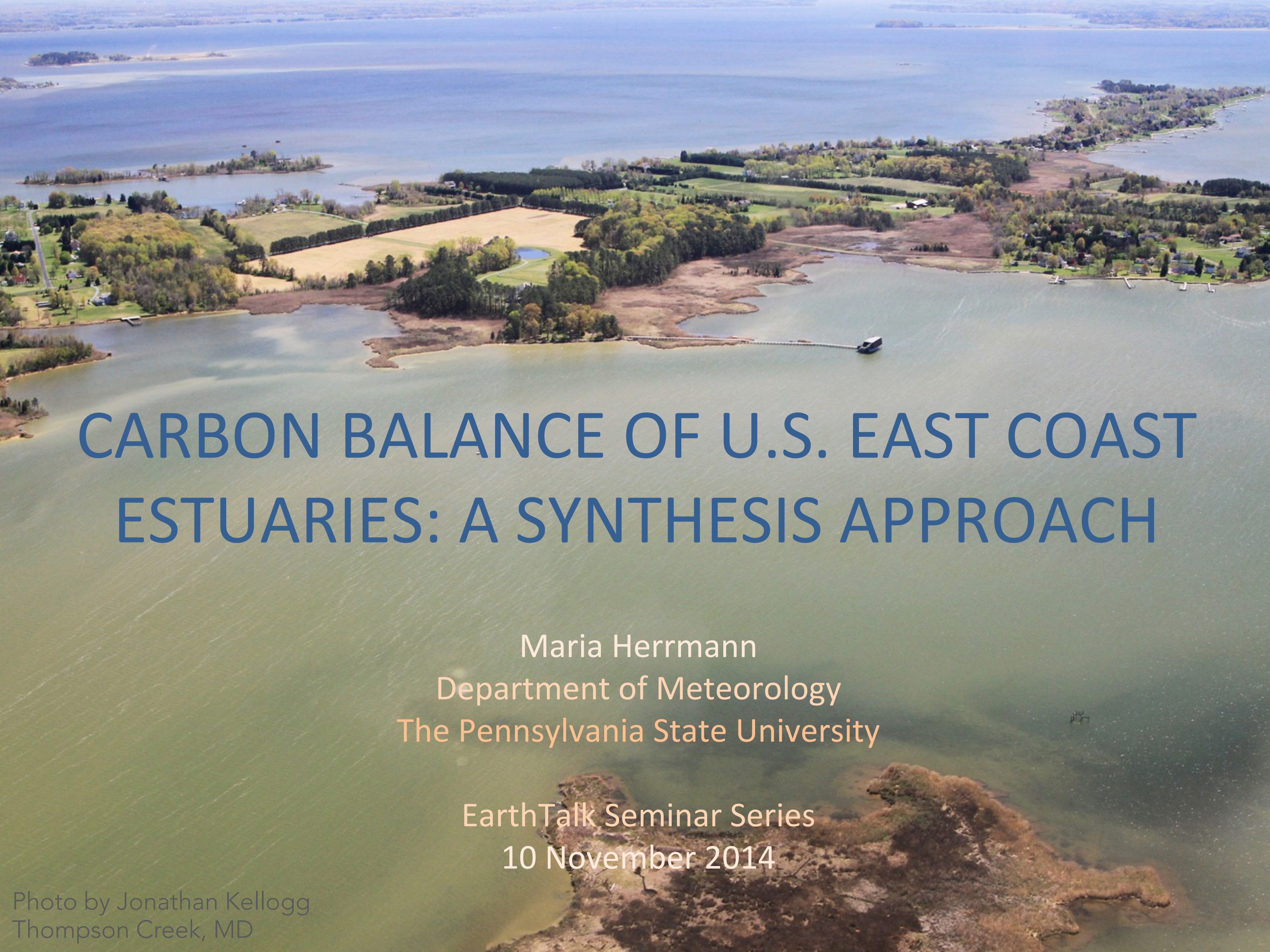

CARBON BALANCE OF U.S. EAST COAST ESTUARIES: A SYNTHESIS APPROACH

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EarthTalk Seminar Series
10 November 2014

Photo by Jonathan Kellogg
Thompson Creek, MD

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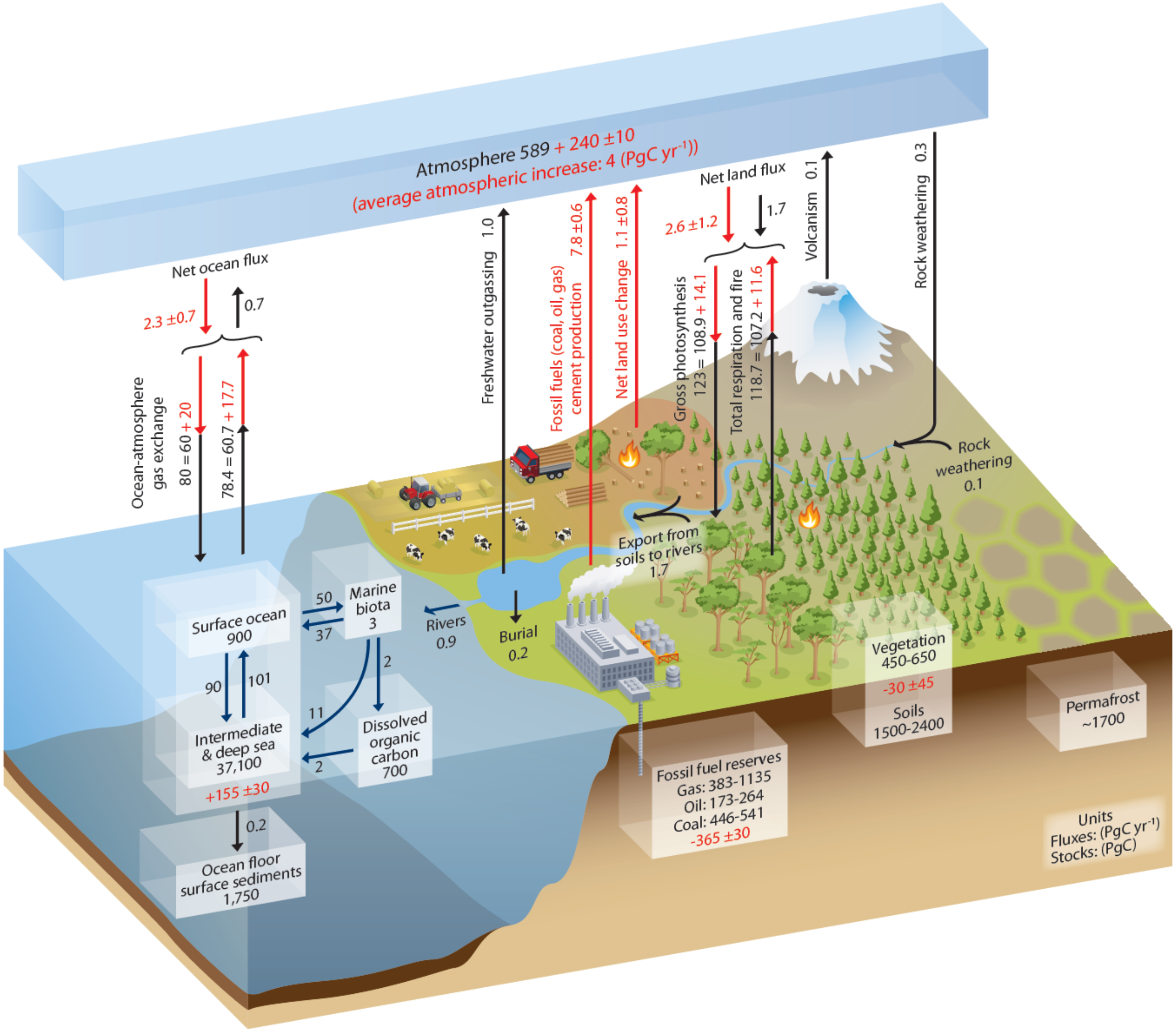
Outline

- Why costal carbon budget?
- Coastal CARbon Synthesis (CCARS) community effort
- TOC and DIC fluxes in U.S. east coast estuaries

