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Short Paper

Marine radiocarbon reservoir corrections (ΔR) for Chesapeake Bay and the Middle Atlantic Coast of North America

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ABSTRACT

Radiocarbon dates from known age, pre-bomb eastern oyster (*Crassostrea virginica*) shells provide local marine reservoir corrections (ΔR) for Chesapeake Bay and the Middle Atlantic coastal area of eastern North America. These data suggest subregional variability in ΔR, ranging from 148 ± 46 ^{14}C yr on the Potomac River to -109 ± 38 ^{14}C yr at Swan Point, Maryland. The ΔR weighted mean for the Chesapeake's Western Shore (129 ± 22 ^{14}C yr) is substantially higher than the Eastern Shore (-88 ± 23 ^{14}C yr), with outer Atlantic Coast samples falling between these values (106 ± 46 and 2 ± 46 ^{14}C yr). These differences may result from a combination of factors, including ^{14}C-depleted freshwater that enters the bay from some if its drainages, ^{14}C-depleted seawater that enters the bay at its mouth, and/or biological carbon recycling. We advocate using different subregional ΔR corrections when calibrating ^{14}C dates on aquatic specimens from the Chesapeake Bay and coastal Middle Atlantic region of North America.

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Introduction

Building reliable chronologies is essential to archaeologists and geoscientists investigating ancient cultural, climatic, and ecological developments. Radiocarbon (^{14}C) dating is the primary means for developing absolute chronologies for the last ~40,000–50,000 yr and is widely used by Quaternary paleoclimatologists, paleoecologists, and archaeologists. As researchers seek higher precision chronologies and focus on questions that require greater chronological accuracy, continued attention has been given to improving and refining methods in ^{14}C measurements, calibration of radiocarbon dates, and selection of suitable reference materials (Taylor, 1987; Stuiver and Reimer, 1993; Stuiver et al., 1998; Reimer and Reimer, 2001; Hughen et al., 2004; Reimer et al., 2004, 2009).

Mollusk shells and other carbonates are used to radiocarbon-date archaeological and paleontological materials from marine and freshwater settings around the world (Erlandson et al., 1996; Kennett et al., 1997, 2002; Deo et al., 2004; Culleton, 2006; Thomas, 2008). Because mixing of atmospheric CO_2 in the upper ocean is slow, the ^{14}C composition of the global ocean reservoir (R) lags behind the atmosphere by roughly 400 yr. Other factors create local deviations from the global average, which is defined as the local reservoir offset or ΔR. The ΔR value includes the net effects of ocean circulation, upwelling, freshwater dissolved inorganic carbon (DIC), and biological processes (Stuiver et al., 1986; Stuiver and Reimer, 1993; Stuiver et al., 1998). With the use of marine reservoir corrections when calibrating radiocarbon years to 'calendar' years, ^{14}C dates on marine shell are sometimes favored over wood charcoal because of potential problems in dating 'old wood' and because they often have a clearer cultural association (Schiffer, 1986; Kennett et al., 2002; Thomas, 2008).

Despite widespread ^{14}C-dating of marine shell, questions remain about ^{14}C-dating marine carbonates in areas like the Chesapeake Bay where only three shells of known age have been ^{14}C-dated (Colman et al., 2002), and where archaeologists have long questioned the use of marine shell as a dating material (Custer, 1989:126–127). Here we present a suite of radiocarbon data obtained from known age, pre-bomb eastern oyster (*Crassostrea virginica*) shells from Chesapeake Bay and the Middle Atlantic Coast of North America (Fig. 1). Shells of known age from prior to atmospheric nuclear weapons testing are useful for calculating ΔR (Little, 1993; Hogg et al., 1998; Reimer and Reimer, 2001; Ulm, 2002; Culleton, 2006; Lewis et al., 2008; Petchy et al., 2008, 2009; Thomas, 2008). The three ^{14}C dated, known-age shells reported by Colman et al. (2002) provided an average reservoir age close to 405 yr (currently the global marine average: Hughen et al., 2004), but they did not calculate ΔR, prompting researchers in the area to generally apply a ΔR of zero (Bratton et al., 2003; Cronin et al., 2005, 2010; Willard et al., 2005). We expand on these initial samples by placing our data in the context of broader environmental variables in the Chesapeake Bay region and documenting subregional differences in ΔR.

