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Transformations of Dissolved Organic Carbon in the Atlantic Layer of the Arctic Ocean

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Abstract

Dissolved organic carbon (DOC) is the largest pool of reduced carbon in the oceans. Carbon fixed in DOC is sequestered for the most prolonged periods when exported with the formation of deep water at high latitudes (Fig. 1). The Atlantic Meridional Overturning Circulation is estimated to export 0.197 PgC/yr but there is great uncertainty about inputs of terrigenous DOC and transformations of the pool during its long transit in the Arctic Ocean (Fontela et al., 2016). This study infers the transformations of DOC in the Atlantic Layer in the Arctic Ocean (Fig. 2) from spatial distributions. DOC concentrations in the Atlantic Layer were measured along hydrographic sections in the Greenland, Iceland, and Norwegian (GIN) Seas and the Arctic Ocean (Fig. 3). The highest concentrations in the Atlantic water (source water to the Atlantic Layer) were found in the Faroe-Shetland Channel (FSC) where it makes its initial northbound entrance into the GIN Seas (Fig. 3A). DOC in the Atlantic Layer then decreases as it flows over two decades to the Canada Basin (Fig. 3C). The Barents Sea Branch Water (BSBW), in contrast, carries large amounts of terrigenous DOC with a fluvial source (Fig. 3B). This input of BSBW ultimately produces an elevated DOC and ventilation in the Amundsen Basin at greater depths (Fig. 3C). The transformed DOC is eventually returned south through Fram Strait with a portion exported with deep water formation (Fig. 3D).

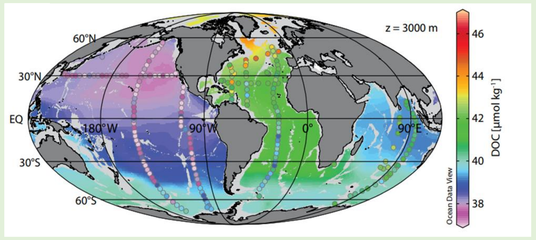

Figure 1: Distribution of dissolved organic carbon (µmol/kg) at 3000 m (Hansell et al., 2009). Note highest concentrations of DOC associated with NADW formation (Fig. 3D). Globally, the input to the deep ocean dominates the DOC signal at depth. All plots made using Ocean Data View (Schlitzer, 2023).

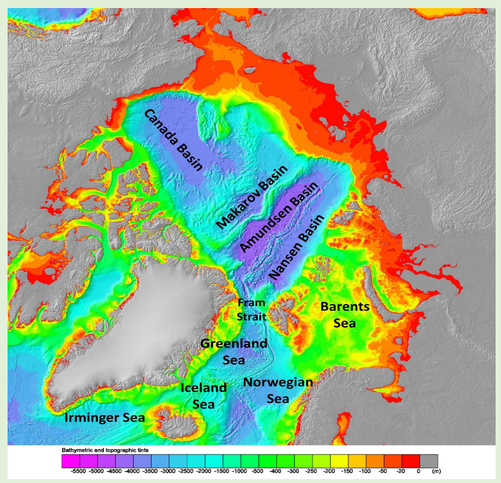

Figure 2: Arctic Ocean bathymetry with relevant basins and seas (Jakonsson et al., n.d.)

