# Processes in the coastal zone



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Ocean Carbon and Biogeochemistry Program Working Group Webinar: Filling the gaps in observation-based estimates of air–sea carbon fluxes

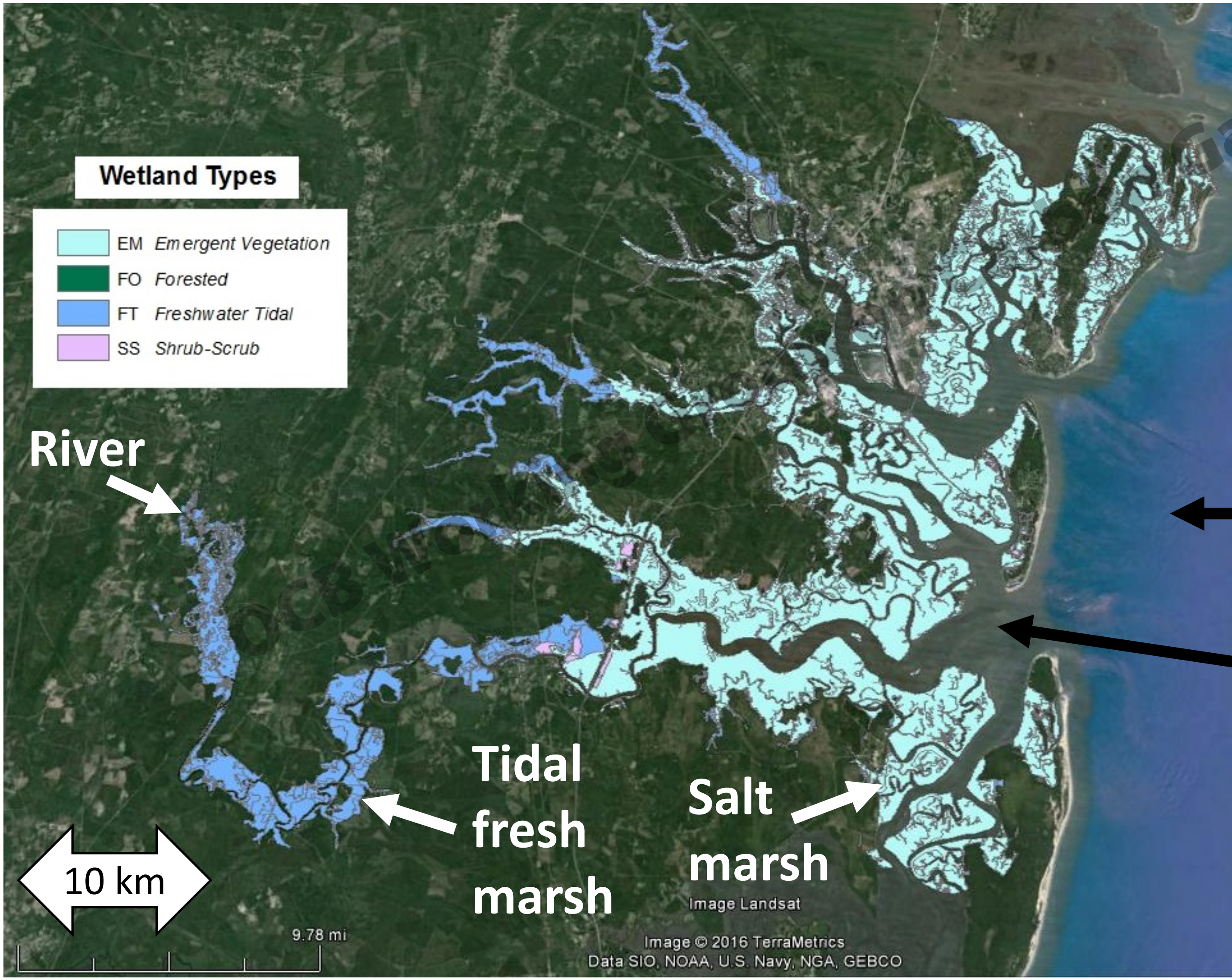
May 5-6, 2020

# Definition of the coastal zone: Tidal waters that are influenced by the presence of the coast

Key points:

- The landward boundary is relatively straightforward to define: the head of tide
- The seaward boundary is less clear, with possible definitions based on distance from land, depth, and slope
- The coastal zone includes tidal wetlands, estuaries, and, by most definitions, large river plumes, shelf waters, boundary currents, and upwelling regions
- To a first approximation, we might separate coastal waters into tidal wetlands, estuaries, shelf waters, and maybe slope waters

# Example from the South Atlantic Bight




Hinson et al. (2017)

# Unique characteristics of the coastal zone

- High nutrient levels, which result from riverine input, upwelling, and tidal mixing
- High primary production, respiration, carbon export from the euphotic zone, and carbon burial
- Importance of vascular plants (e.g., tidal wetlands and seagrass)
- Large human influence
- Large climate-change influence
- High complexity, due, in part, to high spatial and temporal variability

# Questions about the coastal zone related to the working group

- How should the seaward boundary of the coastal zone be defined?
- How well are the world's estuaries and tidal wetlands mapped? E.g., what is the area of each?
- How well is the coastal zone sampled for surface-water $pCO_2$?
- How well can we model the relative impact of winds, currents, surfactants, suspended solids, and fetch on the gas transfer velocity in coastal waters?
- What role does the coastal zone play in natural outgassing of $CO_2$ from the ocean?

# Questions about the carbon budget of the coastal zone



- What is the total carbon budget of the coastal zone? Important terms include:
  - Exchange with the atmosphere
  - Burial
  - Lateral exchange between rivers, groundwater, tidal wetlands, estuaries, shelf waters, and the open ocean
- What is the magnitude of internal transformations of carbon in the coastal zone? Important transformations include:
  - Primary production and respiration
  - $CaCO_3$ precipitation and dissolution
- How has the carbon budget of the coastal zone changed over the industrial era?

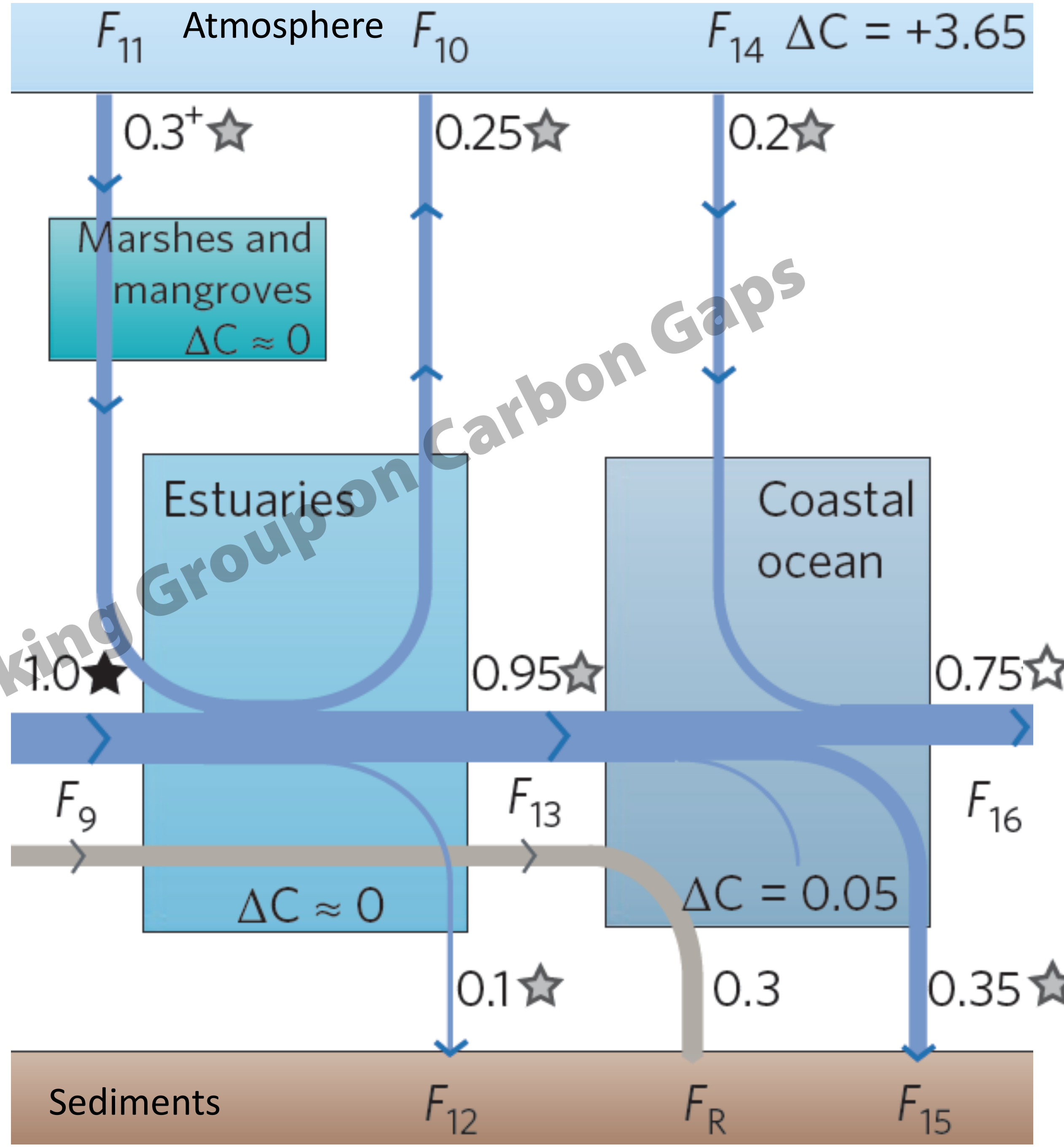
Regnier et al. (2013) modern coastal zone C budget (Pg C yr$^{-1}$)

