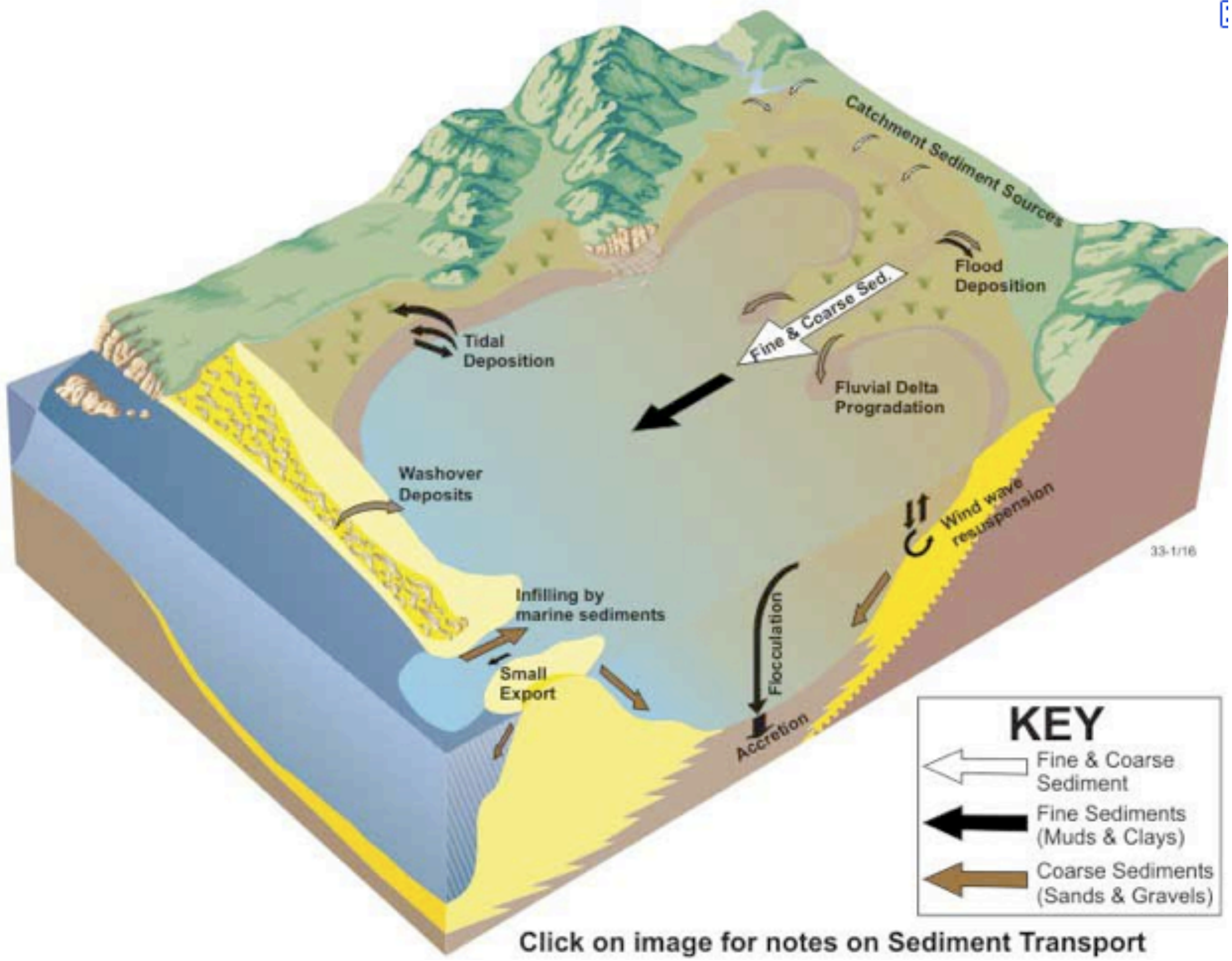
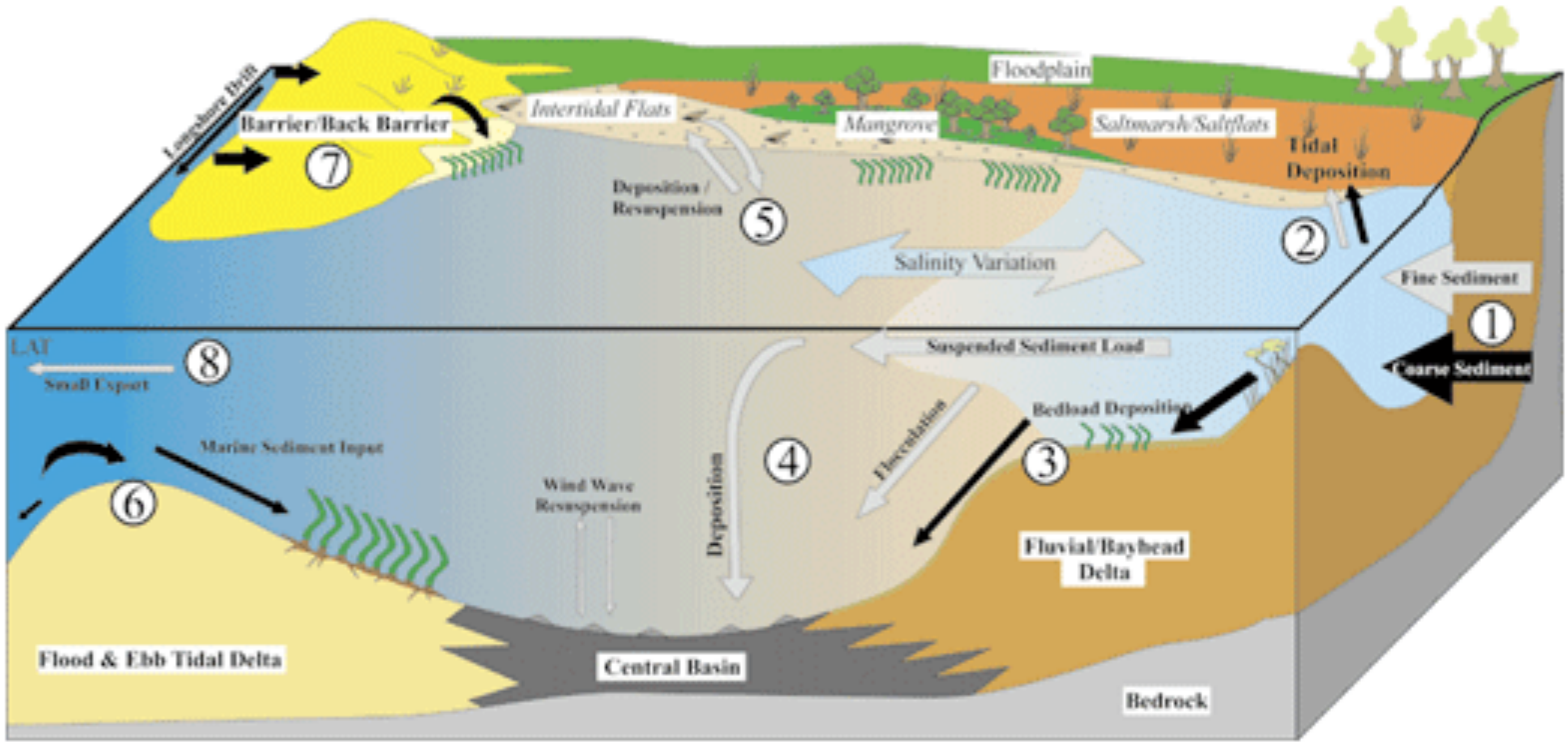
Sediment sources



Riverine input usually settles first near mixing zone
Why? Hydrological slowdown and/or aggregation in salty water

Sediment processes



Likewise, flood delta can result from marine source

Table 5. Sediment Budget (Mg × 10^3) for the South River, Maryland, 1846–1970

Period	Sediment inputs: Fluvial inputs: Cliff erosion	Rhode Rvr average[b]	South Rvr data[c]	Changes in sediment storage: Marsh	Beach	Subtidal storage	Sediment exports[a] (inputs—storage): Minimum	Maximum
1846–1903	796	53	162	46	−3	51	755	864
1903–1933	375	28	85	−2	7	276	122	179
1933–1970	244[d]	34	105	8	9	139[e]	122	139
Total	1415	115	352	52	13	466	999	1182

[a] Minimum based on Rhode River fluvial input data; maximum based on South River fluvial input data.
[b] Based on data collected from the Rhode River, Maryland by the Smithsonian Environmental Research Center (Pierce and Dulong 1977; Correll, Jordan, and Pierce, unpublished data). Calculated as 12.5 Mg/km^2/yr · 73 km^2 · years in period.
[c] Based on South River postflood sediment discharge data. Represents high estimate of sediment yield calculated as 38.7 Mg/km^2/yr · 73 km^2 · years in period.
[d] Decreases in recent cliff erosion rates reflect shoreline protection measures along 36 percent of the shoreline.
[e] Based on average sediment accumulation rate between 1846 and 1933 of 0.17 g/cm^2/yr as determined from changes in subtidal bathymetry.

