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Climate oscillations and trends in the North Atlantic during the last 500 years recorded in shells of Arctica islandica

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Climate models could benefit greatly from annually to seasonally-resolved data in century-scale records of environmental conditions in marine mid to high latitudes. Such data are not currently available. We measured annual growth rates and more than 3,200 isotope samples from 30 shells of the bivalve mollusk Arctica islandica (Linnaeus). The specimens were collected alive in about 30m water depth from the North Atlantic between 1868 and 2003. Ontogenetic ages - based on increment counts and 14C(AMS) dating - ranged from 50 to 374 years. Contemporaneous specimens exhibit synchronous variations in increment width and enabled the construction of a master chronology more than 500 year long. Oxygen and carbon isotopes between major growth lines exhibit clear seasonal cycles further confirming the annual period of shell formation. The highest measured carbon isotope values (on average +2.73 permil) occurred during summer, i.e. during maximum primary productivity. The delta18O(aragonite)-derived temperature time-series cover the periods of 1496-1590 and 1850 to 2003 with a bi-weekly resolution. Temperatures calculated from oxygen isotopes ranged from 4.5 to 9.3 deg C and exhibit a mean value of 6.2 deg C. The latter coincides well with the 1854-2003 mean value of 6.81 deg C for sea-surface temperature between February and September (= growing season of A. islandica in the studied habitats). Neither oxygen nor carbon isotopes exhibit age-related, unidirectional trends. However, delta13C(aragonite) and delta18O(aragonite) values fluctuated at decadal periods of four, six and eight years (NAO-type periods) as well as 12-14 years which may represent teleconnections to cycles in the tropical Atlantic (tropi-

cal Atlantic meridional SST gradient, TAMG). Annual shell growth exhibits the same decadal oscillations and is positively correlated to seasonal delta 18O(aragonite) minima, i.e. warm summer temperatures (R2 = 0.34), and to seasonal delta 13C(aragonite) minima (higher food supply; R2 = 0.42). More than 65 % of the variation in annual shell growth can be explained by summer temperature and food supply. The formation of extremely narrow annual increments coincides with extreme environmental conditions, for example major volcanic eruptions (e.g., Tambora 1815). A period of extremely variable growth occurred during the culmination of the Little Ice Age (in Iceland between ca. 1550 and 1620). Shell growth during 1765-1780, however, was characterized by very little year-to-year variability, probably as the result of extremely mild climate near the end of the Little Ice Age. This study demonstrates that shells of A. islandica provide subseasonal to multidecadal, precisely dated multi-proxies of environmental variables from marine, mid to high latitudes. Such data can be used to validate and complement climate models and further assess human impact on climate and ecosystems.