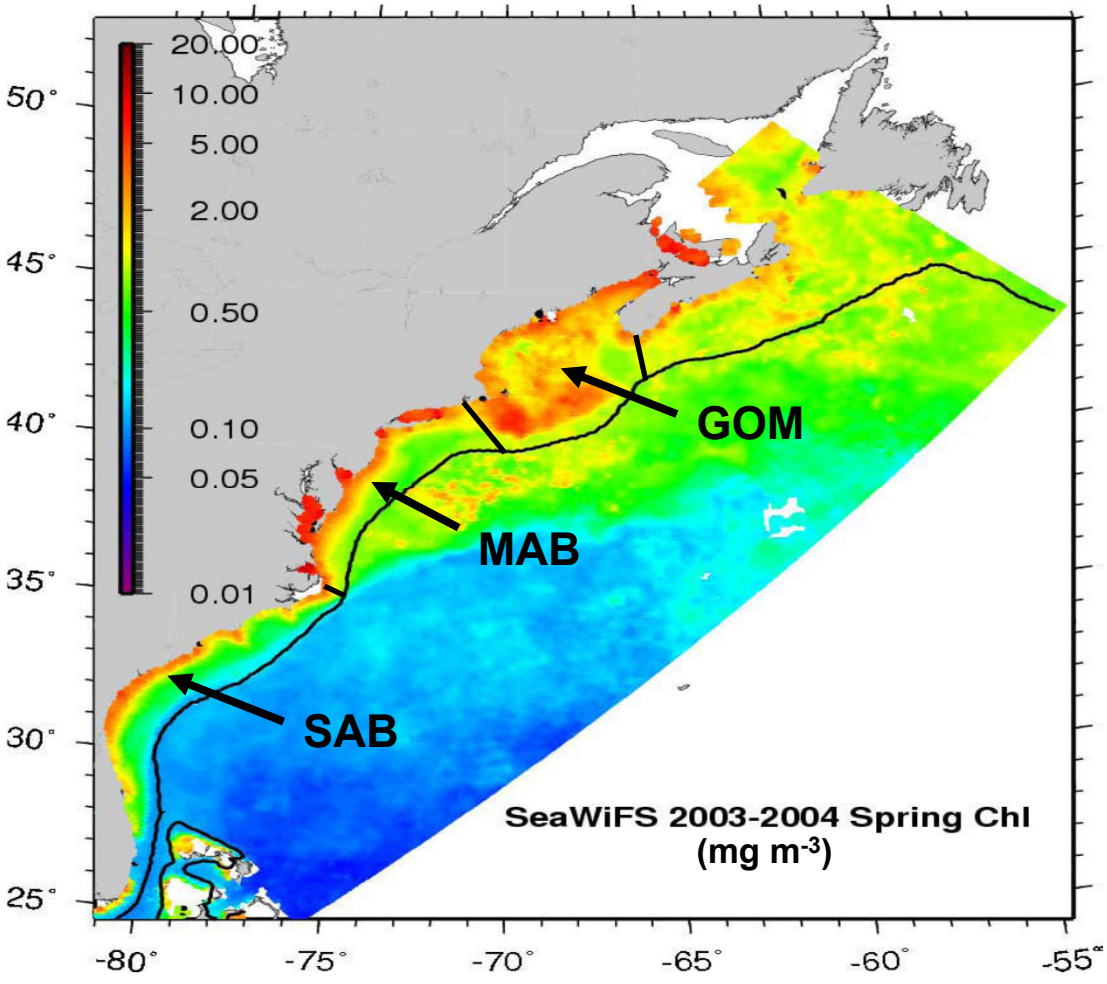
A Timeline of Coastal Carbon Synthesis Activities

- 2005: The North American Continental Margins Workshop
- Spring 2008: OCB Scoping Workshop *Terrestrial and Coastal Carbon Fluxes in the Gulf of Mexico*
- Summer 2008: The birth of the NACP/OCB Interim Coastal Synthesis Activities (with funding acquired from NASA and NSF in 2010-11)
- 2010: Kickoff Coastal Synthesis Workshop
- 2012: The East Coast Carbon Cycle Synthesis Workshop
- 2013: Gulf of Mexico Carbon Cycle Synthesis Workshop
- 2014: Summer Culminating Workshop

East Coast Carbon Cycle Synthesis Workshop

Leads: Marjy Friedrichs (VIMS), Ray Najjar (PSU), Wei-Jun Cai (UDel)

January 19-20, 2012 (Gloucester Point, VA)



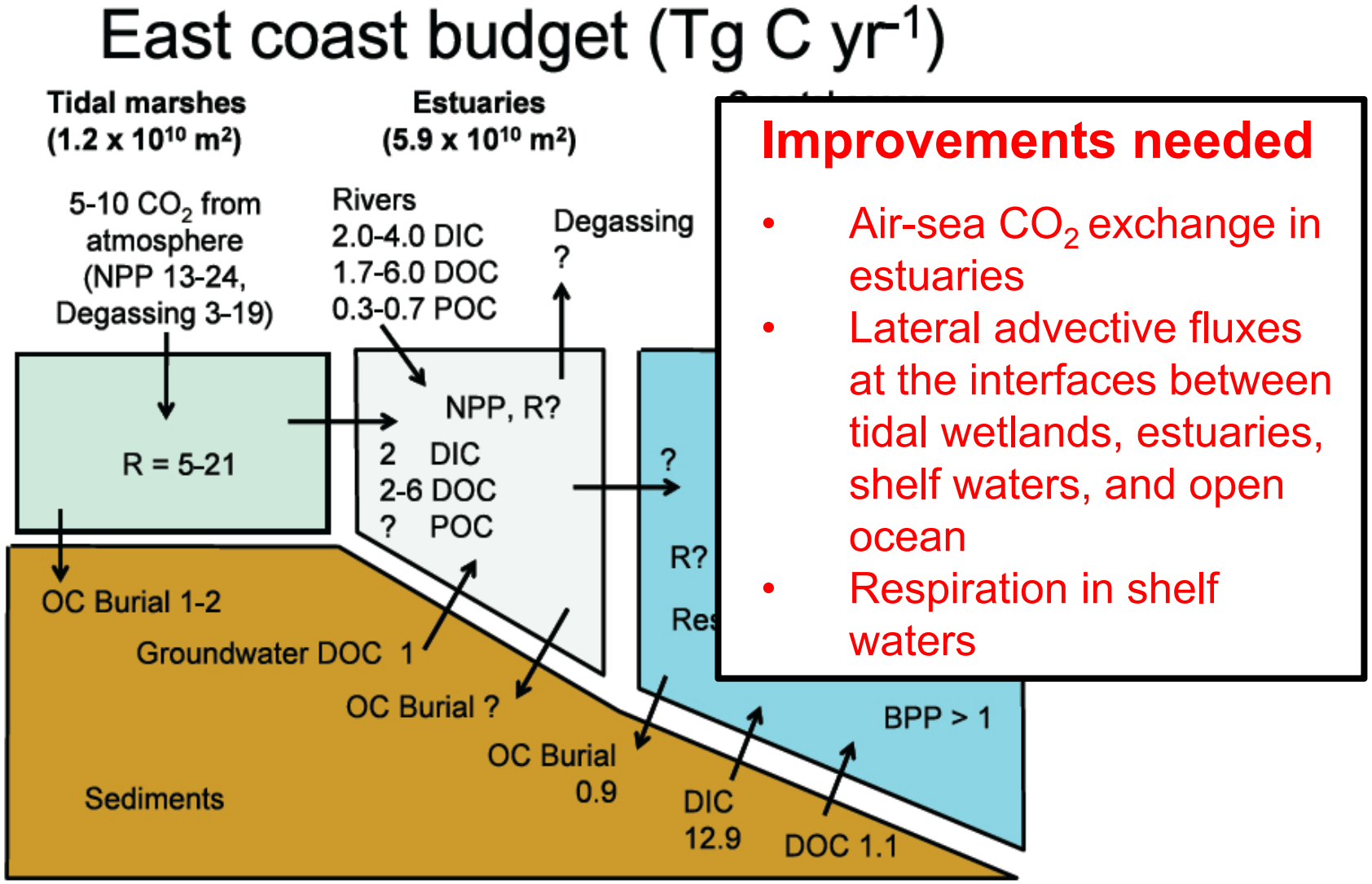
Sub-regions

1. Gulf of Maine
2. Mid-Atlantic Bight
3. South Atlantic Bight

Flux Teams

- Riverine input
- Estuarine fluxes
- Tidal wetland fluxes
- Air-sea exchange
- Sediment-water exchange
- Exchange at the ocean boundary
- Primary production
- Respiration and NCP

