Controls on Sediment/POC Flux and Burial on the Gulf of Mexico Continental Margin (with special emphasis on the Mississippi-Atchafalaya system)

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OBJECTIVES

Role of:

1. Riverine Inputs
2. Estuarine/Tidal Zone Alteration of Inputs
3. Wetland Inputs from Storms
4. Shelf Sediment Burial
5. Inner Shelf Dynamics
6. Hurricanes and the Shelf (Lili/Katrina/Rita)
7. Relative Sea Level Rise
1. Riverine Inputs

Gulf of Mexico Riverine Suspended Sediment Loads

Riverine Inputs in $10^6$ metric tons/y

- Atchafalaya-Red: 11.1
- Mississippi: 124
- Alabama-Tombigbee: 4.0
- Pearl: 1.3
- Sabine: 0.8
- Brazos: 0.8
- Nueces: 0.07
- Colorado: 2.4
- Rio Grande: 0.7
- Appalachicola: 0.2

Sources:
USGS Waterweb, Ryan and Goodell (1972)
Meade and Parker (1985), Meade et al. (1990)
Hudson and Mossa (1997), Horowitz et al., (2001)
Horowitz (2006)
2. Estuarine/Tidal Zone Alteration of Inputs

LOWER (LA) MISSISSIPPI RIVER WATER SURFACE ELEVATION

RIVER STAGE (ft NGVD)

RIVER MILE from HEAD of PASSSES

Knox Landing
Red River Landing
Bayou Sara
Baton Rouge
Donaldsonville
College Point
Reserve
Bonnet Carre
Carrolton (NO)
Chalmette
Braithwaite
Alliance
W. Pointe la Hache
Port Sulpher
Empire
Venice
Head of Passes
Chesvron Dock
SW Pass

FINAL DISCHARGE STATION

ESTUARINE

TIDAL (low discharge)

Maximum

Minimum

high

low
2. Estuarine/Tidal Zone Alteration of Inputs

Low Discharge Mud Storage (1999-2002)

LOW DISCHARGE MUD DEPOSITION

SIDESCAN SONAR

MULTIBEAM BATHYMETRY

14 MT (RM181-13)

124 MT
Post-1993
(Horowitz et al., 2001)
2. Estuarine/Tidal Zone Alteration of Inputs

Low Discharge Mud Storage (1999-2002)

Levee Levee

Estuarine Reach

Low Discharge

High Discharge

Low Discharge Mud Deposition

From Galler and Allison, GSA Bull (2008)

10 MT (RM13-Passes)

124 MT Post-1993 (Horowitz et al., 2001)

From Galler and Allison, GSA Bull (2008)
3. Wetland Inputs from Storms

from Turner et al., Science (2006)
3. Wetland Inputs from Storms

from Wilson and Allison, ECSS (submitted)
3. Wetland Inputs from Storms

<table>
<thead>
<tr>
<th>Site</th>
<th>Shoreline Retreat Rate $^1$ (m/yr)</th>
<th>Maximum Depth of Profile (m)</th>
<th>RSLR Rate $^2$ (m/yr)</th>
<th>Annual Sediment Yield from Translation of Profile (m$^3$ per m of shoreline)</th>
<th>% Sediment Yield Sequestered by RSLR annually</th>
<th>Corrected Annual Sediment Yield (m$^3$ per m of shoreline)</th>
<th>Annual Sediment Yield Estimated from Equilibrium Profile (m$^3$ per m of shoreline)</th>
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</thead>
<tbody>
<tr>
<td>LBB 1</td>
<td>1.59</td>
<td>1.454</td>
<td>0.0111</td>
<td>2.31</td>
<td>0.4</td>
<td>2.32</td>
<td>2.39</td>
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<td>LBB 2.1</td>
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<td>1.24$^4$</td>
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<td>1.26</td>
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<tr>
<td>UBB 3</td>
<td>1.02</td>
<td>N/A$^3$</td>
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<td>IBS 1</td>
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<td>N/A$^3$</td>
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<td>IBS 2</td>
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<td>1.719</td>
<td>0.0104</td>
<td>1.27</td>
<td>0.3</td>
<td>1.274</td>
<td>1.11$^4$</td>
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<tr>
<td>IBS 3</td>
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<td>1.545</td>
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<td>IBS 4</td>
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<td>IBS 5</td>
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<td>0.0104</td>
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<td>0.3</td>
<td>1.22</td>
<td>1.15</td>
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</tbody>
</table>

$^1$From Penland et al., 2000; $^2$From Penland and Ramsey, 1990; $^3$Sites adjacent to deep marsh channels were excluded; $^4$Marsh accumulation rates not calculated for these sites, so not included in corrected yields

