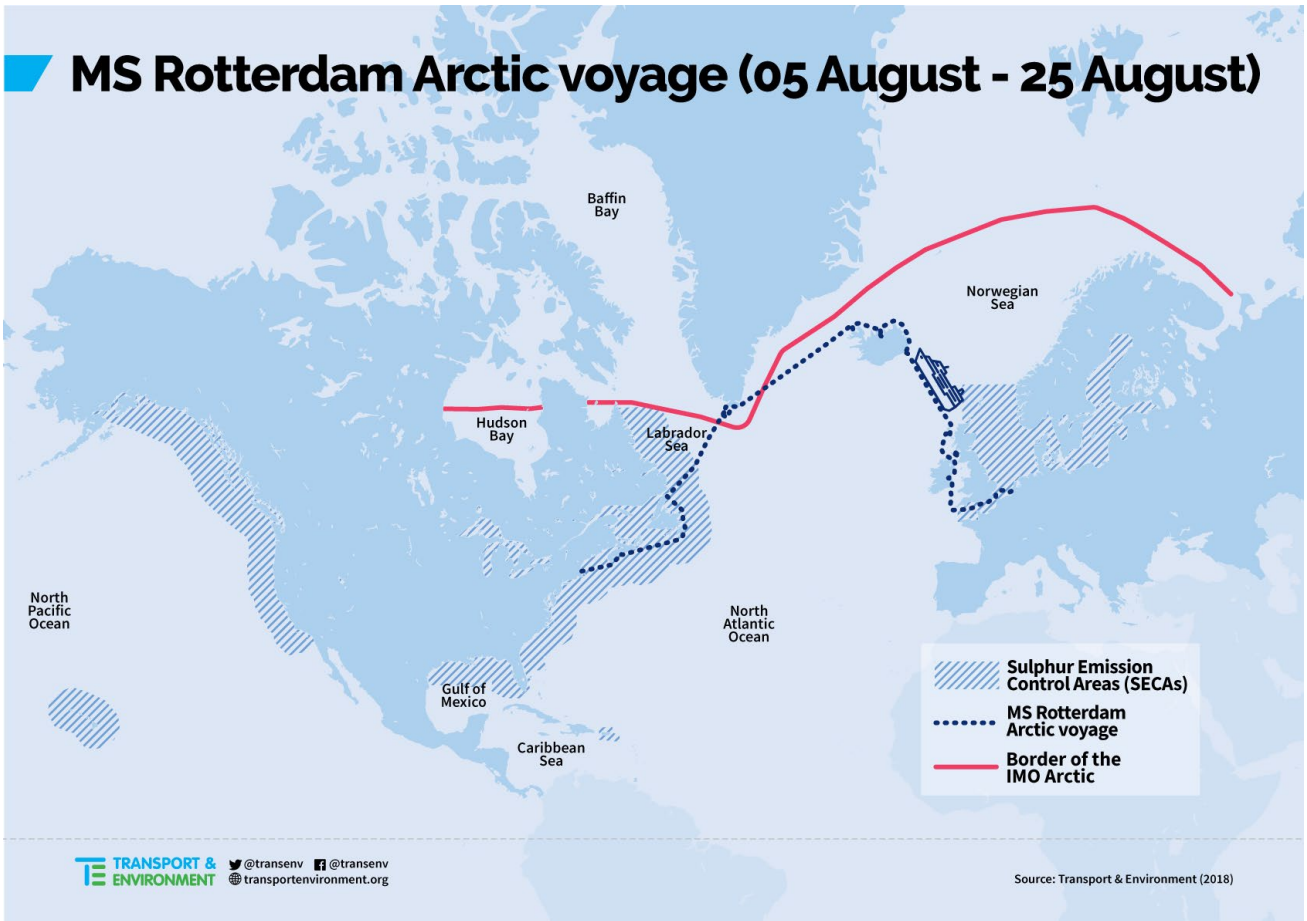


Table 13 presents fuel consumption by MS Rotterdam classified as inbound, within and outbound legs of the journey in relation to the IMO Arctic. These figures were used as the basis for cost analysis below.