Revised East Coast Carbon Budget



Net ecosystem production and organic carbon balance of U.S. East Coast estuaries

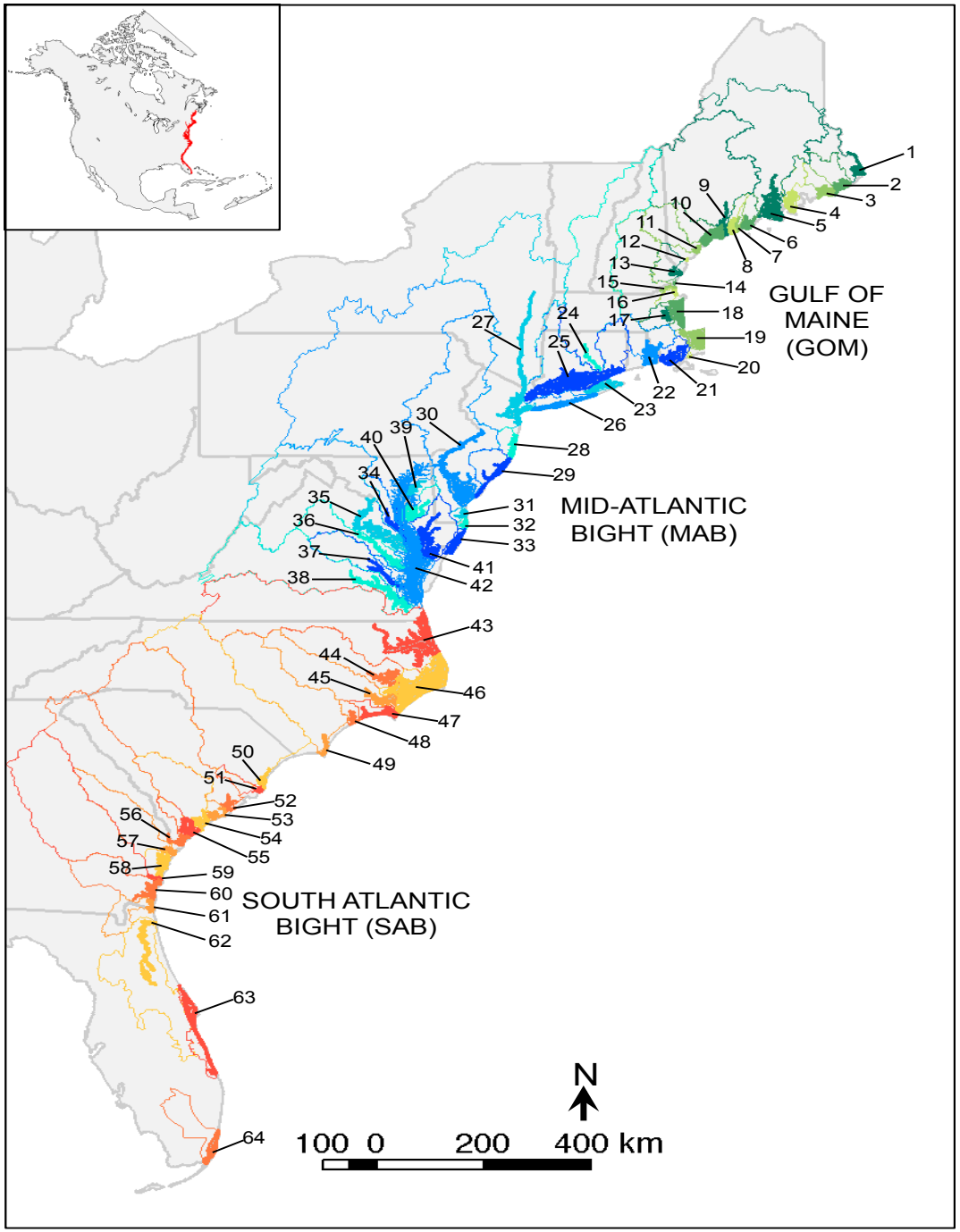
Maria Herrmann, Raymond G. Najjar, W. Michael Kemp, Richard B. Alexander, Elizabeth W. Boyer, Wei-Jun Cai, Peter C. Griffith, S. Leigh McCallister, Richard Smith

(submitted)

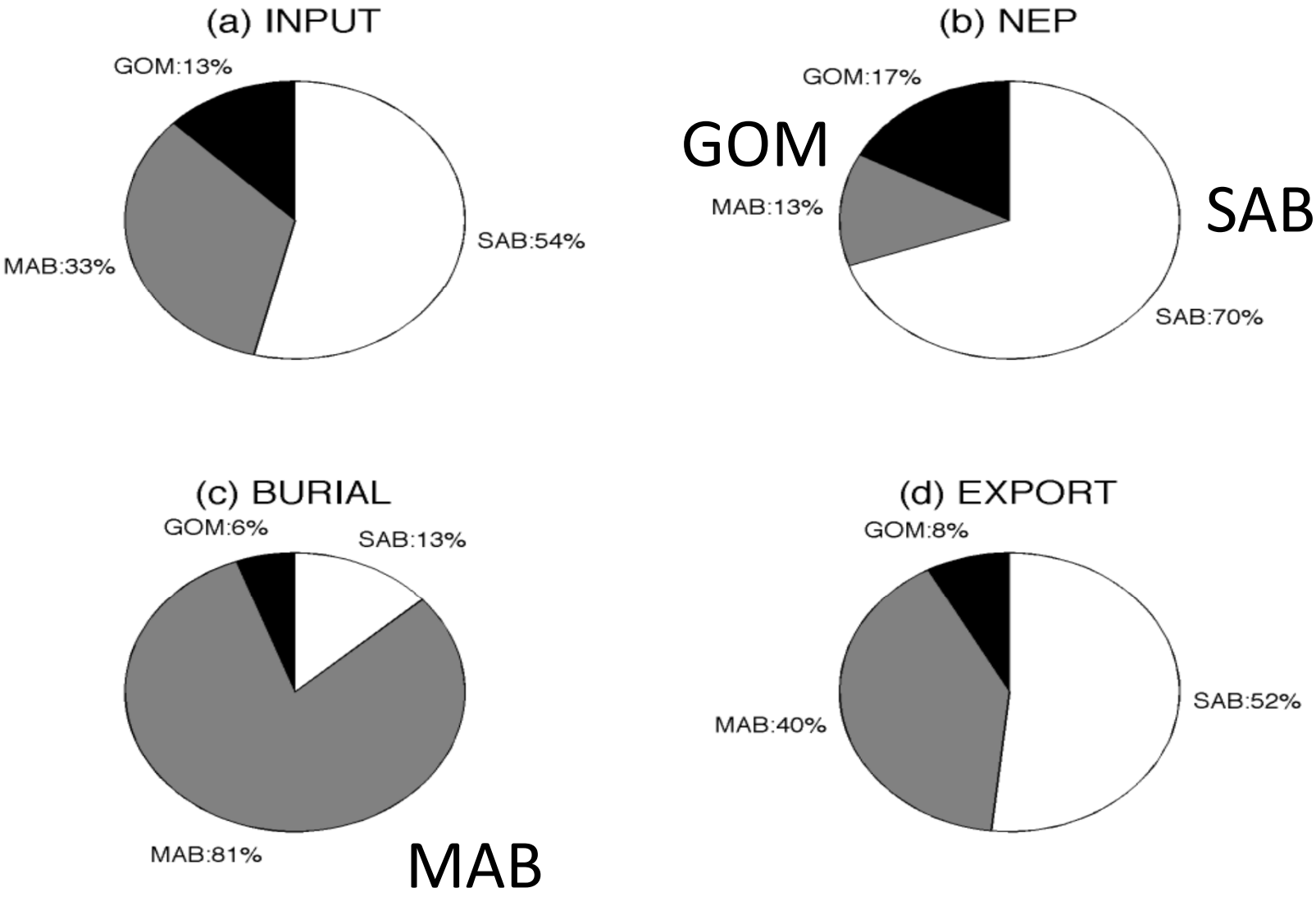
Modelling approach to carbon budget in estuaries:

(to be replicated for Gulf of Mexico)

- relate NEP to riverine loading of DIN:TOC
- relate carbon burial to water residence time
- use SPARROW water quality model to constrain land inputs of OC
- shelf export of OC from difference, assuming steady state.



- 54 watersheds
- Divided into 3 regions


(a) INPUT
GOM:13%
SAB:54%
MAB:33%
(b) NEP
GOM:17%
GOM
MAB:13%
SAB
SAB:70%
(c) BURIAL
GOM:6%
SAB:13%
MAB:81%
MAB
(d) EXPORT
GOM:8%
SAB:52%
MAB:40%

Conclusions

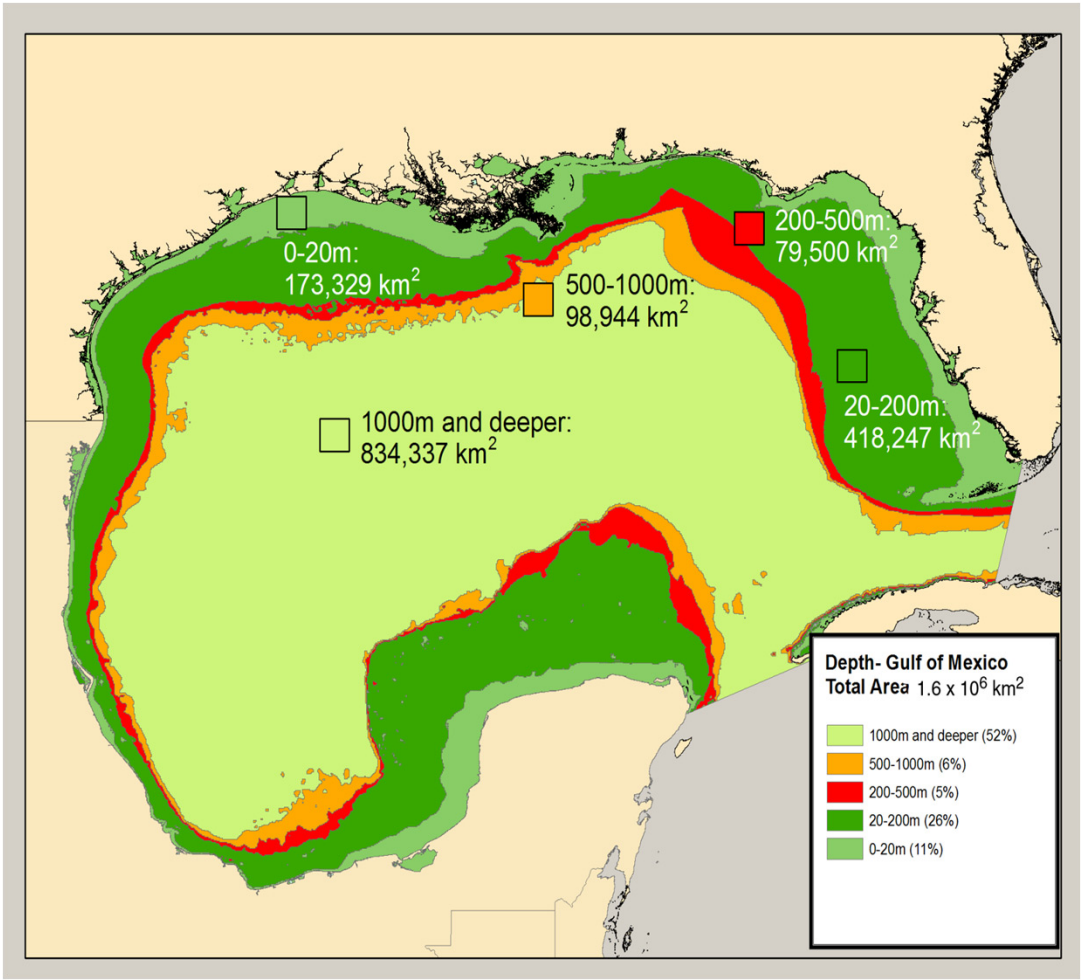
- East Coast estuaries are net heterotrophic
- NEP ~ -1.78 Tg C yr-1
- Area-normalized NEP increases with riverine loading of DIN:TOC

- U.S. East Coast estuarine systems assimilate over 70% of riverine inputs of organic carbon, and allow only about 30% to be exported out to the shelf region.

Gulf of Mexico Carbon Cycle Synthesis Workshop

Leads: Paula Coble (USF) and Lisa Robbins (USGS)

March 27-28, 2013 (St. Petersburg, FL)



Sub-regions

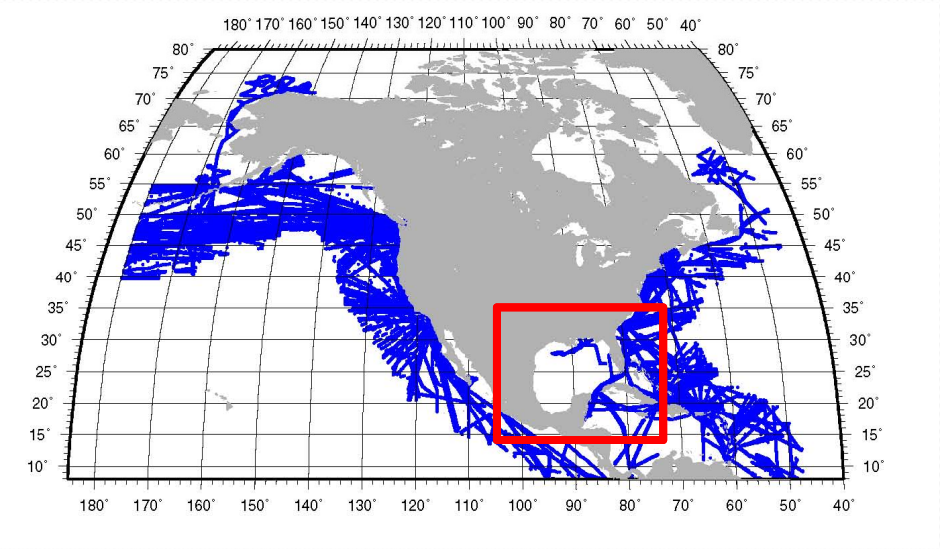
1. 4 coastal regions
2. Open Gulf region

