The Role of the Mississippi River in Wetland Loss in Southeastern Louisiana, U.S.A.

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ABSTRACT / The suspended load of the Lower Mississippi River has decreased almost 80 percent since 1850. The long-term suspended sediment record can be loosely subdivided into three phases: a historic interval prior to 1900, a predam period (1930–1952) and a postdam period (1963–1982). The suspended load decreased 43 percent from the historic to the predam period and 51 percent from the predam to the postdam period. The decreases in suspended load after 1952 coincide with the construction of reservoirs and dams on the Missouri and Arkansas rivers. Earlier decreases may be the result of changes in land use measurement practices. The decrease in suspended load and the elimination of overbank flow by the construction of artificial levees are considered to be major causes of coastal wetland loss in southeastern Louisiana. During the historic period sediment accumulation of the marsh surface was greater than the rate of water level rise. During the pre and postdam periods, the rate of water level rise exceeded sediment accretion on the marsh surface. Although the elimination of overbank sediment clearly exacerbated the wetlands loss, an accelerated rate of water level rise during the past 25 years has been a dominant factor. Based on estimates of available overbank sediment, it is suggested that the most viable management strategy for the wetlands would be the diversion of sediment into selected areas where the land loss is most critical.

Introduction

Louisiana coastal wetlands provide the United States with 28 percent of its seafood harvest, the largest fur harvest, the largest population of over-wintering waterfowl, and a major recreational hunting and fishing area. The rate at which these wetlands are being lost has increased from 17 km^2/yr in 1913 to 102 km^2/yr in 1980 (Gagliano and others 1981; Morgan 1977). This land loss has been attributed to relative rise in sea level, isostatic subsidence, compaction of unconsolidated sediments, plus man-made changes in the coastal marsh and the Mississippi River regime, although the interrelationship and magnitudes of these factors are still not clear. Coastal wetlands in southeastern Louisiana have been built by Mississippi River sediments deposited either directly as deltaic deposits or by marine processes reworking the fluvial deposits.

The sediment discharge of the river includes materials transported as suspended and bed load. The bed load, composed largely of fine sand (in Louisiana), provides sediment that makes up channel, point bar, distributary mouth bar, and coastal beach deposits. These deposits form the skeletal framework upon which the coastal plain has been constructed during the past 6,000 years (Kolb and Van Lopik 1958; Welder 1959). The silt, clay, and some fine sand that comprise the suspended load are carried during flood periods into the interdistributary basins providing infill for the skeletal framework. It has been estimated that between 1950 and 1980 the suspended load of the river has decreased 50 percent (Keown and others 1986; Meade and Parker 1985). This estimate is based partly on the suspended sediment discharge record measured by the U.S. Army Corps of Engineers at Tarbert Landing, MS (includes measurements from Baton Rouge 1949–1958, Red River Landing 1958–1963, Tarbert Landing 1963–1982) (Fig. 1). These measurements, which were initiated in 1950, provide the longest continuous (official) sediment record for the Lower Mississippi River.

In addition to a reduction in the suspended load, the Lower Mississippi River has been confined to its channel. Since the record flood of 1927, the overbank contribution of sediment during flood flows from the River to the wetlands in southeastern Louisiana has been eliminated by the construction of an artificial levee system (Winkley 1977). Recent studies (Ramsey and Moslow 1987; Templet 1987) have argued that the decrease in sediment supply is largely responsible for the rapid wetland loss that has characterized the Louisiana coast over the past 25 years.

The purpose of this study is to examine the historic evidence of the magnitude of change in the suspended sediment discharge of the Lower Mississippi River. These data provide a basis for estimating the amount

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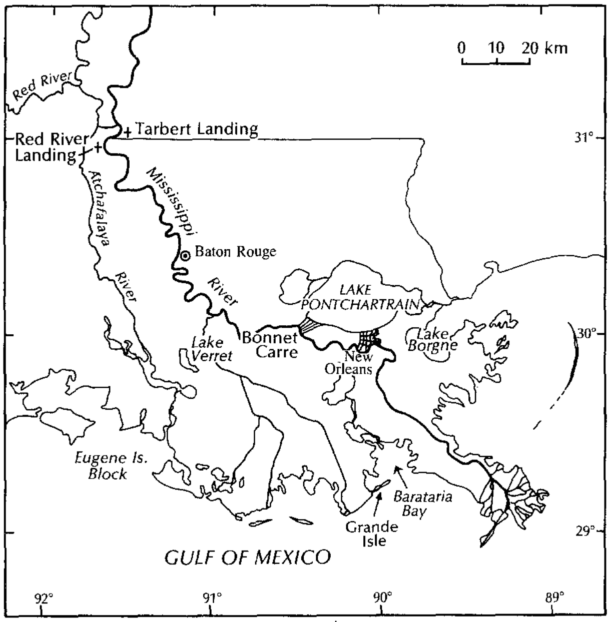

Figure. 1. Index map for southeastern Louisiana.