TOC = Total Organic Carbon

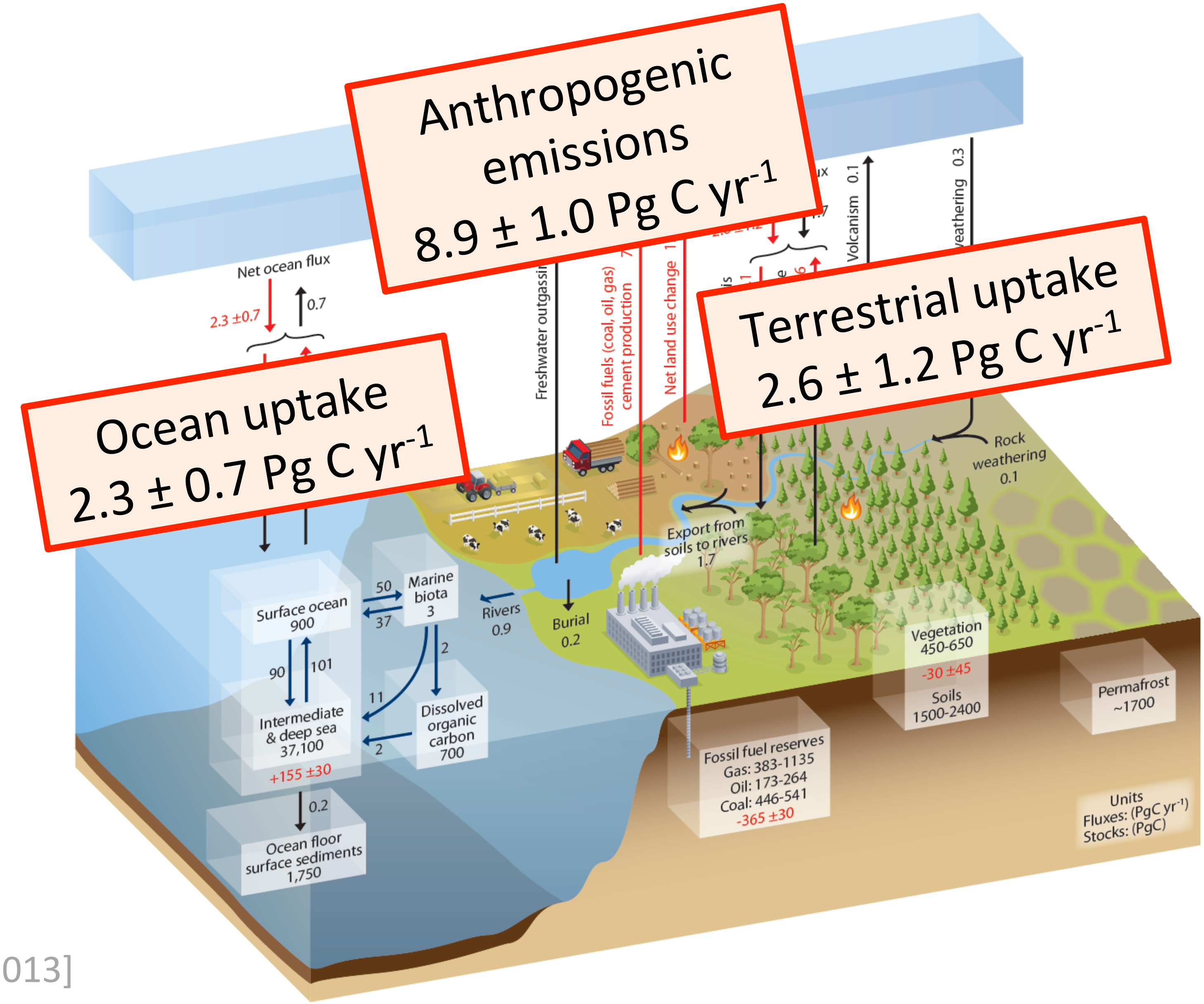
DIC = Dissolved Inorganic Carbon

Role of coastal zone in the global carbon cycle



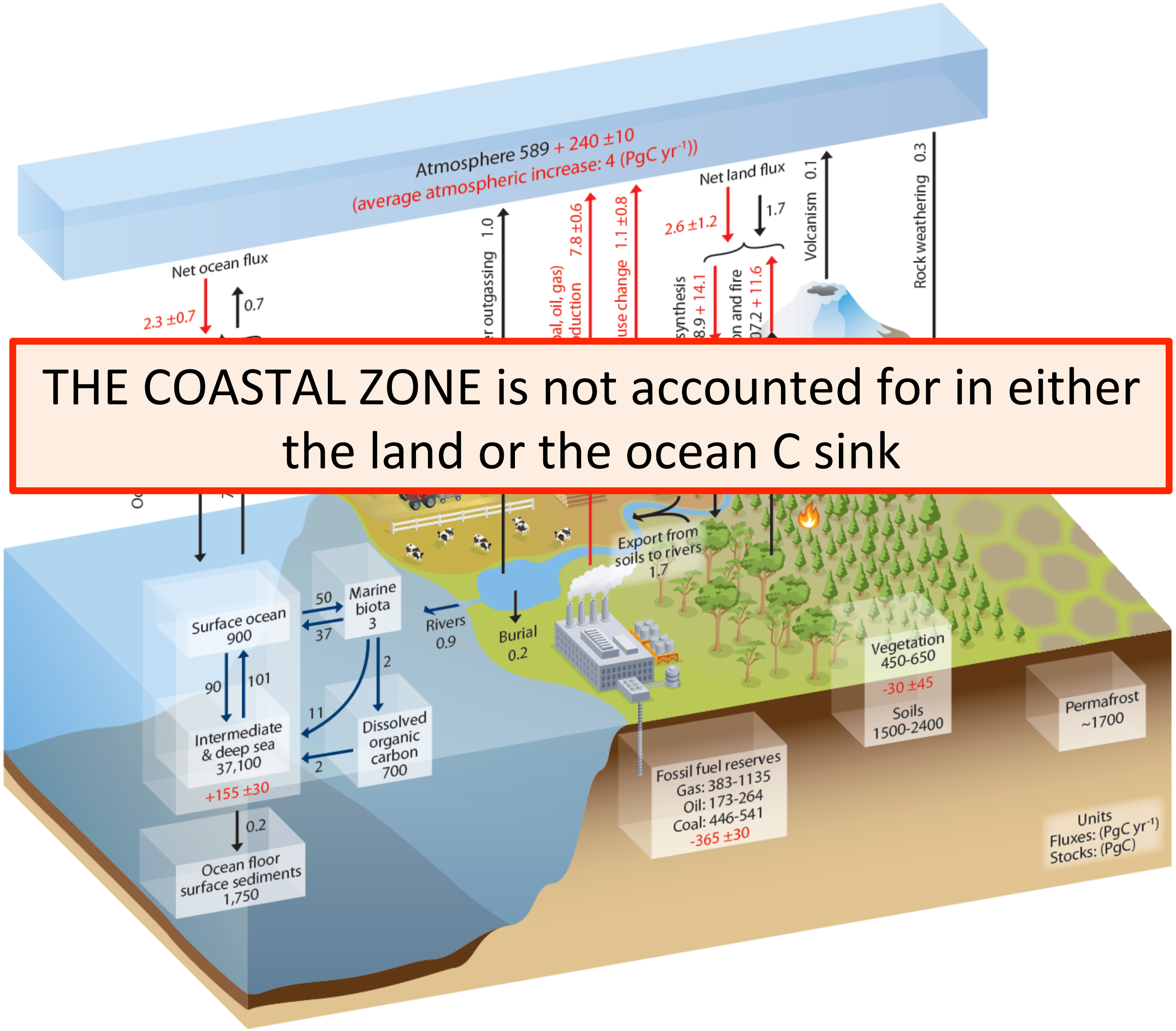
[IPCC, 2013]

Role of coastal zone in the global carbon cycle



[IPCC, 2013]

Role of coastal zone in the global carbon cycle



THE COASTAL ZONE is not accounted for in either the land or the ocean C sink

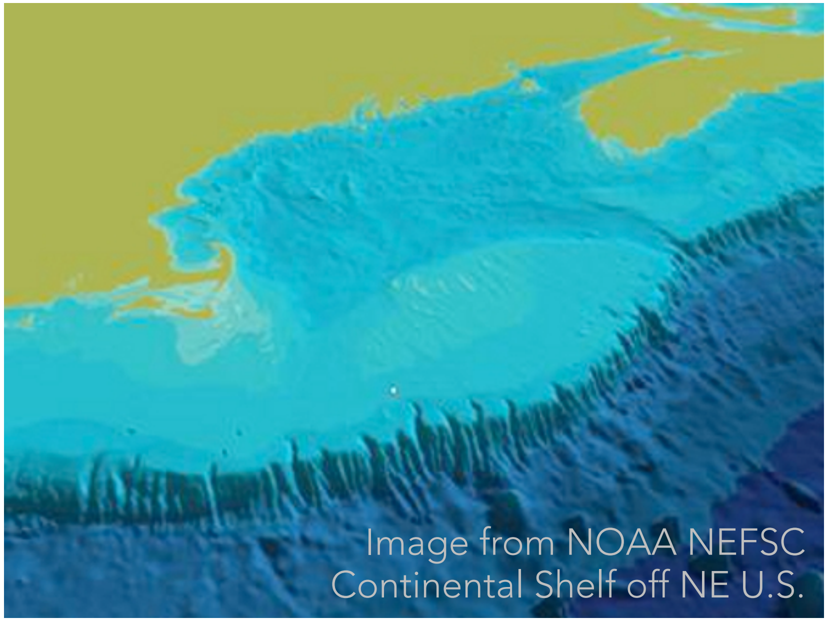
[IPCC, 2013]

