# ‘True British sailors’: A comment on the origin of the men of the *Mary Rose*

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## Abstract

Bell, Lee-Thorp and Elkerton (2009) have recently published an isotopic investigation of the origins of 18 men whose remains were found in the wreck of the *Mary Rose*, Henry VIII’s warship, which sank in 1545. They conclude that a high proportion of the ship’s crew were foreigners and that this may have contributed to confusion onboard ship and the sinking of the vessel. We have re-evaluated the data of Bell et al. and conclude that only one of the 18 sailors demonstrably spent his childhood outside the British Isles.

## Introduction

The sinking of the *Mary Rose* has been the source of much historical debate. The English blamed the sinking on a combination of poor seamanship and bad luck. According to contemporary sources, the ship sank after water gushed in through open gun ports during a badly executed manoeuvre. French accounts suggest that the French navy succeeded in damaging the ship before it went down but since the remains of the *Mary Rose* that were recovered from the Solent in 1982 showed no obvious signs of cannon damage the French claim has long been dismissed as politically-motivated propaganda (Stirland 2000; see, however, Fontana, 2008). It has also been suggested that the *Mary Rose* might have had a large number of foreign mercenaries and ‘prest’ men on board and that this led to poor communication which may well have contributed to the fatal manoeuvre and the ship’s sinking (Stirland, 2000).

Bell et al. (2009) worked from the premise that if there were foreigners on board the *Mary Rose* when she sank then this ought to show up in the oxygen and possibly carbon and nitrogen isotope composition of the teeth of the men who went down with her. This is certainly to be expected as enamel $\delta^{18}O$ is well established as a marker of geographical origin (e.g., Budd et al., 2004). The $\delta^{13}C$ and $\delta^{15}N$ data show no obvious patterning and we concur with the authors that there is no evidence for migration from these values. The enamel carbonate $d18O_{carb}$ values fall between -5.2 and -3.2 ‰ VPDB, with one obvious outlier at -6.7‰ (Figure 1). Bell et al. conclude that at least one third, but possibly two thirds of the ship’s crew were foreigners who spent their childhood in more southerly climes. We believe that this interpretation is based on a misunderstanding of oxygen isotope systematics and that the true picture is quite different.

## Problems with the approach of Bell et al.

The basic assumption behind the approach of Bell et al. to interpreting their data is that enamel carbonate oxygen isotope ($\delta^{18}O_{carb}$) values expressed relative to the VPDB standard can be read alongside drinking water ($\delta^{18}O_{dw}$) or precipitation ($\delta^{18}O_{pptn}$) values, which are expressed relative to the VSMOW standard. The authors base their assumption on the results of an earlier study (Bell et al., 2006) in which they noticed a "curious relationship of relative comparability" between $\delta^{18}O_{carb}$ VPDB and $\delta^{18}O_{pptn}$ VSMOW values that enables us to read them together (Bell et al., 2006: 50). While they acknowledge that it is not recommended to mix scales when comparing data they maintain that there is some utility in doing so because "whilst not understood, the PDB standard builds in a correction factor enabling PDB enamel values to be compared directly to VSMOW precipitation values" Bell et al. (2006: 51-52).

The problem with the 2006 study is that it is based on a very small dataset (nine humans and 16 horses). As a result, the range of human $\delta^{18}O_{carb}$ values in Britain is not well represented by their data. We map, approximately, the locations associated with their humans in Figure 2, along with isopleths of $\delta^{18}O_{pptn}$ (Darling, 2004). It is clear that the range of -7.1 to -5.3 ‰ for $\delta^{18}O_{carb}$ VPDB corresponds to $\delta^{18}O_{pptn}$ ranging from ca. -8.0 to -7.0 ‰ VSMOW. There is therefore no direct equivalence of $\delta^{18}O_{carb}$ VPDB and $\delta^{18}O_{pptn}$ VSMOW. In addition, the total range of $\delta^{18}O_{pptn}$ values in the British Isles is much larger, ranging from below about -5.0 ‰ in the extreme west to below -8.5 ‰ in the east (Darling, 2004). Consequently, we believe it is dangerous either to extrapolate even a broad equivalence of $\delta^{18}O_{carb}$ and $\delta^{18}O_{pptn}$ in humans, or to consider the data of Bell et al. (2006) representative of the British Isles.

