U.S. Department of the Interior
U.S. Geological Survey

Subsidence and Carbon Fluxes in the Sacramento/San Joaquin Delta, California

Subsidence Fact Sheet

INTRODUCTION

The Sacramento/San Joaquin Delta was once tidal marshland and was formed by the confluence of the Sacramento and the San Joaquin Rivers. The delta covers more than 1,000 square miles and is bordered by the major population centers of the San Francisco Bay area, Sacramento, and Stockton (fig. 1). The delta took its current form by the 1930's when drainage of 100 islands and tracts and construction of 2,250 miles of levees were completed.

The land surface on the delta islands has progressively subsided below sea level since the early 20th century. The integrity of the levee network is threatened because subsidence increases the differences in water levels maintained by the levees, which can cause levee failure and consequent flooding of the delta islands. Levee failure affects the quality and beneficial use of water in the delta, which is the major source of California's water supply to millions of residents and acres of agricultural land. This Fact Sheet briefly summarizes the research done by the U.S. Geological Survey, in cooperation with the California Department of Water Resources, to assess the causes of subsidence, processes that affect subsidence, and carbon fluxes in the delta.

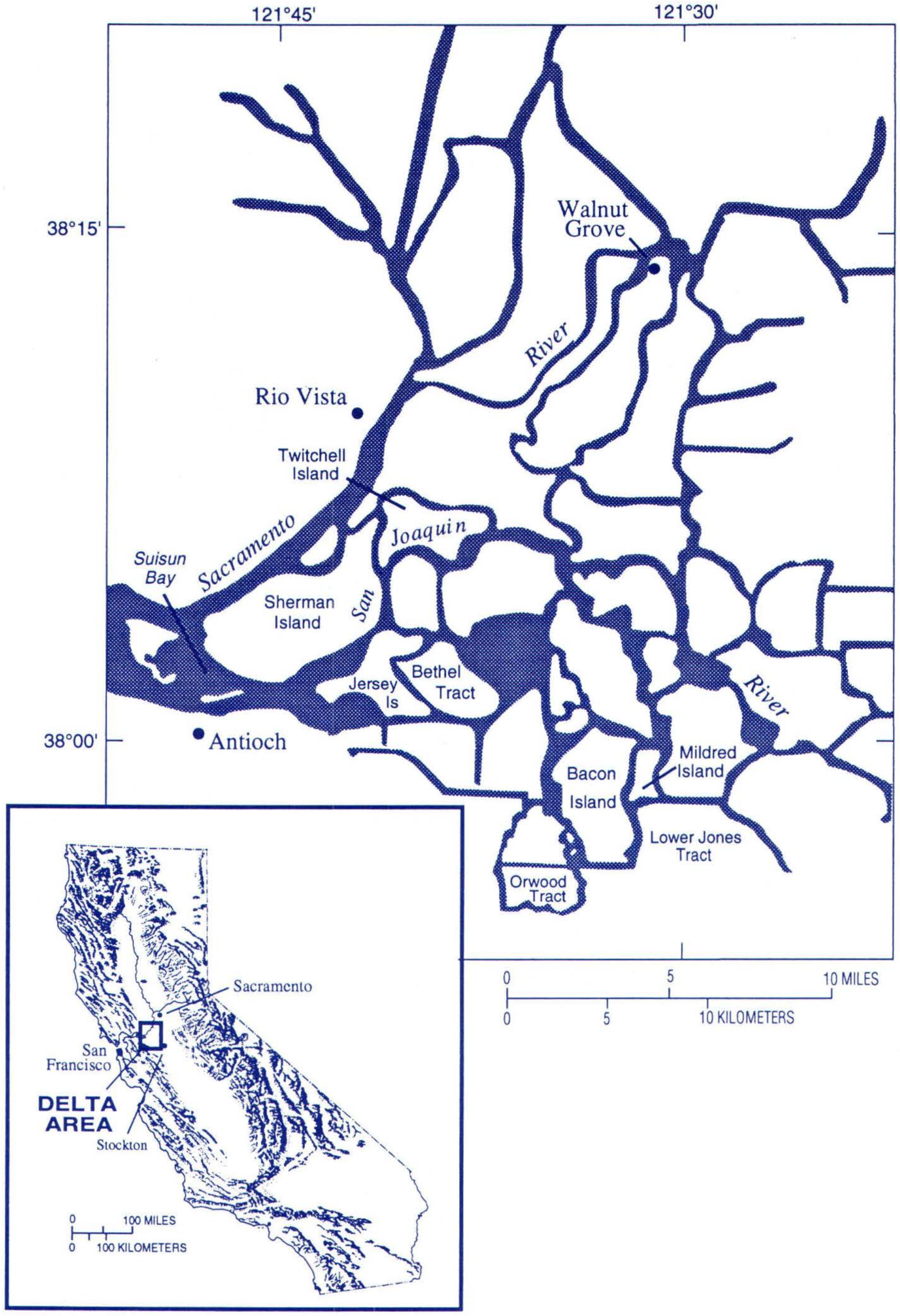

Figure 1. Location of study area and sites.

STUDY OBJECTIVE AND APPROACH

Results of the initial phase of the study demonstrated the small influence of withdrawals of ground water and natural gas on subsidence on the delta islands. Subsequent investigations were directed toward understanding variations of subsidence in space and time by assessing the historical leveling surveys and land surface elevation changes relative to exposure of electrical transmission tower foundations and by evaluating land-surface elevation changes in relation