Response to Reviewer #2.

We would like to thank Reviewer #2 for their thorough and insightful comments, which have significantly helped improve the clarity and accuracy of our manuscript. Below, we provide detailed responses to each of the points raised:

Dear Authors,

This study entitled "Long-term variations of pH in coastal waters along the Korean Peninsula" uses data (including temperature, salinity, pH, and DO) collected by a government agency in Korea from 2010-2020. Long-term data is rare. The authors suggest that coastal biological effects are more important than increasing atmospheric CO2. The data quality is not described in this study. The application of linear regression can be improved. The discussion on biogeochemical processes involving pH should be reevaluated. The major comments are as follows.

➔ Our study concentrated on regions within a 5 km proximity to the shore, where the majority of sea-based economic activities take place. This investigation establishes a baseline for pH and other key parameters, as these nearshore coastal waters had not been thoroughly examined in prior research. The methodologies for data acquisition, sample collection, and parameter calibration are comprehensively detailed in the Methods and Materials section. In the revised version, we have included the results of the statistical analysis.

1. Though the pH probe itself can reach a higher resolution, the resolution of these three pH buffers is unclear. Therefore, the uncertainty for this long-term trend of pH is unclear. Data QA and QC are unclear. What is the standard deviation for these average numbers? Moreover, oceanographers usually use the spectrophotometric method to measure pH or pH calculated by total alkalinity and dissolved inorganic carbon to study long-term pH changes. The pH value measured by a probe can be affected by its salinity. As the salinity varied in the surface water, the effect of salinity changes on this probed pH may also involve the pH changes.

If we understand the comments correctly:

⇨ The revised version will include a table describing the basic features of the data.

We have provided the entire raw and averaged data sets in Supplementary Figures 1-6, which display deviations from the average. The pH probe was calibrated at three points using buffers with pH values of 4, 7, and 10, all of which exhibit acceptable variation with temperature. Calibration was performed daily, and the pH probe has an accuracy of ±0.002. Based on these factors, our pH data set is suitable for scientific analysis. While the spectrophotometric method offers better accuracy and precision, it is not cost-effective. Portable pH measurement devices, as used in long-term studies (e.g., Ishizu et al., 2019), provide a practical alternative. Salinity can serve as a proxy for alkalinity (with lower salinity indicating lower alkalinity) and thus may relate to pH variation. However, salinity itself does not directly affect pH measurement.

2. The analysis method. There are already many new methods that can analyze multiple parameters. The authors only use linear regression. The authors can try to use a better method that can systematically analyze several variables at the same time, such as principle component analysis or similar statistic methods.

➔ Thank you for the suggestions. The revised version will include an analysis of statistical techniques. Principle component analysis (PCA) was conducted in this study. However, the values of Kaiser-Meyer-Olkin Measure of Sampling Adequacy were < 0.5 for all depths and locations, suggesting that the PCA application is not adequate.

3. The definition of pH should be listed here as this study tries to describe the change in pH. Furthermore, why should pH be linearly correlated with other parameters? How and why is pH correlated to DO? Can the authors list the chemical equations to show that they are linear?

➔ pH measures the concentration of [H^+], which can be influenced both directly and indirectly. Directly, pH is affected by CO2 introduction (assuming no buffering effects) through the chemical reactions (see, Introduction). Indirectly, pH can be influenced by various environmental factors such as temperature, salinity, and primary production (see, Dickson, 2010). Low DO levels indicate oxygen consumption, which leads to CO2 production. This increase in CO2 decreases pH.

4. The effect of mixing between freshwater and sea (salinity gradient) on pH variation is

non-linear.

- ⇨ In general, the influence of salinity on pH (or alkalinity) is limited under conditions where salinity is less than 20 (Carstensen and Duarte, 2019). Most of our study sites exhibited salinity levels greater than 23, indicating sufficient alkalinity to buffer pH changes.

5. The authors separated their data into the surface and bottom water in this study. However, the authors did not separate their discussion. In Cai et al. (2011), synergistic acidification is for bottom water. Surface water in the coastal region has been known as a high-productivity region with a high pH value. Is it possible that, though the authors used a long-term dataset, the resolution of the sensor and their standard variation, as well as the analysis method, is not sensitive enough to quantify the effect of acidification?

- ➔ We discussed surface and bottom waters separately where relevant, but we also addressed both simultaneously when applicable. For example, temperature did not correlate well with pH in either surface or bottom waters. However, when discussing DO, we focused on bottom waters, following the approach of Cai et al. (2011). If measurements are consistent in terms of location and technique over an extended period, they can reveal trends. We investigated long-term pH trends in coastal waters because the annual variation in pH is minimal (e.g., -0.0019 per year over 20 years as observed in HOT).

6. The grammar should be thoroughly checked.

- ⇨ Thanks for the comments.