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# REDUCTION OF THE IMPACT ON THE ARCTIC OF EMISSIONS OF BLACK CARBON FROM INTERNATIONAL SHIPPING

## Report of the Correspondence Group on Reduction of the Impact on the Arctic of Black Carbon Emissions from International Shipping

**Submitted by Canada**

**SUMMARY**

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|---|---|
| *Executive summary:* | This document provides the report of the Correspondence Group on Reduction of the Impact on the Arctic of Black Carbon Emissions from International Shipping |
| *Strategic direction, if applicable:* | 3 |
| *Output:* | 3.3 |
| *Action to be taken:* | Paragraph 19 |
| *Related documents:* | PPR 7/INF.15, PPR 7/22 and PPR 8/INF.2 |


## Introduction

1 The Sub-Committee on Pollution Prevention and Response (PPR), at its seventh session, established the Correspondence Group on Reduction of the Impact on the Arctic of Black Carbon Emissions from International Shipping, under the coordination of Canada, with the following terms of reference (PPR 7/22, paragraph 8.12):

.1 advance the development of a standardized sampling, conditioning and measurement protocol, including a traceable reference method and an uncertainty analysis, taking into account the three most appropriate Black Carbon measurement methods (FSN, PAS, LII), to make accurate and traceable (comparable) measurements of Black Carbon emissions;

.2 investigate the linkages between the measurement systems and policy options; and

.3 submit a report to PPR 8.

2 The Correspondence Group communicated via email over a 6-month period from April 2020 to October 2020 and had three rounds of input in accordance with the work schedule set out in annex 1 to this document.

**Participants**

3 The Correspondence Group had participants from the following Member Governments:

CANADA
CHINA
DENMARK
FINLAND
GERMANY
INDIA
IRAN (ISLAMIC REPUBLIC OF)
JAPAN
MALAYSIA
MARSHALL ISLANDS
NETHERLANDS
NORWAY
PAKISTAN
REPUBLIC OF KOREA
SINGAPORE
SWEDEN
UNITED KINGDOM
UNITED STATES

from the following intergovernmental organization:

EUROPEAN COMMISSION

and the following non-governmental organizations in consultative status:

INTERNATIONAL CHAMBER OF SHIPPING (ICS)
FRIENDS OF THE EARTH INTERNATIONAL (FOEI)
COMMUNITY OF EUROPEAN SHIPYARDS' ASSOCIATIONS (CESA)
CRUISE LINES INTERNATIONAL ASSOCIATION (CLIA)
WORLD WIDE FUND FOR NATURE (WWF)
THE EUROPEAN ASSOCIATION OF INTERNAL COMBUSTION ENGINE MANUFACTURERS (EUROMOT)
THE INSTITUTE OF MARINE ENGINEERING, SCIENCE AND TECHNOLOGY (IMarEST)
INTERNATIONAL TRANSPORT WORKERS' FEDERATION (ITF)
WORLD SHIPPING COUNCIL (WSC)
SUPERYACHT BUILDERS ASSOCIATION (SYBAss)
PACIFIC ENVIRONMENT
CLEAN SHIPPING COALITION (CSC)

**Outputs of the Correspondence Group**

4 To address the terms of reference of the Correspondence Group, the Coordinator established three areas of inquiry. These included:

.1 the development of a statement on the linkages between Black Carbon (BC) measurement systems and policy options to control BC (item 2 of the terms of reference);

.2 an investigation into other BC regulations, with the intent to identify potential learnings for IMO (item 2 of the terms of reference); and

.3 the compilation of a list of on-going and planned research projects that will inform the development of a standardized BC sampling, conditioning and measurement protocol, as well as a list of areas where further research is needed to progress the advancement of item 1 of the terms of reference.

5 In the first commenting round of the Correspondence Group, participants were invited to review a preliminary conclusion on the linkages between BC measurement systems and policy options to control BC, prepared by the Coordinator, based on information provided in table 2 of document PPR 7/INF.15 (Canada et al.). The objective of the Coordinator's request was to address item 2 of the terms of reference, which is to "investigate the linkages between the measurement systems and policy options". In particular, the Coordinator sought to identify those BC control policies that, when designed appropriately, may or may not need a standardized BC measurement system to confirm compliance with the policy. The original preliminary conclusion prepared by the Coordinator is presented in annex 2.