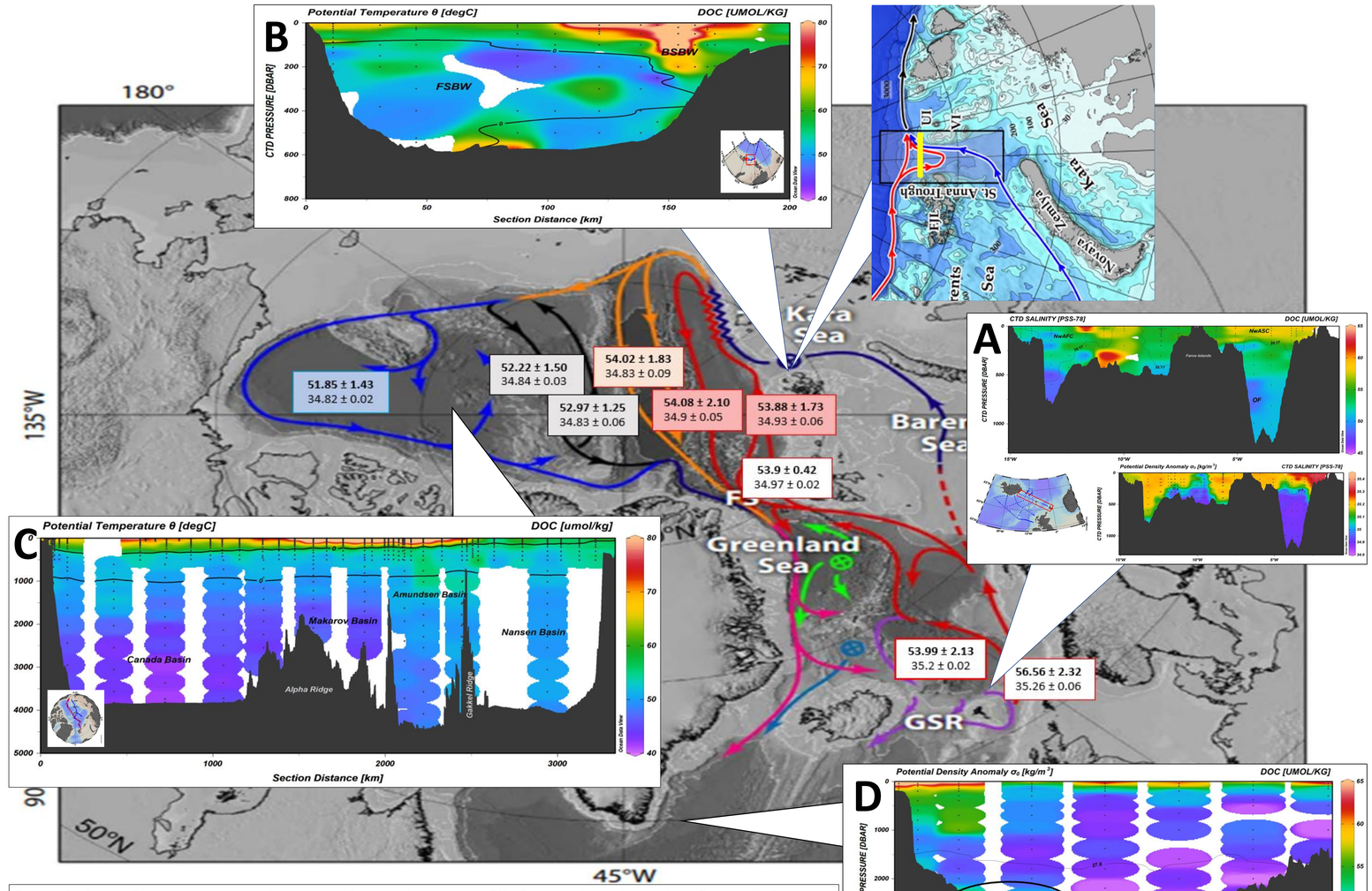

Figure 3: Arctic Ocean subsurface circulation (Atlantic Layer) and GIN Seas surface circulation (Rudels & Carmack, 2022) (arrows). Shown too are DOC concentrations and salinity at specific locations; the upper value in the boxes is DOC µmol/kg (±SD) and the lower is salinity (±SD). Shown in section plots (inserts with maps showing locations) are the spatial distributions of DOC across key sectors including A) Atlantic water entering the GIN Seas across Iceland-Scotland Ridge, B) Atlantic water exiting Barents Sea via St. Anna Trough to join the shelf break boundary current of the Arctic Ocean, C) Atlantic water across the four major Arctic basins, and D) Denmark Strait Overflow Water, which contributes to deep water formation. All data from Hansell et al., 2021.

Findings & Future work

FINDINGS

- DOC in the warm, saline Atlantic Layer of the Arctic Ocean decreases as it is transported from the Faroe-Shetland Channel, across the Arctic, to the Canada Basin
- High input of terrigenous DOC from Barents Sea into the Atlantic Layer via St. Anna Trough leads to elevated DOC at depth in the Amundsen Basin

FUTURE WORK

- Improve data density for DOC distributions in key areas such as Fram Strait, Denmark Strait, the waters north of Greenland, and the Faroe Islands channels
- Examine causes for high ventilation in the Amundsen Basin and its significance to terrigenous DOC export with North Atlantic Deep Water formation

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Fontela et al. *Scientific Reports* **2016**, *6*(1); Hansell et al. *Oceanography* **2009***,* 22(4), 202–211; Hansell et al. (NCEI Accession 0227166). NOAA National Centers for Environmental Information **2021**. Dataset. doi.org/10.25921/s4f4-ye35. Accessed April 12, 2023; Jakobsson et al., *Geophysical Research Letters*, doi: 10.1029/2012GL052219.; Rudels and Carmack, *Oceanography* **2022,** 35(3–4), 52–65, https://doi.org/10.5670/oceanog.2022.116. Schlitzer, R. Ocean Data View, https://odv.awi.de, 2021.