Evidence for Changes in Large-Scale Upwelling in the California Current over the Past 700 Years

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Abstract

Bidecadal radiocarbon measurements on tree rings provide a detailed series of ^{14}C activities at isotopic equilibrium with atmospheric CO_2. This terrestrial series reflects the variable production of ^{14}C in the atmosphere, resulting from variability in cosmic-ray flux, and is used for calibration of the atmospheric ^{14}C ages to dendrochronological ages. The ^{14}C ages of oceanic materials are subject to an additional complication. This is because oceanic radiocarbon ages depend not only on simple exchange with the atmosphere but also on regional variations induced by ocean circulation related to climate change. Most marine environments do not permit development of a comparable series of ^{14}C ages with which to compare the terrestrial tree ring series. However, we have recently begun work on such a series using material from the varved sediments of the Santa Barbara Basin off southern California. We are dating samples of the pelagic pteropod *Limacina helicina*, which lives in the upper 100 meters of the water column and which is sufficiently abundant in these sediments to provide material for AMS dating of intervals as short as 5 years. The varve chronology, although still not perfectly accurate, permits age calibration to within 10 years. We now have a nearly continuous record of ^{14}C dates representing the age of the water over the upper 100 meters. This record now extends from AD 1260 to 1900 and is resolved into intervals that vary from 5 to 20 years. The time series of ocean-terrestrial age differences (the regional ocean-reservoir ages) of contemporaneous samples exhibits variability over centennial time scales that cannot be explained by a constant rate of ventilation of deeper waters. The relative age of the water was oldest at about AD 1450. The ocean reservoir ages show an increase prior to 1450 and a progressive decrease with time after 1450. Although there may be other explanations, we believe this trend is principally the result of changes in large-scale upwelling of water from below 500 meters. These changes were probably also associated with changes in the intensity of the California Current. If this is true, the large-scale upwelling along the eastern boundary of the North Pacific gyre during the past millennium appears to have been at its most intense around AD 1450. The period between 1450 and 1900 appears to have experienced a long-term decrease in pumping of deeper/older water toward the surface.

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