6 Participants were subsequently invited to provide information on any BC control policies (other than those listed in table 2 of document PPR 7/INF.15) that do or do not require the establishment of a standardized sampling, conditioning and measurement system to confirm compliance with the policy and/or information in support of maintaining or revising the preliminary conclusion. Based on the comments received, the conclusion was revised and participants were invited in the second commenting round to review the updated conclusion and provide any final comments on its accuracy, with accompanying proposals as appropriate.

7 In both rounds, participants submitted a wide range of information, including:

.1 suggested revisions to the language of the proposed conclusion;

.2 information about specific BC control technologies, fuels and other measures; and

.3 comments on the BC control policies identified in document PPR 7/INF.15 and other policies.

Tables of comments received in relation to paragraphs 7.2 and 7.3 above are included in document PPR 8/INF.2

8 Several participants raised the concern that some of the policies listed in the conclusion do not always result in BC emission reductions (i.e. modern ship, shore power requirement, switch from HFO to distillate). In response, the Coordinator clarified the objective of the Coordinator's request in relation to the terms of reference and that the purpose of the resulting conclusion was not to recommend one BC control policy option over another, or to presume that these policy options would result in BC reductions in all circumstances. After round 1, the Coordinator also clarified that for the purposes of the Correspondence Group, the objective of the BC measurement method in this context was to confirm individual compliance with the applicable BC control policy and not for evaluating its overall effectiveness as a BC control policy. Additional considerations noted by participants on this topic are included in annex 2.

9 The final conclusion is as follows:

"A Black Carbon emissions limit policy of any kind would require a measurement method to confirm compliance, whereas some other BC control policies (e.g. shore power requirements) to control Black Carbon emissions would not. A focused policy of fuel switch only, including a switch to cleaner fuels, together with a fuel specification, would not require Black Carbon measurement but may, inter alia, require fuel samples, inspection of the bunker delivery note, or inspection of the fuel log to confirm that appropriate fuel is being used."

10 To address the second line of enquiry, participants were invited to identify any relevant limits, reporting requirements or other control measures at the international, national or sub-national level that target or include Black Carbon, including whether the identified

initiatives actively estimate or measure Black Carbon emissions for information or other purposes, and to provide details of the methodology and the associated development process. In total, 18 regulatory limits and reporting requirements were identified, with 12 of these applicable to the maritime sector, some as part of broader categories of targeted sectors.

11 Twelve of the identified instruments may indirectly help to reduce BC through particulate matter (PM) emissions limits, smoke limits and fuel quality specifications. The International Civil Aviation Organization (ICAO) *Non-volatile particulate matter mass engine emissions standard* (2020) and the ICAO *Non-volatile particulate matter (nvPM) mass and number engine emission standards* (2023) for international aviation come closest to a direct BC limit in the aviation sector. Document PPR 8/INF.2 provides a complete list of these initiatives with additional information about each initiative. To help inform IMO deliberations in this area, in the Coordinator's view it could be useful for the IMO Secretariat to reach out to ICAO for further information on the process used to develop the nvPM standards for international aviation. Member States that participated in the development of the nvPM standards at ICAO could also be encouraged to share information about the process with IMO.

12 To address the third area of enquiry, participants were invited to identify if their organization was undertaking or had considered work that would support the development of a standardized Black Carbon sampling, conditioning and measurement protocol, including a traceable reference method and an uncertainty analysis, and to identify the key areas of work where they could provide expertise or where they had a particular interest but did not have the expertise or resources to contribute. The objective of this request was to identify areas where further research may be needed to progress the advancement of item 1 of the terms of reference.

13 Seven participants identified that they had ongoing or planned research projects, and four participants expressed interest in contributing to this work. A summary of the ongoing and planned research to support the development of a standardized Black Carbon sampling, conditioning and measurement protocol is set out in annex 3 to this document. In addition to this information, a number of comments were made by participants in relation to BC measurement more generally. A summary of additional comments received about BC measurement is provided in annex 4.

