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$\delta^{13}C$ Signature of organic carbon in estuarine bottom sediment as an indicator of carbon export from adjacent marshes

R.D. DeLAUNE[1] & C.W. LINDAU[2]
[1]Laboratory for Wetland Soils and Sediments, Center for Wetland Resources; [2]Nuclear Science Center, Louisiana State University, Baton Rouge, LA 70803-7511, USA

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Abstract. The $\delta^{13}C$ signature of organic carbon in estuarine bottom sediment in Louisiana Barataria Basin was used for estimating carbon flux from adjacent marsh. The stable carbon isotope composition of plants, soils and sediments from the basin were determined. The $\delta^{13}C$ content of marsh vegetation ranged from −26.3 to −27.8‰ for C_3 freshwater vegetation in the upper basin to −13.0 to −13.3‰ for C_4 vegetation in the lower basin. The $\delta^{13}C$ content of the highly organic marsh soils were similar to $\delta^{13}C$ content of vegetation present. The $\delta^{13}C$ content of organic carbon from bottom sediment of open water bodies ranged from 27.3 in the upper basin (freshwater) to 16.4 in bottom sediment of salt marsh ponds. The ^{13}C signature of organic carbon in bottom sediment from saline regions corresponded to the size of the body of water. The smaller salt marsh ponds contain sediment with $\delta^{13}C$ values close to that of the C_4 plant *Spartina alterniflora*. Results suggest that phytoplankton rather than *Spartina alterniflora* is the likely organic source in bottom sediment of the larger bay near the coast (e.g. Caminada Bay).

Introduction

Stable carbon ratios can provide information on the origin of organic carbon in coastal wetlands. The stable carbon isotopic ratio in marine sediment depends largely on the relative contribution of terrestrial versus marine sources of carbon. Previous studies have used stable carbon isotope composition of organic material for determining carbon transformation and exchange in the marine environment (Haines 1975; Torgersen & Chivas 1985). Most $\delta^{13}C$ studies of estuarine have attempted to trace transport of terrestrial material to nearshore waters.

Carbon isotopic measurements have been reported to be of limited value for deciphering the complex carbon flows that occur in estuaries (Fry & Sherr 1984). Most studies using stable carbon isotopes for estimating carbon export in estuaries have used only the $\delta^{13}C$ signature of organic material in the water column. To date there have been limited studies of $\delta^{13}C$ signature

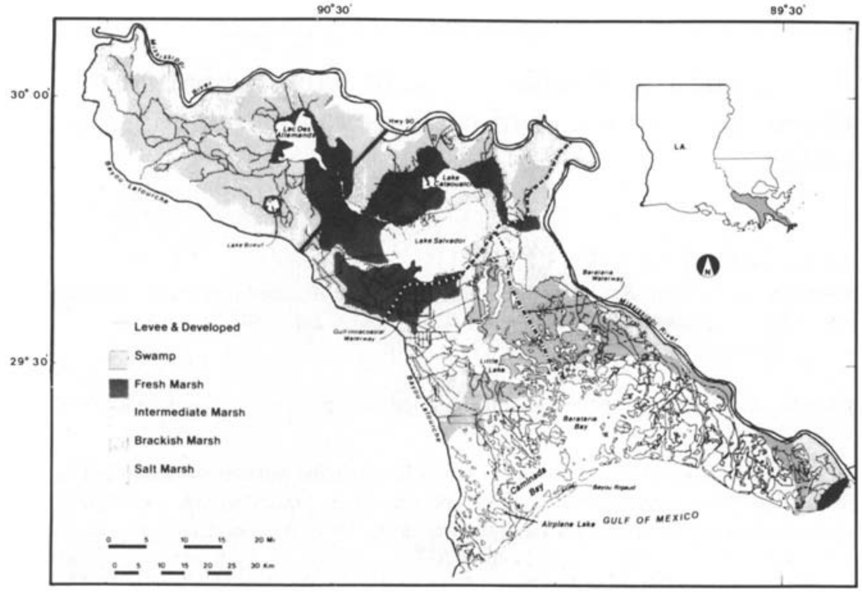

Fig. 1. Barataria Basin showing sites at which samples were taken (modified from Day et al. 1982).

of bottom sediment of water bodies in coastal estuaries for estimating carbon transport from adjacent marshes.