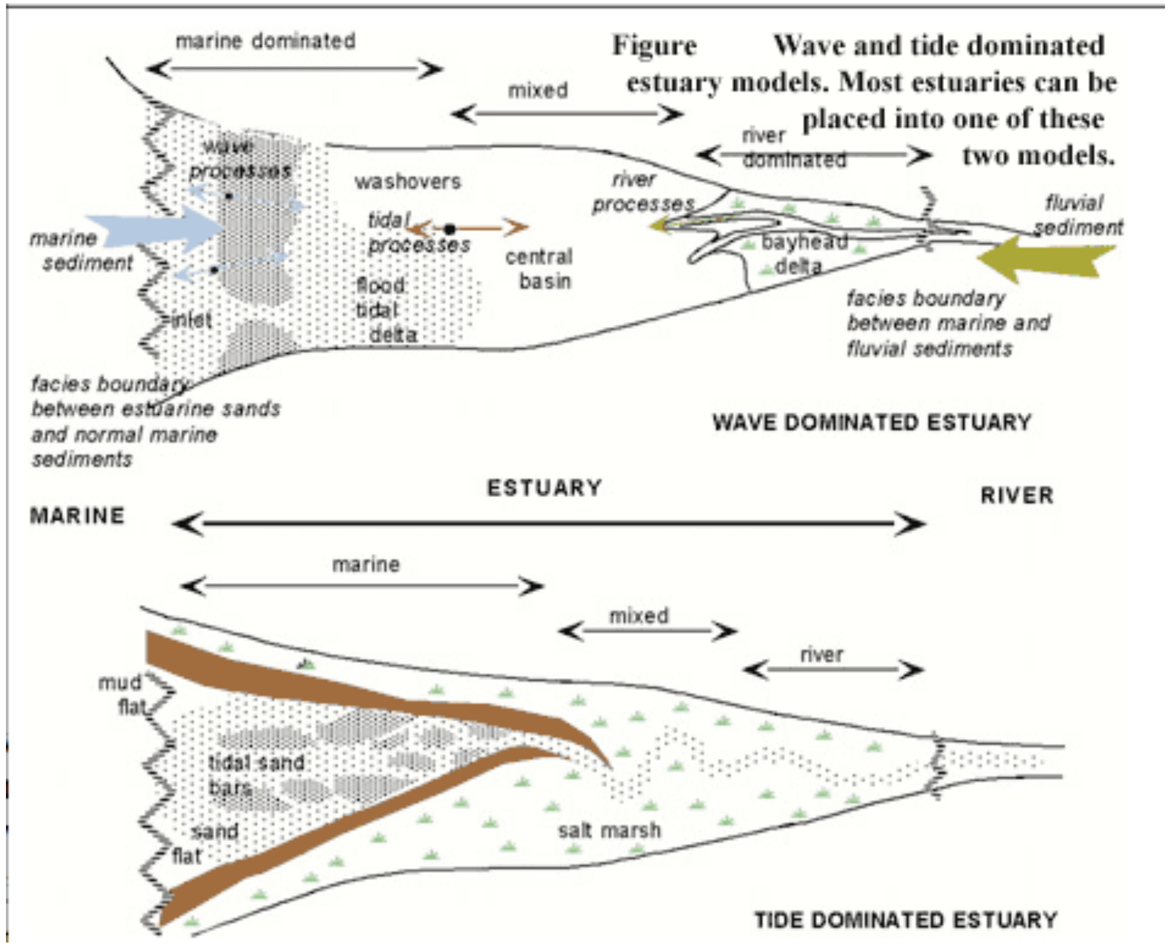
Figure 3. Erosion of a typical cliff face along the upper South River estuary. Groundwater sapping as well as wave attack (largely from boat wakes) appear to be responsible for the ongoing rapid erosion.

Cliff erosion can dominate sediment supply

Upland and Coastal Sediment Sources in a Chesapeake Bay Estuary
W. Andrew Marcus and Michael S. Kearney
Annals of the Association of American Geographers
Vol. 81, No. 3 (Sep., 1991) (pp. 408-424)

First depocenter is not necessarily the last

Resuspension: Need to get physical energy to the bottom



Slow resuspension/resettling by tide/wave reworking

Flushing by large, rare events (Mississippi, Kennebec)

Sedimentary features as function of tidal range

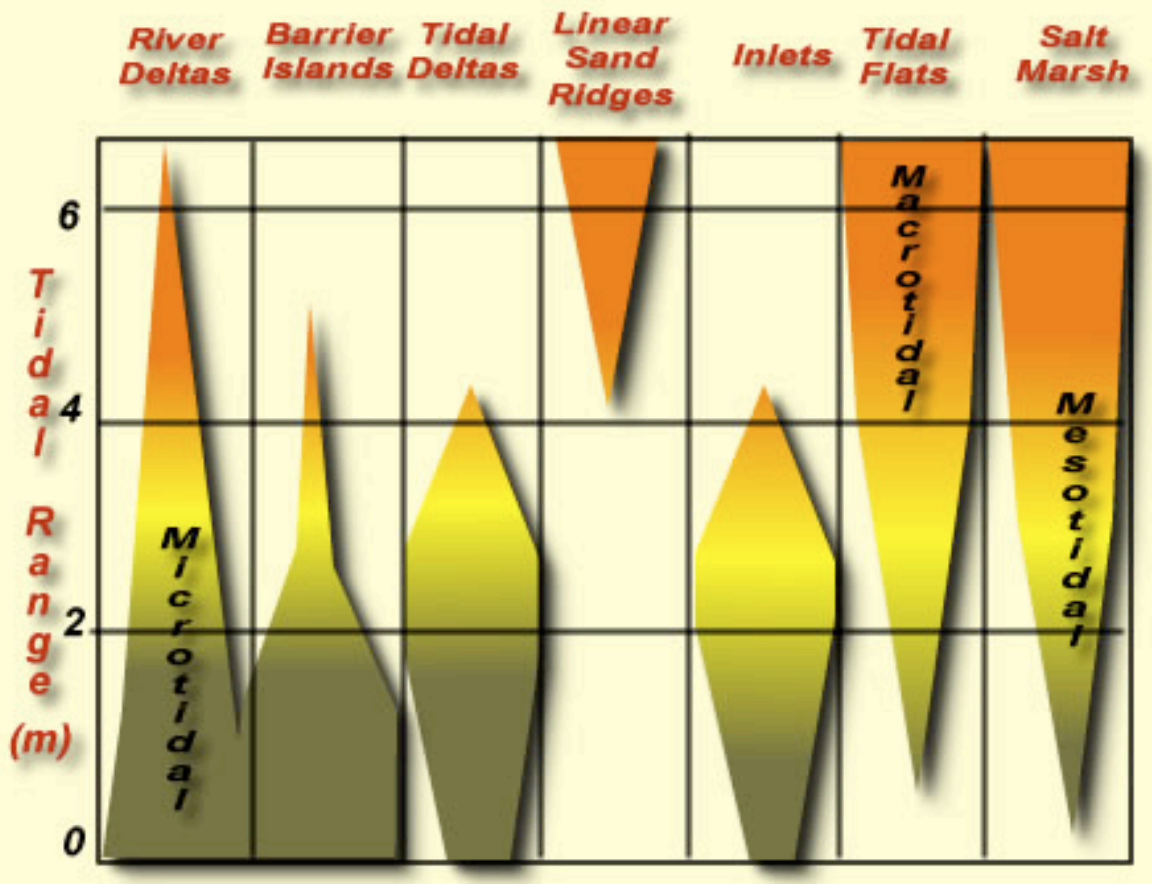
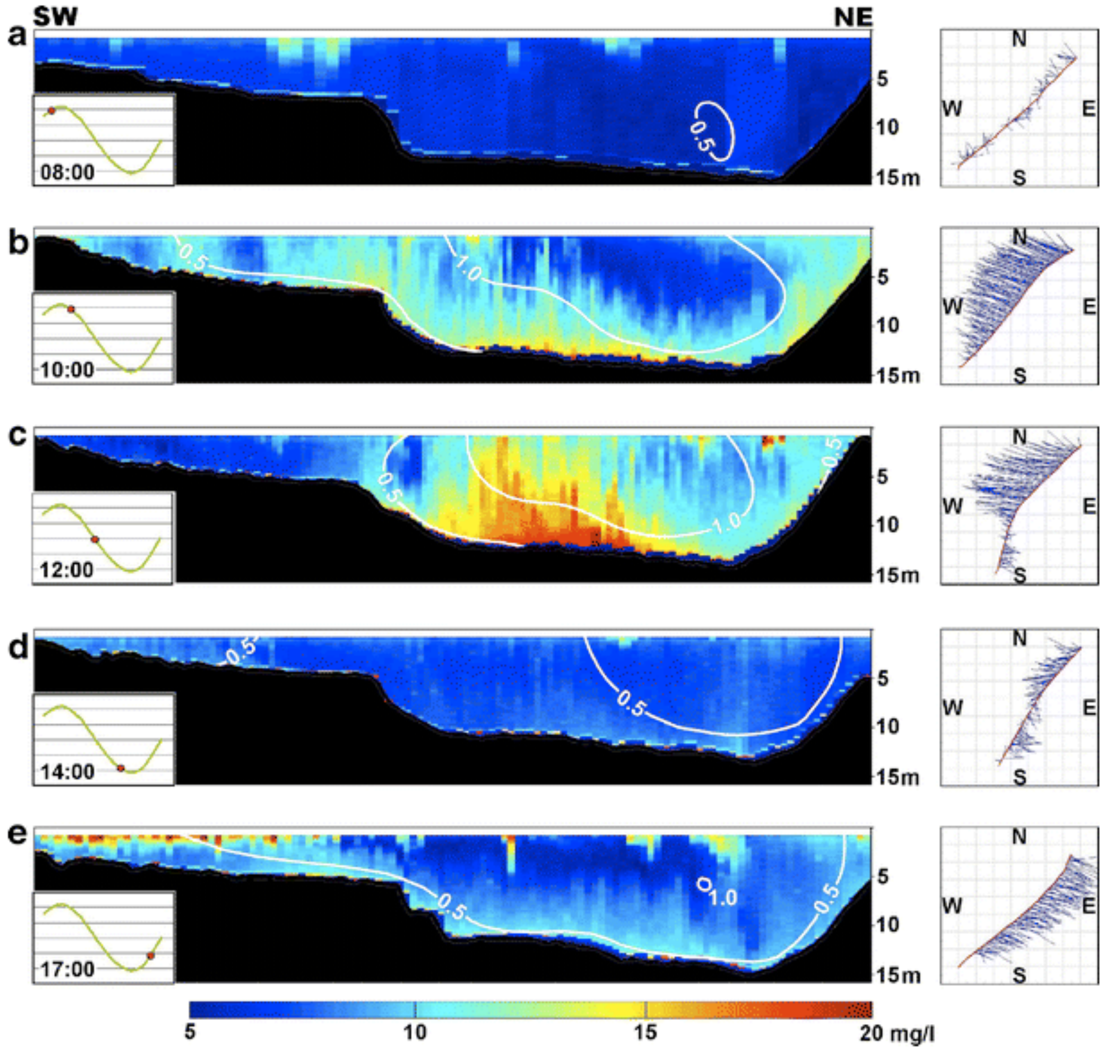


