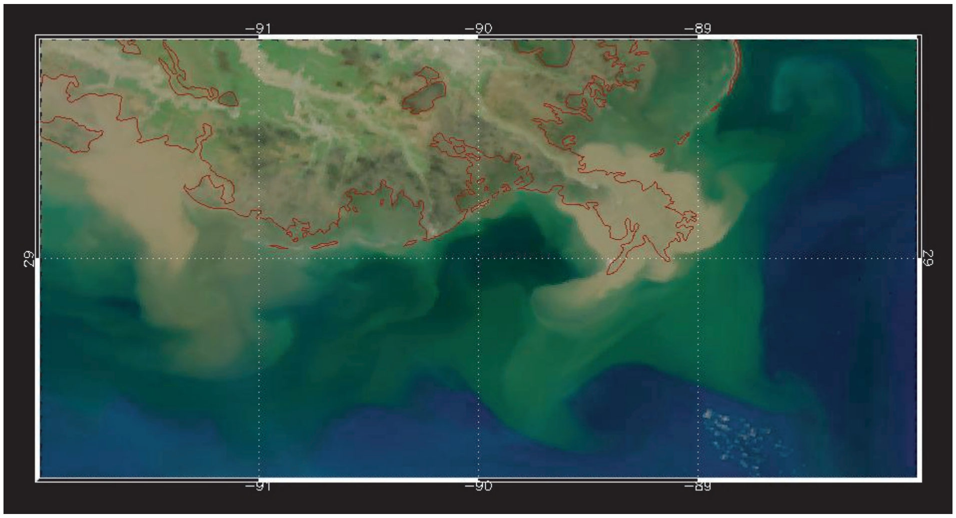
Evaluating Basin/Shelf Effects in the Delivery of Sediment-Hosted Contaminants in the Atchafalaya and Mississippi River Deltas – a New U.S. Geological Survey Coastal and Marine Geology Project



SeaWiFS sediment plume image of the Mississippi/Atchafalaya River deltas during Cruise 1 (USF data).

Project Summary:

This project responds to the demand to better understand and assess lower Mississippi sediment-hosted pollutant accumulation, deposition, and transport to the Gulf of Mexico. We have chosen to compare the storage and delivery of environmentally relevant contaminants (i.e., polycyclic aromatic hydrocarbons (PAHs), pesticides, nutrients, and trace metals) in both the lower Atchafalaya and Mississippi River systems, two systems in which the same riverine load is processed quite differently. Such a strategy allows us to directly target the variable effects of river and shelf sediments as a controlling mechanism for the fluvial delivery of contaminants to the Gulf of Mexico. We will also reconstruct and evaluate a complete historical inventory of these pollutants in this heavily industrialized corridor by looking at the geochronological record within shallow sediments. Results will be used to assess the environmental impact of sediment-hosted contaminants and will be evaluated in a comprehensive hydrogeologic context (i.e., what is the role of subsidence, erosion, river discharge in the ultimate delivery of these pollutants to the Gulf of Mexico?).

Project Objectives and Strategy:

The Mississippi River tracks an ancient mid-continental rift valley as it drains 41% of the 48 conterminous United States. Suspended-sediment concentrations have been decreasing in the mainstem Mississippi (Fig. 1) from the 1950s to present due to dam/reservoir construction and erosion-sensitive agricultural practices. The yearly mean discharge of ~ 580 km^3 of water and 200 million metric tons of suspended sediment to the Gulf of Mexico (Fig. 2) place this river system well within the top 10 largest rivers of the world. The Mississippi River receives a significant proportion of its water budget from the Ohio River, but the Missouri River contributes the majority of suspended particles (Meade, 1996). This bi-modal influx of water and sediment yields only a loose relationship between discharge and suspended-sediment concentration (Fig. 3A,B) in the mainstem river. A three-year record at Tarbert Landing, MS, indicates that usually much more than 70% of the suspended load consists of fines –