to carbon fluxes and changing water-management practices. Subsidence data were obtained from the historical leveling surveys done on Bacon Island, Mildred Island, Lower Jones Tract, and Sherman Island. The evaluation of carbon fluxes relative to subsidence is ongoing on Sherman Island, Jersey Island, and Orwood Tract. Land-surface elevation changes and carbon fluxes also are being evaluated for different flooding regimes as part of a proposed conversion of Twitchell Island wildlife habitat.

RELATION OF SUBSIDENCE TO ORGANIC-MATTER CONTENT AND CARBON FLUXES

Evaluation of historical subsidence data indicates that subsidence is slowing

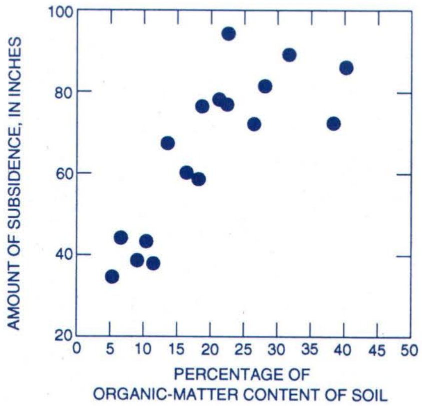

Figure 2. Relation of subsidence from 1910 to 1988 to organic-matter content of soil on Sherman Island.

over time and that areal variability of subsidence rates is related to the organic matter in the soil. Subsidence at the electrical transmission tower foundations from 1910 to 1988 correlates with organic-matter content of soil on Sherman Island (fig. 2); the relation explains about 70 percent of the areal variance in the amount of land subsidence during this 78-year period.

Land surfaces in the central delta (Mildred and Bacon Islands and Lower Jones Tract) have subsided an average of about 3 inches per year (in/yr) since 1921. Sherman Island in the western delta has subsided less than 1 in/yr since 1910. The higher subsidence rates on the central delta islands are the result of more organic matter in the soils than on western delta islands. Sherman Island and other western delta islands have been subject to more inundation and sediment deposition from the Sacramento and the San Joaquin Rivers, which result in less organic matter in the soils and lower subsidence rates relative to the central delta islands. The organic-matter content of surface soils in the central delta is about 50 percent compared with about 20 to 30 percent for the western delta.