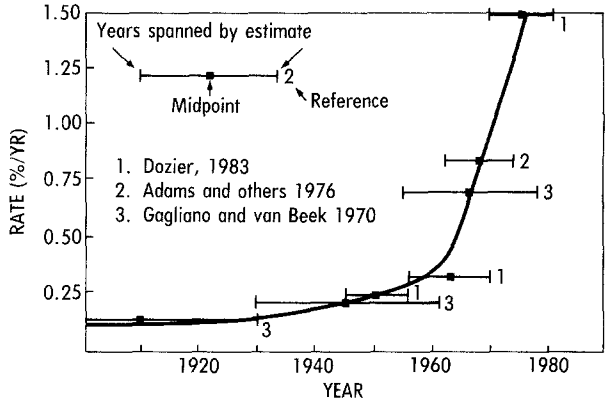

Figure 2. Rate of wetland loss in the vicinity of the Mississippi River delta (after Dozier 1983).

and importance of overbank sediment contributions to the wetlands both historically and for possible future use.

Coastal Wetlands

An increase in the area of coastal wetlands during the Holocene indicates that sediment accreted more rapidly than any rise in relative water level. Since 1900, this trend appears to have been reversed with the rate of wetland loss accelerating rapidly after 1960 (Fig. 2). Rates of aggradation and water level rise are difficult to establish. The rate of water level rise includes eustatic sea level rise as well as isostatic subsidence and compaction of the underlying sediments. The long term rate of sea level rise for the Gulf coast is approximately 2.2 mm/yr, based on the 70-plus year gage records from the west Florida coast (Hicks and others 1983).

The water level along the Louisiana coast has exhibited both spatial and temporal variations. Regional changes in the water level along the Louisiana coast include rises of 9.9 mm/yr at Grande Isle, 8.4 mm/yr at Eugene Island, the 16 mm/yr at Sabine Pass, Texas (Hicks and others 1983) (Fig. 1). However, the rate of rise at Eugene Island since 1960 has been 13 mm/yr (Hicks and others 1983) and n the vicinity of Lake Verret, Louisiana (Fig. 1) has been 13.6 mm/yr (DeLaune and others 1986). Ramsey and Moslow (1987) have estimated that since 1962 the rate of water level rise in coastal Louisiana may be 2.5-times greater than from 1942 to 1962. When eustatic sea level rise is subtracted from these rates, it is apparent that the rate of water level rise along the Louisiana coast is dominated by subsidence (Nummedal 1983). The current high rate of water level rise may reflect cyclic variations in the subsidence rate or human activity such as fluid withdrawal (water, oil, and brine). The 80 year tide-gage record at Galveston, TX exhibits this rapid increase in water level rise since 1940, apparently the result of fluid withdrawal (Gabrysch and Bonnet 1975). Prior to this (1908–1930), the rate of rise at Galveston was 4.5 mm/yr (Hicks and others 1983). A long-term average rate of water level rise was determined for the Louisiana coastal zone, in the vicinity of Grande Isle (Fig. 1) based on a ^{14}C-based sea level curve (Nummedal 1983). During the past 1000 years, the rate of rise was estimated at 2.75 mm/yr.

Vertical accretion rates on the marsh surface have been determined from sediment cores using ^{137}Cs dating methods (DeLaune and others 1983; Hatton and others 1983; DeLaune and others 1978). Between 1963 and 1978, the accretion rate in wetlands adjacent to the Mississippi River has averaged 7.9 mm/yr. This accretion includes accumulation of both organic matter and mineral sediment. The amount and rate of mineral sediment accumulation decrease inland from the Gulf Coast indicating that secondary landward redistribution of older deltaic, marine, marsh, and bay sediments by marine processes has replaced fluvial sources of sediments reaching the marsh (Hatton and others 1983). These data also indicate that rates of vertical sediment accretion and water level rise vary both temporally and spatially across the coastal zone and that during the past 20 years the rate of water level rise has significantly exceeded that of vertical accretion on the marsh surface. An evaluation of the volume of sediments delivered to the marsh surface by overbank flow from the Mississippi River will aid in determining (1) what effect eliminating this sediment

