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Multi-centennial Record of Labrador Sea Primary Productivity and Sea-Ice Variability Archived in Coralline Algal Ba/Ca

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Arctic sea-ice thickness and concentration have dropped by approximately 9% per decade since 1978. Concurrent with this sea-ice decline is an increase in rates of phytoplankton productivity, driven by shoaling of the mixed layer and enhanced transmittance of solar radiation into the surface ocean. This has recently been confirmed by phytoplankton studies in Arctic and Subarctic basins that have revealed earlier timing, prolonged duration, and increased primary productivity of the spring phytoplankton bloom. However, difficulties of navigating in remote ice-laden waters and harsh polar climates have often resulted in short and incomplete records of in-situ plankton abundance in the northwestern Labrador Sea. Alternatively, information of past ocean productivity may be gained through the study of trace nutrient distributions in the surface water column. Investigations of dissolved barium (Ba) concentrations in the Arctic reveal significant depletions of Ba in surface seawaters due to biological scavenging during the spring phytoplankton bloom. Here we apply a barium-to-calcium (Ba/Ca) and carbon isotope (δ^{13}C) multiproxy approach to long-lived crustose coralline algae in order to reconstruct an annually-resolved multi-centennial record of Labrador Sea productivity related to sea-ice variability in Labrador, Canada that extends well into the Little Ice Age (LIA; 1646 AD). The crustose coralline alga *Clathromorphum compactum* is a shallow marine calcareous plant that is abundant along the eastern Canadian coastline, and produces annual growth increments which allow for the precise calendar dating and geochemical sampling of hard tissue. Algal Ba/Ca ratios can serve as a promising new proxy for surface water productivity, demonstrating a close correspondence to δ^{13}C that does not suffer from the anthropogenically-induced carbon isotope decline (ex. Suess Effect) beginning in the 1960s. Coralline algal Ba/Ca demonstrates statistically significant correlations to both observational and proxy records of sea-ice extent and transport variability, and shows a persistent pattern of covariability that is broadly consistent with the timing and phasing of the Atlantic Multidecadal Oscillation (AMO). Lower algal Ba/Ca values are interpreted as increased productivity (via biological scavenging) coinciding with warming sea surface temperatures and melting of sea-ice, and vice versa. This relationship is further supported by negative correlations between algal Ba/Ca and spatially averaged chlorophyll α concentrations determined from Sea-Viewing Wide Field-of-View Sensor (SeaWiFS; 1998 – 2009) ocean colour data. Extended comparisons to a multi-centennial tree-ring proxy AMO index demonstrates more frequent positive Ba/Ca excursions (indicating reduced productivity) associated with AMO cool phases during the Little Ice Age, followed by a step-wise decline in Ba/Ca (indicating increasing productivity) from 1910 to present levels – unprecedented in the last 365 years. Our multi-centennial record of coralline algal Ba/Ca in the Subarctic northwest Atlantic demonstrates a long-term increasing trend in primary productivity that is in agreement with recent satellite-based productivity in the Arctic Ocean. This ongoing increase in phytoplankton productivity is expected to fundamentally alter marine biodiversity and trophic dynamics as warming and freshening of the surface layer is projected to intensify over the coming century.