LTER Contributions to Understanding the Coastal Eutrophication Problem

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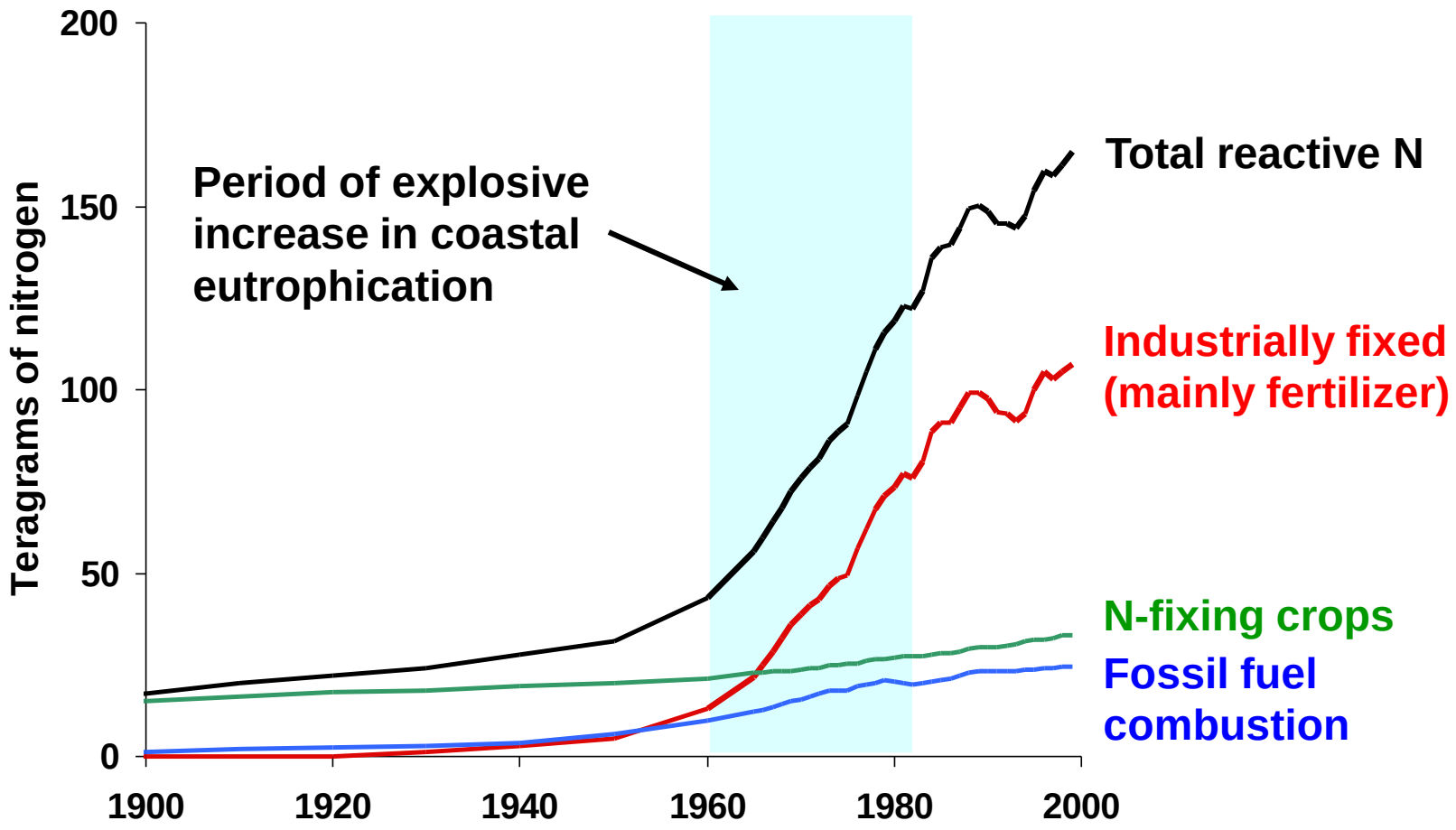
Grand challenge: Altered biogeochemical cycles

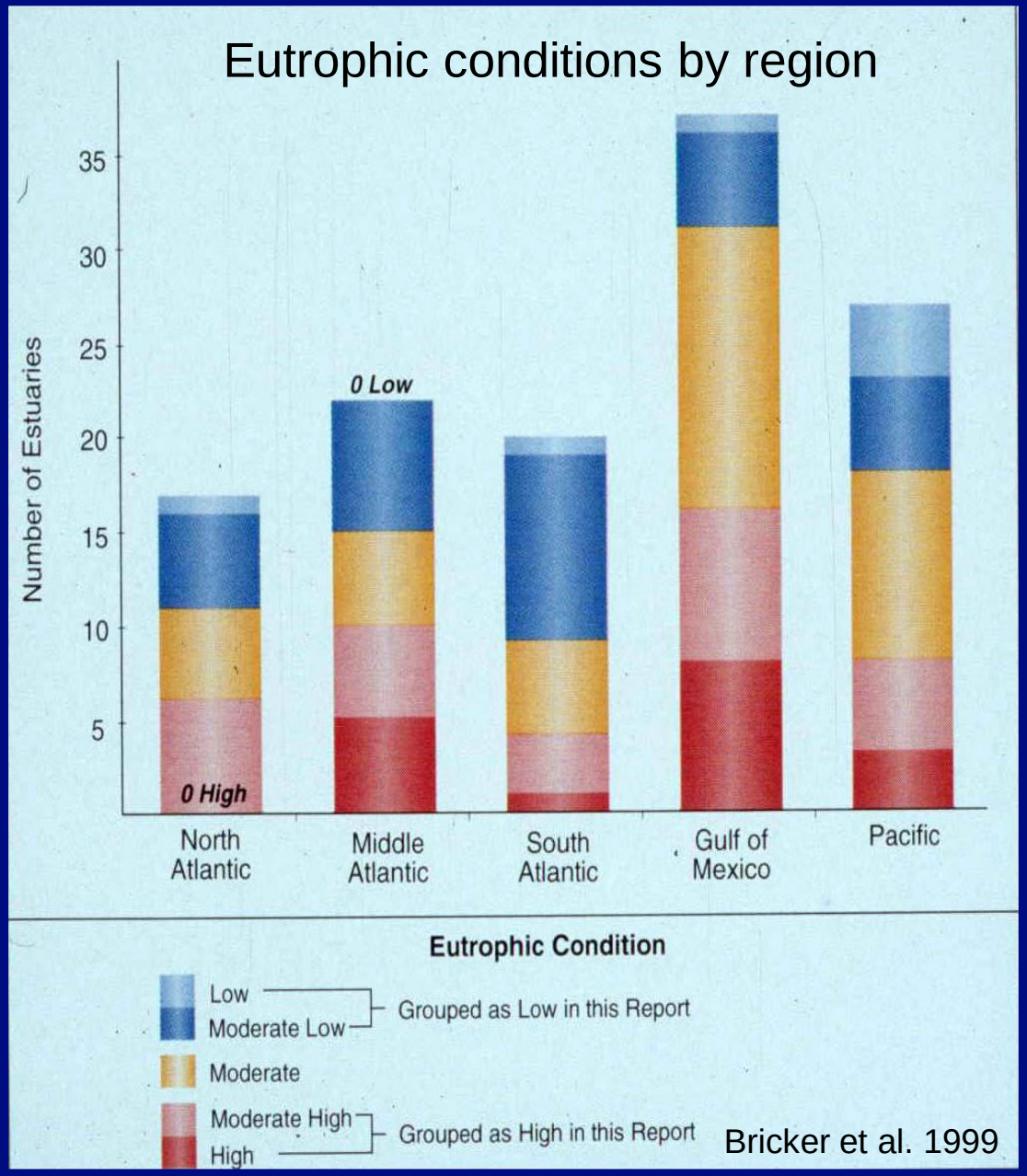
Nutrient over-enrichment of the coastal zone