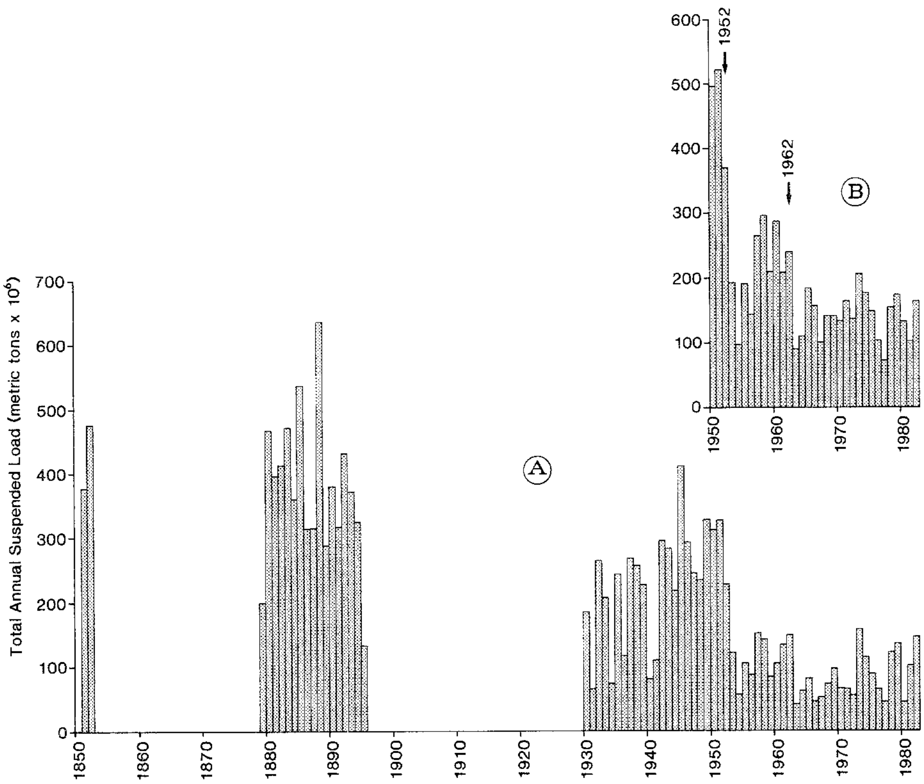

Figure 3. Total annual suspended load for the Mississippi River (A) below New Orleans based on data from Humphreys and Abbot, 1851 to 1852; Quinn, 1879 to 1895; and New Orleans Water and Sewage Board, 1930 to 1982; (B) U.S. Corps of Engineers data for Baton Rouge, 1949–1958; Red River Landing, 1958–1963: and Tarbert Landing 1963–1982.

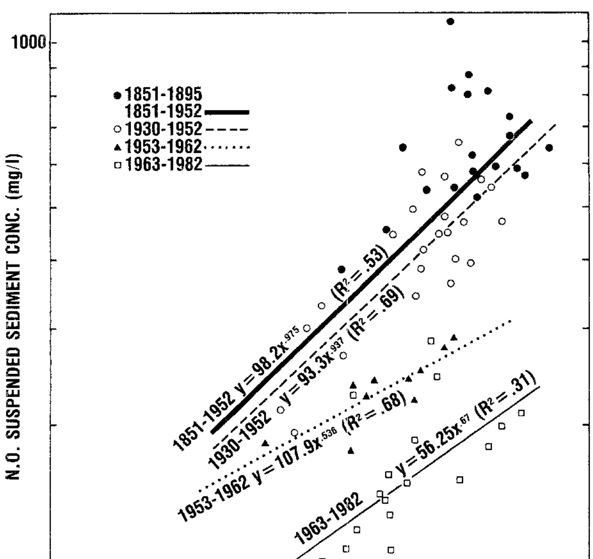

Figure 4. Relation between average annual sediment concentration and annual discharge at New Orleans. Three distinct groupings are evident in the data: 1851–1952; 1952–1962; 1963–1982 (modified from Kesel 1988).

source has had on the vertical accretion rate and the subsequent problem of wetland loss and (2) whether reestablishing this sediment source would have a significant future role in alleviating the problem.

Trends In The Suspended Sediment Regime

Changes in suspended sediment discharge of the Lower Mississippi River, which have previously been determined from the Tarbert Landing data, have been extended with the inclusion of measurements from Humphreys and Abbot (1861) from 1851 to 1852, Quinn (1894, 1896) from 1879 to 1895, and the New Orleans Sewage and Water Board (NOSWB) from 1930 to the present. All measurements were made in the vicinity of New Orleans (Humphreys and Abbot, NOSWB) or at the River mouth (Quinn). Although the sampling procedures are different at each location, except for Humphreys and Abbot, the sediment measurements were probably not greatly in error considering the range and rate of change in sediment concentration in such a large river (U.S. Inter-Agency Committee on Water Resources 1940, p. 22). Although the sediment measurements, reported by Humphreys and Abbot (1861) may be the least reliable, they compare well with suspended loads reported in the Quinn survey (1894, 1896). Further discussion of these data sources has been presented elsewhere (Kesel 1988). This long-term record (Fig. 3) indicates that the amount of suspended sediment carried to the Gulf by the Lower Mississippi River has decreased 79 percent since 1851 (Kesel 1988). Three loosely defined phases (Fig. 4) can be recognized in this sediment

Table 1. Comparison of average annual suspended load for Lower Mississippi River.

	Average annual suspended load (tons × 10^6) (percent decrease from previous period) Periods				
	Historic	Predam	Post-MO[c] closure	Post-ARK[d] closure	Historic–present
Station	(1851–95)[a]	(1930–52)	(1953–62)	(1963–82)	(1851–1982)
Tarbert	N.D.	463[b]	214 (−54) −70	141 (−34)	N.A.
New Orleans and delta	396	227 (−43)	112 (−51) (−64)	82 (−27)	(−79)

[a]1851–1952; 1879–1895.
[b]1950–1952.
[c]Missouri River.
[d]Arkansas River.

