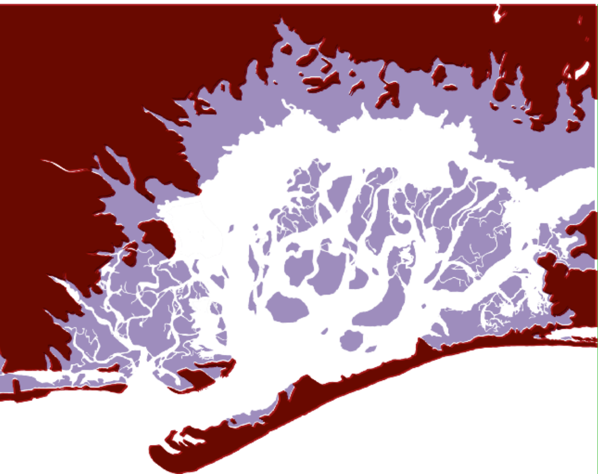
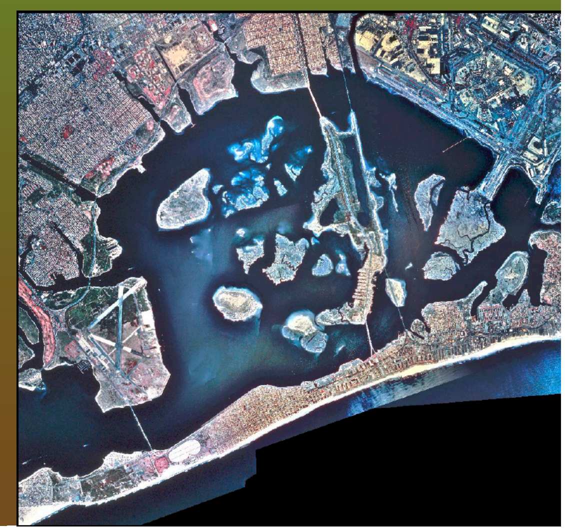


JAMAICA BAY SYMPOSIUM: STATE OF THE BAY – PAST, PRESENT, FUTURE

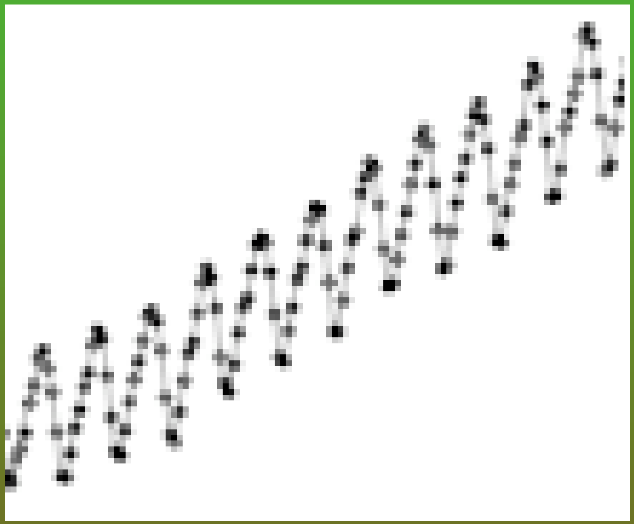
Biogeochemical, Structural,and Functional Regulators of *Spartina Alterniflora* and The ecological mosaic of Jamaica Bay

Paul S. Mankiewicz, Ph.D.
The Gaia Institute
www.thegaiainstitute.org
October 28, 2008



The Gaia Institute

Source vs Sink Scale



Source Larger Than Sink

Sink Larger Than Source

Maximizing/Optimizing Matter & Energy Flows in Ecological Systems

Designing & Building for the Diversity & Productivity of Life

Conserving & Building Habitat For the Communities that Sustain Us

Using Water & Nutrients to Capture Carbon

Three Measures:

Biodiversity
Ecological Productivity
Distributed Ecosystem Services

Ecological Engineers Structure Flow in the Estuary

Keystone Species Structure the Energy Flow in Food Webs

The Mass of Organisms Regulates
the Mass of Nutrients:

Nutrient Concentration Regulates
Ecosystem Growth & Development

Intrinsic Dilemma

The scale of the biota does not match the mass of nutrient inputs

Nutrients do not enter productive food webs that enhance ecosystem services

Temperate Estuary Productivity

Category	g dry wt/sqm/yr	
phytoplankton	2,090	1
periphyton	300	1
copepod	36.5	1
predator	1 to 5	1
estuaries	200 to 4000	2