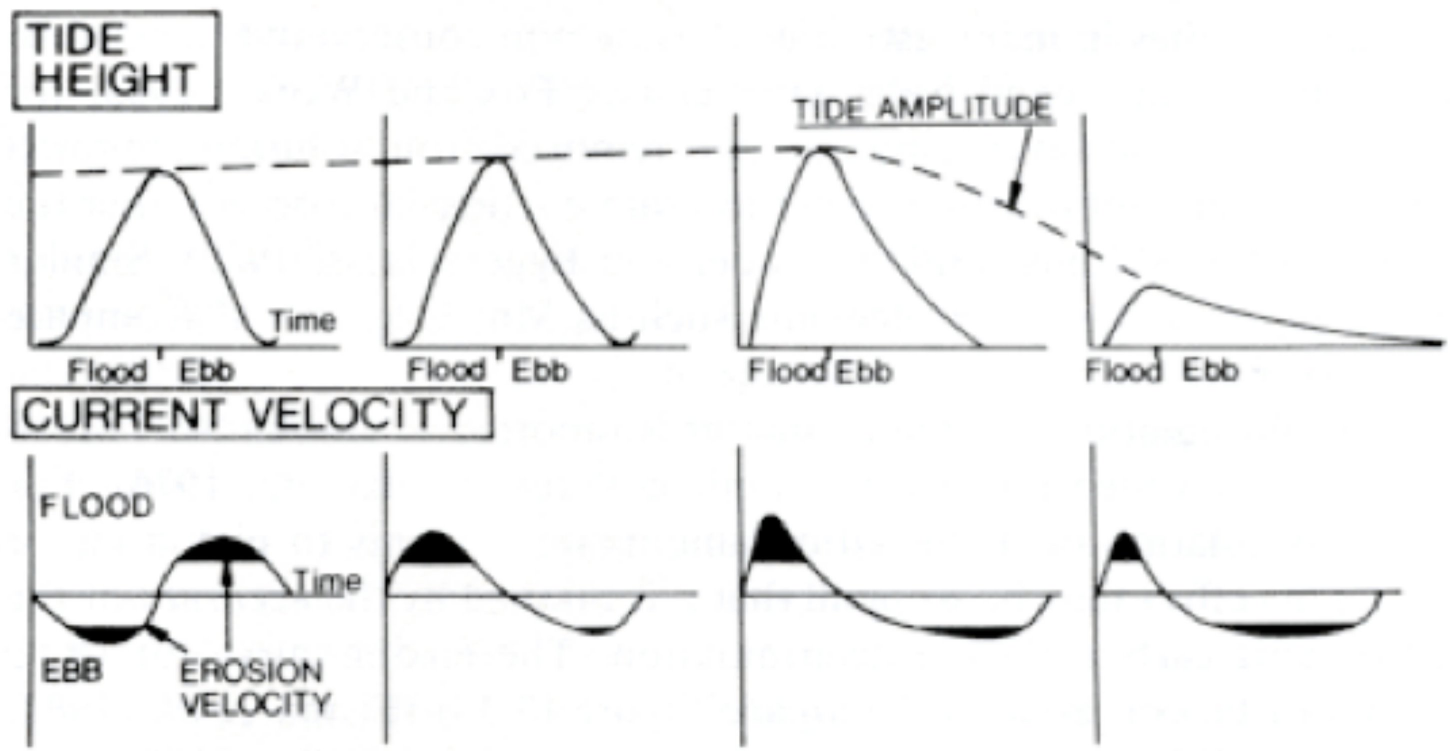
Figure 1. Distribution of coastal landform in along microtidal, mesotidal and macrotidal coasts, as defined by tidal range. From Hayes, 1975.

Tidal current Resuspension



Ocean Dynamics: Theoretical, Computational and Observational Oceanography (2009)
Suspended sediment transport in the German Wadden Sea—seasonal variations and extreme events
Alexander Bartholomä, Adam Kubicki, Thomas H. Badewien and Burghard W. Flemming

Tidal asymmetry matters



Scheme of asymmetry effect of tides in an estuary with high tidal wave on upstream transport of suspended matter (from Allen *et al*., 1980)

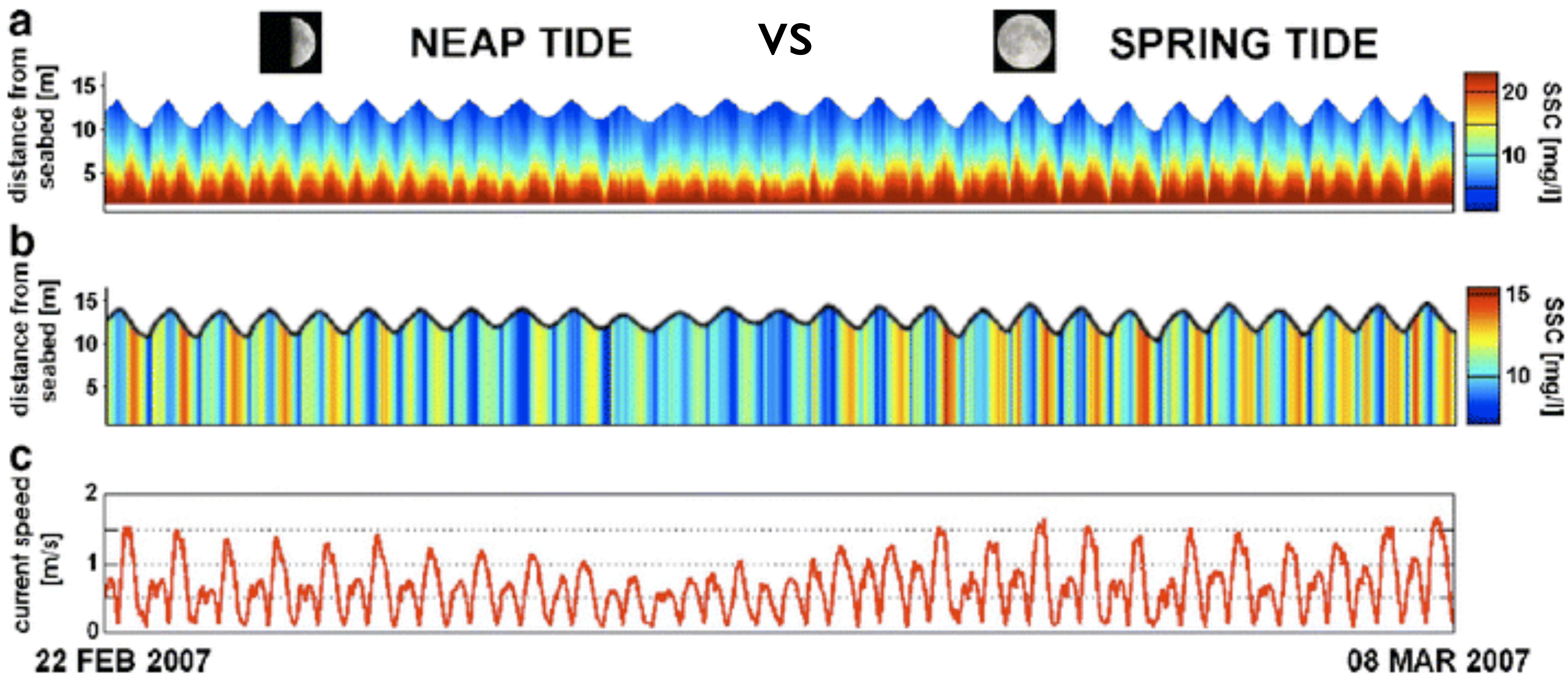


Fig. 6 **a** SSC values at different water depths and **b** depth-integrated SSC values during calm weather conditions between 22nd February and 8th March 2007. Note the difference of concentration during neap- and spring-tide periods observed as the increase of SSC values in the centre and upper section of the water column.

Ocean Dynamics: Theoretical, Computational and Observational Oceanography (2009)
Suspended sediment transport in the German Wadden Sea—seasonal variations and extreme events
Alexander Bartholomä , Adam Kubicki, Thomas H. Badewien and Burghard W. Flemming

Another energy source - windwaves f(depth, stratification)

