# Latitudinal gradient of Middle to Late Holocene sea surface temperatures recorded in fossil giant clam (*Tridacna gigas*) shells from Ryukyu Islands

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The Holocene, the most recent geological period from 11.7 ka to modern, is characterized by relatively warm and stable climatic conditions compared to the glacial periods and has experienced several remarkable climatic events (e.g., Holocene climate optimum, 4.2 ka event, Greek minimum, Dark age cold period). However, due to the nonlinear nature of the climate system, climate changes generally cause various regional/local variations, making it difficult to obtain a complete image of any climatic event. Thus, more paleoclimatic records must be collected from many sites over the globe.
Biogenic carbonates such as bivalve shells, corals, foraminifers, and brachiopods have been widely used to reconstruct past marine environments (e.g., sea surface temperature, salinity, pH). Giant clam (subfamily Tridacninae) shells are recently considered useful as a paleoclimate proxy of tropical-subtropical ocean regions in line with corals. The oxygen isotope composition ($\delta^{18}O$) of giant clam shells can be used to reconstruct past SST of the growth sites at high resolution because of their high shell growth rates and aragonite precipitation under oxygen isotopic equilibrium with ambient seawater.
We measured $\delta^{18}O$ and $\delta^{13}C$ values of five fossil giant clam (*Tridacna gigas*) shells dated at ca. 6.0–5.0 ka and 3.0 ka collected from Ryukyu Islands (Yoron Jima at 27.0˚N latitude, Irabu Jima at 24.8˚N, Ishigaki Jima at 24.3˚N, and Kohama Jima at 24.3˚N), southwestern Japan. Based on the $\delta^{18}O$-SST relationship established from modern tridacnine shells from the Ryukyu Islands, we estimated monthly-to-seasonal resolved SSTs in these islands during the Middle to Late Holocene. Then, based on our results and reconstructed SSTs using fossil corals (*Porites spp.*) collected from the Ryukyu Islands, we interpreted paleoclimate variations around this region during the Middle to Late Holocene.
Firstly, the spectral analysis showed seasonal and interannual components from all the $\delta^{18}O$ and $\delta^{13}C$ time series; the latter likely corresponds to the El Niño/Southern Oscillation. Then, our results and compiled records showed SST variations were almost the same relative to the present from 7 ka to 6 ka. From 6 ka to 5 ka, reduced SST seasonal fluctuations were observed from our data. More significant summer SST reduction (~1.6˚C) than winter (~1.1˚C) during this period can be explained by the weakening of the East Asian Summer Monsoon. However, considering some sediment records of the Okinawa Trough and Yangtze delta indicating stable SST variations from 6 ka to 5 ka, the declining SST trend was considered a mild transition.
Furthermore, the coral SST record at 5 ka showed greater SST seasonality and higher summer SST. Factors responsible for the significant differences between coral- and tridacnine-based SSTs include:

1. Local SST differences within the same habitat.
2. The accuracy of thermometers ($\delta^{18}O$-SST, Sr/Ca-SST).
3. Problems inherent in the applied thermometers.

Finally, from 4 ka to 3 ka, during which cool and arid conditions were globally dominant, the giant clam shells dated at 3.0 ka showed significantly high SSTs (especially in winter) and slight seasonality

 

compared to coral-based SST estimation. Because simple SST interpretation needs unrealistic marine environment change, we concluded more stable SST fluctuations from 4 ka to 3 ka around the Ryukyu Islands.
Our results indicate a milder marine environment around the Ryukyu Islands during the Middle to Late Holocene than previously reported. In addition, reconstructed SSTs from tridacna shells and corals may raise a problem related to SST estimation using different types of proxy and thermometry.

Keywords: Tridacna shell, oxygen isotope, carbon isotope, Holocene, Ryukyu Islands

 