Flux Teams

- Riverine input
- Fluxes in estuaries, sediment water exchange
- Air-sea fluxes
- Cross shelf flux
- Primary production
- Respiration and NCP
- Submarine groundwater discharge

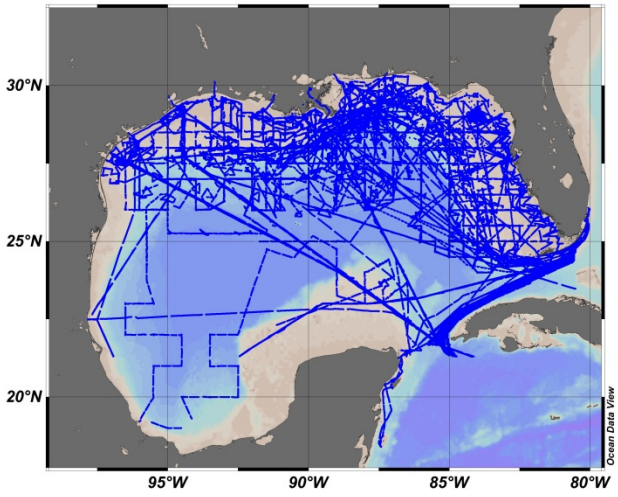
pCO_2 air-sea flux data

Takahashi, 2009
Data up to 2007



Locations where pCO_2 data were obtained around North America as presented in the SOCCR report (Chavez et al., 2007). Note the lack of data in the Gulf of Mexico.

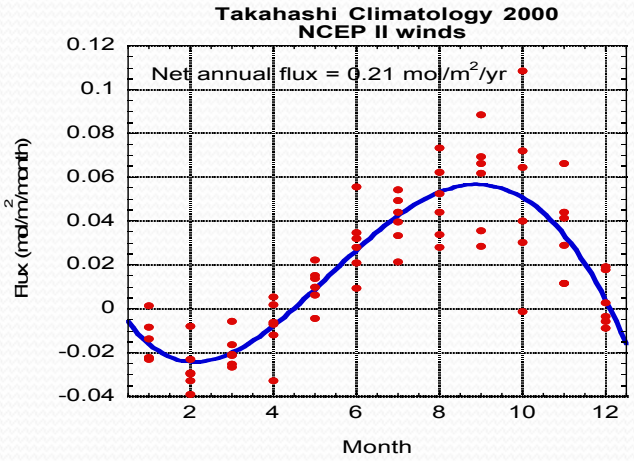
Our newly compiled data, up to 2012



- Over 375+K data points
- Years 1996-2012
- 196 cruises, (more to be added shortly)
- Combined result of Ships of Opportunity and dedicated research cruises

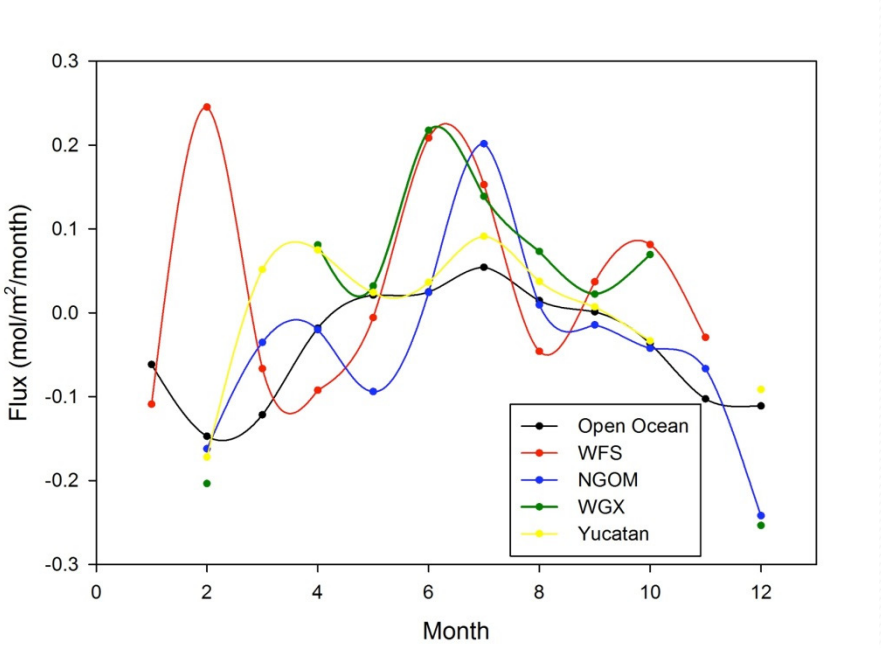
Flux Monthly Variability

The Gulf is a sink with a Net Annual Flux of -0.19 mol C/m²/year
(-3.57 Tg C/year)



Net Annual Flux:
+0.21 mol C/m2/year

-2 cruises
-summer data



Net Annual Flux (including coastal regions):
- 0.19 mol C/m²/year

*p*CO2 Flux Calculations

pCO2

	Flux (molC/m²y)	std	wind source	ΔpCO2	Max ΔpCO2	Min ΔpCO2	N
WFS	0.37	0.11	CCMP monthly avg	16.90	963.80	-240.83	>35K
Northern GOM	-0.44	0.37	CCMP monthly avg	-5.01	2423.51	-333.17	~95K
Western Gulf	0.18	0.05	CCMP monthly avg	18.83	121.04	-115.39	>10K
Mexico- Yucatan	-0.09	0.05	CCMP monthly avg	18.30	390.18	-236.5	~8K
Open GOM	-0.48	0.07	CCMP monthly avg	3.22	407.82	-306.76	>150K
Total	-0.19	0.08	CCMP monthly avg				>300K

Wind product used: CCMP monthly average, binned to 1x1° grid in region 1 (open ocean) and 0.5x0.5° grid in coastal areas (regions 2-5).