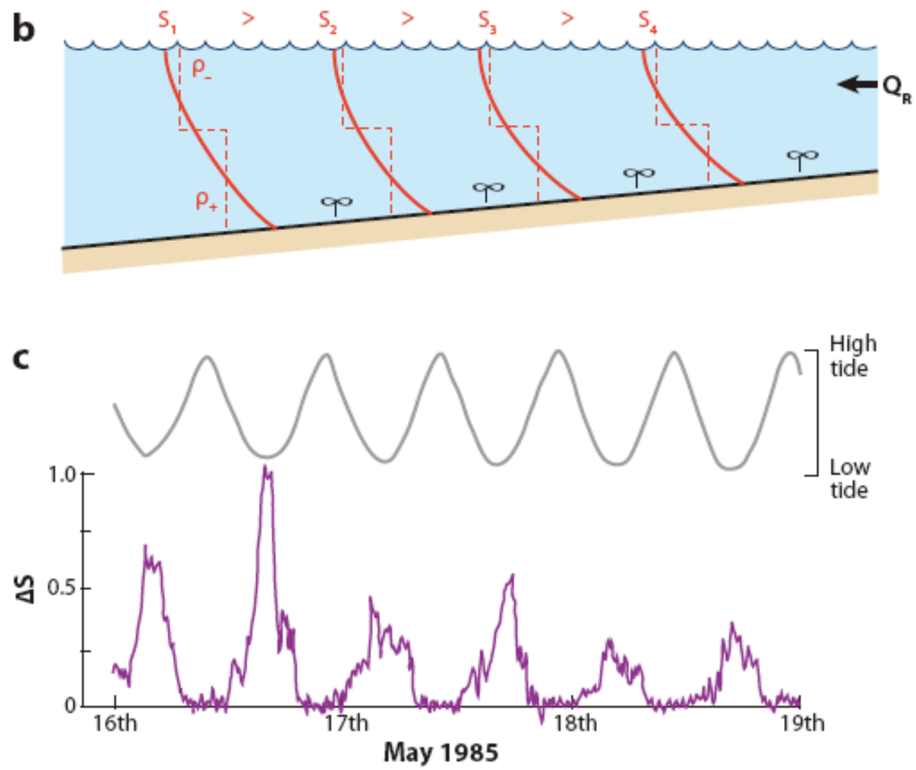


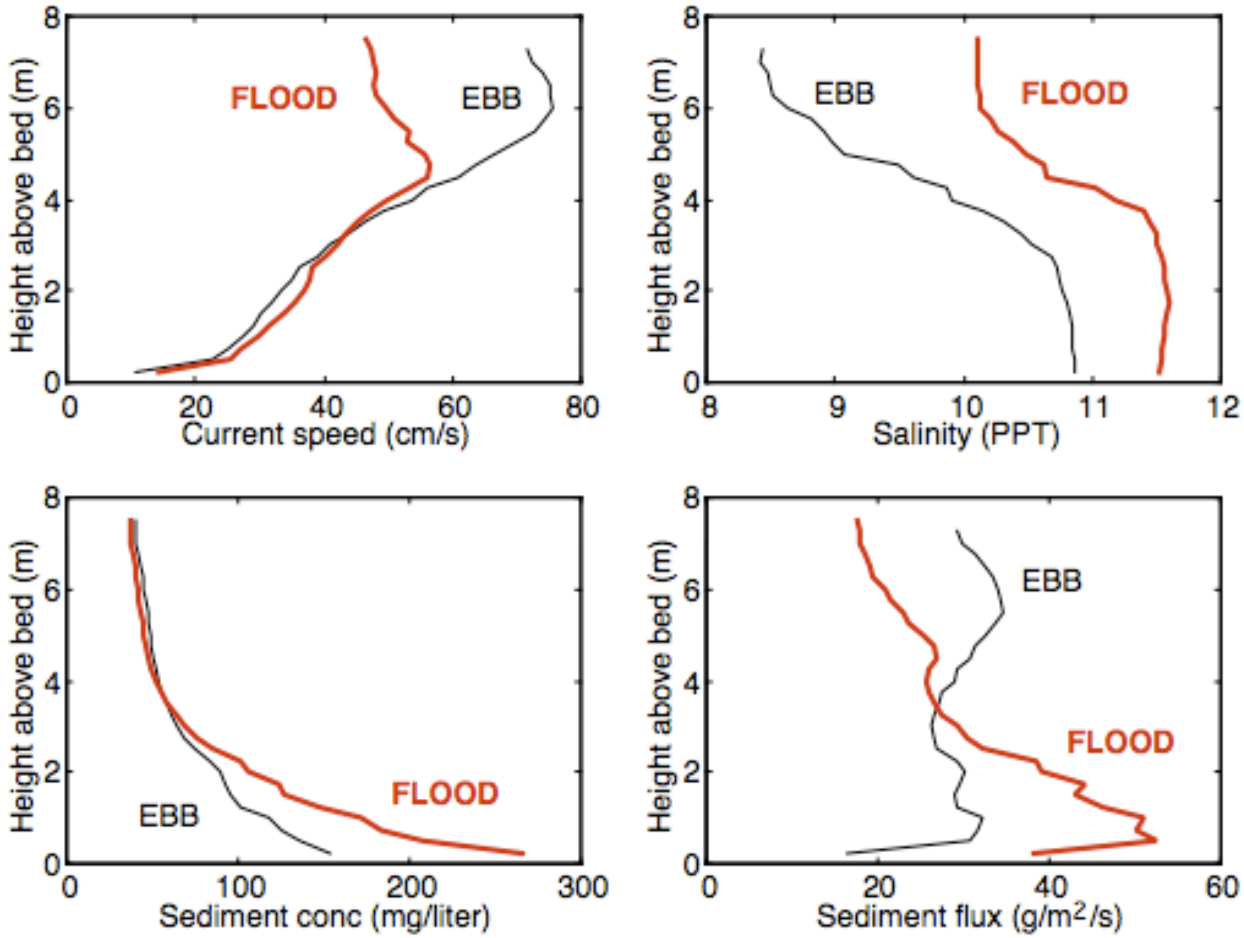
Figure 7

Schematic of the tidal-straining mechanism (*upper panels*) and evidence from Liverpool Bay of the associated tidal periodicity of stratification (*lower panel*) (based on Simpson et al. 1990, reprinted with permission). The top panel illustrates well-mixed conditions at the end of the flooding tide and the vertical profile of ebbing velocity. The solid lines in the second panel show the distortion of the salinity contours by the ebb, and the dashed lines indicate the influence of mixing. The time series in the bottom panel indicates alternation between well-mixed and stratified conditions, with maxima at the end of ebb (low tide).

Changes in stratification between flood and ebb
--> changes in wind-induced resuspension

Annu. Rev. Mar. Sci. 2010. 2:35–58

Fig. 1: Peak Flood vs. Peak Ebb, Upper York Estuary 4/6/99

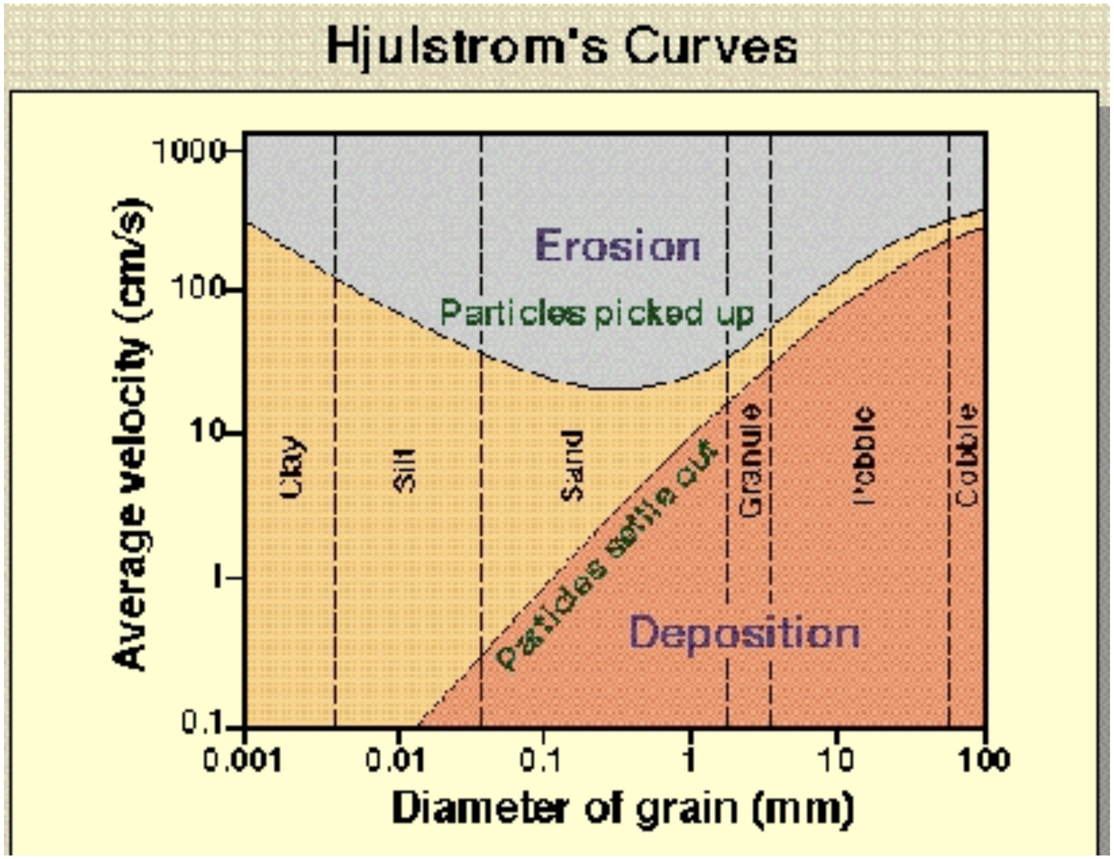


Greater stratification and lower pycnocline on ebb reduce near-bed turbulence, resulting in less suspension and less near-bed sediment flux on ebb

Sediment Transport Associated with Tidal Asymmetry in Stratification, Mixing and Resuspension in the York River Estuary

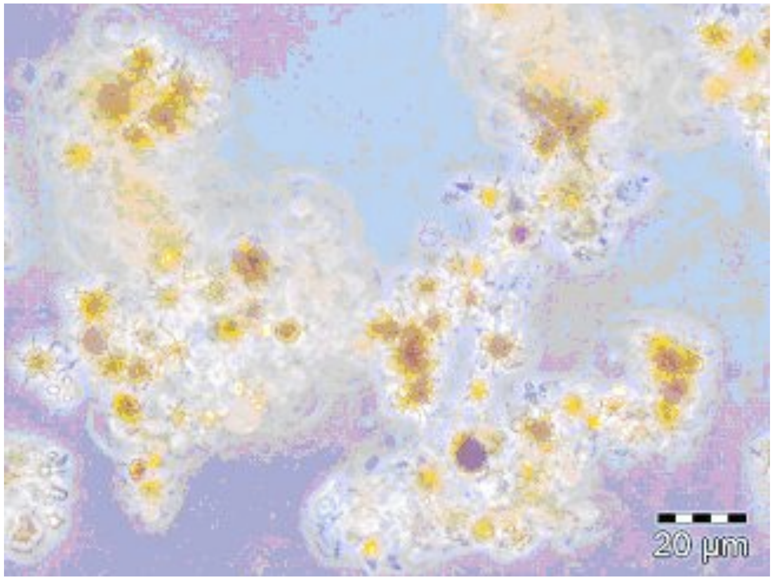
Carl T. Friedrichs, Malcolm E. Scully and Grace M. Battisto

Sediment is complex, with many grain sizes of minerals plus other materials



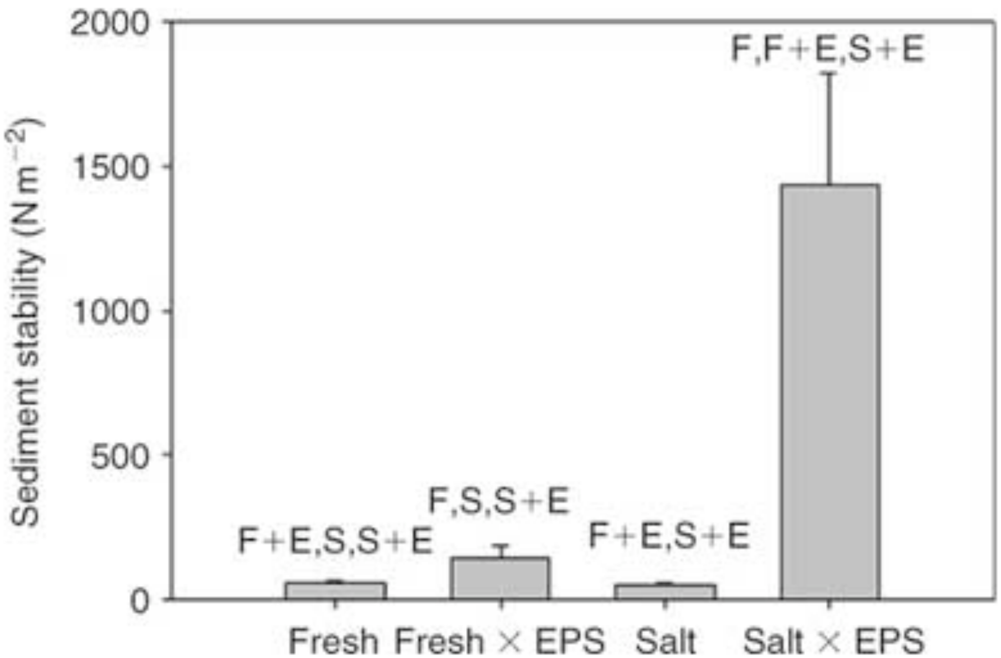
Oversimplified generalization

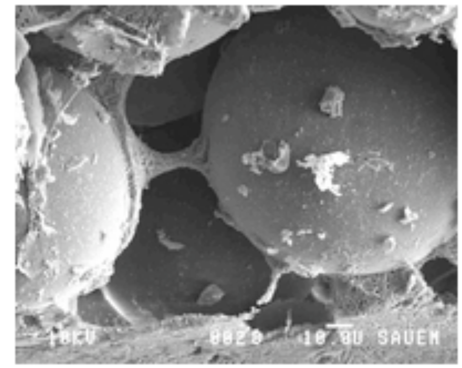
But in fact most resuspended sediment under mild conditions is aggregates, not single grains



Resistance to erosion responds to combination of salt and goo (as in "flocculation")

Fig. 6. Response of sediment stability to additions of salt, extracellular polymeric substances (EPS) and salt and EPS. F (freshwater), F+E (freshwater and EPS), S (saltwater) and S+E (saltwater and EPS) denote significant differences between the value of the labelled treatment response and the values of the other three responses determined using Mann–Whitney *U*-tests.





