East Coast and Gulf of Mexico Interim Synthesis

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“It is very important to quantify carbon fluxes in coastal margins of the area adjacent to the North American continent, lest regional budgets of carbon on land be misattributed.”
Overview

• Examination of coastal margin contributions to the carbon cycle
  – *Global*
  – *North American*
    • Gulf of Mexico
    • East Coast

• Carbon management-related issues for GMx and East Coast
  – *Watershed nutrient linkages to hypoxia*
  – *Ocean acidification*
  – *Wetlands loss*
  – *Coastal margin atmospheric boundary conditions*

• Status of coastal synthesis activities

• Gulf Intensive Experiment?
Land
Carbon Management
Land Use Practices
Forest Management
Agriculture, Fertilizer
GHGs
Energy and Biofuels
Development

• Decision Support Issues Related to Carbon Management
• Basis for a Gulf Intensive Study?

Coastal Margin
Nutrients and Hypoxia
Ocean Acidification
Wetlands Loss
Coastal Restoration
Water Quality
Fisheries Habitat
Sea Level Rise

Ocean Carbon Reservoir
Carbon Sequestration?
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Conceptual Model of Ecosystem Processes

Spring/Early Summer (Moderate or Declining Discharge)

Far-field Plume

Biological Pump and Mixing Effects on pCO₂

Near-field Plume

CO₂

Food Web Processes
Remineralization
Photodegradation

Primary Production

Export

Light Penetration

Mixing

Export

Export

Ocean

River
Significance of Coastal Ecosystems to Global C Cycling

- As much as 15-30% of ocean primary production occurs in the coastal margin
- 80-85% of the organic matter burial, primarily near large river deltas
- 90% of the sedimentary mineralization
- 50% of the deposition of calcium carbonate
Significance of Coastal Ecosystems to Global C Cycling

• Global riverine C exports to the ocean approach or exceed 700 Mt C per y (McKee et al., 2003)

• This is a substantial flux between land and ocean ecosystems and comparable to the net atmospheric fluxes of carbon
Significance of Coastal Ecosystems to North American C Cycling

- Riverine exports from the coterminous U.S. are estimated at 30-40 Mt C per y (Pacala et al., 2001), roughly 6-13% of the estimated net carbon uptake by the North American continent.
- Large impact on coastal ecosystem processes.
- Represents only a small fraction of total carbon transport and transformation on margins.
Significance of Coastal Ecosystems to North American C Cycling - GMx

- Of the roughly 30-40 Mt C per y riverine carbon exported from the coterminus U.S., a large fraction (~17 Mt C per y) is exported by the Mississippi and Atchafalaya river systems at what is essentially a point source.

- Shelf export of C to the deep ocean is poorly understood.
Significance of Coastal Ecosystems to North American C Cycling

- SOCCR report identifies North American coastal zones as a net atmospheric source (19 Mt C per y) with large uncertainty.
- Of this, a large sea-to-air flux is attributed to the Gulf of Mexico (14+9 Mt C per year).

This number is based on very small dataset and associated with very large uncertainties (Chavez and Takahashi, SOCCR, 2007).
Recent work has provided more information

EPA survey cruises (data acquired by Wei-Jun Cai, see Poster #188)

http://ocean.otr.usm.edu/~w301130/research/gulfcarbon_new.htm
Satellite-derived $p\text{CO}_2$
(posters # 188)

- Net sink inshore in June and net source offshore
- Source in Sep
• USGS collecting carbon data in Florida coastal waters
  – carbon flux
  – Ocean acidification
July 2007
NOAA
GOMECC cruise

http://www.aoml.noaa.gov/ocd/gcc/GOMECC/
5 Years at a Northeast U.S. Coastal Site - G. of Maine
Vandemark, Salisbury, McGillis, Sabine and many other collaborators

- Rich data set for C monitoring and process studies
- Monthly cruise data (2004-) and daily CO2 buoy obs. (2006-)
- Hourly inshore and offshore surface atmos. CO2 data
- Substantial snowmelt and river discharge