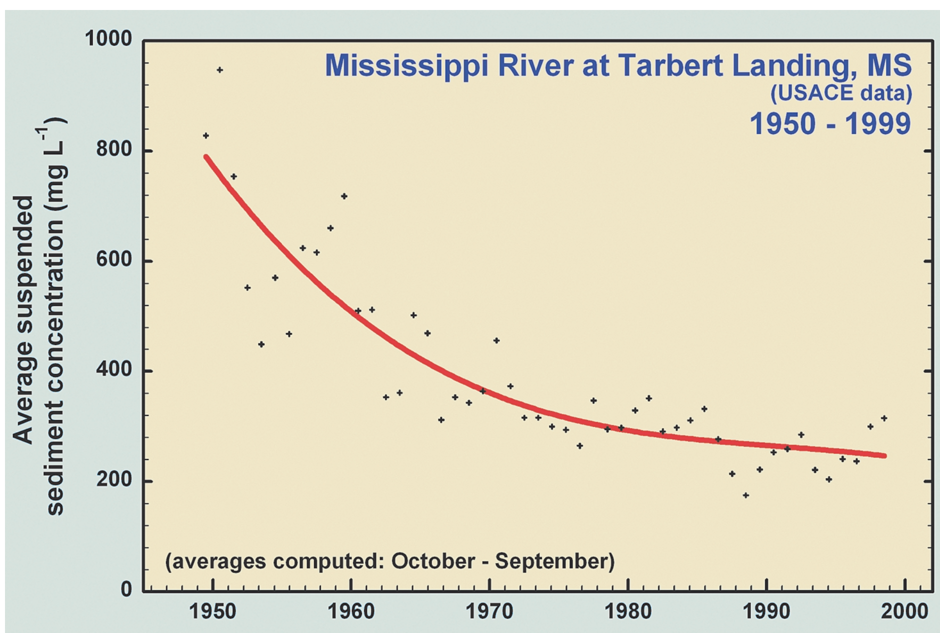


Fig. 1. 50 years of suspended sediment concentrations in the mainstem Mississippi River at Tarbert Landing, MS (USACE data).