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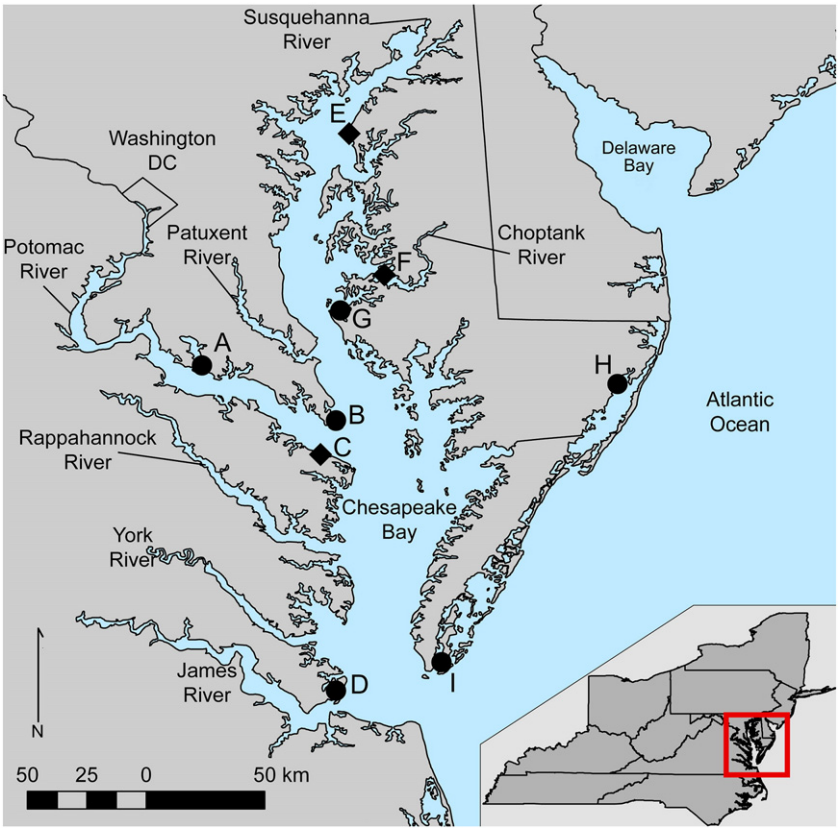

Figure 1. Chesapeake Bay and the Middle Atlantic Region showing the collection locations of oysters analyzed for this study (circles) and samples reported by Colman et al. (2002) (diamonds). Letters correspond to Sample ID numbers in Tables 1 and 2.

Materials and methods

Radiocarbon dates for pre-bomb (< AD 1950) eastern oysters were obtained from six shells housed at the Department of Invertebrate Zoology, National Museum of Natural History (NMNH), Smithsonian Institution (Table 1). We also present three ^{14}C dates on known age, pre-bomb shells from the Philadelphia Academy of Sciences reported by Colman et al. (2002), updating ΔR for these specimens using the IntCal09 and Marine09 (Reimer et al., 2009) datasets. Four of the nine museum shells are from the Western Shore of Chesapeake Bay, ranging from the Potomac River mouth to Buckroe Beach, Virginia at the mouth of the James River. Three shells are from the Eastern Shore from Kent County to the Little Choptank River. Two additional specimens are from the Atlantic Coast of the Delmarva Peninsula at Sinepuxant Bay, Maryland, and Magothy Bay, Virginia. All specimens are assumed to have been collected live, with the presence of dried flesh near ligament attachments supporting this assertion (Petchy et al., 2008, 2009). For two samples (NMNH# 153104 and 348635) the dates given are for the date they were cataloged, which we assume corresponds to within a few years of their collection. These two shells provided comparable ΔR values to other nearby specimens. Collectively, these shells yield good geographic coverage, with gaps north of the Potomac River on the Western Shore and south of the Little Choptank River on the Eastern Shore. Suitable specimens for ^{14}C dating from these areas have not been located.

Accelerator Mass Spectrometry (AMS) radiocarbon analysis for the six samples reported here was performed by Beta Analytic, Inc. (Miami, FL). All AMS dates were on shell fragments removed from complete left or right eastern oyster valves. Eastern oysters are suspension feeders, making them well-suited for ^{14}C dating (Petchy et al., 2008, 2009). The oyster valves were sectioned using a Buehler Isomet slow-speed saw. After sectioning, a ~10-mm subsample of shell was removed from the ligament area of the shell to ensure that as many individual shell growth bands were sampled as possible to alleviate problems of intra-shell variability (Culleton et al., 2006). These shell subsamples were rinsed in tap water, air-dried, and sent to Beta Analytic, Inc. for analysis. Prior to analysis, the shell subsamples were etched in a dilute HCl bath to remove potentially altered

Table 1
Eastern oyster (*Crassostrea virginica*) specimen collection information (All samples are from the Department of Invertebrate Zoology, Smithsonian Institution, Washington, DC.

ID#[a]	Museum Cat. #	Year Collected	Location	Comments
Chesapeake Bay, Maryland/Virginia				
A	431055	1927	Cobb Island, Potomac River, Maryland	Multiple valves collected. Dried flesh present in the hinge ligament area.
B	153104	1898	Point Lookout, Maryland	Oyster specimen was growing on historic dentures recovered from the reef. Sample valve not connected to denture. Year given is for date cataloged. Dried flesh present in the hinge ligament area.
D	379843	1916	Buckroe Beach, Virginia	Specimens from near mouth of James River.
G	348635	1923	Town Pt., Little Choptank River, Maryland	Year given is for the year cataloged. Dried flesh present in the hinge ligament area.
Middle Atlantic Coast, Maryland/Virginia				
H	601742	1945	Ocean City, Sinepuxant Bay, Maryland	Collected in shallow water on a muddy bottom. Dried flesh present in the hinge ligament area.
I	485428	1916	Magothy Bay, Virginia	Dried flesh present in the hinge ligament area.

[a] ID numbers correspond with Table 2 and Figure 1.