

Including estimates of Black Carbon emissions in the Fourth IMO GHG Study

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The logo for the International Council on Clean Transportation (ICCT). It features the lowercase letters 'icct' in a bold, dark blue font. The letter 'i' has a small blue circle above it. Below the letters, the full name 'THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION' is written in a smaller, dark blue, all-caps font.

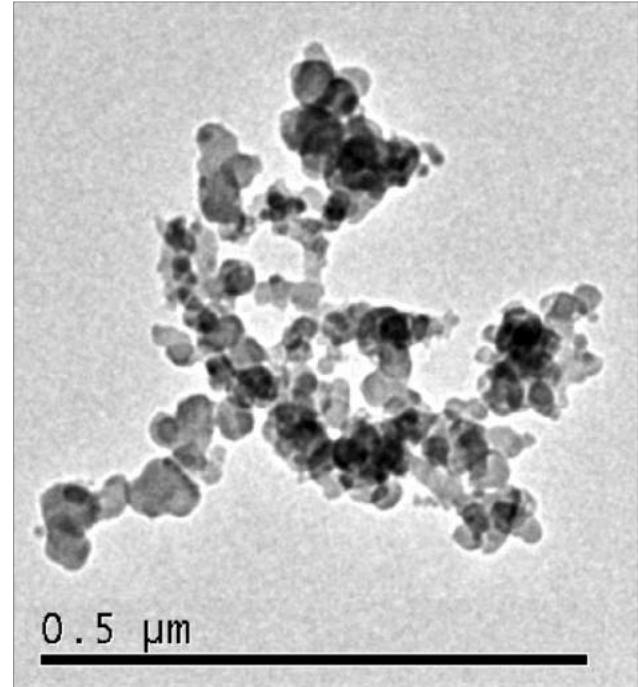
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Black Carbon



http://apps.startribune.com/blog/user_images/arctic_13.jpg

Courtesy: Star Tribune



Courtesy: UC-Riverside

Black carbon is a small, dark component of particulate matter and is classified as a short-lived climate pollutant.

Black Carbon contributes to climate change

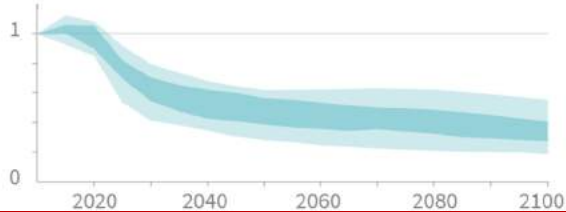
- Black Carbon is one component of particulate matter (PM) and is the **second largest anthropogenic contributor to global warming**, after carbon dioxide:
 - BC “is the second most important human emission in terms of its climate forcing in the present-day atmosphere” (Bond, et al., 2013, p. 5381).
- Black Carbon, therefore, is a **relevant substance that contributes to climate change.**

IPCC: BC must fall to achieve 1.5°C

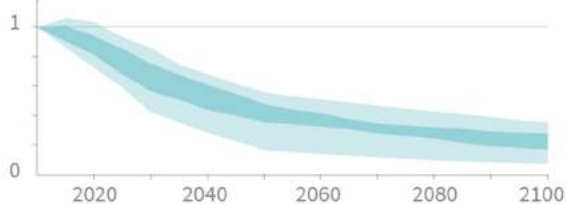
Non-CO₂ emissions relative to 2010

Emissions of non-CO₂ forcers are also reduced or limited in pathways limiting global warming to 1.5°C with **no or limited overshoot**, but they do not reach zero globally.