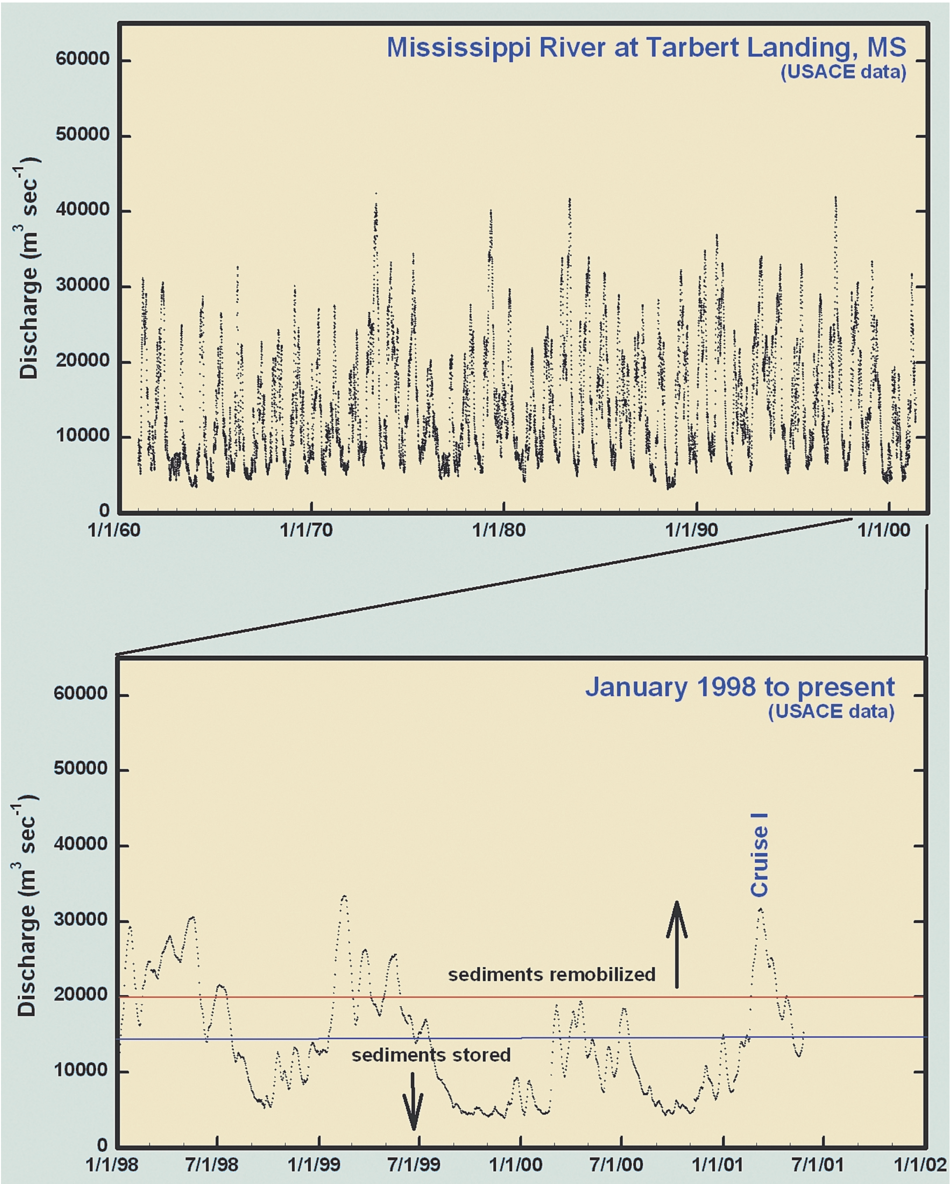


Fig. 2. A) 40 years (1960 – to present) of mainstem Mississippi River discharge measured at Tarbert Landing, MS (USACE data).
B) Discharge from 1/1/98 to present.

particles that are less than 0.062 mm in size (Fig. 4B).

Almost all (> 92%) of the trace-element load in the Mississippi River is transported downstream in particulate form, either as suspended sediment (including colloids) or bed load (Trefry et al., 1986; Taylor et al., 1990; Swarzenski and McKee, 1999). Seasonal sediment storage and remobilization in the Atchafalaya/Mississippi River system, as well as physico-chemical shelf effects therefore control the ultimate delivery of reactive pollutants to the Gulf of Mexico (Shiller and Boyle, 1993; Swarzenski and McKee, 1999; Mossa, 1996; Allison et al., in press). In the lower reaches of the Mississippi River, sediments are typically stored (Fig 2B) during low discharge ($Q < 14,000$ m^3 sec^{-1}) and remobilized during high discharge stages ($Q > 20,000$ m^3 sec^{-1}) (Demas and Curwick, 1988; Mossa, 1996). During such periods of storage, key diagenetic reactions such as remineralization and the reduction of Fe/Mn carrier phases can significantly change the solubility of certain scavenged contaminants (Trefry and Presley, 1986, Santschi et al., 2001). Similar geochemical reactions also occur in floodplain, deltaic or shelf sediments, and thus the fate of sediment-hosted contaminants during down-stream and across-shelf transport collectively define pollutant loading to the Gulf of Mexico (Goñi et al., 1997).

Our working hypothesis for this project is that differential processing of terrigenous, sediment-hosted contaminants in the lower Atchafalaya and Mississippi Rivers and their respective receiving basins (shelf versus shelf break) and flood plains can significantly alter the environmental fate and ultimate availability of these constituents. This differential processing is primarily due to the discharge of Atchafalaya River waters into a broad, shallow inner shelf environment, while Mississippi River waters discharge into the Gulf of Mexico, beyond the shelf break (Fig. 5). We are addressing this differential processing by collecting water, suspended sediment and bottom sediment samples in these two river systems (i.e., lower river, floodplain and shelf).

