A 1500-year diatom-based summer temperature reconstruction from Beppu Bay, southwest Japan

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A 1500-year record of fish scale abundance from Beppu Bay revealed centennial or millennial scale variability of anchovy and sardine abundance in the Japanese coastal ocean. Comparison between the records of fish abundance (anchovy or sardine) in Japanese coastal seas and in the seas off California showed close link but coherent or anti-phase patterns between them. The link of the fish abundance between eastern and western margins of the North Pacific suggested an existence of a basin-wide climate-marine ecosystem regime shifts on centennial timescale. Although the long-term climate variability of the North Pacific would be vital for precise predictions of climate and marine ecosystem changes, it is still not well-described.

A weighted averaging (WA), or weighted averaging partial least squares (WA-PLS) regression method have been widely used as a powerful tool for climate reconstructions for the last few decades. Although the reconstructions using the methods have been well-documented on diatom assemblages in the lakes and their sediments, it is possible that the methods are also able to be applied in anoxic marine sediments with well-preserved diatom fossils like those of Beppu Bay in Japan. Using this method, we have attempted to reconstruct air temperature for the last 1500 years from the Beppu Bay sediments.

In order to detect most influential environmental variables in determining the distribution of fossil diatom taxa, we performed redundancy analysis (RDA) and canonical correspondence analysis (CCA) using the relative abundance of sedimentary diatom species and observed meteorological and sea level data. Since the age model of the core sample have increasing errors toward the past, 5-year running means of diatom assemblages and observed environmental variable data were employed for the analyses. As a result, an environmental variable which was most attributed to the axes of RDA and CCA component 1 was mean summer temperature (May to October). For a regression model in this study, a two-component WA-PLS model was selected on the basis of the low root mean square error of prediction (RMSEP = 0.19 degrees C) and high coefficient of determination (r2= 0.87) between observed and predicted values of summer temperature. Reconstructed temperature followed the increasing trend of air temperature and the decadal-scale variability in the observed record, supporting the validity of our regression model for the reconstruction. Sensitivity of the Beppu Bay diatom community to summer temperature might reflect the sensitive responses to light conditions or nutrient availability which are related to thermal structures in the water column through strength or duration of stratification influenced by summer temperatures.

The reconstructed record for the last 1500 years showed the range of 21 to 23 degrees C; highest temperature occurred after the late 1980's. The values during this interval were 0.5-0.9 degrees C higher than those during some high temperature stages before 1980AD. The 100-year scale variability of summer temperature was also found in the record.