Vascular plants segregate into two groups in relation to their $\delta^{13}C$ composition. Plants with C-3 pathway of photosynthesis have low $\delta^{13}C$ values, whereas C-4 plants are enriched in ^{13}C. Algae are reported to have intermediate $\delta^{13}C$ values (Haines 1976). Terrestrial organic matter (C-3 plants) is depleted in ^{13}C relative to either marine plankton or *Spartina alterniflora* (Fortugne & Duplessy 1986).

Louisiana Barataria Basin has a distinct zonation of salt marsh species, brackish marsh species and freshwater marsh species (Bahr & Hebrard 1976). Adjacent to which are open water bodies with corresponding salinity levels.

The purpose of the study was to
— determine the stable carbon isotope composition of vegetation along a salinity gradient extending inland from the coast in Louisiana Barataria Basin
— to determine the $\delta^{13}C$ signature of organic material found in bottom sediment of water bodies adjacent to individual marsh units and
— estimate the contribution of organic matter from marsh macrophyte to water bodies in Barataria Basin.

Table 1. Stable carbon isotope composition of marsh and soil vegetation.

	Marsh vegetation	$\delta^{13}C$	
Fresh marsh	(*Panicum hemitomon*)	−26.3	(soil −27.8)
Fresh marsh	(*Sagittaria falcatta*)	−27.8	(soil −26.6)
Intermediate	(*Spartina patens*)	−13.5	(soil −15.8)
Brackish	(*Spartina patens*)	−13.0	(soil −14.9)
Salt	(*Spartina alterniflora*)	−13.3	(soil −16.0)

Materials and methods

Vegetation and soil samples were collected from fresh, intermediate, brackish, and salt marshes of Barataria Basin (Fig. 1). Bottom sediment was collected from open water bodies along the same salinity gradient using a Peterson dredge. Vegetation representing individual plant species was collected from 5 sites at each location covering an area of approximately 1ha. The plant material was dried at 65 °C, ground, and subsamples were taken for stable carbon isotope analysis. Surface marsh soil samples were taken at 0–15 cm depth at approximately the same locations at which plant samples were taken from the individual marshes. Soil or sediment was composited, dried, and ground, and subsamples taken for stable carbon isotope analysis.

Carbon isotope analysis was performed with a double-collecting mass spectrometer on CO_2 from combusted plant or sediment samples. The sediment was pretreated with weak acid to remove any carbonate minerals. The $^{13}C/^{12}C$ ratio is expressed in parts per thousand (‰) relative to PDB standard.

Results and discussion

The $\delta^{13}C$ content of marsh vegetation ranged from −26.5 to −27.8 for C_3 freshwater vegetation in the upper basin and from −13.0 to −13.3 for C_4 vegetation in the lower basin (Table 1). The $\delta^{13}C$ content of the organic marsh soils were similar to $\delta^{13}C$ content of vegetation present. The $\delta^{13}C$ content of the marsh soils was about 2‰ depleted in ^{13}C compared to whole plant tissues, except for the *Sagittaria falcatta* marsh (Table 1). The lower $\delta^{13}C$ values may reflect the ^{13}C content of the plant lignin, a part of the plant resistant to decomposition. Research recently completed by Benner (personal communication, February 1987) has shown that the lignin component of selected vascular plants, including *Spartina alterniflora*, was depleted in ^{13}C compared to the whole tissue. Organic carbon in the bottom sediment from major open water bodies in Barataria Basin showed a down basin trend (freshwater to saltwater) of increasing $\delta^{13}C$ values from −27.3 in

