Addressing and restoring three keystone habitats:
salt marsh, eelgrass and shellfish beds
‘Together’

Photo: T. Kates, Full Frame Digital

Anamarija Frankic

UMass Boston

www.gbh.umb.edu

Harvard GSD
March 9, 2011

Overview

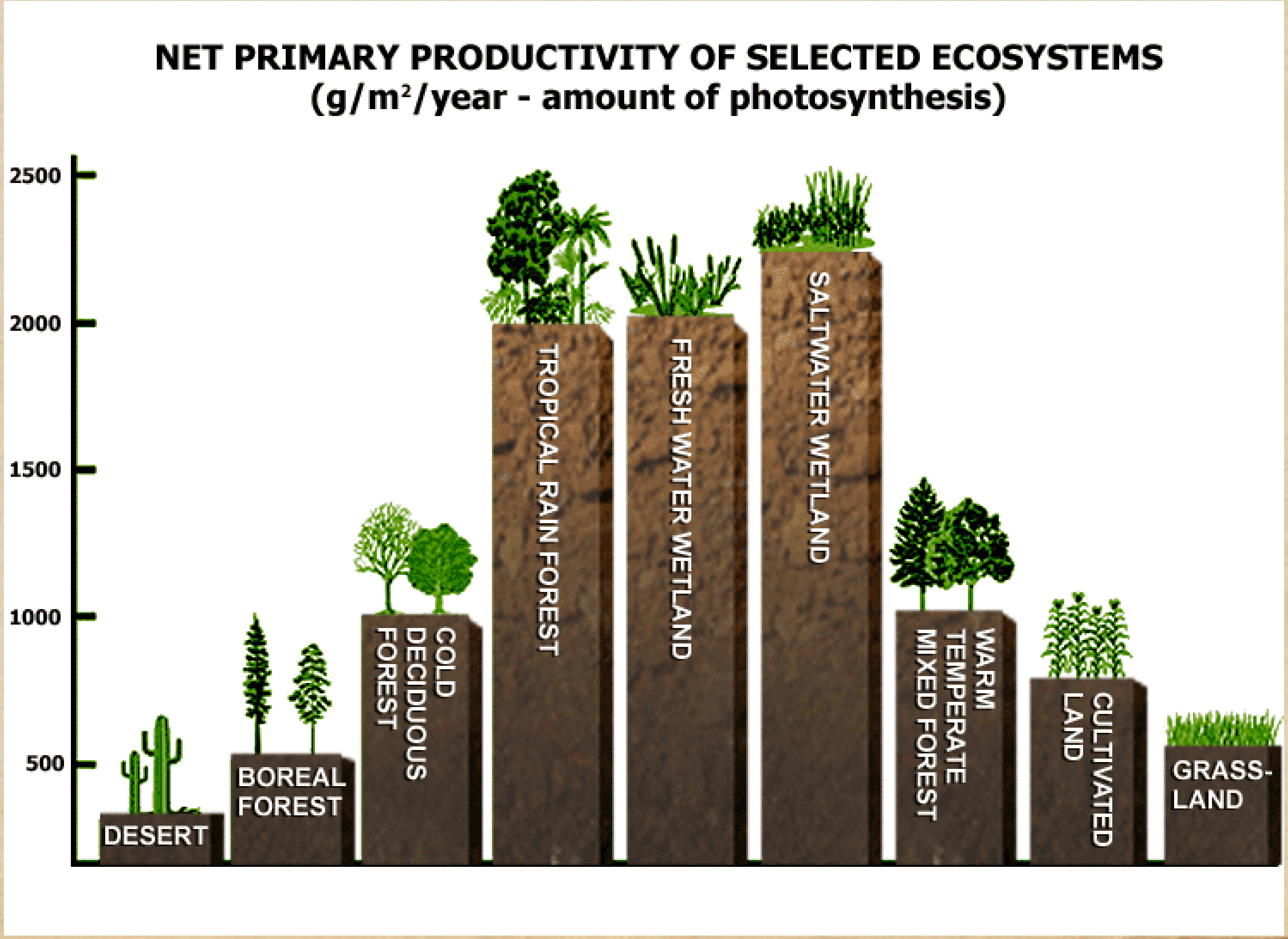
Photo: A. Frankic

- Why care?
- Salt Marsh
- Shellfish beds
- Eel grass beds
- Estuaries

- Next steps: Biomimicry in Restoration

Photos: R. Zottoli

Why Care?


NET PRIMARY PRODUCTIVITY OF SELECTED ECOSYSTEMS
(g/m²/year - amount of photosynthesis)
2500
2000
1500
1000
500
DESERT
BOREAL FOREST
COLD DECIDUOUS FOREST
TROPICAL RAIN FOREST
FRESH WATER WETLAND
SALTWATER WETLAND
WARM TEMPERATE MIXED FOREST
CULTIVATED LAND
GRASS-LAND

Why Care?

Ecosystem type	Standing carbon stock (gC m^{-2})		Total global area ($*10^{12}$ m^2)	Global carbon stocks (PgC)		Longterm rate of carbon accumulation in sediment (gC m^{-2} yr^{-1})
	Plants	Soil		Plants	Soil	
Tidal Salt Marshes			Unknown (0.22 reported)			210
Mangroves	7990		0.157	1.2		139
Seagrass meadows	184	7000	0.3	0.06	2.1	83
Kelp Forests	120-720	na	0.02-0.4	0.009-0.02	na	na

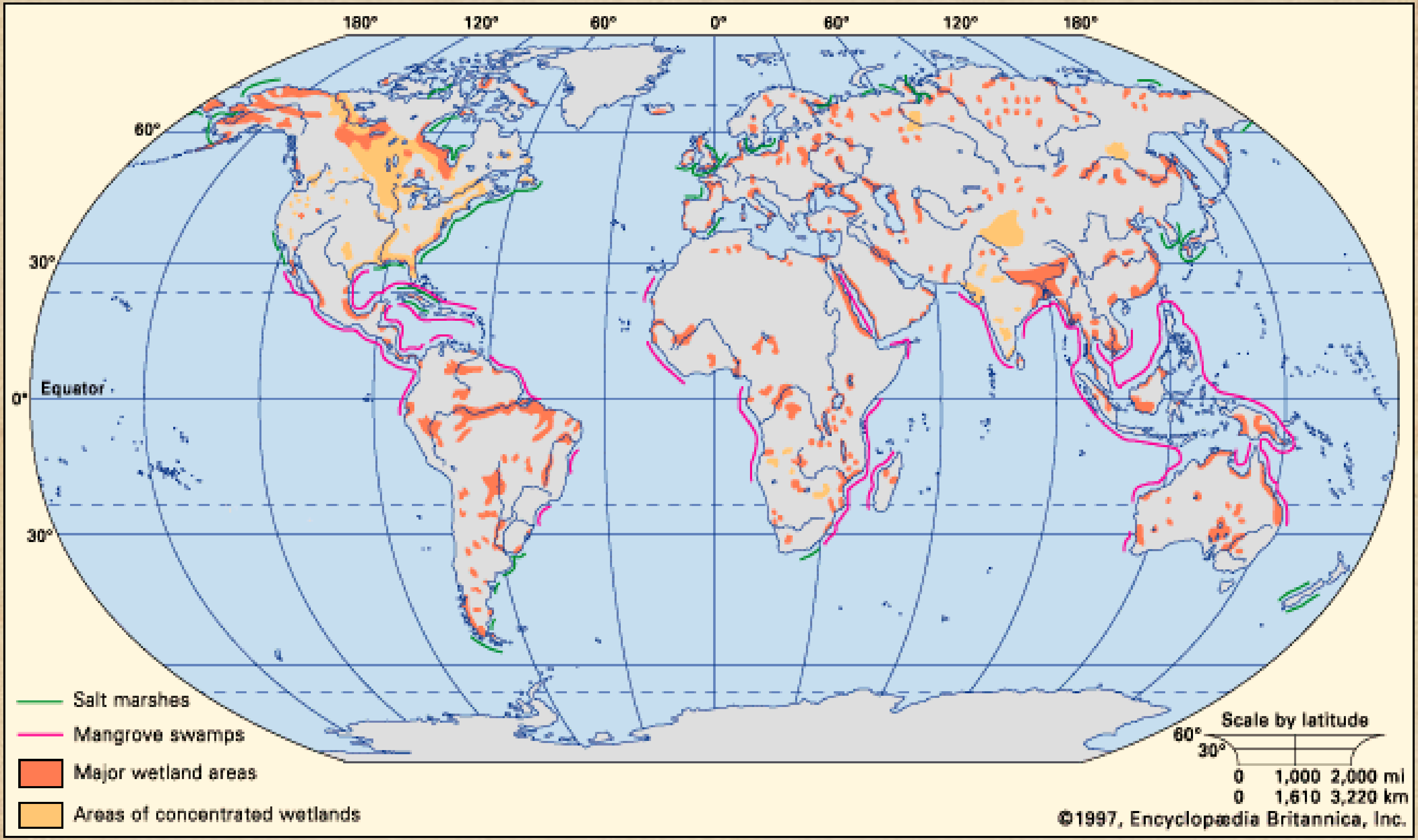
IUCN, 2009. The management of natural coastal carbon sinks.