Table 13: Fuel consumption by MS Rotterdam on the inbound, within Arctic and outbound legs of the journey (tonnes)

	outside-Arctic (inbound)		**Arctic & post-Arctic** (outbound)
Fuel consumption (tonnes)	**ECA**	**Non-ECA**	
	185	895	832
Total	**1912**		

Table 14 presents total fuel costs for MS Rotterdam during the entire voyage under the business as usual (BAU) and Arctic HFO ban scenarios for the years 2018 and 2021. As it can be seen HFO ban would increase fuel costs/per voyage of the ship 14-23% depending on the year of analysis.

Table 14: Fuel costs for the ship/voyage

	2018	**2021**
BAU (HFO)	€ 715,279	€ 775,163
Arctic HFO ban	€ 881,762	€ 883,739
delta	€ 166,483	€ 108,576
change in %	*23%*	*14%*

Table 15 summarizes the estimated impact of additional fuel costs (due to Arctic HFO ban) on the cruise passenger tickets. As it can be seen, ticket prices would increase by only €4-6 per day if the additional costs

resulting from HFO ban are fully passed on to the passengers. As is the case with other journeys, if the costs are to be shared between the cruise operator and the passengers, these already small ticket price increase would be much smaller.

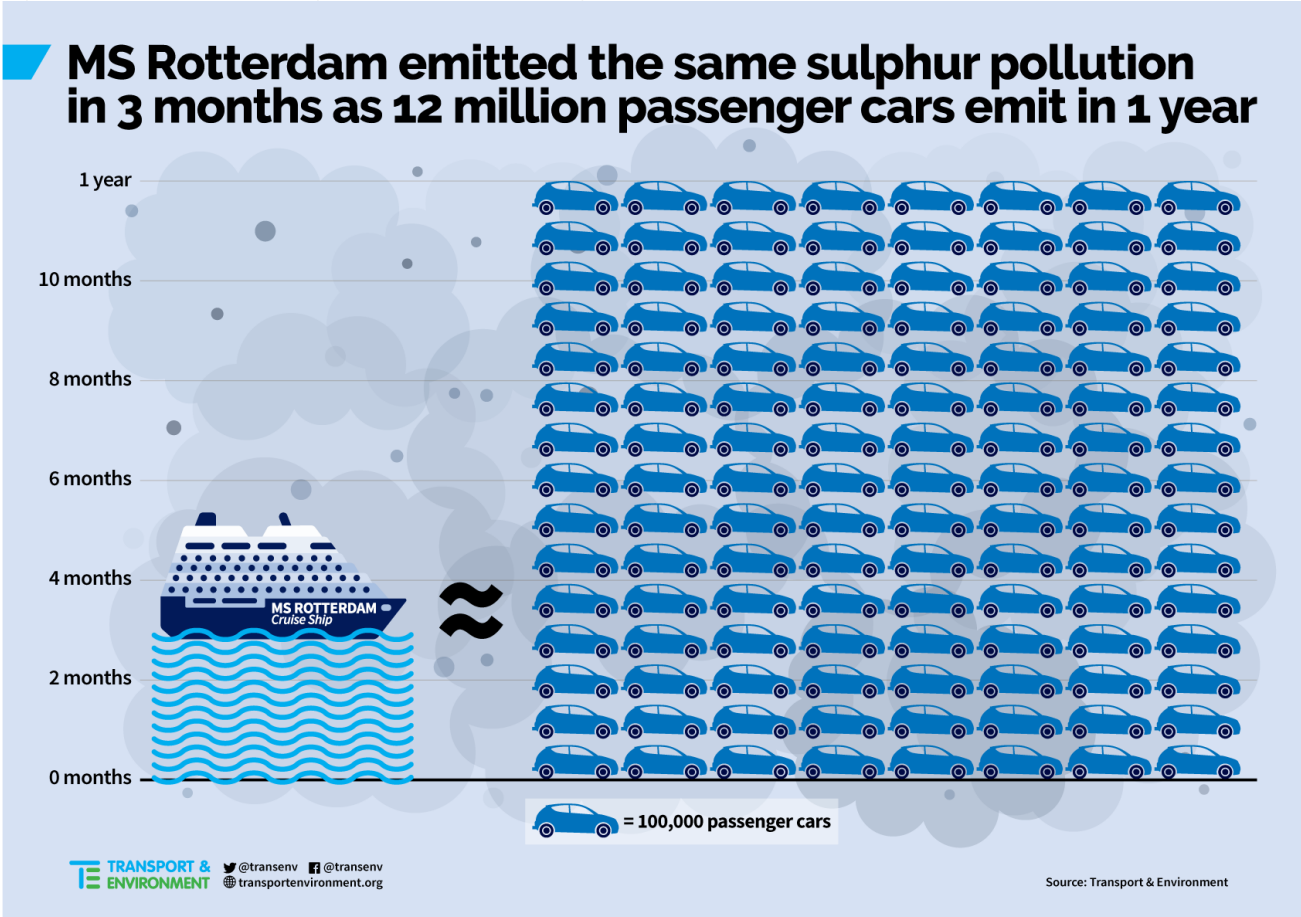
Table 15: Additional costs of Arctic HFO ban on cruise passenger tickets

