

Supplementary Figure 1 | Singular Spectral Analysis (SSA) of time series. Annually averaged Ba/Ca time series (solid) and the gap-filled Ba/Ca time series (dashed) from 1646 to 2009. The linear trend in gap-filled time series did not significantly differ from the unfilled time series (significant at the 99% level). Linear least squares regression fits both time series (blue). The detrended gap-filled Ba/Ca record was used for correlations to the proxy AMO index.

Supplementary Note 1

Crustose Coralline Algae

Crustose coralline algae are calcareous photoautotrophic marine algae that are abundant and geographically widespread, forming hard rock-like encrustations in shallow rocky sublittoral zones worldwide³. Coralline algae of the genus *Clathromorphum* form annual growth increments, and are exceptionally abundant in subarctic regions of the North Atlantic, North Pacific, and Arctic Oceans. In the Northwest Atlantic, the coralline algae can form accretions of up to 10.5 cm in thickness (at an average vertical extension rate of 170 µm/year), resulting in age spans of several hundred years⁴. In fact, a living specimen of *Clathromorphum compactum* collected from the northern Labrador, Canada has been dated using annual layer counting methods, backed by radiocarbon dating to an age of 646 years⁴. Thus, as a result of their abundance, distribution, longevity, and formation of clear and distinct annual growth increments; coralline algae have become excellent high-resolution paleoclimate archives for reconstructing past changes in the ocean environment.

Over the past decade, a number of different geochemical methods have been utilized to examine: stable oxygen isotopes $(\delta^{18}O)^{5,6}$, trace element compositions (ex. Mg/Ca, Ba/Ca, Sr/Ca, U/Ca)^{7,8,9} and growth increment widths¹⁰. Proxy data obtained from *Clathromorphum* have been calibrated to in-situ water temperatures in a year-long field study⁶, and inter and intra-specimen comparisons of geochemical data have demonstrated high reproducibility^{7,11}. This wealth of proxy information spanning multidecadal to multicentennial timescales has provided us with a better understanding of variations in sea surface temperature^{9,12,13}, cloud cover and shallow marine light dynamics^{10,14}, Arctic sea-ice cover⁴; and their associations with large-scale multi-

decadal climate oscillation patterns (ex. Pacific Decadal Oscillation, North Atlantic Oscillation, El Niño Southern Oscillation, Aleutian Low) that were previously unresolvable due to the short record of oceanographic observations.

Supplementary References

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