1. Correll, David L. 1978. Estuarine Productivity.

BioScience, Vol. 28, No. 10, pp. 646-650

2. Whittaker, R.H., Likens, G.E. 1975. The Biosphere and Man.

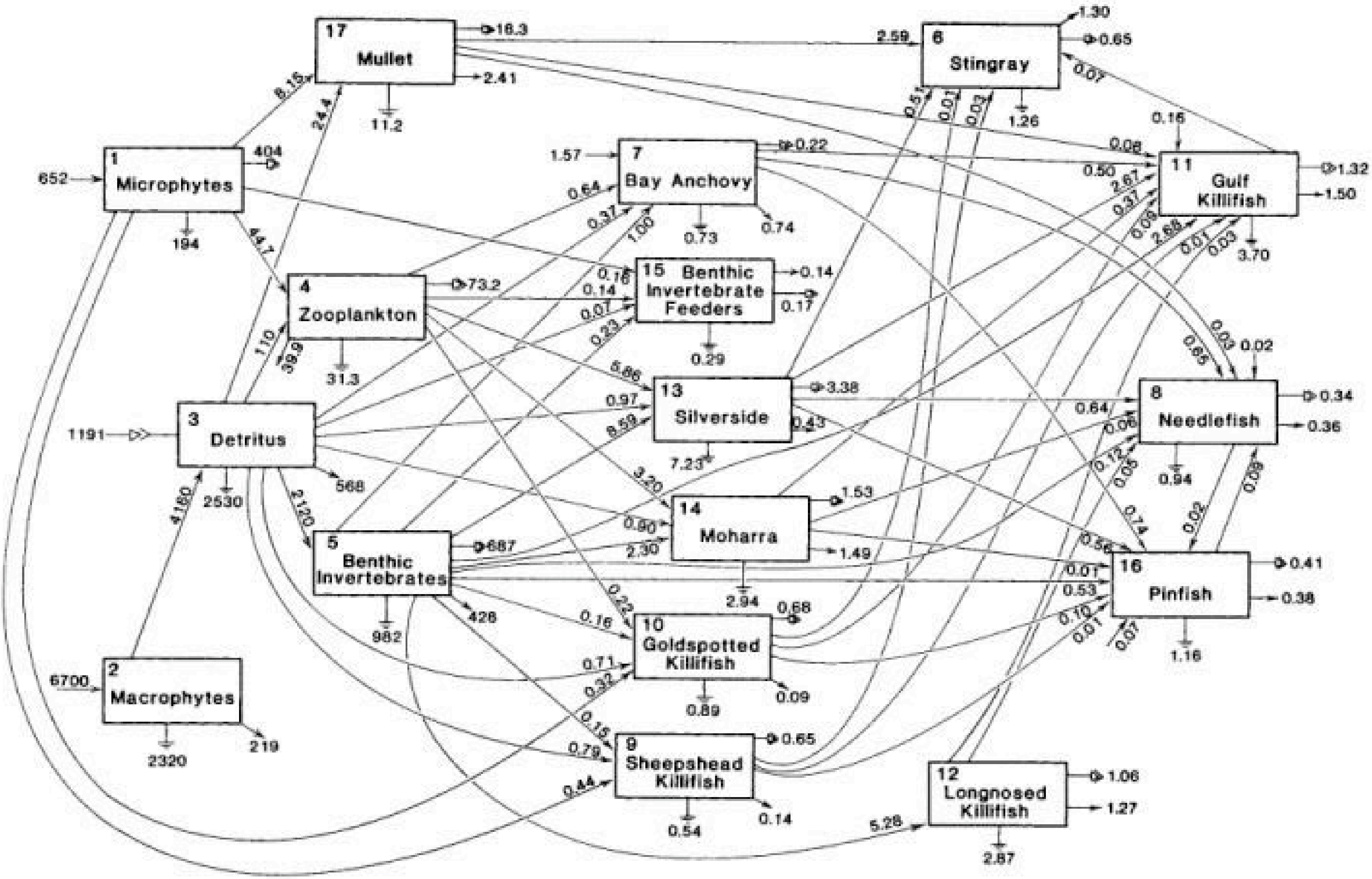
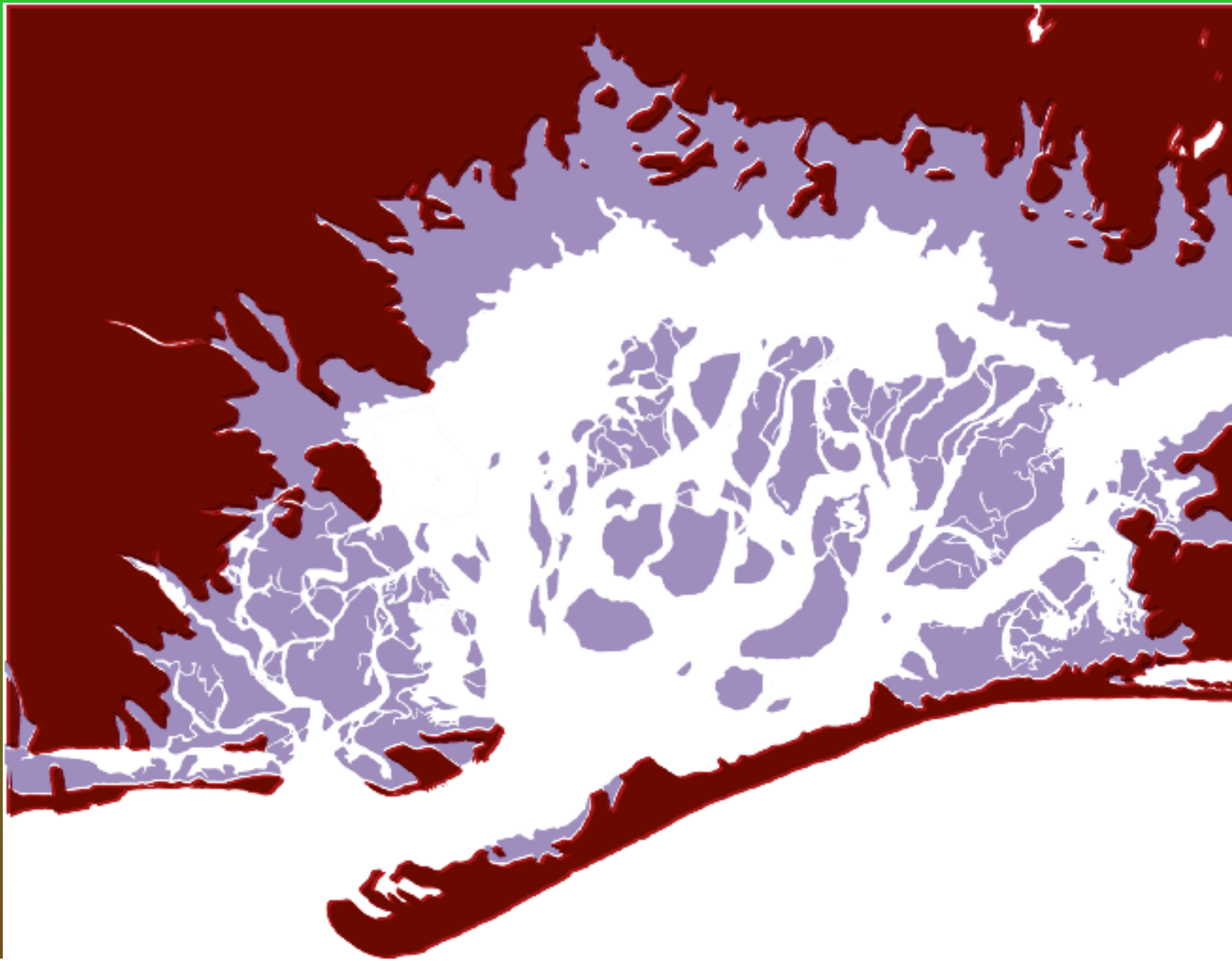


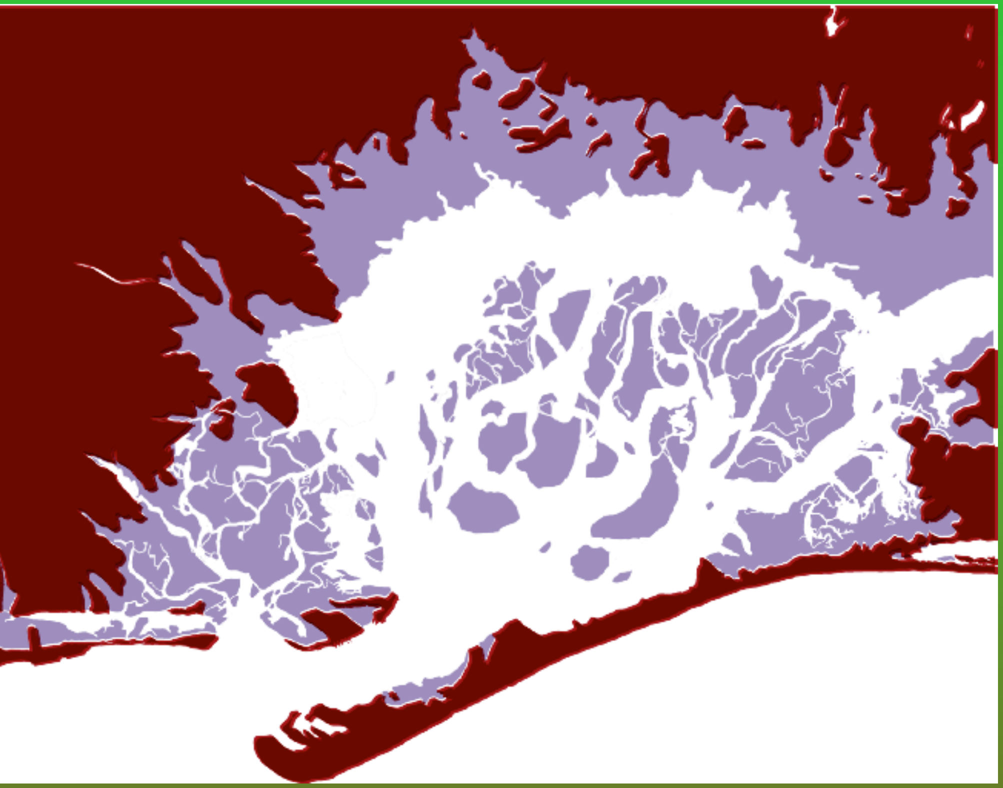
FIGURE 4.10. A schematic of carbon flows (mg m^{-2} d^{-1}) among the taxa of a marsh gut ecosystem, Crystal River, Florida. The linked arrows depict returns to the detritus (after M. Homer and W. M. Kemp, unpublished manuscript). Reprinted by permission of the publisher from Identifying the Structure of Cycling in Ecosystems, by R. E. Ulanowicz, Mathematical Biosciences, Vol. 65. Copyright 1983 by Elsevier Science Publishing Co., Inc.

