

**Title:** Climatic Controls on Metabolic Constraints in the Ocean

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**Summary:**

This paper is quite interesting and logically organized. The motivating questions are made clear in the Introduction and the figures are appropriately used to tell the story. In general, the writing is quite clear outside of the Methods section, the last paragraph of the Discussion, and portions of the Conclusions paragraph. The authors will need to correct what seem to be multiple typos throughout the Methods section before this can be published, so I am **recommending minor revisions**. I also recommend that the authors consider adding a schematic to visually clarify relationships between key metrics of the paper. This would increase the accessibility of the paper significantly and serve as a valuable reference for the Discussion section, particularly when explaining some of the more complex impacts of oxygen and temperature changes on ectotherm habitability of high and low latitudes.

**Comments and Suggested Edits:**

Line 27: Typo. Signals → signal

Line 44: It may be valuable to incorporate the concept of higher oxygen demand, independent of oxygen supply or circulation changes.

Lines 109-110: Typo?  $B^\sigma$  is in the equation but you define  $B^\delta$

Line 117:  $E_0$  is undefined at this point, so this section of text is confusing.

Equation 1: The B term is missing, and this equation should be labeled equation 2. Even though the B term is ultimately dropped, it should be included for clarity, following Deutsch et al., 2020 equation 1.

Line 123: the  $E_S$  term was not included in the supply equation, should it be?

There are a lot of equations buried in the text – I would advise pulling them out and double checking all notations for consistency.

The text describing  $\Phi_{crit}$  is confusing. Is the goal to say that the minimum  $\Phi$  value found within the habitat domain of a given species, based on available data, reflects an empirical estimate of  $\Phi_{crit}$  value? If so, please state more clearly.

Line 139: This text is not clear. Please stick to one concept at a time. For example: “ $\Phi$  is derived by dividing  $\Phi$  by  $\Phi_{crit}$ , so when  $\Phi$  falls below 1, the organism can no longer sustain its active metabolic demand and will need to make physiological tradeoffs. Account for these active metabolic requirements, we use an adjusted definition of the hypoxic tolerance trait,  $A_c = A_o / \Phi_{crit}$ , where  $A_c$  is termed the “ecological hypoxia tolerance”, consistent with Howard et al., 2020.”

Line 161: It's not clear how this relationship yields cold tolerance, please elaborate, or reword for accuracy.

Figure 1b. It may help to clarify in the figure caption that below the  $pO_2$  lines shown, the organism would experience an oxygen deficit relative to its active metabolism requirements, effectively signifying the species-specific hypoxic conditions, based on physiological traits, for this range of temperatures.

Figure 2: Center the global map on the Pacific to make the transect location easier to see.

Figure 3: Add prime to  $\Phi$  color bars.

Line 347: Can you validate this hypothesis by looking at interannual variations in model density versus temperature or oxygen?

Figure 8 Caption: Note that the same decades for differencing apply to the top row of plots in addition to the bottom row.

Line 480: Is this a typo? Aren't high temperature regions mostly suited for organisms with high-temperature tolerance or reduced temperature sensitivity (Figure 2)?

Line 494: Should this say epipelagic and mesopelagic? This entire paragraph stands out as being particularly unclear relative to all other text (outside of the methods).

Line 498: Sentence starting with "At depth" could be reworded for clarity.

Line 500: By "distinct" do you mean correlations of opposite sign?

Line 509: It's not clear what is meant by "concomitant  $pO_2$ -temperature correlations in the forced trends". I assume this means trends of the same sign, but it would be ideal if this were clearly stated.

Line 516: Suggest changing to: "We here showed that, while warming is the primary mechanism driving climate change, the direct effect of warming on marine ecosystems is largely confined to the upper ocean."

Line 521: Suggest changing to: "We find that forced perturbations to  $pO_2$  and temperature will strongly exceed those associated with the natural system..."