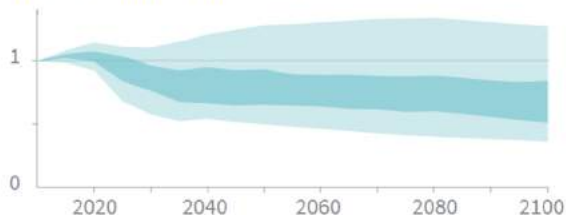
Methane emissions



Black carbon emissions

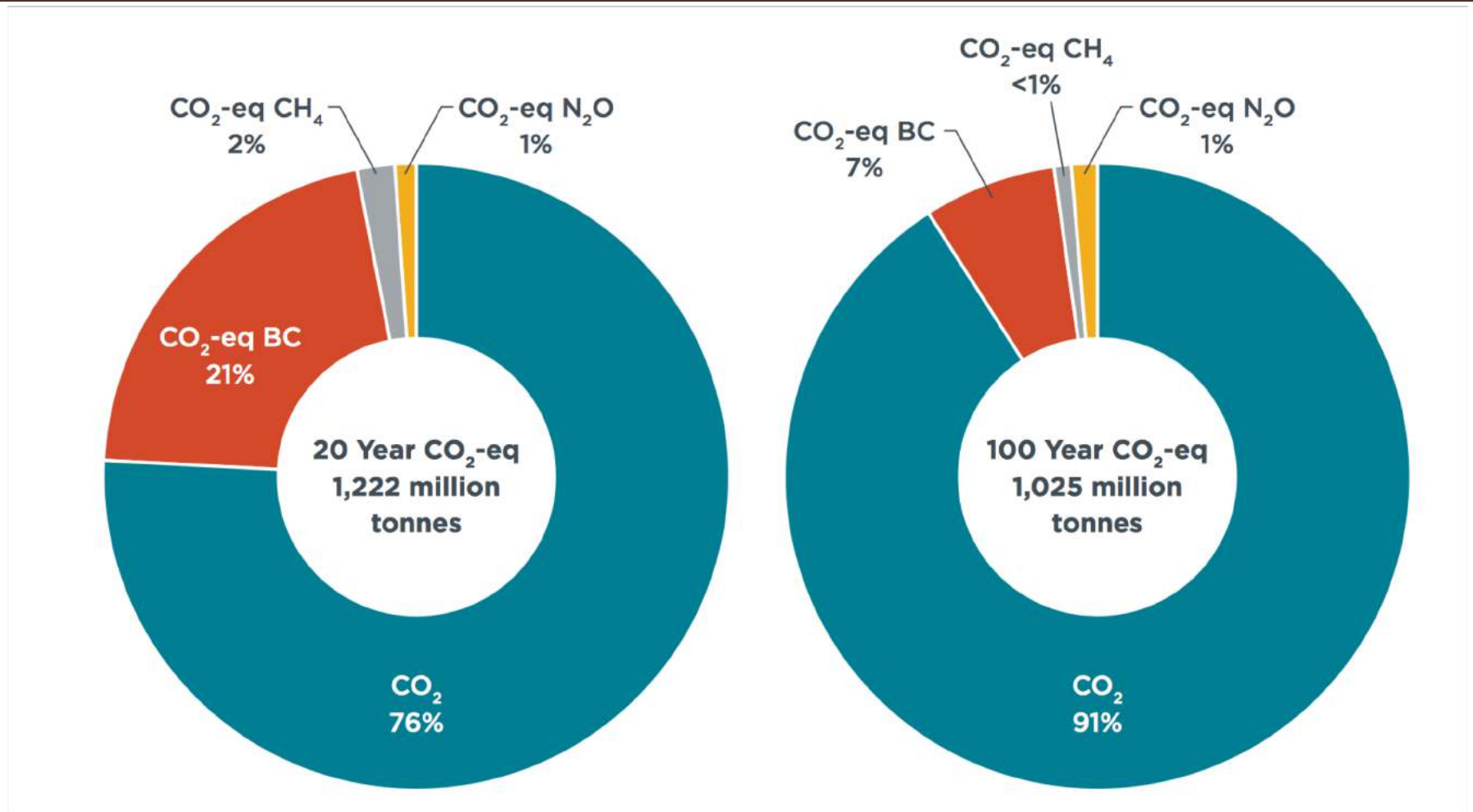


Nitrous oxide emissions



“Modelled pathways that limit global warming to 1.5°C with no or limited overshoot involve **deep reductions** in emissions of methane and **black carbon** (35% or more of both by 2050 relative to 2010).” (IPCC SR 1.5, p. SPM-16)

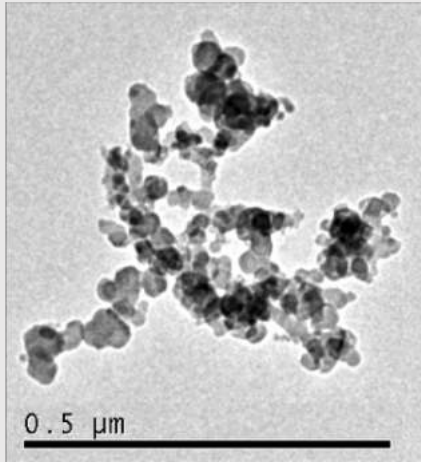
Black Carbon is also the second most important climate-forcing emission from the shipping sector



Source: Olmer et al. (2017). *Greenhouse gas emissions from global shipping, 2013-2015*. Available at: <https://www.theicct.org/publications/GHG-emissions-global-shipping-2013-2015>

IMO is working to address the impact on the Arctic of BC from international shipping

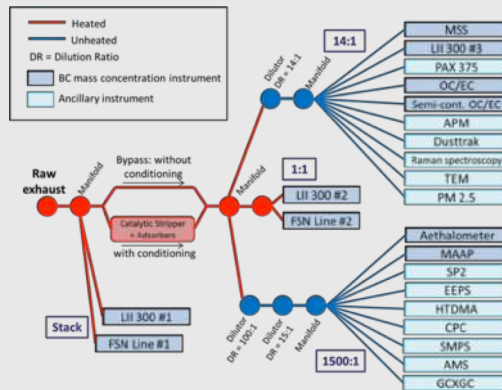
Step 1: Definition of BC



2015: Definition

Bond et al.