Results of ongoing research indicate that subsidence in the delta is caused primarily by the oxidation of peat to carbon dioxide (CO_2). The peat is a complex mass of carbon; microorganisms utilize it as an energy source and release CO_2. The CO_2 fluxes measured on Jersey and Sherman Islands and on Orwood Tract since April 1990 are related primarily to soil temperature. For example, the CO_2 flux at five

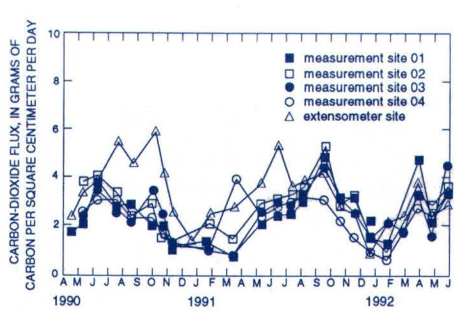

Figure 3. Carbon-dioxide fluxes measured at Orwood Tract sites, April 1990 to June 1992.

sites within a 20-acre field on Orwood Tract is shown in figure 3. Temperature effects account for the high fluxes from late spring to and early autumn.

Differences in moisture content and spatial variability in the organic-matter content and thickness of the peat account for most of the variability in CO_2 fluxes among the sites. CO_2 fluxes are normally highest under low moisture contents. Because thicker peats have more carbon available for microorganisms to utilize, more CO_2 is released. The peat at the extensometer site on the Orwood Tract is thicker than that at the other sites and usually drier; therefore, CO_2 fluxes are usually the highest at that site. More than 30 pounds of carbon per day in the form of CO_2 flows out from an acre of drained peat soil in the delta.

Subsidence was measured with an extensometer and calculated from CO_2-flux measurements. The extensometer measures changes in land-surface elevation of the peat layer relative to the underlying mineral layer. Decreases in land-surface elevation are due to carbon loss (oxidation of peat) and declining water levels from

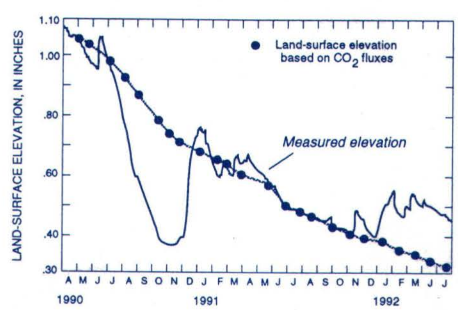

Figure 4. Land-surface elevation measured and calculated from carbon-dioxide fluxes on the Orwood Tract.

spring to early autumn. Increases in land surface elevation during the winter months are due to rising ground-water levels because the peat soils are buoyant. The net land-surface elevation loss of about 0.3 in/yr, which occurred during the length of record, generally agrees with the subsidence calculated from the loss of CO_2 (fig. 4).

STUDY FINDINGS AND WATER MANAGEMENT CHANGES

Water- and land-management practices and environmental factors influence carbon mass balances and determine whether land surfaces of the delta islands will accrete or subside. Water- and land-management practices include irrigation and drainage and other agricultural practices. Environmental factors include the chemical composition of waters that flood the islands, water temperature, and the thickness and characteristics of the peat.

Preliminary findings on Twitchell Island indicate that constant flooding substantially lowers carbon fluxes relative to either intermittent flooding or constant drainage. During a 6-month period, the amount of carbon that left the flooded site was three to five times less than the amount that left three sites that were either drained constantly or intermittently flooded. The differences in the amounts of carbon that left the other sites were not significantly different. A net accumulation of carbon also was detected on the flooded island. These preliminary findings indicate that subsidence can be stopped by permanent flooding. Planned flooding will substantially change the carbon budget by decreasing the amount of oxygen within the organic soils and probably will result in decreased subsidence rates.

For more information on studies of land subsidence in California please write:

District Chief
U.S. Geological Survey
Water Resources Division
Federal Building, Room W-2234
2800 Cottage Way
Sacramento, California 95825