Galloway et al. 2003

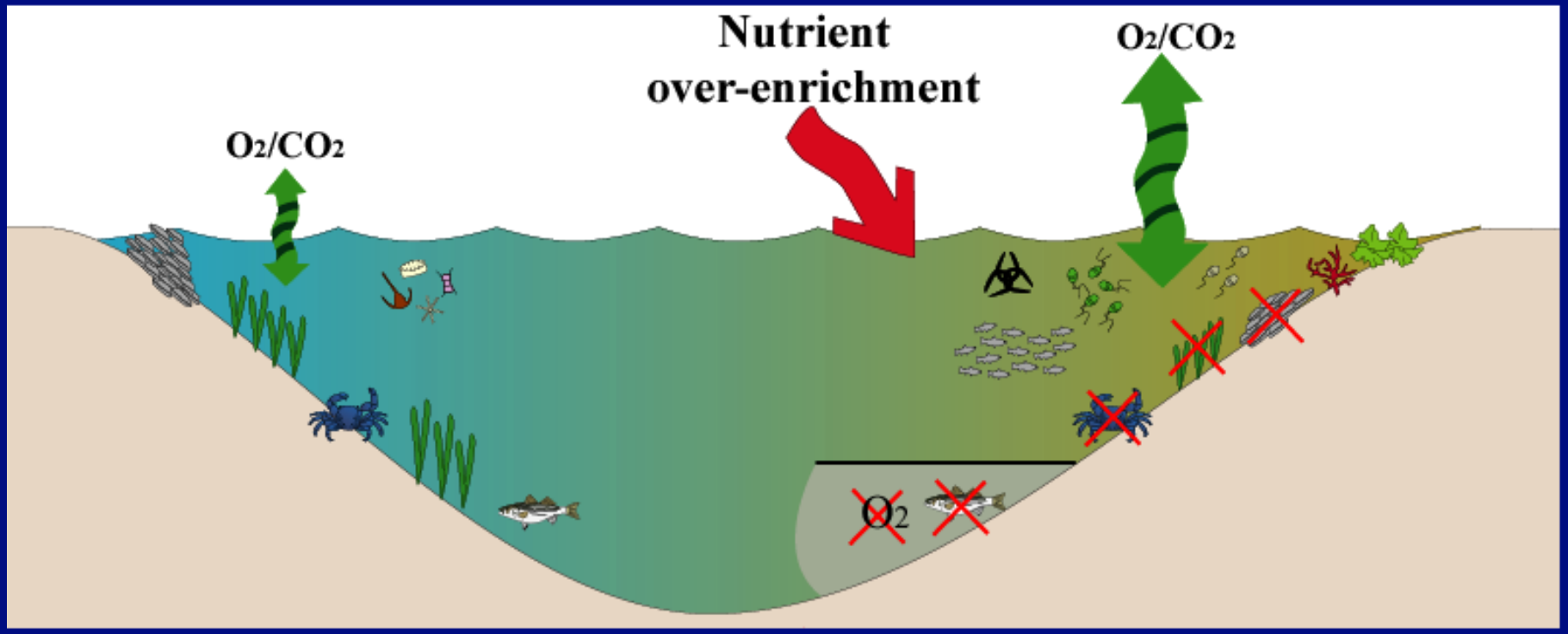
Symptoms of eutrophication are prevalent in the nation's estuaries

67% of estuarine surface area shows signs of moderate-high impact

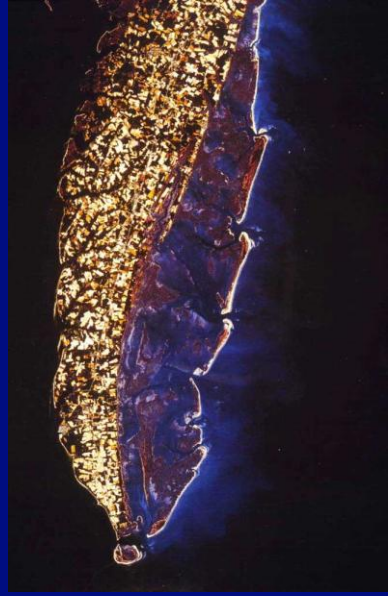


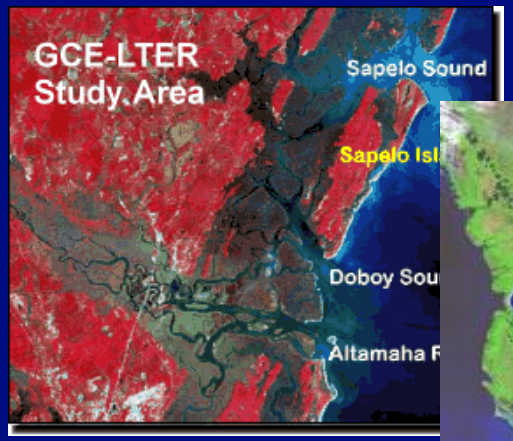
Bricker et al. 1999

What are the consequences of eutrophication?



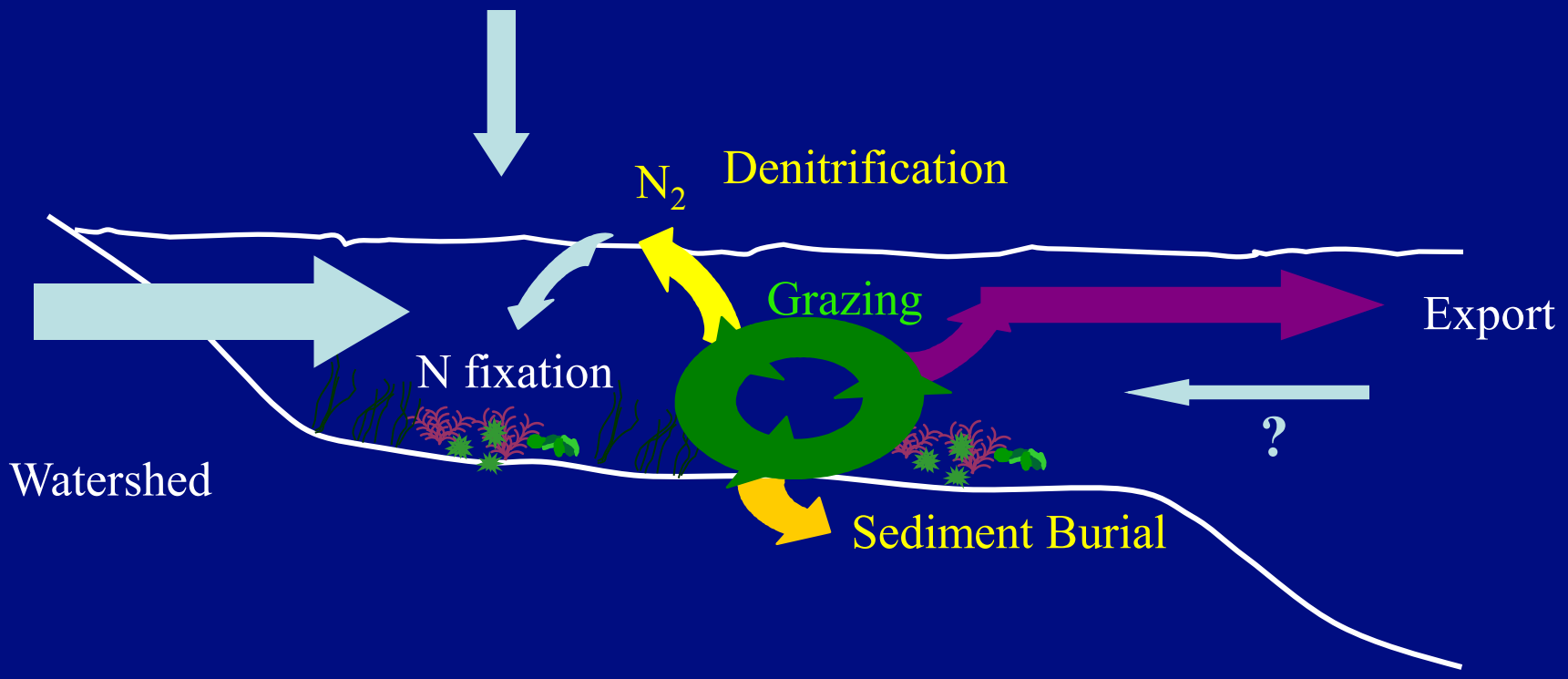
Coordinated network-level approach at coastal LTER sites





What controls the different responses to eutrophication?

What are the possible fates of watershed nutrients?



