Some Compelling Reasons for Moving Beyond Competing Interests to Achieve a Common Purpose

J. David Rogers, Ph.D., P.E., P.G., C.E.G., C.HG.
Karl F. Hasselmann Chair in Geological Engineering
Natural Hazards Mitigation Institute
Missouri University of Science & Technology
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The Mississippi River experienced a ‘record flood’ in 2011...
Comparison between the 1927 and 2011 floods

From Mullen (2012)
Every time the river floods, the stage-discharge relationships rise... Should we be concerned?
Is it being caused by Global Sea-Level Rise?

Sea-Level Change Data and Projections

- Satellite observations
- Tide gauge observations

~1mm/yr
~3.0 mm/yr

from IPCC 2007

Graph showing global sea-level change from 1800 to 2100, with estimates of the past, instrumental record, and projections of the future.
The Loop Effect is just one of several ailments associated with an aging engineering infrastructure.
The Loop Effect

- **Stage-Discharge ‘Loop Rating Curve’**
  Typical increases in flow stage that accompanies successive peak flows, first observed in the 1973 Flood.
Reasons for unstable stage-discharge relationships:

Since 1950 the river has been working via entropy to *re-establish its original length*, losing some of the channel capacity gained by the streamlining carried out during the two previous decades.

Sediment is deposited adjacent to and within most of the structural cutoffs when high flows drop rapidly. These deposits degrade channel efficiency. Other complications: sediment starvation by reservoirs and submerged navigation training structures, such as groins.
Comparison of 1973 & 2011 at Vicksburg

Stage-Discharge Curves Comparing 2011 and 1973 Mississippi River Floods at Vicksburg MS

\[ y = 0.0918x^{0.4393} \]

\[ R^2 = 0.9081 \]

Kemp and Rogers (2011)
Comparison of 1973 & 2011 at Natchez

Stage-Discharge for Mississippi River at Natchez in 1973 and 2011

\[ y = 0.047x^{0.4927} \]
\[ R^2 = 0.9653 \]

\[ y = 0.0435x^{0.4932} \]
\[ R^2 = 0.904 \]

Kemp and Rogers (2011)
Comparison of 1973 & 2011 at Red River Landing

Comparison of Stage-Discharge Curves from 2011 and 1973 at Red River Landing

\[ y = 0.2548x^{0.3861} \]
\[ R^2 = 0.9725 \]

\[ y = 0.1165x^{0.4391} \]
\[ R^2 = 0.9519 \]

+1.8 feet @ 1.5 million cfs

Kemp and Rogers (2011)
Comparison of 1973 and 2011 Stage-Discharge at Red River Landing upstream of Baton Rouge

(A)

\[ y = 6.5848 \ln(x) - 51.451 \]
\[ R^2 = 0.9541 \]

\[ y = 6.6728 \ln(x) - 53.006 \]
\[ R^2 = 0.9465 \]
And falling stages...
Comparison of 1973 and 2011 Stage-Discharge at Belle Chasse

(B)

1973
\[ y = 2.8198 \ln(x) - 24.294 \]
\[ R^2 = 0.8639 \]

2011
\[ y = 3.453 \ln(x) - 31.022 \]
\[ R^2 = 0.9193 \]
So, what’s happening to the channel below New Orleans that would cause stage levels to fall?
The high-stand mud ediface digitate (birdfoot-shaped) delta deposited by the Mississippi River is the only delta in the world that extends out to the edge of the Continental Shelf (image from Fisk, 1956).
Notice that muddy appendage sticking out into the gulf....
The Delta Cycle: Delta Lobe Switching

1. Sale–Cypremont 4600 years BP
   Teche 3500-2800 years BP
2. Teche 3500-2800 years BP
3. St. Bernard 2800-1000 years BP
   Lafourche 1000-300 years BP
4.  
5. Plaquemine 750-500 years BP
   Balize 550 years BP
6. Gulf of Mexico

Atchafalaya Bay
Mississippi “Bird Foot” Delta
New Orleans
Mississippi River
Mississippi River Subdeltas

- Map by Sherwood Gagliano (1969) showing the six most recently deposited subdeltas of the Mississippi River in the Balize Lobe
Historic land loss in the Birdsfoot Delta through 2005, shown in orange. There is very little land mass physically constraining the main stem channel, and its flow is becoming diffuse, especially during this year’s flows. Less than a third of the river’s flow now makes it to the main navigation outlets (from LSU Marine Sciences).