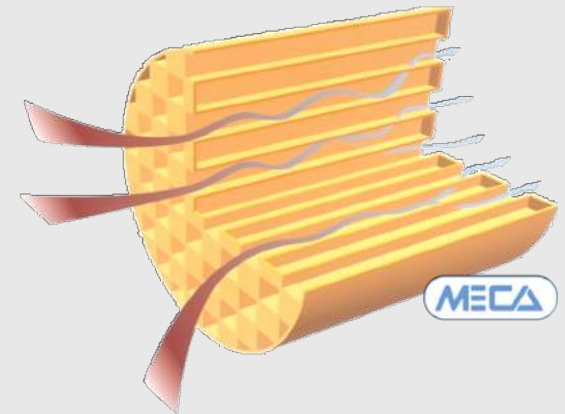
Step 2: Appropriate Measurement Methods



2018: Measurement Methods

FSN, PAS, LII

Step 3: Appropriate Control Measures



2019: Control Measures
(IMO identified 41 candidate BC control measures at PPR 6)

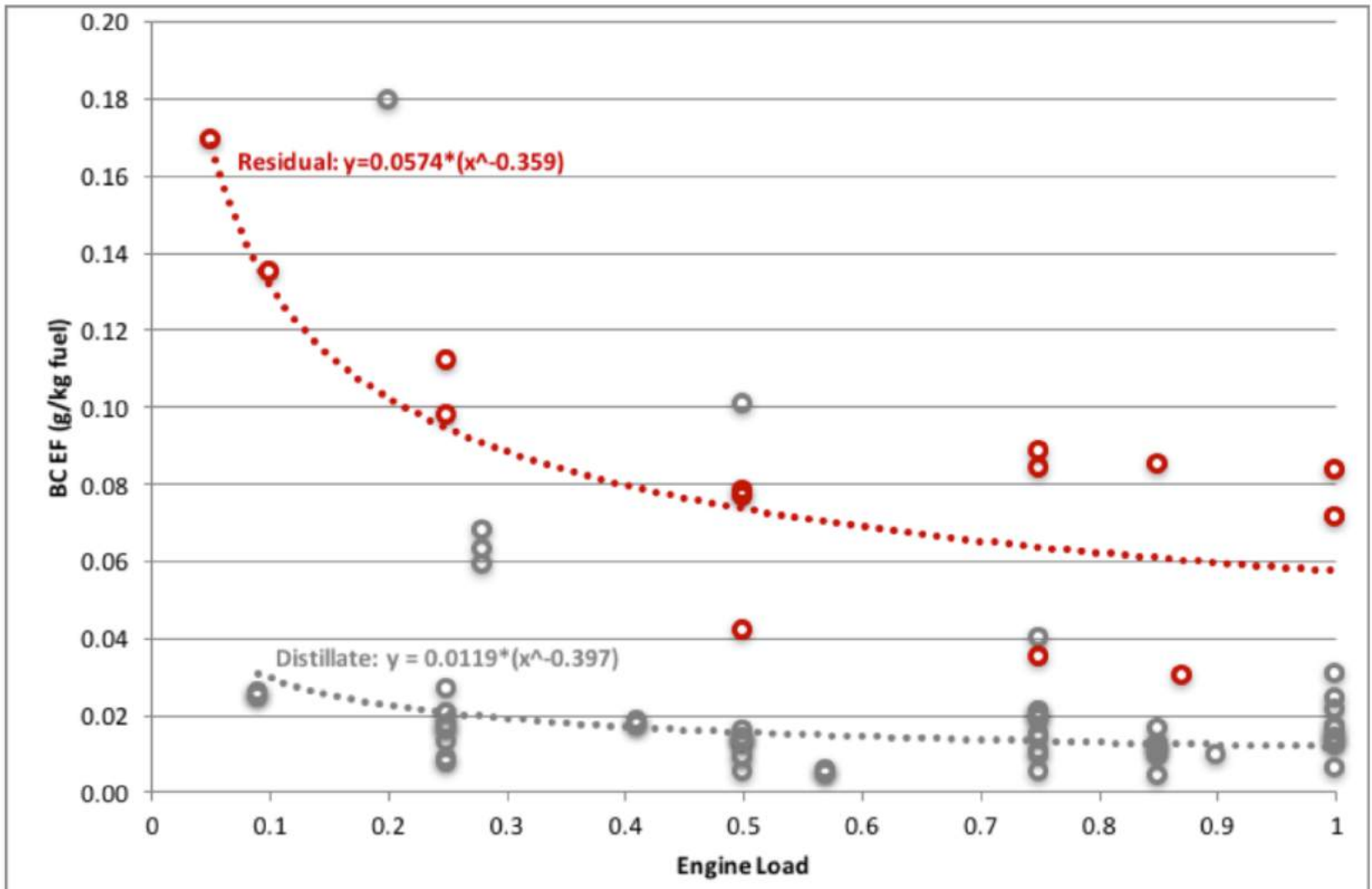
Black Carbon emissions data are available

