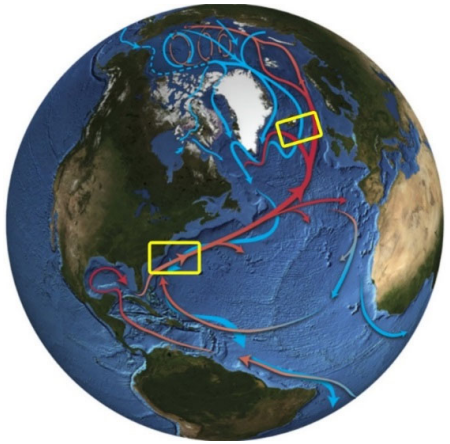
Atlas meeting 2020

atlas
UNDERSTANDING DEEP ATLANTIC ECOSYSTEMS

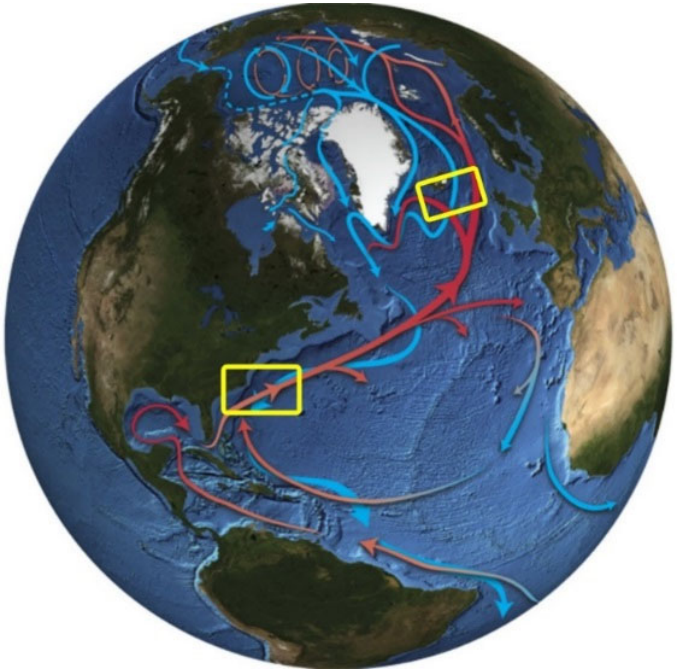
David J. R. Thornalley & Peter Spooner
University College London

Atlantic Paleo Circulation: Long-term context for the modern ocean

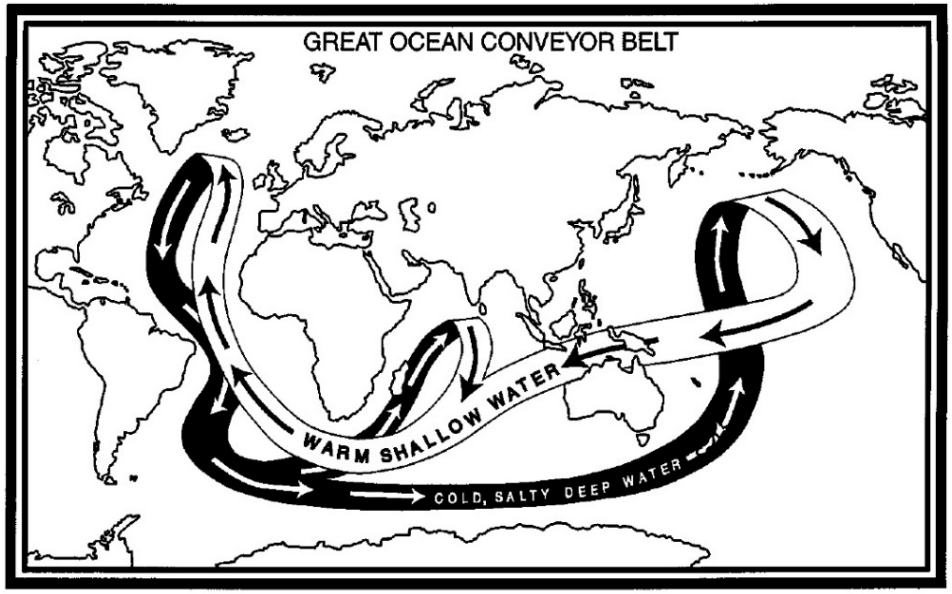


This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 678760 (ATLAS). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.

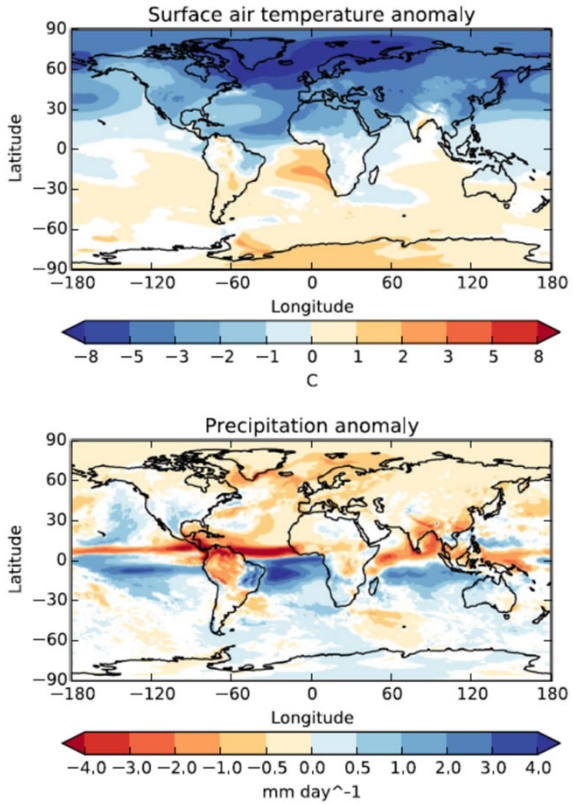
PART I: The Atlantic Meridional Overturning Circulation (AMOC)