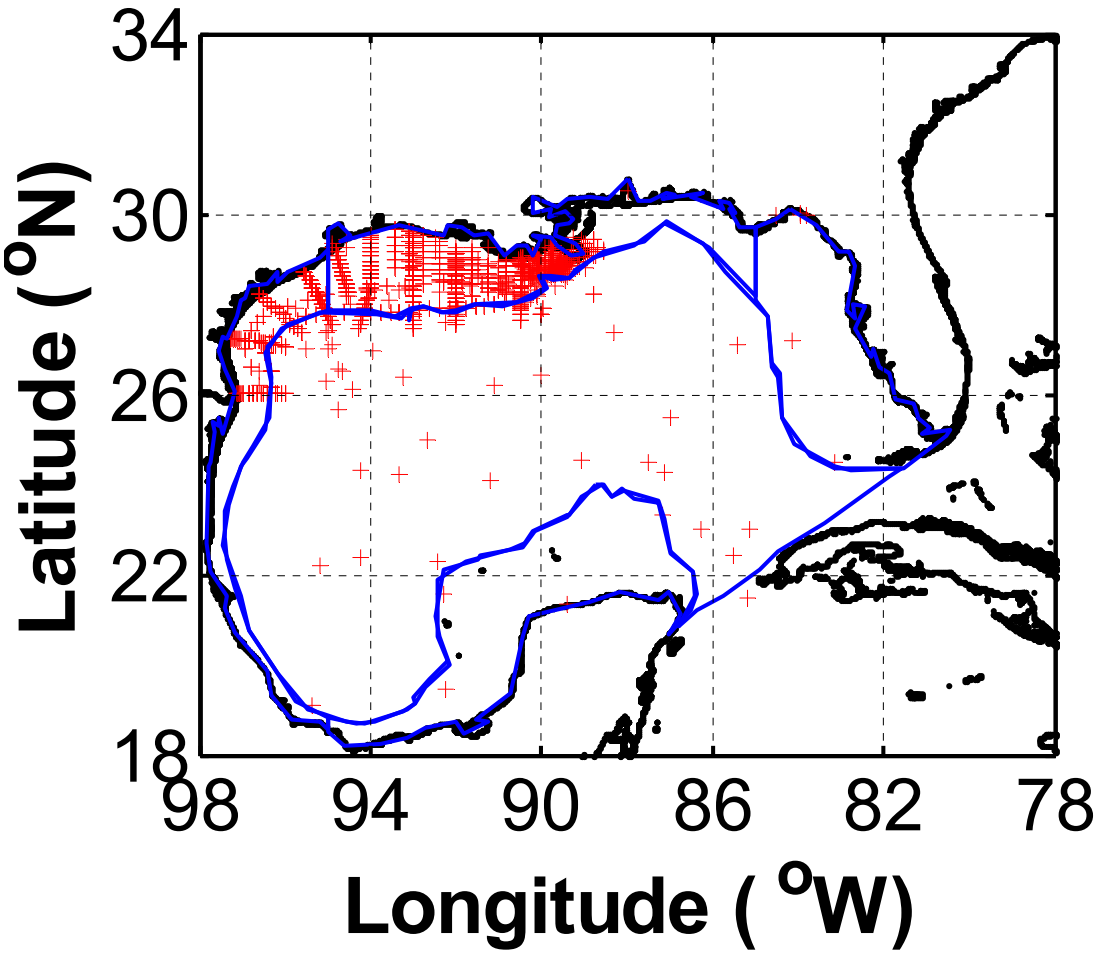
$F=K_0 k \Delta pCO_2$; $k=0.251 \langle u^2 \rangle (Sc/660)^{-0.5}$

Primary Productivity Measurement Types

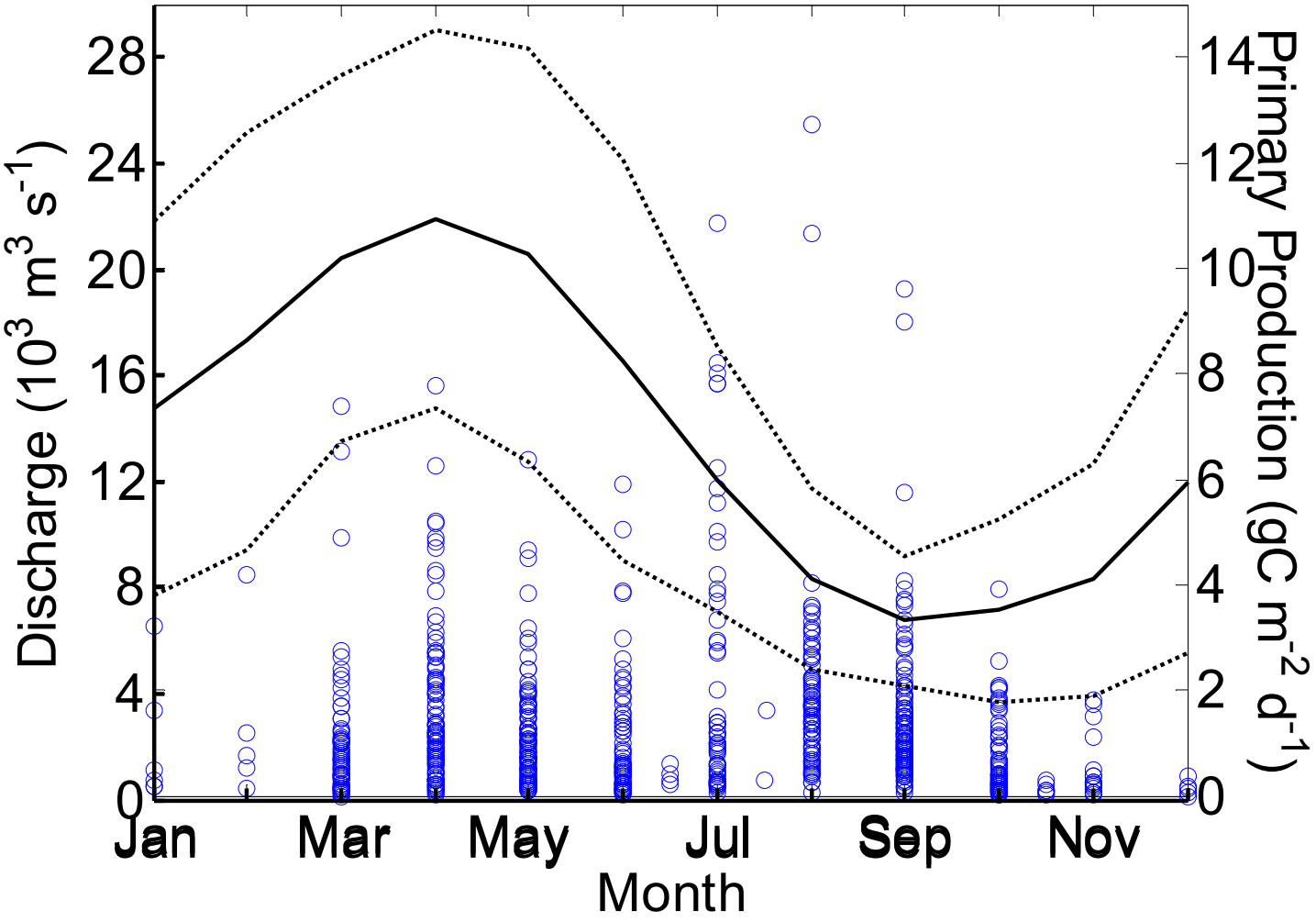
- ^{14}C-based primary production estimates - bottle incubations
- Oxygen-based primary production estimates
- Other (^{13}C, ^{18}O, etc.) – few of these in the Gulf
- Satellite-derived primary production estimates
- Ecosystem models of primary production
- Benthic primary production