Electron microscope image shows in detail how the bacterial biofilm links glass spheres with each other (© Gerbersdorf / Lubarsky)

Spears, B. M., Saunders, J. E., Davidson, I., and Paterson, D. M. (2008). Microalgal sediment biostabilisation along a salinity gradient in the Eden Estuary, Scotland: unravelling a paradox. *Marine and Freshwater Research* **59**, 313–321.

After resuspension comes
Export
or
Redeposition within estuary

How long does it take water to clear?

Muddy rivers coming into ocean - hours to days

Estuary after a windstorm - hours

Physics of sediment deposition

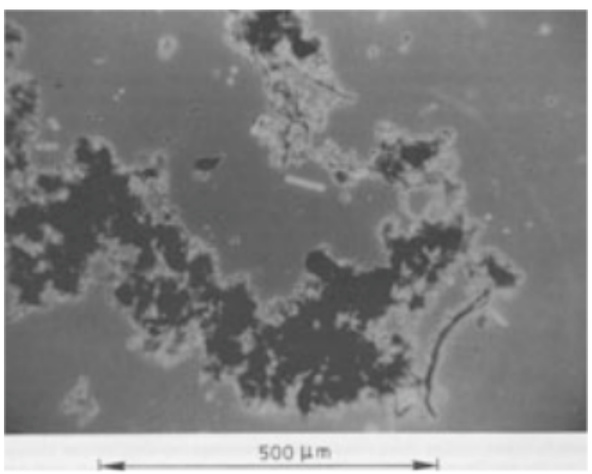
Settling rate described (semi-quantitatively) by

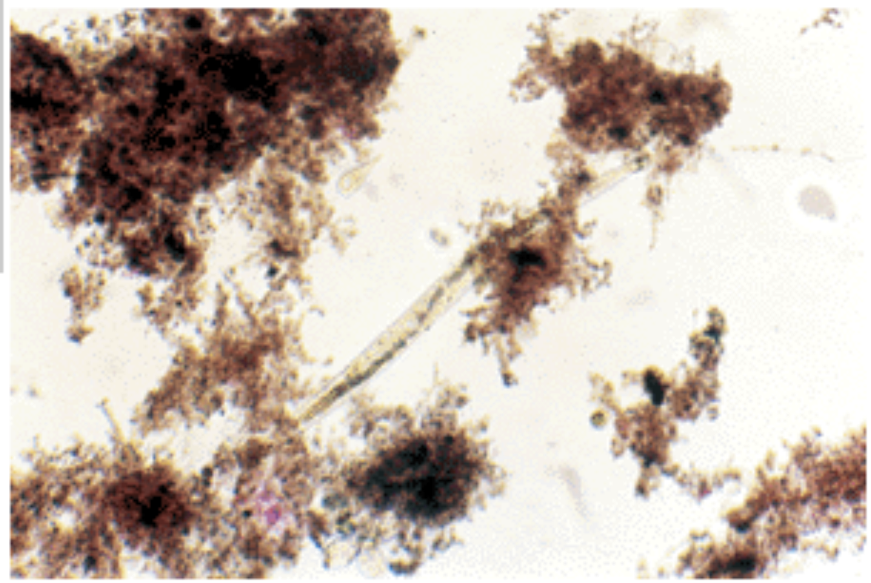
Stokes Law

$$v_S = \frac{g\ (\rho_P - \rho)\ D_P^2}{18\ \mu}$$

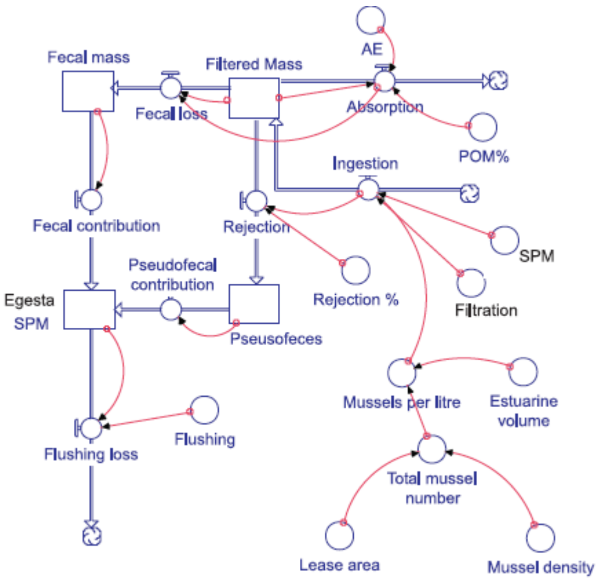
particle diameter

fluid viscosity





Tough to know density or even size



Biologically enhanced deposition

Figure 1: intertidal mussel beds south of the barrier island

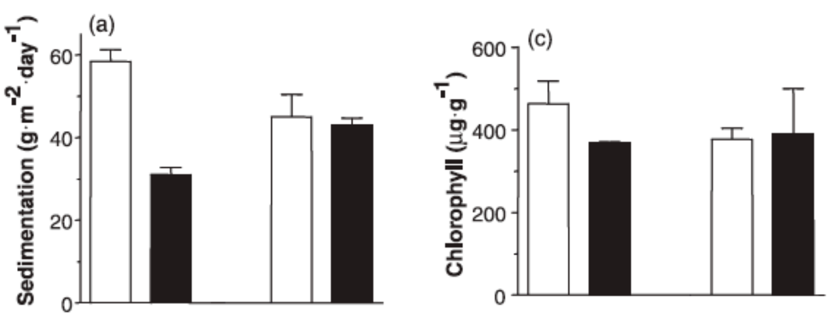
Table 1. Characteristics of mussel cultivation sites in field studies.

Estuary	Tidal range (m)	Total volume (m^3)	Tidal prism (m^3)	Cultured area (m^3)	Residence time (days)	Depletion index* I_D at 96 $L \cdot h^{-1}$	Depletion index* I_D at 56 $L \cdot h^{-1}$
Tracadie Bay	0.6	4.58×10^7	9.80×10^6	7.13×10^6	3.4	0.05	0.09
Savage Harbour	0.6	7.97×10^6	2.39×10^6	1.50×10^6	2.3	0.06	0.11

Note: Mussel cultivation area is total leased area; actual cultured area may be less.
*The depletion index is defined as the ratio of mussel clearance time to residence time as in eq. 2. Two values are given for different individual mussel filtration rates.

Grant et al. Can. J. Fish. Aquat. Sci. **62**: 1271–1285 (2005) 1281

Fig. 10. Results of sediment trap studies in Tracadie Bay and Savage Harbour. Values are mean + SE; n = 2 traps for each value. (a) Mass fluxes; (b) percent particulate organic matter (POM); (c) chlorophyll concentration; (d) percent chlorophyll of total pigments. muss, mussel culture; ref, reference sites.



...applies to sediment as well as food

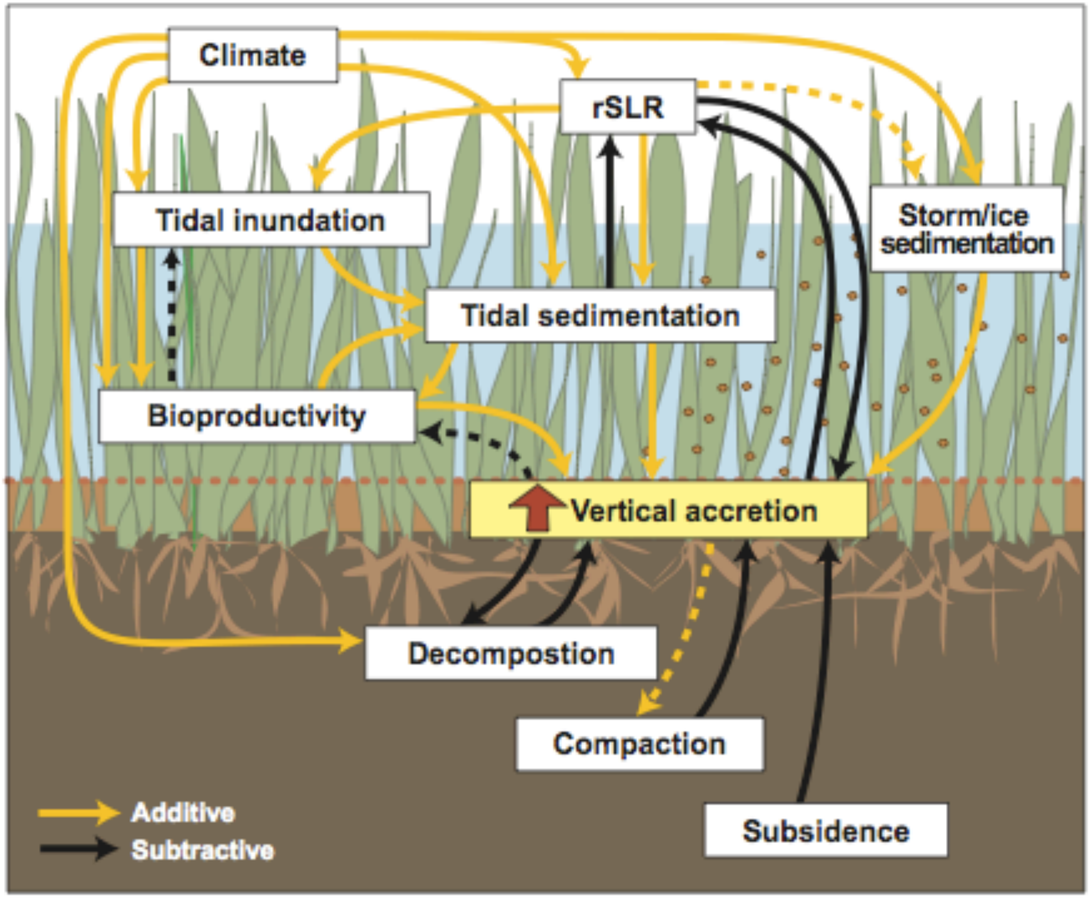


Figure 7

Conceptual model of the major factors affecting marsh elevation (after Argow 2006).

