

Interactive comment on “Large spatial variations in coastal ¹⁴C reservoir age – a case study from the Baltic Sea” by B. C. Lougheed et al.

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Received and published: 16 March 2013

General comments

Lougheed and co-authors present results of an investigation into the radiocarbon (¹⁴C) reservoir offset (R(t)) in the Baltic Sea, using an extensive dataset based on 30 known-age, pre-bomb mollusk shells. They investigate the relationship between R(t) and hydrographic conditions in the Baltic, focusing specifically on the mixing relationship of fresh and marine waters. They test the hypothesis that the higher ¹⁴C content of fresh water (from terrestrial runoff) versus marine waters means R(t) will co-vary with the proportion of these two end-members at Baltic sample sites. They find that R(t) is correlated with salinity (and hence freshwater input) in the study area. As the δ¹⁸O of aragonite in the shell samples is also significantly correlated with salinity (and with

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R(t)), they conclude that $\delta^{18}\text{O}$ aragonite is a means to estimate R(t) for the Baltic. From these data they are able to produce a new spatial picture of Baltic R(t), based on existing salinity measurements and their regression equations.

This work represents a very worthwhile addition to the literature, and will contribute significantly to current efforts to produce accurate ^{14}C reservoir corrections for coastal and estuarine regions. Addressing the underlying mechanisms for reservoir effects is an important goal, as is proper quantification of realistic uncertainties that should be attached to R(t) determinations; the authors consider both these points carefully in their manuscript. It is good to see a manuscript that considers the applicability of the results so carefully, particularly highlighting where these are limited (e.g. cautioning against application of mollusk-derived R(t) to bulk sediment). The methodological approach is valid, the scientific contribution of the manuscript is relevant to the scope of *Climate of the Past*, and the presentation is clear and well structured.

Specific comments

The authors interpret R(t) >500 ^{14}C years as indicative of hard water effects. These values therefore represent an integration of the ^{14}C content of fresh and marine water components, plus a ^{14}C -dead geological carbonate-derived component in the DIC at a site. It was not possible however, to reliably identify or quantify the hard water component in shell samples; $\delta^{13}\text{C}$ aragonite was only weakly correlated with R(t) and not correlated with salinity. It is a reasonable hypothesis that input of hard water (of infinite ^{14}C age) is responsible for R(t) values elevated above that of the 100% marine component (i.e. >500 ^{14}C years). But if it was not possible to reliably identify/quantify a hard water component in shells in the study on an isotopic basis, how can the authors be sure that a hard water component has not affected at least some of the samples with R(t) <500 ^{14}C yr? If the size of the hard water component in freshwater inputs varies geographically, could this not explain some of the variability in the R(t) vs salinity plots? A further point is that influx of hard water would not necessarily be picked up via $\delta^{13}\text{C}$ aragonite as the $\delta^{13}\text{C}$ of geological carbonates and seawater $\delta^{13}\text{C}$ DIC are both

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close to ~0‰.

The species *Macoma balthica* is an infaunal feeder (as are the other species in the study); are the authors confident that there is no possibility that 14C-dead CaCO₃ could be ingested by these mollusks during feeding that would affect the shell 14C content?

In section 5.3 ($\delta^{18}\text{O}$ aragonite as a *Macoma* R(t) proxy) the authors state that the $\delta^{18}\text{O}$ aragonite signal is dominated by the $\delta^{18}\text{O}$ of freshwater and marine end members, with little impact from temperature fractionation effects. This is supported by an assessment that salinity variability (assessed by standard deviation) in the study area is 4.4 PSU, compared to a “standard deviation of . . . temperature values. . . only 1.5°C”. However, the individual temperature values for sample locations have associated uncertainties (\pm) of up to $\pm 5.7^\circ\text{C}$; the average is $\pm 3.0^\circ\text{C}$. The standard deviation of values therefore seems to underestimate the realistic variability in assessments for the variable of temperature; the average measurement uncertainty would be a more conservative measure.

Technical corrections:

Ensure all data in any individual column of the supplementary table is given to a consistent number of significant figures (e.g. Mean temp data and associated uncertainties)

In the introduction, a slightly more detailed discussion of 14C calibration with specific reference to marine samples would be useful. Highlight the current atmospheric calibration curve is IntCal09, with a separate marine curve (Marine09) for samples composed of marine carbon. This would also be a good point to describe the parameter ΔR for completeness.

In the introduction also explain more fully the major mechanism underlying the 14C marine reservoir effect - 14C decay of water masses while separated from the atmosphere-ocean interface reduced their 14C content relative to the atmosphere. Re-

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introduction of these ^{14}C -depleted water masses to the surface results in the ^{14}C reservoir effect.

Hydrographic setting section: specify the $\delta^{18}\text{O}$ of the Baltic sea end members.

When using 'age', specify when ' ^{14}C age' is meant

Section 'Radiocarbon dating and calculation of reservoir ages': define the terms in the equation for ΔR

Section 4.1.3: Define the values for $\delta^{18}\text{O}_{\text{marine}}$ and $\delta^{18}\text{O}_{\text{runoff}}$ in the text.

Could the sections 4.2.1 to 4.2.4 be conflated into a single larger section?

Interactive comment on Clim. Past Discuss., 9, 891, 2013.

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