Jamaica Bay Historic Shoreline



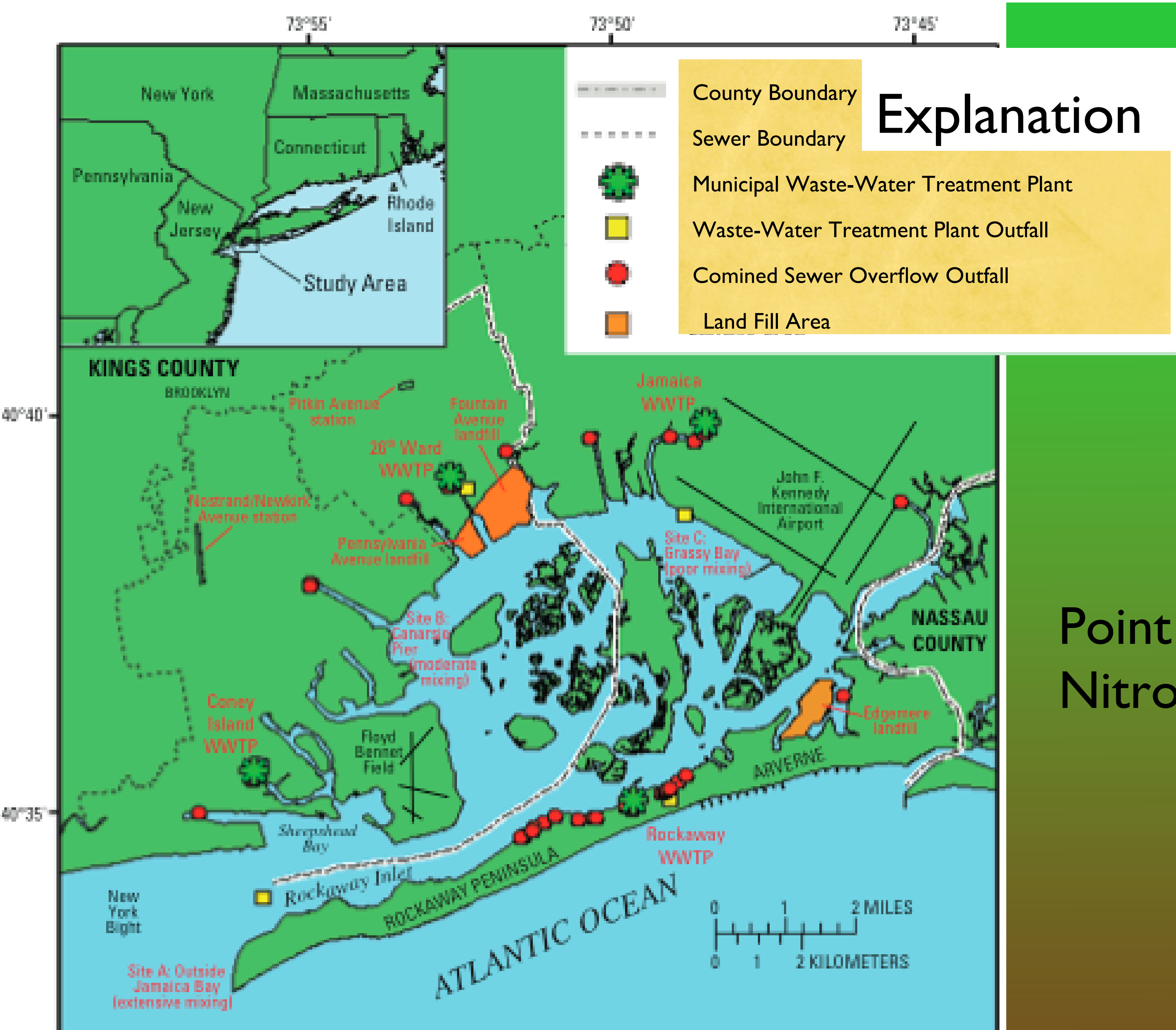
Present Jamaica Bay Shoreline:

Past & Present Jamaica Bay Shoreline:



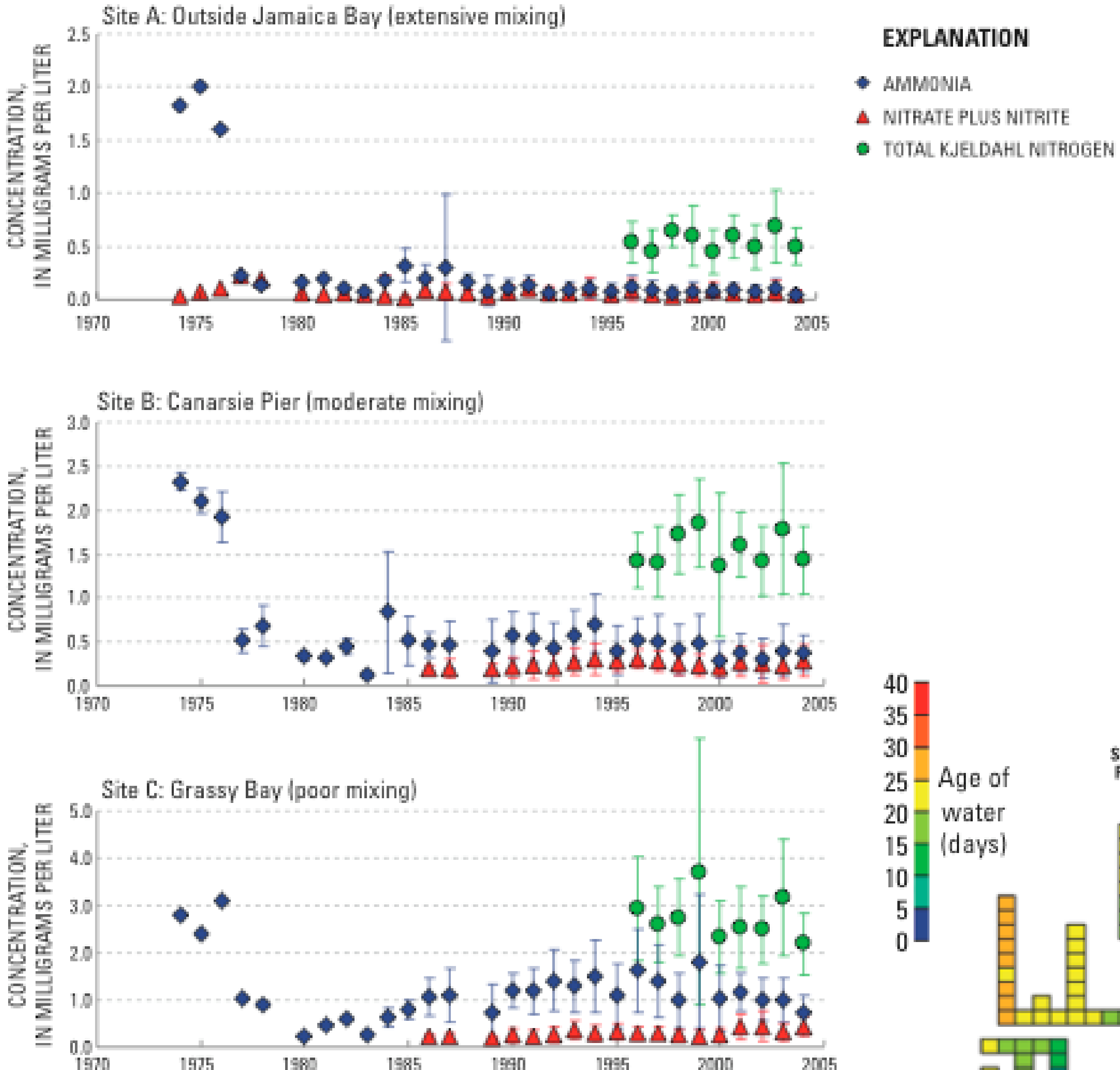
Each of the 30 creeks would have had an average discharge velocity of 10 cfs; smaller creeks might move at half this velocity or less; larger ones would sustain discharges at one to several orders of magnitude greater.

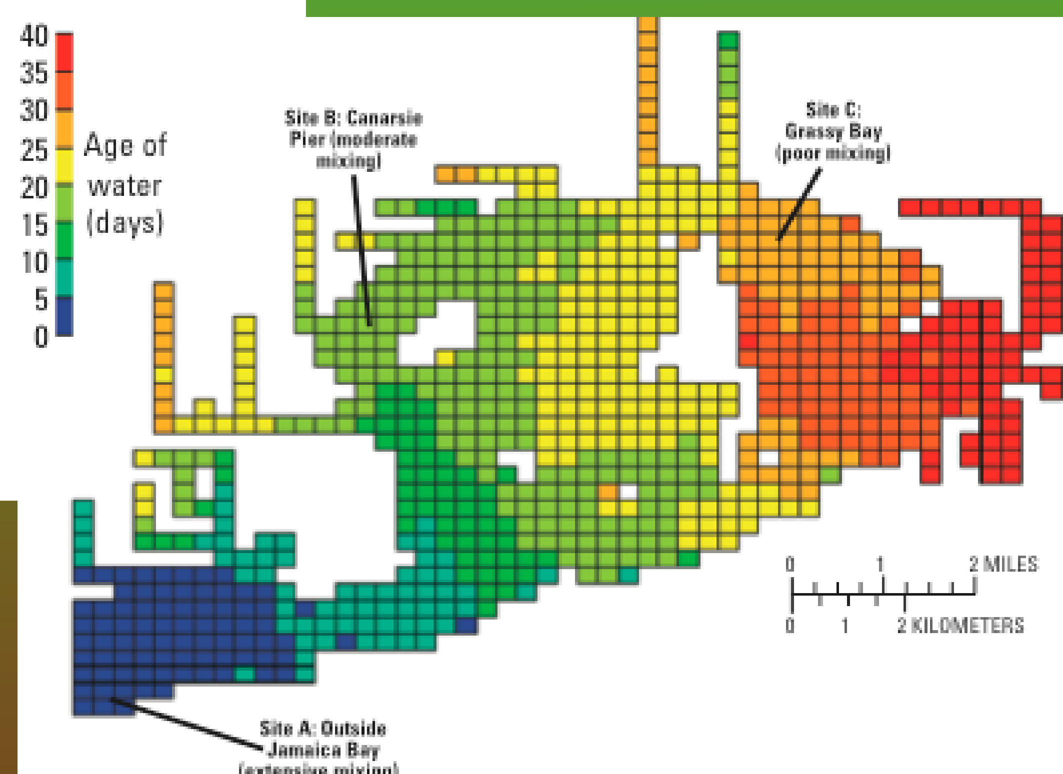
Point Sources For Nitrogen



Base modified from U.S. Geological Survey, 1:100,000, Long Island West; 1984
Projection UTM Zone 18N, Datum NAD27

