### Expert Assessment of Organic Carbon Stocks and Vulnerability in Subsea Permafrost

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**Does subsea permafrost carbon matter?**

*During the Last Glacial Maximum (26,100 BP)*

- Subsea permafrost (perennially frozen sediment, soil, and other material) exists under portions of the shallow continental shelves of the Arctic Ocean \([1,2]\). This permafrost formed prior and during the Last Glacial Maximum (LGM) when unglaciated portions of the exposed continental shelves accumulated hundreds of billions of tons of carbon in ice-rich permafrost \([1,4]\).

- As ice sheets and glaciers melted after the Last Glacial Maximum, sea level rose ~130 m. This inundated several million square kilometers of terrestrial permafrost and the organic matter it contained.

*Ice-sheet and glacial melt caused huge sea-level rise (14,000 BP)*

- Ever since it was flooded, the subsea permafrost has been thawing, which could potentially release CH4 and CO2 from its large carbon pool. The continental shelves of the Arctic Ocean and surrounding seas contain large stocks of organic matter and CH4 hydrates. The size of these carbon deposits and their vulnerability to climate change are highly uncertain, though it has been hypothesized that they may influence the global climate system on decadal to centennial timescales.

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**Conclusions**

- Experts estimated that 300 (100 to 700; median and interquartile range) gigatons of carbon (GtC) is currently stored in organic matter on the continental shelves of the Arctic Ocean, a decrease of ~45% since the LGM.

- Current methane hydrate stocks were estimated at 35 GtC (11.25 to 103.75) and current fluxes of CH4 and CO2 to the atmosphere were estimated at 3.5 teragrams (Tg/yr) (2.5 to 7.5) and 26 Tg/yr (1.37 to 42.25) respectively.

- Estimates of changes in future emissions of CH4 and CO2 were highly uncertain, though there is general agreement that a policy-relevant increase of carbon emissions could occur by 2100 and 2300. At 2050, for RCP4.5, 5.68 Tg/yr (2.79 to 6.51) CH4, and 38.4 Tg/yr (18.36 to 168.75) CO2 emissions were estimated. For RCP8.5, 4.42 Tg/yr (0.87 to 9.04) CH4 could be emitted by 2050 and, 41.6 Tg/yr (19.21 to 188.75) CO2.

- While these estimates will certainly be revised by future research, expert assessment is an important way to inform policy makers and the public about the possible magnitude of the subsea permafrost feedback to climate change.

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**Meta-analysis of previous studies**

- We reviewed nearly 100 academic papers from 1949 to 2019, including all that were retained when we searched subsea permafrost to understand the current state of knowledge uncertainties and identifying the experts of the field.

- Critical research questions are:
  1. Assess risks of abrupt CO2 and CH4 release, two of the major anthropogenic greenhouse gases,
  2. Provide a critical long-term perspective on vulnerability of carbon currently being thawed from subsea permafrost
  3. Generate first-order estimates of energy resources on the continental shelves.

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**Subsea permafrost warming and carbon release**

**Predicted carbon dioxide net flux from subsea permafrost**

**Predicted methane net flux from subsea permafrost**

**Subsea permafrost extent**

**Predicted soil organic carbon in subsea permafrost**

**Methane stocks in subsea permafrost**