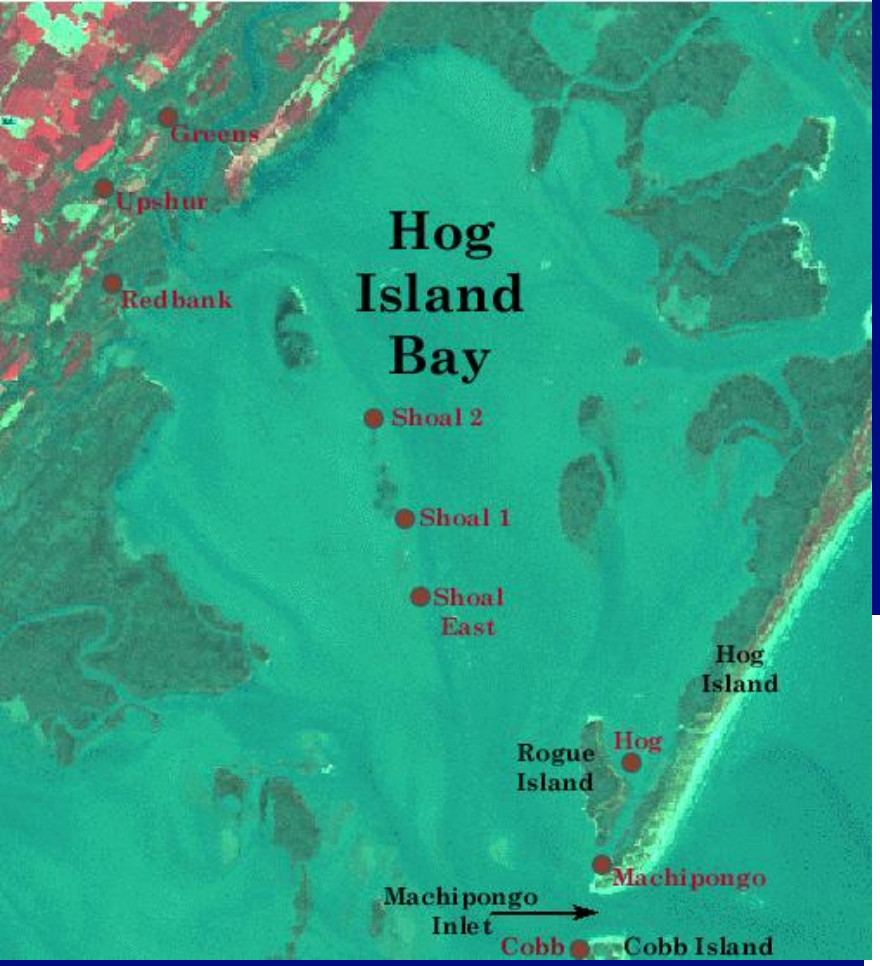
Why do different coastal systems respond differently to nutrient enrichment?

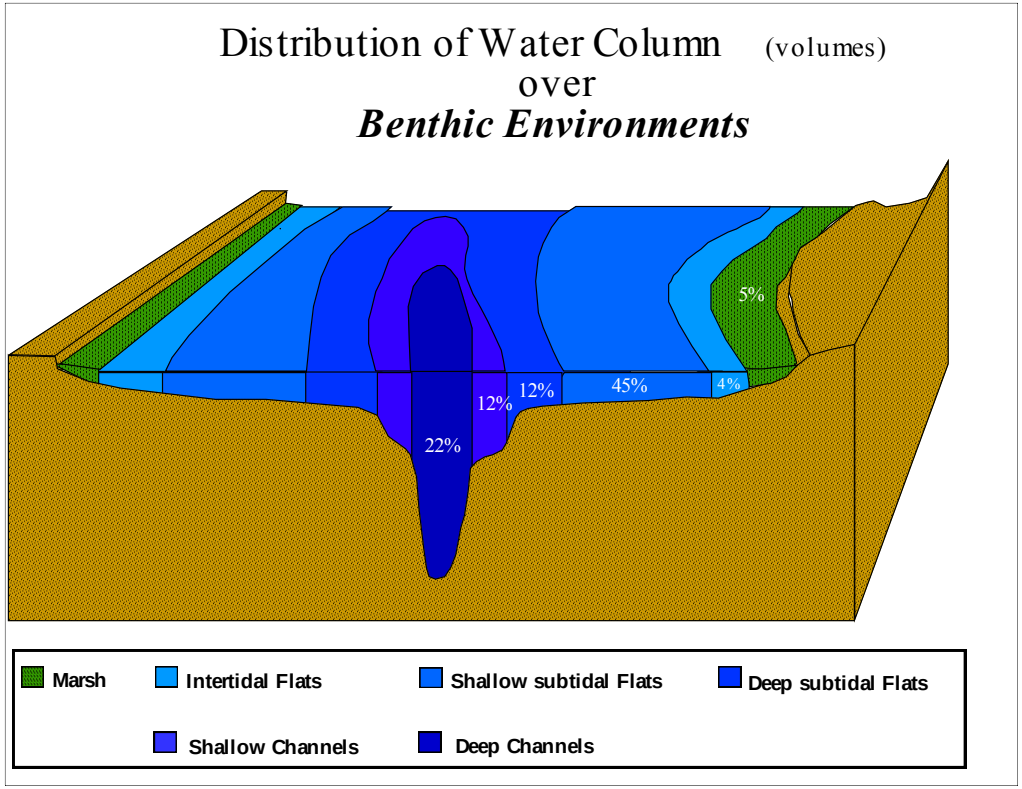
Virginia Coast Reserve: a coastal bay ecosystem

How do feedbacks from plant metabolism modulate the response to nutrient loading?

What is different about coastal bay ecosystems?

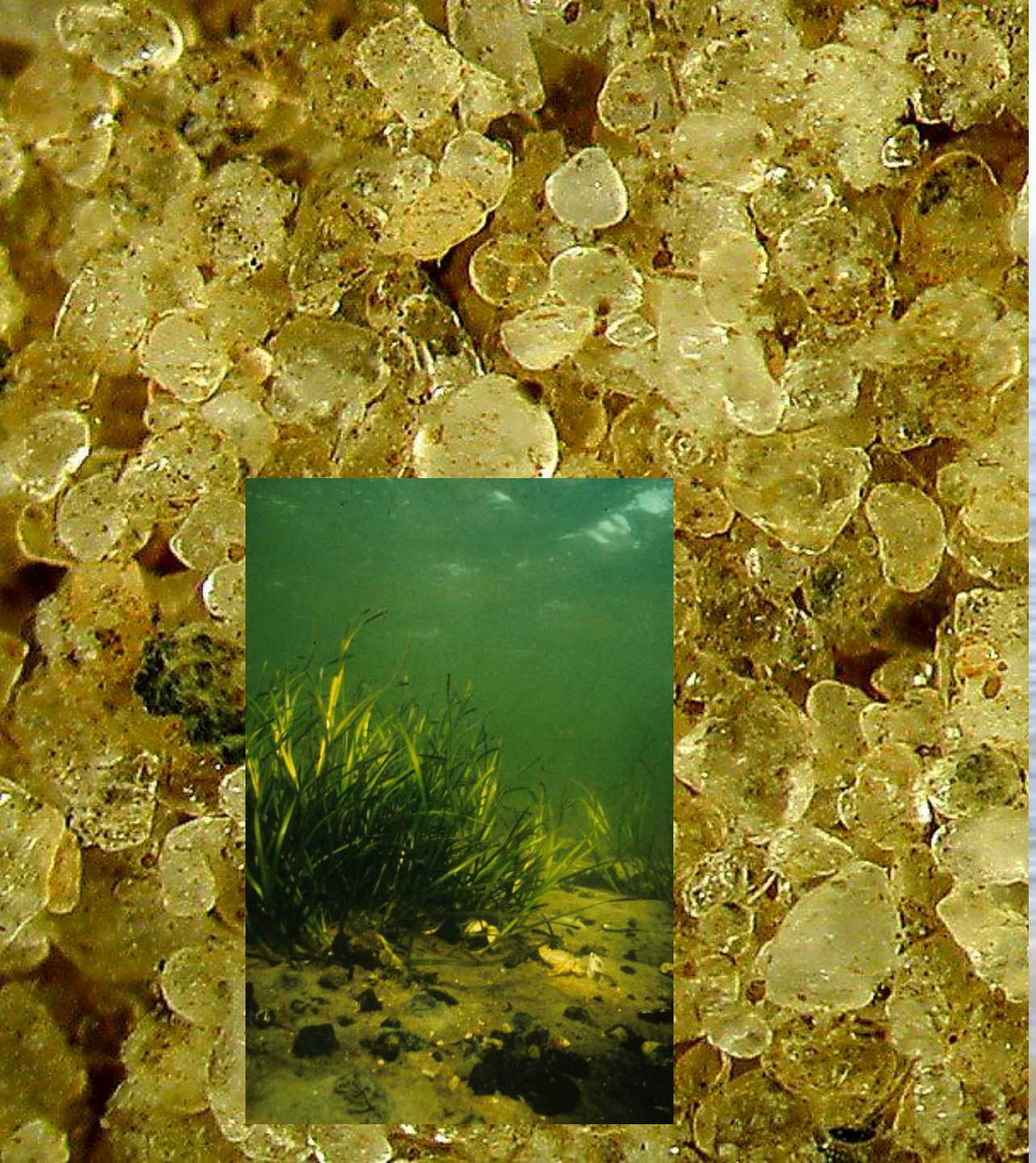
- watersheds are small
- little/no riverine input
- seafloor is in photic zone