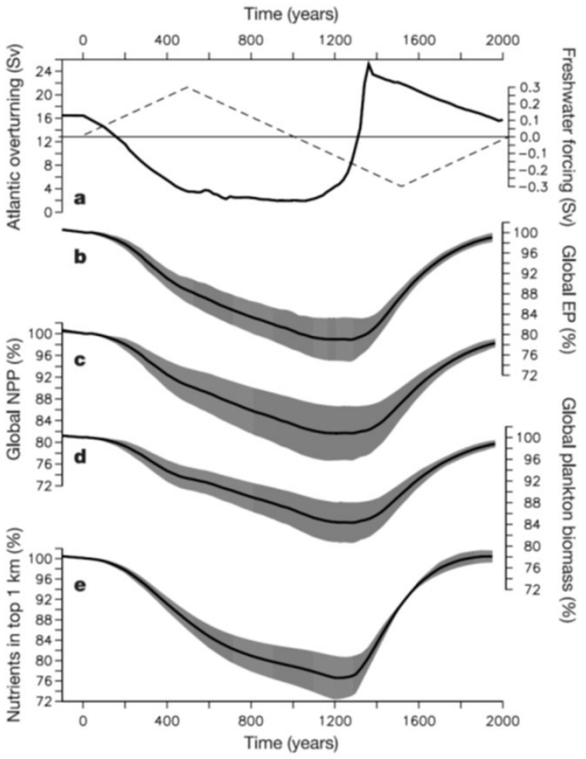


- Conversion of warm salty waters to colder, denser water occurs in the Arctic Mediterranean and subpolar North Atlantic
- Transports heat, carbon and nutrients around the global ocean

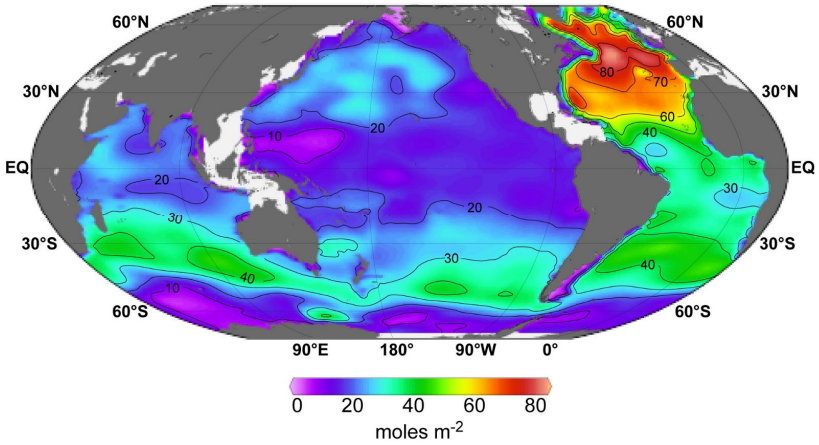


Why do we care about the AMOC?





- Climate
- CO_2 uptake and deep ventilation
- Regional sea-level
- Regional control on sea-ice and glaciers
- Ecosystems



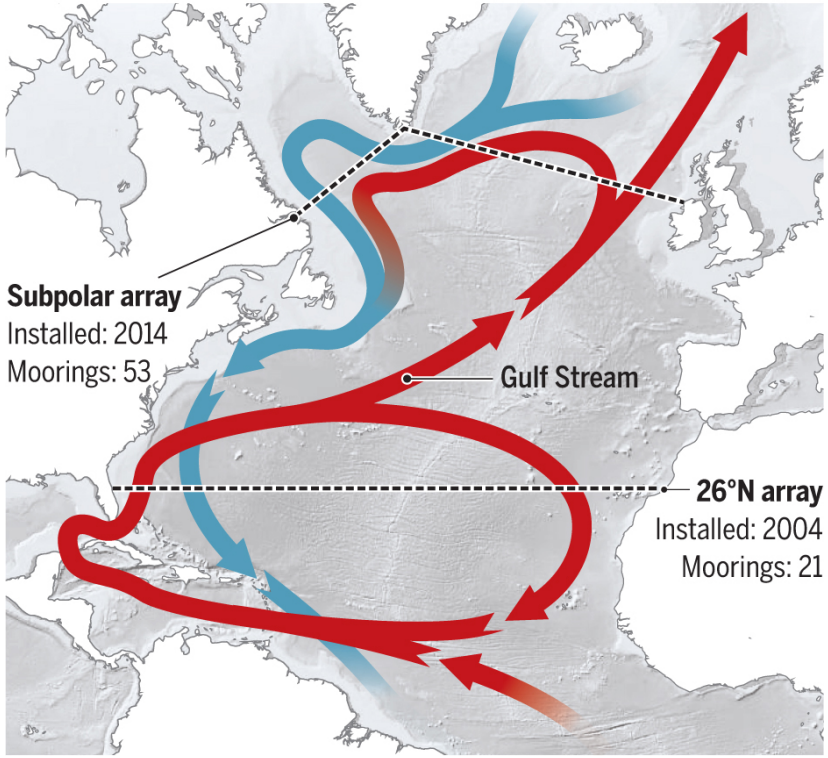
AMOC observations

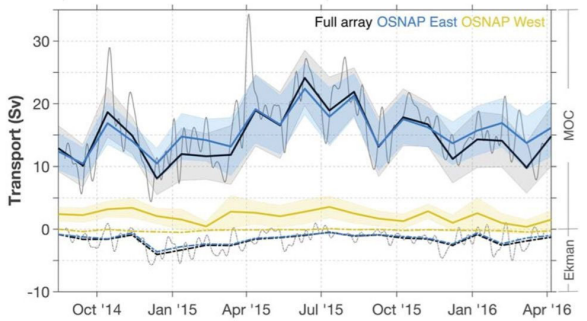
- Rapid array 26ºN monitoring conveyor (Srokosz & Bryden 2015)
- Highly variable
- ~0.5 Sv/yr decline (10x more than models predict)
- New OSNAP measurements downplay Lab Sea (Lozier et al 2019)