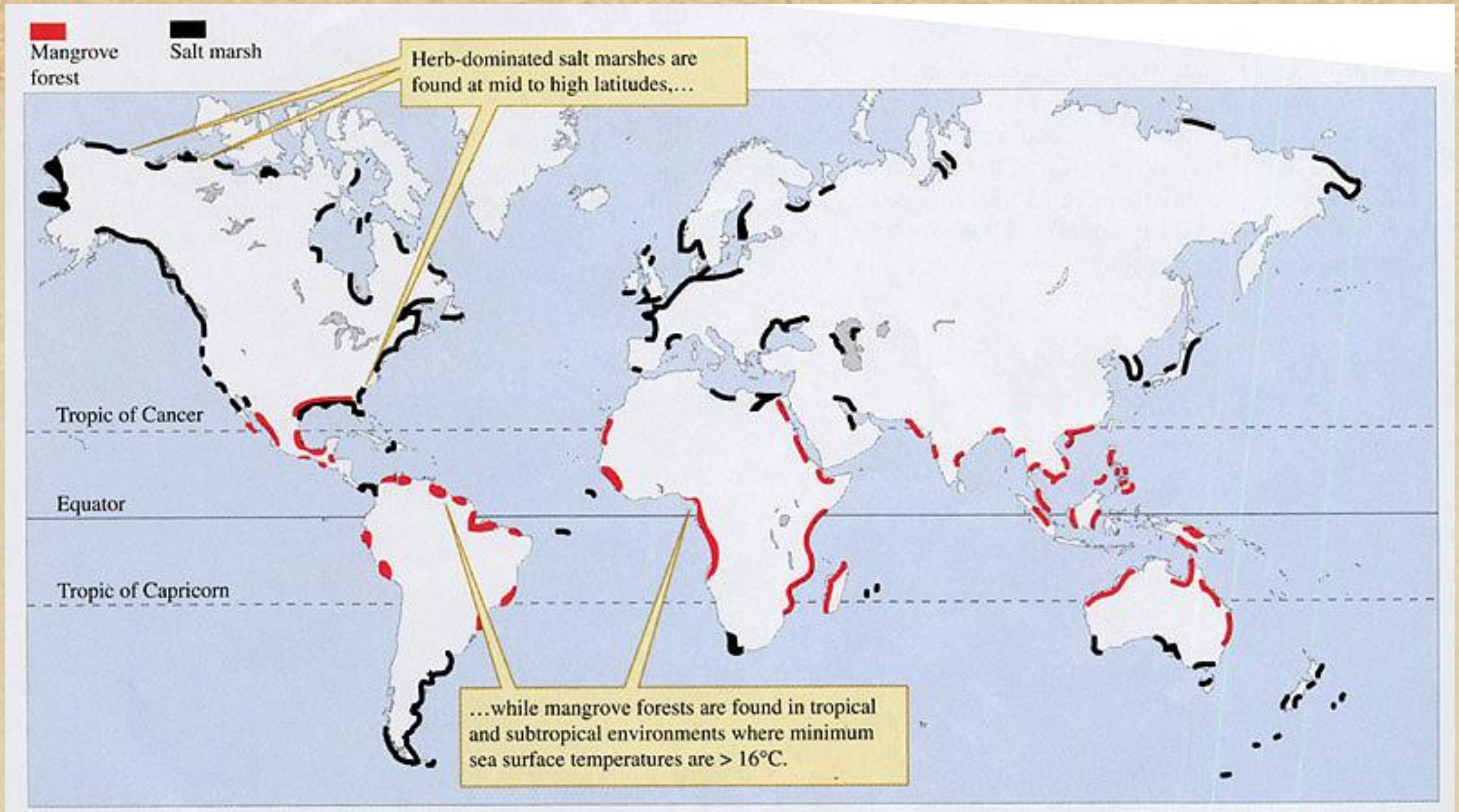
Why care about shellfish, eel grass and salt marsh?

- Trophic transfer
(Heck, K.L., et al., 2008)
- Corridors for movement
(Beck, et al. 2001; Gillanders, B.M., et al., 2003)
- Filtration and Protection from Nitrogen loading
(Valiela, I. & M. Cole, 2002)
- Sediment trapping and stabilizing
(Bos, A.R, et al., 2007; Agawin, N. & C. Duarte, 2002)
- Buffer s from storm surge and sea level rise
(Gambi, M.C., et al., 1990; Morris, J.T., et al., 2002)

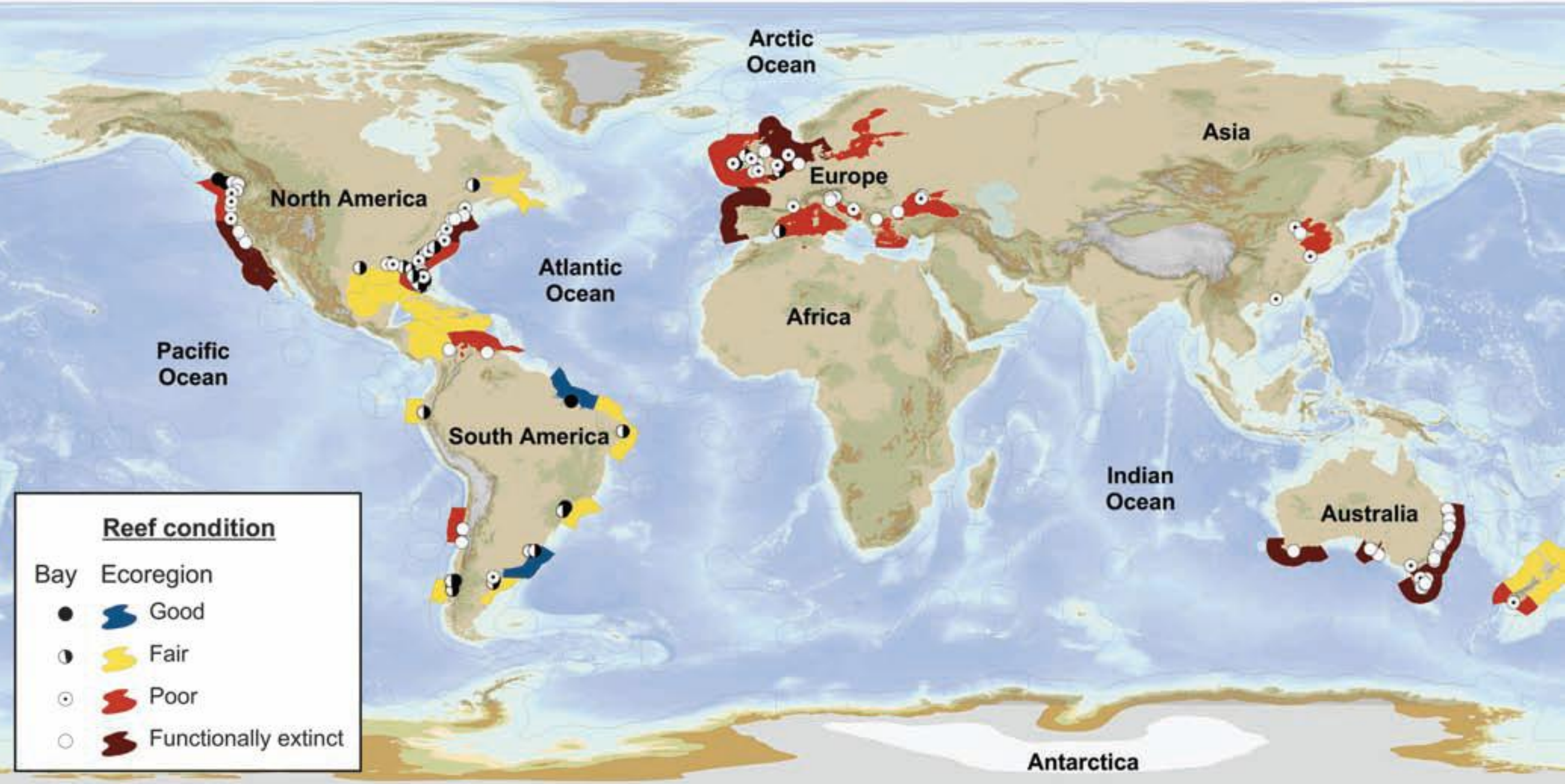
Photo: A. Frankic

Global Distribution



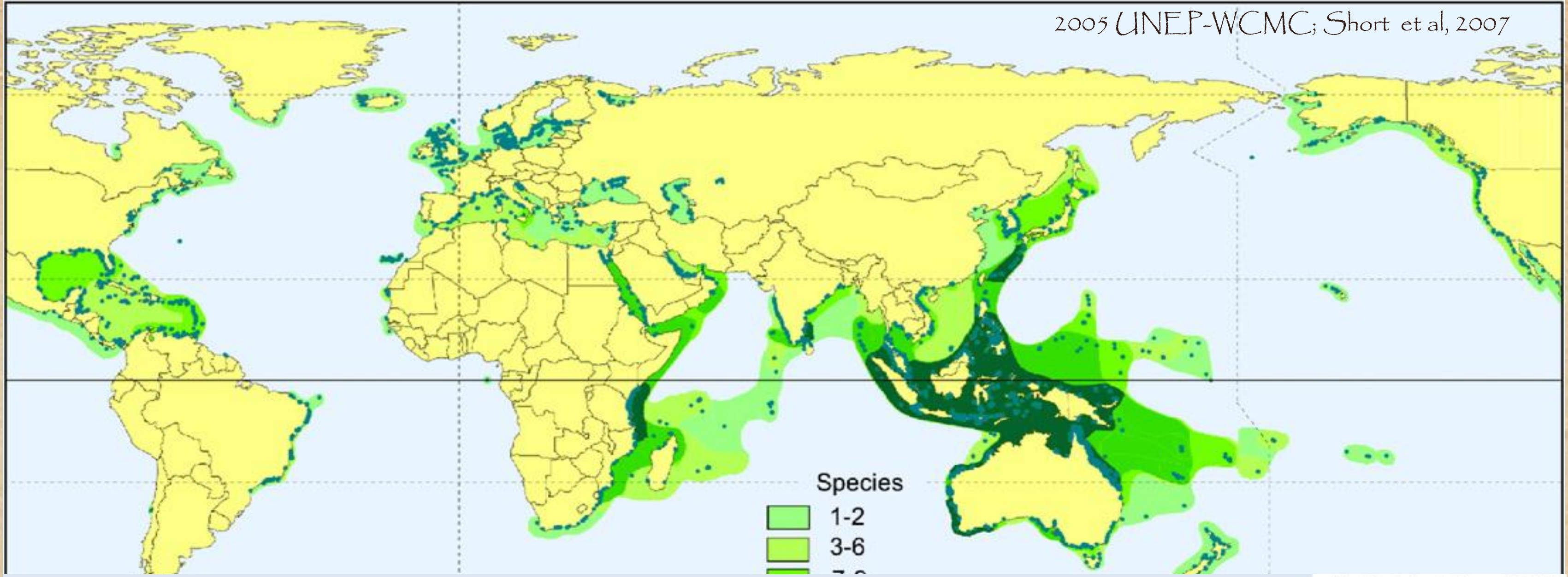

Mangrove forest
Salt marsh
Herb-dominated salt marshes are found at mid to high latitudes,...
Tropic of Cancer
Equator
Tropic of Capricorn
...while mangrove forests are found in tropical and subtropical environments where minimum sea surface temperatures are > 16°C.