Table 2. Comparison of annual suspended loads for stations on Missouri and Mississippi Rivers (modified from Keown and others 1986).

	Average annual suspended load (tons × 10^6)	
Station	Before 1953	After 1953
Hermann, MO[a]	289.2	89.0
Hannibal, MO[b]	32.9	20.3
St. Louis, MO[c]	290.2	95.4

[a]Missouri River.
[b]Mississippi River above confluence with Missouri River.
[c]Mississippi River below confluence with Missouri River.

record and include a pre-1900 historic period, a predam period (1930 to 1952) and a postdam period (1963–1982). The high volume of suspended load that prevailed during the historic period were 43 percent higher than those of the predam period (Table 1), most likely reflecting improved agricultural land management techniques in the Mississippi Valley (Knox 1987, Ouchi 1986, Bennett 1939). Decreases in the suspended sediment regime since 1952 appear to have resulted from the construction of reservoirs and dams on major tributaries. This postdam sediment reduction (Table 1) includes a 51 percent decline by 1953–1962 related to a 70 percent decrease in the sediment contributed by the Missouri River (Table 2) and a further 27 percent decrease after 1963 most likely reflecting an 87 percent decrease in sediment supplied by the Arkansas River (Kesel 1988).

In addition to the reduction in suspended load, there has also been a significant decrease in the size of sediment carried in suspension (Kesel 1988). The proportion of sand in suspension measured at Tarbert Landing from 1950 to 1982, located 490 km upriver from the mouth, has decreased 50 percent from that reported for 1879–1895 (Fig. 5). The sand fraction in suspension measured by the U.S. Geological Survey at Belle Chasse (New Orleans), 170 km upriver from the mouth, suggests a 72 percent decrease when compared to the 1879–1895 period. The data from Belle Chasse covers a much shorter time period (1977–1983), but are from a site closer in proximity to the river mouth where the Quinn survey was conducted. The difference between the Tarbert Landing and Belle Chasse stations may reflect downriver channel sorting or storage. Measurements downriver from Baton Rouge indicate that since 1932 the proportion of sand transported as bedload also has decreased by approximately 50 percent (Keown and others 1986). A decrease of this magnitude in the sand fraction would play a significant role in the deterioration of the skeletal framework of the marsh surface or the subaerial land surrounding the delta front.

Overbank Sediment Contribution To Wetlands

Unconfined Overbank Contributions

Suspended sediments are introduced into wetlands adjacent to the river by overbank flow during flood periods when the levees are topped by unconfined flow or are breached by the confined flow associated with crevasse splays. The unconfined flow involves only that portion of the water column above the levee crest while a crevasse, which may extend 10 to 15m below the levee crest, diverts a greater proportion of the water column. Since 1927, overbank flow downriver of Tarbert Landing has been all but eliminated by the construction of artificial levees built to federal standards. The amount of sediment available for unconfined overbank flow, were it not confined by artificial levees, was determined for the postdam pe-

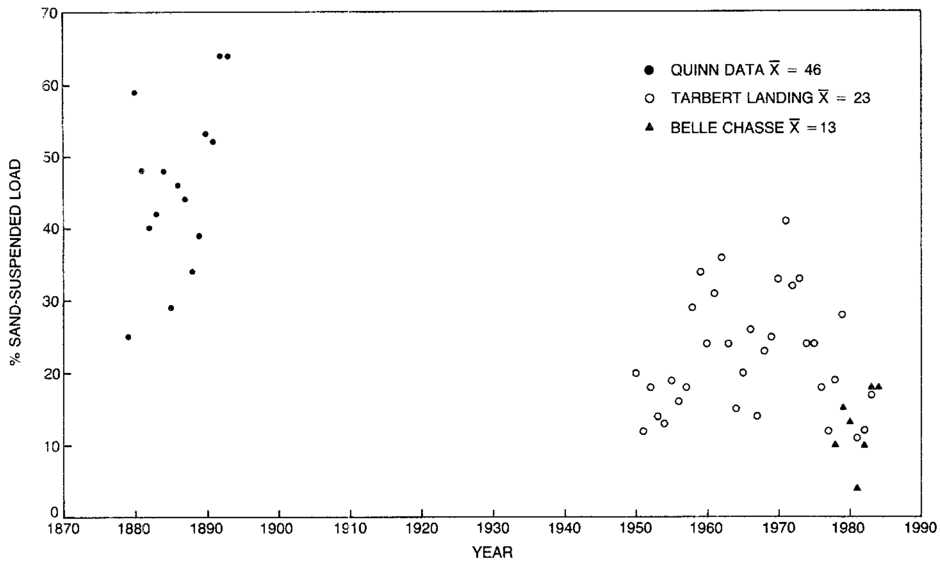

Figure 5. Changes in the percentage of sand carried as suspended load, based on data from Quinn (1894), Tarbert Landing (USCOE), and Belle Chasse (USGS) (from Kesel 1988).