- Under IMO's Black Carbon Work Plan, Member States and Industry have measured BC from marine engines and ships and have estimated BC emission factors.
- Canada, Denmark, Finland, Germany, Japan, Netherlands, Republic of Korea, USA, and EUROMOT have measured BC from engines and on-board ships and have presented the results at the ICCT black carbon workshops and submitted them to PPR.

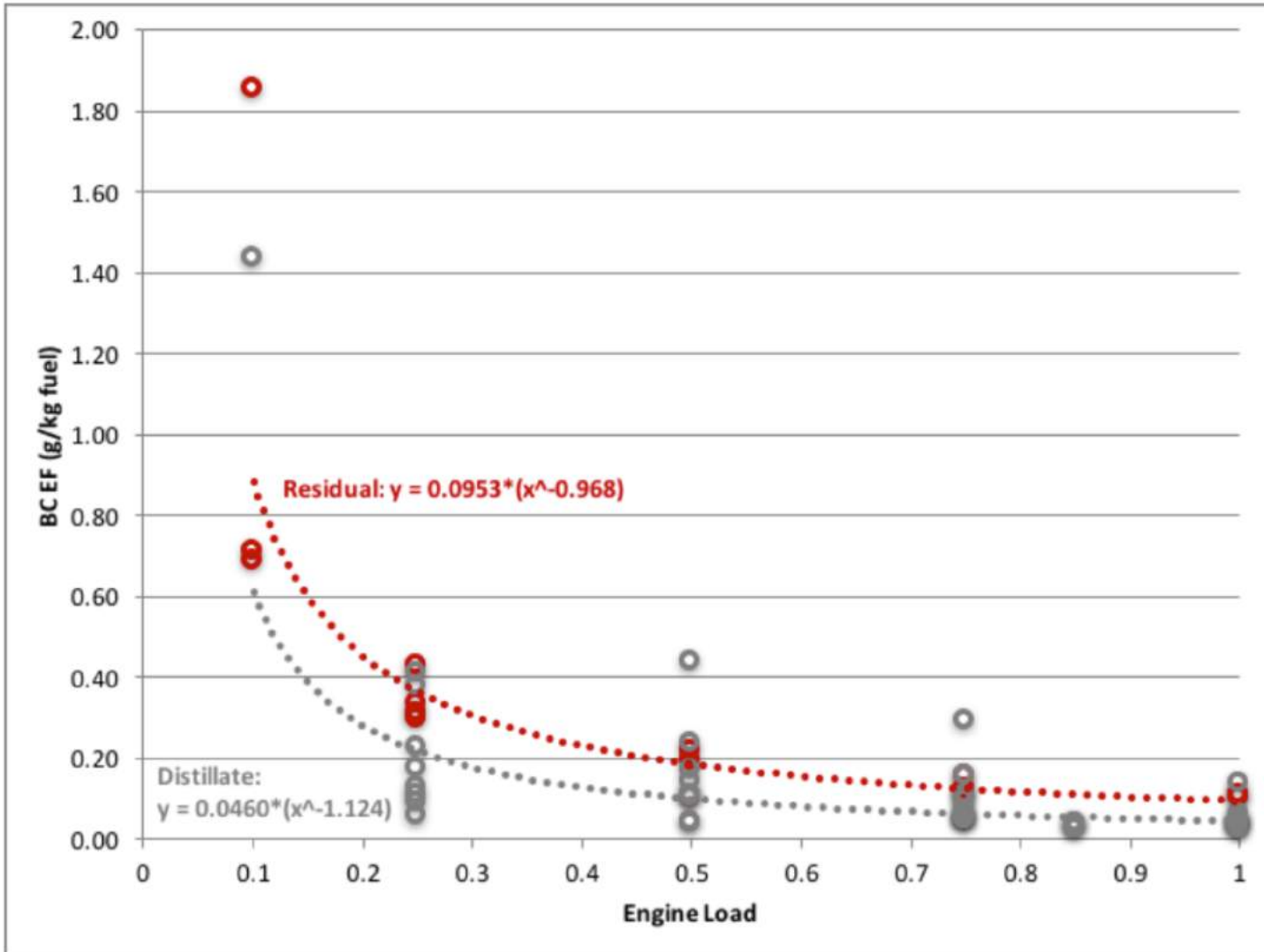
Estimating BC Emission Factors for ships using residual and distillate fuels