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Barataria Bay</td>
<td>$58.3 \times 10^5$</td>
<td>1.5</td>
<td>$80.2 \times 10^5$</td>
<td>$4.2 \times 10^6$</td>
<td>$24.7 \times 10^6$</td>
<td>$7.3 \times 10^4$</td>
<td>$42.5 \times 10^4$</td>
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<tr>
<td>Breton Sound</td>
<td>$62.2 \times 10^5$</td>
<td>1.5</td>
<td>$88.9 \times 10^5$</td>
<td>$5.3 \times 10^6$</td>
<td>$25.9 \times 10^6$</td>
<td>$9.1 \times 10^4$</td>
<td>$44.7 \times 10^4$</td>
</tr>
</tbody>
</table>

from Wilson and Allison, ECSS (submitted)
4. Shelf Sediment Burial

50-60% of input buried

from Corbett, McKee and Allison, CSR (2006)
4. Shelf Sediment Burial

Allison et al., GRL (2007)
4. Shelf Sediment Burial

Allison et al., GRL (2007)
4. Shelf Sediment Burial

Neill and Allison, MG (2005)

~61% of input buried (bay/delta/chenier coast)
5. Inner Shelf Dynamics

Atchafalaya River at Simmesport

DISCHARGE (m³/s)

2003 2004 2005 2006

WINTER FRONTS

0 200 400 600 800 1000 1200

0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000

DISCHARGE (m³/s)

0 200 400 600 800 1000 1200

0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000

Atchafalaya River Mouth
Marsh Island
Atchafalaya Bay
Chenier Plain

SOFT MUD
SAND
CONSOLIDATED MUD
SANDY SOFT MUD
SANDY SHELLY BAY MUD

29.8
29.4
29.0
28.6

-93 -92.6 -92.2 -91.8 -91.4 -91

FEWATER BAYOU
Marsh Island
Atchafalaya Bay
Atchafalaya River Mouth

UF Tripod
Tulane Tripod

SEAWARD LIMIT OF MUDDY SUBAQUEOUS DELTA

PROXIMAL
DISTAL

% OF SAMPLE

0 20 40 60 80 100

% SAND
% SILT
% CLAY

PROXIMAL
DISTAL

DEPTH IN CORE (cm)

0 50 100 150 200 250

0 20 40 60 80 100

% SAND
% SILT
% CLAY

Kasten Core X-radiographs (bright=coarse)

AS-1
AS-4

Basal Shell Hash
Prodelta Layer
Early Phase (shelly/sandy)
5. Inner Shelf Dynamics

Maximum Backscatter Intensity

Jaramillo et al., JGR (submitted)
5. Inner Shelf Dynamics

Corbett et al., CSR (2004)
6. Hurricanes and the Shelf

Atchafalaya River Mouth
Marsh Island
Atchafalaya Bay
Chenier Plain

Allison et al., CSR (2005)

VOLUME
160 million tons

Seismic Limit of Subaqueous Delta
6. Hurricanes and the Shelf

Table 1. Estimates of total mass accumulation of sediment, organic carbon and nitrogen on the seabed due to the combined Rita and Katrina events in contrast to annual inputs by rivers and regional primary production.

<table>
<thead>
<tr>
<th></th>
<th>Sediment</th>
<th>Organic Carbon</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rita/Katrina Accumulations (g)</strong></td>
<td>$1.16 \times 10^{15} \pm 1.56 \times 10^{14}$</td>
<td>$1.36 \times 10^{13} \pm 2.46 \times 10^{12}$</td>
<td>$1.56 \times 10^{12} \pm 2.5 \times 10^{11}$</td>
</tr>
<tr>
<td><strong>Annual Inputs (g/y)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined Mississipi/Atchafalaya Rivers</td>
<td>$2.16 \times 10^{14}$</td>
<td>$3.62 \times 10^{12}$</td>
<td>$3.96 \times 10^{11}$</td>
</tr>
<tr>
<td>Regional Net Primary Production</td>
<td></td>
<td>$1.05 \times 10^{13} \pm 3.82 \times 10^{12}$</td>
<td>$1.74 \times 10^{12} \pm 6.36 \times 10^{11}$</td>
</tr>
<tr>
<td><strong>Non-Hurricane Accumulations (g/y)</strong></td>
<td>$1.18 \times 10^{14}$</td>
<td>$1.17 \times 10^{12}$</td>
<td>$1.40 \times 10^{11}$</td>
</tr>
</tbody>
</table>

Seabed accumulation rates account for the porosity values measured in storm and non-storm deposits. Estimates of annual inputs (river discharge and primary productivity) and of non-hurricane accumulations are from Gordon and Goni, 2004.
6. Hurricanes and the Shelf

Hurricane Katrina (2005)

DARK = COARSER GRAINED
Modern Shoreface-Inner Shelf Evolution
Galveston Island, Texas

7. Relative Sea Level Rise

Sidescan & Subbottom Seismic

Bathymetry
NOAA (1934) vs. Multibeam (2001)

from Robb, Allison and Dellapenna (2003)