HOTSPOTS



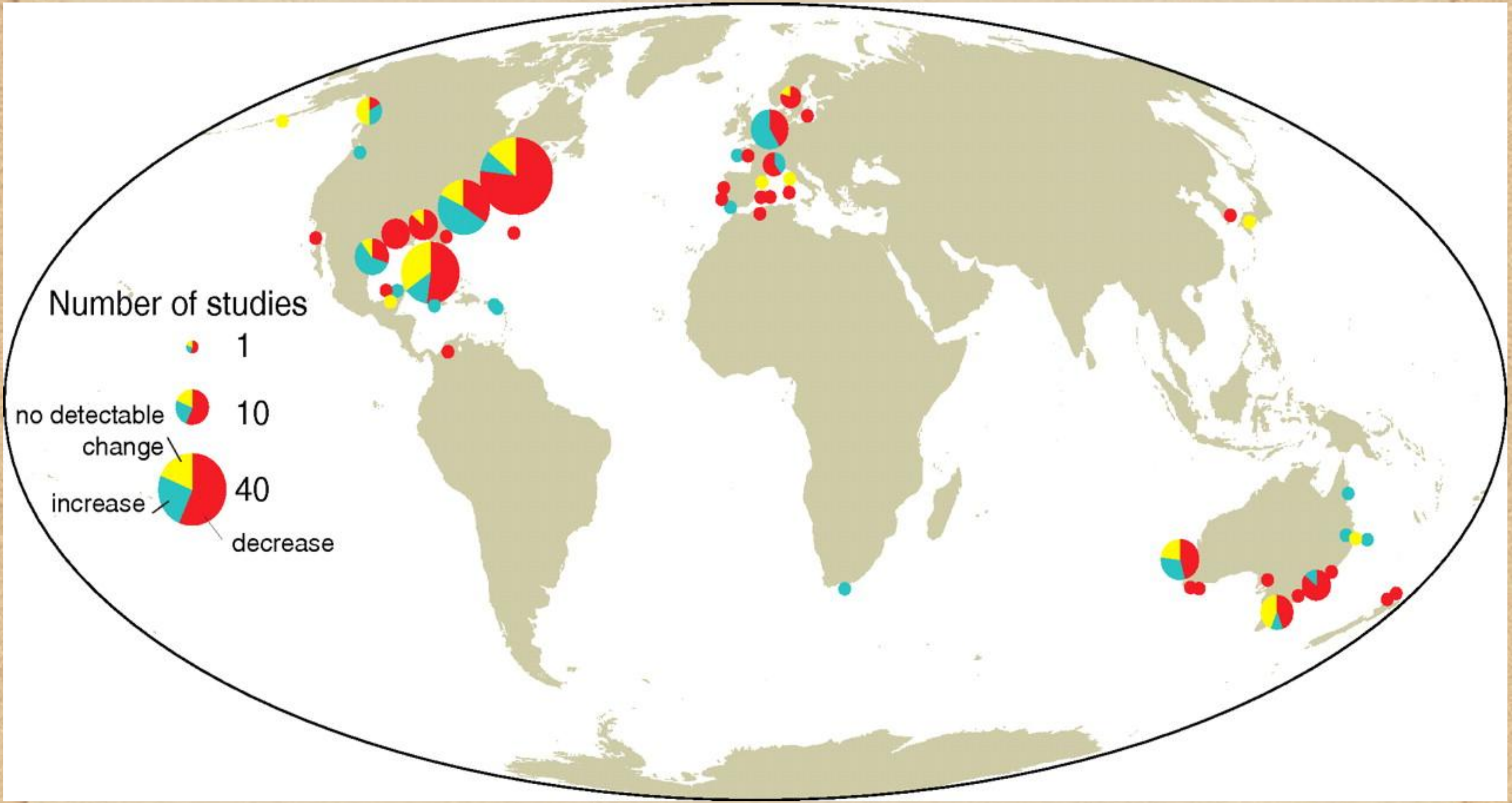
Shellfish beds : > 90% loss of Oyster Reefs

Beck et al, 2010. Bioscience



UNEP-WCMC, 2009; Waycott et al., 2009.

Global map indicating changes in seagrass area plotted by coastline regions.

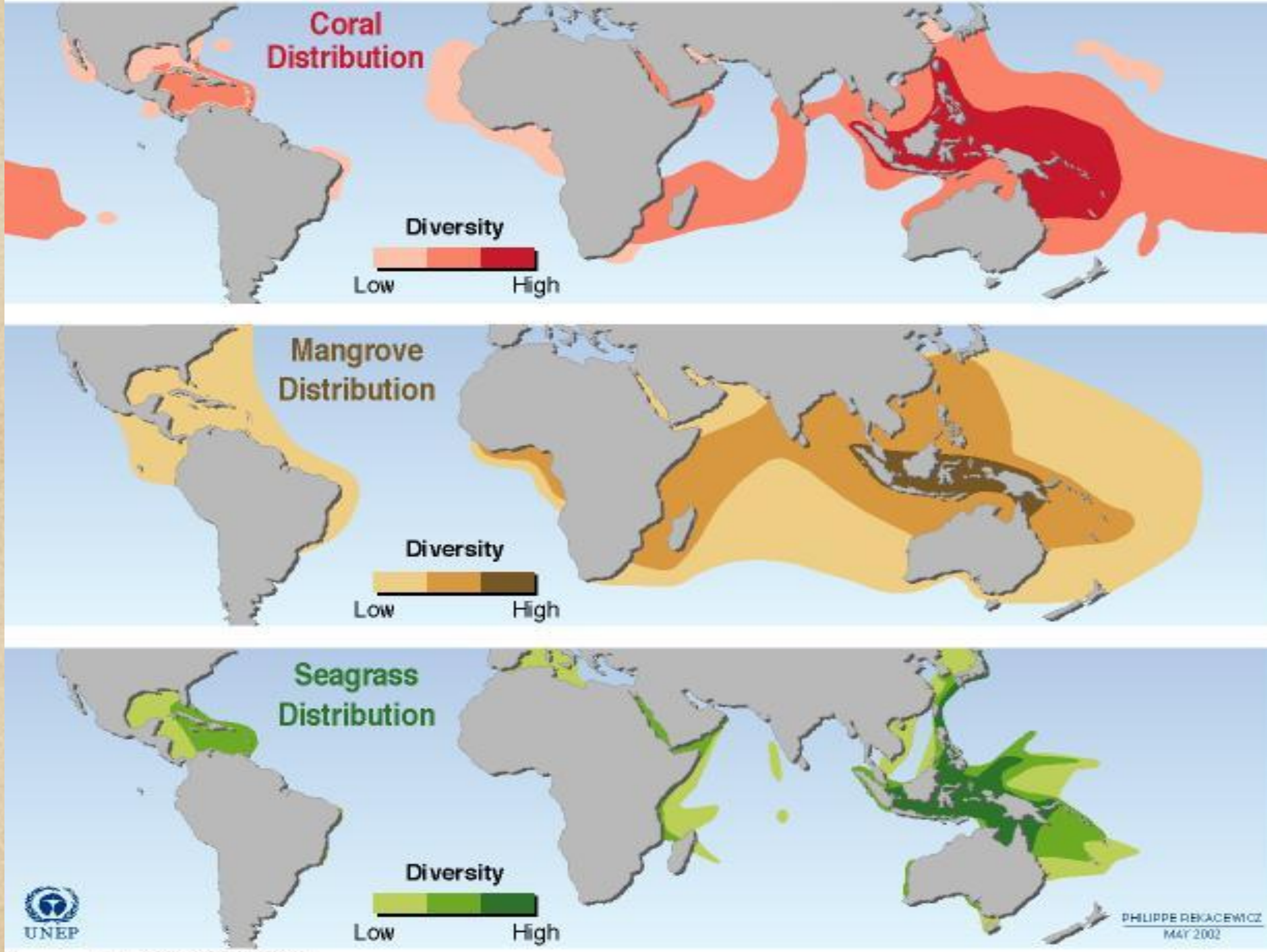


Only about 177,000 sq km of seagrasses are left globally

Waycott M et al. PNAS 2009;106:12377-12381

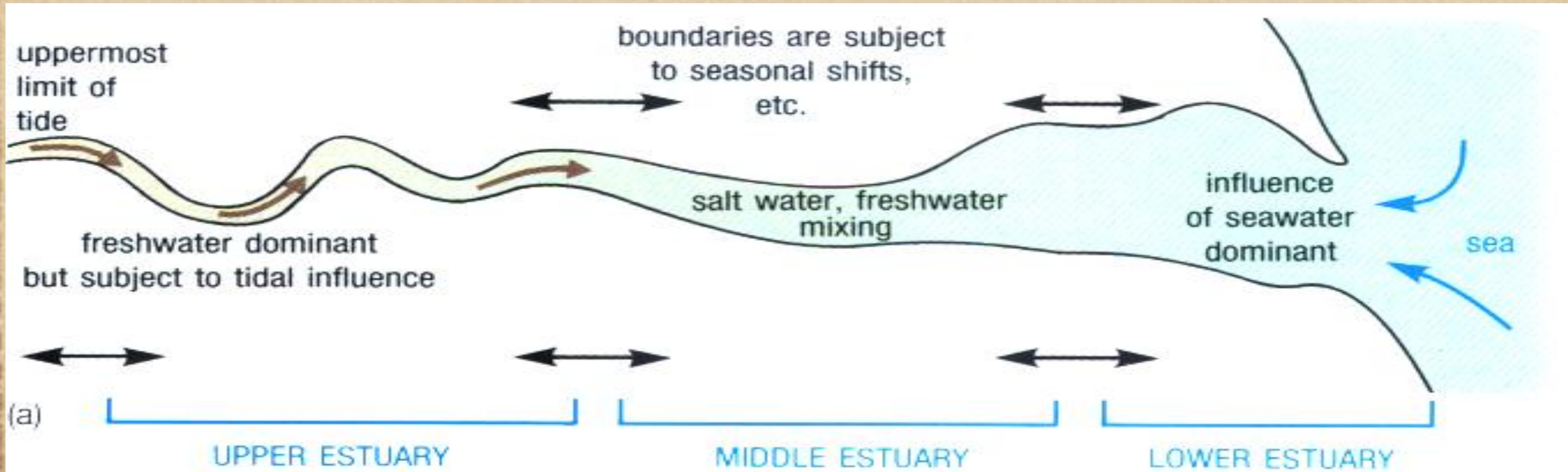
PNAS

Global Distribution of Coral, Mangrove and Seagrass Diversity



Source : UNEP-WCMC, 2001.