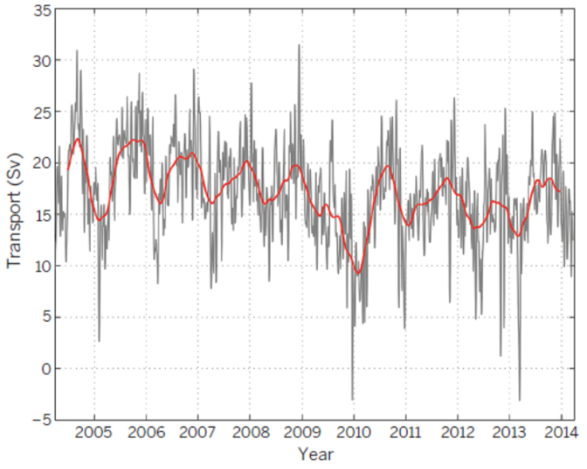
- **Natural decadal variability or long-term trend?**

In circulation

Arrays monitor circulating currents in the Atlantic Ocean, in which warm shallow waters move north (red), while cold deep waters move south (blue).

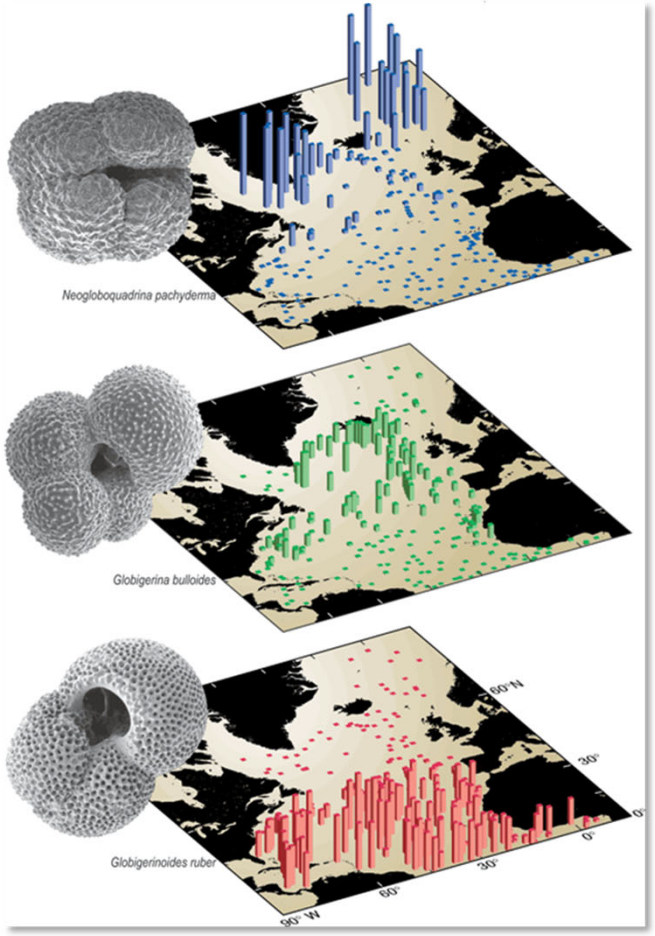






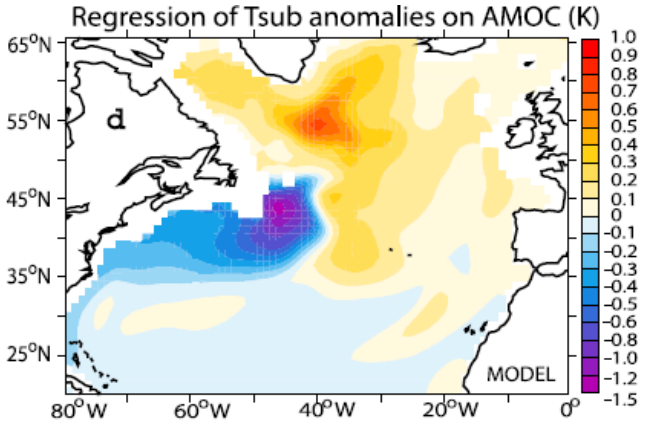
Using sediment cores to reconstruct AMOC

- High sedimentation rate marine cores
- Examine the types and chemistry of surface and bottom dwelling organisms (foraminifera)
- Depth transects of cores to examine vertical water structure and different deep-sea currents

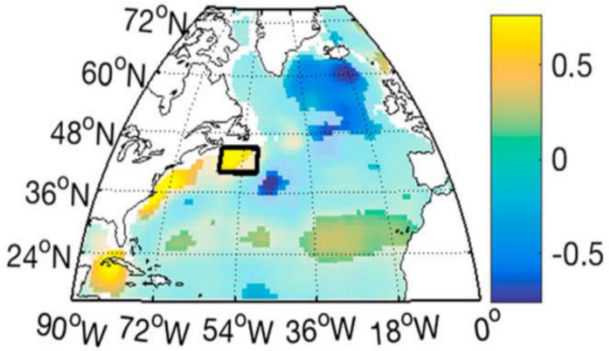


How do we reconstruct AMOC?