Further, Bell et al.'s approach contradicts our current theoretical and empirical understanding of oxygen isotope systematics in the body. Numerous studies have shown that the relationship between the isotopic composition of the body's oxygen pool and that of drinking water is not direct but linear and species-specific (e.g., Kohn 1996; Longinelli, 1984; Luz et al., 1984). Oxygen in body water derives from a combination of oxygen in food and drink (itself mostly derived, directly or indirectly, from local precipitation) and breathed atmospheric oxygen. Consequently, when $\delta^{18}O_{bw}$ is expressed as a linear function of $\delta^{18}O_{dw}$, the gradient of the relationship is less than one (Luz et al., 1984). Enamel carbonate and phosphate are in isotopic equilibrium with body water at 37 ºC at the time of formation but, as Bell et al. (2009: 168) rightly point out, the chemical routes differ, so that the values are offset (Iacumin et al., 1996; Bryant et al., 1996; Martin et al., 2008).

Other problems of interpretation become apparent with a closer examination of the data from the *Mary Rose*. The reported enamel $\delta^{18}O_{carb}$ values range between -6.7 and -3.2 ‰ VPDB. However, contrary to Bell et al., the majority of individuals do not "cluster around a value of about -5 to -6 ‰" (Bell et al., 2009: 171). In fact, only two of the 18 individuals fall within this range. The rest of the crew all have $\delta^{18}O_{carb}$ above -5 ‰, with the exception of individual 6 who has a much more depleted enamel $\delta^{18}O_{carb}$ value of -6.7 ‰. The $\delta^{18}O_{pptn}$ values in Great Britain range from about -5 ‰ in the extreme west to -8.5 ‰ in the east (Figure 2; Darling, 2004). If we accept Bell et al.'s assumption that $\delta^{18}O_{carb}$ values directly reflect $\delta^{18}O_{pptn}$, then strictly speaking only three of the 18 individuals from the *Mary Rose* have values that are consistent with a British origin. However for the reasons given above, we believe that such a scenario is untenable and we suggest an alternative interpretation.

## Re-interpreting the data

Since oxygen isotopes fractionate as they are incorporated into body tissue some form of calibration or correction is required before the measurements can be compared with environmental data. The existing calibrations relate phosphate oxygen isotope ratios to drinking water ratios, so first a conversion from carbonate to phosphate is necessary. Several studies have investigated the fractionation between carbonate and phosphate oxygen in mineralised tissues. Iacumin et al. (1996) found $\alpha=1.0090\pm0.0007$ (n=31), Bryant et al. (1996) found $\alpha=1.0086\pm0.0007$ (n=42), and Martin et al. (2008) found $\alpha=1.0082\pm0.0007$ (22 measurements on two teeth); other, smaller, studies are summarised in Martin et al. (2008). Since the studies by Iacumin et al. (1996) and Bryant et al. (1996) have the largest number of data points, they are probably the most reliable. Combining their reported values gives $\alpha=1.0088\pm0.0005$.

The relationship between human skeletal phosphate and drinking water has been characterised by several studies (Longinelli, 1984; Luz et al., 1984; Levinson et al., 1987). Daux et al. (2008) recently synthesised the data from these studies and we adopt their equation here. The equation of Daux et al. (2008) has an uncertainty of prediction of 0.5 ‰, which combined in quadrature with the 0.5 ‰ uncertainty on the carbonate-phosphate fractionation and the 0.2 ‰ measurement uncertainty of Bell et al. (2009) gives a total uncertainty in a predicted drinking water value of 0.73 ‰. On the basis of these fractionation and calibration factors, we obtain a range of $\delta^{18}O_{dw}$ for the *Mary Rose* men of

-8.2 to -5.0 ‰ (VSMOW) for the main group and -10.5 ‰ for the outlier (individual 6 whose value is 2.8 s.d. from the mean). The range of $\delta^{18}O_{pptn}$ values for the British Isles is -8.5 to -5.0 ‰, from which it is clear that only the outlier is inconsistent with a British origin.