14 After reviewing the round 1 input on this topic, the Coordinator compiled a list of research needs and gaps for consideration by the participants in the second commenting round. Participants were further invited to review the list and identify whether they thought the list of ongoing or planned work in this area adequately addressed the list of research needs/gaps, and if there were any additional needs/gaps for addition to the list. In total, eleven needs/gaps were identified in seven research areas including: scrubber impact, instrument calibration, onboard sampling, type approval, fuel properties/engine type/load, parametric testing, engine tuning and BC transport in the Arctic. The full list of identified needs/gaps is provided in annex 5.

15 Participants were also invited to provide any other information or considerations relevant to the terms of reference of the Correspondence Group. A wide variety of information was received in response to this request, the bulk of which was recategorized into the comment summaries for the other requests from the Coordinator, as contained in document PPR 8/INF.2. A table of additional useful resources was also compiled and is also provided in document PPR 8/INF.2.

16 Finally, as part of round 3, participants were invited to review the draft report and provide feedback. Based on the input received, the draft report was revised accordingly. The input received from participants in round 3 and the coordinator's disposition of comments received is included in document PPR 8/INF.2.

17 In summary, this Correspondence Group produced the following nine outputs:

.1 a statement on the linkages between BC measurement systems and policy options to control BC (paragraph 9 of this document) with associated considerations (annex 2);

.2 a list of direct and indirect BC emission limits and reporting requirements internationally (PPR 8/INF.2, annex 7);

.3 the identification of an emissions limit in the aviation sector that comes closest to a BC limit and involves the direct measurement of nvPM (which is used as a surrogate for BC in the aviation sector) (paragraph 11);

.4 a summary of ongoing and planned research to support the development of a standardized BC sampling, conditioning and measurement protocol (annex 3);

.5 a summary of additional comments received from participants about BC measurement (annex 4);

.6 a list of areas where further research is needed to progress the advancement of the development of a standardized BC sampling, condition and measurement protocol (annex 5);

.7 a summary of comments received on BC control measures (such as technologies, fuels, etc.) (PPR 8/INF.2, annex 5);

.8 a summary of comments received on BC control policies (PPR 8/INF.2, annex 6); and

.9 a list of additional resources (PPR 8/INF.2, annex 8).

18 The Coordinator would like to thank the participants of the Correspondence Group for their participation and valuable input over these last few months. While not all of the information submitted was directly related to the terms of reference of the Correspondence Group, it was all very relevant to the IMO work on BC and will be incredibly useful as the Organization progresses in discussions about BC control policies for international shipping.

**Action requested of the Sub-Committee**

19 The Sub-Committee is invited to note the above information, in particular the nine outputs of the Correspondence Group listed in paragraph 17, and take action, as appropriate.

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**ANNEX 1**

**WORKPLAN AND SCHEDULE OF THE CORRESPONDENCE GROUP ON REDUCTION OF THE IMPACT ON THE ARCTIC OF BLACK CARBON EMISSIONS FROM INTERNATIONAL SHIPPING**

| Date | Schedule of the CG | | Working arrangements |
|---|---|---|---|
| | PPR 7 | | |
| 27 March 2020 | CG round 1 | Deadline: 29 May 2020 | • Ask for comments on draft conclusion on linkages between Black Carbon policies and control measures.<br>• Ask for examples of other Black Carbon control measures.<br>• Ask about relevant work related to the first element in the remit.<br>• Ask for any additional information. |
| 30 June 2020 | CG round 2 | Deadline: 3 August 2020 | • Share the information collected through round 1 and ask for comments.<br>• Present summaries, conclusions and ask questions based on content received in round 1. |
| 26 September 2020 | CG: confirmation of report content | Deadline: 9 October 2020 | Share draft report for confirmation. |
| 17 December 2020 | PPR 8 bulky documents submission deadline | | |
| 22 to 26 March 2021 | PPR 8 | | |

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# ANNEX 2

## ORIGINAL PRELIMINARY CONCLUSION PREPARED BY THE COORDINATOR AND ADDITIONAL CONSIDERATIONS NOTED BY PARTICIPANTS

*A Black Carbon emissions limit of any kind would require a measurement method, whereas other measures (for instance, modern ship or shore power requirements) to control Black Carbon emissions would not. A fuel-based requirement may require fuel samples.*

Considerations noted by participants on the conclusion prepared by the Coordinator:

.1 Many participants noted the importance of developing a standardized BC measurement system, whether it was for the purposes of determining compliance with a control policy or for assessing the effectiveness of a control policy. A number of participants noted the importance of demonstrating, through supporting measurements and other evidence, the effectiveness of a BC control policy before its selection.