- Based on measurement data from Finland , USA (University of California –Riverside), and EUROMOT.
 - Finland: 4-stroke, 1.6 MW, Tier 0 marine test engine on HFO and MGO
 - USA:
 - 2-stroke, 16.6 MW, Tier 0 w/ EGCS on a container ship using HFO
 - 2-stroke 70 MW, Tier II on a containership using MGO
 - EUROMOT
 - 35 tests on a mix of 2-stroke and 4–stroke marine engines; 5 engines operated on residuals, 20 on marine distillates, 6 on ULSD, and 4 on LNG. We used the data from the engines that operated on residuals and distillates to create the EFs, leaving 24 engines: none were Tier 0, five were Tier I, 13 Tier II, 6 Tier III.

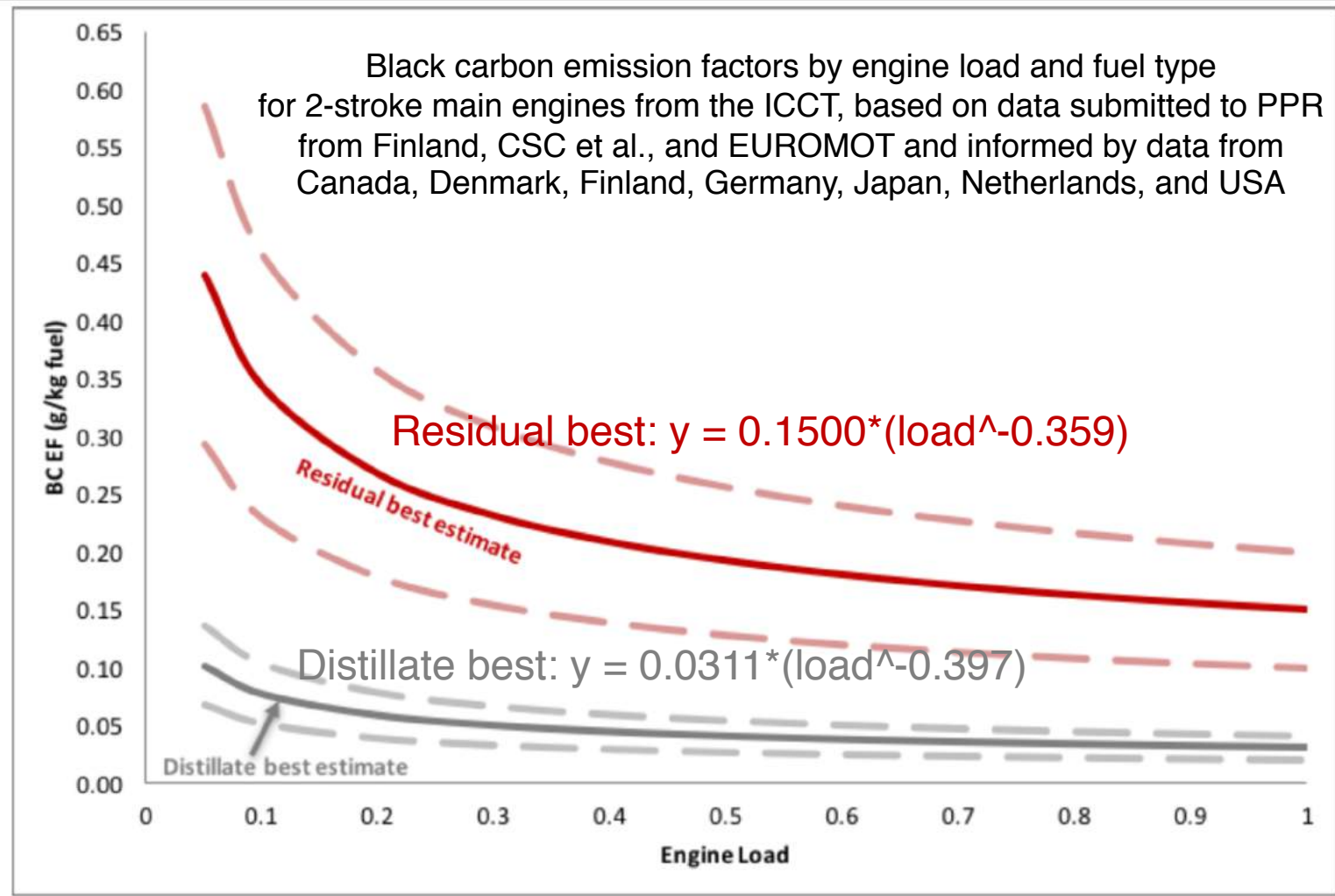
Raw, unadjusted, BC EFs (2-stroke)