riod using the Tarbert Landing water and sediment data for 1963 to 1983. The assumptions involved in this analysis include: (1) a bankfull discharge of 25.5 $\times$ 10^3 m^3/s which was estimated on the basis of natural levee height and (2) a suspended sediment concentration for the upper portion of the water column that was 5 percent less than the mean concentration (Wells 1980). The proportion of water discharge above bankfull flow was computed from daily records and that proportion was used to calculate the suspended sediment carried by the above bankfull flow. The amount of sediment that would have been available for overbank flow during this 21-year period was 73.6 $\times$ 10^6 tons. This amounts to 14 percent of the suspended load carried by flood flows, but only slightly more than 2 percent of the total suspended load carried during the entire 21-year period. Using a density of 1.0 m^3 equals 1.4 tons (U.S.W.E.S. 1931), this tonnage of sediment would produce a vertical accumulation covering a 10,000 km^2 area of 5.3 mm or an annual rate of 0.25 mm/yr. An area of 10,000 km^2 was determined from historic maps, which indicate the extent of overbank flooding below Baton Rouge prior to 1900 (Elliott 1932). The effect of the reduction in the suspended load on the overbank accumulation rates of past periods can be estimated using the percentage change between the postdam period and the historic and predam periods (Table 1). The vertical accumulation rate over the 10,000 km^2 area during the predam period (1930–1952) was estimated at 0.7 mm/yr based on a 64 percent reduction in the suspended load. The accumulation rate over the same area during the historic period (pre-1900) was estimated to have been 1.2 mm/yr, considering a 79 percent decrease in suspended sediment from the historic to the postdam period.

Crevasse Splay Contributions

Crevasse splays occur during flood stage when overbank flow becomes concentrated in a well-defined channel with enough scour capacity to erode permanent or semipermanent breaks in the levee. Crevasses generally develop on the river along the concave (outside) bank of meander bends, but can also develop at the river mouth producing subdeltas. Prior to the construction of artificial levees, crevasse splays were a common occurrence along the lower river during bankfull periods but have been eliminated since 1928 (Winkley 1977; Elliott 1932). Crevasses provide avenues for flood waters and sediments to enter adjacent backswamp and interdistributary basins. Intermittent or short-duration crevasses result in a branching pattern of small levee ridges and abandoned channels extending for a short distance into the basin areas. Crevasse splays that persist for longer periods may extend out many km from the main channel. The life span of crevasses is not well documented, but as indicated by archaeological evidence, they may function and remain as topographic features for several hundred years (Gagliano and Van Beek 1970). Data on the magnitude and frequency of crevasse splays are rare. During the period from 1849 to 1927, the river below Baton Rouge experienced 23 flood years, which produced crevasse splays (Vogel 1930). The number of crevasses per flood year was generally less than four, but as many as 20 were recorded in 1892. During the same period, Gunter (1950) estimated that a crevasse occurred once every

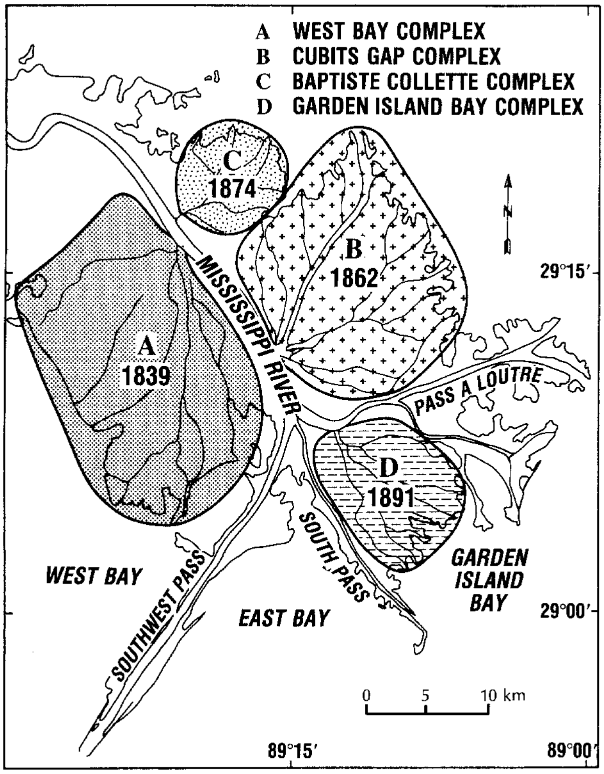

Figure 6. Subdeltas of the Modern Mississippi River (after Coleman and Gagliano, 1964).