Schematic of a typical Estuary



Intertidal Zonation – Where? And Why?

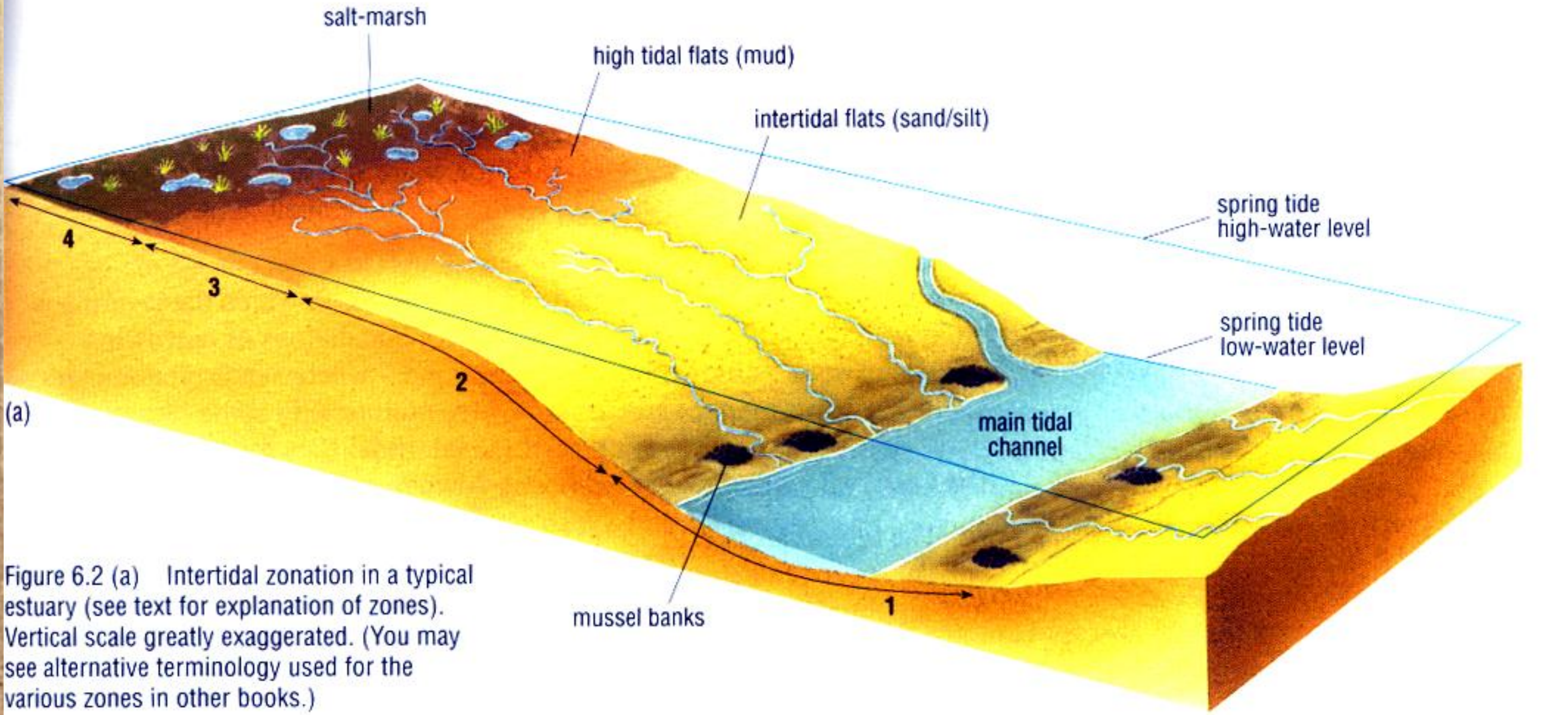
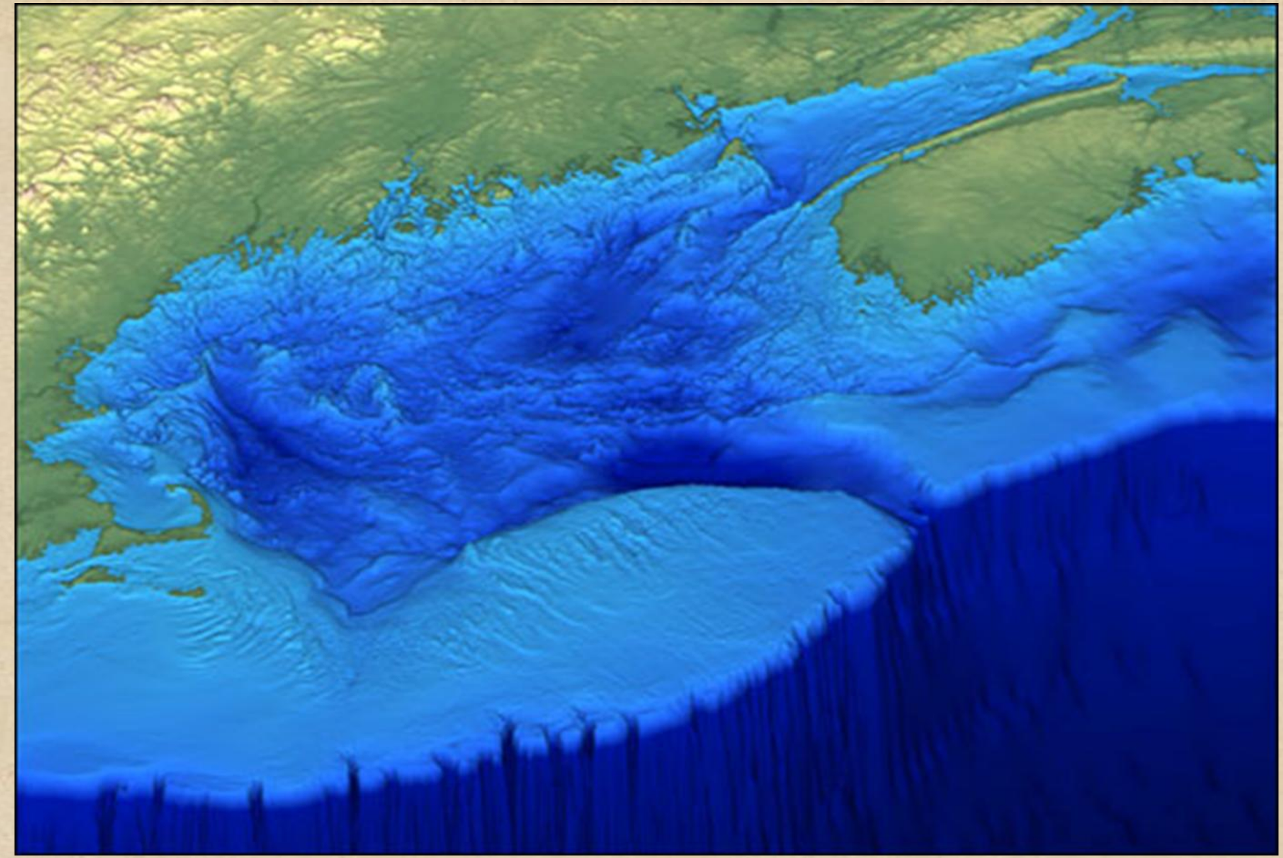
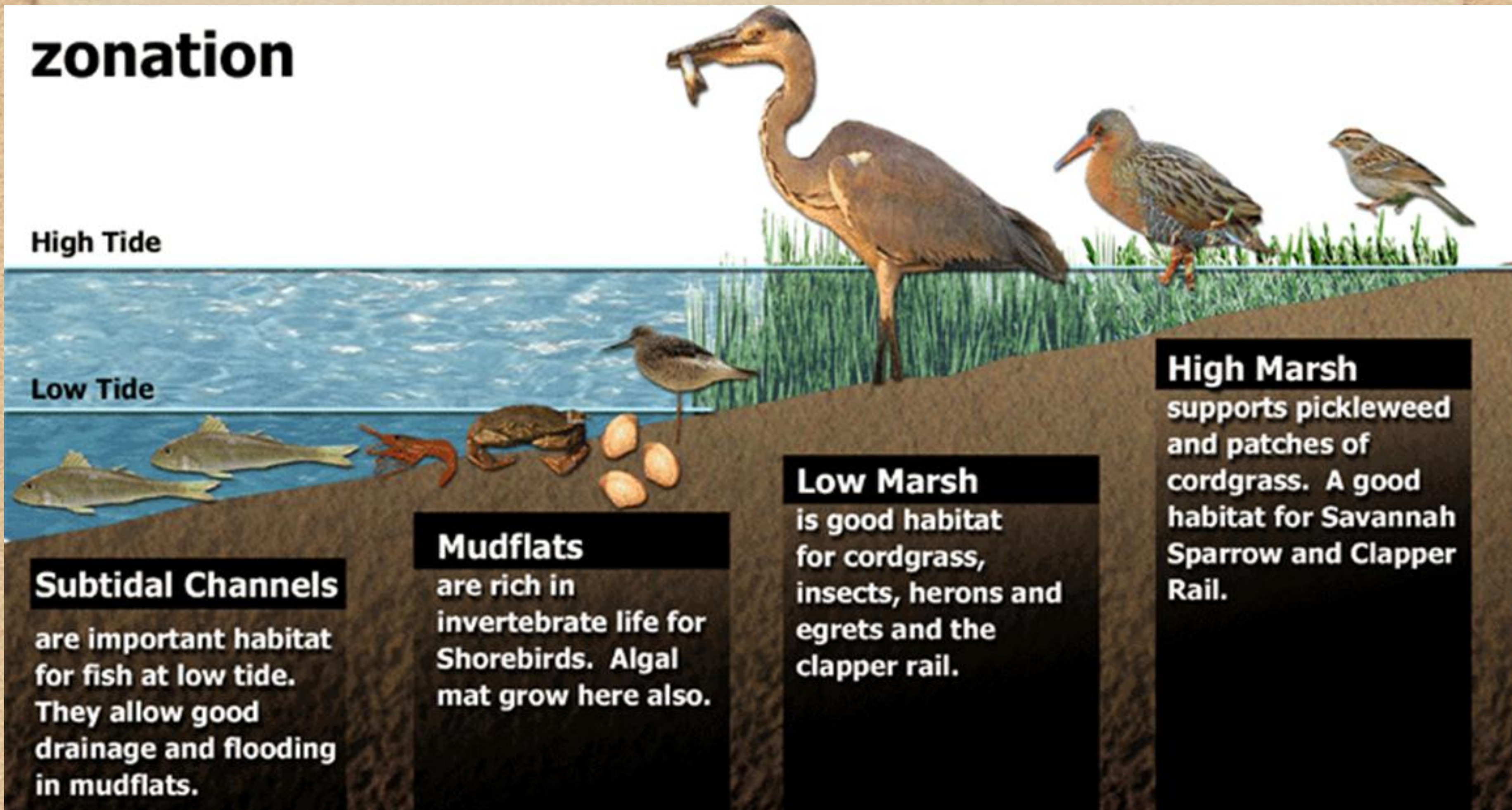