Land-ocean continuum …

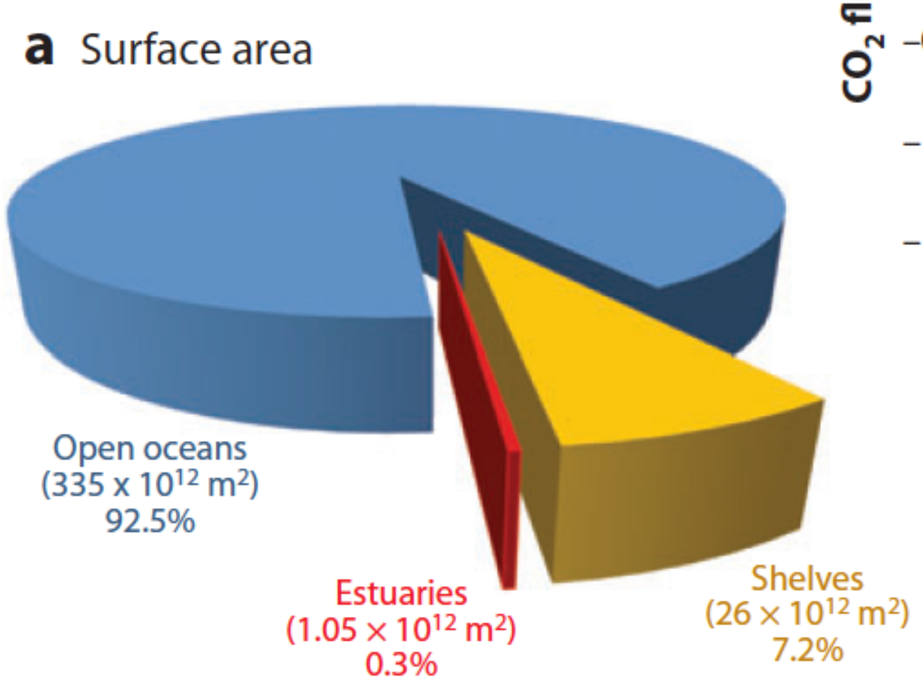
… tidal streams

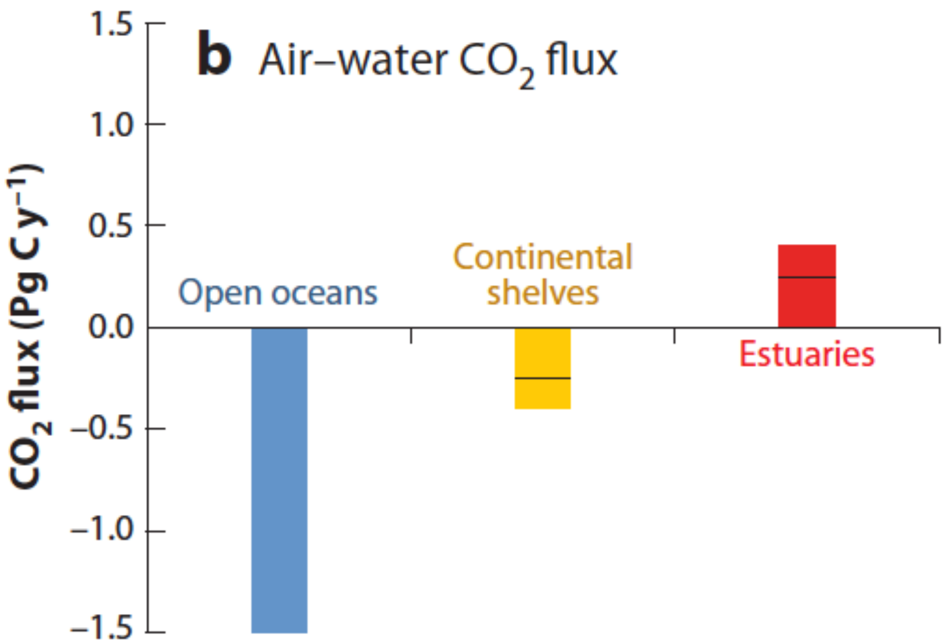
… bays and estuaries

… salt marshes, mangroves, sea grass beds, etc.



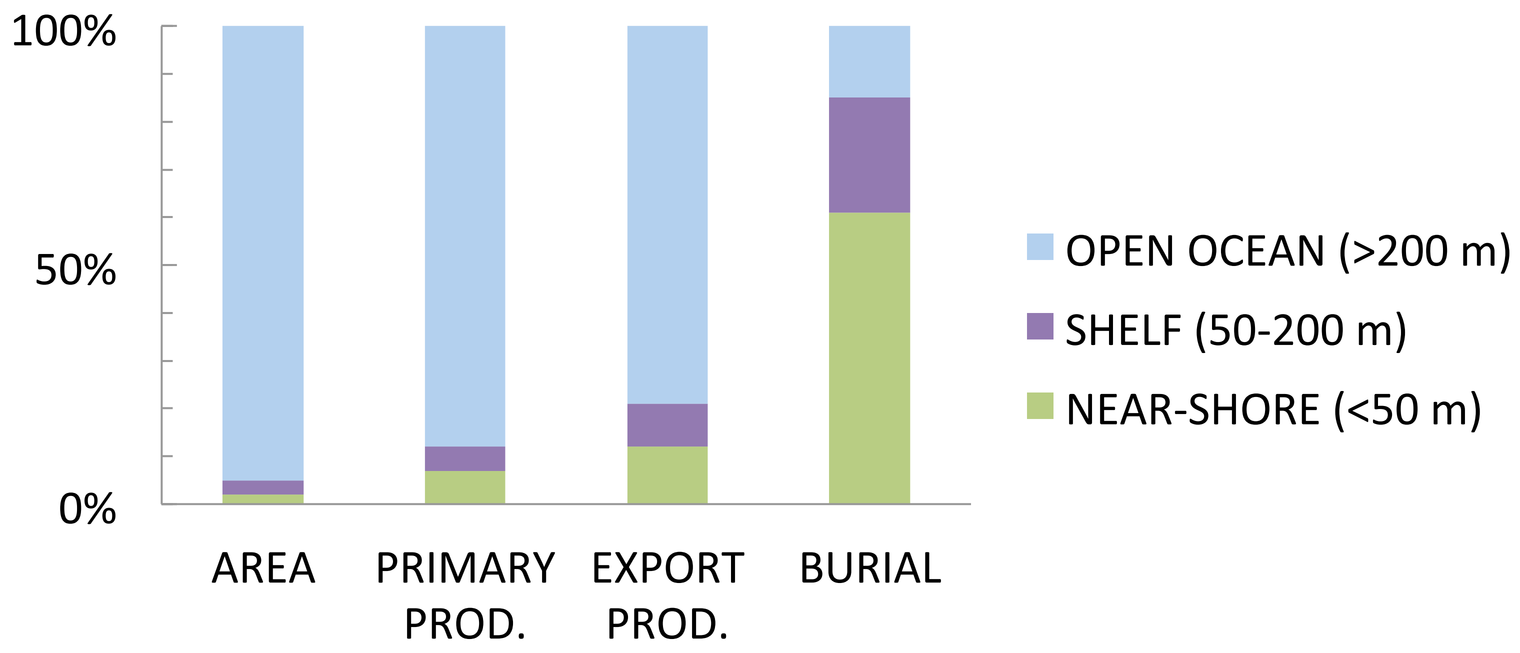
Global synthesis: Cai [2011]





Global modeling: Dunne et al. [2007]

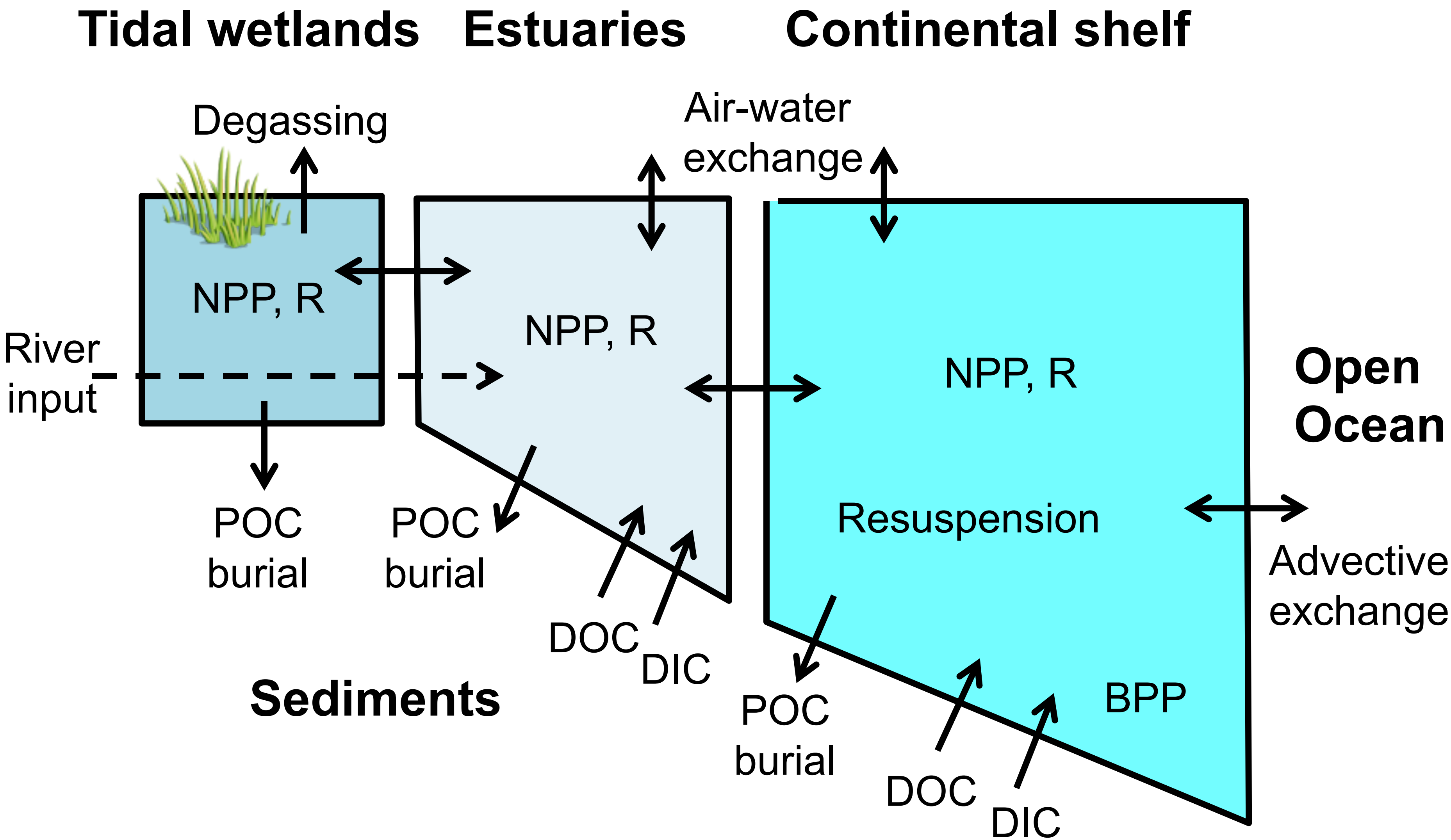
Relative contribution of three depth regions