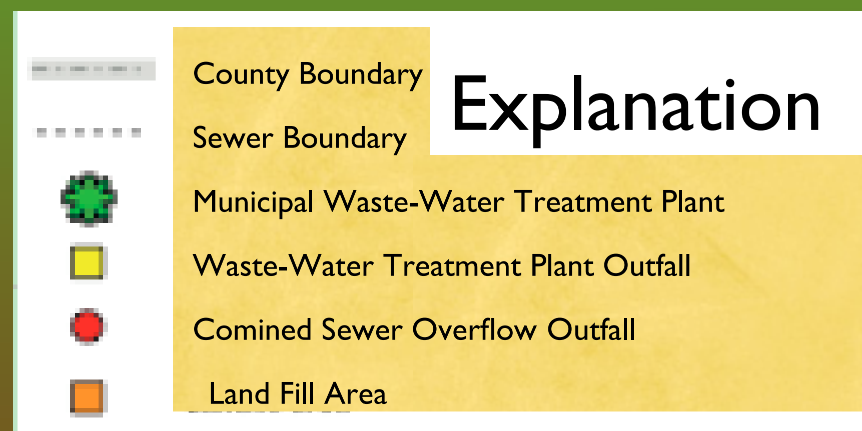
Figure 1. Location of Jamaica Bay, Long Island, N.Y., and selected point and nonpoint sources of nitrogen.


Site A: Outside Jamaica Bay (extensive mixing)
Site B: Canarsie Pier (moderate mixing)
Site C: Grassy Bay (poor mixing)
CONCENTRATION, IN MILLIGRAMS PER LITER
1970
1975
1980
1985
1990
1995
2000
2005
EXPLANATION
AMMONIA
NITRATE PLUS NITRITE
TOTAL KJELDAHL NITROGEN

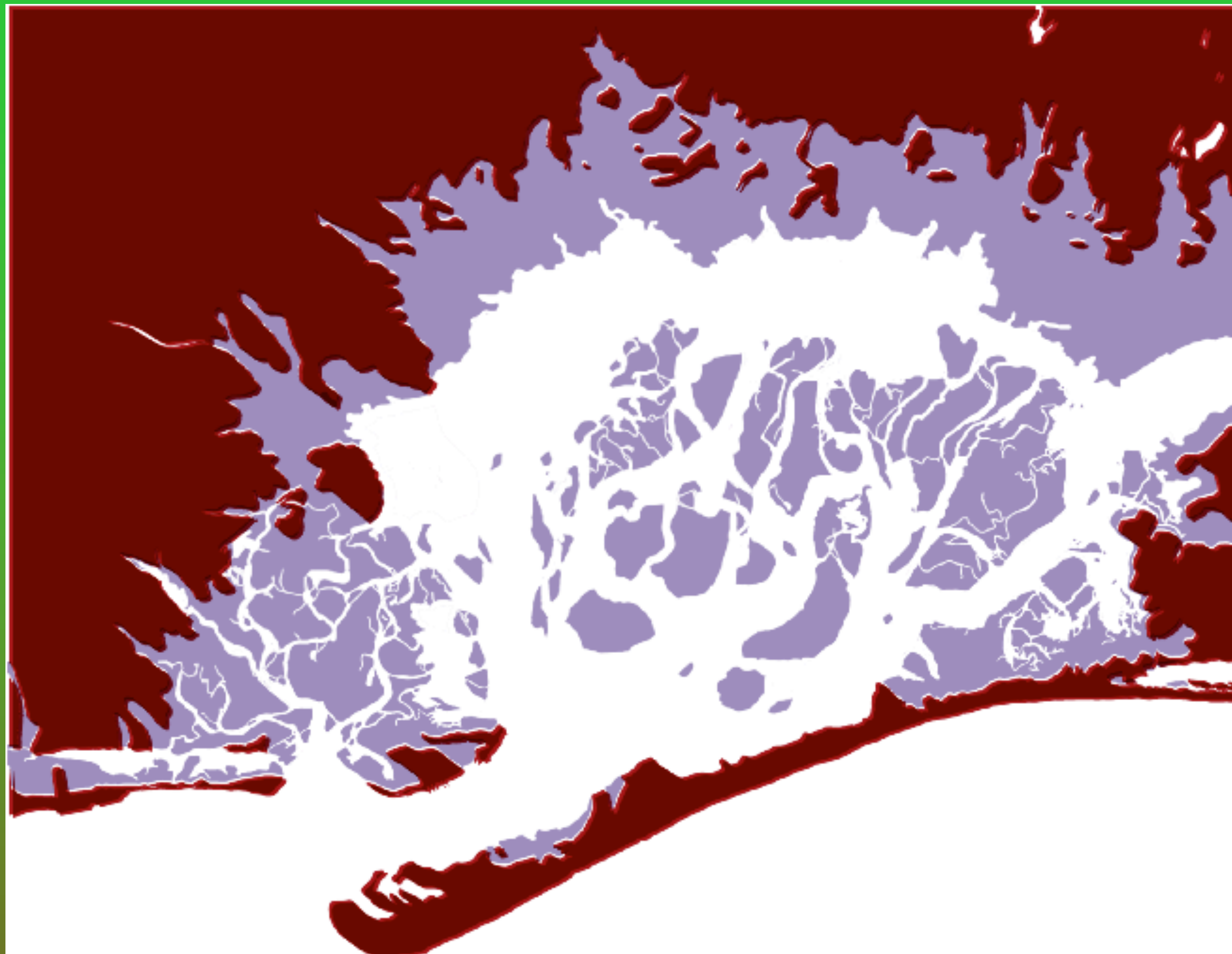

Age of water (days)
0
5
10
15
20
25
30
35
40
Site B: Canarsie Pier (moderate mixing)
Site C: Grassy Bay (poor mixing)
Site A: Outside Jamaica Bay (extensive mixing)
0 1 2 MILES
0 1 2 KILOMETERS

Jamaica Bay Treatment Discharge: By Plant

	Capacity MGD	Drainage Area (Acres)
26 Ward	85	5,907
Coney Isl.	110	15,087
Jamaica	100	25,313
Rockaway	45	6,259