	2018	2021
Original ticket prices (€)	3392	3392
Price increase per ticket	€ 119	€ 77
New ticket price (€)	3511	3469
Hike on ticket prices per journey/passenger	3%	2%
Ticket price increase per day/passenger	€ 6	€ 4

4. Discussions

Globally shipping industry remains one of the least regulated mode of transport from environmental point of view. Marine fuel remains the dirtiest fuel type used by any mode of transport; it emits huge amounts of sulphur oxides (SOx) when combusted. The best marine sulphur standard (1000 ppm) that applies in SECAs is still 100 times worse than road standard (10 ppm) for passenger vehicles. Outside SECAs ships burn fuels with on average 25,000 ppm sulphur content, although up to 35,000 ppm sulphur content is still legally permissible. As a result, MS Rotterdam has emitted around 150 metric tonnes of SOx over *3 months*. This is equivalent of SOx emissions from more than 12 million passenger cars over *1 year* (Figure 5).

Figure 5: SOx emissions: a single cruise ship vs. passenger cars



In addition to considerable air pollution, (residual) maritime fuel also poses considerable danger into marine environment when spilled, especially in environmentally sensitive areas like the Arctic. To reduce environmental damage risks associated with HFO (residual fuel) spills, a proposal has been brought before the IMO to ban the use and carriage of HFO in the Arctic. In order to understand the potential economic impact of this proposal, we have analysed the likely costs increase per cruise passenger ticket if the additional fuel costs are passed on by the ship operator. We have analysed this for a) historical 2018 fuel price, and b) forecasted 2021 fuel price scenarios.

2018 fuel price scenario

Under this scenario, Arctic HFO ban would have increased ticket prices per passenger by 4-7% for the 3 analysed summer voyages. This would mean an average of 6% increase for all three summer voyages.

In absolute terms, this would translate into €6-8/day price increase per ticket for three summer voyages. This would mean an average of €7/day increase on ticket prices per passenger.

Comparing this increase to the price of items on the menu of Holland America Line ships (Table 16), this increase is equivalent to the price of a glass of wine (€5.22-6.96), 2 bottles large bottles of mineral water (€5.66)[16] and less than the lunchtime 'Bento box' (€8.48)[17]. Therefore the increase in per day ticket price from a switch to cleaner fuel for the Arctic appears insignificant.