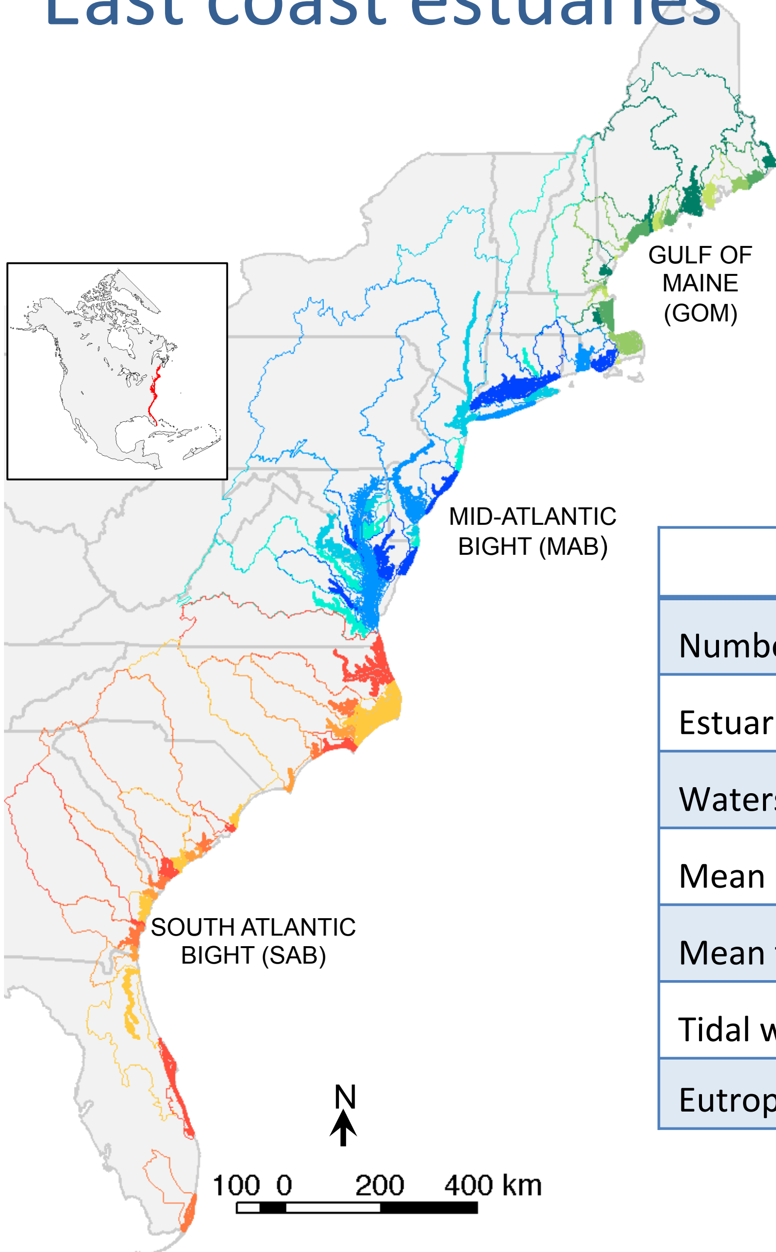
Coastal Carbon Data Synthesis (CCARS) Activity

- A community effort facilitated jointly by the North American Carbon (NACP) Program and Ocean Carbon and Biogeochemistry (OCB) Program
- Overarching goal: synthesis of observational and modeling results on carbon cycle fluxes and processes along the North American continental margins
- Five regions: Pacific Coast, East Coast, Gulf of Mexico, Arctic Ocean, Great Lakes

CCARS control volume approach to coastal C cycle



East coast estuaries

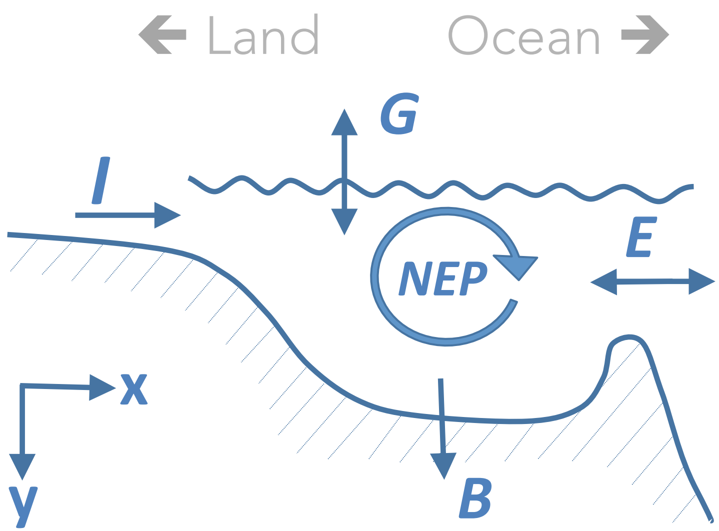


Sources: NOAA's National Estuarine Eutrophication Assessment [NEEA; Bricker et al., 2007] and Coastal Assessment Framework [NOAA, 1985]

	GOM	MAB	SAB
Number of estuaries	19	13	20
Estuarine area (10^3 km^2)	5	20	12
Watershed area (10^3 km^2)	86	297	331
Mean estuarine depth (m)	21	8	3
Mean tidal height (m)	3	0.9	0.6
Tidal wetland area (10^3 km^2)	0.4	3.1	6.7
Eutrophication status	lowest	highest	moderate

A box-model approach

- "BOX" = open water of estuary



STEADY STATE MASS BALANCES

TOC: $0 = I_{TOC} + NEP - B - E_{TOC}$

DIC: $0 = I_{DIC} - NEP - G - E_{TOC}$

BOUNDARY FLUXES

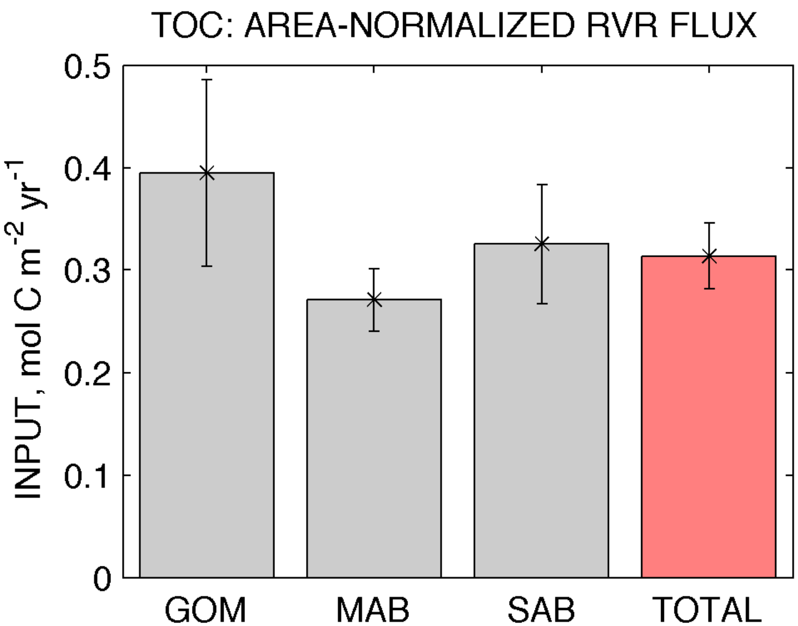
- Input across estuary-land boundary (*I*)
- Estuary-atmosphere exchange (*G*)
- Burial in the sediment (*B*)
- Estuary-coastal ocean exchange (*E*)