We can thus evaluate the effect of seasonal sediment storage, early dia-

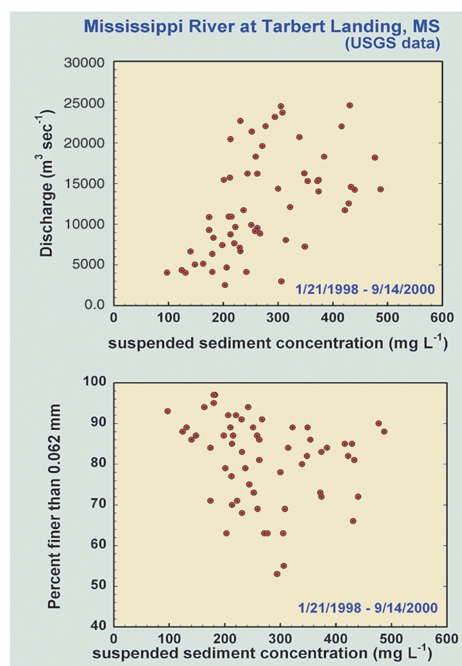


Fig 3. A) Discharge versus suspended sediment concentration and
B) Percent fines versus suspended sediment concentration at Tarbert Landing, MS. (data compiled by USGS).

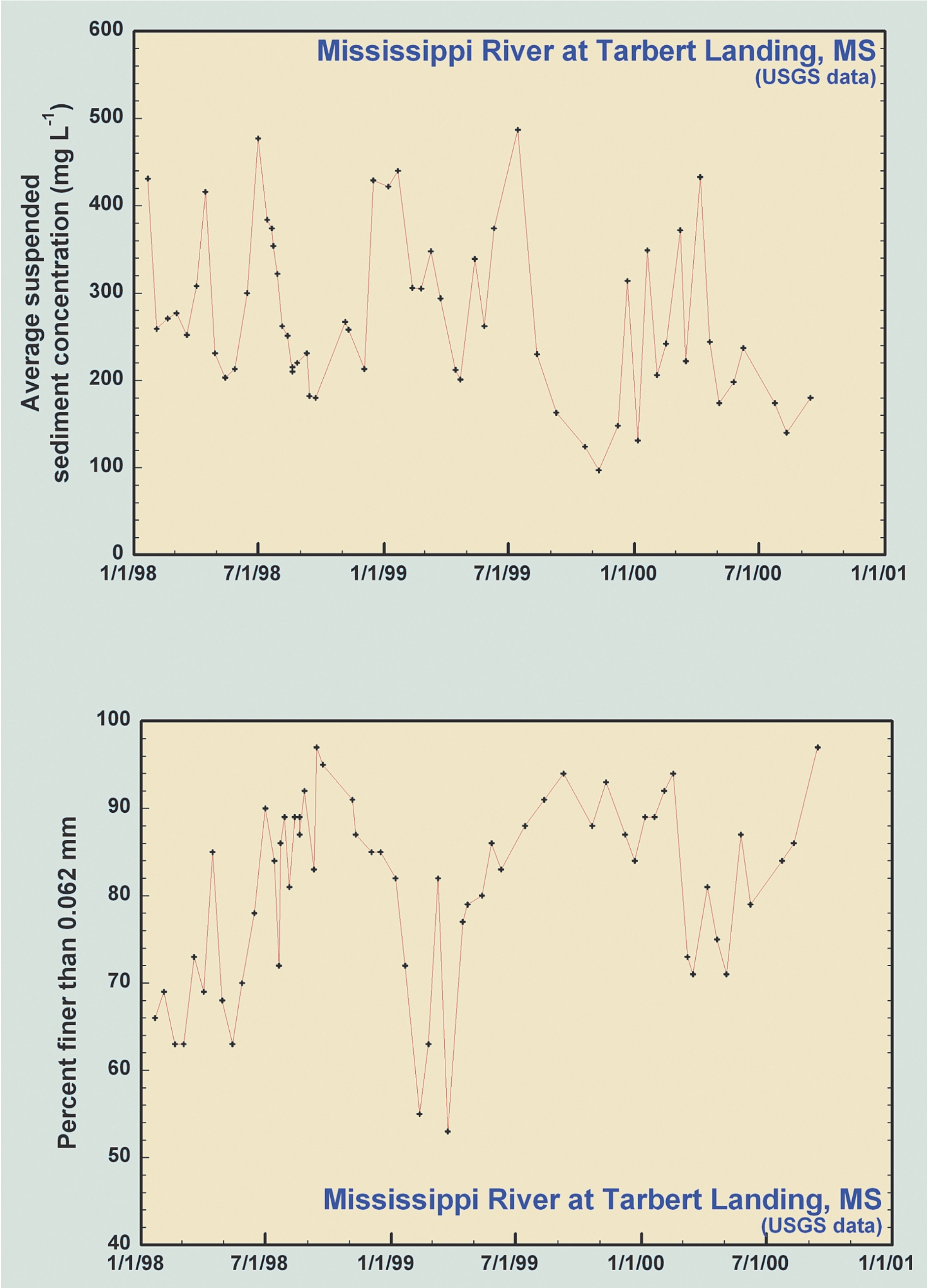


Fig. 4. A) Suspended sediment concentrations and
B) Percent fines in the mainstem Mississippi River from 1/1/98 to present (compiled by USGS).

genetic reactions, remobilization and eventual deposition on the following subset of sediment-hosted pollutants: (a) pesticides, PAHs and other organic pollutants, (b) trace metals that exhibit variable particle affinities or bioavailabilities (e.g., U, V, Mo, Ba, Sr, Fe and Mn), and (c) organic carbon and nutrients. The following specific objectives are addressed for each river system under variable discharge regimes:

(a) examine the extent of early diagenesis by looking at sediment/pore water profiles of such constituents as Fe, Mn, U, Mo, V, nutrients and organics;

(b) examine the biogeochemical transformations that occur as a result of sediment remobilization (resetting geochemical gradients);

(c) assess the historical inventory of pollutants and their transformation reactions;

(d) evaluate the overall delivery of sediment-hosted pollutants that eventually reach the Gulf of Mexico.

Results from (a-d) will be used to develop predictive models of pollutant transport, environmental fate and overall ecosystem health.

Potential Impacts and Major Products:

Knowledge gained from this process-oriented project on the fate of sediment-hosted pollutants in the lower Mississippi River system will enhance our understanding of the integrated suite of processes (geologic framework, hydrology, biology) responsible for the flux of contaminants to the Gulf of Mexico. Because this river system traverses one of the most industrialized corridors in the world, the potential contaminant influx (past and present) to the Gulf of Mexico through either the Atchafalaya or Mississippi River systems is significant. Recent sediment geochronologies should be able to provide a reconstruction of historic contaminant inventories for the lower Mississippi River system over the last ~ 100 years. Such a study will provide an integrated and comprehensive model that can then also be applied to other river/ocean mixing systems.

Under the leadership of Robert Meade and others, the U.S. Geological Survey recently concluded an in-depth contaminant study in the mainstem Mississippi River (Meade, 1996). This new project will extend those efforts to the deltas of the Mississippi/Atchafalaya Rivers, as well as the Gulf of Mexico inner-shelf region. This project will also tie directly into the newly launched USGS Gulf of Mexico Initiative, and will be able to provide key linkages to other research agencies and academia that have an active research interest in the Mississippi River/Gulf of Mexico.