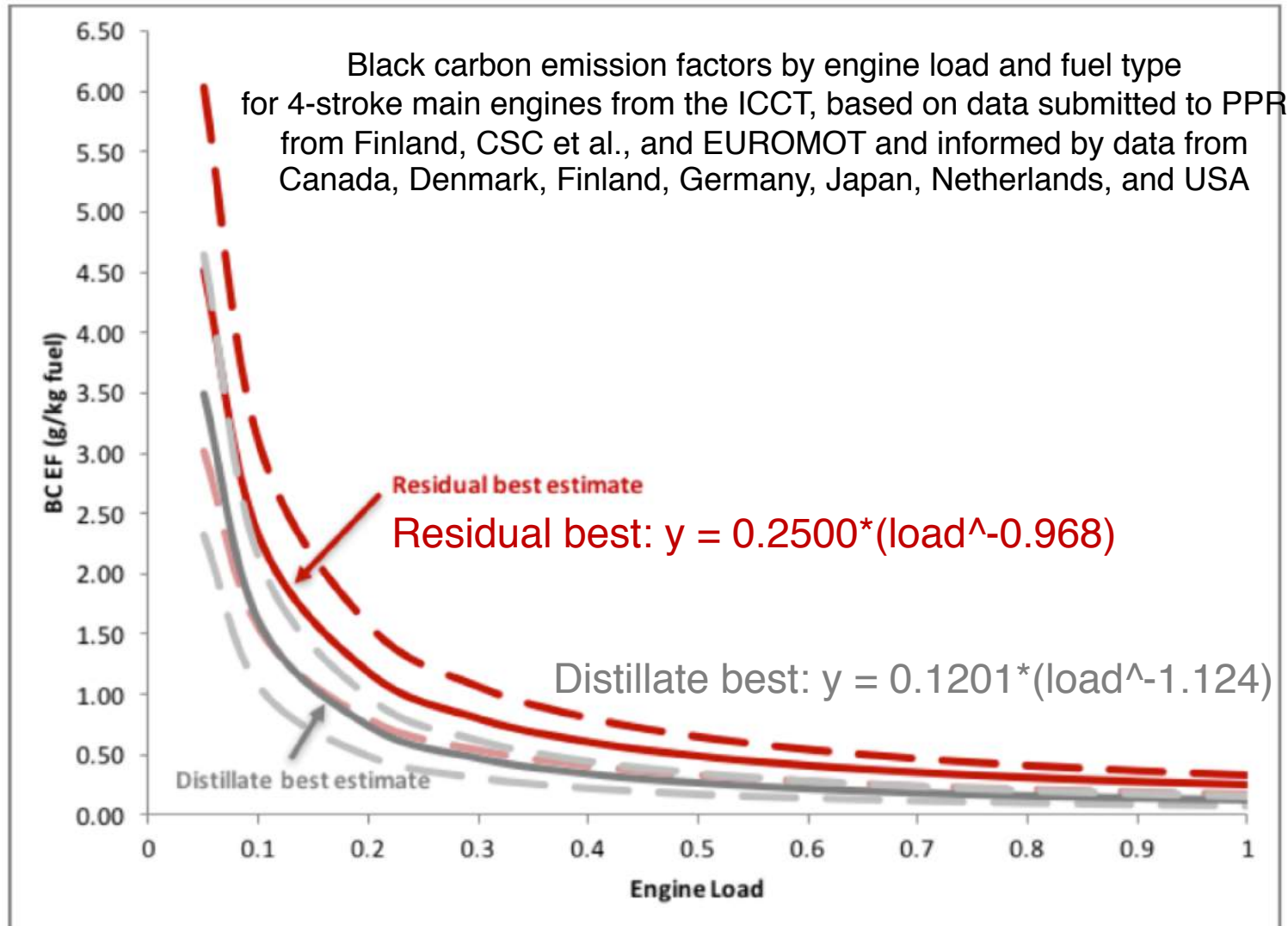
Raw, unadjusted, BC EFs (4-stroke)