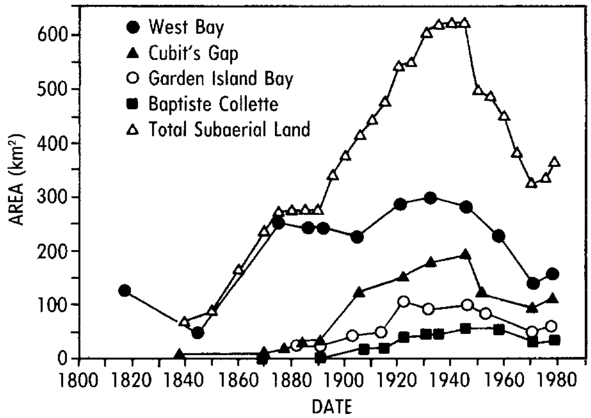

Figure 7. Composite and individual subaerial land changes in the Mississippi River delta (from Wells and Coleman 1987).

two years in the vicinity of New Orleans. The average area covered by a crevasse splay was about 1675 km^2, with the largest covering 5600 km^2 and the smallest 550 km^2 (Vogel 1930).

Subdeltas at the mouth of the river formed by crevasses (Fig. 6) account for more than 80 percent of the new land built around the active delta during historic time (Gagliano and others 1981; Wells and Coleman 1987). Data on the sediment characteristics for the major historic subdeltas are included in Table 3. Subdeltas progress through a sequence of stages that are dependent on the interaction of sediment supply, marine erosion, and subsidence. Figure 7 shows the rates of growth and deterioration of the subdeltas. The most abrupt decrease in land area occurred around 1950, which coincided with the major reduction in suspended load carried by the River and, after 1960, with a high rate of water level rise.

Channel crevasses form and prograde during flood stage but are inactive during low-water stage, unlike subdelta types which, is scoured deeply enough, maintain flow during low-water stage. There is little data on the contribution of channel crevasses to the sediment budget of the wetlands. The Bonnet Carre crevasse, located on the north bank of the River about 32 km upriver from New Orleans (Fig. 1) provides some comparative data. From 1849 to 1874, the crevasse overflowed five times during flood flows. A survey was conducted to estimate the amount of distribution of sediment contributed by these crevasses to Lake Pontchartrain (Hardee 1876). Sediment volume data from this survey are included in Table 3. The crevasse was replaced by the construction of the Bonnet Carre spillway in 1931. The spillway, in effect, is an artificial and controlled crevasse used to protect New Orleans by diverting portions of major Mississippi River floods into Lake Pontchartrain (Fig. 1). The spillway has been operated seven times since 1937. Sediment discharge characteristics for these events are given in Table 3 and indicate that the sediment volumes passing through the spillway were appreciably less than that which passed through during the crevasse phase. The primary reasons for this were the reduction in suspended sediment load and a decrease in the duration of the discharge since the rate of flow and the size of the area through which the discharge flowed were comparable. A decrease in the sediment volume passing through the Bonnet Carre can also be recognized during the spillway phase (Fig. 8) and largely reflects the decline in suspended load of the river between the predam and the postdam periods (Table 3).

The data in Tables 3 and 4 indicate the importance of crevasses for transporting sediment into adjacent wetlands as well as suggesting some differences between the crevasse and subdelta environments. The Bonnet Carre crevasse received sediment during flood flows while sediment input to subdeltas occurred throughout the year (Table 3). The sediment input to Bonnet Carre appears to have been much greater on a per flood event than it was to the subdeltas on an annual basis. These differences in sediment storage, however, may be more likely related to the sediment

Table 3. Sediment characteristics for major crevasses.

Crevasse	Area (km²)	Bonnet Carre Time	Sediment Rate ($m^3 \times 10^6$)	Sediment Volume ($m^3 \times 10^6$)
		Historic Period		
Bonnet Carre Crevasse	319	1849–1874	46[a]–61[b]/flood	229–306
		Predam Period		
Bonnet Carre Spillway		1937	9.5/flood	9.5
		1945	23.0/flood	23.0
		1950	9.5/flood	9.5
		Average	14/flood	
		Postdam Period		
		1973	9.8/flood	9.8
		1975	1.5/flood	1.5
		1979	6.3/flood	6.3
		1983	6.3/flood	6.3
		Average	6.01/flood	
		Subdeltas		
Cubits Gap	171	1862–1971	19–29/yr	3500
Garden Island Bay	78	1891–1971	4–8/yr	950
West Bay	231	1845–1971	19–24/yr	3300
Baptiste Collette	44	1891–1971	5–9/yr	750
Average	131		12–18/yr	

[a]Based on original survey of Hardee for L. Ponchartrain.

[b]Includes estimate for 90 km² subaerial portion of crevasse.

Sources: Hardee 1876, Saucier 1963, Gunter 1953, Saucier 1963, USCOE files, New Orleans, Gagliano and others 1971, Wells and Coleman 1987.