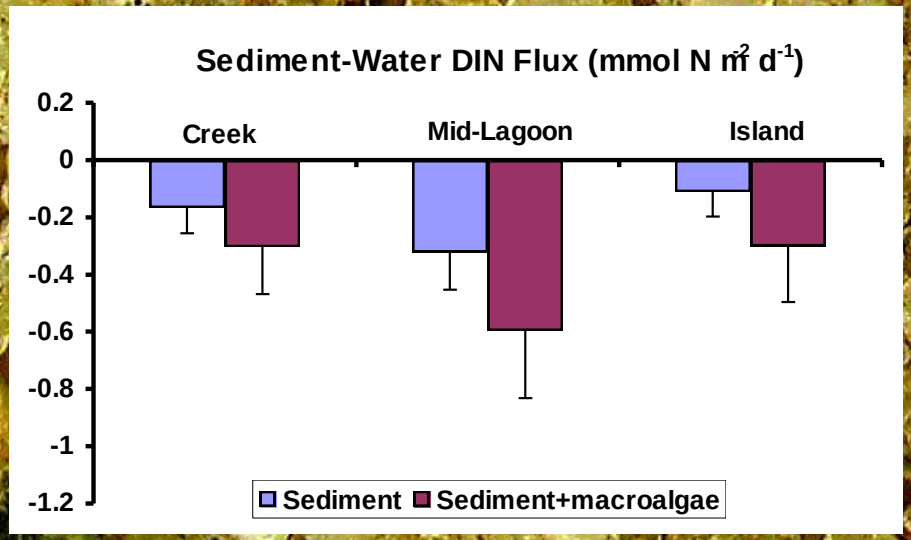


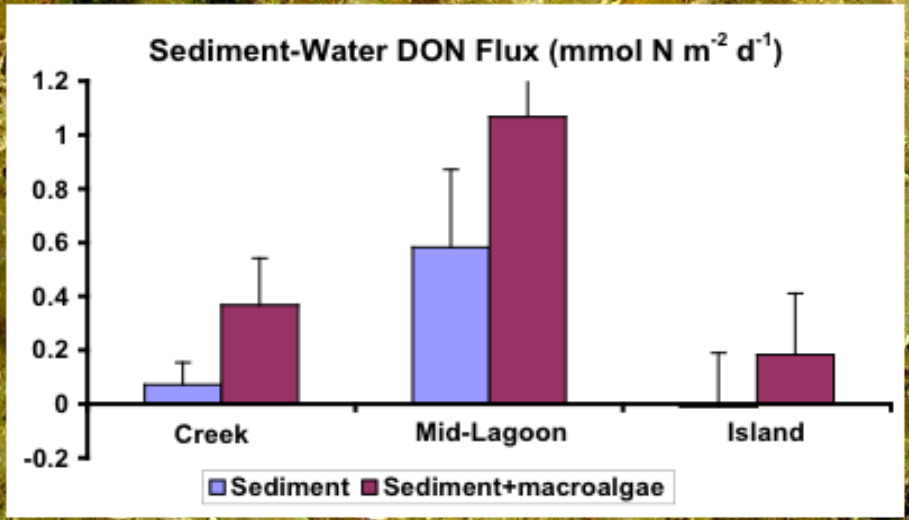
BUT:

external nutrient loading rates are similar to deep estuaries

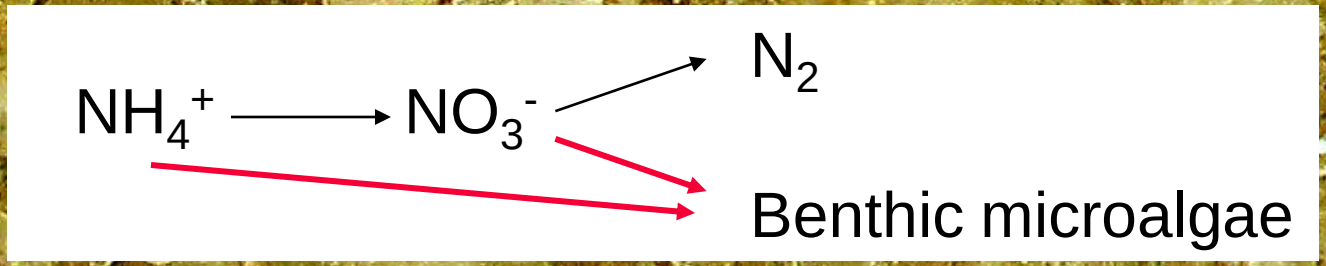


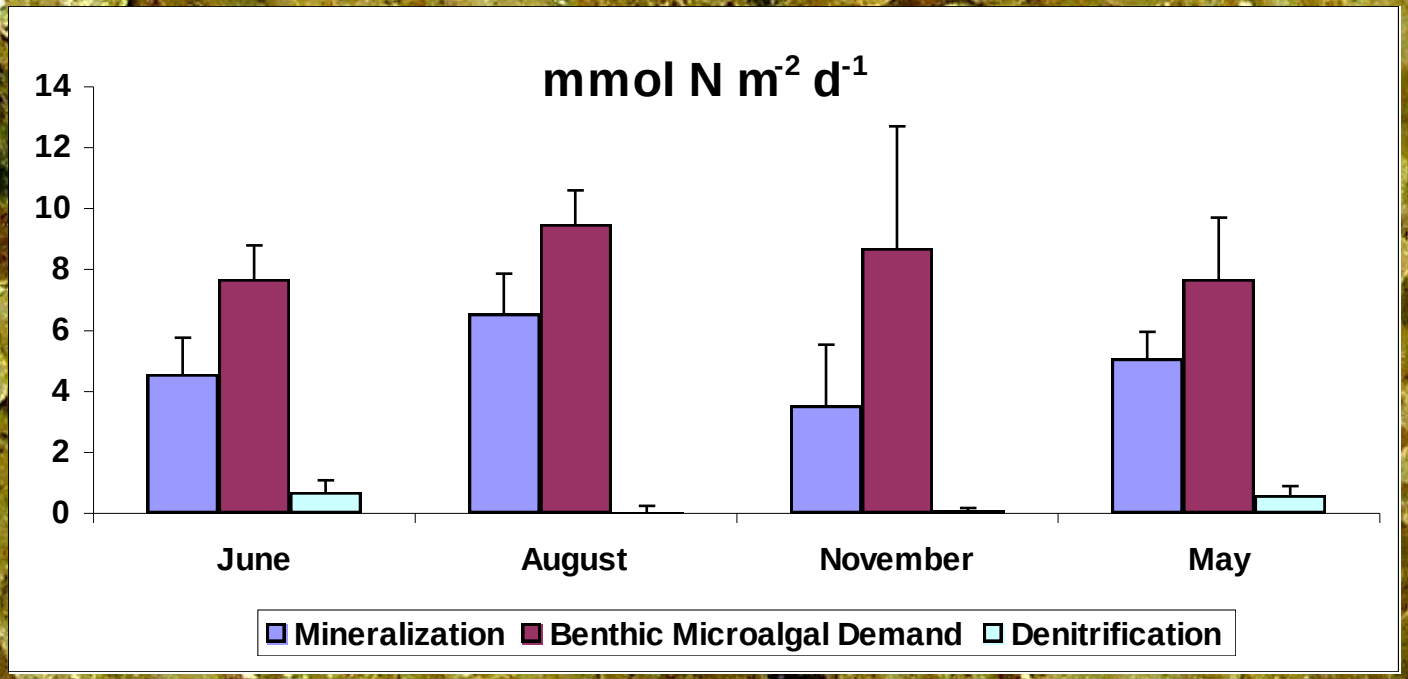
Benthic algae prevent release of inorganic nutrients to water column, and stimulate release of organic nutrients