.2 One participant noted that a standardized BC measurement system was integral to the design of a BC policy and to evaluate policy effectiveness that regardless of the individual policy options considered, the development of a standardized BC measurement system was necessary.

.3 One participant noted that a standardized measurement system was not necessary for evaluating the effectiveness of specific BC control measures (i.e. specific BC control technologies, fuels and other measures), which could already be estimated. For this reason, it was recommended that future discussion should focus on BC control measures (see table 1 in annex 5 to document PPR 8/INF.2).

.4 One participant suggested a 3-year international study to monitor BC emissions from Arctic ships in order to provide data to aid the identification and selection of an appropriate BC control measure in the region. In response to this statement, one participant commented that this was not necessary as the issue had been discussed for many years; that shipping inside and outside of the Arctic may be relevant; and that appropriate BC control measures had already been identified.

.5 A number of participants also noted the need for more research to better understand BC emissions from large, low-speed marine diesel engines, at various engine load conditions to ensure that any BC control policy would be effective.

.6 Type approval of various BC control technologies (for instance, EGCS, ESP and PM filters) was noted as being a possible control measures to demonstrate compliance with an emissions limit policy.

.7 One participant also identified a need for onboard monitoring of BC in ship exhaust using a BC measurement method (i.e. FSN), particularly as technologies age and deteriorate and as "clean" fuels may be improperly prepared before use. Another participant recommended to reduce the list of the current BC measurements to the FSN method only.

.8 Some participants questioned the reference to a "modern ship" in the preliminary conclusion. For round 2, a footnote was included with information from document PPR 7/INF.15, noting that the specific definition necessary for such a policy did not prejudge whether or not a standardized BC measurement system was required. As many participants continued to raise concerns about the reference to a "modern ship", it was removed from the final conclusion.

.9 One participant noted that regardless of the chosen BC control policy, it would be important to both monitor its effectiveness in reducing BC emissions from shipping and to implement a means for monitoring compliance with the policy.

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**ANNEX 3**

**SUMMARY OF THE ONGOING AND PLANNED RESEARCH TO SUPPORT THE DEVELOPMENT OF A STANDARDIZED BLACK CARBON SAMPLING, CONDITIONING AND MEASUREMENT PROTOCOL**

| Country/ Organization | Research/Project | Timeline |
|---|---|---|
| Denmark | Development of a BC "MCEMS" cost-effective monitor based on micro-sensor technique: the project will compare FSN results during tests in October 2020 at a test engine site. As we are still testing a prototype, we are still aiming for a proof of concept. Assessment of calibration, accuracy and repeatability will be involved at a later stage. | Ongoing – prototype before 2020 |
| Germany | Ongoing project to compare FSN with PAS measurement method and investigating the influence of aromatic content of fuels on BC emissions of a modern medium-speed marine test engine with common rail injection system. | Ongoing – 3 years |
| China | A research project on BC emission reduction measures was ongoing, which included developing BC emission sampling and measurement systems; studying the potential of BC emission reduction measures; and developing BC emission inventories. | Ongoing |
| Finland | "BC footprint" project will support development needs of calibration methods for BC emission measurements. | Ongoing |
| Finland | Research project for sampling and measurement conditions (protocol) for FSN, PAS and LII.<br>• Verification of dilution ratio with traceable calibration methods when dilution is needed in the measurements<br>• Identifying critical parameters (pressures, temperatures, etc.) for each measurement principle and definition of acceptance criteria<br>• Boundaries of environmental conditions (for instance, ambient temperature, vibrations) for reliable operation of each measurement principle<br>• Capability of each measurement principle for reliable BC measurements from different exhaust matrices from marine engines<br>• Repeatability (within laboratory) and reproducibility (between laboratories)<br>• Uncertainty of BC emission results with each measurement principle | Ongoing – scheduled for completion by the end of 2021. |
| Canada | Research into the optical, physical and chemical characteristics of BC emissions using different fuels, engine operations, conditioning and sampling methods, and evaluation of the effect they have on instrument response. | Ongoing<br><br>Research work including measurement campaigns planned through to |