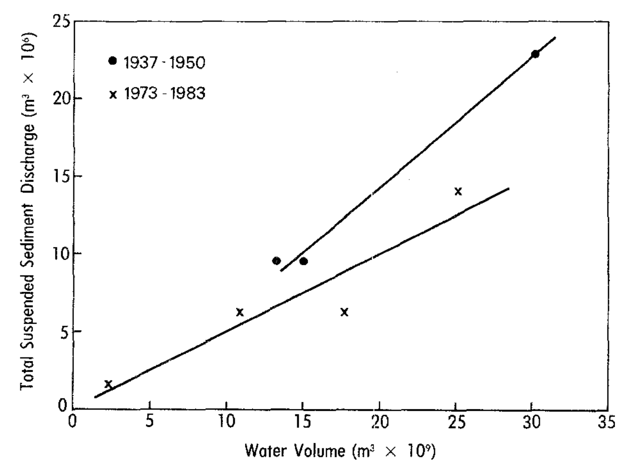

Figure 8. Relation between total suspended load and water volume flowing through the Bonnet Carre spillway during the pre and postdam periods.

trapping efficiency of the system and to the amount of loss by erosion processes. The subdelta environments have a lower retention rate as a result of the greater exposure to marine erosion processes.

The Bonnet Carre spillway data and the record of suspended sediment from Tarbert Landing were used to determine and compare the potential unconfined overbank sediment volume with the sediment volume discharged through the spillway (Table 4). During the postdam period, the spillway was activated four times. The number of days that it was open represents only 40 percent of the total time the river was at or above flood stage. The potential unconfined overbank sediment volume was computed for both the time when the spillway was open and the entire flood period, using the assumptions and calculations previously outlined. The approximately 23.9 × 10^6 m^3 of sediment discharged through the spillway during these four events is slightly greater than the potential sediment volume available for unconfined overbank flow for the same time period (Table 4). If the proportion be-

Table 4. Comparison of sediment volumes from spillway and unconfined overbank flows.

Year	Bonnet Carre ($m^3 \times 10^6$)	Overbank[a] (spillway) ($m^3 \times 10^6$)	Overbank[b] (total) ($m^3 \times 10^6$)
1973	9.8	11.4	12.2
1975	1.5	1.1	2.6
1979	6.3	3.2	12.5
1983	6.3	4.5	12.9
Total	23.9	20.2	40.2

[a]Unconfined overbank sediment for period when spillway was open.

[b]Total unconfined overbank sediment for entire flood period.

Table 5. Deposition rates for Bonnet Carre Spillway (crevasse).

Period	Open Phase Sediment volume /flood ($m^3 \times 10^6$)	Open Phase Deposition rate[b] (mm/flood)	Entire flood period[a] Sediment volume /flood ($m^3 \times 10^6$)	Entire flood period[a] Deposition rate (mm/flood)
Historic	61	36	61	36
Predam	14	8.4	28	16.8
Postdam	6	3.6	12	7.2

[a]Projection estimate (except historic period) based on proportion from Table 4.
[b]Based on an area of 1675 km^2.

tween these two volumes is projected to the total unconfined overbank sediment available for the entire flood period, the sediment discharged through the spillway would have been about 47.6 $\times 10^6$ m^3. Thus, if the spillway had remained open for the entire flood period, the sediment discharge would have been nearly double.

The average vertical sediment accumulation that would be contributed by crevasse splays to the wetlands during the historic, predam, and postdam periods (Table 5) can be estimated from sediment volumes in Table 3. During the historic period, the Bonnet Carre crevasse remained open during the entire flood period and a sedimentation rate of 36 mm represents the vertical accumulation during each flood event over an average crevasse splay area of 1675 km^2 (Table 5). Sediment accumulations during the predam and postdam periods were determined from spillway data (Table 3) and these values were increased to reflect the entire flood period using the relationship from Table 4. The proportion of the reduction in sediment accumulation (between the historic and postdam periods) on the crevasse surface during the entire flood event (Table 5) is the same order of magnitude as that noted for the suspended load in the river (Table 1). These data may provide a gross estimate of the sediment that is presently available to wetlands if controlled diversions, with spillway-type structures, are used during flood events.

Net Elevation Changes In The Marsh-water Interface

The overall impact of the suspended load reduction on the marsh-water interface can be estimated by calculating the net elevation change for each period. The net change in the elevation of this surface represents a balance between build up by marsh accretion and overbank disposition and the rate of water level rise. The net effect of such a change ultimately results in a gain or loss of wetland area. An estimate for this balance during each period is shown in Table 6. The rate of water level rise for the historic period included the Galveston gauge record prior to 1930 (Hicks and others 1983) and the ^{14}C derived rate (Nummedal 1983). Rates for the predam and postdam periods were determined from data for Grande Isle, Eugene Island (Hicks and others 1983) and Lake Verret (DeLaune and others 1986).

An average rate of 7.9 mm/yr was used for the accretion of sediment and organic matter to the marsh surface during each period based on the ^{137}Cs dating of the marsh cores (DeLaune and others 1983; Hatton and others 1983; DeLaune and others 1978). The previously determined overbank contributions, both confined and unconfined flows, of suspended sediment from the Mississippi River was used in Table 6. The average annual sediment rate from crevasse splays was calculated on the basis of a crevasse producing flood occurring every second year. The sediment input from crevassing would increase vertical accretion in local areas.