- Land loss shown in orange
- During the next large runoff event, the river will likely jump its banks somewhere above Head-of-Passes
- We’ll be stuck with wherever it decides to go
This is what is left of the Balize Delta Lobe... not enough to constrain the river at high flows
• There are essentially TWO Mississippi Rivers: a HIGH FLOW river during floods, and a NORMAL FLOW river.

• The employment of dual levees, lengthening of the jetties, and the silt load of the river have combined to **heighten the channel bed** and **lower the hydraulic grade**, lifting the river’s flow surface.
The east channel off Head of Passes used to convey 25% of the river’s flow. That’s now fallen just to 7 or 8%. Dredge spoils have been placed in Pass-a-Loutre and it has become blocked. Two new channels are siphoning water off to the west, at Tiger Pass and Grand Pass. The 11-mile long Bohemia Spillway and Bayou Baptiste Collette lie along the lower river’s eastern bank. These four outlets are now siphoning off about 67% of the river’s flow, above Southwest Pass.
The outflow deceleration is responsible for about 20 to 30% of the siltation occurring in the lower Mississippi River channel, while the other 70 to 80% of the accumulated sediment is not explained (Barras et al., 2009).
Landsat Image from April 10, 2011 when the discharge at Tarbert Landing was running 900,083 ft³/s. This shows the sediment plume created by overbank flow, beginning at the Bayou Lamocque bend (RK 55), halfway between Bohemia and Fort St. Phillip, about 22 km upriver of the 1983 east bank plume.
Discharge is Bypassing the Bird’s Foot through Upstream Passes
(with the result being the channel is growing shorter!)

Grand Pass
Baptiste Collette
South Pass silted in!
This is because the delta is sinking

At the Bird’s Foot: 0.5 - 0.8 ft/decade

Data from: West Bay Sediment Diversion ERDC Report: Brown et al., 2009
Cumulative Deposition in Undredged Reaches = 8.6 Million yd$^3$/y

RSLR Sediment Accommodation in Dredged and Undredged Reaches = 3.0 Million yd$^3$/y

Sediment is now being deposited upstream of traditionally dredged reaches.

Reaches 10 – 12 dredged 806,452 yds$^3$ annually
Lower Mississippi River Thalweg & Water Surface Elevations: RK520 AHP to Gulf of Mexico (RK32 BHP)

High Discharge (46,000 m$^3$·s$^{-1}$) May 19, 2011

Low Discharge (4,100 m$^3$·s$^{-1}$) August 24, 2012

Subsidence (mm·yr$^{-1}$)

Water Surface and Thalweg Elevation (m, NAVD88)

Toe Salt Wedge August 24, 2012

Pleural Salt Wedge

Temporary Salt Sill

2004 Thalweg

$y = -9E-07x^3 + 0.0008x^2 - 0.1842x - 22.289$

$R^2 = 0.5305$

ORCS  Tarbert Landing  St. Francisville  Baton Rouge  Bonnet Carre  Carrollton  Belle Chasse  Venke  Head of Passes  GOM

Distance Above and Below Head of Passes (km)
So, the ‘depositional center’ of the lower Mississippi River is *moving upstream* each year, increasing dredging costs. In 2010 the dredging cost $100 million, and for the first time the Corps was unable to maintain the 45 ft deep navigation channel....

Since 1877 the jetties have extended the river’s length by 11.3 km, lowering the hydraulic gradient, while sea level has risen 13 inches.
Sea Level Rise is also an issue
Projected Submergence: 2000 vs 2100

The diagram illustrates the projected submergence of the coastline between 2000 and 2100. The section labeled 'a' shows the current land surface elevation, with features such as the Prairie Terrace, Modern Alluvial Ridge, and Lafourche Alluvial Ridges. The section labeled 'b' depicts the submergence scenario for the year 2100, highlighting areas like the Submerged Pontchartrain Marshes and Submerged Lafourche Delta Plain Marshes. The contrast between the two sections emphasizes the significant changes expected in coastal topography due to projected sea level rise.
So, why should *we* care about any of this?
Status Quo for Navigation

- Limited funding for dredging Southwest Pass
- Reduced draft levels mean lost revenues
- Shallow draft users depend on a thriving deep-draft system at mouth of the river
- River mouth is becoming geologically unstable, in ways that could threaten all navigation
- Obsolescence of fixed port infrastructure
THE BULK GOODS & PRODUCTS PRODUCED IN AMERICA’S HEARTLAND ARE SHIPPED OUT OF LOUISIANA PORTS