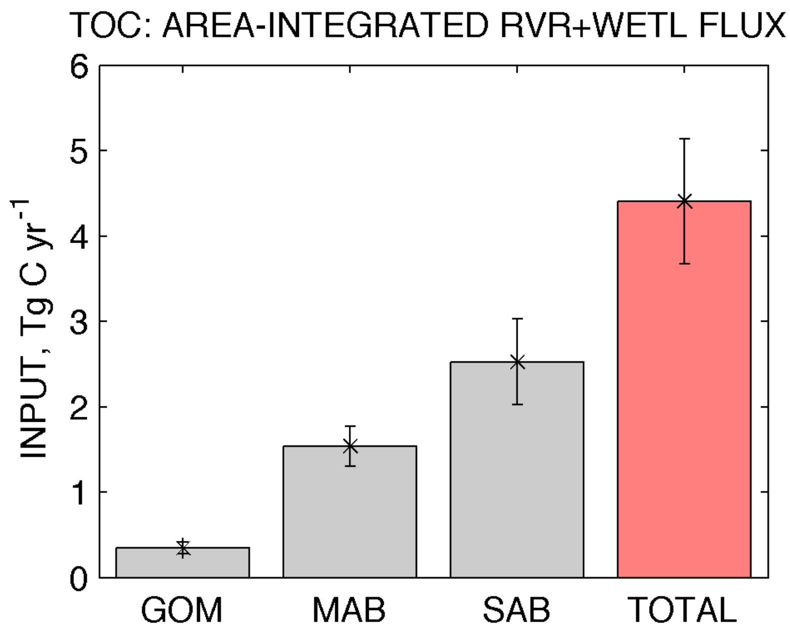
INTERNAL PROCESSES

- Net Primary Production (*NPP*)
  source of TOC, sink of DIC
- Heterotrophic respiration (*R*)
  source of DIC, sink of TOC
- *COMBINE*: Net Ecosystem Production
  $NEP = NPP - R$
  source of TOC, sink of DIC

TOC Input across the landward boundary (I_{TOC})

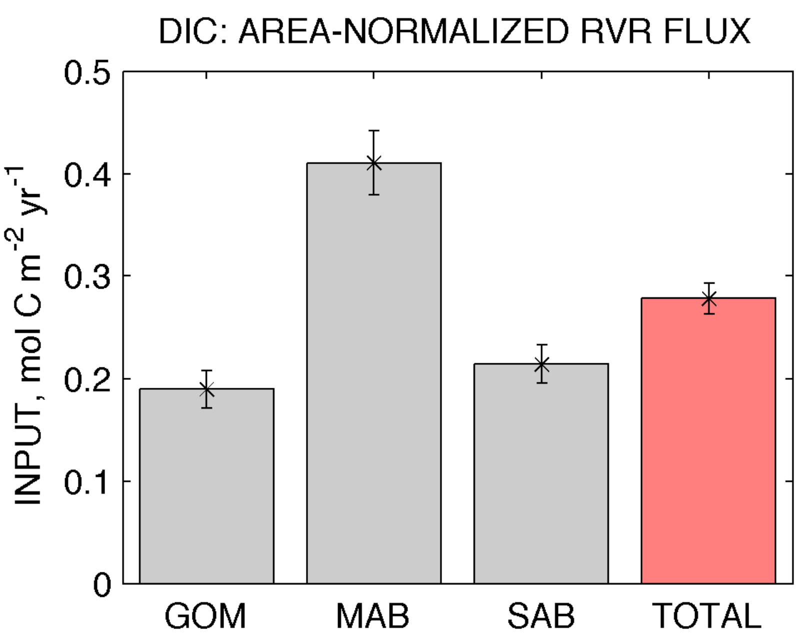
- Area-normalized river estimates: USGS monitoring data [Stets&Striegl 2012], DLEM watershed model [Tian et al., subm.], SPARROW watershed model [Smith et al., 1997; Shih et al., 2010]
- Area-normalized tidal wetland flux = 15 ± 0.7 mol C m^{-2} yr^{-1} from 12 literature references [in Herrmann et al., subm.]

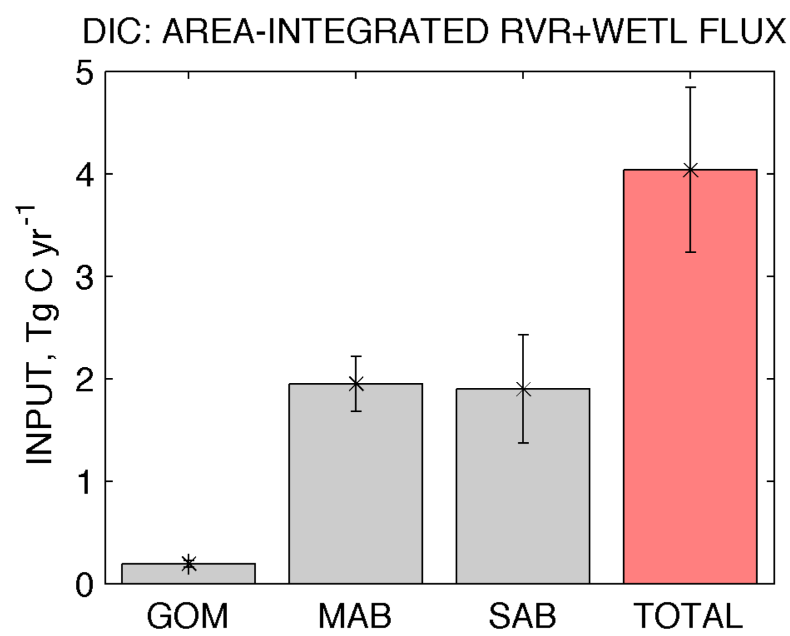




DIC Input across the landward boundary (I_{DIC})

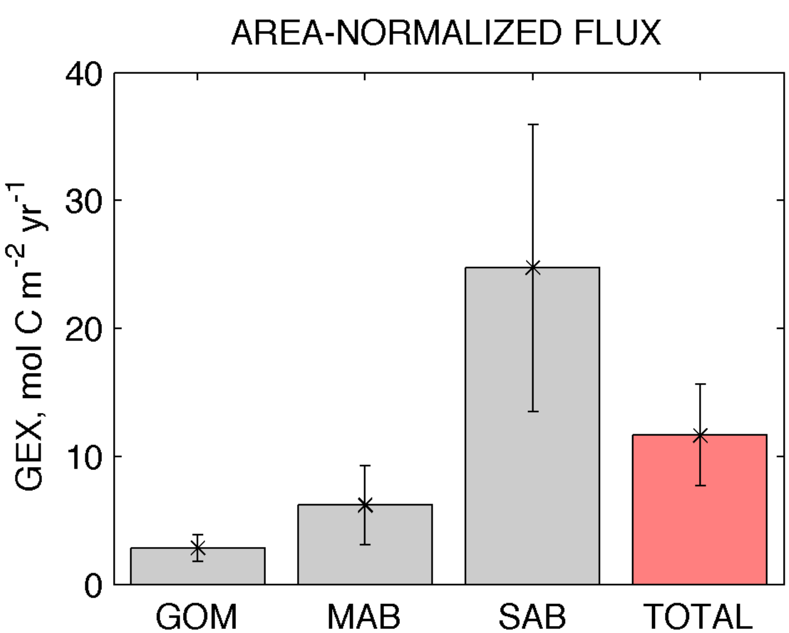
- Area-normalized river estimates: USGS monitoring data [Stets&Striegl 2012], DLEM watershed model [Tian et al., subm.],
- Area-normalized tidal wetland flux = 13 ± 7 mol C m^{-2} yr^{-1} from Cai [2011] – only one SAB system, subjective 50% error

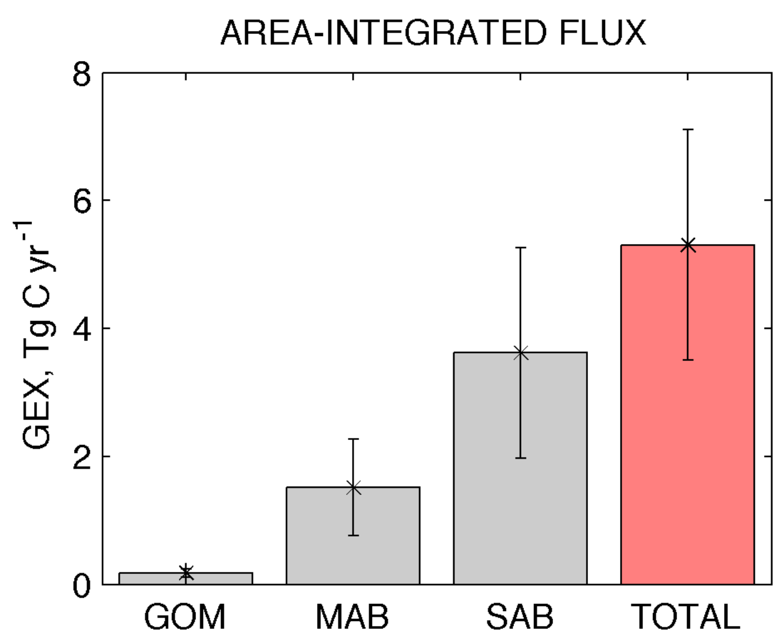




Gas exchange (*G*)