Jamaica Bay Biotic Capacities for NO3 Removal

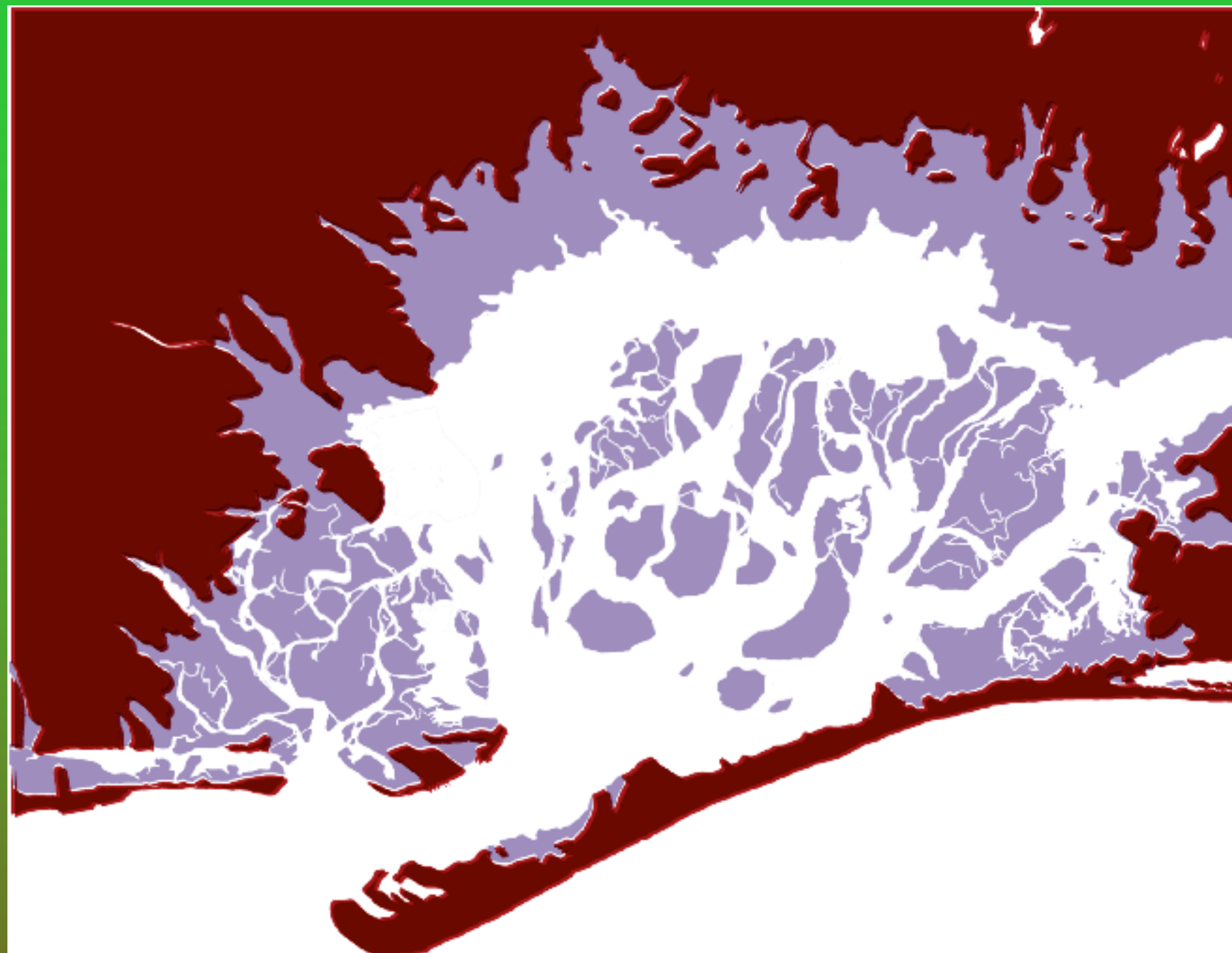


Removal of 35,000 lbs NO3 per day would require

$\approx$ 320 sq. mi. saltmarsh, or

$\approx$ 65 square miles of mash with ribbed mussel beds

Biotic Control of Biogeochemical Cycles in Jamaica Bay



As presently scaled, with sterile bulkhead and borrow pits, nutrient loads are probably between 5 and 20 times larger than the nutrient processing and removal capacities of the biota

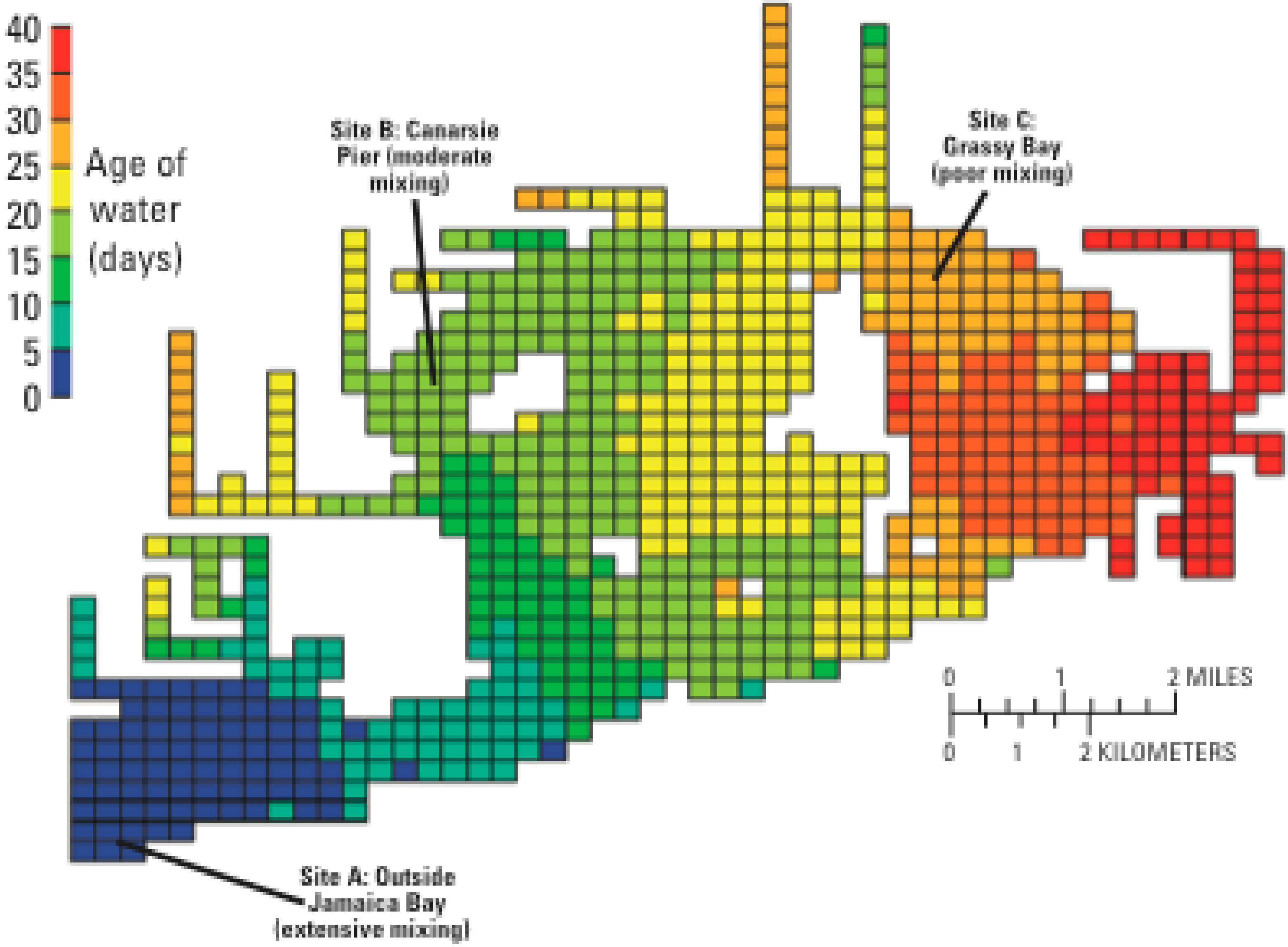


Figure 2. Age and extent of surface-water mixing at three sites on Jamaica Bay, Long Island, N.Y., as defined by a coupled hydrodynamic/water-quality model (From Richard Isleib, HydroQual, Inc., written commun., 2006).

Water Residence Time in Jamaica Bay

Two major biotic vectors,
i.e., variables with magnitude and direction,
govern marsh establishment or loss:
growth and development
above & below grade; and,
microbial breakdown
of marsh peat and humic matter

Two major physical vectors govern oxidation-reduction in *Spartina alterniflora* marshes:

1. inundation and filling of pore volume with incoming tides

2. emptying of pore water through plant leaf and stem evaporation.

Spartina roots import oxygen and incorporate silica-based sediments. Where pore spaces are sturcturally capable of withstanding surrounding hydrostatic pressure, 0.2 to 2 + cms of water can be evapotranspired each day, removing 500 to 2,000 cubic feet of water per acre per day.

