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ORIGINAL PAPER

A late Holocene paleo-productivity record in the western Gulf of Maine, USA, inferred from growth histories of the long-lived ocean quahog (*Arctica islandica*)

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Abstract To investigate environmental variability during the late Holocene in the western Gulf of Maine, USA, we collected a 142-year-old living bivalve (*Arctica islandica*) in 2004, and three fossil *A. islandica* shells of the Medieval Warm Period (MWP) and late MWP / Little Ice Age (LIA) period (corrected $^{14}C_{AMS}$ = 1030 ± 78 AD; 1320 ± 45 AD; 1357 ± 40 AD) in 1996. We compared the growth record of the modern shell with continuous plankton recorder (CPR) time-series (1961–2003) from the Gulf of Maine. A significant correlation ($r^2 = 0.55$; $p < 0.0001$) exists between the standardized annual growth index (SGI) of the modern shell and the relative abundance of zooplankton species *Calanus finmarchicus*. We therefore propose that SGI data from *A. islandica* is a valid proxy for paleo-productivity of at least one major zooplankton taxa. SGIs from these shells reveal significant periods of 2–6 years (NAO-like) based on wavelet analysis, multitaper method (MTM) analysis and singular spectrum analysis (SSA) during the late Holocene. Based on established physical oceanographic observation in the Gulf of Maine, we suggest that slope water variability coupled with North Atlantic Oscillation (NAO) dynamics is primarily responsible for the observed SGI variability.

Keywords *Arctica islandica* · Shell growth · Climate variability · Paleo-productivity · Gulf of Maine · North Atlantic Oscillation (NAO)

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Introduction

The Gulf of Maine is a mid-latitude sea situated in the northwestern Atlantic Basin located along a hydrographic and faunal transition zone that is sensitive to minor climate shifts (Fig. 1) (e.g., marine ecosystem response to climate in the North Atlantic; MERCINA 2001, 2003). The Gulf of Maine is an extremely productive ocean environment that supports a rich and dynamic ecosystem. Because of its geographic location, changes in the strength and/or position of slope water currents (e.g., Labrador Current, Gulf Stream) are thought to significantly affect the oceanography (temperature, salinity, productivity, etc.) in the Gulf of Maine (Dickson et al. 1996; Keigwin and Pickart 1999; Pickart et al. 1999; MERCINA 2001; Greene and Pershing 2001; Conversi et al. 2001). Further, dominant modes of climate variability in the North Atlantic such as the North Atlantic Oscillation (NAO) have been linked to variability in ecosystem dynamics (e.g., Drinkwater and Mountain 1997; Drinkwater et al. 2003). Understanding the mechanisms responsible for the observed interannual-to-decadal changes in zooplankton levels in the Gulf of Maine remains