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δ^{18}O seawater-sea surface salinity relationship for northern coastal Papua New Guinea: Calibration and applications in coral paleoclimatology

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Sea surface salinity (SSS) in the tropical western Pacific generally co-varies with sea surface temperature (SST) and El Niño-Southern Oscillation (ENSO) cycles, and is an important variable in this highly coupled system. However with limited instrumental SSS data from the western tropical Pacific, extending our knowledge of SSS prior to the instrumental period has become an imperative for understanding ENSO dynamics. In recent years the use of sub-annual scale coral proxy data has emerged as a possible tool for reconstructing and extending records of SSS.

The oxygen isotope ratio (ratio of ^{18}O to ^{16}O, δ^{18}O), routinely measured in coral skeletal samples, reflects SST and the oxygen isotope ratio of seawater ($\delta^{18}O_w$), in varying proportions dependent on the oceanographic setting. If the SST effect is removed then $\delta^{18}O_w$ remains and this can be used as a proxy for SSS, as both $\delta^{18}O_w$ and SSS vary with the surface ocean balance between precipitation and evaporation. When $\delta^{18}O_w$ is derived from coral samples it is termed the oxygen isotope residual ($\Delta\delta^{18}$O). However, the $\Delta\delta^{18}$O is generally used only as a qualitative indicator of SSS changes.

In order to quantify the $\Delta\delta^{18}$O-SSS relationship seawater samples from Blup Blup, Koil and Muschu Islands, Papua New Guinea (PNG), were measured for both δ^{18}O and salinity. The δ^{18}O and salinity in the water samples were found to co-vary, and the data was then used to construct the $\delta^{18}O_w$-SSS calibration for the northern coastal Papua New Guinea region. The $\delta^{18}O_w$-SSS slope is remarkably similar to that found for two other $\delta^{18}O_w$-SSS calibrations from the tropical Pacific. Since coral $\Delta\delta^{18}$O is

a measure of $\delta^{18}O_w$ the $\delta^{18}O_w$-SSS calibration equation can be used to reconstruct SSS from $\Delta\delta^{18}O$.

The $\Delta\delta^{18}O$-SSS calibration was applied to a modern Muschu Island coral to explore the precipitation-evaporation balance of the northern coastal PNG region. The coral was analysed at seasonal resolution for $\delta^{18}O$ for 1991-1997. IGOSS (satellite) SST was used to remove the SST component from the coral $\delta^{18}O$ record, leaving $\Delta\delta^{18}O$. $\Delta\delta^{18}O$ variability was the dominant influence on the Muschu coral $\delta^{18}O$. Using the $\Delta\delta^{18}O$-SSS calibration the mean coral-derived SSS was $\sim$33psu for 1991-1997, reflecting the generally fresher western equatorial Pacific waters around PNG and freshwater inputs from the nearby Sepik River. Seasonal SSS minima reflect the seasonal rainfall precipitation maximum. SSS maxima occurred in January and were especially strong during El Niño years. These results suggest that it is possible to obtain meaningful SSS records for investigating SSS variability in recent times and, with large changes in SSS inferred from foraminifera geochemistry for the mid-Holocene western equatorial Pacific, the $\delta^{18}O_w$-SSS calibration may provide a basis to quantify SSS in mid-Holocene fossil corals.