UNH shipboard pCO2 and in situ data at www.cooa.unh.edu and soon at CDIAC

we acknowledge NOAA/PMEL, UMaine, NDBC, USGS
Inner shelf a source and mid- and outer shelf sinks for carbon

Jiang et al., 2008
• Denitrification associated increase in alkalinity (Fennel et al., 2008)

Simulated (a) primary production, (b) sediment denitrification and (c) annual alkalinity flux due to denitrification

Poster #182: Carbon Cycle Simulations for the East Coast Continental Shelf of North America (Katja Fennel, Michael Previdi, John Wilkin, Raymond Najjar)
• Mid-Atlantic Bight net export of DOC of 4-7 Mt C per y (Vlahos et al., 2002)

• ~0.8 Mt C per y associated with terrestrial inputs

• DOC an important flux term

Fig. 3. Surface DOC concentrations in μM C for (a) April 1994, (b) March 1996 and (c) August 1996 cruises. Red circles represent station locations. Contours were generated using SURFER version 6 (Golden Software Inc.) using a kriging method.
DOC reservoir in the southern MAB for winter-spring 2005 to 2007

DOC Reservoir = \( \approx 1.2 \times 10^{12} \text{ g C} \)

10-100m, 36° to 39°N, -77 to -74°W

DOC Reservoir = [surface DOC] \times \text{depth} \times \text{pixel width} \times \text{pixel height}

Poster #18: Biogeochemical, Remote Sensing, and Modeling Approaches to Evaluating the Sources and Fates of Dissolved Organic Matter and Particles in the U.S. Middle Atlantic Bight (Mannino et al.)

Gulf of Maine

Poster #179: Land to ocean carbon coupling between the Penobscot watershed and Gulf of Maine (Balch et al.)
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Mississippi River Watershed

Drainage basin encompasses 41% of the lower 48 United States

Largest river basin in North America and third largest in the world

Source: Goolsby et al. 1999. NOAA Coastal Ocean Program Decision Analysis Series No. 17. NOAA Coastal Ocean Program, Silver Spring, MD.
Linkage of Productivity to Nutrient Inputs

- Satellite evidence points towards linkages between high chlorophyll and river outflow (Lohrenz et al., 2008)
Fractional area planted in corn in the 2004–2006

Long term increases in DIN Flux and more recent increase in 2007

Cai and Lohrenz, 2007

Donner S. D., Kucharik C. J. PNAS 2008;105:4513-4518
River N load is main long-term driver of hypoxia

Area of Mid-Summer Bottom Water Hypoxia
(Dissolved Oxygen < 2.0 mg/L)

- d drought
- h hurricane
- no data

Source: N. Rabalais, LUMCON
Coastal Wetlands Loss

- Coastal wetlands loss for the U.S. Atlantic and Gulf of Mexico has averaged 59,000 acres (~24,000 ha) per year between 1998 and 2004, which equates to roughly 5 Mt C per year.

- The majority of this loss is in Florida and Louisiana and is largely due to coastal erosion and development.

- The fate of this carbon is unknown, but a significant portion is exported through the coastal margin.

Coastal Margin as a Boundary Condition for Atmospheric Carbon Flux Estimates

- Predominant prevailing winds carry Gulf of Mexico air masses over much of the continental US and flow outward over the East Coast.
- The Gulf of Mexico is the “intake manifold” and eastern U.S. coast is the “tailpipe” of the continental carbon cycle (after Colm Sweeney and Scott Denning).
Ocean Acidification

NOAA collecting data in deepwater. USGS systematically collecting carbon data in coastal shelf area.
- Coastal acidification by rivers (Salisbury et al. 2008)
- Low aragonite saturation levels near Kennebec River outflow

See Feely et al. talk, Thursday noon
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Coastal Interim Synthesis Activities