Adjusted BC EFs (2-stroke)



Adjusted BC EFs (4-stroke)



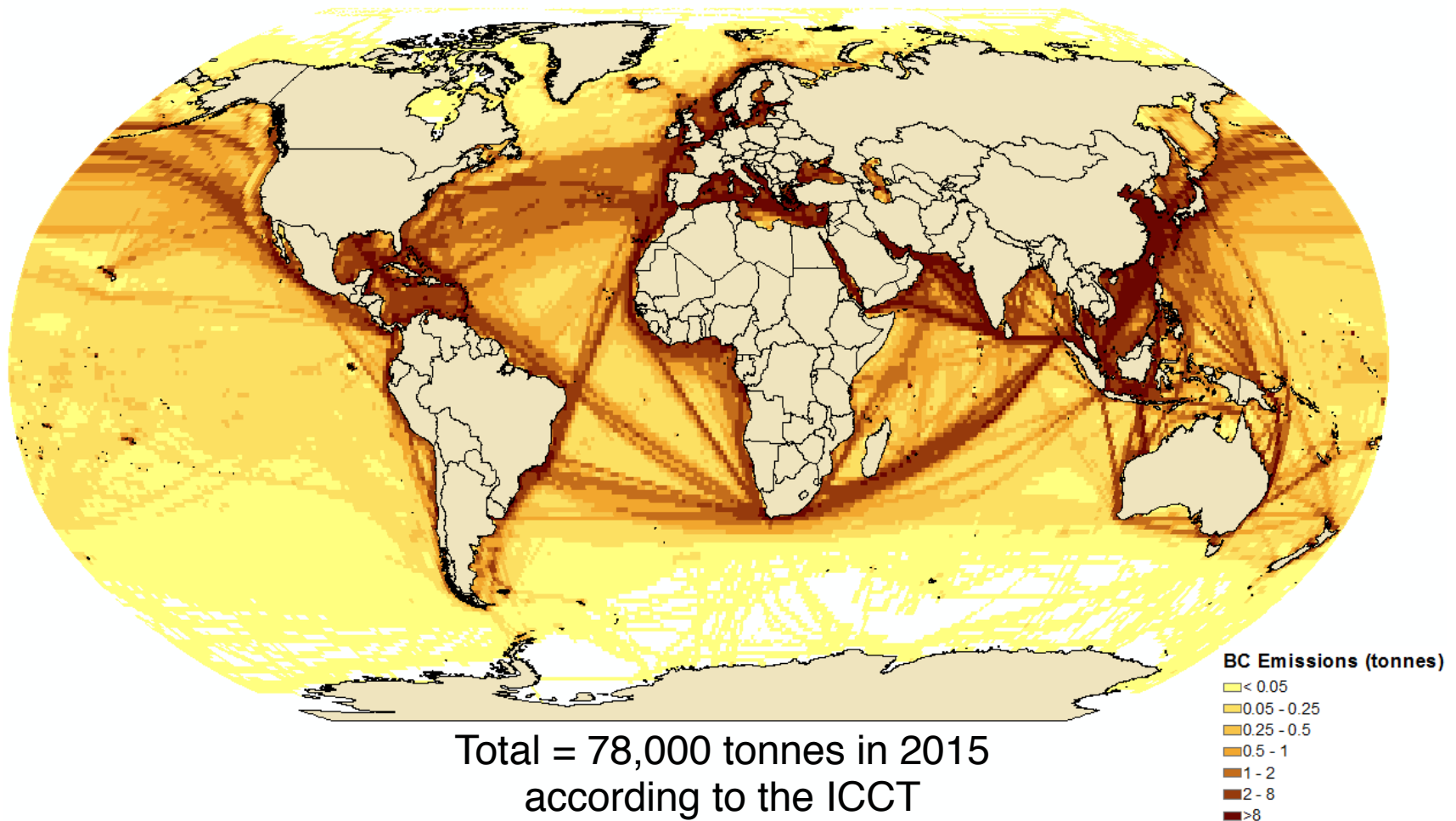
Adjusted BC EFs

Table F-3. Black carbon main engine emission factors

Engine Load (%)	Engine Type	Unit	HFO		Distillate		LNG
			2-stroke	4-stroke	2-stroke	4-stroke	
≤ 5	SSD/MSD/HSD	g/kg fuel	0.44 (0.29-0.59)	4.52 (3.02-6.03)	0.10 (0.07-0.14)	3.48 (2.32-4.65)	--
10	SSD/MSD/HSD	g/kg fuel	0.34 (0.23-0.46)	2.31 (1.54-3.08)	0.08 (0.05-0.10)	1.60 (1.07-2.13)	--
15	SSD/MSD/HSD	g/kg fuel	0.30 (0.20-0.40)	1.56 (1.04-2.08)	0.07 (0.04-0.09)	1.01 (0.68-1.35)	--
20	SSD/MSD/HSD	g/kg fuel	0.27 (0.18-0.36)	1.18 (0.79-1.58)	0.06 (0.04-0.08)	0.73 (0.49-0.98)	--
25	SSD/MSD/HSD	g/kg fuel	0.25 (0.16-0.33)	0.95 (0.64-1.27)	0.05 (0.04-0.07)	0.57 (0.38-0.76)	--
30	SSD/MSD/HSD	g/kg fuel	0.23 (0.15-0.31)	0.80 (0.53-1.06)	0.05 (0.03-0.07)	0.46 (0.31-0.62)	--
35	SSD/MSD/HSD	g/kg fuel	0.22 (0.15-0.29)	0.69 (0.46-0.92)	0.05 (0.03-0.06)	0.39 (0.26-0.52)	--
40	SSD/MSD/HSD	g/kg fuel	0.21 (0.14-0.28)	0.60 (0.40-0.81)	0.04 (0.03-0.06)	0.34 (0.22-0.45)	--
45	SSD/MSD/HSD	g/kg fuel	0.20 (0.13-0.27)	0.54 (0.36-0.72)	0.04 (0.03-0.06)	0.29 (0.20-0.39)	--
50	SSD/MSD/HSD	g/kg fuel	0.19 (0.13-0.26)	0.49 (0.32-0.65)	0.04 (0.03-0.05)	0.26 (0.17-0.35)	--
55	SSD/MSD/HSD	g/kg fuel	0.19 (0.12-0.25)	0.44 (0.30-0.59)	0.04 (0.03-0.05)	0.24 (0.16-0.31)	--
60	SSD/MSD/HSD	g/kg fuel	0.18 (0.12-0.24)	0.41 (0.27-0.54)	0.04 (0.03-0.05)	0.21 (0.14-0.28)	--
65	SSD/MSD/HSD	g/kg fuel	0.18 (0.12-0.23)	0.38 (0.25-0.50)	0.04 (0.02-0.05)	0.19 (0.13-0.26)	--
70	SSD/MSD/HSD	g/kg fuel	0.17 (0.11-0.23)	0.35 (0.23-0.47)	0.04 (0.02-0.05)	0.18 (0.12-0.24)	--
