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Ice on Hold: A Late Holocene Tale from the Barents Sea

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1. INTRODUCTION

The Barents Shelf is among the most dynamic sectors of the Arctic Ocean system, acting as a climatic frontier where polar and Atlantic influences meet. While the broader Arctic experienced sea-ice intensification from ~5 ka BP onwards—largely attributed to orbitally forced Neoglacial cooling (Wanner 2021)—our study reveals a distinctly delayed response on the northwestern Barents Shelf. This finding challenges traditional expectations of synchronous cryospheric change across high northern latitudes and raises questions about the role of regional oceanography in modulating sea-ice cover.

Earlier paleoclimate records, including glacier re-advances on Svalbard (Farnsworth et al. 2020) and declining summer insolation (Laskar et al. 2004), suggest atmospheric conditions had long become favorable for ice growth. Yet, the northwestern Barents Shelf remained largely ice-free until well into the Late-Holocene. Here, we investigate the underlying mechanisms of this delay using multi-proxy analyses of a sediment core.

2. MATERIALS AND METHODS

Our reconstruction is based on sediment core JM09-020, retrieved from Storfjordrenna, south of Svalbard (Fig. 1, 76°19′N, 19°42′E; 253 m water depth). The core was sampled every 4–6 cm and subjected to dinoflagellate cyst (dinocyst) analysis. The cyst assemblages were used to infer changes in sea-surface conditions, seasonal ice presence, and Atlantic Water (AW) inflow. Auxiliary proxy datasets include alkenone-based sea surface temperature (SST) reconstructions (Łącka et al. 2019), stable carbon isotopes of benthic foraminifera, and XRF-derived Ba/Ti ratios as a proxy for organic productivity (Łącka et al. 2015). Chronological control was achieved through radiocarbon dating and recalibration using the Marine20 calibration curve (Heaton et al. 2020) and a local reservoir correction.

To validate our findings regionally, we compared our results with biomarker-derived sea-ice records from the Olga Basin (core NP05-11-70GC) using the $P_{III}IP_{25}$ index (Berben et al. 2017). Details of the methodology can be found in Telesiński et al. (2024).

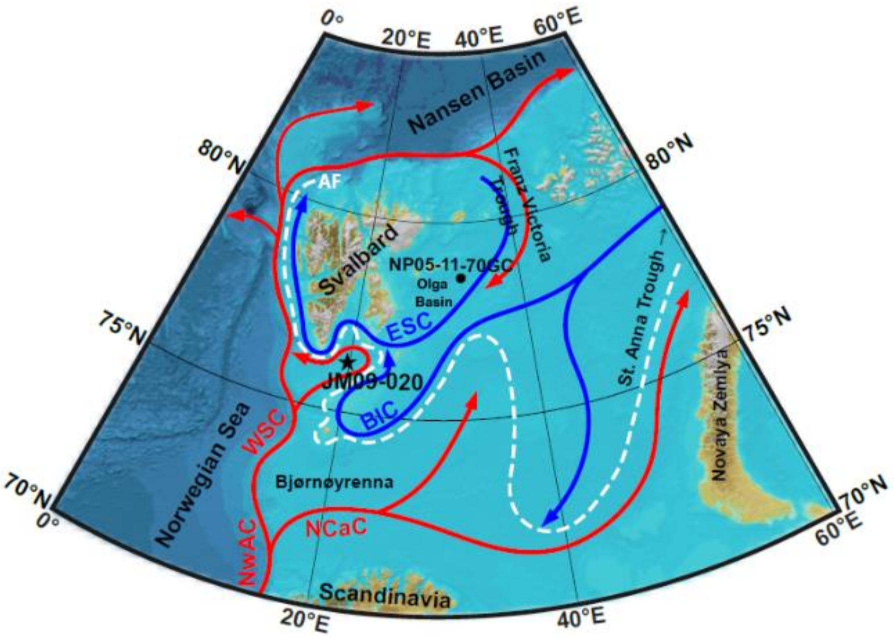

Fig. 1. Schematic map showing present-day surface water circulation in the Barents Sea. Red arrows indicate Atlantic Water, light blue arrows – Polar/Arctic Water, and white dashed line – Arctic Front (AF). The location of core JM09-020 is marked with an asterisk. The location of core NP05-11-70GC (Berben et al. 2017), also discussed in the paper, is marked with a dot. BIC – Bear Island Current, ESC – East Spitsbergen Current, NCaC – North Cape Current, NwAC – Norwegian Atlantic Current, WSC – West Spitsbergen Current.