Table 16: The price of menu items served onboard MS Rotterdam

Menu item[18] [19]	Price dollars	Price euros[20]
'Bento' lunch Box	$9.75	€8.48
Burger and fries	$4.95	€4.31
Smoked salmon benedict	$7.50	€6.53
Greek yoghurt	$4.95	€4.31
Mineral water (1L)	$3.25	€2.83
Glass of red wine	$8.00	€6.96
Glass of white wine	$6.00	€5.22
Signature cocktail	$6.95	€6.05

Source: MS Rotterdam Menu http://www.cruisewithgambee.com/holland-america-drink-prices/ accessed 18/09/2018 https://www.cruisemapper.com/deckplans/ms-Rotterdam-717 accessed 18/09/2018

[16] http://www.cruisewithgambee.com/holland-america-drink-prices/

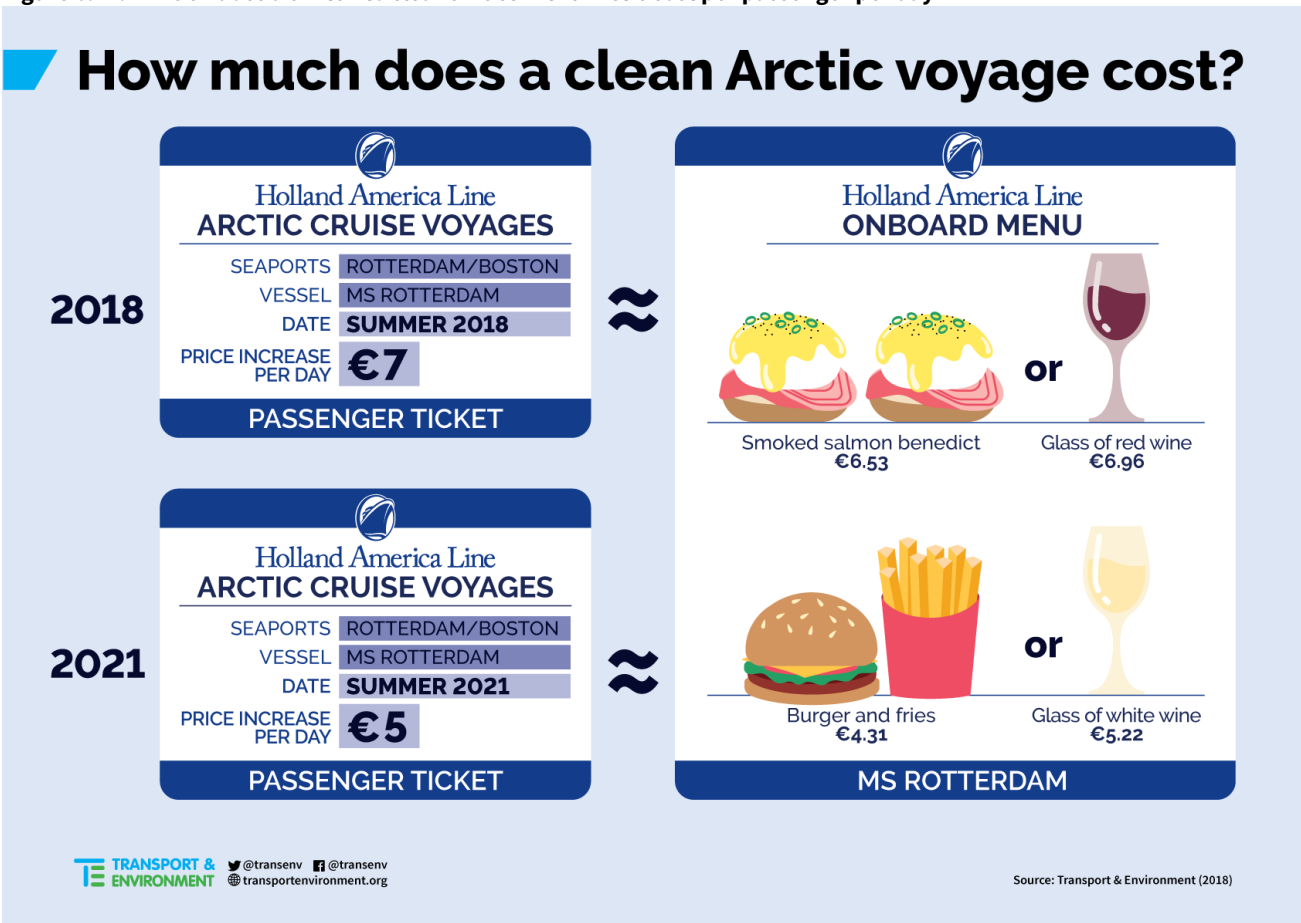
[17] http://www.cruisemapper.com/deckplans/ms-Rotterdam-717