Annu. Rev. Earth Planet. Sci. 2008. 36:601–47

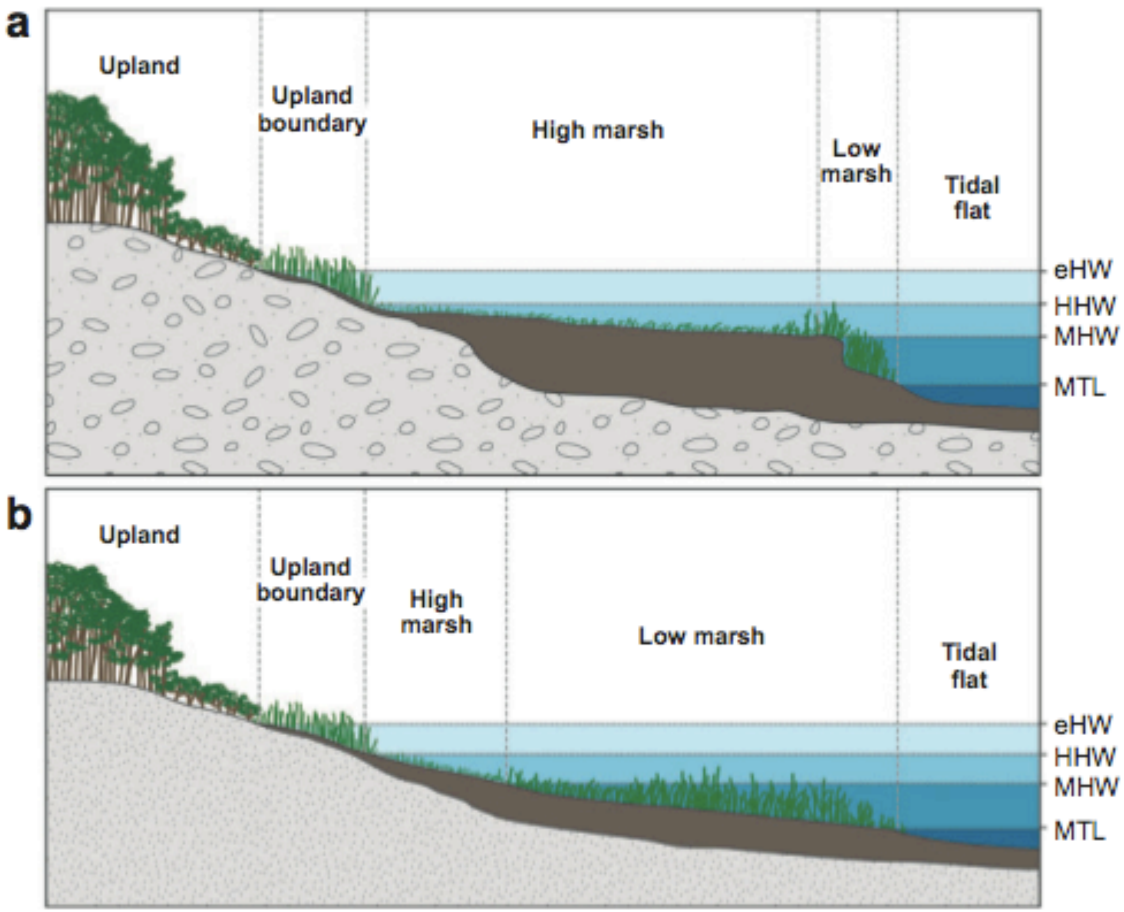


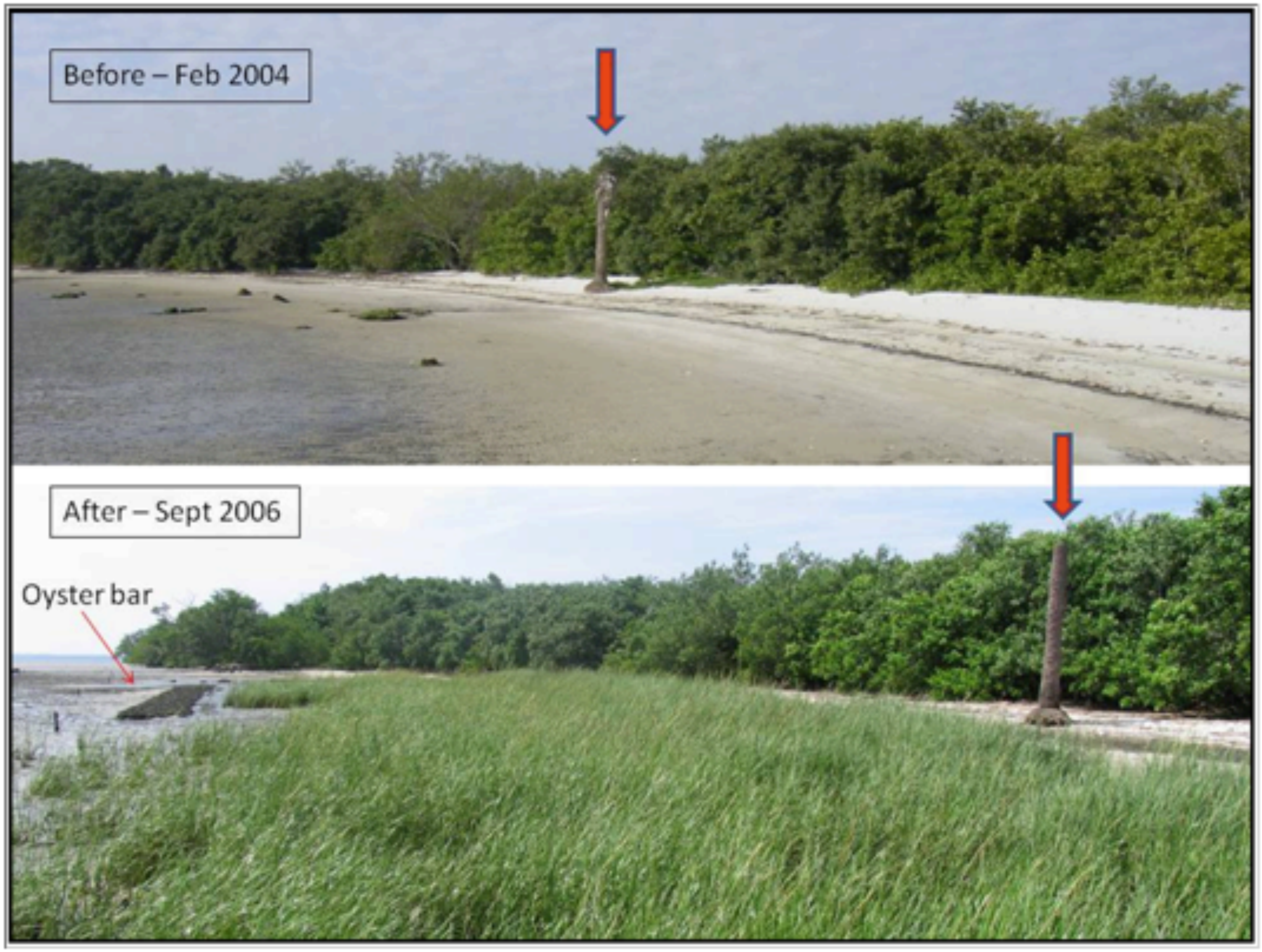
Figure 8

Platform (*a*) versus ramped (*b*) morphologies in tidal wetlands (after Argow 2006). Marsh zones are shown relative to mean tide level (MTL), mean high water (MHW), mean spring high water (HHW), and extreme high water (eHW).

Lowes Cove?

Annu. Rev. Earth Planet. Sci. 2008. 36:601–47

Synergies between animal and plant biodeposition

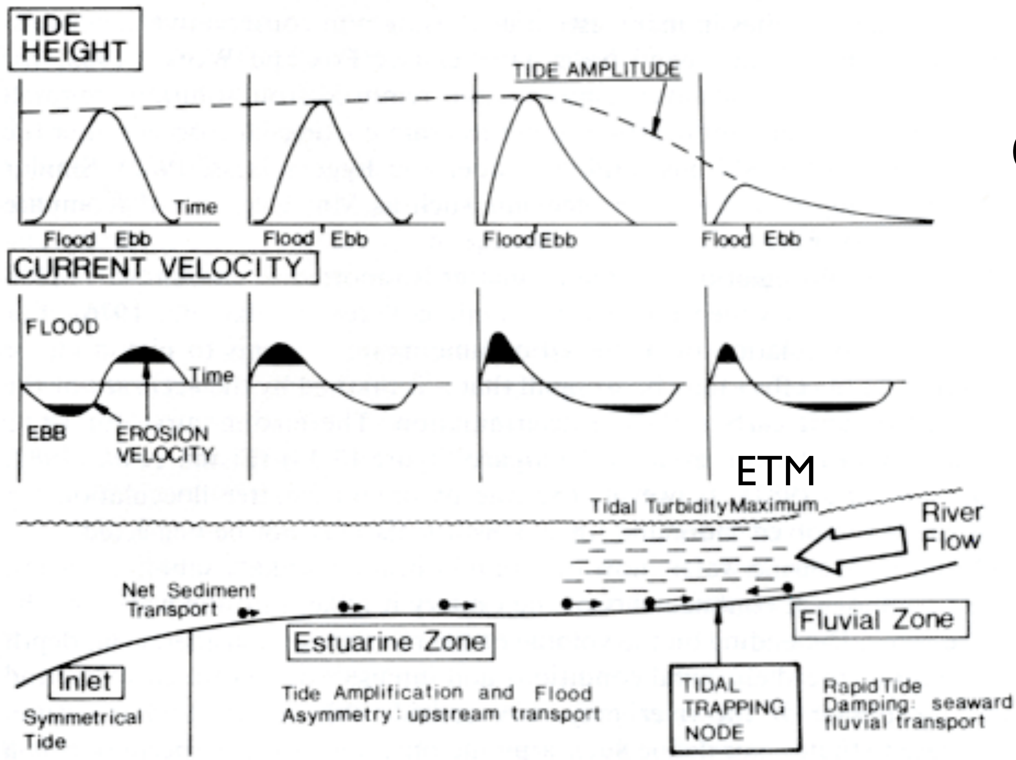


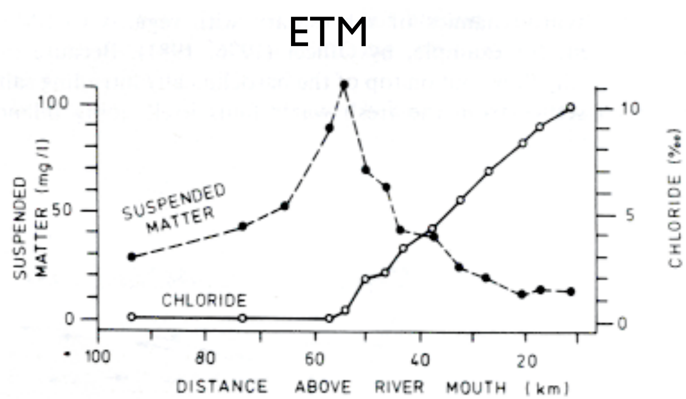
Phase 1, before and after reef establishment.

