

Biogeosciences Discuss., referee comment RC1  
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## Comment on bg-2022-10

Anonymous Referee #1

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Referee comment on "Intra-skeletal variability in phosphate oxygen isotope composition reveals regional heterothermies in marine vertebrates" by Nicolas Séon et al.,  
Biogeosciences Discuss., <https://doi.org/10.5194/bg-2022-10-RC1>, 2022

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### General Comments

This paper is welcome because it addresses a technique that has been used to estimate body temperatures of extinct animals from measurements of oxygen isotope in fossil bone and teeth. It recognises that temperature is not uniform throughout the body of aquatic vertebrates (and also terrestrial ones) and shows that isotope analysis of regional bones result in temperatures that are reasonably expected to occur in them. Two groups of extant aquatic species are chosen to represent marine mammals that show regional hypothermy in the limbs and endothermic fish that show regional endothermy by adaptively warming the red muscle, eyes and visceral organs. The results support the use of the method and are strikingly illustrated. The isotope analysis is done according to methods established in the authors' world-class laboratory. The sample sizes are adequate, carefully analysed statistically and interpreted thoughtfully. The writing is generally clear, well organised and extremely well referenced with relevant citations. There are only a few unusual expressions and typographical mistakes that may be rectified by proofreading by a native English writer.

The major problems of the paper involve (1) terminology and (2) use of references. There are suggestions below about terms that may better describe regional patterns of temperature throughout the body. Unfortunately, there appear to be several references that are not used appropriately. Classical references are fine for original ground-breaking research, but more recent papers are best for citing, because presumably they contain the foundational papers as well as recent developments. Some examples are given below.

### Specific comments (referenced to line numbers)

30-37 Some of the citations here and in the rest of the introduction are not very useful or even appropriate. For example, in referencing ectotherms, Rodbard (1953) is a short

popular article on 'warm-bloodedness', nearly 70 years old and poorly referenced. The Hight and Lowe (2007) one is more recent, but as it apparently speculates on whether elevated Tb in leopard sharks aggregating in shallow embayments is behavioural thermoregulation. Crawshaw and Hammel (1971) is about Antarctic fish. Norbert Smith's (1979) review of Tb in crocodylians has been long ago superseded (by, for example, G. Grigg and D. Kirshner 2015: *Biology and Evolution of Crocodylians*). Sherwin (2010) is a manual for animal husbandry and Allali et al. (2013) apparently concerns circadian clocks in camels, both not the best references for thermal physiology. The introduction would be better if no references were given for generally accepted facts than old specific references that provide little support for the points that the authors are making. Alternatively, more recent reviews on ectothermy and endothermy could be used, for example the Oxford Scholarship 'Ecological and Environmental Physiology Series'. The authors should carefully review the appropriateness and utility of all references in the paper, not only those in the introduction.

60-63 (also lines 234-235) Here it is essential to provide a citation or two for actual data for regional heterothermy in extant animals.

71-74 The groups of animals in the study are classified as either 'homeothermic endotherms' or 'poikilothermic endotherms'. Many would consider the first case misleading, because marine mammals are not wholly homeothermic, but regionally hypothermic, as the authors demonstrate. Also the second case of warm organs in fish seems like a contradiction in terms. 'Poikilotherm' meaning variable temperature is rarely used lately, and for good reason. For example, normal ectothermic fish living in the deep sea cannot be called poikilotherms because their body temperatures are constant. What is important here is that the mammals studied here have cool limbs and the fish have some warm organs. Therefore I would recommend redefining the groups in your study as two types of 'regional heterotherms'. 'Regional' is important to distinguish it from 'temporal heterotherms' which are endotherms that enter hibernation or torpor. In this study, the mammals allow the appendages to cool and the fish warm certain organs. This is simply defined and does not need special titles. You might label sections 4.2.1 'Marine mammals' and 4.2.2 'Endothermic fish'. In any case, avoid the term 'poikilotherm' and its variants.

144-9 Please explain in greater detail the possible reasons for the differences in predicted temperatures in teeth of fishes and mammals. One would expect that tuna teeth would form under cold conditions, because tuna respire by ram-ventilation in which the seawater constantly flows in and around their teeth. In contrast, marine mammals have closed mouths. Yet the temperatures derived from isotopes are the opposite to expectations. Also, please give a little more detail about remodelling of fish bone. I was not aware that this occurs (=do not know the citations), so please point out how it differs from the amniote paradigm involving secondary osteons.

225-231 This final section seems to undermine the whole approach by suggesting the basis for the technique is not up to date. Please clarify this section by evaluating how much the equations differ and what is the magnitude of the difference. Would the study be compromised in its conclusion?

## Technical corrections

35 Delete 'and thermolysis'. This word means breaking down tissue or cells with heat. It is not appropriate.

38 Instead of 'non-normothermic conditions is extremely...'; I suggest 'at ambient temperatures below the thermal-neutral zone can be...'.

44 Instead of 'thermometer reading' use 'thermometry'.

52 I think that both food and water would be taken in by both groups.

74 See notes above about the use of 'poikilothermic'.

141 Instead of 'results' use 'result'.

154 Use 'prey', which is the plural.

156 Can you provide some numbers for the bone variability to compare with 0.4 for water?

155 Use 'appendicular skeleton', not 'these skeletal regions'.

171 Use 'little', not 'few'.

177 This equation refers to temperature, but the preceding sentence refers to temperature differences. It is confusing.

188 Carey et al. (1984) indicate that heat in tunas is also produced in the viscera.

201 Use 'have' not 'has'.

210 and 215 Here and earlier reference is made to thermal imaging. I would remove this, because it is irrelevant in these cases.

449 Note subscript and superscript errors.

453 It is hard to see the stars. The red around the eyes is misleading, especially since the eye is warm, but apparently not measured in this study. If the ring could be white, it would not be confused with the red on the temperature scale.

461 Use 'equal', not 'equals'.

465 In the footnote to the table, use 'taken' not 'taking'.