Project collaborators/cooperators

Mead Allison (TULANE)	stratigraphy, geophysics
Bernie Coakley (TULANE)	stratigraphy, geophysics
Chuanmin Hu (USF)*	remote sensing/plume dynamics
Frank Muller-Karger (USF)*	remote sensing/plume dynamics
Jack Kindinger (USGS)	stratigraphy, geophysics
Keith Kvenholden (USGS)	organic geochemistry
Tom Lorenson (USGS)	organic geochemistry
Sid Mitra (USGS)	organic geochemistry
Brent McKee (TULANE)	inorganic geochemistry
Franco Marcantonio (TULANE)	inorganic geochemistry
Antonio Mannino (USGS)	organic geochemistry
Bill Orem (USGS)	organic geochemistry
Bob Rosenbauer (USGS)	inorganic geochemistry
Peter Swarzenski (USGS)	inorganic geochemistry/geochronology

*University of South Florida

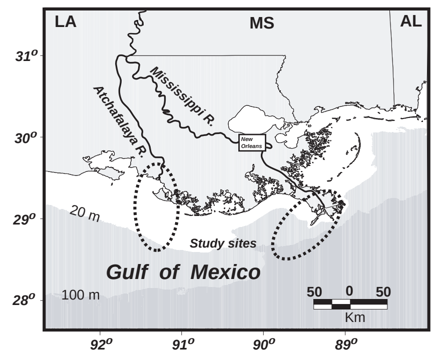


Fig. 5. Site location map.

References Cited

Allison, M.A., Kineke, G.C., Gordon, E.S. and Goñi, M.A. Development and reworking of an annual flood deposit on the inner continental shelf off the Atchafalaya River. Continental Shelf Research. In Press.

Demas, C.R. and Curwick, P.B. (1988) Suspended-sediment and associated chemical transport characteristics of the lower Mississippi River, Louisiana: Louisiana Department of Transportation and Development Water Resources Technical Report No. 45, pp., 44.

Goñi, M.A., Ruttenberg K.C. and Eglinton T.I. (1997) Sources and contribution of terrigenous organic carbon to surface sediments in the Gulf of Mexico. Nature 389, 275-278.

Meade, R.H. (1996) Contaminants in the Mississippi River, 1987-1992, Eds., U.S. Geological Survey, Circular 1133, pp. 140.

Mossa, J. (1996) Sediment dynamics of the lowermost Mississippi River: Engineering Geology, 45, 457-79.

Santschi, P.H., Presley, B.J., Wade, T.L., Garcia-Romero, B. and Baskaran, M. (2001) Historical contamination of PAHs, PCBs, DDTs, and heavy metals in Mississippi River Delta, Galveston Bay and Tampa Bay sediment cores. Mar. Environ. Res., 52(1), 51-79.

Shiller, A.M. and Boyle, E. (1991) Trace elements in the Mississippi River delta outflow region: Behavior at high discharge. Geochim. Cosmochim. Acta. 51, 3273-3277.

Swarzenski, P.W. and McKee, B.A. (1999) Seasonal uranium distributions in the coastal waters off the Amazon and Mississippi Rivers. Estuaries, 21, 379-390.

Trefry, J.H. III and Presely, R.J. (1982) Manganese fluxes from Mississippi delta sediments. Geochim. Cosmochim. Acta 46, 1725-1726.

Trefry, J.H. III, Nelson, T.A., Trocine, R.P., Metz, S. and Vetter, T.W. (1986) Trace metal fluxes through the Mississippi River delta system, in Kullenberg, G. Eds., Contaminant fluxes through the coastal zone. Rapparts et Proces-Verbaux des Reunions Conseil International pour l'Exploration de la Mer, 186: 277-288.

Taylor, H.E., Garbarino. J.R. and Brinton, T.I. (1990) The occurrence and distribution of trace metals in the Mississippi River and its tributaries. Sci. of the Total Environ., 97/98, 369-384.

For more information please contact:

Peter W. Swarzenski..........................727-803-8747 x 3072
U.S. Geological Survey......................727-803-2032 FAX
600 4th Street South..........................pswarzen@usgs.gov
St. Petersburg, FL 33701