| Country/ Organization | Research/Project | Timeline |
|---|---|---|
| | Canada, through its National Metrology Institute, intends to participate in the development of a chain of traceability for Black Carbon emissions from ships. | March 2022. (Experiencing delays due to the COVID-19 pandemic) |
| European Commission | European Metrology project 16ENV02 – EMPIR Black Carbon Project (coordinator: the National Physical Laboratory, UK)<br>Funded under European Commission Horizon 2020<br>Black Carbon Metrology for light absorption by atmospheric aerosols. EMPIR is a European project that is working on traceable reference methods for BC. The project will provide a workable solution to the major problem of lacking SI traceability.<br>http://www.empirblackcarbon.com/ | Ongoing – delayed due to the COVID-19 pandemic.<br><br>Project ends December 2020 |
| European Commission | EN 16909 New Work Item (chaired by the Joint Research Center of the European Commission – JRC)<br>EN 16909 was developed by CEN TC264/WG35 for the measurement of organic and elemental carbon (OC&EC) in PM2.5 deposited on filters. The new work item addresses the equivalence of automatic (online) methods for measuring OC and/or EC.<br>https://ec.europa.eu/info/departments/joint-research-centre_en | Ongoing<br><br>The drafting of a technical report/ technical specifications started in 2019. This new work item will be the main focus of CEN TC264/WG35 from 30 June 2020. |
| Germany | German R&D Project "SAARUS".<br>The aim of the project is to reduce ship-based emissions through optimized and extended exhaust gas cleaning to protect the atmospheric and maritime environment.<br>The focus is on the emission of fine particles smaller than 2.5 µm (PM2.5). Furthermore, the pollution by pollutants due to incomplete fuel combustion will be investigated. As this project is focusing on particle size and aft-scrubber application it can contribute important results also for BC debate.<br>https://www2.saacke.com/fr/nouveautes/nouveautes/scrubbers-optimised-for-fine-dust-separation-the-next-level-of-exhaust-gas-cleaning/ | Ongoing<br><br>Project ends May 2022. |
| Republic of Korea | The project for measurement of emission on board.<br><br>Project to measure $NO_X$, $SO_X$, CO, $CO_2$ with gas analyser and BC with FSN on board. And investigating the influence of fuels and engines on BC emissions of a low/medium speed marine engine on various ships. | Project deadline extended to December 2024 |
| Republic of Korea | The analysis of BC, OC from particulate matters from marine engine on laboratory and ship. | Project deadline |

| Country/ Organization | Research/Project | Timeline |
|---|---|---|
| | The project is to analyse and compare ship-based particulate matters (BC, organic carbon, and sulfate) and measurement methods from fuels and engine type. | extended to Dec. 2021 |
| Canada | Establishment of a technical working group to develop a standardized BC sampling, conditioning and measurement protocol for marine engines for consideration as an international standard through the International Organization for Standardization (ISO), Society of Automotive Engineers (SAE) or other international standard setting authority. | **Planned**<br><br>Currently delayed due to the COVID-19 pandemic. Invitations had been planned for spring 2020. Given the time required to organize and coordinate measurement campaigns and report results, it is expected that it could take 2-3 years before a draft product could be submitted to an international standard setting authority. |

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# ANNEX 4

## SUMMARY OF ADDITIONAL COMMENTS RECEIVED ABOUT BC MEASUREMENT

1 BC measurement instruments could be influenced by sample conditioning, which had an impact on the results. BC measurements using FSN and PAS showed good correlation when sample conditioning was followed in accordance with instructions of the instrument manufacturer.

2 Any standardized BC measurement system would need to include information on the fuel basis/reference fuel it was validated against.

3 FSN is a standardized method for diesel engines. It conforms to ISO 10054 and the recently updated ISO 8178-3:2019 standard.

4 When considering measurement methods, it is crucial to know the purpose of the measurement, whether measurements are to be verified on a test bed or on board. If the purpose is not clear, it is difficult to assess which measurement method is the most appropriate. In general, repeatability of onboard measurements is lacking. FSN is simple, easy to maintain and appropriate for measurement both on a test bed and on board, though measurements on board would be associated with a number of practical challenges that would need to be addressed.

5 BC measurement equipment to be used on board ships must be robust and reliable taking into account the harsh environment at sea and also that ships may navigate in areas where the availability of service technicians can be scarce.

