Consequences of Warming in the Arctic Ocean

A warming Arctic Ocean due to increasing global temperatures and its consequences for sea ice and biogeochemistry

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Abstract

Arctic Ocean circulation is characterised by an inflow of relatively warm and saline water from the Pacific and Atlantic Oceans, and an outflow of cold and fresh Polar Water. Historically, large parts of the Arctic Ocean have been covered in perennial sea ice. With anthropogenic emissions of carbon to the atmosphere, air and ocean temperatures are rising. This effect is especially seen in the Arctic Ocean and causes a decrease in sea ice extent. The consequences of fossil fuel burning impacts both the biology and the biogeochemistry of the Arctic Ocean. Arrival of new species may change food webs and ecosystems. Combined with ocean acidification, this may be dire news for a region vulnerable to change.

Context

- The Arctic Ocean (AO) is a landlocked sea with four topographic gaps connecting it to the global ocean [8]
- Inflow of Atlantic Water (AW) through the Fram Strait and the Barents Sea
- Inflow of Pacific Water (PW) through the Bering Strait
- The channels between the AO and the Canadian Archipelago

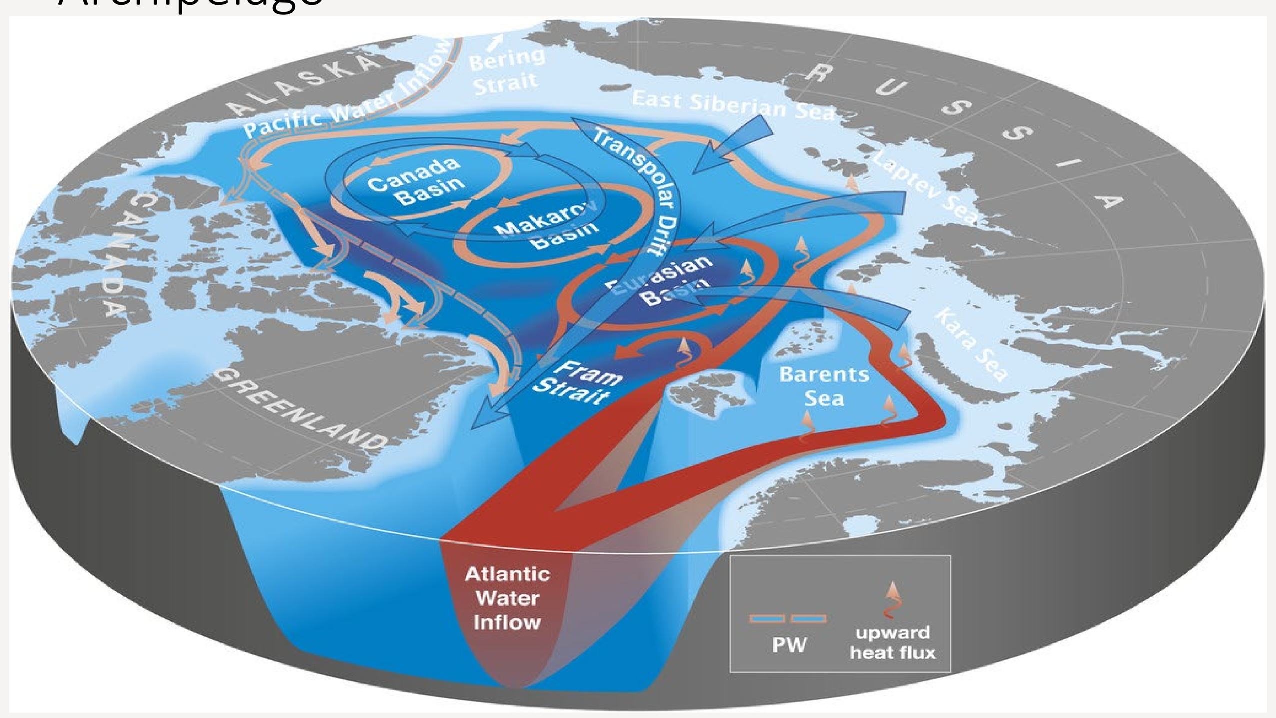

Fig. 1: Schematic Illustration of The Arctic Ocean with its circulation and the connection to the global ocean [1].

