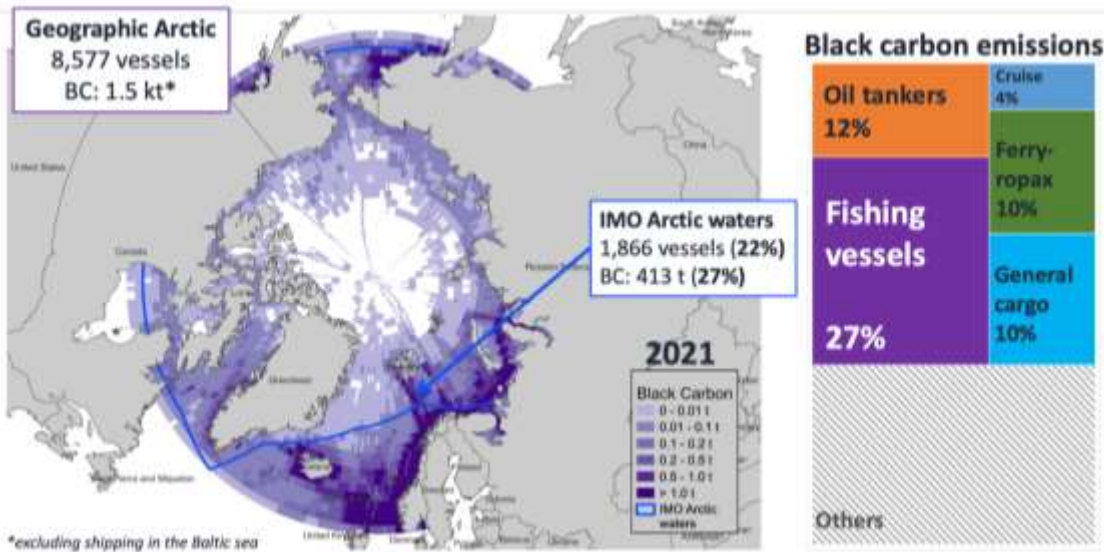




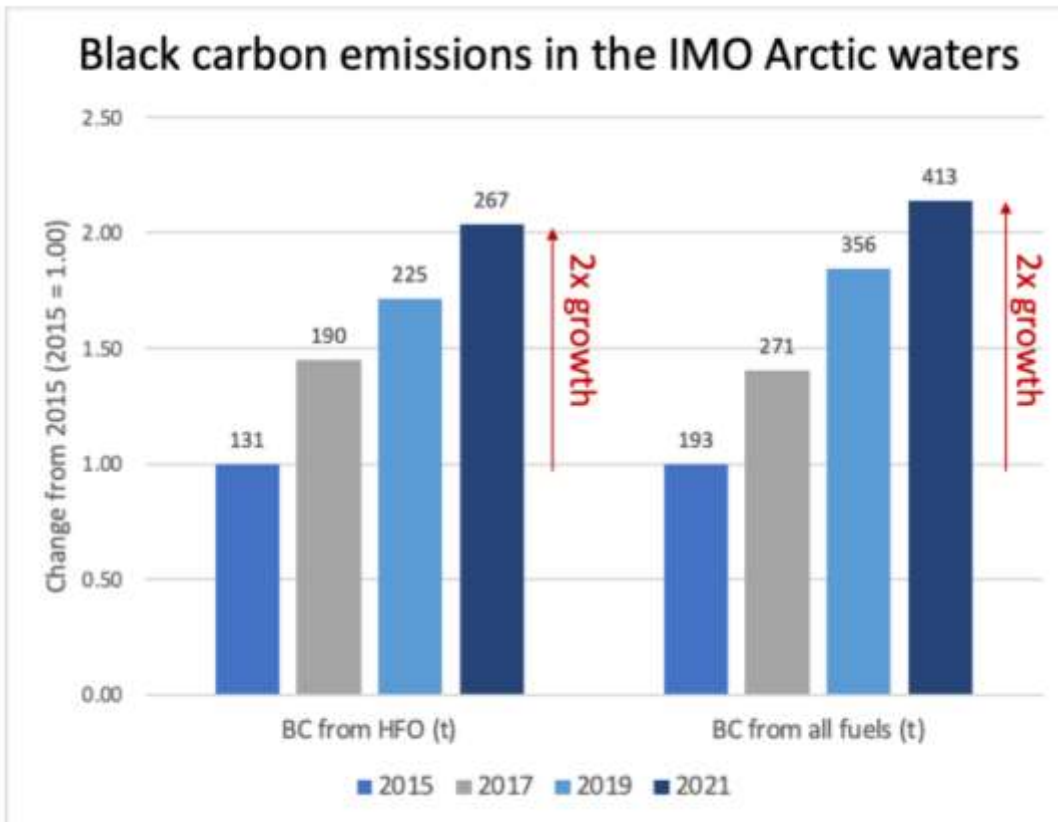
## Black carbon emissions from Arctic shipping: a review of main emitters and time trends.

Black carbon (BC) emissions from shipping contribute to climate change and air pollution, which affects both human health and the environment. In this analysis, we quantified and mapped BC shipping emissions in the Geographic Arctic (area above 58.95 °N) and in the IMO Arctic waters. We identified the main contributors based on ships and fuel types. We also tracked changes in BC emissions over six years (2015-2021).

Our study found that 8577 vessels sailed in 2021 in the Geographic Arctic (area above 58.95 °N) and emitted 1.5 kilotonnes of BC. The top three most common vessel types in the region (fishing vessels, oil tankers, and cargo ships) accounted for 50% of the total BC emissions, with fishing vessels being the most frequent ship type in the fleet (a quarter of the entire fleet).



We observed that a bit over half of the fuels burned in the Geographic Arctic were distillates (2 million tonnes), responsible for the largest portion of emitted BC in the Arctic (55%). 33% were residual fuels, 5% of which were used by ships equipped with scrubbers. Together, they were responsible for 44% of BC emissions. Finally, liquefied natural gas (LNG) represented only 13% of the fuels burned in the Geographic Arctic and was responsible for only 1% of BC emissions. The IMO Arctic waters include 1866 vessels and 413 tonnes of BC emissions, covering only 22% and 27% of the Geographic Arctic, respectively. However, between 2015 and 2021, BC emissions in the IMO Arctic doubled. Residual fuels remain the main source of BC emissions in the IMO Arctic waters (64% of the total emissions).



To reduce BC emissions, we recommend requiring ships operating in Arctic waters to use distillate instead of residual fuels, which could cut BC emissions by 50% to 80% for ships that currently use residual fuels. Overall, our findings demonstrate the need for continued efforts to reduce BC emissions from shipping in the Geographic Arctic and promote the use of cleaner fuels.