- Initiated at July 2008 OCB Meeting in Woods Hole
- Five regions established with leads
  - East Coast and Gulf of Maine – Wei-Jun Cai and Cindy Pilska
  - Gulf of Mexico – Paula Coble
  - West Coast – Simone Alin
  - Arctic – Helmuth Thomas
  - Great Lakes – Galen McKinley
- Wiki: http://coastalcarbon.pbwiki.com/
Gulf of Mexico

- Terrestrial and Coastal Carbon Fluxes in the Gulf of Mexico Scoping Workshop, St. Petersburg, FL, May 2008

- Workshop website and report online
  http://www.whoi.edu/sbl/liteSite.do?litesiteid=23613&articleId=36027
Coastal Synthesis Breakouts

Breakout Session I: Sampling Strategies and Measurements on the East and West Coastal Environments of the US for Carbon Cycling
Chairs: Antonio Mannino, Burke Hales

Breakout Session II: Challenges in Modeling Coastal Ocean Carbon Cycling
Chairs: Marjy Friedrichs, Raymond Najjar

Breakout Session III: Coastal Interim Synthesis Planning Session
Chairs: Paula Coble, Simone Alin
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Sources and Export of nitrogen and organic carbon from land to coastal areas in North America as estimated by DLEM-NE model during 1961-1990 (Liu and Tian, Poster # 95)
Summary and Conclusions

- The Gulf of Mexico and eastern U.S. coastal margins are economically critical regions.
- Substantial fraction of the U.S. population.
- Coastal carbon fluxes represent a significant fraction of total carbon budget.
- Carbon management strategies will have impacts on coastal ecosystems.
- Interdisciplinary land-ocean study of the carbon cycle of North America is needed linking watershed and coastal margins on a larger and more interdisciplinary scale than has been done previously.
More Coastal Synthesis Presentations (coming up next!)

Recent (and Future) Advances in Carbon Cycle Synthesis along the North American Pacific Coast - Simone Alin et al.

Diagnosing carbon dynamics in diverse ocean environments using in-situ optical and remotely-sensed data - Joe Salisbury, Amala Mahadevan, Bror Jonsson, Doug Vandemark, Christopher Hunt, Huijie Xue
Coastal Synthesis Posters

179: Land to ocean carbon coupling between the Penobscot watershed and Gulf of Maine (William M Balch, George Aiken, Andrew Barnard, Thomas Huntington, Christina Orrico, Collin Roesler, Huije Xue)

180: Carbon Fluxes in the Gulf of Mexico – A report on the Ocean Carbon and Biogeochemistry Scoping Workshop on Terrestrial and Coastal Carbon Fluxes in the Gulf of Mexico; St. Petersburg, Florida, May 6-8, 2008 (Paula Coble, Lisa Robbins)

182: Carbon Cycle Simulations for the East Coast Continental Shelf of North America (Katja Fennel, Michael Previdi, John Wilkin, Raymond Najjar)

Coastal Synthesis Posters

186: Variability of carbon sinks and fluxes in coastal ecosystems (Bror Fredrik Jonsson, Amala Mahadevan, Joseph Salisbury)

188: Satellite Assessment of CO2 Distribution, Variability and Flux and Understanding of Control Mechanisms in a River Dominated Ocean Margin (Steven E. Lohrenz, Wei-Jun Cai)

189: Remineralization in the Mid-Atlantic Bight and the Gulf of Maine inferred from climatologies of dissolved oxygen and primary production (Raymond Najjar, Jay O'Reilly)


192: Carbon Measurements in the Gulf of Maine (Douglas Vandemark, Joseph Salisbury, Chris Hunt, Shawn Shellito, Robert Talbot, Ruth Varner, Wade McGillis, Christopher Sabine, Stacy Maenner)

193: The Effects of Land Use on Riverine CO2 Isotopic Signatures in the US Gulf Coast (Fanwei Zeng, Carrie A. Masiello)