Atlantic Water Inflow and Sea Ice Retreat

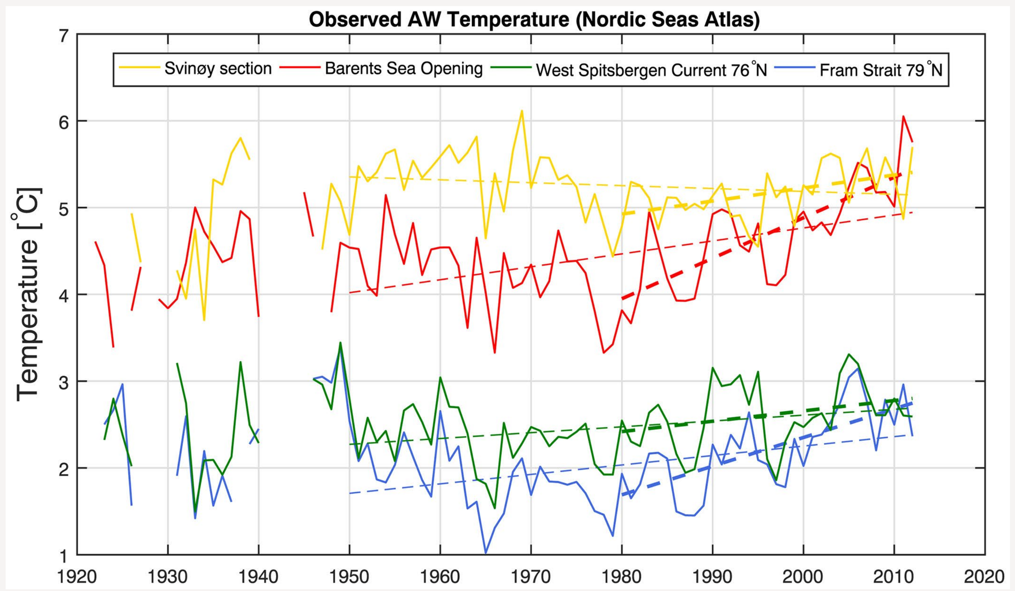

Fig. 2: Change in observed Atlantic Water (AW) temperature in the Nordic Seas from 1920-2015 [2].

The Atlantic water

- +1.0 °C warming in the Barents Sea (Fig. 2)
- Increased transport of 1 Sv
- In the Barents Sea, the AW temperature shows large variations on decadal time scales [2]
- A warming trend in core temperature of AW entering the AO (1977 – 2015, [2])

Sea Ice Decrease

- AW key heat source for the Arctic Ocean
- Sea ice extent, age, and thickness decrease (Fig. 3 and 4, [6, 7])
- SIE decline of 2.6 % per decade (Fig. 3)
- Arctic lost more than half of its sea ice volume over the last 40 years [1]
- Current conditions are younger and thinner sea ice (Fig. 4)

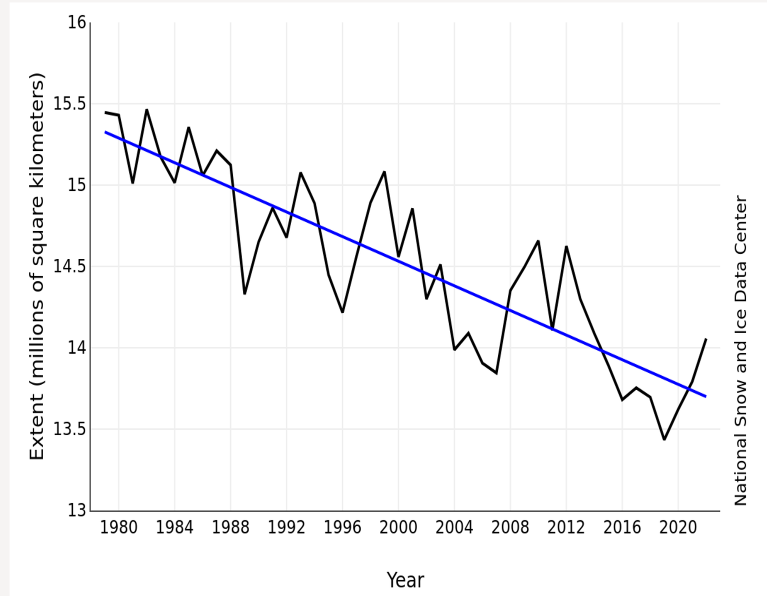

Fig. 3: Monthly April sea ice extent (SIE) in the Arctic from 1979 to 2022 [6].