The net changes in elevation of the marshwater surface determined in Table 6 are only a first approximation and do not take into account such factors as local subsidence due to fluid withdrawal, compaction, or canal and pipeline construction, which may increase salt water intrusion and subsequent deterioration of the marsh surface. During the historic period, the marsh surface had a positive balance resulting in sediment accumulation and build up of the marsh surface. The predam and postdam periods were marked by an increasing negative balance that corresponds to the overall trend in wetlands loss (Fig. 2). Locally, crevasse splays would have supplied enough sediment to produce a positive balance, except during the postdam period when the available sediment accumulation would not have maintained the marsh surface above water level (Table 6). This shift on the marsh surface from a positive balance between sediment accumulation and water level rise in the historic period to a negative one in the predam and postdam periods cannot be attributed entirely to a reduction in the suspended load of the Mississippi River. A positive balance could not be achieved presently over the entire marsh surface even if the highest sedimentation rate for the historic period prevailed today given the current rate of water level rise. Clearly, the overbank sediment contribution from the Mississippi River, if distributed in the normal manner, could not maintain the marsh surface above the present rate of water level rise.

Among the possible methods for reducing or reversing wetlands loss would be the diversion of the

Table 6. Net elevation change of marsh-water interface (rates in mm/yr).

Period	Water level rise (−)	Marsh accretion (+)	Overbank deposition (+)	Crevasse deposition (+)	Balance[a] with	Balance[a] without
Historic						
Galveston						
(pre-1930)	4.5	7.9	1.2	36 (18)[b]	22.6	4.6
^{14}C curve	2.8	7.9	1.2	36 (18)	24.3	6.3
Predam						
(1930–1952)	10.0	7.9	0.7	16.4 (8.2)	6.8	−1.4
Postdam						
(post-1963)	13.0	7.9	0.3	7.1 (3.5)	−1.3	−4.8
	Potential Net Elevation Change in Rapid Land Loss Areas (1300 km^2)					
Postdam	13.0	7.9	2.9	9.1 (4.5)	2.3	−2.2

[a]Balance with or without crevasse.

[b]Parentheses represent crevasse deposition based on an annual basis if flood interval was every two years.

available overbank sediment from the Mississippi River into critical areas where land loss is most rapid. Gagliano and others (1981) have outlined the rates of wetland loss in southeastern Louisiana. The areas with the highest rates are located within 50 km of the river and cover an area of approximately 1300 km^2. The potential effect of diverting the available overbank sediment into these areas was determined for the postdam period (Table 6). The sediment volumes in Table 5, used to compute sediment accumulation for the larger areas, were distributed over the 1300 km^2. The dispersion of both unconfined and confined overbank sediment over this marsh area would result in positive accretion to the surface if the present rate of water level rise is maintained (Table 6). If the rate of water level rise, in this case, exceeds 16 mm/yr, other measures, such as channelling additional water from below bankfull levels or pumping sediment dredged from the river bed into these areas, would have to be taken to increase sediment volumes.

Conclusion

The suspended load of the Lower Mississippi River has decreased by almost 80 percent since the latter half of the nineteenth century. There also appears to have been a concomitant, if not equally large, decrease in the proportion of suspended sand. Decreases in the amount and size of suspended sediments may be largely due to changes in land use practices upstream and the construction of dams and reservoirs on major tributaries such as the Missouri and Arkansas rivers. Three loosely defined periods that reflect the decrease in suspended load are an historic interval prior to 1900, a predam period (1930–1952), and a postdam period (1963–1982).

The Mississippi River suspended load provides a major source of sediment for the wetlands of southeast Louisiana. Suspended sediments are introduced into these areas by unconfined flow across levee crests and by confined flow associated with crevasse splays. The construction of an artificial levee system adjacent to the river has eliminated the input of overbank sediment to adjacent wetlands. The elimination of this sediment source is considered a major cause of wetland loss in southeast Louisiana.

Presumably, if artificial levees were not in existence today, the overbank sediment would be sufficient to maintain the marsh surface above water level. This argument is not supported by estimates of the volume of overbank sediment that would have been available for deposition during the historic, predam, and postdam periods. The majority of loss or gain in the wetlands is determined by the balance between the rate of sediment accumulation on the marsh surface and the rate of water level rise. During the historic period when the rate of water level rise appears to have been relatively low, sufficient sediment was available to maintain a positive balance on the marsh surface. The rate of water level rise during the predam and postdam periods was much higher and available sediment would not have been sufficient to maintain a positive balance on the marsh surface. Although a decrease in suspended load would exacerbate this situation, a positive balance would not be achieved on the present marsh surface even if the rate of sediment accumulation for the historic period prevailed today. With the current level of suspended load and the present rate of water level rise, historic natural fluvial processes of overbank flooding and crevassing cannot maintain the marsh surface. The most viable approach appears to be the controlled diversion of overbank sediments into limited areas where the highest rates of land loss occur. Because the estimates in this article are based on flows at or above bankfull, the volume of sediment could also be increased by diverting a greater proportion of the water column.

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