3. RESULTS AND DISCUSSION

Our data indicate that the Storfjordrenna site remained ice-free from the Early Holocene until ~2.3 ka BP. *Echinidinium karaense*, a winter drift ice-indicative species (Telesiński et al. 2023), disappeared from the record after 8 ka BP and only reappeared at ~2.1 ka BP (Fig. 2).

A productivity peak at 2.3 ka BP suggests the proximity of the marginal ice zone, followed by a decline coinciding with increased winter ice cover. Notably, the abundance of *Operculodinium centrocarpum* s.l.—indicative of AW surface influence (Telesiński et al. 2023)

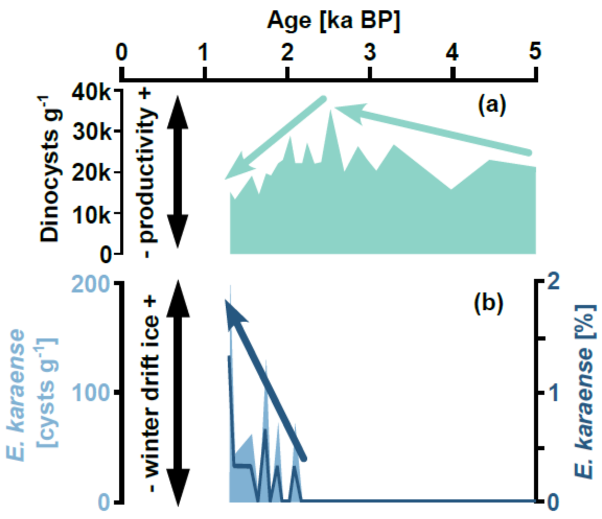

Fig. 2. Paleoceanographic proxies of Late Holocene changes in the northwestern Barents Sea from core JM09-020: (a) Dinocyst flux [cysts cm^{-2} yr^{-1}], (b) Flux [cysts cm^{-2} yr^{-1}] and relative abundance [%] of *Echinidinium karaense*.

—also peaked at this time before rapidly decreasing, signaling subsurface intrusion of AW beneath Arctic Water (ArW).

We propose that the delayed sea-ice response in the western Barents Shelf is primarily due to sustained surface influence of AW well into the Late-Holocene. The Arctic Front, typically topographically constrained, may have migrated further north and east during the Holocene Thermal Maximum, reducing the impact of cooling on local sea-ice formation. Only once AW was fully subducted below ArW did the conditions for sea-ice growth prevail.

This ~2 kyr lag between atmospheric cooling and sea-ice expansion implies a system with significant inertia, where oceanographic buffering via AW advection delays surface responses. Given the modern “Atlantification” processes resulting from enhanced northward heat transfer (Årthun et al. 2012), this has implications for the reversibility of current sea-ice loss.

4. CONCLUSIONS

Our record from Storfjordrenna provides robust evidence for a delayed sea-ice response in the northwestern Barents Shelf, occurring ~2.3–2.1 ka BP, despite Neoglacial atmospheric cooling beginning around 5 ka BP. This regional lag, likely driven by persistent AW inflow, highlights the importance of subsurface ocean dynamics in controlling Arctic cryosphere evolution.

Key takeaways:

- Paleoproxy evidence suggests a ~2 kyr delay in sea-ice re-expansion.
- Only once AW fully subducted below ArW did the conditions for sea-ice growth prevail.
- Modern warming may induce long-term loss in Arctic ice, even if global cooling resumes.

These findings underscore the challenge of reversing sea-ice decline in the Barents region and provide crucial insights into the temporal dynamics of polar climate systems.

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