Primary Production from Ship-based Studies

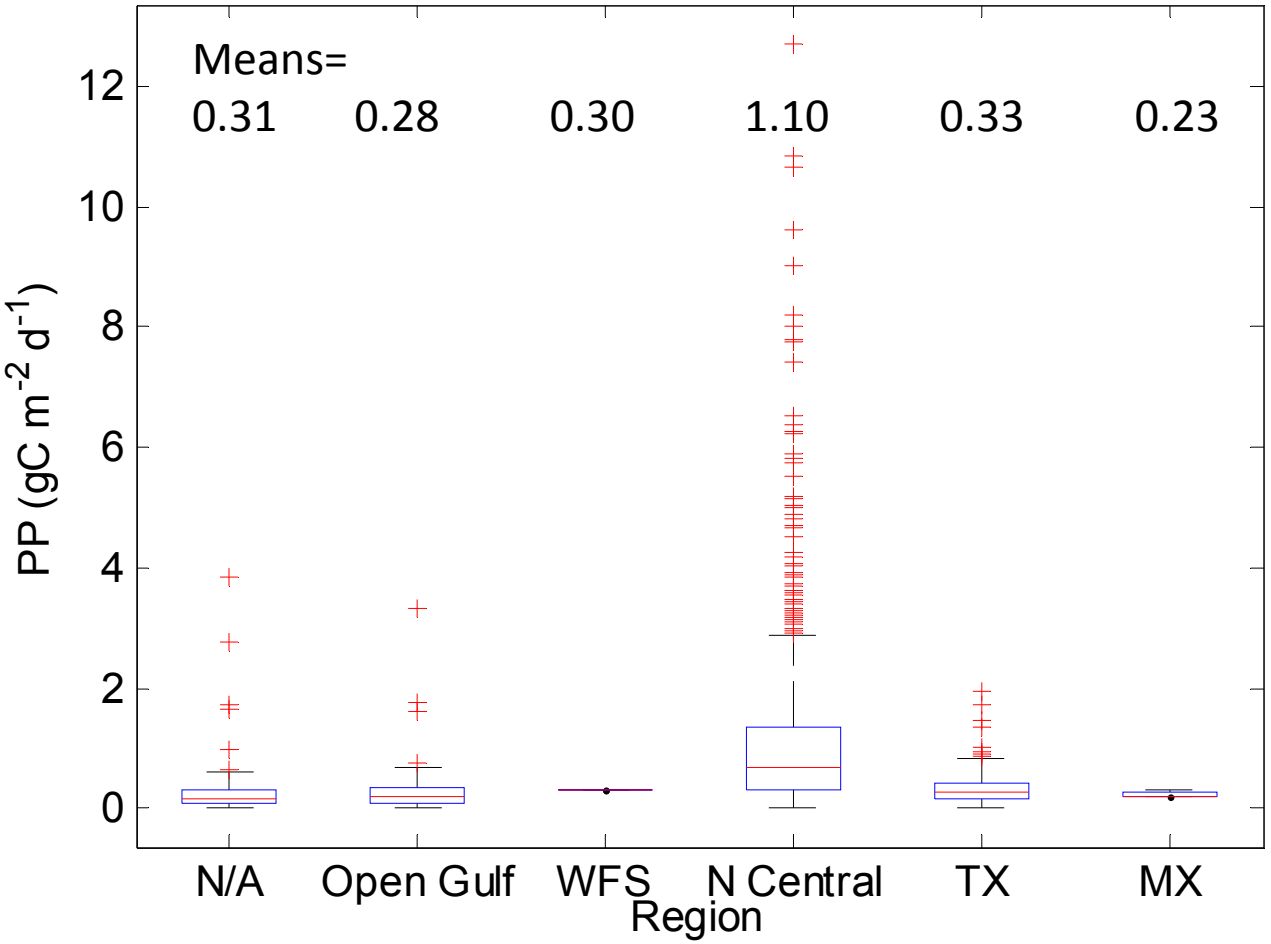
- Mainly concentrated in the north central Gulf
- More data available on the WFS?



Gulf Productivity by Month



Gulf Productivity by Region



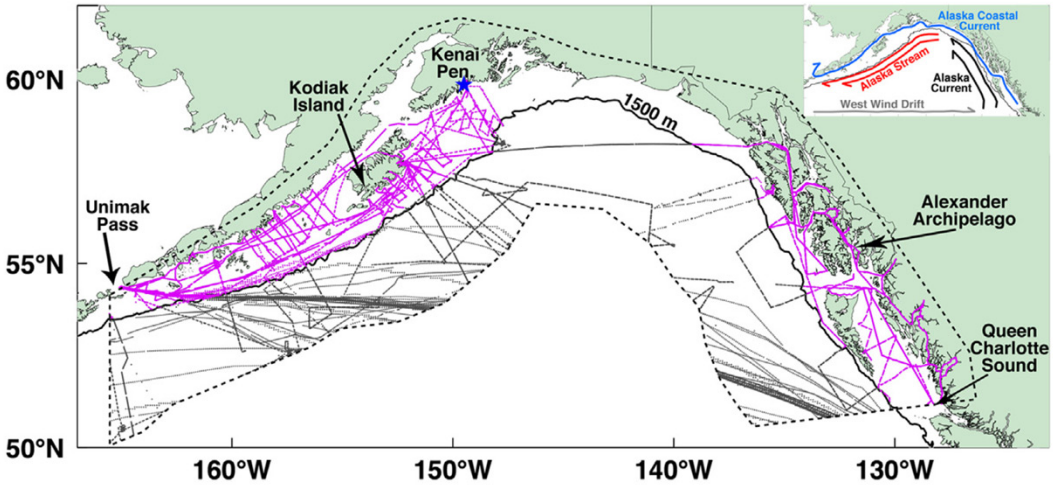
Gulf of Mexico Status

- DIC data are on the wiki, other data will follow
- Draft report nearly complete
- Expect final version release Fall 2013
- Plans to extend East Coast estuary model to Gulf of Mexico

The Gulf of Alaska coastal ocean as an atmospheric CO_2 sink

Wiley Evans and Jeremy T. Mathis, 2013, CSR, 65, 52-63

Compiled dataset of direct surface pCO_2 observations



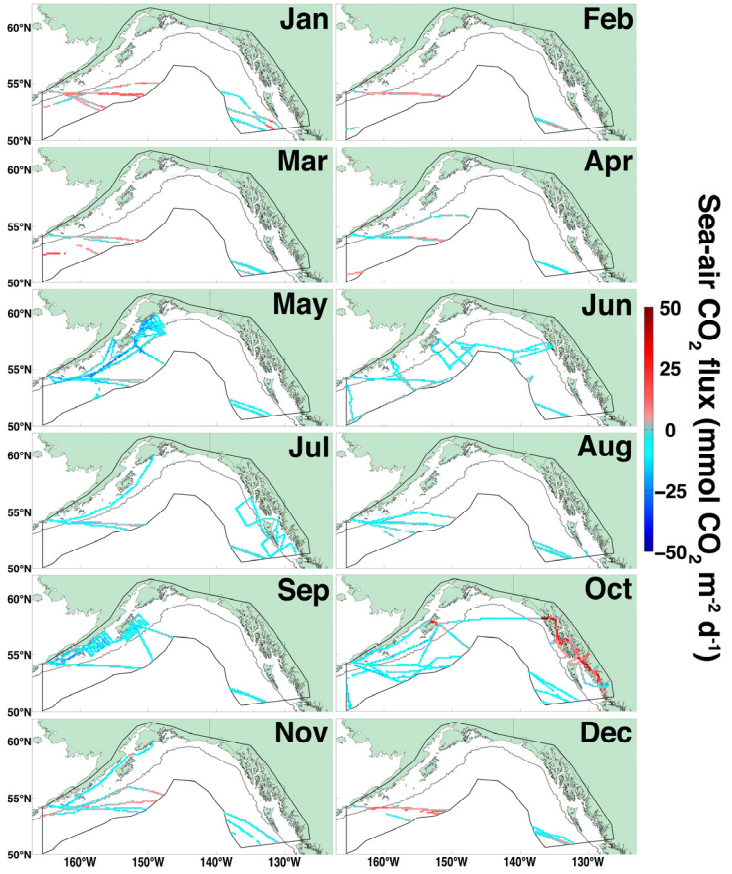
Coastal ocean (80k) vs. continental margin (60k)?

Monthly area-weighted sea-air CO2 fluxes (mmol m^{-2} d^{-1})

Month	Coastal ocean $F_{CO_2(aw)}$		Continental margin $F_{CO_2(aw)}$	
January	3.5	SA = 30 x 10^{11} m^2	3.2	SA = 8 x 10^{11} m^2
February	3.4		3.3	
March	2.0		−0.1	
April	−0.4		−2.2	
May	−10.0		−13.0	
June	−5.2		−12.0	
July	−5.1		−7.0	
August	−4.4		−8.7	
September	−10.4		−12.5	
October	−2.1		3.2	
November	−3.0		−6.1	
December	1.9		4.6	
Annual mean	**−2.5**	➔ **36 Tg yr^{-1}**	**−4.0**	➔ **14 Tg yr^{-1}**

Annual mean fluxes scaled to SA = difference in CO_2 uptake

Sea-air CO_2 flux climatologies:
(1) Reconstructed atmospheric pCO_2
(2) Calculated monthly climatologies of ΔpCO_2, SST, salinity, pCO_2 solubility on 0.1° by 0.1° grid
(3) Couple with monthly wind data from Scatterometer Climatology of Ocean Winds (SCOW; Risien and Chelton, 2008)



Large GOA coastal ocean CO_2 uptake impacts the flux estimate from the North American coastal ocean (Chavez et al., 2007). An updated synthesis is needed.