close or Esc Key

http://southeastaquatics.net/projects/oyster-reef-for-shoreline-stabilization

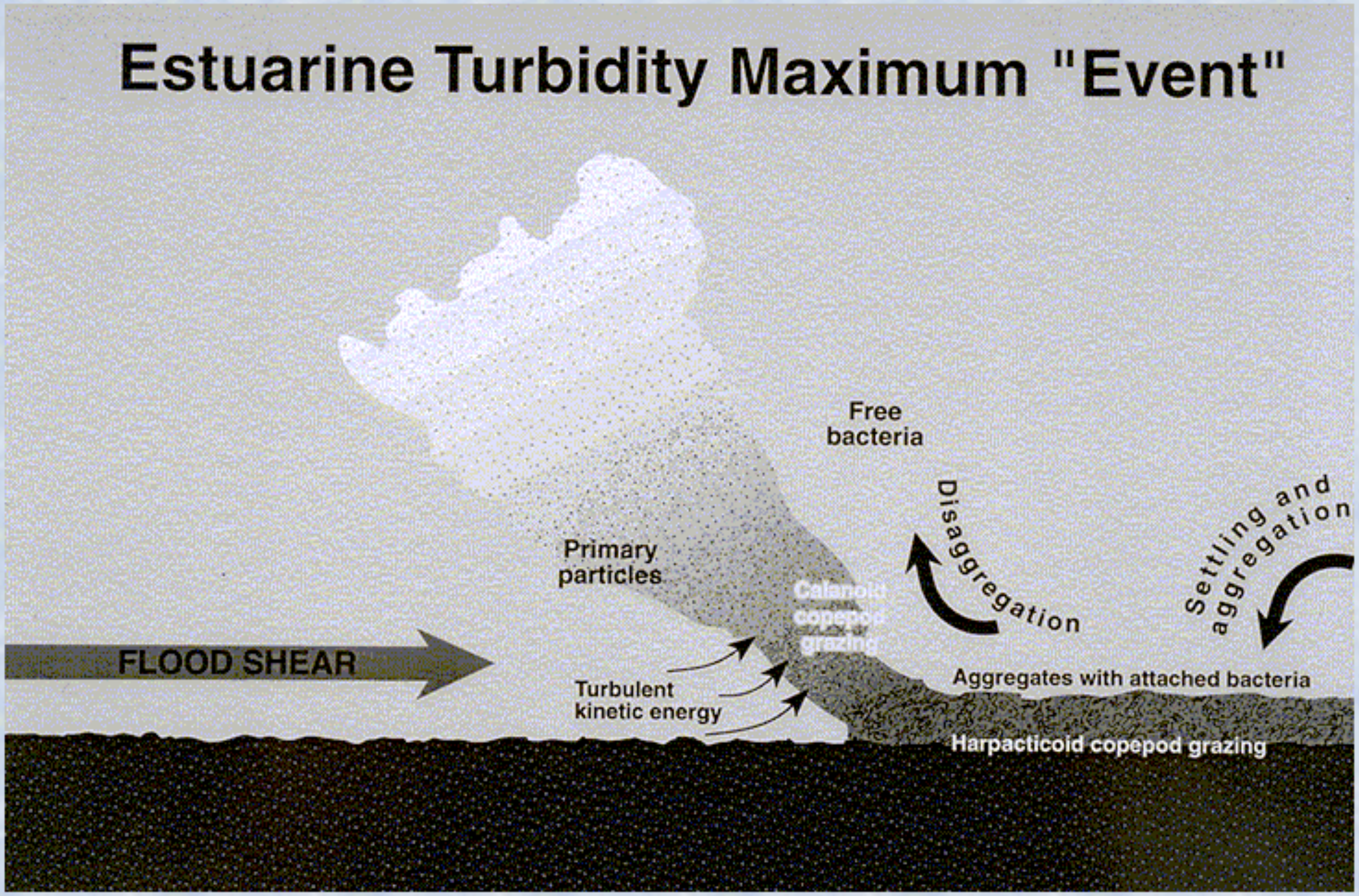
ETM
One explanation





p-p plot would show sharp, positive, nonconservative mixing

Heterotrophic organisms respond to this water column accumulation



(Figure courtesy of Blake Feist)

For the connections among hydrology, ETM, and fish in Chesapeake, see video at
http://www.schooltube.com/video/cf120a5e885e6dfe69f9/From-Physics-to-Fish

Fluid Muds

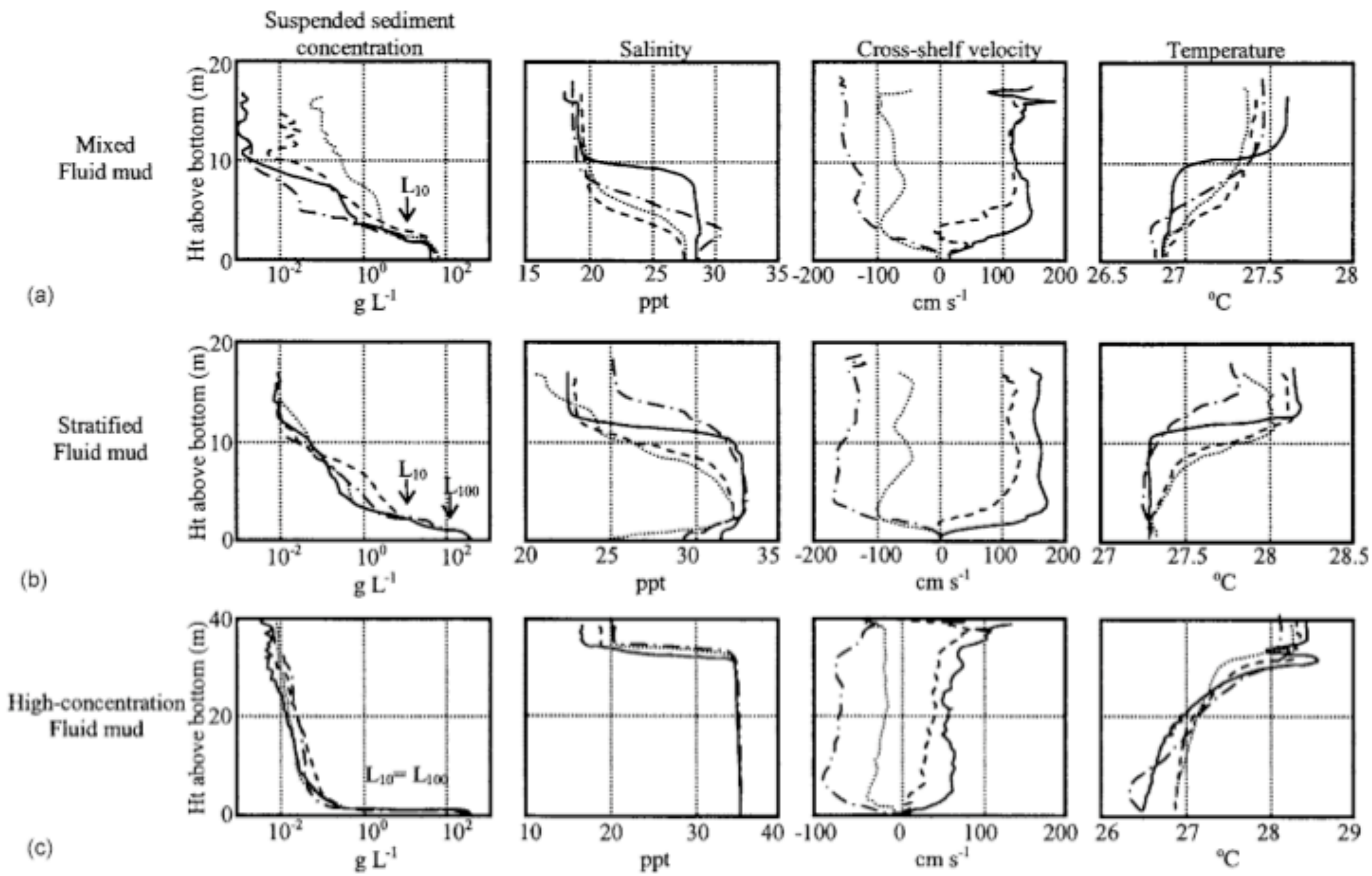


Fig. 9. Examples of sediment concentration, salinity, cross-shelf velocity and temperature for different types of fluid mud: (a) mixed fluid mud; (b) stratified fluid mud; and (c) high-concentration fluid mud. Each plot shows profiles from maximum ebb (positive) to maximum flood (negative) currents. Plotted profiles are every other hour in order of solid, dashed, dotted, dash-dot (reprinted from Kineke et al. 1996, with permission from Elsevier).