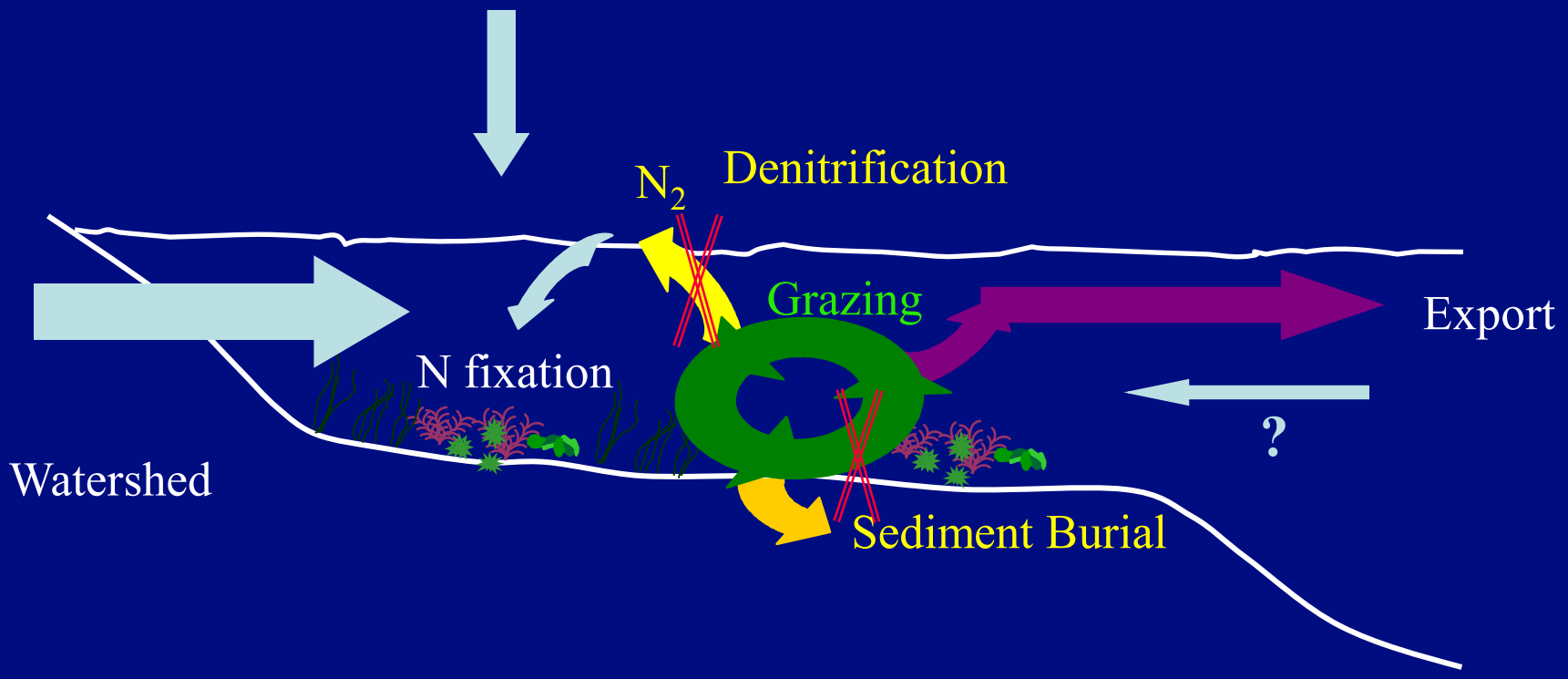


Competition with benthic microalgae makes denitrification an unimportant sink for N in coastal bays





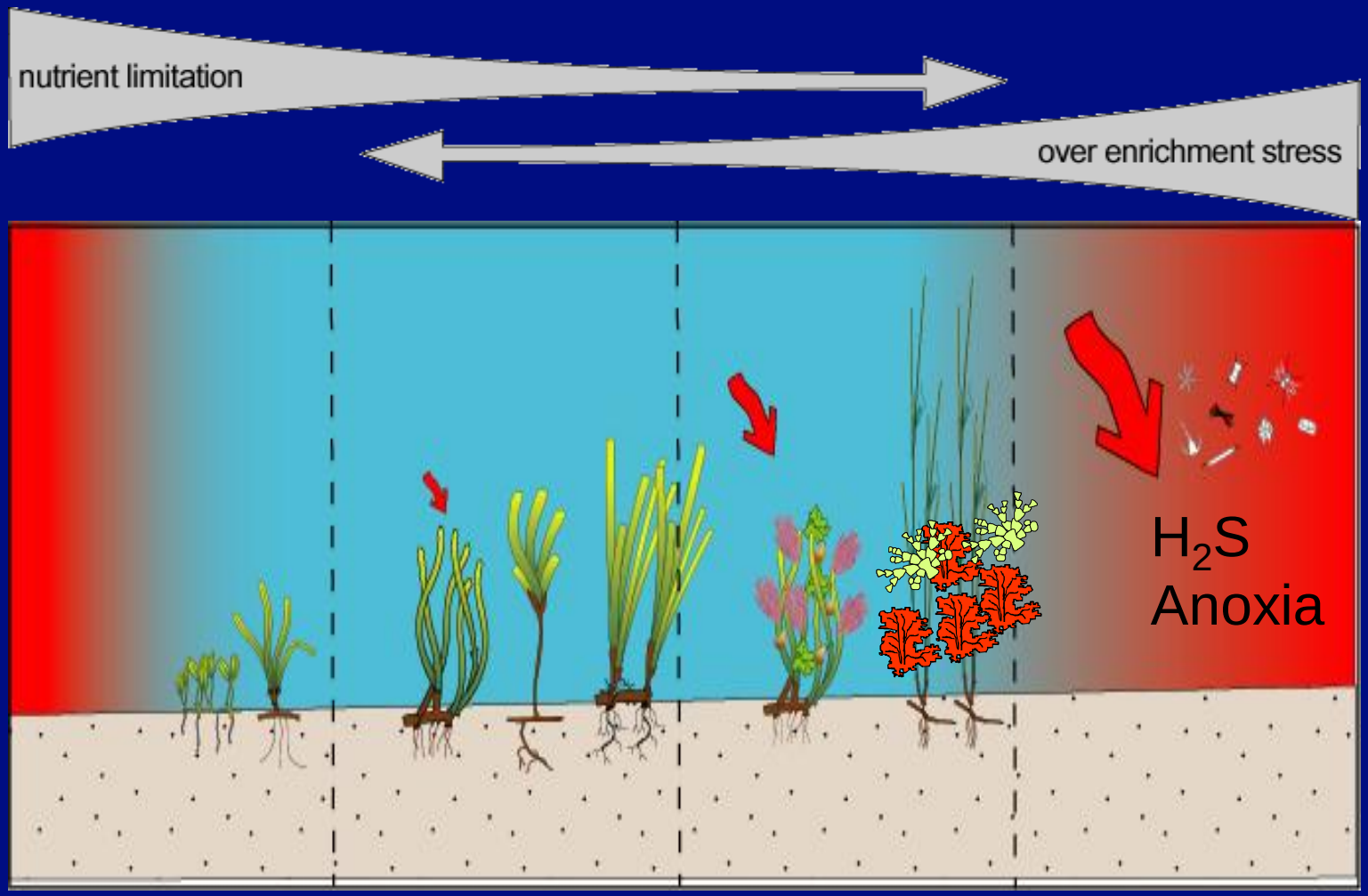
Benthic plant assimilation is key to the fate and transport of N in coastal bays



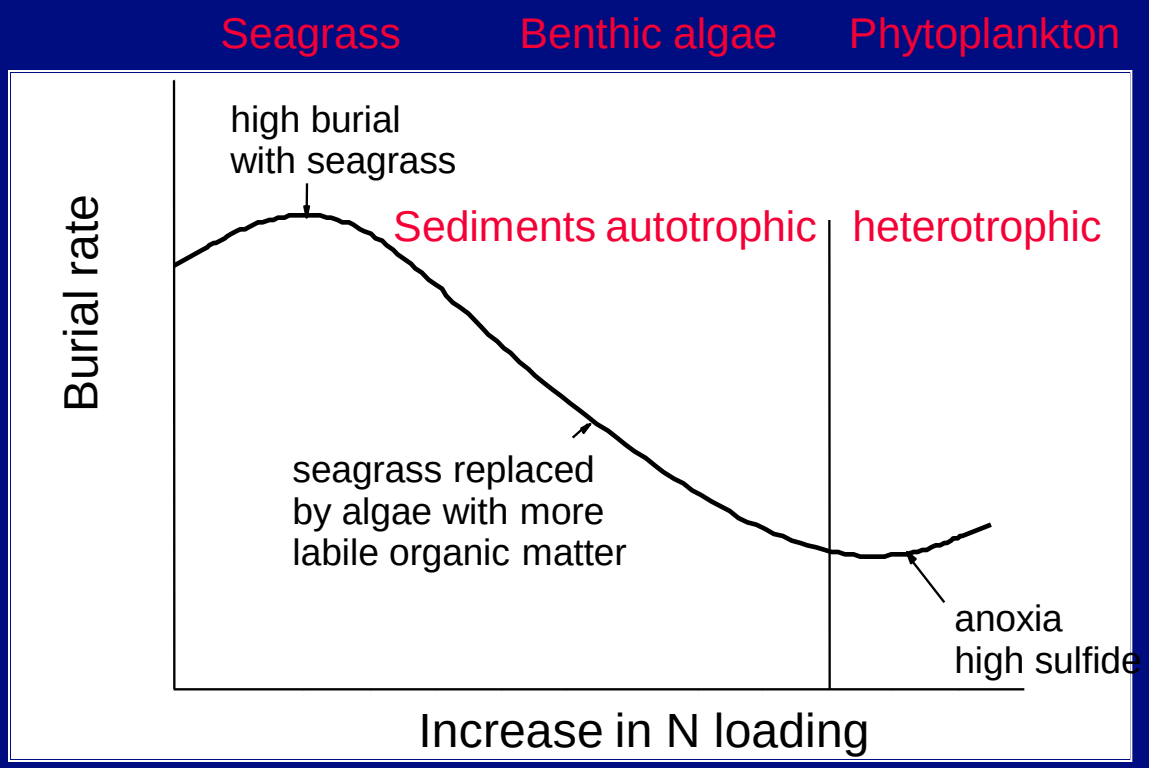
Primary producer assimilation is similar or equal to external nutrient loadings typical of coastal bays.