75	SSD/MSD/HSD	g/kg fuel	0.17 (0.11-0.22)	0.33 (0.22-0.44)	0.03 (0.02-0.05)	0.17 (0.11-0.22)	--
80	SSD/MSD/HSD	g/kg fuel	0.16 (0.11-0.22)	0.31 (0.21-0.41)	0.03 (0.02-0.05)	0.15 (0.10-0.21)	--
85	SSD/MSD/HSD	g/kg fuel	0.16 (0.11-0.21)	0.29 (0.19-0.39)	0.03 (0.02-0.04)	0.14 (0.10-0.19)	--
90	SSD/MSD/HSD	g/kg fuel	0.16 (0.11-0.21)	0.28 (0.18-0.37)	0.03 (0.02-0.04)	0.14 (0.09-0.18)	--
95	SSD/MSD/HSD	g/kg fuel	0.15 (0.10-0.21)	0.26 (0.17-0.35)	0.03 (0.02-0.04)	0.13 (0.08-0.17)	--
100	SSD/MSD/HSD	g/kg fuel	0.15 (0.10-0.21)	0.25 (0.17-0.35)	0.03 (0.02-0.04)	0.12 (0.08-0.17)	--
All	ST	g/kWh	0.08	0.08	0.06	0.06	--
All	GT	g/kWh	0.005	0.005	0.004	0.004	--
All	LNG-Otto	g/kWh	--	--	--	--	0.003
All	LNG-Diesel	g/kWh	--	--	--	--	0.002

For more information, see Appendix G of Source: Comer et al. (2017). *Black carbon emissions and fuel use in global shipping, 2015*. Available at <https://www.theicct.org/publications/black-carbon-emissions-global-shipping-2015>

Black Carbon emissions inventories for ships exist and can be updated and improved



Conclusions

1. Black carbon is the second largest contributor to shipping's climate warming impacts.
2. Black carbon is a relevant substance that contributes to climate change.
3. Black carbon has been measured from marine engines and from ship stacks.
4. Black carbon emission factors are available and can be improved.
5. Black carbon emissions inventories for global shipping exist and can be improved.
6. Black carbon emissions estimates can and should be included in the Fourth IMO GHG Study.

Thank you!

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