95% confidence range:

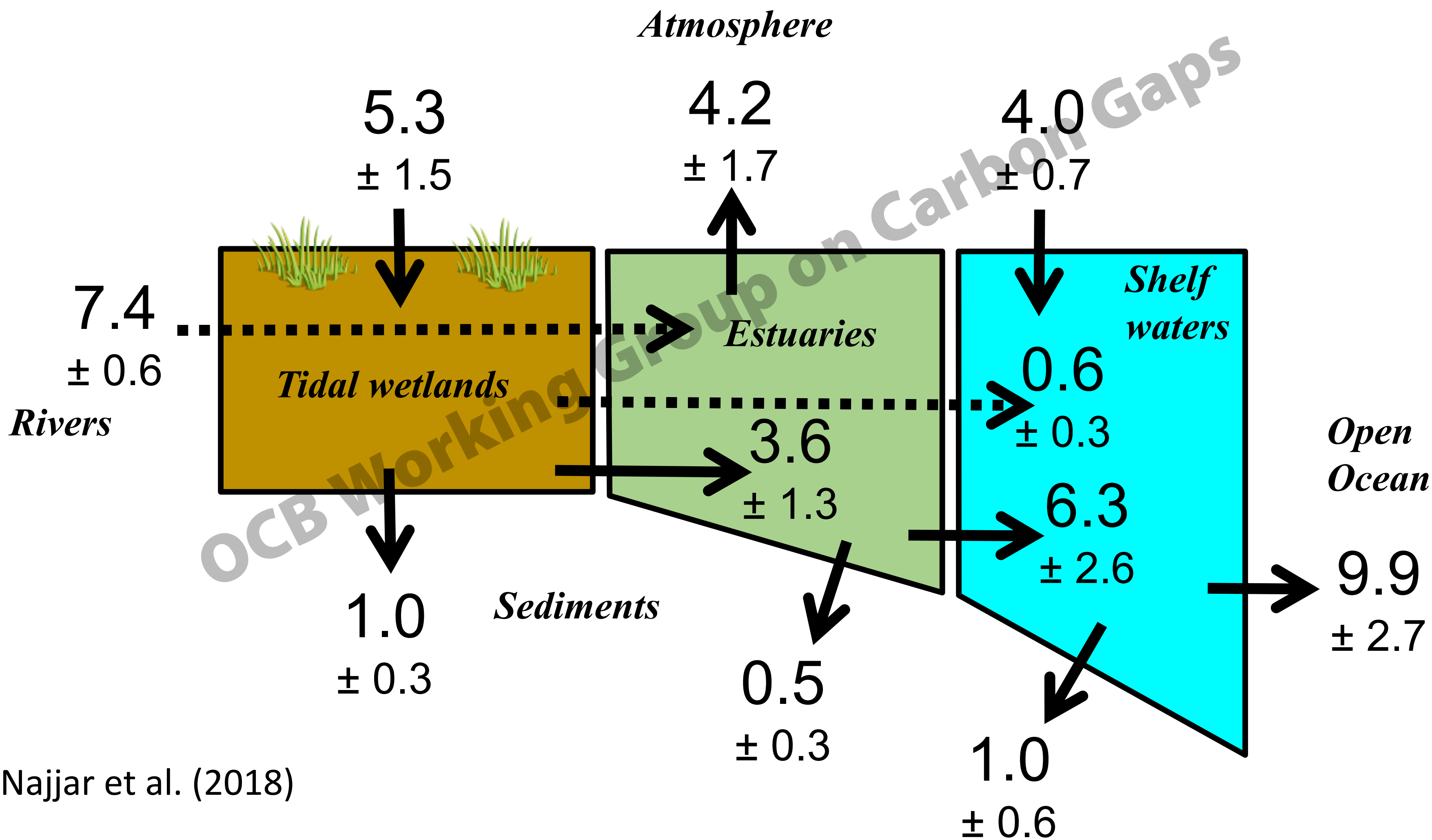
★ ± 50%

☆ ± 100%

☆ > ± 100%



# Total carbon budget (Tg C yr$^{-1}$) of Eastern North American coastal waters indicates importance of all 3 ecosystems and transfers between them (mean ± 2 standard errors)






Najjar et al. (2018)

Note that estuarine burial has since been revised upward (Hutchings et al., 2020)

# How well do we know the global areas of tidal wetlands and estuaries?

- Woodwell et al. (1973) still widely cited; scales up U.S. areas based on coastline lengths
- Dürr et al. (2011) greatly improved global estuarine area estimation, but comparison with U.S. east coast area suggests an underestimate (Najjar et al., 2018)
- Mangrove area well constrained (Giri et al., 2011; Bunting et al., 2018) but salt marsh area varies by an order of magnitude (Mcowen et al., 2017)

# A new global estimate of carbon burial in estuaries



- Hutchings et al. (2020) combined data on sedimentation rate, bulk density, and TOC mass fraction to estimate burial in estuarine sediments of the contiguous United States to be 64 [44 – 97, 95% confidence] g C $m^{-2}$ $yr^{-1}$.
- Applied to global estuarine area of 1.1 x $10^{12}$ $m^2$ (Dürr et al., 2011) the global burial rate is estimated to be 0.07 [0.05 – 0.11, 95% confidence] Pg C $yr^{-1}$

# A new global estimate of carbon flux from tidal wetlands to estuaries

- Eastern North American synthesis of Najjar et al. (2018):