1. Temperature fingerprints

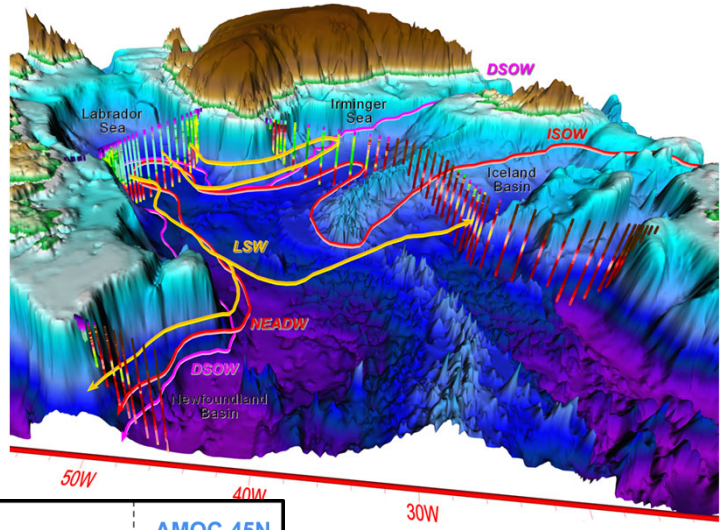


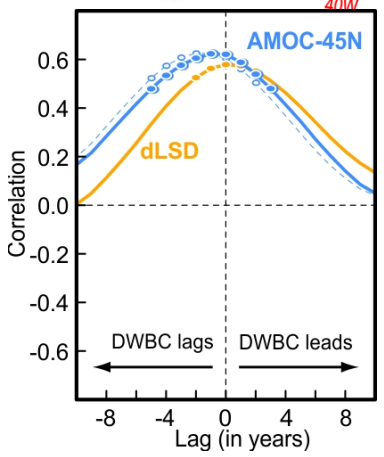
Modelled AMOC fingerprint
(Zhang, 2008)



Observed AMOC fingerprint
(Smeed et al 2018)

2. Flow speed of major deep sea currents





Major return flow of deep water as Deep Western Boundary Current

Coupled to AMOC in models

Thornalley et al., 2018

Proxy – observation comparison

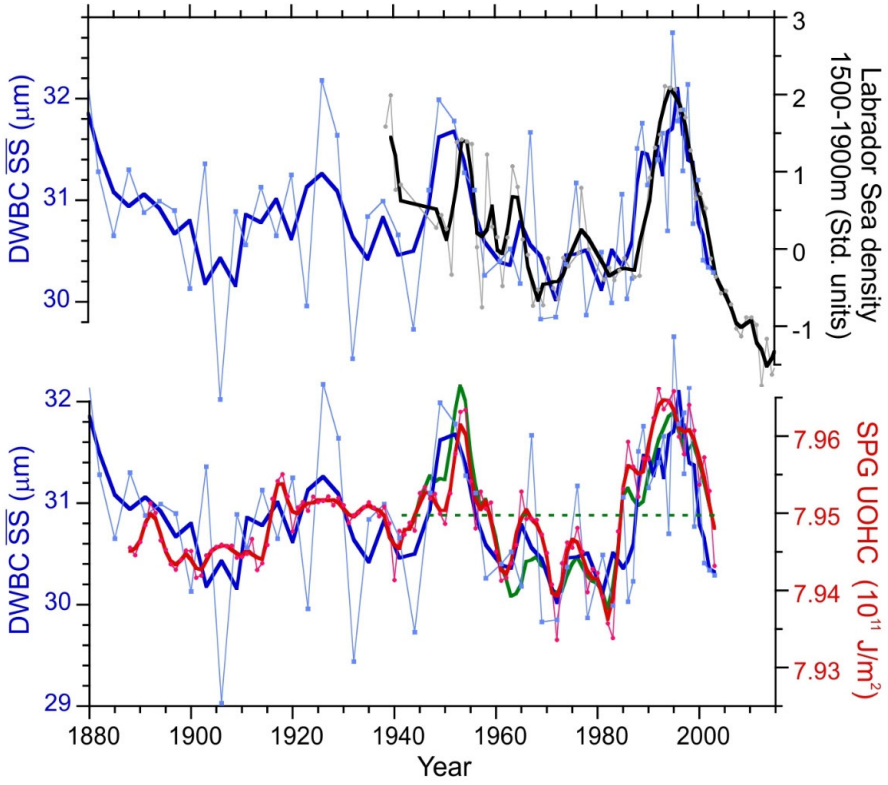
Thornalley et al 2018:

-Proxy reconstructed flow speed of DWBC [1.7km Cape Hatteras]

-Deep Labrador Sea density [from Yashayaev]

-Subpolar gyre upper ocean heat content (12 yr lag) [EN4 data]

-Tsub AMOC fingerprint (12 yr lag) [from Joyce and Zhang 2010; WOD09 data]