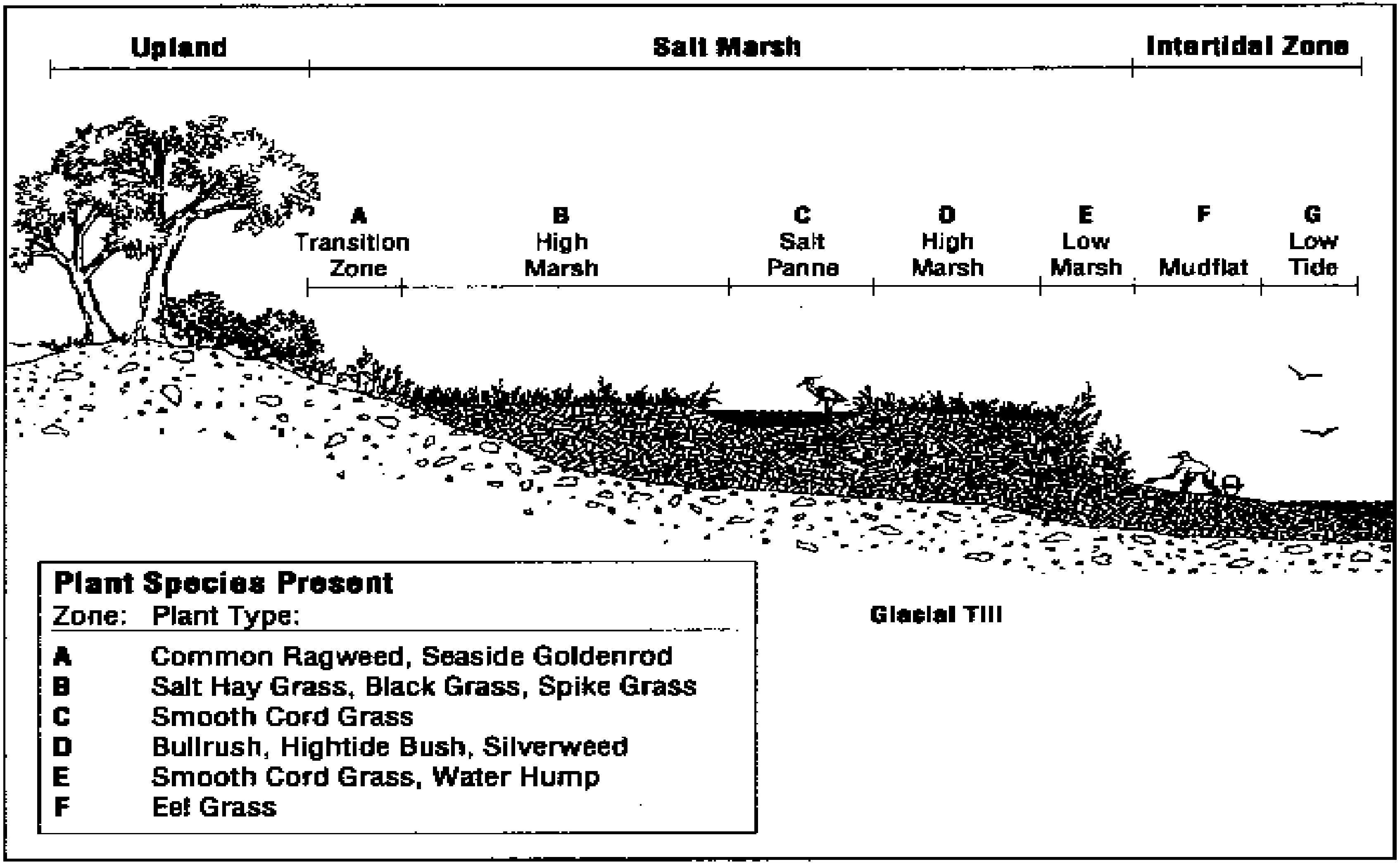
Figure 6.2 (a) Intertidal zonation in a typical estuary (see text for explanation of zones). Vertical scale greatly exaggerated. (You may see alternative terminology used for the various zones in other books.)



http://www.gomoos.org/aboutgulfme/

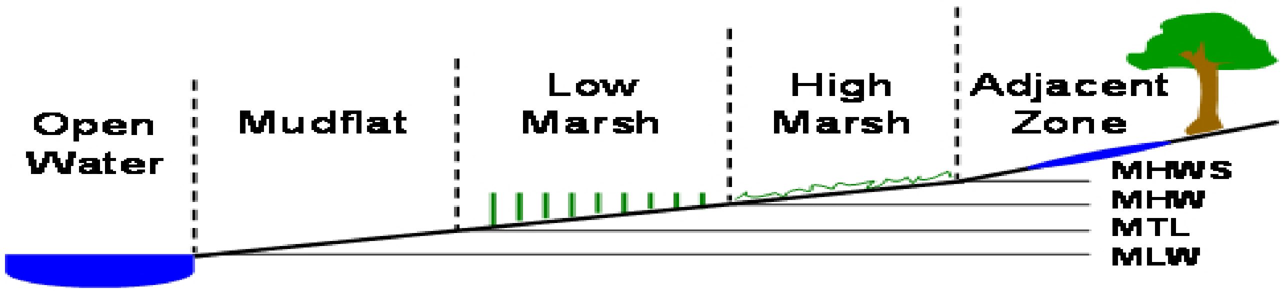
http://www.oceanmotion.org/html/resources/etopo.htm


zonation
High Tide
Low Tide
Subtidal Channels
are important habitat for fish at low tide. They allow good drainage and flooding in mudflats.
Mudflats
are rich in invertebrate life for Shorebirds. Algal mat grow here also.
Low Marsh
is good habitat for cordgrass, insects, herons and egrets and the clapper rail.
High Marsh
supports pickleweed and patches of cordgrass. A good habitat for Savannah Sparrow and Clapper Rail.



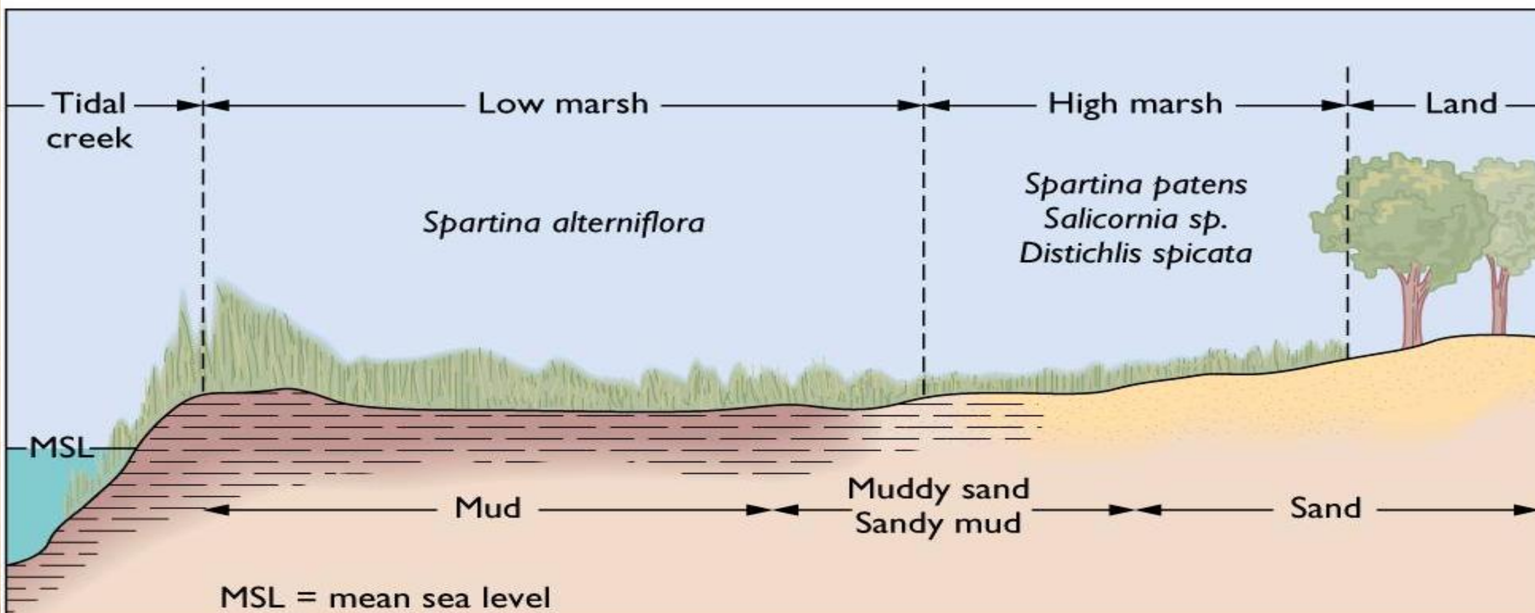
http://www.mass.gov/czm/coastlines/2008/ebbflow/czscience.htm