  - Twelve estimates of net TOC export (per unit area of wetland): mean ± 2 standard errors = 185 ± 71 g C $m^2$ $yr^{-1}$
  - Four estimates of net DIC export = 235 ± 120 g C $m^2$ $yr^{-1}$
  - Guesstimate for total C export = 400 g C $m^2$ $yr^{-1}$
- Global mangrove area = 13.76 x $10^{10}$ $m^2$ (Bunting et al., 2018)
- Global tidal marsh area = 2.2–40 x $10^{10}$ $m^2$. Most recent estimate: 5.5 x $10^{10}$ $m^2$ (McCowen et al., 2017)
- Global tidal wetland area range: 16–54 x $10^{10}$ $m^2$
- 400 g C $m^2$ $yr^{-1}$ x 16–54 x $10^{10}$ $m^2$ = 0.06–0.22 Pg C $yr^{-1}$

# Summary points

- All three main components of the coastal zone—tidal wetlands, estuaries, and shelf waters—play important roles in coastal zone carbon budgets
- Riverine input is relatively well known (Li et al., 2017), but uncertainties remain due to temporal variability (non-zero correlation between concentration and discharge) and basins lacking data
- Uncertainties in the areas of tidal wetland and estuaries are potentially large, confounding estimates of global C fluxes in these systems
- For shelf waters, the air–sea flux is relatively well constrained but burial is not (varying from 0.2 to 1 Pg C $yr^{-1}$, Krumins et al., 2013)
- Several important budget terms in the coastal zone (net ecosystem production and lateral transfers) are determined by difference and hence have potentially large errors

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