[18] http://www.cruisewithgambee.com/holland-america-drink-prices/ accessed 18/09/2018

[19] https://www.cruisemapper.com/deckplans/ms-Rotterdam-717 accessed 18/09/2018

[20] An exchange rate of 0.87 $/€ was used for price conversion.

Figure 6: How much does a switch to cleaner fuel in the Arctic cost per passenger per day



2021 fuel price scenario

Under this scenario, Arctic HFO ban would have increased ticket prices per passenger by 2-4% for the 3 analysed summer voyages. This would mean an average of 3% increase for all three summer voyages.

In absolute terms, this would translate into €4-6/day price increase per ticket for three summer voyages. This would mean an average of €5/day increase on ticket prices per passenger.

Lower increase in ticket prices in 2021 could arguably be explained by the forecasted decrease in price gap between HSHFO and MGO after the implementation of the IMO 2020 global sulphur cap (Table 2).

This increase is equivalent to price of a burger (€4.31), the Greek yoghurt (€4.31)[21] or a glass of white wine (€5.22) onboard of the MS Rotterdam (Table 16).

5. Conclusions

Ban on the use and carriage for on-board use of HFO (residual fuel) in the Arctic, as proposed by Finland et al. (MEPC 72/11/1) will likely incur certain operational, mainly, fuel costs for the shipowners/operators. If these costs are fully or partially passed onto cruise passengers, HFO ban would increase the price of passenger tickets. This study has analysed these costs for cruise industry using three summer 2018 trips of MS Rotterdam to the Arctic as case studies. The main purpose of the analysis is to better understand the

[21] http://www.cruisemapper.com/deckplans/ms-Rotterdam-717

nature of the likely cost impact of the Finland et al. proposal and contribute to informed decision-making at the IMO.

The analysis was based on real technical specifications (obtained via Google search) and operational profile of MS Rotterdam (obtained from its AIS records via MarineTraffic). In general, this study finds that the likely cost impact of Arctic HFO ban will be small for ship owners and/or cruise passenger. Notably, if the ban were already in place in 2018, the price of average cruise passenger ticket would go up by only €7/passenger per day (assuming full costs pass-through). This price increase would be equal to the price of a glass of wine sold on board of MS Rotterdam. If the ban enters into effect in 2021 as proposed by Finland et al. the price increase per passenger ticket would be €5/day (assuming full costs pass-through), which is comparable to a price of burger sold on board. This smaller increase in ticket prices may be explained by the forecasted lower difference in price of high Sulphur HFO and distillate fuel prices after the implementation of the International Maritime Organisation's (IMO) 2020 global Sulphur cap.

These findings lead us to conclude that Arctic HFO ban can be implemented immediately with limited impact on cruise industry. Considering the luxury nature of cruise shipping, any (small) increase in ticket prices should be acceptable for cruise passengers, especially considering that these costs would serve to the protection of the pristine environment that underpins the very growth in this industry segment.