- The Port of South Louisiana ships more than 200 million tons of cargo annually.
- Southern Louisiana ports handle 18% of all US waterborne commerce (457 million tons annually).
Top 15 US Ports by Volume

Port Location

South Louisiana, LA
New Orleans, LA
Plaquemines, LA
Lake Charles, LA
Baton Rouge, LA
Corpus Christi, TX
Texas City, TX
Beaumont, TX
Houston, TX
Mobile, AL
Long Beach, CA
Los Angeles, CA
Huntington- Tristate
New York/New Jersey
Hampton Roads, VA

Cargo Volume (tons)

Data from American Association of Port Authorities, 2008
CARGO HANDLED IN U.S. PORTS DURING 2010
BY BULK CARRIERS (TONS) AND
CONTAINER SHIPS (TEUs)

- Seattle & Tacoma, WA
- Duluth & Superior, MN
- New York, NY
- Philadelphia, PA
- Baltimore, MD
- Norfolk, VA
- Savannah, GA
- Charleston, SC
- Jacksonville & Port Everglades, FL
- Tampa, FL
- San Juan, PR
- Oakland & San Francisco, CA
- Los Angeles & Long Beach, CA
- Pascagoula, MS
- Lower Mississippi River, LA
- Beaumont, TX
- Mobile, AL
- Lake Charles, LA
- Corpus Christi, TX
- Honolulu, HI

Inset A

10^6 Tons
- 401 - 450
- > 90
- 0 - 50

10^5 TEUs
- < 20

Waterways
A 73 Barge ‘Tow’ between New Orleans and Baton Rouge

Nowhere but on the Lower Mississippi River...
Where are all of these materials going?
Reducing the import deficit with China

**U.S. exports to China via Louisiana, 2000 - 2009**

- **Louisiana exports to China (Values in 2009 $USD (millions))**

**Breakdown of shipments, 2009**

- 79.6%: Grain and other agricultural products
- 12.0%: Chemicals
- 2.6%: Primary metal manufacturing
- 2.1%: Processed foods
- 2.7%: Waste and scrap
- 0.9%: Other goods

- 2.1%: Other goods
NATIONWIDE IMPACT ON OIL & GAS RESOURCES

25-30 percent of your total United States energy production Traverses Louisiana's deteriorating coast
NATIONWIDE IMPACTS ON DISTRIBUTION OF NATURAL GAS

GOM: “aorta” of the U.S. natural gas circulatory system

Source: Energy Information Administration, US Department of Energy
Economic Losses at Various Channel Depths will be significant

### Table 23
Incremental Losses at Various Channel Depths (Dollar figures in millions)

<table>
<thead>
<tr>
<th>Depth in Feet</th>
<th>Direct Spending</th>
<th>Total Spending</th>
<th>Earnings</th>
<th>Federal Taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>44-45</td>
<td>$455.23</td>
<td>$891.49</td>
<td>$121.53</td>
<td>$14.15</td>
</tr>
<tr>
<td>43-44</td>
<td>$593.98</td>
<td>$1,132.07</td>
<td>$157.04</td>
<td>$18.35</td>
</tr>
<tr>
<td>42-43</td>
<td>$772.74</td>
<td>$1,445.97</td>
<td>$203.30</td>
<td>$23.80</td>
</tr>
<tr>
<td>41-42</td>
<td>$1,073.69</td>
<td>$2,018.40</td>
<td>$275.42</td>
<td>$32.56</td>
</tr>
<tr>
<td>40-41</td>
<td>$1,643.00</td>
<td>$3,171.05</td>
<td>$417.50</td>
<td>$49.58</td>
</tr>
<tr>
<td>39-40</td>
<td>$1,887.83</td>
<td>$3,693.39</td>
<td>$470.63</td>
<td>$56.30</td>
</tr>
<tr>
<td>37-38</td>
<td>$2,082.72</td>
<td>$4,109.96</td>
<td>$520.31</td>
<td>$62.20</td>
</tr>
<tr>
<td>36-37</td>
<td>$2,371.36</td>
<td>$4,689.44</td>
<td>$602.18</td>
<td>$71.56</td>
</tr>
<tr>
<td>35-36</td>
<td>$2,371.35</td>
<td>$4,689.45</td>
<td>$602.20</td>
<td>$71.56</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>$1,472.43</strong></td>
<td><strong>$2,871.25</strong></td>
<td><strong>$374.46</strong></td>
<td><strong>$44.45</strong></td>
</tr>
</tbody>
</table>

Source: Author’s Calculations
Steel containers were first used by the Pennsylvania Railroad in 1934 to curb stevedore pilferage!

