Clim Dyn (2008) 31:183–194
DOI 10.1007/s00382-007-0344-8

Coupled North Atlantic slope water forcing on Gulf of Maine temperatures over the past millennium

Alan D. Wanamaker Jr · Karl J. Kreutz · Bernd R. Schöne · Neal Pettigrew · Harold W. Borns · Douglas S. Introne · Daniel Belknap · Kirk A. Maasch · Scott Feindel

Received: 26 March 2007 / Accepted: 15 November 2007 / Published online: 4 December 2007

Abstract To investigate ocean variability during the last millennium in the Western Gulf of Maine (GOM), we collected a 142-year-old living bivalve (*Arctica islandica* L.) in 2004, and three fossil *A. islandica* shells (calibrated $^{14}C_{AMS}$ = 1030 ± 78 AD; 1320 ± 45 AD; 1357 ± 40 AD) for stable isotope and growth increment analysis. A statistically significant relationship exists between modern GOM temperature records [shell isotope-derived (30 m) ($r = -0.79$; $P < 0.007$), Prince 5 (50 m) ($r = -0.72$; $P < 0.019$), Boothbay Harbor SST ($r = -0.76$; $P < 0.011$)], and Labrador Current (LC) transport data from the Eastern Newfoundland Slope during 1993–2003. In all cases, as LC transport increased, GOM water temperatures decreased the following year. Decadal trends in the North Atlantic Oscillation (NAO) and the Atlantic Multidecadal Oscillation (AMO) influence GOM water temperatures in the most recent period, with water temperatures decreasing during NAO and AMO negative modes most likely linked to LC transport and Gulf Stream interaction. Mean shell-derived isotopic changes ($\delta^{18}O_c$) during the last 1,000 years were +0.47‰ and likely reflect a 1–2°C cooling from 1000 AD to present. Based on these results, we suggest that observed cooling in the GOM during the last millennium was due to increased transport and/or cooling of the LC, and decreased Gulf Stream influence on the GOM.

A. D. Wanamaker Jr · K. J. Kreutz · H. W. Borns · D. S. Introne · D. Belknap · K. A. Maasch
Climate Change Institute and Department of Earth Sciences, University of Maine, Orono, ME 04469-5790, USA

A. D. Wanamaker Jr (✉)
School of Ocean Sciences, University of Wales at Bangor, Menai Bridge, Anglesey LL59 5AB, UK
e-mail: oss609@bangor.ac.uk

B. R. Schöne
Increments Research Group, Department of Paleontology, Institute of Geosciences, University of Mainz, Johann-Joachim-Becher-Weg 21, 55128 Mainz, Germany

N. Pettigrew
School of Marine Sciences, University of Maine, Orono, ME 04469-5790, USA

S. Feindel
Darling Marine Center, University of Maine, Walpole, ME 04573, USA

1 Introduction

The oceanography along the slope of the Eastern Canadian coast and the deep Gulf of Maine (GOM) is strongly influenced by the position, strength, and properties of the Labrador Current (LC) (Fig. 1). The LC has two distinct branches of flow: the principal branch that flows generally southward along the continental slope, and an inner branch that flows over the Labrador and Newfoundland continental shelf regions (Lazier and Wright 1993). At times, water of LC origin extends from the western Labrador Sea to the Middle Atlantic Bight (e.g., Petrie and Drinkwater 1993; Loder et al. 2001), and has a net cooling effect on both air and coastal water temperatures along the Canadian Atlantic provinces (e.g., Drinkwater et al. 1999). Han and Li (2004) estimated an annually averaged flow of ~6 Sv (1 Sv = 10^6 m^3 s^{-1}) for the LC along the Eastern Newfoundland Slope (200–3,000 m) using TOPEX/Poseidon satellite altimeter data (Fig. 1). Gatien (1976) identified two types of slope waters outside the GOM and along the Scotian Shelf, Labrador Slope Water (LSW) and Warm Slope Water (WSW). From the Labrador Sea, the cold,