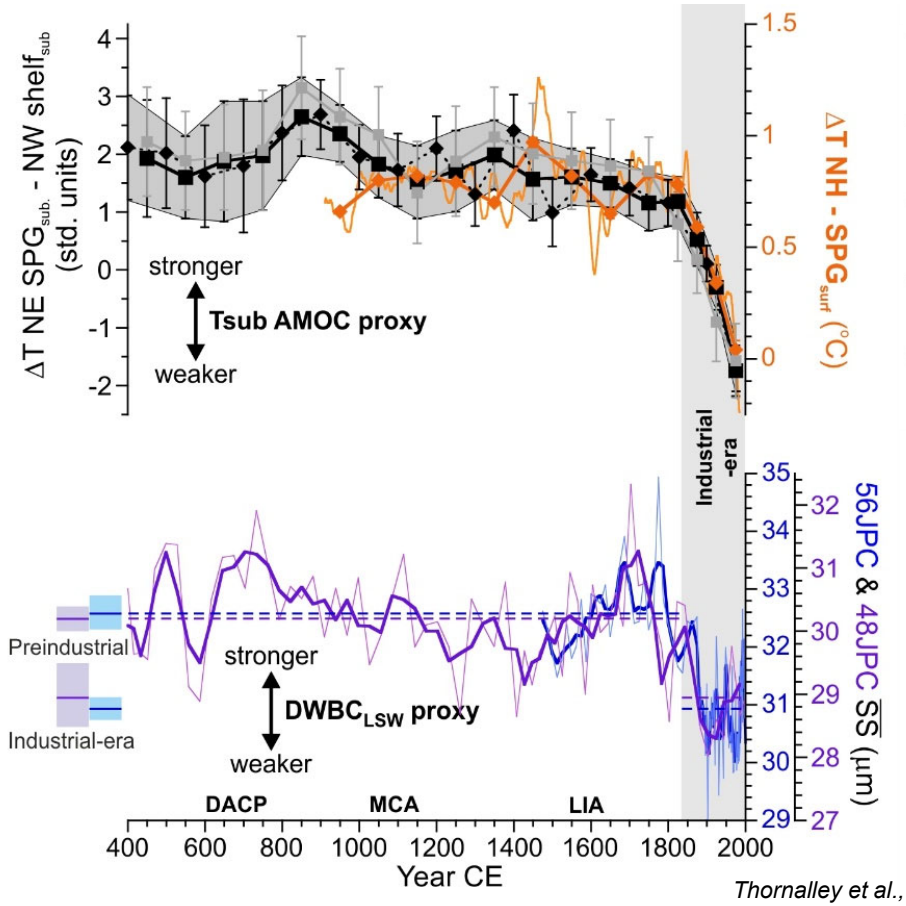


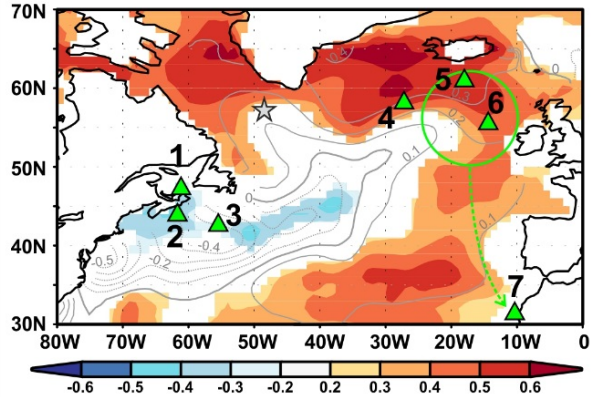
dLSD, DWBC flow speed, SPG UOHC and Zhang Tsub suggest persistent multidecadal variability throughout C20th.

UCL

Context of recent AMOC change

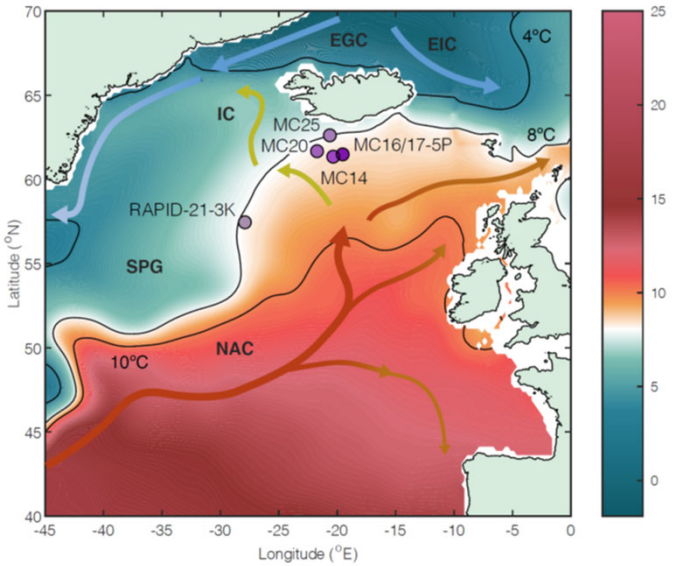
- Proxies suggest recent variability sits on a larger shift from stronger AMOC prior to ~1850 AD to modern weaker state.
- Tsub (and Rahmstorf et al, 2015) suggest continued, gradual decline
- $DWBC_{LSW}$ (and observational based Zhang Tsub) suggest little C20th decline
- 12 year lagged relationship between $DWBC_{LSW}$ and NE Atlantic temperature