Pedersen et al. 2004

As the biological structure changes with eutrophication, how does the fate of nutrient inputs change?



Conceptual models:

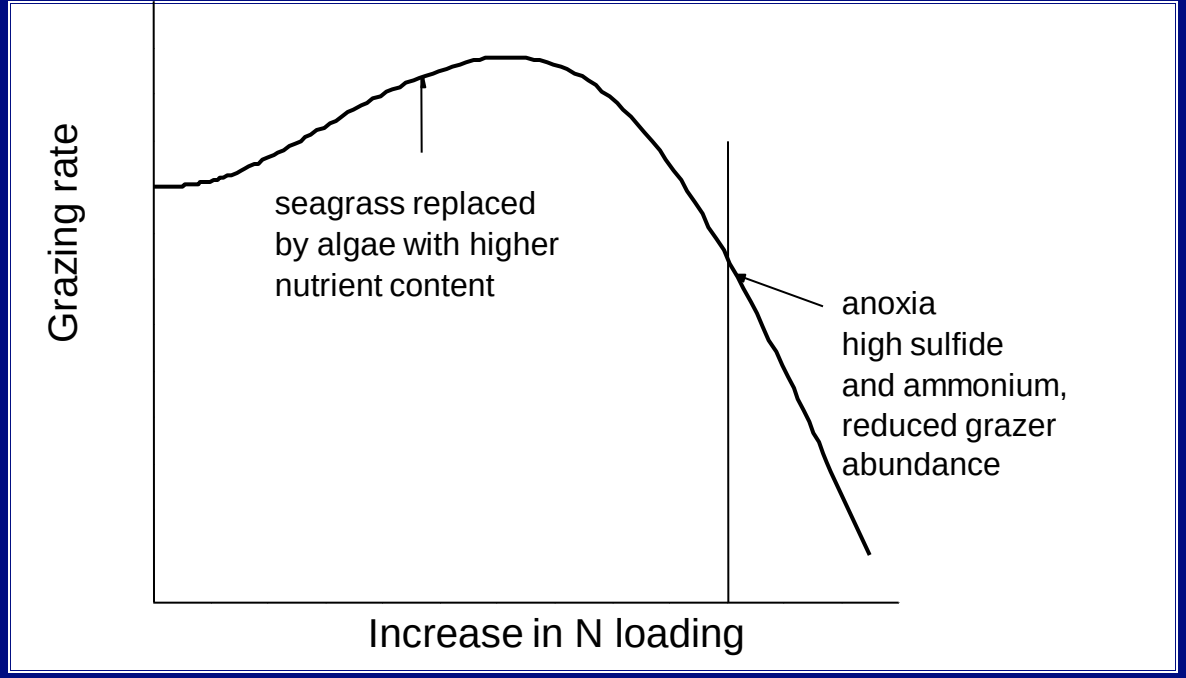


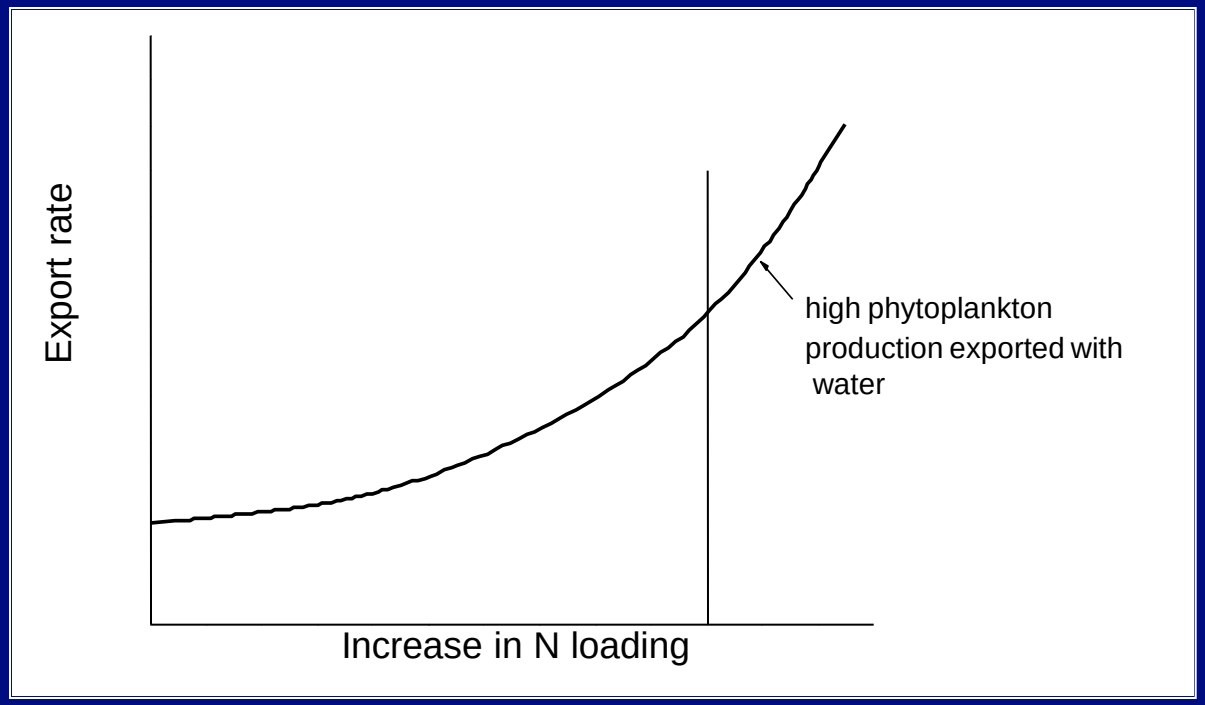
As eutrophication proceeds, burial decreases

Conceptual models:

Transfer to higher trophic levels declines

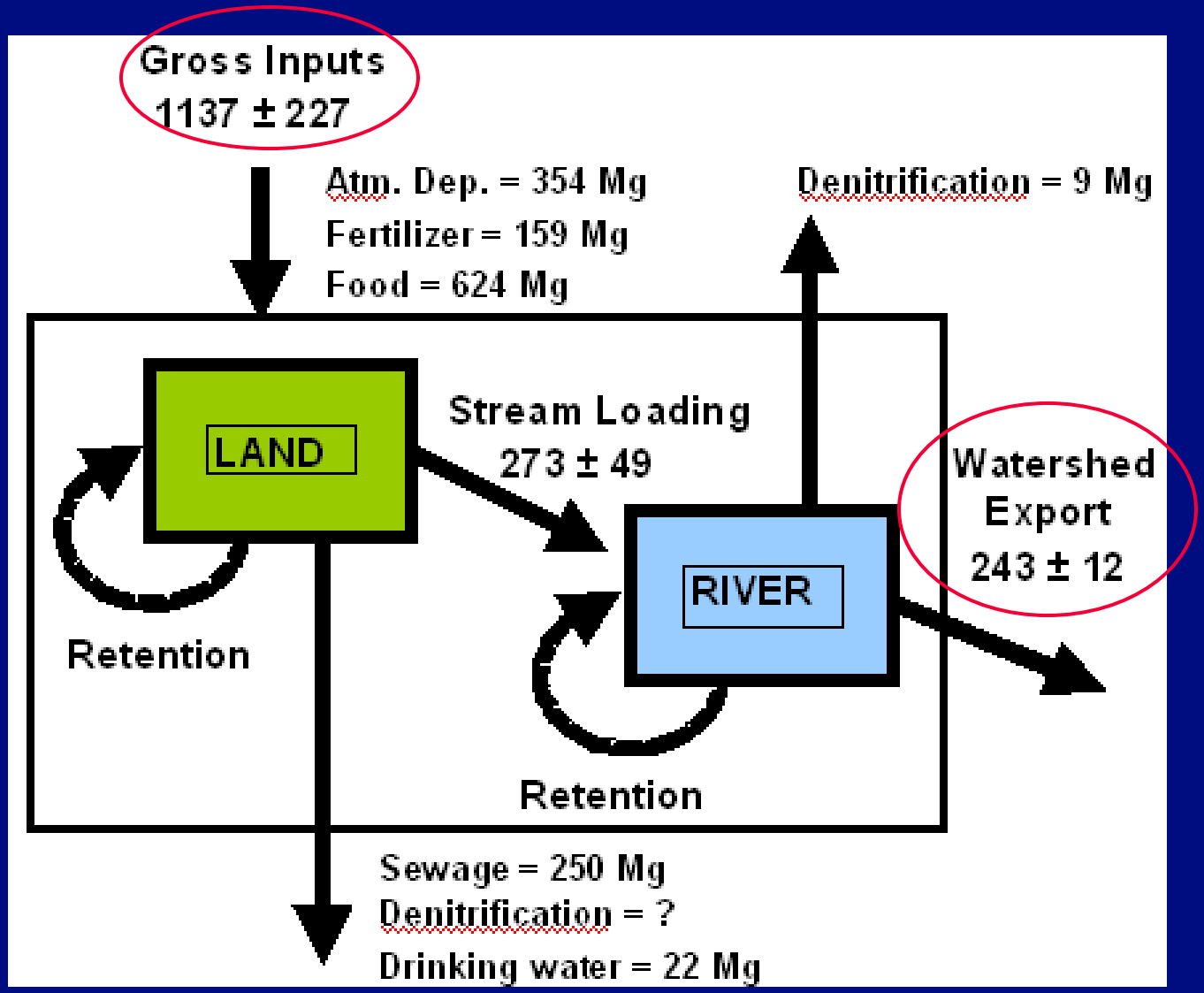
and nutrient export increases

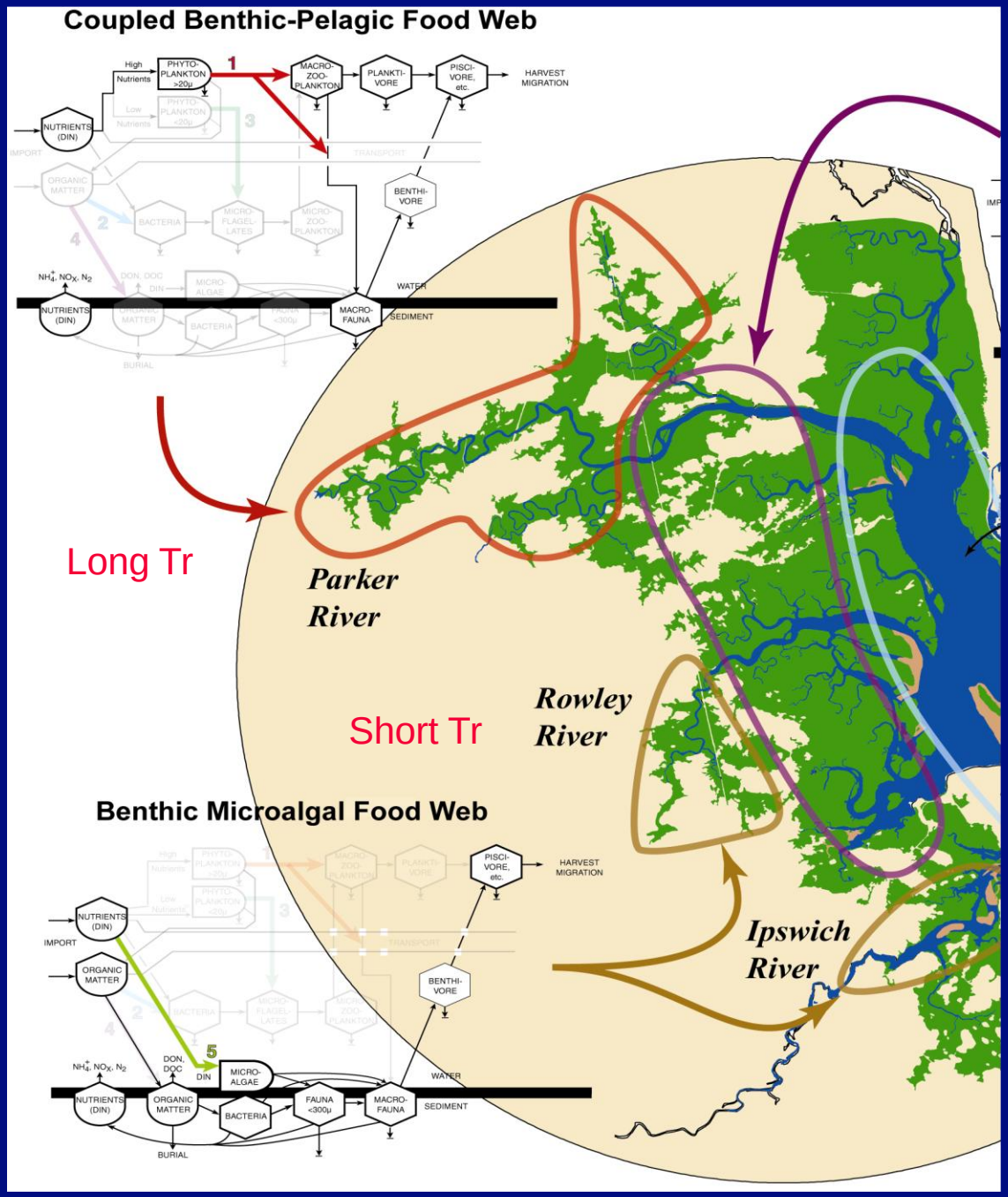




PIE: Are salt marsh dominated estuarine systems less susceptible to eutrophication?

What is the capacity of the watershed to retain N?





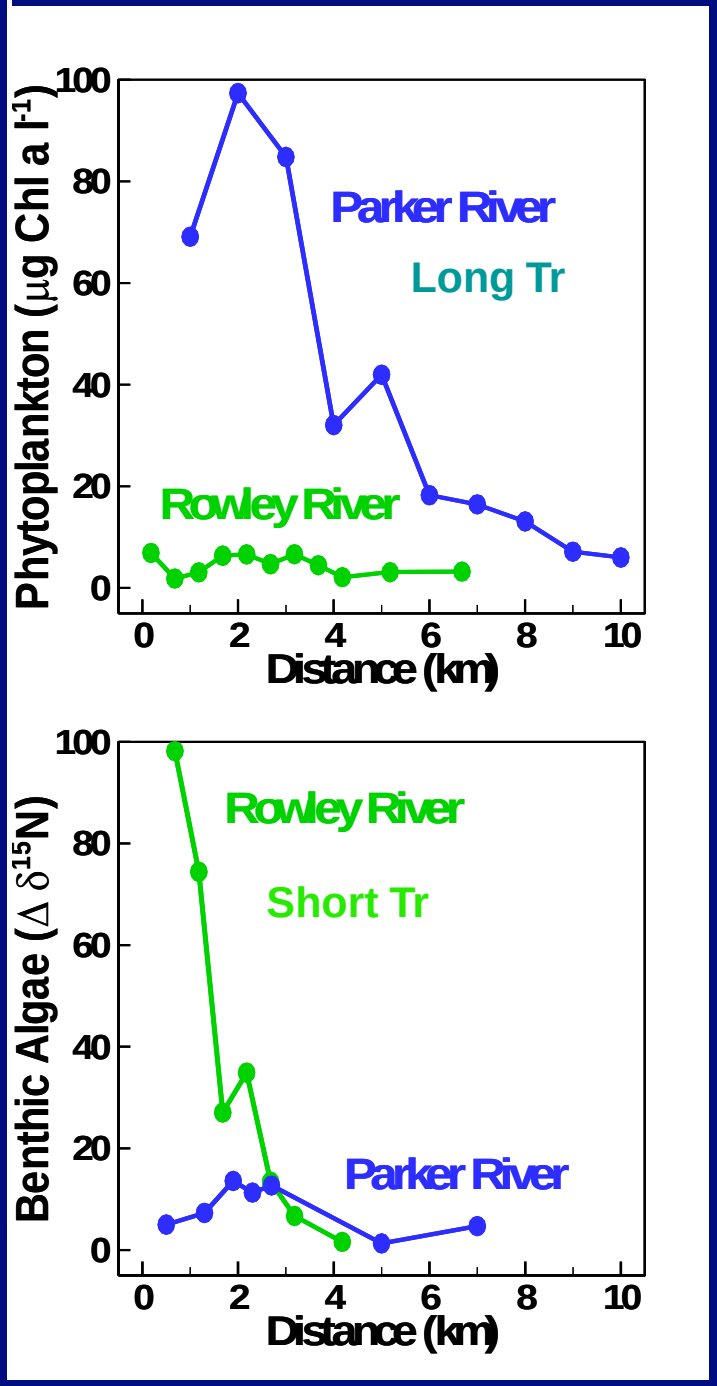
Estuarine spatial complexity is related to water residence time