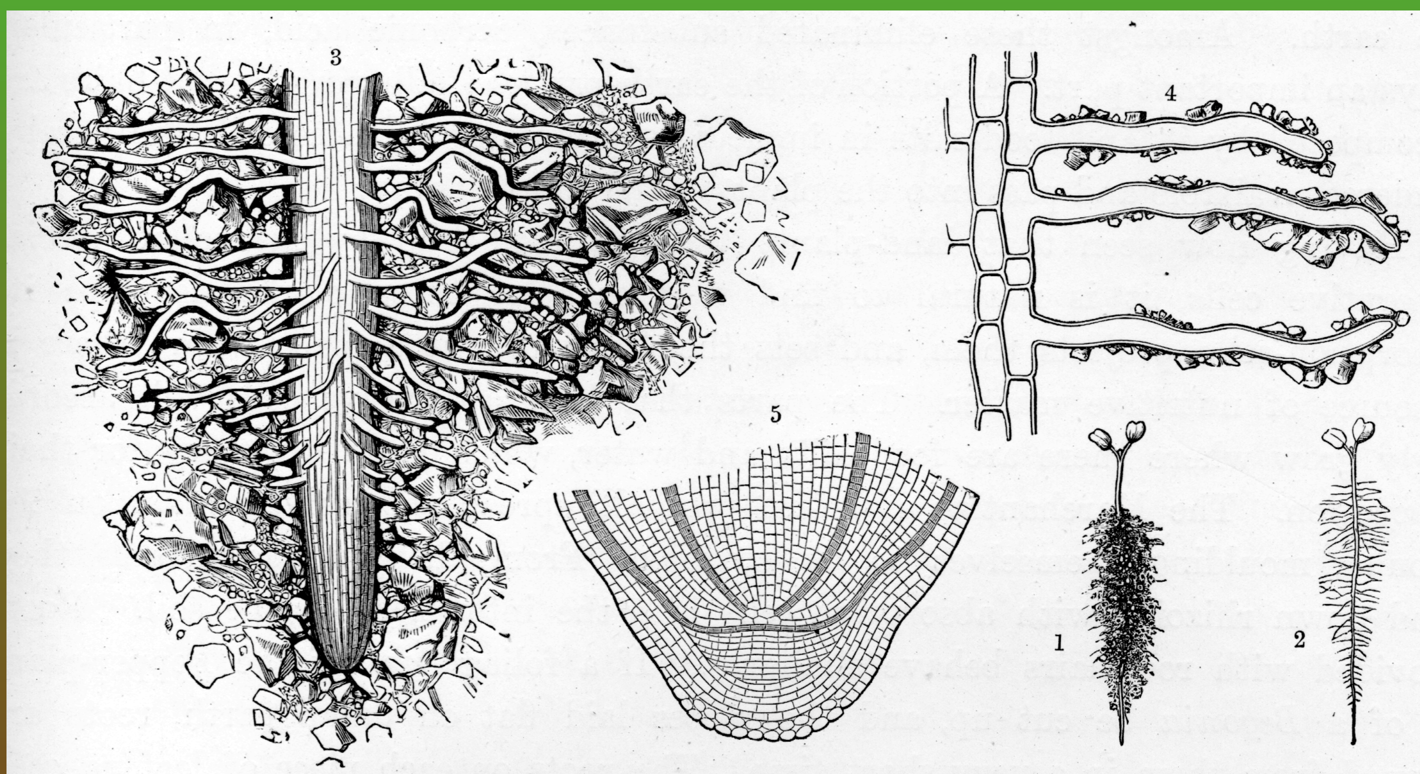
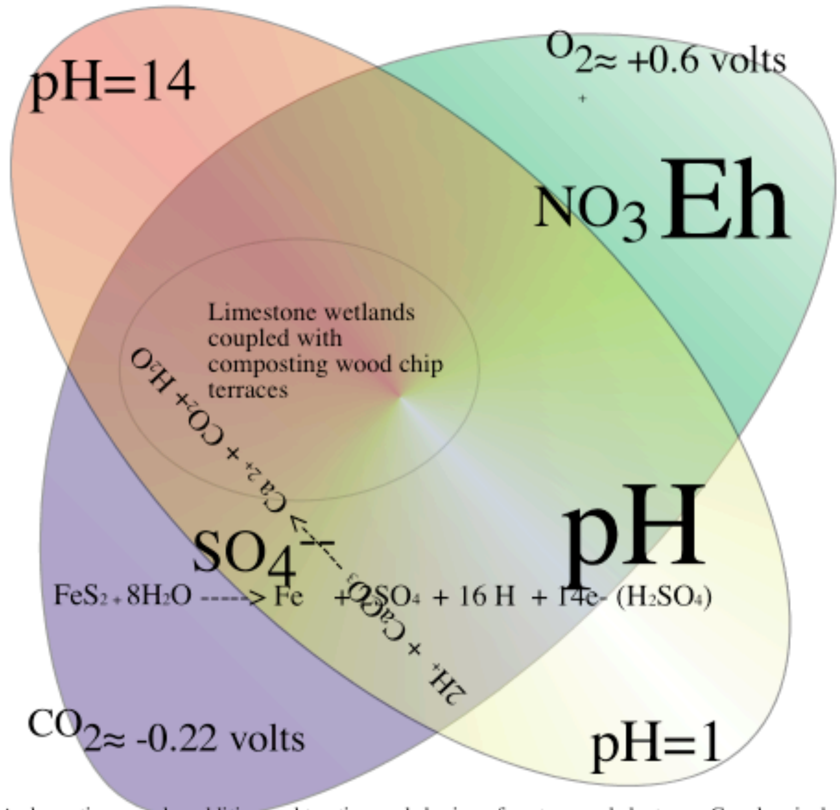


Fig. 12.—Absorptive Cells on Root of *Penstemon.*



Chemical reactions run by addition, subtraction and sharing of protons and electrons. Geochemical control of these reactions can be described in terms of pH and Eh, scientific shorthand describing the availability of positive and negative charges. These two great polarities of global chemistry interact strongly with one another, and organisms play a major regulatory role here, with virtually all free oxygen on the earth produced by plants, and global cycles of nitrogen, sulfur, and carbon mediated by microbes and major groupings of organisms.

Where oxygen is available in moist environments, the sulfides in pyrite are oxidized to sulfate, then sulfuric acid, releasing iron and other metals into solution. In acidic, oxygen rich environments, as in the top center of the overlapping spheres above, iron, aluminum, and other metals are deposited as oxides on rock and plant surfaces. But in oxygen poor environments, where free oxygen has been removed, and sulfate and carbon are available in electronic rich environments, such as would exist at the bottom of a wetland, calcite dissolves, creating high pH, basic conditions.

Carbon energy sources from rotting wood can provide food for sulfate reducing bacteria where there is no oxygen, producing sulfides, which precipitate out iron and other metals. Composting wood surrounding a wetland constructed on crushed marble could together act to move conditions to the left midsection of the above graphic. Such conditions could be established by terracing forest and wetland habitat on tailings at the Elizabeth Mine: metals could be removed, and acidity neutralized.

Water Removal Capacity

Spartina can empty 4 to 20 cm of capillary water from the surface of a saltmarsh.

Where water does not refill this zone from the edges, biotic control regulates hydrology, suppressing nitrate and sulfate reduction

Fiddler crabs accentuate hydraulic conduction and loss in the mid marsh

A simple hypothesis follows:

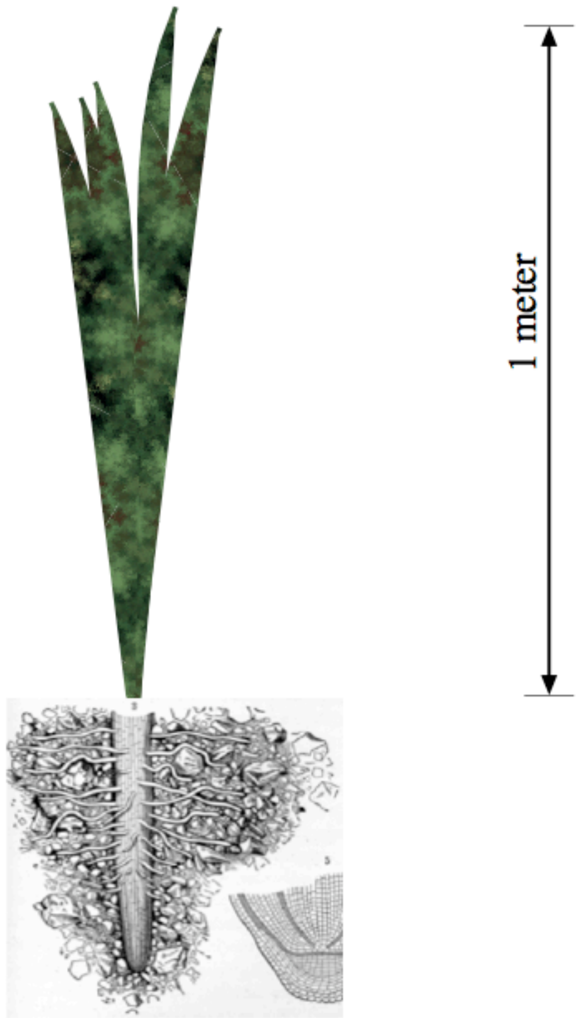
Marshes increase in scale if and only if plant shoot and root scale remove pore water between tidal cycles