Sediments as processing zones
Anoxic metabolism very important in estuarine sediments

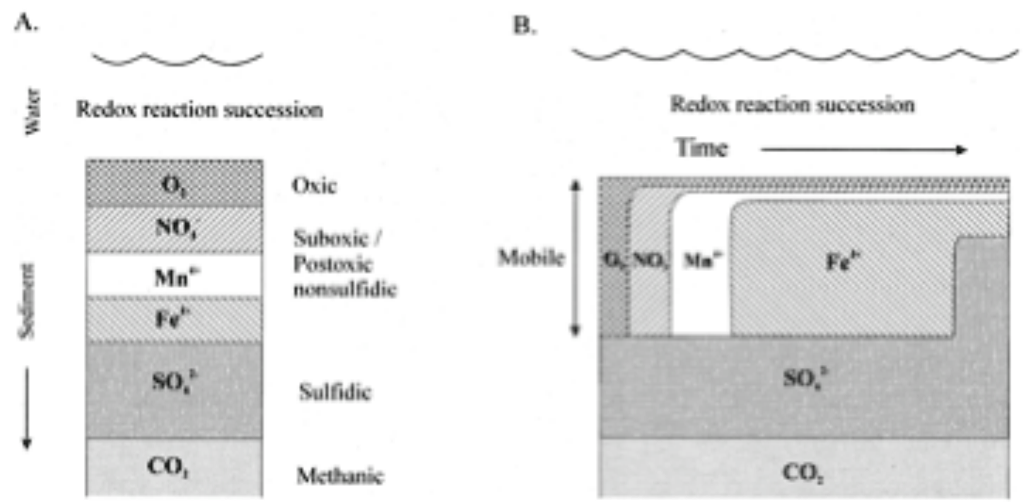
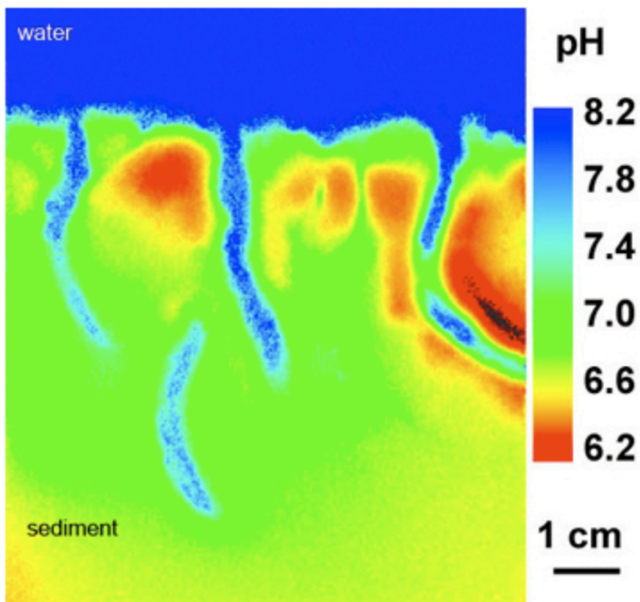


Figure 6. (A) Classic general redox reaction zonation with depth and time in steadily accreting sedimentary deposits. Relative zonal depth scaling depends on absolute and relative fluxes of oxidants and reductants. Terminology applied to individual zones is indicated. (Adapted from Aller, 1982; Berner, 1980.) (B) Unsteady redox succession and diagenetic ingrowth sequence in the surface mobile zone following a reoxidation–exchange event. Duration of individual redox stages is largely a function of oxidant and reactive reductant abundance (entrainment) following disturbance. Suboxic conditions often dominate the mobile zone for extended periods.

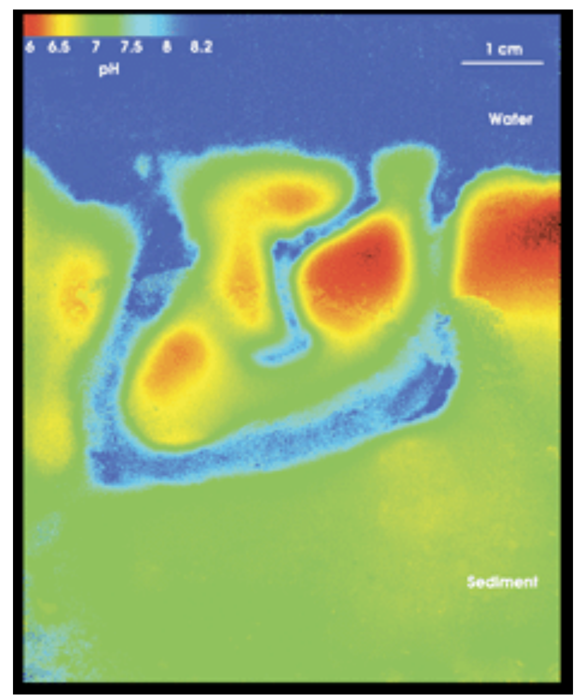
Animal-bacteria interactions

Worms' World: Biogeochemical Heterogeneity and Dynamics of the Seafloor as Revealed by 2-D Optical Sensors



Wednesday - February 18, 2009
Pacific Forum – 3:00 p.m.

A false-color image reveals a vertical section of the pH distribution associated with the burrow of the "clam worm" Nereis diversicolor in Flax Pond, a salt marsh on the north shore of Long Island in New York. Low-pH regions below the sediment/water interface and around the burrow represent sites of remineralization and oxidation. Courtesy of Robert C. Aller.



Different sedimentary zones process organic matter differently

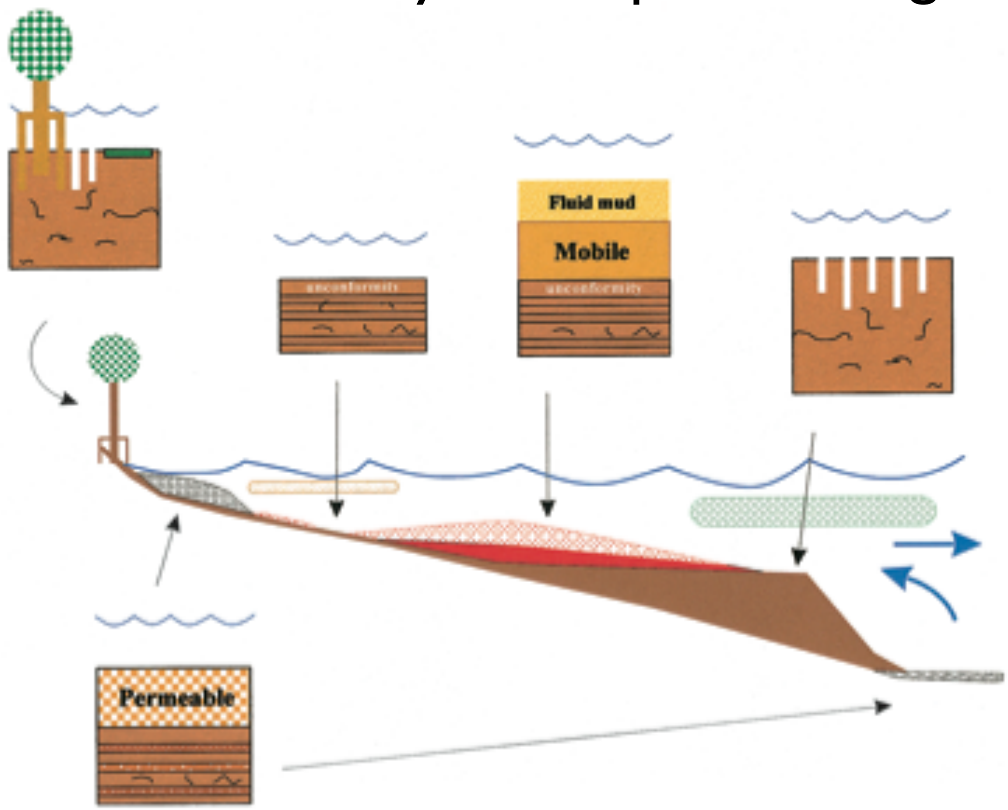
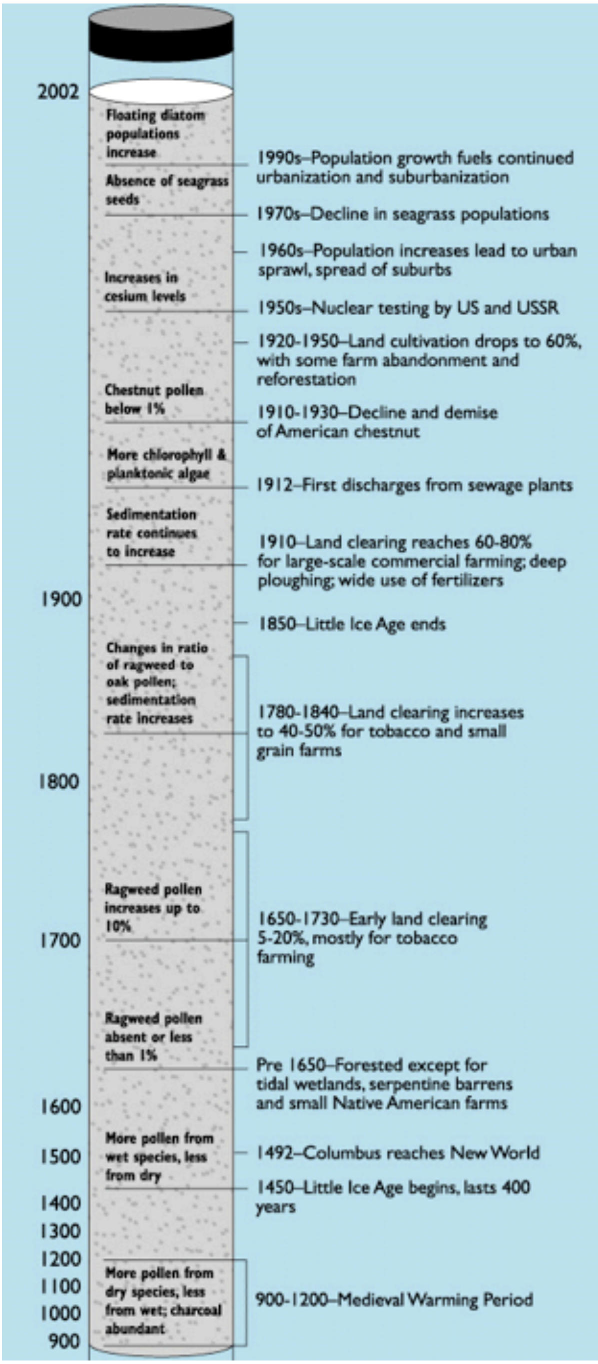


Figure 3. Different diagenetic regimes dominate individual sedimentary facies and thus can be present in regular spatial associations within margin environments. Material exchange on a variety of timescales takes place between these facies. One possible idealized spatial pattern of diagenetic regimes found in tropical clinoform deltaic systems is illustrated schematically in the inshore—offshore cross-section. Large expanses of energetic topset regions in such systems are characterized by mobile suboxic mud (red) underlying oxygenated water. These batch reactor regions are often in close spatial association with locally scoured seafloor (see also Fig. 4). Sediment storage sites of high net deposition and bioturbation are found seaward within the foreset zone (brown). Additional common regimes are the rhizosphere-dominated shoreline, permeable channel and bar sands, and relict sands distal to bottomset deposits. Turbid waters (brownish water zone) can inhibit primary production inshore and highest autochthanous production rates may be found over the outer topset and foreset storage regions (greenish water zone). Large scale 'estuarine flow' and tidal oscillation promotes cross shelf material exchange between diagenetic facies as demonstrated by numerous physical, chemical and biological tracers in case studies. (Modified from McKee *et al.*, 2004.)

Journal of Marine Research, 62, 815–835, 2004



Sediments as recorders for estuarine processing

What would bioturbation do to these signals?