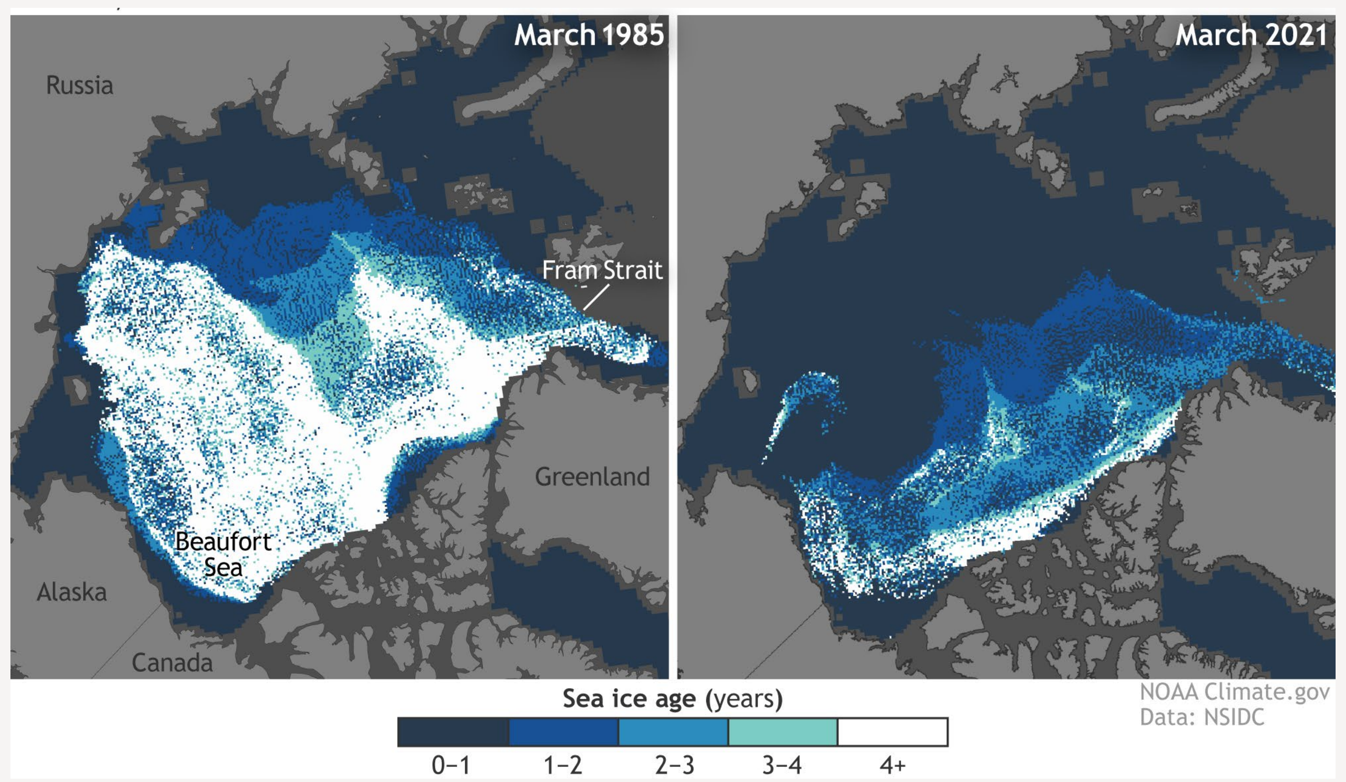

Fig. 4: Comparison of sea ice age between 1985 and 2021 [7].