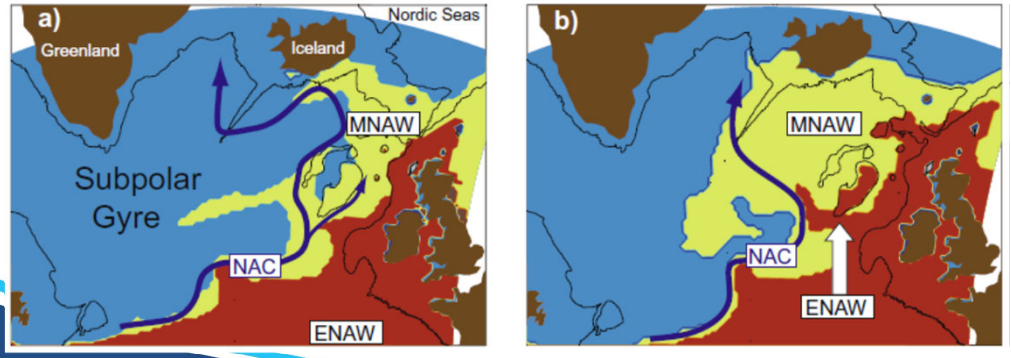




Thornalley et al., 2018

PART II: Northeast Atlantic surface changes



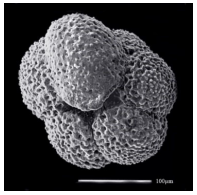


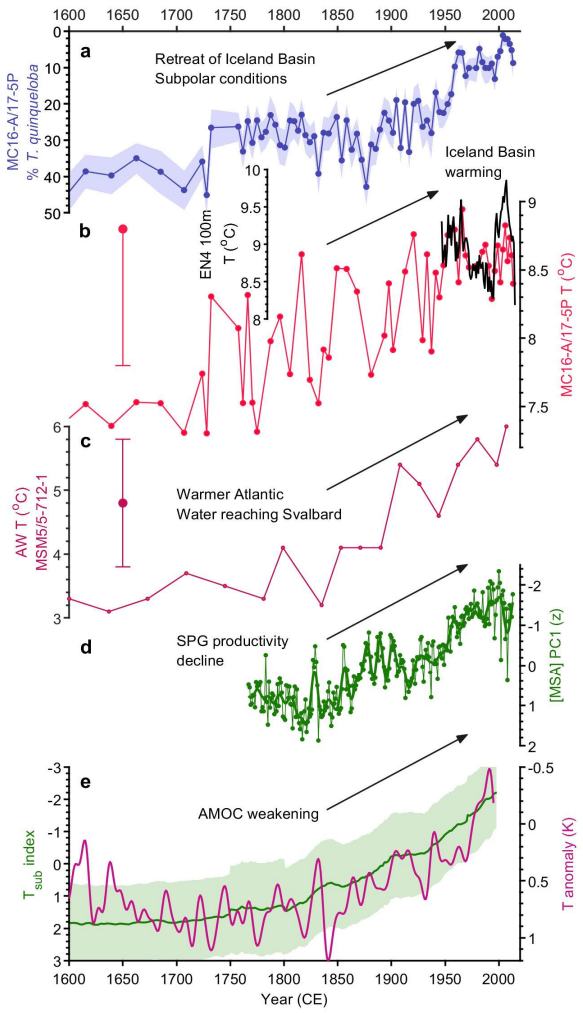
- Main region for Atlantic inflow to Nordic seas
- Upstream influence on properties of deep-water formation regions, Arctic inflow and sea ice
- Bottom-up control on regional ecosystems
- Site of diverse and economically important marine resources

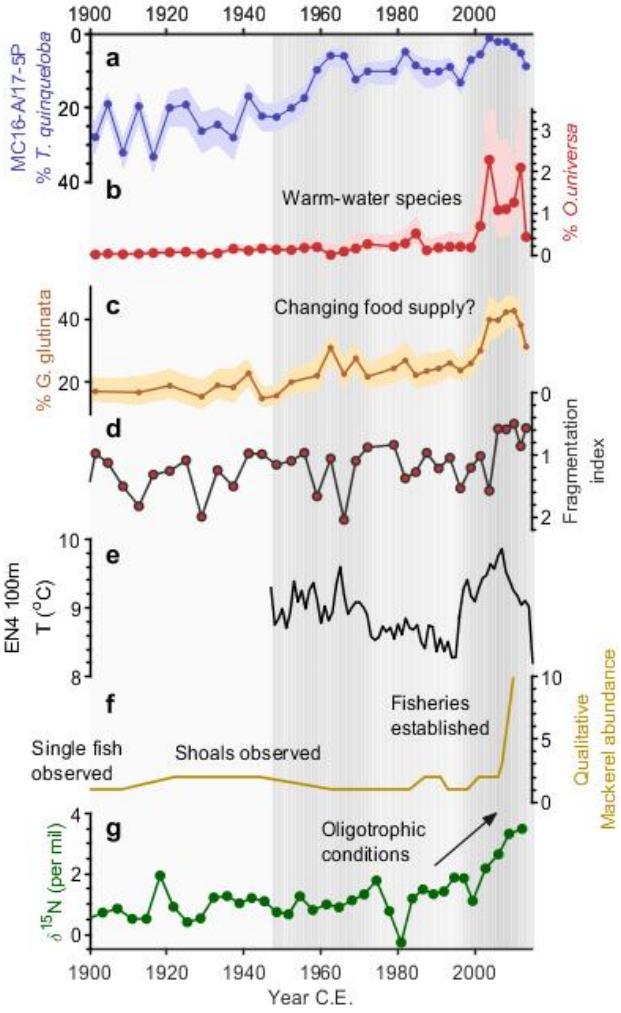
Industrial-era conditions in the Iceland Basin