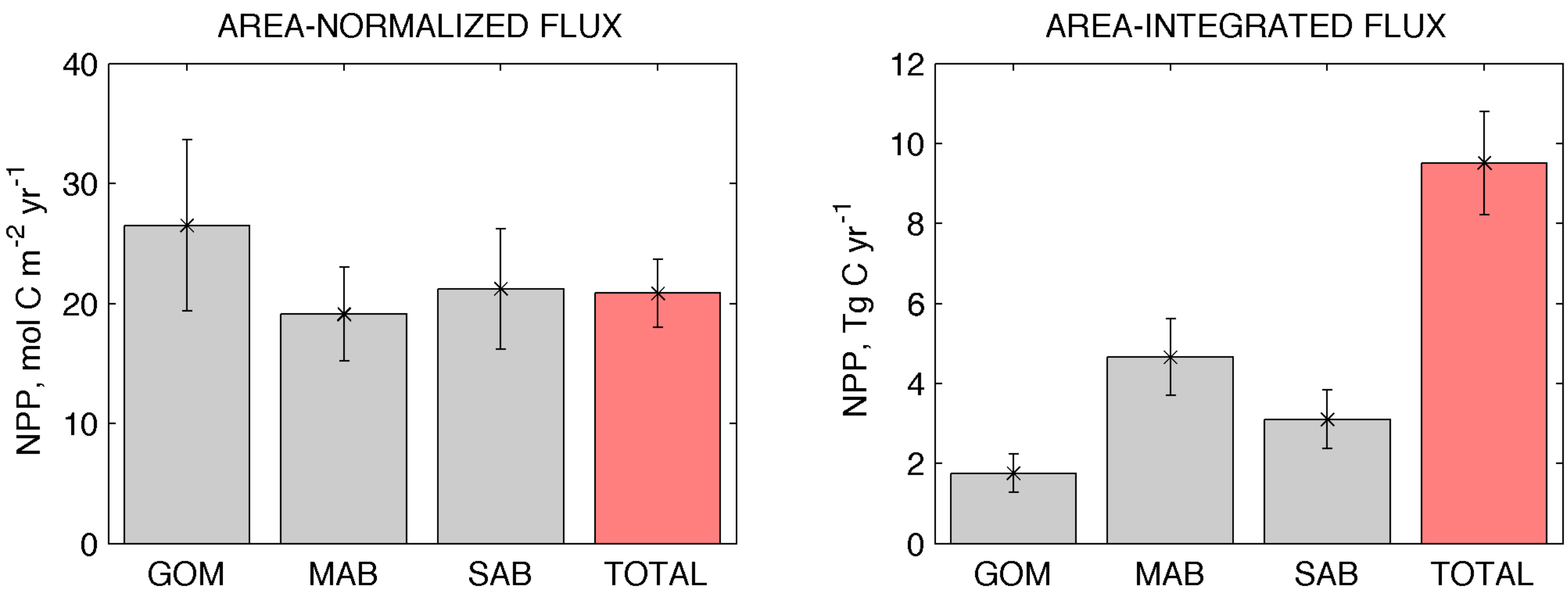
- Area-normalized estimates: Hunt et al. [2011], Raymond & Hopkinson [2003], Raymond et al. [2000], Jiang et al. [2008], Cai & Wang [1998], and Wang & Cai [2004]
  - N_{GOM} = 6, N_{MAB} = 1, and N_{SAB} = 5
  - Outgassing in all systems; increases towards the south
  - System-level estimates range range from 1 to 43 mol C m^{-2} yr^{-1}
- Regional area extrapolation





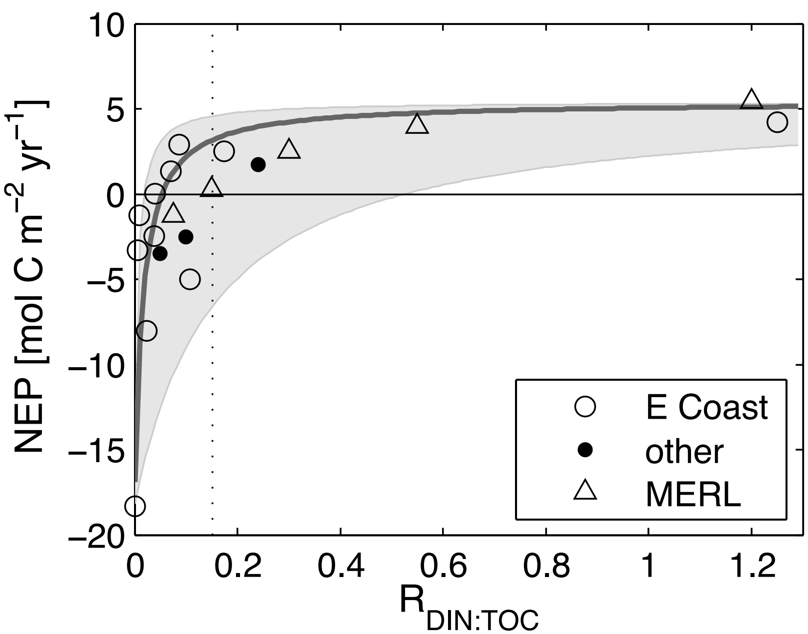
Net primary production (*NPP*)

- Area-normalized estimates from Cloern et al. [2014] and Dame et al. [2000]
  - N_{GOM} = 3, N_{MAB} = 13, and N_{SAB} = 10
  - System-level estimates range from 1 to 46 mol C m^{-2} yr^{-1}
  - No clear spatial gradient
  - Magnitude ~ GES
- Regional area extrapolation



Net ecosystem production (*NEP*)

- Area-normalized estimates: references in Herrmann et al. [subm.]
  - $N_{GOM} = 1$, $N_{MAB} = 7$, and $N_{SAB} = 2$, $N_{OTHER} = 8$
  - System-level estimates range from -18 to 5 mol C m^{-2} yr^{-1}
- To scale up: *NEP = f(DIN:TOC)* for 52 systems
  - DIN:TOC from SPARROW



Net ecosystem production (*NEP*)