## Conclusion

We have shown that the identification by Bell et al. (2009) of immigrants amongst the *Mary Rose* crew is flawed because:

1) There is no direct equivalence of $\delta^{18}O_{carb}$ VPDB and $\delta^{18}O_{pptn}$ VSMOW as claimed by Bell et al. (2006);
2) This claim contradicts established understanding of oxygen isotope systematics in the human body, which requires the use of a calibration equation to obtain $\delta^{18}O_{dw}$ from $\delta^{18}O_{carb}$;
3) Even if this claim were true they have misinterpreted their own data by claiming a cluster of values around $\delta^{18}O_{carb}$ VPDB of -6 to -5 ‰.

We show instead that:

4) It is possible to relate $\delta^{18}O_{carb}$ to $\delta^{18}O_{dw}$ by taking the published values for the fractionation between carbonate and phosphate oxygen in mineralised tissues, and combined them with the calibration of Daux et al. (2008) relating phosphate values to drinking water;
5) When this is done and compared to the range of British $\delta^{18}O_{pptn}$, only one of the 18 Mary Rose men has $\delta^{18}O_{carb}$ inconsistent with a British origin.

Thus the hypothesis “that a significant proportion of the crew did indeed hail from more southern shores” is neither supported nor refuted by the isotopic evidence. The identifiable non-British sailor probably came from a more northerly or easterly area.

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Figure 1: $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$ (left axis) values for 18 Mary Rose individuals, reported in Bell et al. (2009). Error bars are 1 s.d. measurement errors. The right axis shows our calibration of these values to drinking water values, and the grey area represents the approximate range of drinking water values available in the British Isles..

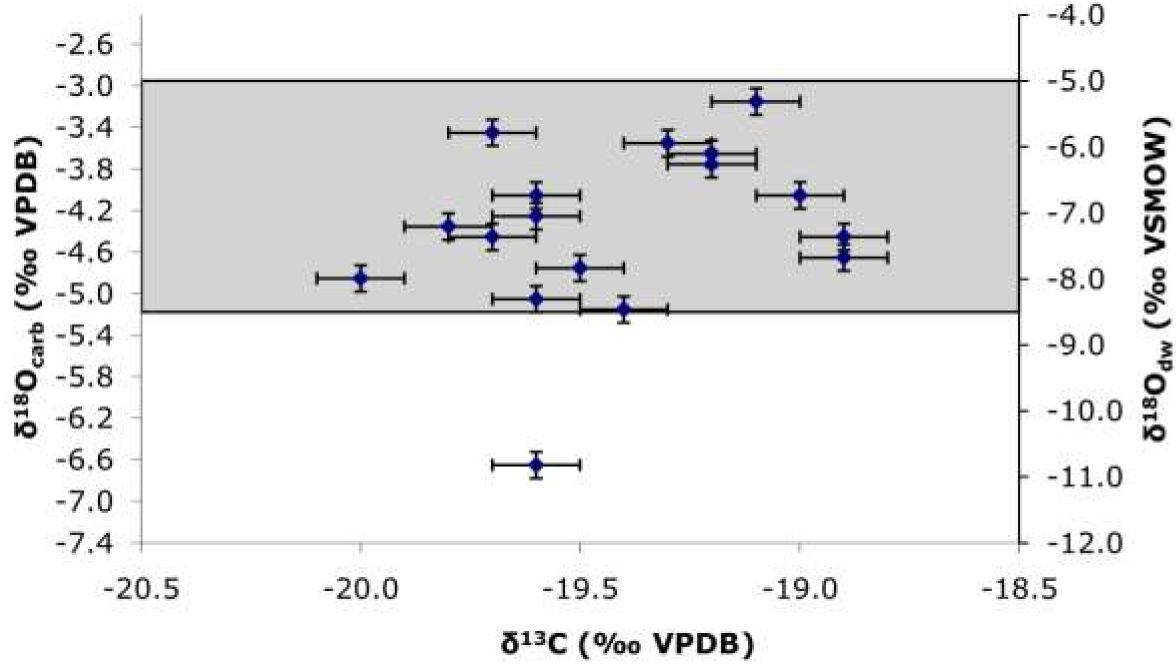

Figure 2: Oxygen isotope isopleth map of groundwaters in the British Isles in ‰ VSMOW (Darling, 2004) with the sample locations of Bell et al. (2006) approximately indicated. One sample from “Channel Islands etc.” has been omitted, as “etc.” makes the location vague.