Bering Sea CO_2 Synthesis, 2008-2012

Cross, J.N., Mathis, J.T., Frey, K.E., Danielson, S., and Evans, W.M., 2013. GRL, in prep

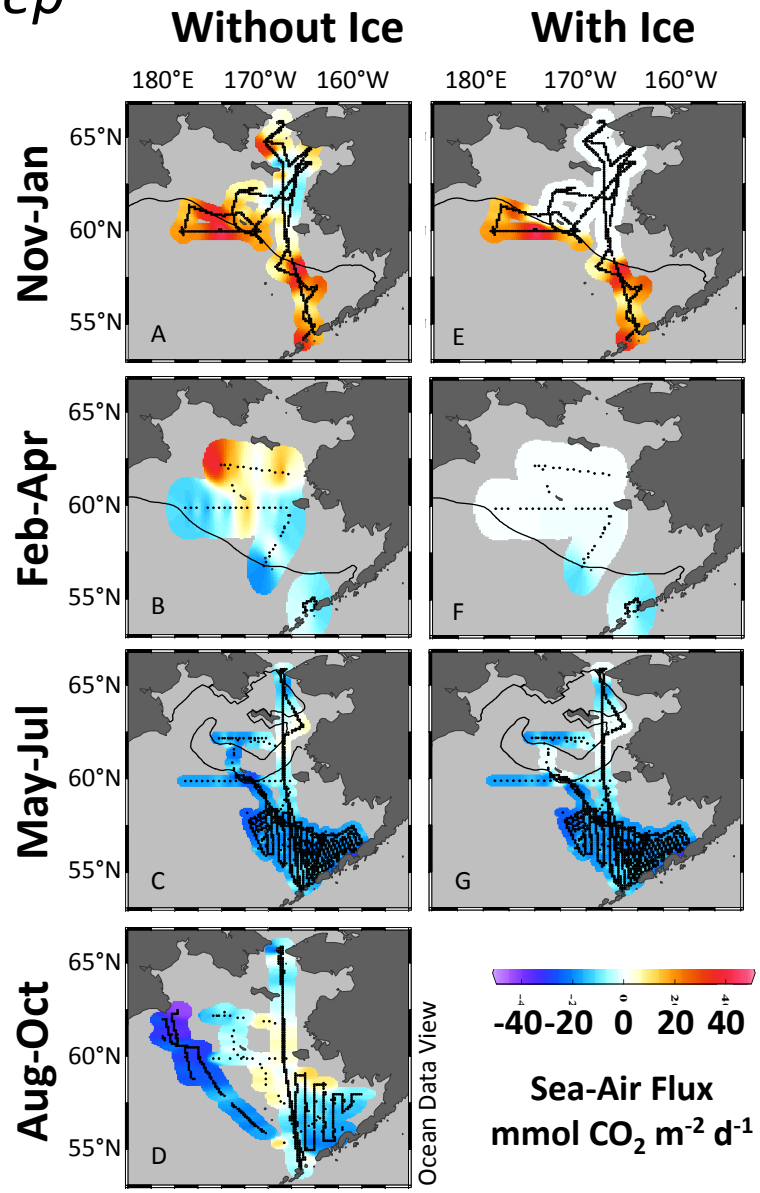
- Recent use of underway pCO_2 systems has enabled **best spatiotemporal data coverage ever available in this region:** underway record + surface CTD samples = data for full shelf during open water and ice-covered seasons

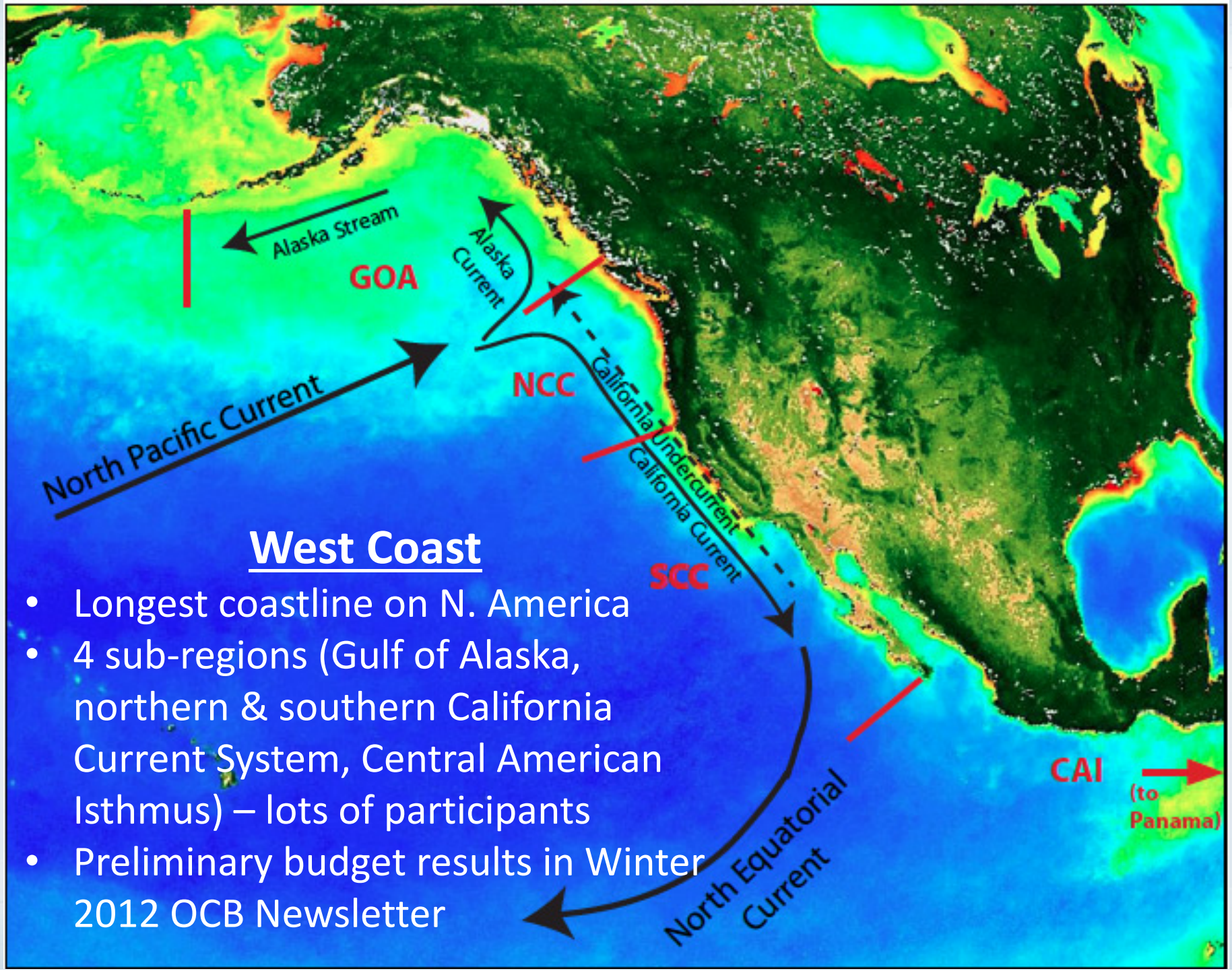
- Assuming ice cover completely prohibits sea-air exchange, **accounting for ice cover increased the size of the annual Bering Sea CO_2 sink by ~26.3%** by blocking CO_2 efflux from the ocean surface layer Nov-Apr