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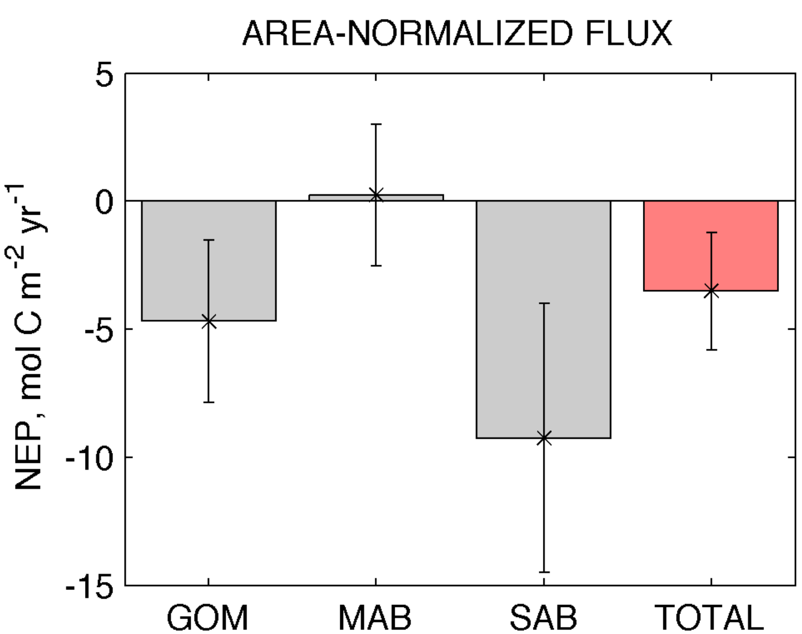
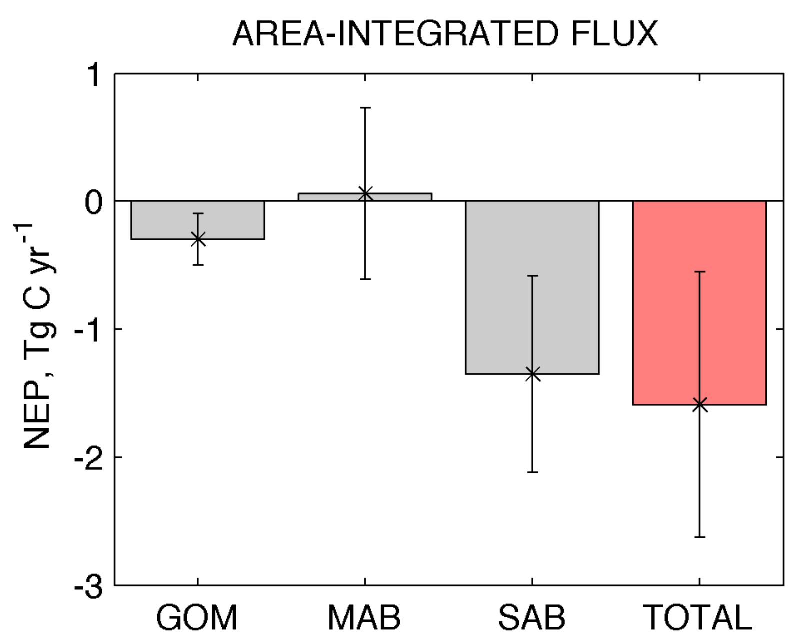
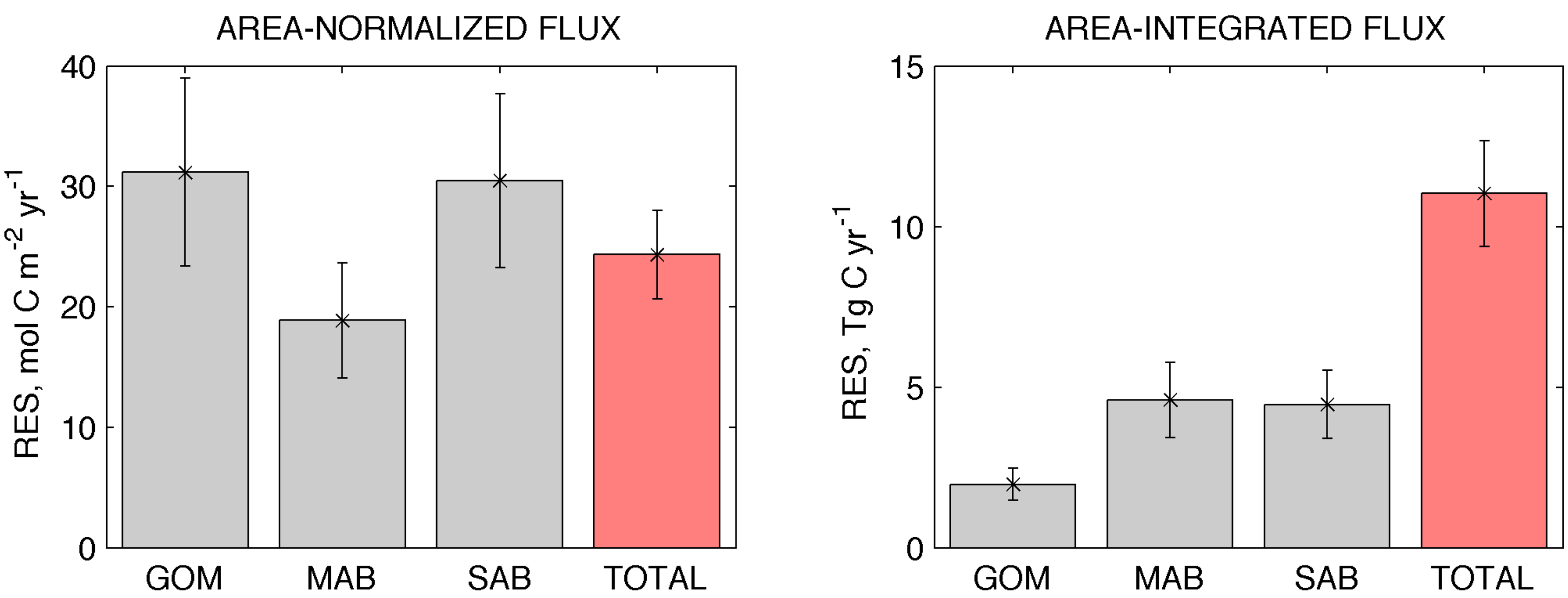


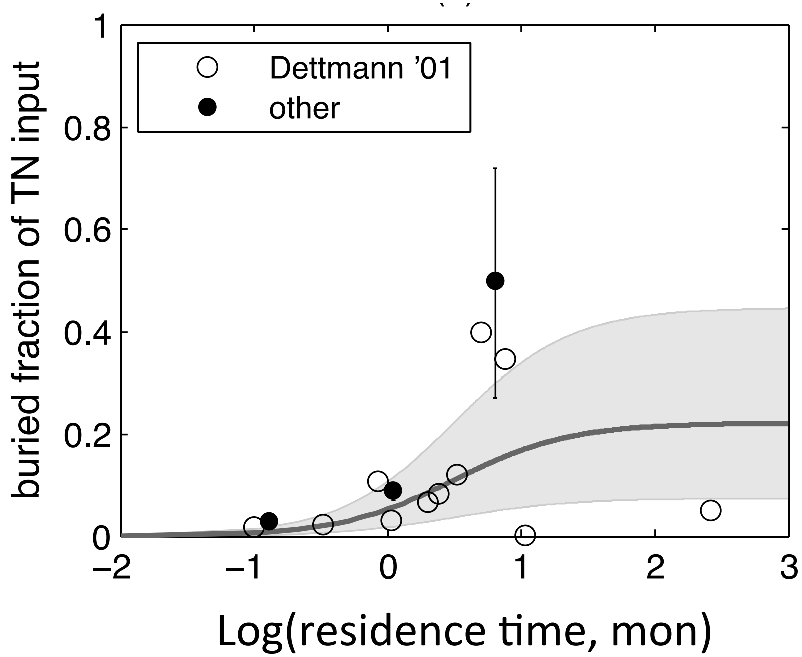


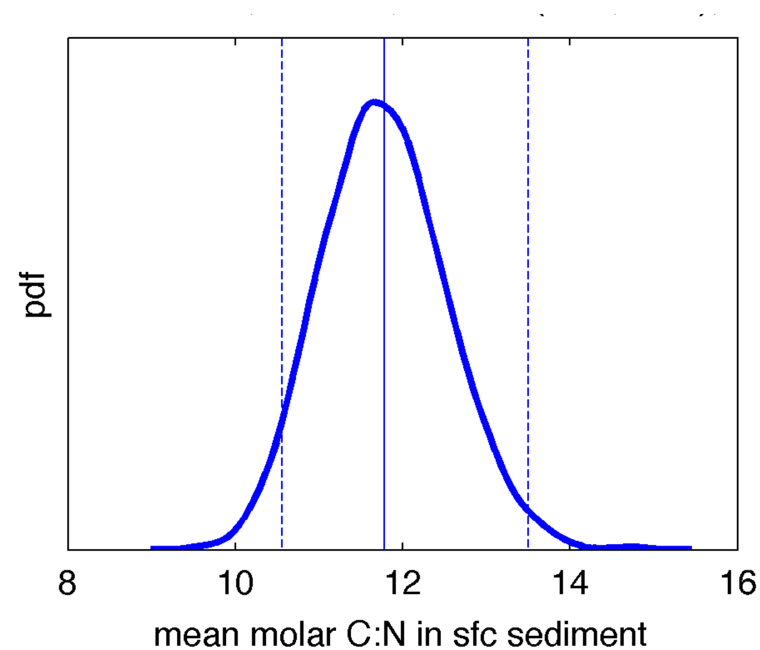
Heterotrophic respiration (*RES = NPP - NEP*)



Burial in the sediment (*B*)

- Area-normalized estimates ~ non-existent
- Relatively more information on N burial: Nixon et al. [1996], Dettmann [2001]
- To scale up: *B = f(residence time, TN)* for 52 systems
  - TN from SPARROW
  - Residence time from salt budgets
  - 12 burial molar C:N ratios: references in Herrmann et al. [subm.]