Eutrophication simulated by $^{15}NO_3^-$ additions to 1st order tidal creek

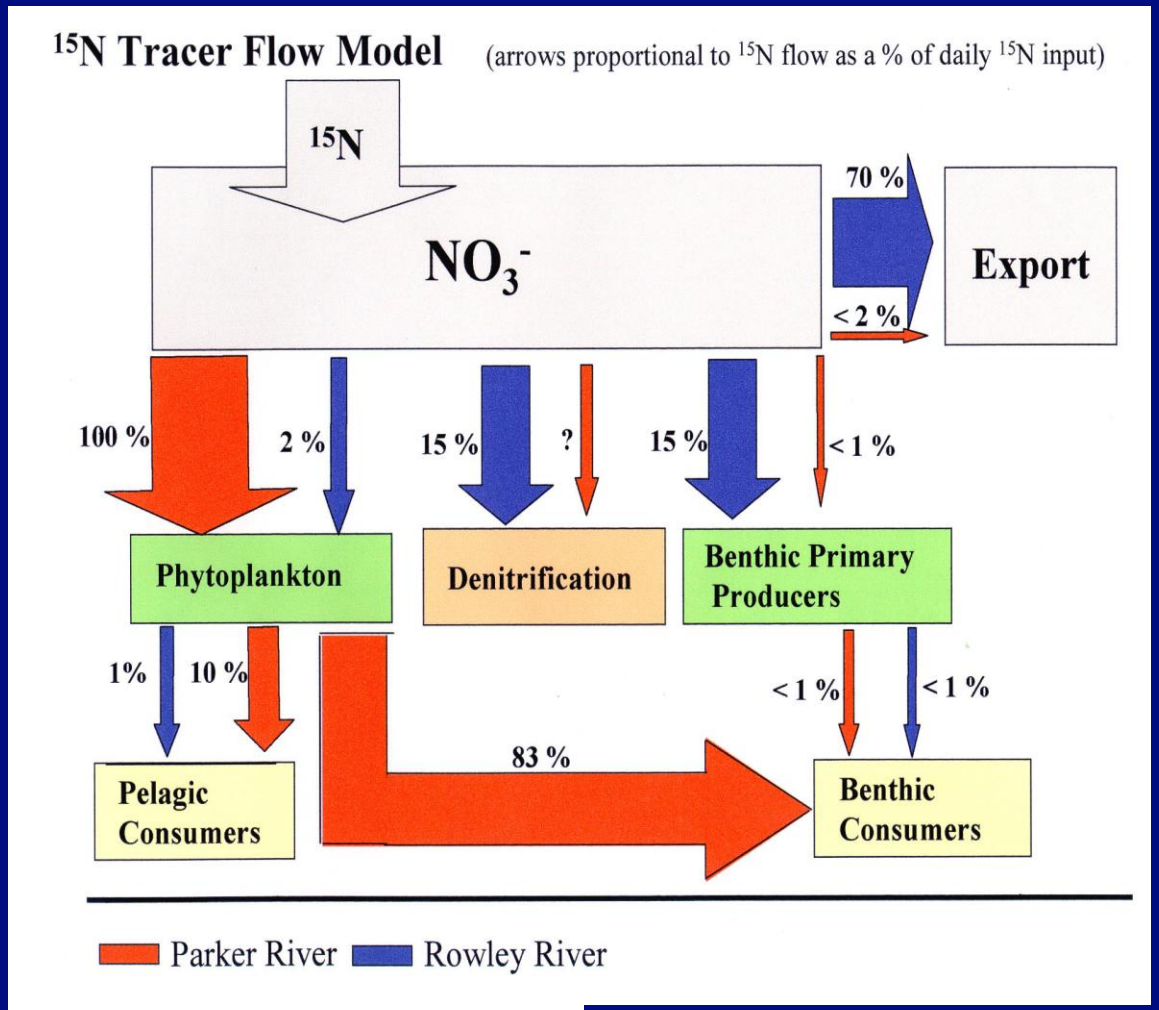
Eutrophication simulated by $^{15}NO_3^-$ additions to 1st order tidal creek

Long residence time – phytoplankton dominate

Short residence time – benthic algae dominate



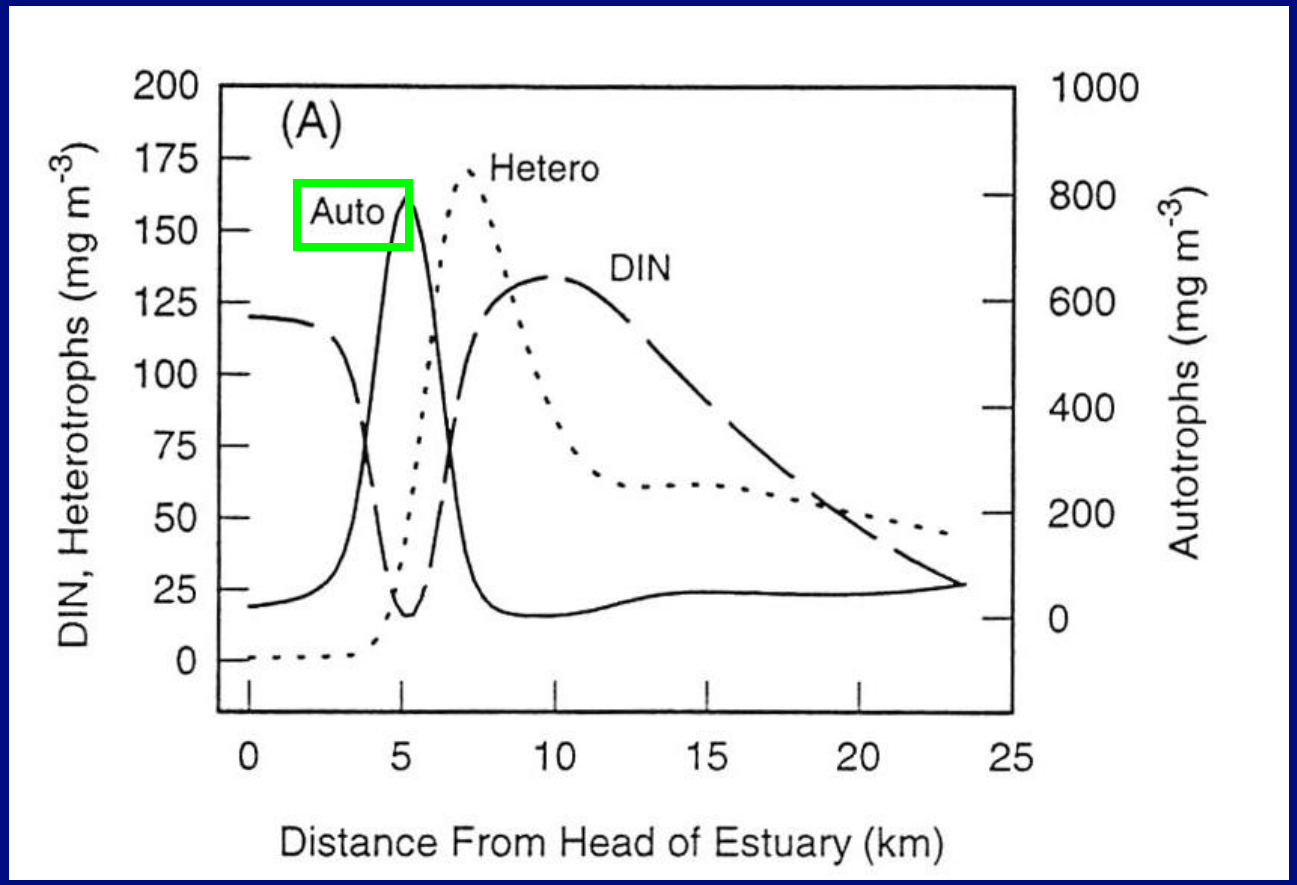
Modeling: to synthesize results



Tr long Tr short

Food web structure, as dictated by water residence time, determines how N is processed and its fate within the system

Modeling: predicting spatial patterns



Phytoplankton blooms are limited to the head of the estuary where residence time is long. When coupled to land use change and watershed export models, model can be used to forecast algal blooms.

Summary

- LTER's 3-tiered approach:
  - broad-scale long-term monitoring
  - process-based measurements
  - development of predictive models

- Comparative studies within network provide opportunities to understand regional and system-type differences
  - integration with regional efforts of NOAA, USGA, EPA

- Eutrophication models need to include the importance of biotic feedbacks and water residence time on nutrient cycling, and to capture dynamic events