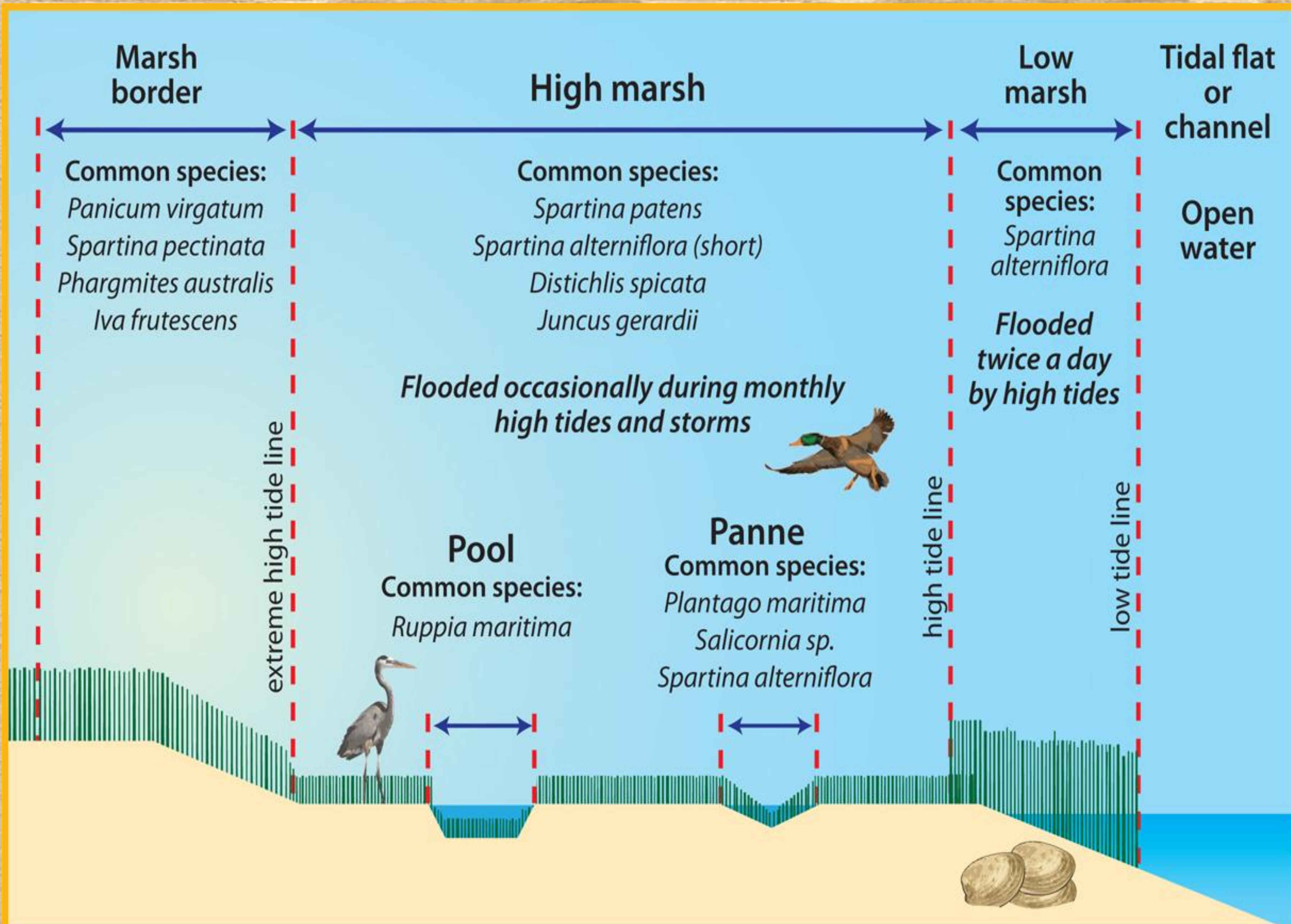
Salt Marsh Zonation



Low Marsh:
Spartina alterniflora
High Marsh (often brackish):
Spartina patens, Distichlis spicata

MHHS - Spring High Water
MHW - Mean High High Water
MSL - Mean Tide Level
MLW - Mean Low Water





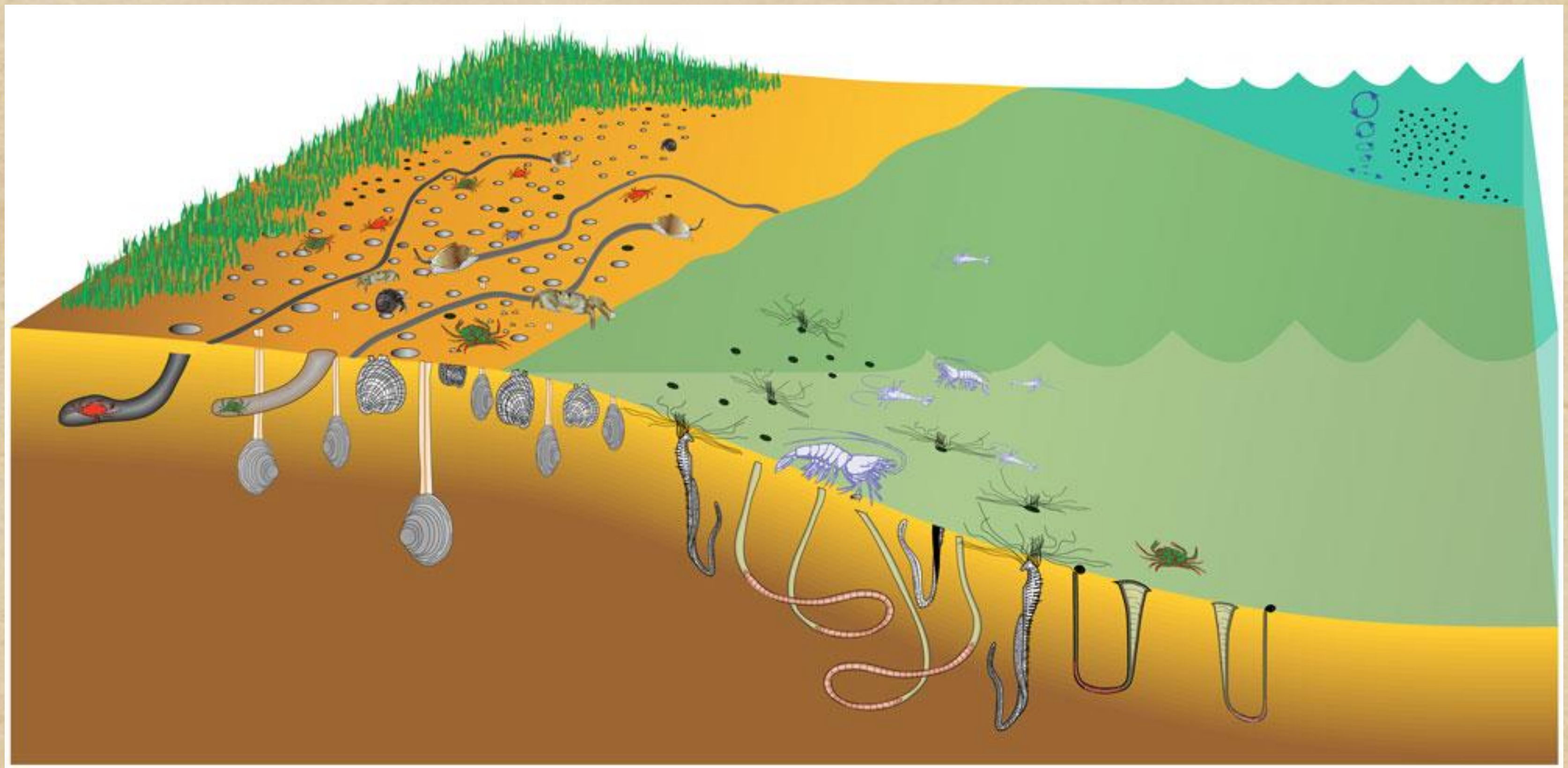
http://www.seagrant.umaine.edu/book/export/html/335

The requirements for development of salt marshes:

- fine-grained sediments
- no strong waves or tidal currents
- salty conditions to grow
- a temperate or cool temperature; freezing temperatures can occur, but are not damaging the plants
- a wide tidal range, important because it limits the erosion, makes deposition of sediments possible and causes a well-marked zonation
- biodynamic coupling between saltmarsh and mudflat/sandflat!

Photos: A. Frankic

Positive feedback loops in ecosystem engineering: sediment transport, bioturbation, hydrodynamic conditions, biodiversity, etc.



Modeling? (Bouma et al, 2005)

Pioneer salt marsh plants colonizing bare intertidal sand habitat

(Photos by D. Frankengebrg, Bear Island, NC)

From the coast into an estuary and a river...

Extensive salt marsh developed on intertidal sands and mud flats;

Patches of salt marsh in the high salinity section of the estuary but not intertidal area; less than near the ocean and sources of sediment; at low tide;

(Photos by D. Frankengebrg, White Oak River estuary, NC)

Typical salt marsh plant zonation pattern:

black needle rush (back) and cord grass;

Salt marsh invading a forest
(estuarine fringe pine forest)
a sign of rising sea level

(Photos by D. Frankengebrg)