- **Annual shelf-wide CO_2 flux: ~-9.4 Tg C yr^{-1}**

	Study	Bering Sea annual flux (Tg C yr^{-1})
Model	Walsh and Dieterle (1994)	3.4
Data Synthesis	Chen and Borges	11
Climatolc	Tahahashi et al. (2009)	37
Production Season Data	This study	157 ± 35
Production Season Data	Chen et al. (2004)	200

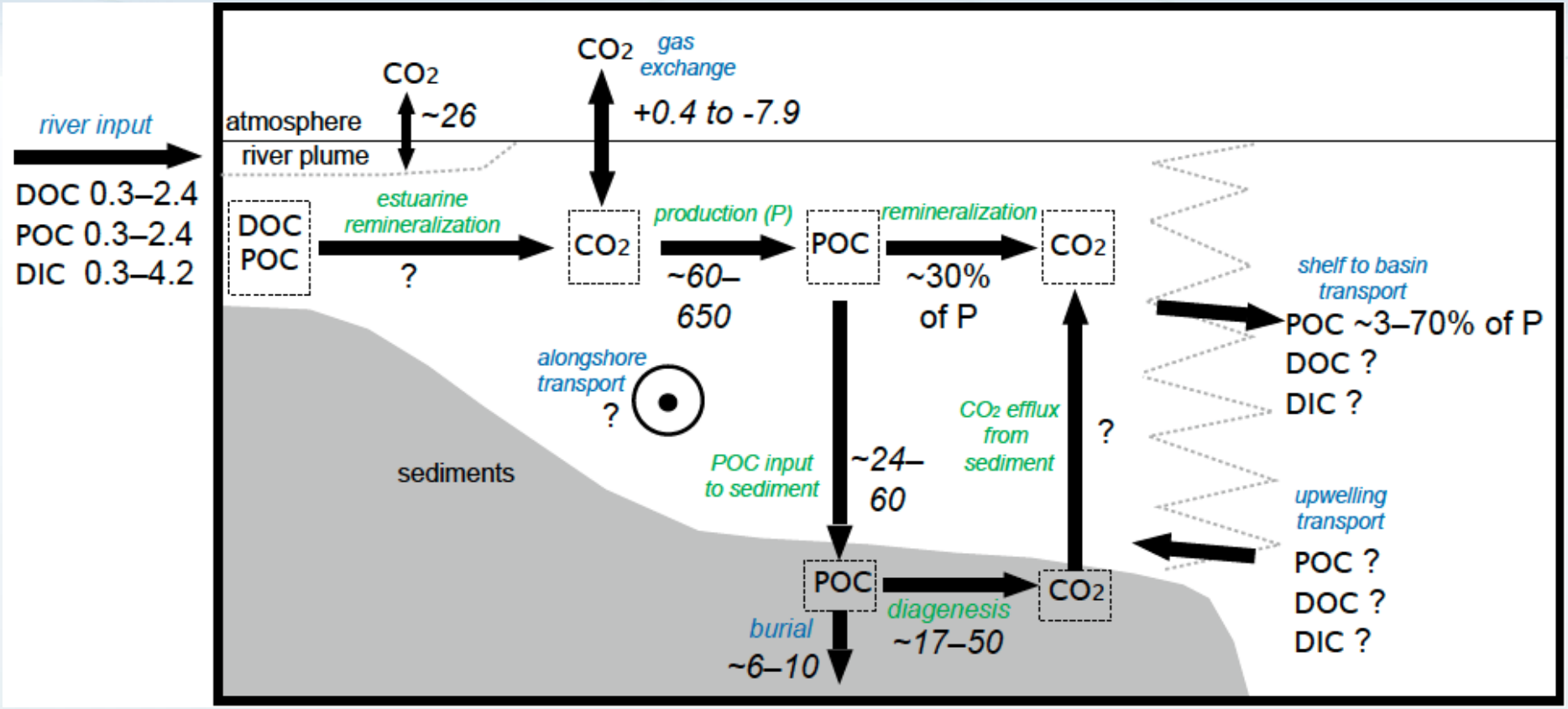
from Bates , 2011





West Coast

- Longest coastline on N. America
- 4 sub-regions (Gulf of Alaska, northern & southern California Current System, Central American Isthmus) – lots of participants
- Preliminary budget results in Winter 2012 OCB Newsletter



Synopsis of preliminary budget

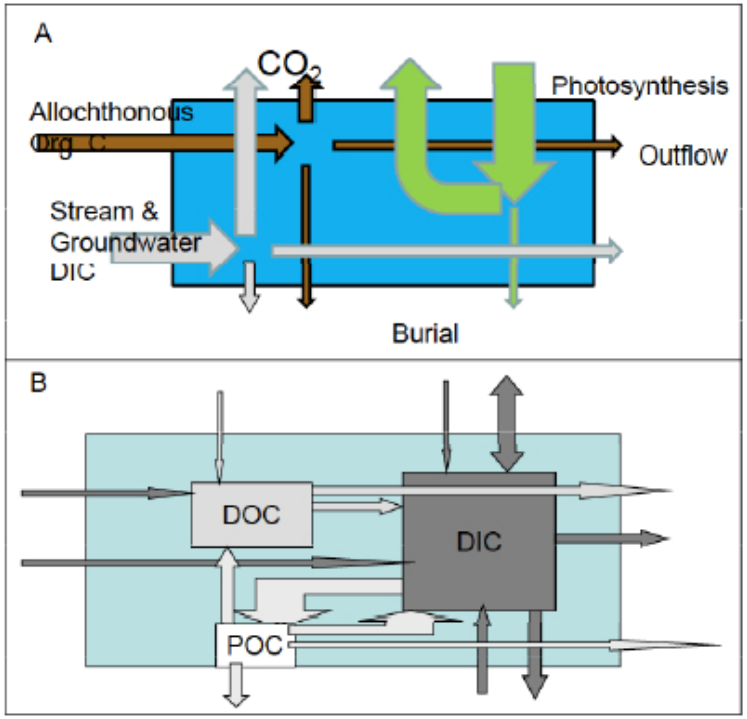
- Preliminary budget spans all four sub-regions.
- Best known fluxes are air-sea flux and terrestrial inputs.
- Least constrained fluxes appear to be remineralization, cross-shelf transport, and carbon metabolism in estuaries.
- Work on-going to fill in the many gaps in preliminary budget.

Laurentian Great Lakes

- Leader: Galen McKinley
- Sub-regions: Progress to date mostly in Lake Superior (most well developed data-modeling approaches)
- Status: To be developed opportunistically as funding allows

Great Lakes Carbon Budget Summary

- CO_2 source = 0.1-10s Tg C/yr (wide range based on model and literature-based estimates)
- Key unknowns: NPP, R (mean values and spatial distribution), surface pCO_2 (temporal evolution)
- Priorities: Surface pCO_2, more winter observations, satellite algorithm development



McKinley et al. 2011; Urban et al. (in prep)

A Timeline of Coastal Carbon Synthesis Activities

For reports, data, and updates:

- http://coastalcarbon.pbworks.com/w/page/15143273/FrontPage

Acknowledgements

- A cast of thousands (actually, hundreds of coastal carbon researchers)
- Funding from NASA and NSF
- Support from OCB and NACP Program Offices