- 20th century decline in subpolar species

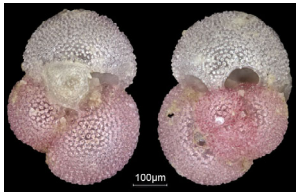
Subpolar

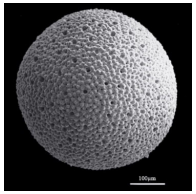






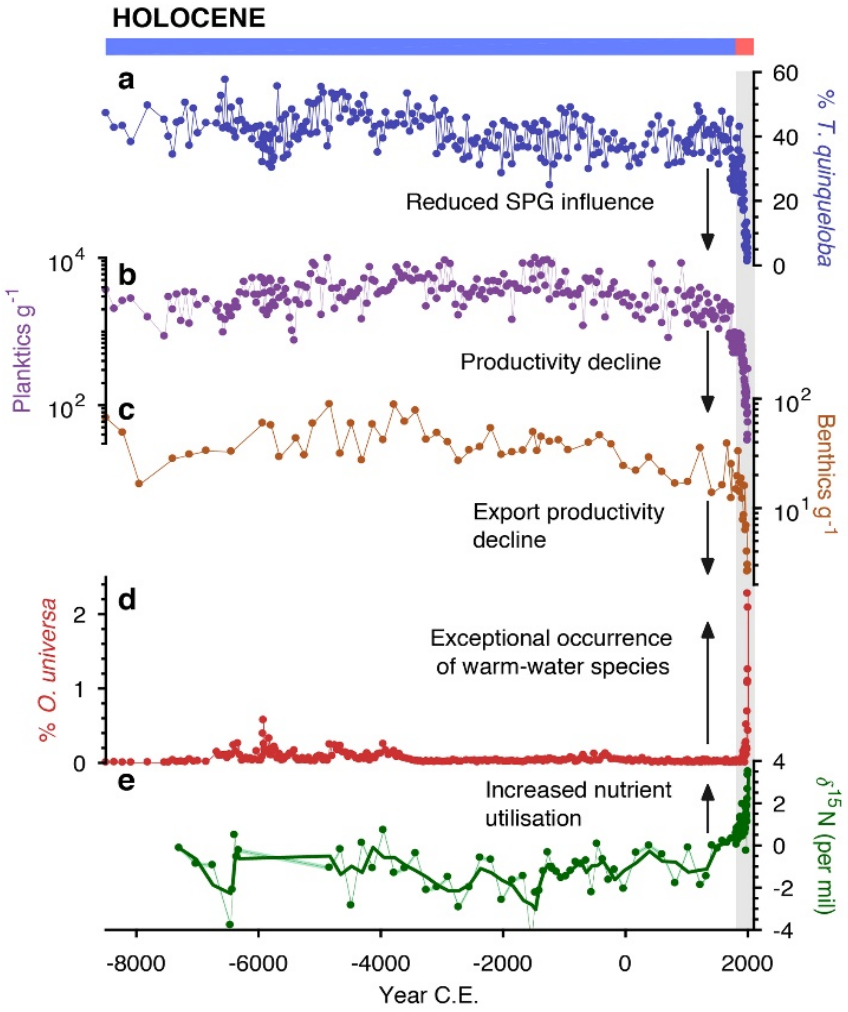
Recent occurrence of (sub)tropical species

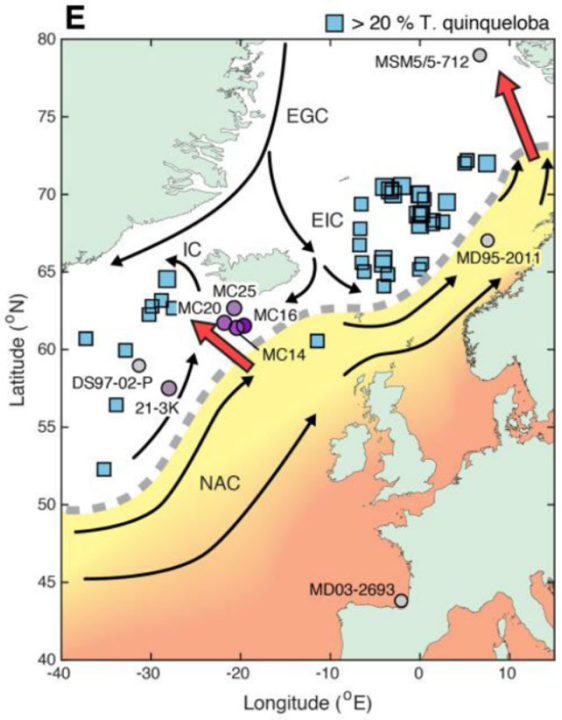




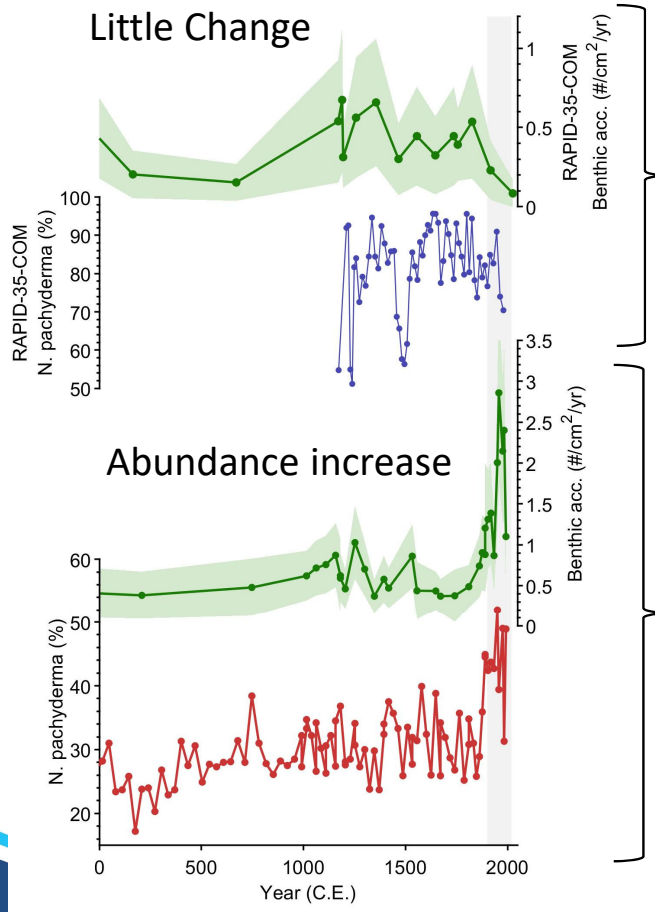
A unique Holocene SPG contraction

- Subpolar conditions south of Iceland for ~10,000 years
- 20th century decline in foraminifera abundance and subpolar species
- 1990s-2000s increase in warm species and nutrient utilisation
- Consistent with increased penetration of oligotrophic subtropical water

