Clams before Columbus?

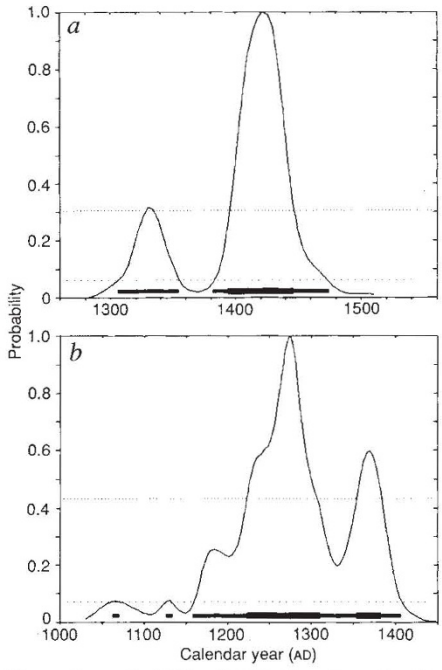
SIR — Zoologists and geologists agree that specimens of *Mya arenaria* (the American soft-shell clam) from the Holocene found in Europe first appeared in the sixteenth century, after the voyage of Columbus[1]. But we have dated a sample from the Kattegat region on the east coast of the Skaw in northern Jutland, Denmark, that pre-dates Columbus's voyage. This result implies that contact between America and Europe existed before the sixteenth century.

M. arenaria is known to have been transferred from America to Europe by man[1] because of zoological evidence that the larvae could not have spread spontaneously to Europe from America. The species has stayed in America since the Pliocene, whereas it died out in Europe at the beginning of the Pleistocene[2].

During our study of the Holocene coastal and faunal development of the Skagen Odde in northern Jutland, it became clear that the east coast offered the possibility of a close examination of the youngest fauna and coastal development[3]. For more than 1,000 years, the coast has migrated eastwards because of the accumulation of successive barrier sand systems.

The molluscan fauna of today is dominated by *Cardium, Spisula*, *Macoma* and *M. arenaria*. We took three samples from the east coast of the Skaw, all dominated by *Cardium edule* (common edible cockle), but with fragments of *M. arenaria*. The assemblage of molluscs from the site has been dated by conventional radiocarbon dating on the basis of *C. edule* using 50 g from each of the three samples. The C. *edule* shells were etched in hydrochloric acid to remove the surface layers. At least 10% of the mass of the shells was removed for analysis at the ^{14}C dating laboratory in Copenhagen. The conventional radiocarbon datings of the three samples (K-5848 to K-5850) showed calibrated ages in the range AD 1400–1650. We subsequently radiocarbon dated one *M. arenaria* specimen from each of the three samples by accelerator mass spectrometry (AMS) using about 20 mg of each sample. The shells were given standard chemical treatment including acid etching to remove the surface layers (at least 20% of the total mass) for analysis at the AMS dating laboratory at the University of Aarhus. The age of the *M. arenaria* sample (II) found in the sand barrier furthest from the coast (AAR-883, AD 1245–1295 at ± 1 s.d.) without doubt predates Columbus's voyage in 1492. The figure shows the age probability distribution of the two radiocarbon datings of the oldest sample. It is obvious from the distribution that there is a very slight probability of the sample being younger than Columbus's discovery of America in AD 1492.

These finds of *M. arenaria* raise the question of an earlier transfer from America to Europe than previously assumed[2]. In AD 1542, the French first colonized the east coast of America, but since the discovery of North America by Leif Ericson in around AD 1000, repeated trade by Nordic people settling in Greenland has been recorded. Consequently, *M. arenaria* could have been transferred from North America to Europe by the Vikings, but it still remains to be seen when *M. arenaria* invaded Europe.



The age probability distribution in calendar years for the two radiocarbon datings of the oldest sample (II). *a*, Conventional date on *C. edule* (500 ± 50 years BP). *b*, The AMS date on *M. arenaria* (720 ± 80 years BP).

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1. Hessland, I. *Arkiv for Zool.* **37A**, No. 8, 1–51 (1945).
2. Strauch, F. *Abh. senckenberg. naturforsch. Ges.* **531**, 1–210, (1972).
3. Petersen, K. S. *Quatern. Int.* **9**, 53–60 (1991).

Temperature oscillations

SIR — The application of singular spectrum analysis to climatic temperature records has been the subject of recent debate[1–4]. Tsonis and Elsner[4] rightly emphasize the importance of considering several data records and illustrate the difficulty of determining whether or not two empirical orthogonal functions (EOFs) form an oscillatory pair by visual inspection.

Here, we resolve issues raised by the most serious reponse of Tsonis and Elsner[4] to our note[3]. If a Toeplitz structure is imposed on the lag-covariance matrix, singular spectrum analysis gives two EOFs resembling interdecadal oscillations when applied only to the past 90 years of the IPCC global temperature series[5]. Tsonis and Elsner[4] mistakenly attributed our remarks concerning this Toeplitz case to the corresponding non-Toeplitz case (shown in their figure), hence the disparity. In fact, the non-Toeplitz case they introduced illustrates an interesting special case of a degenerate singular spectrum, which we will discuss elsewhere. The fact that the Toeplitz approach of Ghil and Vautard seems to succeed better in this instance does not indicate conclusively that it is preferable, as the non-Toeplitz approach also has important advantages (such as unbiased reconstruction near the endpoints of a linear trend; M.R.A. and L.A.S., manuscript in preparation).

In short, our aim[3] was to explain why different conclusions from the IPCC data set were derived in refs 1 and 2. Our explanation gives no special role to the early decades; the different results arise from a simple artefact of singular spectrum analysis which does not establish (or require) the statistical significance of the oscillation. We suggest future work should avoid using rank order and visual appearance of EOFs as the primary significance criteria in singular spectrum analysis, focusing instead on testing quantitative null hypotheses.

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1. Ghil, M. & Vautard, R. *Nature* **350**, 324–327 (1991).
2. Elsner, J. B. & Tsonis, A. A. *Nature* **353**, 551–553 (1991).
3. Allen, M. R., Read, P. L. & Smith, L. A. *Nature* **355**, 686 (1992).
4. Tsonis, A. A. & Elsner, J. B. *Nature* **356**, 751 (1992).
5. Houghton, J. T. *et al. Climate Change, the IPCC Scientific Assessment* (Cambridge University Press, 1990).