Structural Ecology of Ecological Engineers

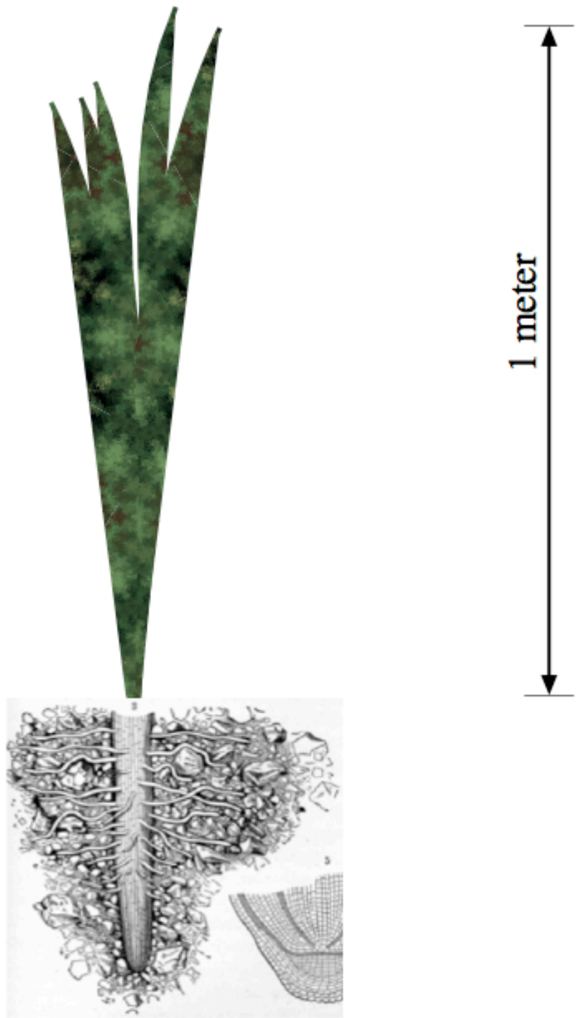
Energy Flows are captured: radiation and shear energies by *Spartina, Zostera, and Seaweeds*; shear forces and entrained flow by mussels and oysters

Material Flows of sediments are entrained by *Spartina* and Zostera shoots and roots, passively structured and actively filtered by mussel beds and oyster reefs

The Rhizosphere/peat/accumulating sediment structure develops as a nutrient storage zone and biogeochemical reactor



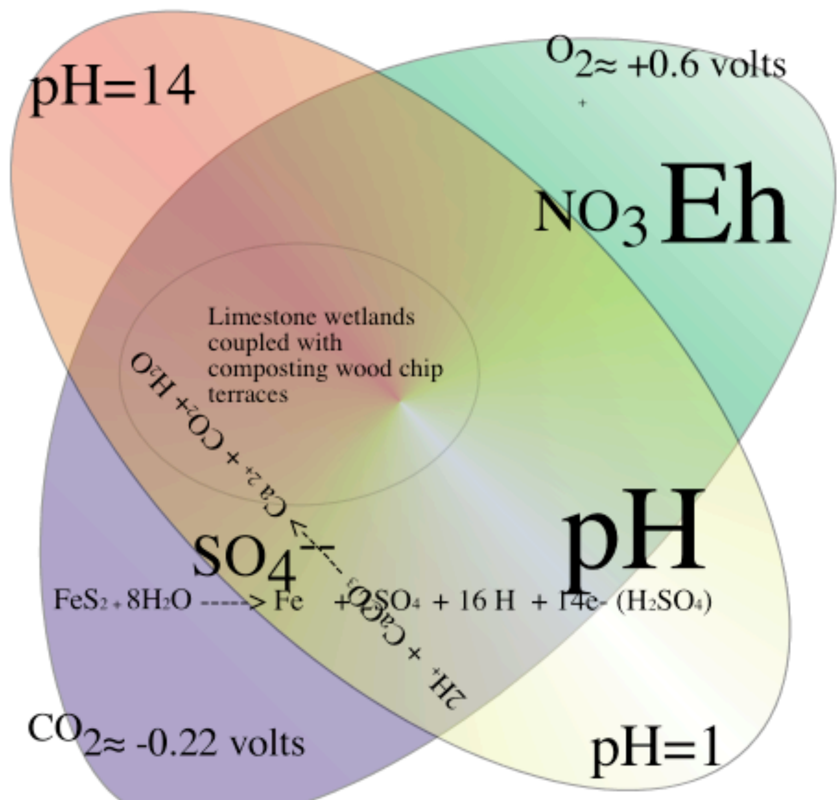
Spartina alterniflora **growth and development hypothesis: in the top third of the tidal cycle, saltmarsh plants will grow to about a meter in height.**



But, denitrification, and the majority of carbon storage occurs below grade, in an environment which emerges from the interaction between Spartina and sediment inputs.