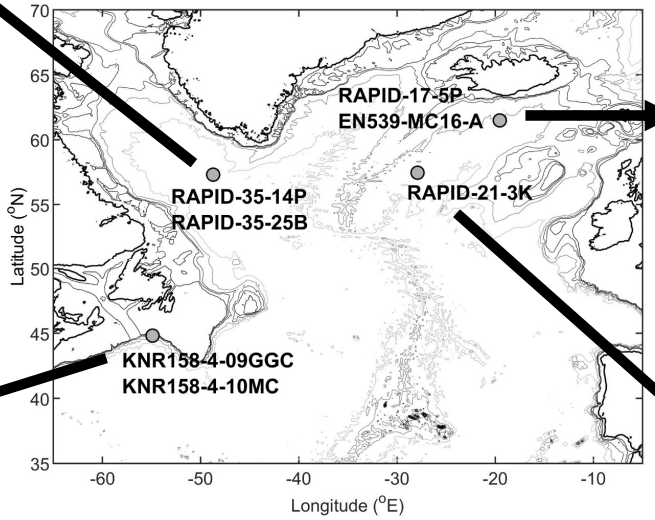




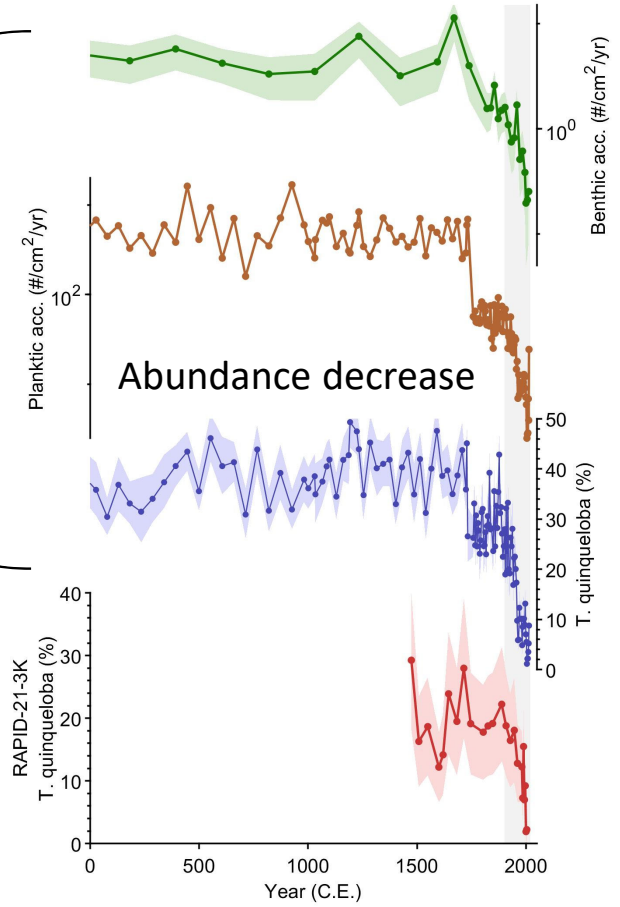
Impacts of AMOC and SPG change



Marine ecosystem work (reconstructing past abundance and assemblage and nutrient status(?)).

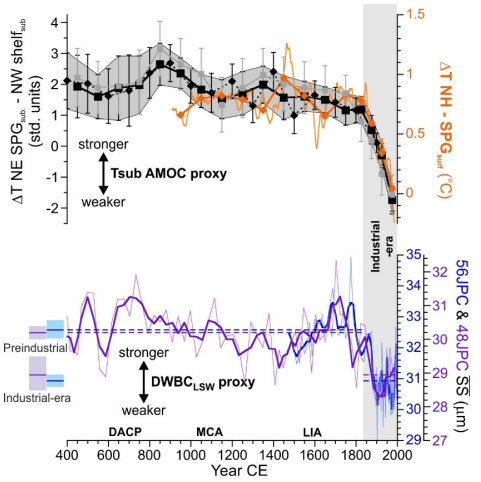


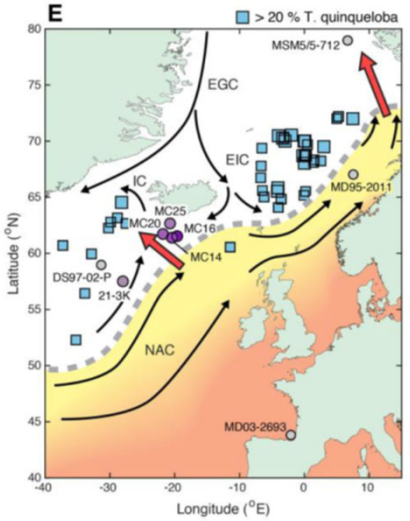
Surface productivity (food supply) control on benthic fauna → sites with large surface AMOC response see large benthic change.



Summary

- Exceptionally weak industrial-era AMOC (caused by weak LSW and ISOW).
- Has AMOC weakening continued through the 20th century? Relative cooling of SPG may be related to horizontal gyre circulation rather than deep components of AMOC.
- Unprecedented 20th century changes in subpolar gyre circulation caused pronounced changes in Northeast Atlantic hydrography and ecosystems.
- Recent variability is not simply 'typical ongoing decadal variability'. Likely future no-analogue conditions. Reliance on climate model projections.
- Better understanding of post Little Ice Age and 20th century changes is required for assessing climate model sensitivity and projections of AMOC.





Contact: d.thornalley@ucl.ac.uk

Follow ATLAS

@eu_atlas

@EuATLAS