pine forest

red cedars

freshwater sawgrass

black needle rush

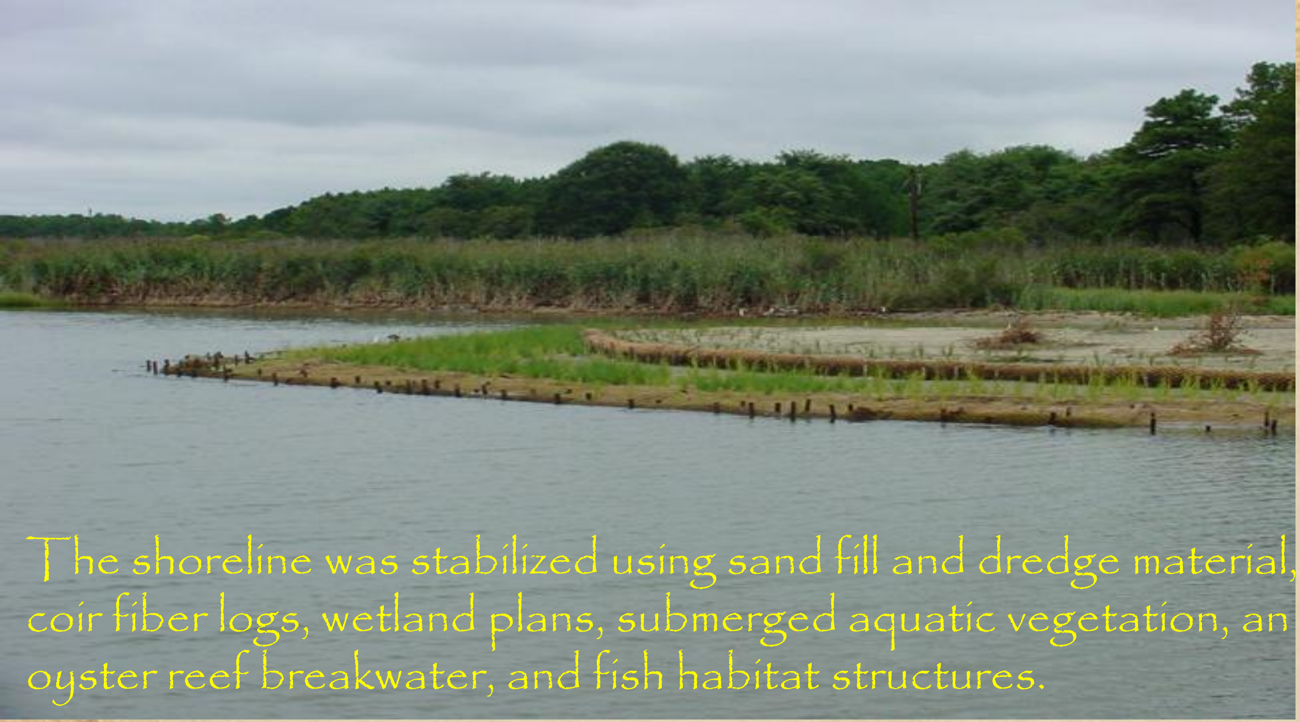
"Living shorelines" (soft structures) are defined as shoreline stabilization techniques that use natural habitat elements to protect shorelines from erosion while also providing critical habitat for wildlife.

http://www.dep.state.fl.us/northwest/ecosys/section/restoresaltmarsh.htm

Before and after shoreline restoration at Grande Lagoon, FL

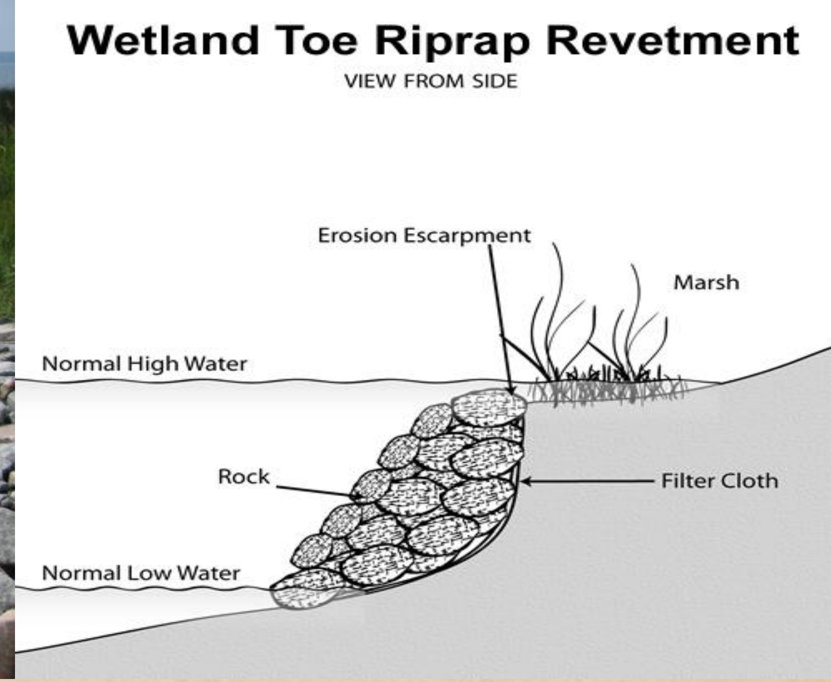
These areas are often exposed to high wave energy as the result of the disappearance of historical oyster reefs. In order to achieve maximum protection for a newly created salt marsh from wave energy, increase biodiversity, and create a living shoreline, several different restoration projects are combined with salt marsh restoration. These include the installation of oyster reef breakwaters and the reintroduction of seagrass beds (SAV) into areas of historical abundance.

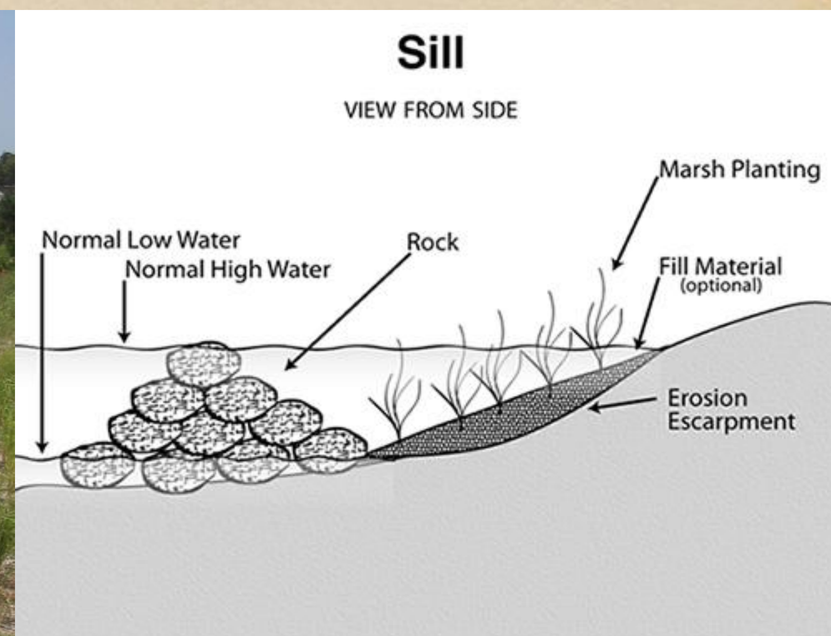
Think about Ch. Bay status and trends between oyster reefs, eel grass and salt marshes?



Horsehead, NC

Tampa Bay, FL


Wetland Toe Riprap Revetment
VIEW FROM SIDE
Erosion Escarpment
Marsh
Normal High Water
Rock
Filter Cloth
Normal Low Water


Sill
VIEW FROM SIDE
Marsh Planting
Normal Low Water
Normal High Water
Rock
Fill Material
(optional)
Erosion
Escarpment

www.GFFinc.net
Manhattan restoration project in 2008;

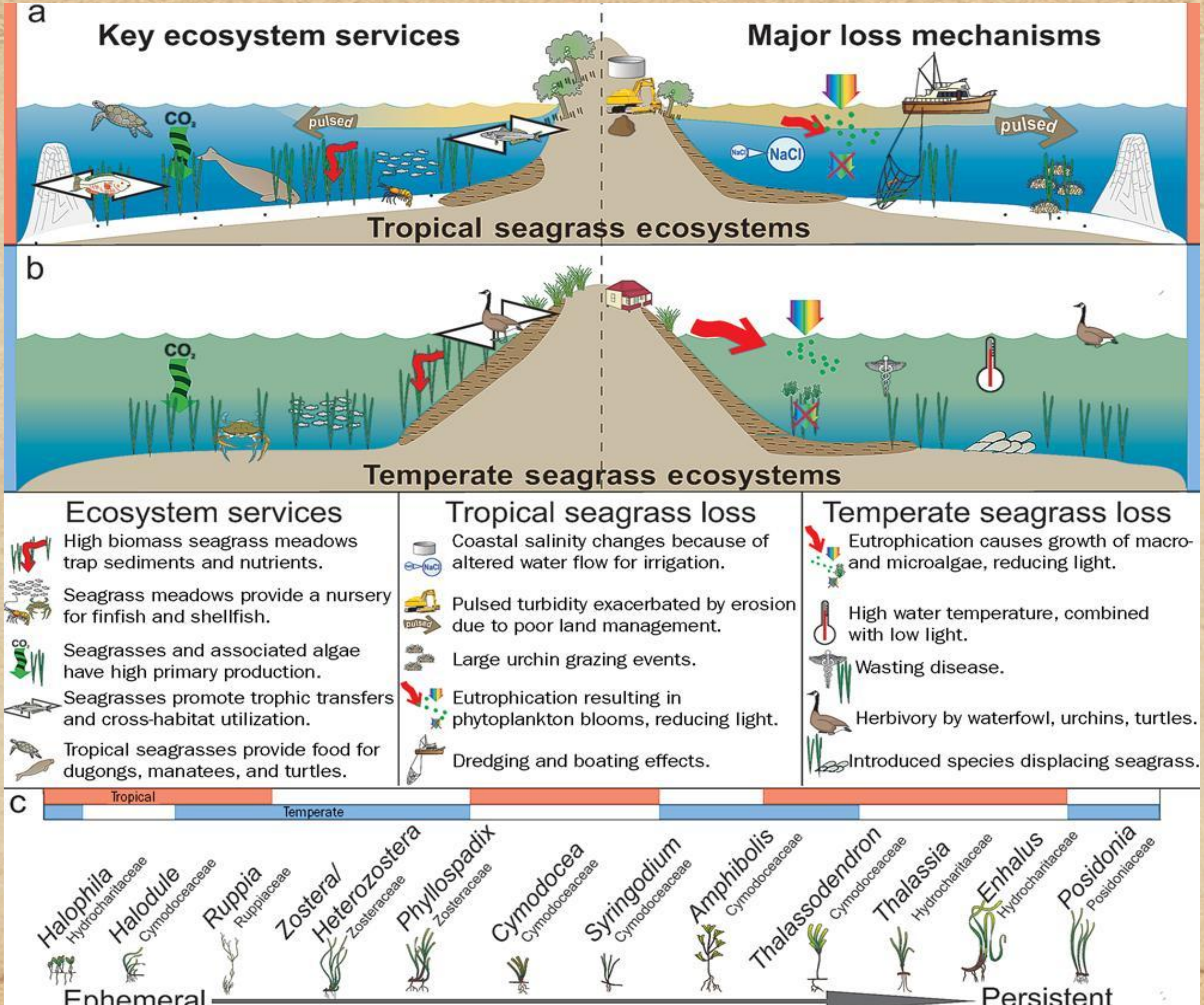
Not convinced (yet) Why to use "soft" , "living" structures instead of hard traditional ones?
(e.g. seawalls, revetment, jetties, groins, bulkheads)