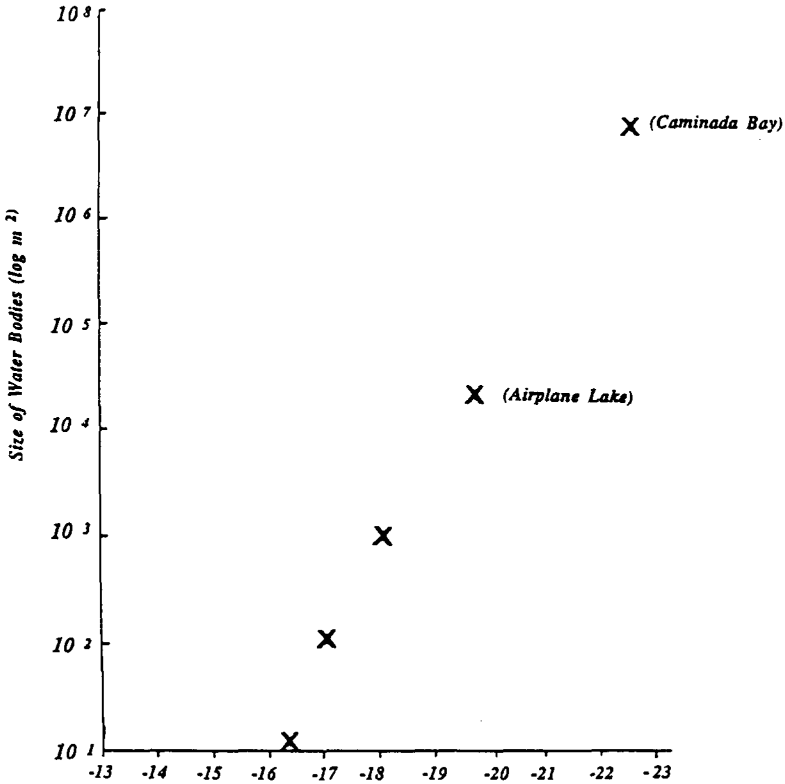

Fig. 2. Stable carbon isotope composition of organic matter in bottom sediment from saline water bodies of different surface areas.

freshwater bottom sediment of Lac des Allemands to −22.8 in saline bottom sediment in Caminada Bay. This suggests that there is not a distinct terrestrial origin of organic carbon from upper basin region collected in the bottom sediment of the large saline water bodies near the coast. Phytoplankton rather than *Spartina alterniflora* is the likely organic carbon source in the bottom sediment of the larger bays (Caminada) near the coast. Sherr (1982) also showed that *Spartina* carbon was an important component of organic matter in the intertidal sediments of a Georgia salt marsh estuary and was less important in subtidal sediments. A mixing of *Spartina alterniflora* and C-3 plant matter could also result in intermediate carbon isotopic ratios in the lower saline bottom sediments. Such a mixing of sources has been proposed by other researchers (Sherr 1982; Schwinghamer et al. 1983; Simenstad & Wissmar 1985).

There was some influence of organic carbon from marsh macrophytes on ^{13}C content of organic carbon in bottom sediment from the saline region of the basin. There was a linear relationship between size of waterbody and

Table 2. Stable carbon isotope composition of organic matter in bottom sediment.

Open water bottom sediment	$\delta^{13}C$
Lac des Allemands	−27.3
Lake Cataouatche	−26.9
Lake Salvador	−26.6
Little Lake	−26.1
Caminada Bay (1)	−22.7
Caminada Bay (2)	−22.8
Airplane Lake ($1.9 \times 10^5 m^2$)	−19.9
Salt marsh pond ($1000 m^2$)	−18.2
Salt marsh pond ($100 m^2$)	−17.1
Salt marsh pond ($10 m^2$)	−16.4

$\delta^{13}C$ signature of organic carbon in the bottom sediment (Fig. 2). *Spartina alterniflora* ($\delta^{13}C$ −13.3) is apparently contributing more organic material to the smaller lakes found within the salt marsh. Airplane Lake, a $1.9 \times 10^5 m^2$ lake whose drainage is derived completely from an adjacent *Spartina* salt marsh, contains sediment organic material nearer in isotopic composition to that of the C_4 plant *Spartina alterniflora* than Caminada Bay. Bottom sediment of interior marsh ponds had $\delta^{13}C$ values even closer to that of *Spartina alterniflora* plant material and may also be reflecting the $\delta^{13}C$ signature of *Spartina* lignin or other refractory humic material.

The result presented is supported by earlier studies of Feijtel et al. (1985) who, using a mass balance approach, determined that carbon export from marshes to adjacent water bodies decreased with distance from the coast, with greater export being from *Spartina alterniflora* salt marsh. This approach indicated limited export from fresh and intermediate marshes in the upper basin.

Due to $\delta^{13}C$ signature of C-3 marsh vegetation of fresh and intermediate marshes being similar to that of phytoplankton it was not possible in this study to determine the contribution of these marshes to the organic pool of adjacent water bodies. However, since there is less water exchange between marsh and water bodies in the interior fresh and intermediate marsh units, there is likely to be only a limited export of organic carbon to adjacent water bodies in these ecological units. There likely exists a relation between size of water bodies and contribution of marsh to the organic pool. But again, due to less water exchange it would be less than reported in this study for saline regions in the lower basin.

Results presented do not give the true contribution of organic carbon from marsh to the aquatic environment. There are isotope effects in many chemical, physical and biological processes which can alter carbon isotope abundance. However, the results presented, taking into account the possible limitations, demonstrate that organic carbon export from salt marshes is a major organic source to marsh ponds and organic matter contributions from *Spartina alterniflora* decrease with the size of water bodies or the distance from the marsh.

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