Biogeochemical Consequences

Invasion of Foreign Species

- Reduced sea ice extent opens new transport pathways between the Pacific and Atlantic Oceans
- Organisms can be transported via the Transpolar Drift
- Example: the Pacific diatom species *Neoenticula seminae* (Fig. 5) newly observed in the Nordic Seas [3]
- Invasion of new species may change food webs and ecosystems

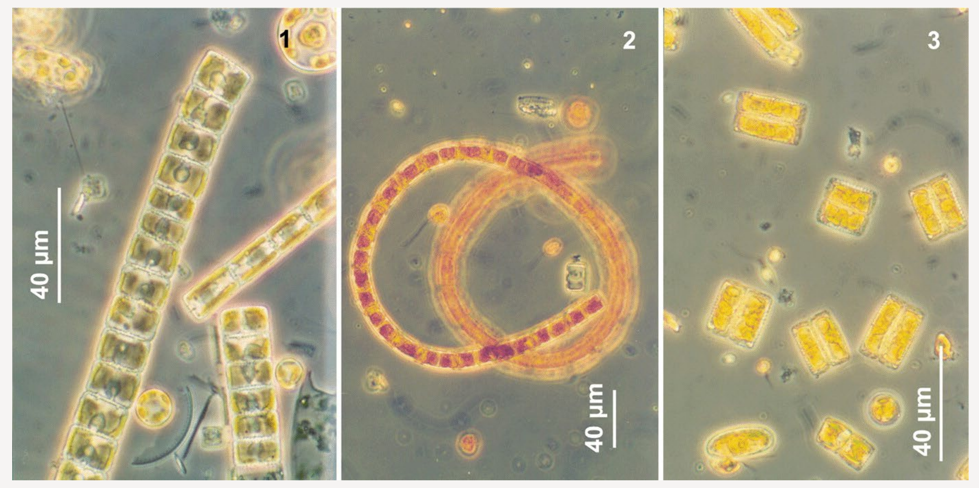

Fig. 5: Diatom *Neoenticula seminae* found in Gulf of St. Lawrence in the Northwest Atlantic as seen under light microscopy [4].

Acidification

- High latitudes are strong sinks for anthropogenic carbon due to low oceanic temperatures
- Carbon uptake reduces the water's buffer capacity, making the Arctic Ocean region vulnerable to pH change (acidification)

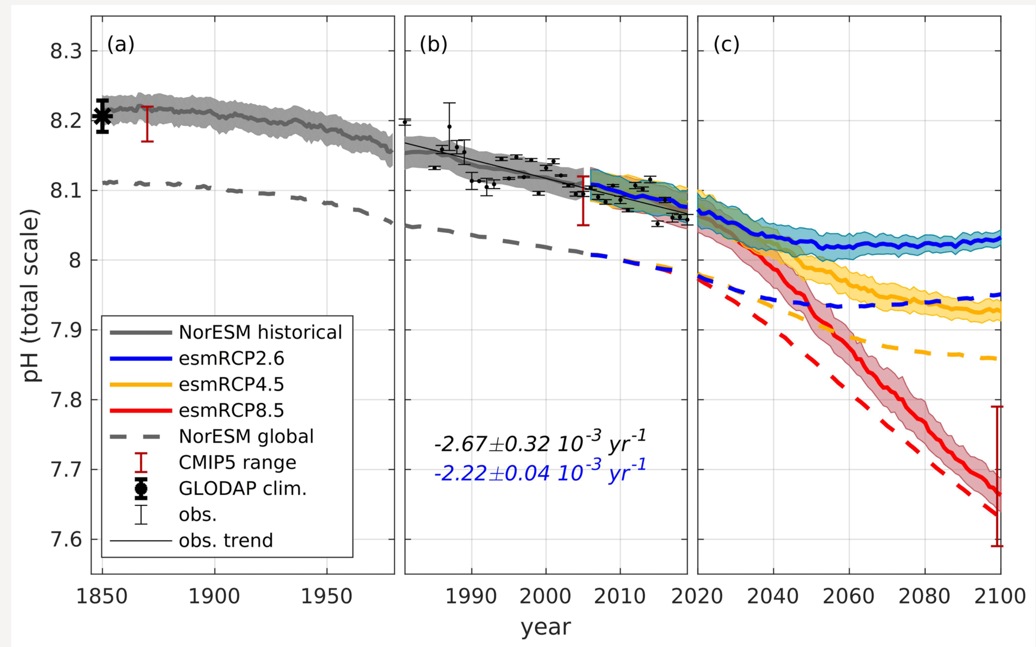

Fig. 6: Historical (1850-1980), current (1981-2019) and projected (2020-2100) pH averaged over the upper 200 m of the Nordic Seas [5].

- Figure 6 shows decreased pH over the Nordic Seas since 1850
- Projections show further reductions
- Acidification in Nordic Seas may propagate to the Arctic Ocean
- Reduced pH is an issue for calcifying organisms

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