Carbon isotopic composition of wetlands sediments as indicator of salinity and vegetation change in brackish marshes

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The stable carbon isotope ratio ($^{13}C/^{12}C$) of marsh sediments has been developed as a proxy for salinity change in Northern California wetlands sediments. Marshes with elevated salinity favour plant species which use the C_4 photosynthetic pathway, for example, *Distichlis spicata* and *Spartina foliosa.* Many C_4 plants are adapted to drought and, by analogy, to high-salinity conditions. Another important species in the saltmarshes is *Salicornia virginica.*, which uses the CAM photosynthetic pathway. In freshwater marshes, C_3 plants, such as *Scirpus.*, *Typha.*, *Phragmites*, and *Juncus*, are dominant.

C_4 plants have substantially higher $\delta^{13}C$ values (~ −14‰) than C_3 plants (~ −29‰), due to fractionation during carbon fixation within the plant leaf (Smith and Epstein, 1970; O'Leary, M.H., 1981). *Salicornia* has a $\delta^{13}C$ value of about −26‰ (similar to C_3). If the carbon isotopic composition of marsh vegetation is preserved in soil organic matter, the $\delta^{13}C$ value of marsh sediments can serve as a proxy for past vegetation composition (Delaune, 1986; Chmura and Aharon, 1995). In this study, we use the $\delta^{13}C$ values of sedimentary organic carbon, in addition to the pollen composition, to evaluate changes in marsh vegetation, and hence salinity, over time.

Collection of modern sediments from marshes in San Francisco Bay along a salinity gradient allowed the calibration of $\delta\ ^{13}C$ in the sediments and salinity. We further showed that the $\delta\ ^{13}C$ values of *Salicoria*, a CAM plant, vary with salinity between about −24‰ and −28‰ (with higher values occuring at higher salinity).

Sediments were cored from Rush Ranch Marsh in the northern part of the San Francisco Estuary to reconstruct changes in vegetation and environmental conditions during the late Holocene. The Rush Ranch carbon isotope record shows an increase in $\delta^{13}C$ of 11‰ between 45 cm and the top of the core (Fig. 1). This indicates a shift towards more salt-tolerant C_4 species during the last ~ 100 years. The pollen record from the same core also indicates increased salinity during this time period. The most likely cause of the salinity change has been upstream storage and water diversion within the Sacramento–San Joaquin watershed. However reduced rainfall and freshwater inflow to the estuary was also a factor.

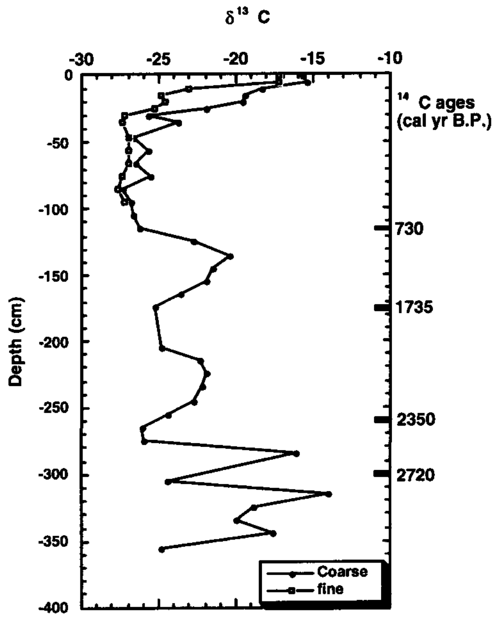

FIG. 1. $\delta^{13}C$ values of sedimentary organic carbon from San Francisco Bay marsh sediments, plotted against depth. Calibrated radiocarbon ages on seeds is shown on the right-hand column.

Two earlier periods of increased $\delta\ ^{13}C$ (by 5 to 7‰) indicate increased salinity at Rush Ranch 3000 cal yr B.P. to 2500 cal yr B.P. and 1750 cal yr B.P. to 750 cal yr B.P. These dry periods are coincident with two periods of drought in the western United States, recorded by lake level records, tree-stumps, treering records, and other palaeoclimate records (Stine, 1994). Previous coring of estuarine sediments in the bay showed a major hiatus which occurred during the period from about 700 to 1800 cal yr. B.P., coincident with the younger dry period (Ingram *et al.*, 1996). Our isotope record suggests that fresh-water inflow to the bay was reduced enough to cause a significant shift in marsh vegetation in San Francisco Bay.

References

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