Dear Associate Editor Peter Landschützer,

Thank you for supporting publication of our manuscript following minor revisions. Our point-by-point responses to each reviewer are collated below. Additionally, we have updated supporting information Table S1 and Figures S1 by substituting the pH and $[H^+]$ trends determined from Bates et al. (2014) with those determined from Dore et al. (2014) as the latter publication provided the mean $[H^+]$ conditions.

Sincerely,

Authors

Reviewer #1

Thank you for providing constructive feedback on the manuscript. Below we address each comment from your review.

1. In this technical note, we cannot address all problems associated with interpreting pH changes. The manuscript is focused entirely on the common problem of misinterpreting or misrepresenting the meaning of pH changes, i.e., that a pH change represents a relative rather than an absolute change in $[H^+]$. Addressing other problems would lengthen the paper and divert the reader from this sole objective. Furthermore, on the *Biogeosciences* page that describes manuscript types, it states that Technical Notes "should be short (a few pages only)". Thus, adding other concerns, such as this analytical issue, is not feasible.

2. We agree that biological responses to ocean acidification are complex and require consideration of the full seawater chemistry, not just pH. However, we think this topic extends beyond the article scope. Additionally, unlike for all other carbonate system variables whose changes are absolute, the logarithmic scale of pH means that its changes are equivalent to relative changes in $[H^+]$. We chose to emphasize this.

3. We have deleted this sentence.

4. In response to this comment, and feedback from a voluntary reviewer regarding the coastal ocean analogue to our open ocean examples, we have added a sentence near Line 114:

   Yet, at another Equatorial Pacific site (0 °N, 155 °W; Sutton et al., 2014), there is a similar $[H^+]$ trend to that of the Irminger Sea site because the initial pH differs. **While we focus here on pH changes in the open ocean, pH changes also occur in coastal waters where they tend to be larger (Carstensen and Duarte, 2019).** Recognizing that a change in pH represents a relative change in $[H^+]$, **regardless of location**, and examining long-term trends in both parameters should improve interpretation of chemical changes across ocean domains.

Reviewer #2

Thank you for supporting publication of the manuscript and for providing constructive feedback.

Below we address each comment from your review in order of appearance.

The manuscript was submitted as a Technical Note rather than a Research Article because the concepts and content are not original. Instead, the manuscript explains an important aspect of pH change analysis and interpretation that is relevant to how the oceanographic community conceptualized ocean acidification. By providing concise explanations and clear illustrations of the key concept, the message can be delivered in a short, accessible format that is more likely to be read, leading to broader implementation of the recommendations.

We deleted the sentence on line 477 as it was unnecessary and potentially confusing.

The Figure 3 caption has been updated (**bold text**) as follows:
Shown are the decadal changes in (**b**) A-pH and (e) A-[H^+] (nmol kg^{-1}) relative to the 1950s as well as the surface ocean (**c**) pH and (**f**) [H^+] (nmol kg^{-1}) **monthly anomalies relative to the annual mean** at KEO and DPN during the 1950s (thin lines) and 2090s (thick lines). Global maps show the total change in (**g**) A-pH and (**h**) A-[H^+] (nmol kg^{-1}) between the 1950s and 2090s.

Referee #1 found the extensive referencing useful in guiding the reader to additional resources on related topics. Ocean pH changes are studied across a broad range of space and time scales and within numerous oceanographic subdisciplines. Each discipline contributes a unique perspective and applies different research tools. In effort to make the article relevant to a range of oceanographers considering pH changes, examples from different subdisciplines were used (i.e., work involving time-series, autonomous sensors, numerical modeling, and hydrography), requiring extensive citation of prior literature. Still, we have made an effort to reduce the total number of citations as well as redundant citation appearances throughout the text – shortening the reference list by 1.5 pages.

Stephen Gonski

Thank you for your interest in the manuscript and for providing constructive feedback.

Below we address each comment from your review in order of appearance.

We agree that challenges associated with merging ocean pH observations remain a barrier to creating accurate, long-term pH records. The difficulties result from the problems inherent in clarifying the likely uncertainties in pH measurements made by different individuals at different times or places and are exacerbated by changes in measurement technique and/or calibration approach (pH scale) between research groups. However, we do not think this short Technical Note is the ideal place in which to address such complex challenges. On Line 43 we note that pH

is presented on the total hydrogen ion scale throughout the article and thereafter focus on issues associated with the presentation and interpretation of pH change data that are already on a common pH scale.

Thank you for bringing the Carstensen and Duarte, 2019 publication to our attention. We have elected not to add a fourth, coastal example to the manuscript, as pH changes will always represent relative changes in $[H^+]$ no matter the location. We also feel that lengthening the manuscript and providing more than one example for any of the three cases presented would make it less accessible. Finally, on the *Biogeosciences* page that describes manuscript types, it states that Technical Notes "should be short (a few pages only)". However, we agree that the difference in open ocean and coastal pH trend magnitudes is interesting and worth pointing out in the context of the article. Thus, we have added the following, bolded sentence:

Line 114: Yet, at another Equatorial Pacific site (0 °N, 155 °W; Sutton et al., 2014), there is a similar $[H^+]$ trend to that of the Irminger Sea site because the initial pH differs. **While we focus here on pH changes in the open ocean, pH changes also occur in coastal waters where they tend to be larger (Carstensen and Duarte, 2019).** Recognizing that a change in pH represents a relative change in $[H^+]$, **regardless of location**, and examining long-term trends in both parameters should improve interpretation of chemical changes across ocean domains.

While pH is a useful notation for displaying wide ranges in $[H^+]$, hydrogen is the chemical element that organisms interact with in the environment. We think this is self-evident and haven't provided further comment on the matter as it would distract from the main point.

We agree that the comparison of proton concentration and saturation state changes with depth is useful in practice, but in this case would distract from the key point of the article.

We agree that proton budgets are useful for quantifying process contributions to local acidification. However, this topic lies outside the scope of the article and would distract from the main point.