6 Onboard measurement of BC should be: 1) capable of installation in the exhaust duct of each combustion device to be controlled; 2) sufficiently robust to withstand the conditions of such installation; 3) simple to operate, maintain and calibration/zero-span check; 4) readily automated; and 5) capable of providing a recordable and retainable output.

7 One participant suggested applying lessons learned from the application of requirements for continuous measurement for scrubbers approved against scheme B. One participant responded that by the end of 2020, almost 4,000 ships were sailing with EGCS equipped with continuous emission monitoring systems (CEMS) for $CO_2$/$SO_2$ and demonstrated capability related to technology, reliability, availability and service aspects.

8 The same participant also noted that significant experience existed in the onshore sector measuring and reporting dust emissions continuously. A key benefit was that it gave the ship operator a choice regarding fuel and engine operation.

9 Another participant confirmed that although FSN was not suitable for continuous monitoring, it was suitable for onboard sampling. Opacimeters were suitable for continuous monitoring, however, they were not sensitive to BC and were excluded from the list of suitable measurement methods.

10 One participant noted that no additional work was considered necessary if the FSN approach was followed but would need a review stage to evaluate experience before moving to a tighter FSN limit. Another participant commented that FSN was an established technique and was seen as being deployable.

11 One participant suggested retrofitting of ships with scattered light dust measuring technology (EN15267) to measure and monitor BC at any time. Another participant responded that research had shown that online dust monitors were not sensitive to BC and were not regarded as suitable by engine manufacturers to measure or monitor BC.

12 One participant pointed out that the already developed BC measurement and reporting protocol addressed both the need for reporting as well as the need for a thorough description of the applied measurement procedure. Another participant stated that critical information was missing from the protocol template itself and would require amendment in advance of any further BC measurement studies within IMO. Another participant responded to this suggesting that no fundamental work would be needed if a FSN approach was adopted and inviting participants to provide feedback on their experience with the protocol.

13 One participant stated that the BC measurement principle should be able to be applied in a wide range of potential configurations and highlighted the importance of specifying the frequency of BC measurements (i.e. continuous vs. spot check).

14 One participant noted that black smoke measurements may be quite similar to current BC measurements as both are based on the measurement of light attenuation by exhaust particles deposited on a filter.

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# ANNEX 5

## LIST OF IDENTIFIED RESEARCH NEEDS AND GAPS

Exhaust gas cleaning system impact:

- Two participants specifically noted the need for a measurement standard to determine the impact the exhaust gas cleaning system has on black carbon emissions. One participant noted that it might be appropriate to consider the exhaust gas cleaning system impact on BC measurements when Canada establishes a technical working group to develop a standardized BC sampling, conditioning and measurement protocol for marine engines.

- One participant noted a need for more research to determine the effectiveness of exhaust gas cleaning systems when used with a multitude of fuel types beyond HFO.

Calibration:

- Three participants specifically noted the need for a calibration standard.

- One participant noted that for FSN, a calibration standard for VLSFO and other fuel standards may be needed.

Onboard sampling:

- One participant noted the need for an onboard sampling protocol.

- One participant noted that in case of onboard continuous measurements using sensors, research was needed on the accuracy and reliability (measurement errors) of such methods, including comparison with FSN, PAS and LII in the laboratory.

Type approval:

- Two participants identified a need for a standardized measurement method for type approval of diesel engines.

Fuel properties/engine types/load:

- Four participants identified the need for further evaluation of the effect of fuel properties on BC emissions (for example, hydrocarbon composition (aromatics, paraffins), H/C ratio and metal content of fuel), with two of these participants specifically identifying the need for this type of research in relation to large, slow speed marine diesel engines at different engine loads.

Parametric testing:

- One participant identified a need for further comparison of BC emissions by means of three different methods (FSN, PAS and LII) for different types of engines (2/4 stroke, slow/medium/high speed), operational load (for example, 25/50/75/100% of MCR) and types of fuel oils (HS-HFO with scrubber, LS-HFO, LFO, MGO and any other available fuel oils with identified specifications).

Engine tuning:

- Two participants noted the need for further evaluation of the possibilities to tune medium-speed engines to reduce BC emissions. This would support considerations of the need for fuel regulations for marine engines.

BC transport into Arctic:

- One participant noted the need to study transport of BC into the Arctic by atmospheric currents.