<table>
<thead>
<tr>
<th>Generation</th>
<th>Length</th>
<th>Draft</th>
<th>TEU</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Generation</td>
<td>135 m</td>
<td>&lt; 9 m</td>
<td>500</td>
</tr>
<tr>
<td>Second Generation</td>
<td>200 m</td>
<td></td>
<td>800</td>
</tr>
<tr>
<td>Third Generation</td>
<td>215 m</td>
<td>10 m</td>
<td>1,000 - 2,500</td>
</tr>
<tr>
<td>Fourth Generation</td>
<td>250 m</td>
<td>11-12 m</td>
<td>3,000</td>
</tr>
<tr>
<td>Fifth Generation</td>
<td>335 m</td>
<td>13-14 m</td>
<td>5,000 - 8,000</td>
</tr>
</tbody>
</table>

Container ships have continued evolving into larger and larger vessels.
The Global Container Fleet is Growing as are the size of the vessels.
And so are the Bulk Carriers, which are the lifeblood of New Orleans

92,500DWT Post Panamax Bulk Cargo Carrier

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
<th>Deck to Deck</th>
<th>Access Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length b.p.</td>
<td>222.00 m</td>
<td>A deck to B deck</td>
<td>2.80 m</td>
</tr>
<tr>
<td>Breadth mld.</td>
<td>38.00 m</td>
<td>B deck to C deck</td>
<td>2.80 m</td>
</tr>
<tr>
<td>Depth mld.</td>
<td>20.70 m</td>
<td>C deck to D deck</td>
<td>2.80 m</td>
</tr>
<tr>
<td>Scantling draft</td>
<td>14.90 m</td>
<td>D deck to Bridge deck</td>
<td>2.80 m</td>
</tr>
<tr>
<td>MCR</td>
<td>12240 kW</td>
<td>Bridge deck to compass deck</td>
<td>2.80 m</td>
</tr>
<tr>
<td>Service speed</td>
<td>14.1 knots</td>
<td>Upper deck to forecastle deck</td>
<td>2.40 m</td>
</tr>
</tbody>
</table>
• Beginning in 2014, the new Panamax vessels will be about 160 ft wide with a fully loaded draft of 50 ft, requiring navigation channels to be deepened to at least -55 ft.
Problem Solving Begins by Identifying Common Interests

- Opportunity for deeper (55 ft) and more reliable and sustainable navigation entrance
- Reduce dredging costs by employing newer dredging technologies, such as slurry conveyance
- Use dredged sediment for land-building
- Seek a healthy Delta that protects shallow and deep-draft channels and ports from storms
- Forge political alliances to achieve both ecological and economic goals
The Mouth of the Mississippi is a Hard Place for Nature or Man to Build, but is critical to $10 Billion in exports, mostly agricultural products.

The fundamental *engineering problem* is that the delta is rapidly disappearing, for a variety of reasons...
This lecture will be posted on my Missouri S&T website as a pdf file for easy downloading. It is not copyrighted.

www.mst.edu/~rogersda/levees/

Mississippi Delta Region

THE DEGRADING MISSISSIPPI DELTA: HOW MUCH LONGER CAN IT BE SUSTAINED?

By J. David Rogers, Ph.D., PE, P.G., MASCE

The Mississippi River, as noted in the previous section, is the second largest river in the world and it carries approximately 5 percent of the water flowing across the entire United States. The discharge of the Mississippi River is about 190,000 cubic feet per second. The Mississippi River flows through 11 states and empties into the Gulf of Mexico. The discharge of the Mississippi River is seasonal, with the highest flows occurring during the spring and summer months. The discharge of the Mississippi River is also affected by human activities, such as the construction of dams and levees.

Some History

In 1834, the U.S. Army Corps of Engineers was established to construct levees along the Mississippi River to prevent floods. The levees were constructed to protect the surrounding area from flooding. In the late 19th century, the levees were expanded and improved to protect the area from floods. In the 20th century, the levees were again improved to protect the area from flooding.

The Mississippi Delta

The Mississippi Delta is a region located at the mouth of the Mississippi River. The delta is a flat, low-lying area that is formed by the river's sediment. The Mississippi Delta is home to many species of plants and animals, including many endangered species.

The Mississippi River Delta

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