CZM MA

Ecological Services Provided By Coastal Ecosystem Engineers

	Coral Reefs	Mangroves	Shellfish
Regulating	Protection of beaches and coastlines from storm surges and waves	Protection of beach and coastlines from storm surges, waves, and floods	Protection of coastlines from storm surges and waves
		Water quality maintenance	Water quality maintenance
	Reduction of beach and soil erosion	Reduction of beach erosion	Reduction of marsh shoreline erosion
		Climate regulation	
	Formation of beaches and islands	Stabilization of trapping land by trapping sediments	Stabilization of submerged land by trapping sediments
Provisioning	Subsistence and commercial fisheries	Subsistence and commercial fisheries	Subsistence of commercial fisheries
	Fish and invertebrates for the ornamental aquarium trade	Aquaculture	Aquaculture
	Pharmaceutical products	Fuelwood	
	Building materials	Building materials	Building materials (lime) and tools
	Jewelry and other decoration	Traditional medicines	Jewelry and other decoration (shells)
Cultural	Tourism and recreation	Tourism and recreation	Tourism and recreation
	Spiritual and aesthetic appreciation	Spiritual-sacred sites	Symbolic of coastal heritage
Supporting	Cycling of nutrients	Cycling of nutrients	Cycling of nutrients
	Nursery and foraging habitats	Nursery and foraging habitats	Nursery and foraging habitats


a
Key ecosystem services
Major loss mechanisms
CO2
pulsed
pulsed
NaCl
Tropical seagrass ecosystems
b
CO2
Temperate seagrass ecosystems
Ecosystem services
High biomass seagrass meadows trap sediments and nutrients.
Seagrass meadows provide a nursery for finfish and shellfish.
Seagrasses and associated algae have high primary production.
Seagrasses promote trophic transfers and cross-habitat utilization.
Tropical seagrasses provide food for dugongs, manatees, and turtles.
Tropical seagrass loss
Coastal salinity changes because of altered water flow for irrigation.
Pulsed turbidity exacerbated by erosion due to poor land management.
Large urchin grazing events.
Eutrophication resulting in phytoplankton blooms, reducing light.
Dredging and boating effects.
Temperate seagrass loss
Eutrophication causes growth of macro- and microalgae, reducing light.
High water temperature, combined with low light.
Wasting disease.
Herbivory by waterfowl, urchins, turtles.
Introduced species displacing seagrass.
c
Tropical
Temperate
Halophila Hydrocharitaceae
Halodule Cymodoceaceae
Ruppia Ruppiaceae
Zostera/Heterozostera Zosteraceae
Phyllospadix Zosteraceae
Cymodocea Cymodoceaceae
Syringodium Cymodoceaceae
Amphibolis Cymodoceaceae
Thalassodendron Cymodoceaceae
Thalassia Hydrocharitaceae
Enhalus Hydrocharitaceae
Posidonia Posidoniaceae
Ephemeral
Persistent

Green future for urban harbors? But How?

www.ny.curbed.com
GRO Architects

http://oceanworld.tamu.edu/resources/oceanography-book/Images/ahupuaa.jpg

Ahupua'a Vision for Boston Harbor

Yellow - watersheds – Neponset, Charles, Mystic; focus on green roofs and other pervious surfaces for water-energy nexus in order to restore the watersheds self-sustainability;

Blue - Urban coastal intertidal area includes: a)the Harbor walk (potential sites for native species of shellfish, e.g. oysters, mussels); b)salt marsh; c) tidal mud flats with soft shell clam; and d) eelgrass beds; and

Green - Boston Harbor Islands tidal areas with similar key coastal habitat restoration activities.

(Source: Frankic and Greber, 2010)

Next Steps: Biomimicry and Coastal Restoration

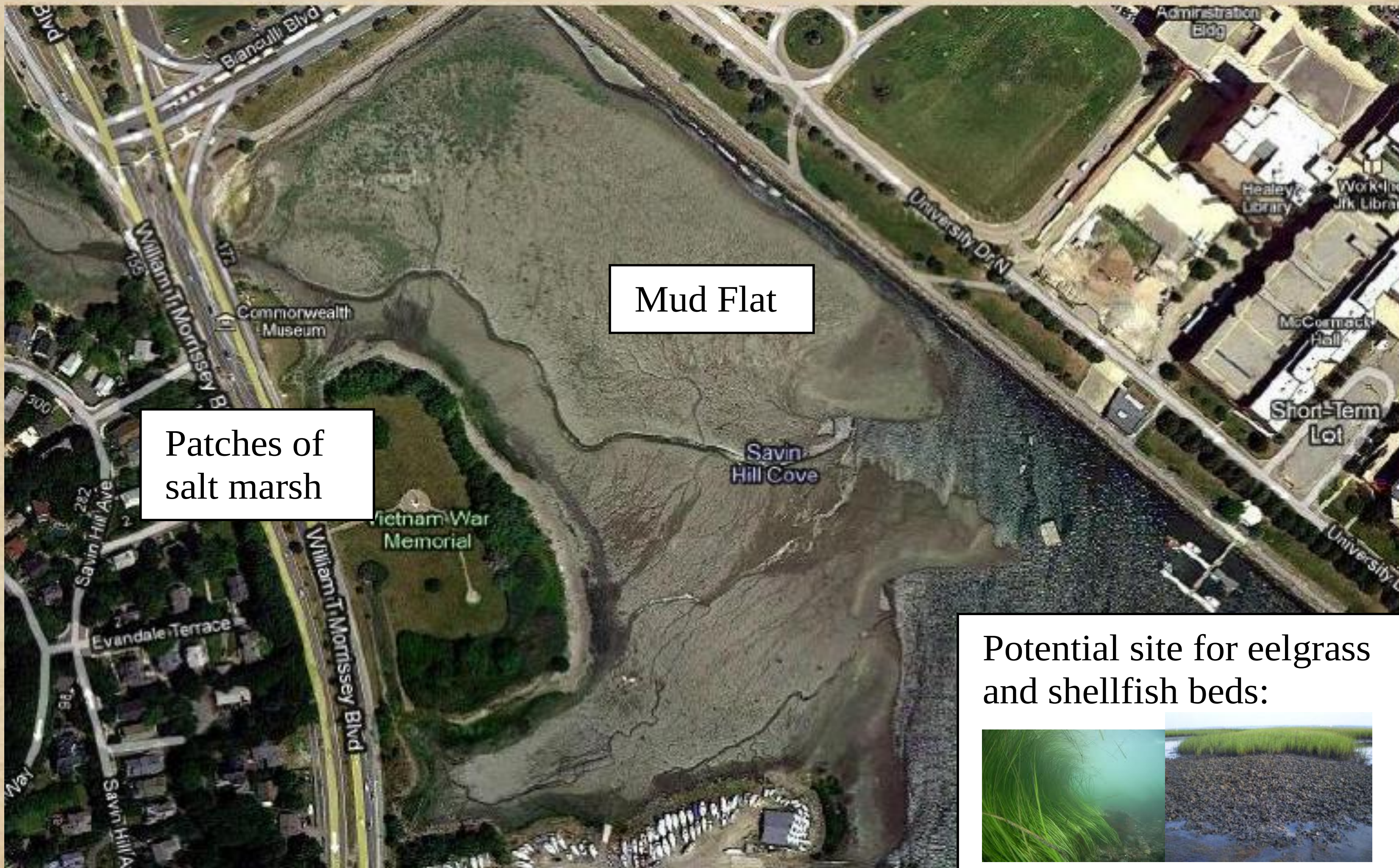
Project Sites at UMass Boston

Google Earth

Two Project Sites at UMass Boston

Google Earth

General Hypothesis - by combining restoration of three keystone coastal habitats they will respond and recover better, as well as provide ecological services more effectively and efficiently in the long run.



Savin Hill Cove

Savin Hill Cove a potential site for a "Living Lab" at UMass Boston

Patten Cove

Photos: A. Frankic

Biomimicry for Multi Habitat Restoration
(Frankic et al, 2011 . *in press*)

Biomimicry Life's Principles	**Keystone coastal habitats**	***Biomimicry Application:***		
		Research Activities at **Sites 1 & 2**	**Design & Restoration Activities at Pier 5**	**Human Systems (e.g. Green Harbors)**
Evolve to survive: interdependent, fostering community based relationship		Assessing relationships between habitats and evolving adaptations	Established floating habitats of three interconnected coastal communities;	Teaching and learning by working in a "living lab" at an educational facility
Be resource efficient: low energy multi-functional processes, recycling, fit form to function;		Trophic exchange, water-energy recycling,	In situ water-energy nexus, self-recyclable and self-sustainable cyclic positive feedback loops;	Water-Energy Nexus
Resilient - adapting to changing conditions;	Salt Marsh Eel Grass Shellfish	Assessing diversity, function, self-renewal and health of each habitat;	Floating coastal habitats retain resiliency in the face of sea level rise, storm surge, water quality etc.	Green Holistic Education for Green Jobs and Green Sustainable Economy
Integrate Development and Growth: self-organize,		Habitats carrying capacity and sustainability; nested relationship in ecosystems	Floating coastal habitats are nested within clear physical space and limits.	
Be locally attuned and responsive: cyclic processes and feedback loops		In situ water-energy nexus, self-recyclable and self-sustainable cyclic positive feedback loops	Biomimicing ecosystems and functions that would likely exist if the build structures were not there.	
Live using only friendly chemistry (water base chemistry and self-assembly)		Water quality and quantity conditions	Use of local, natural untreated materials, such as granite, sustainable and recycled wood for build structures.	Greening Coastal Urban Areas (e.g. Green Boston Harbor)

Resources:

- http://na.unep.net/atlas/index.php
- http://na.unep.net/atlas/google.php
- Canada – Knife River delta and snow gees http://na.unep.net/atlas/webatlas.php?id=91
- Defina et al, 2007. Self-organization of shallow basins in tidal flats and saltmarshes.
- Bouma et al, 2005. Flow hydrodynamics on a mudflat and in salt marsh vegetation: identifying general relationships for habitat characterizations.
- Fagherazzi et al, 2005. Critical bifurcation of shallow microtidal landforms in tidal flats and salt marshes.
- Gedan et al, 2009. Centuries of Human-Driven Change in Salt Marsh Ecosystems.
- Doody, J.P. 2008. Salt marsh conservation, management and restoration. Springer.
- NOAA/CSC. Digital Coast


THANK YOU!

Photos by A. Frankic, Amazon Delta