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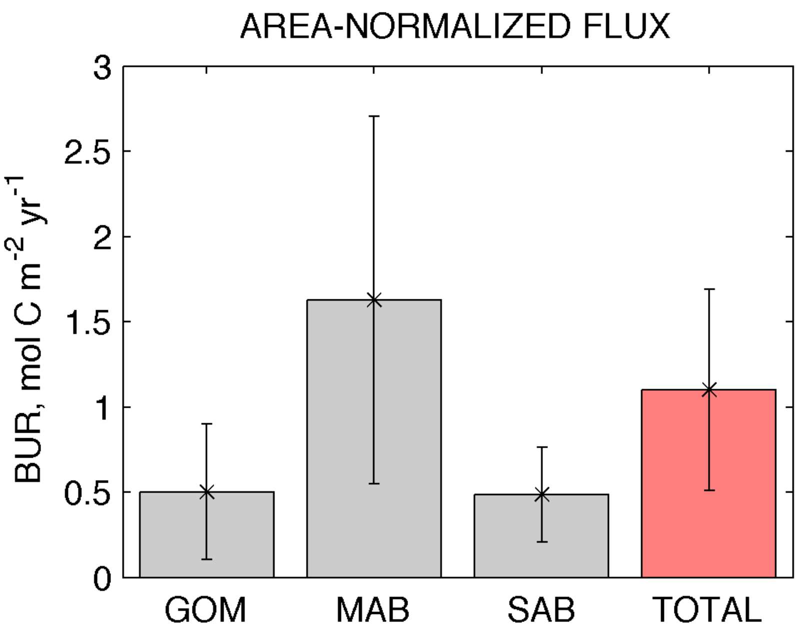
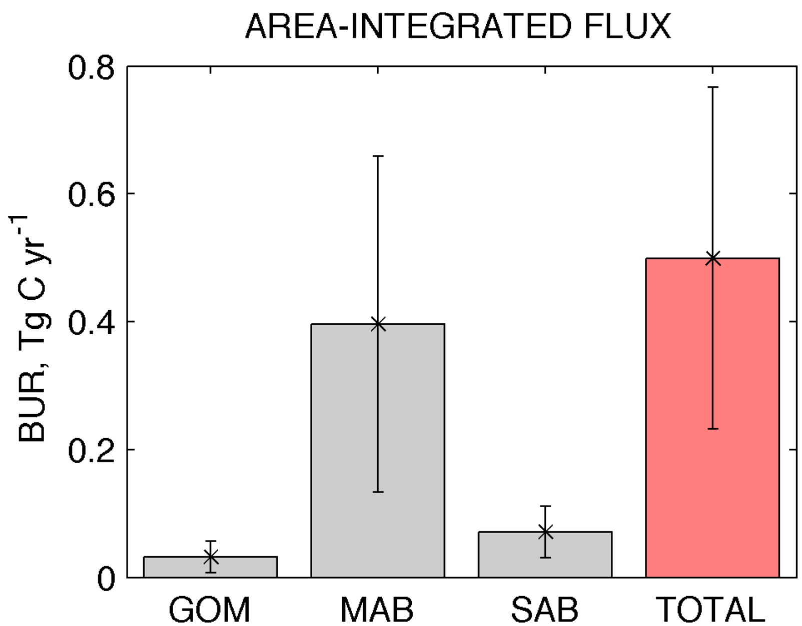
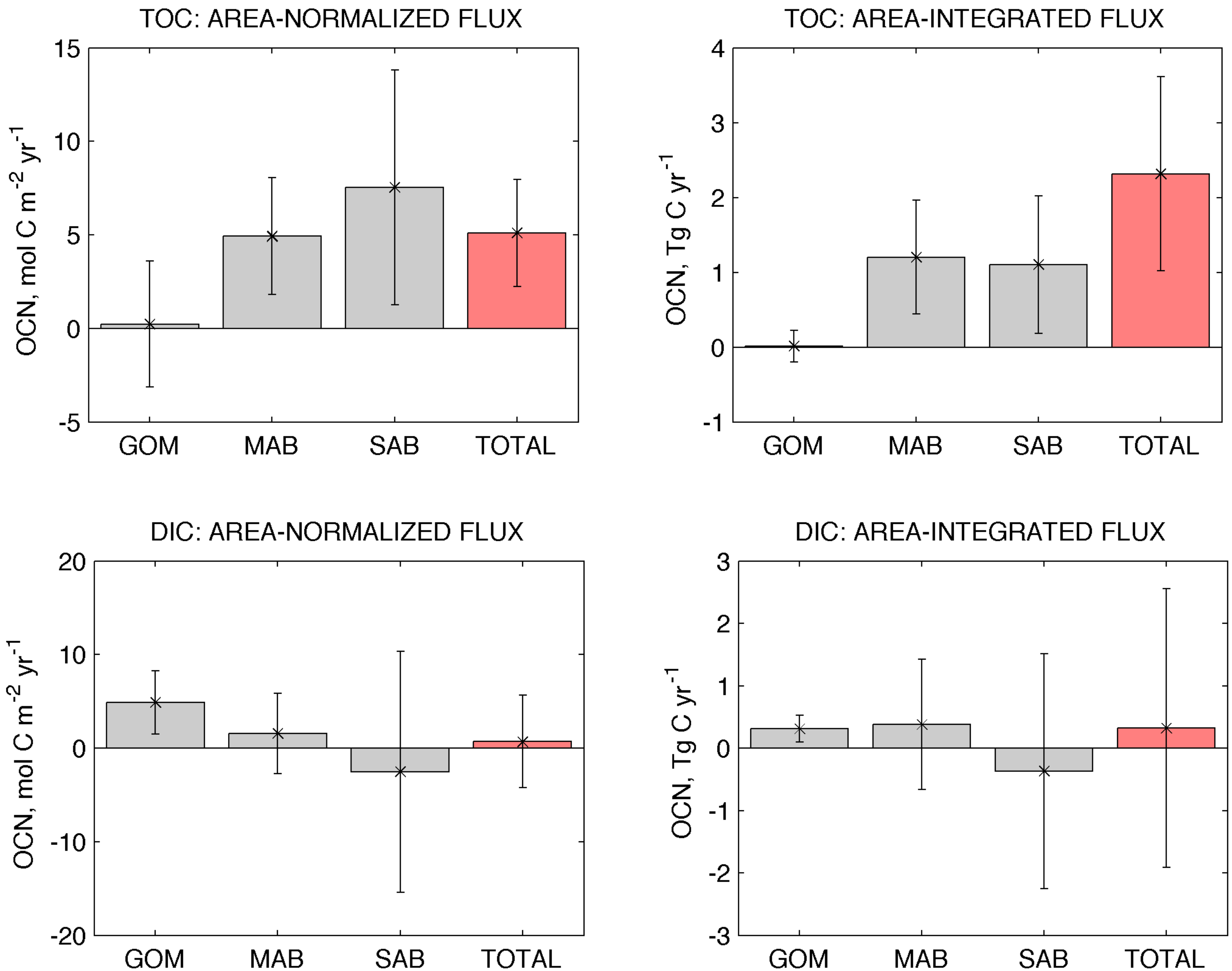


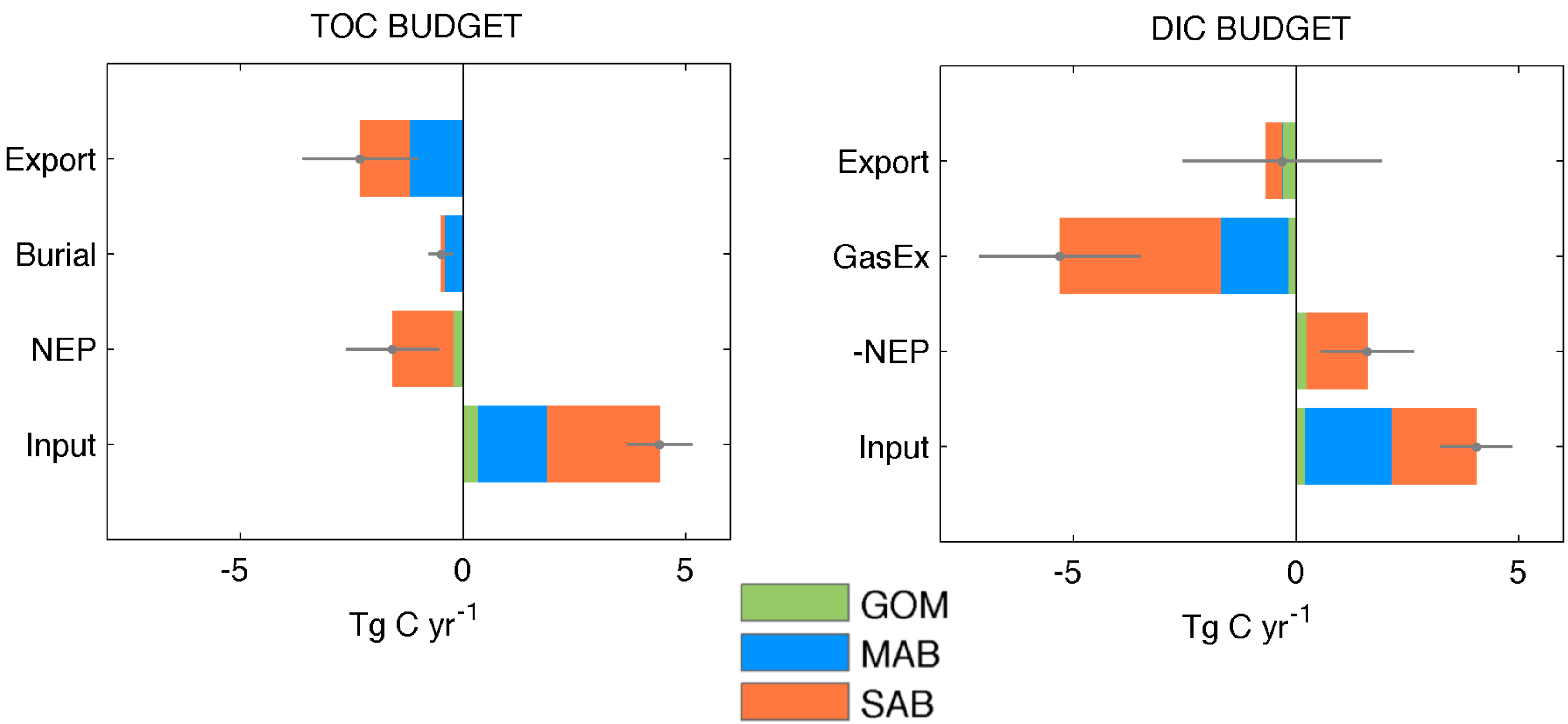


Exchange of TOC and DIC across the ocean boundary (*E*) – residual from the mass balances



Summary and conclusions: TOC and DIC budgets

- Best constraints on riverine fluxes
- Poorest constraints on sedimentary processes, respiration, fluxes in tidal wetlands
- Additional data mining and modeling can take us further
- But new observations and urgently needed



THANK YOU

All landscape photographs used in this presentation are publically available at IAN Image Library ian.umces.edu/imagelibrary

Photo by Heather Lane
Blackwater Wildlife Refuge, MD

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