Spartina growth and development vector is not suppressed by continuous flooding

Clasons Point
East River



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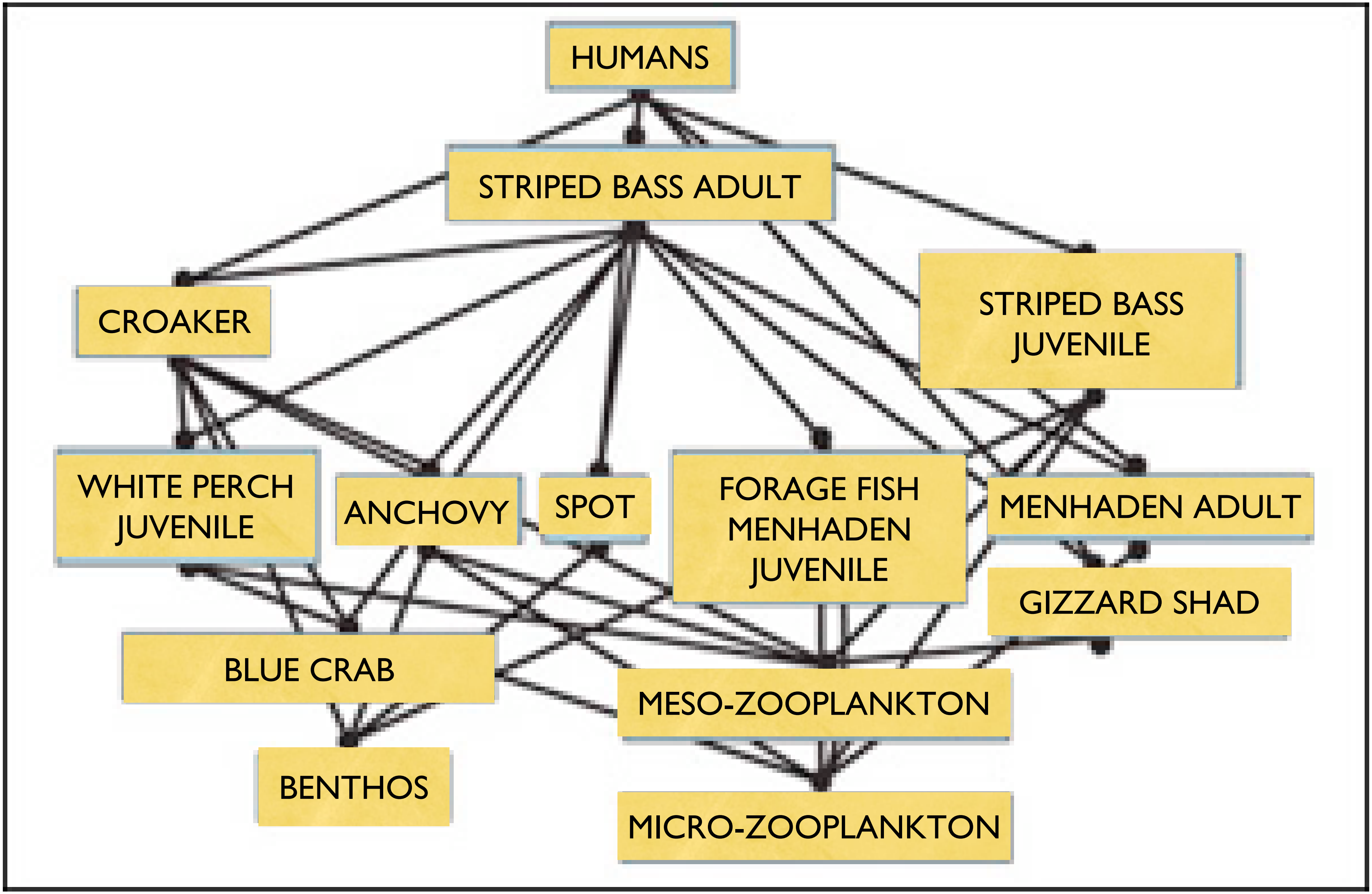
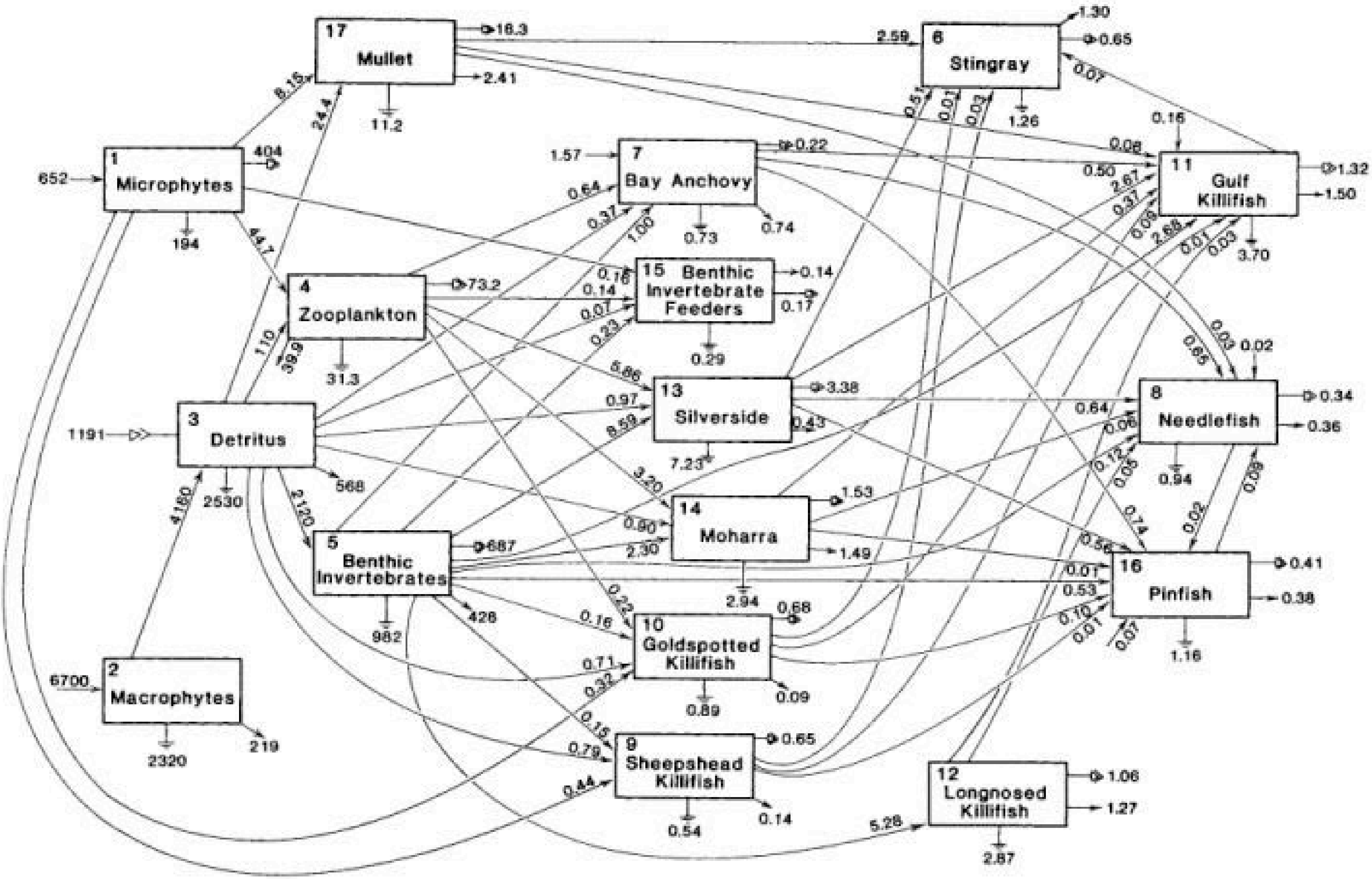

HUMANS
STRIPED BASS ADULT
CROAKER
STRIPED BASS JUVENILE
WHITE PERCH JUVENILE
ANCHOVY
SPOT
FORAGE FISH MENHADEN JUVENILE
MENHADEN ADULT
GIZZARD SHAD
BLUE CRAB
MESO-ZOOPLANKTON
BENTHOS
MICRO-ZOOPLANKTON



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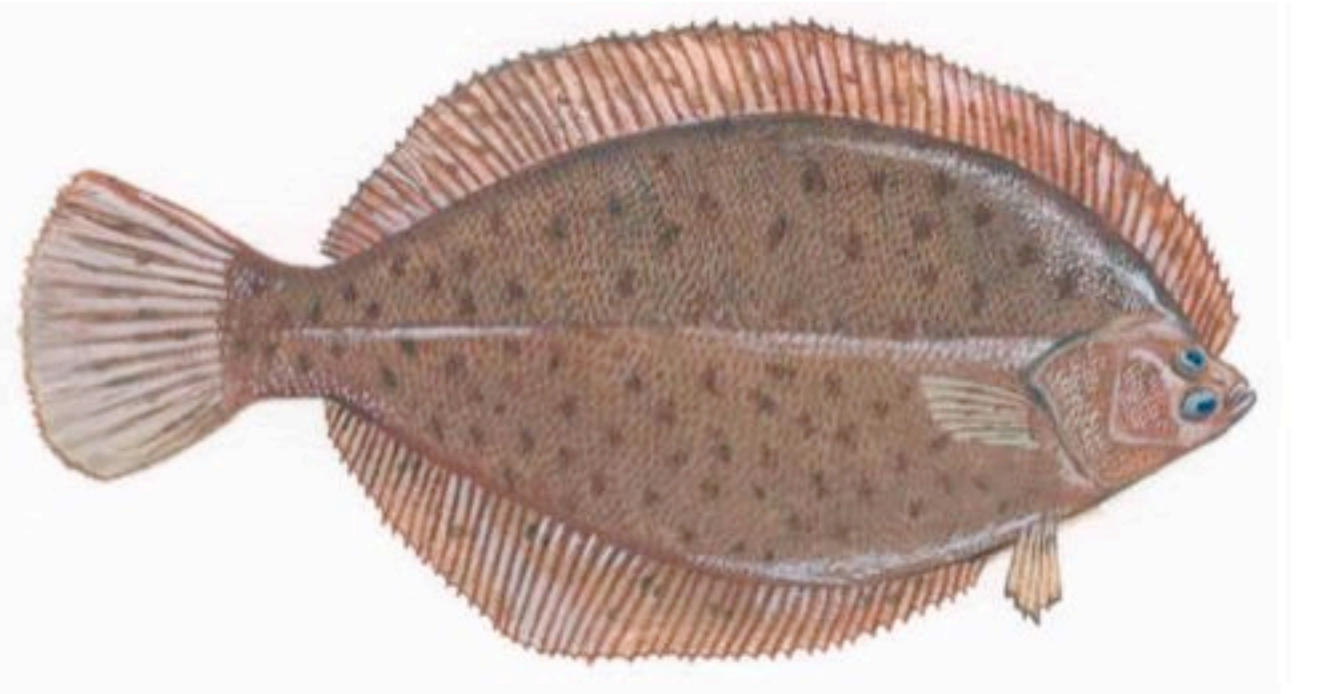


Fundamentals of Ecology

Energy Flows

Material Flows

Caveats:

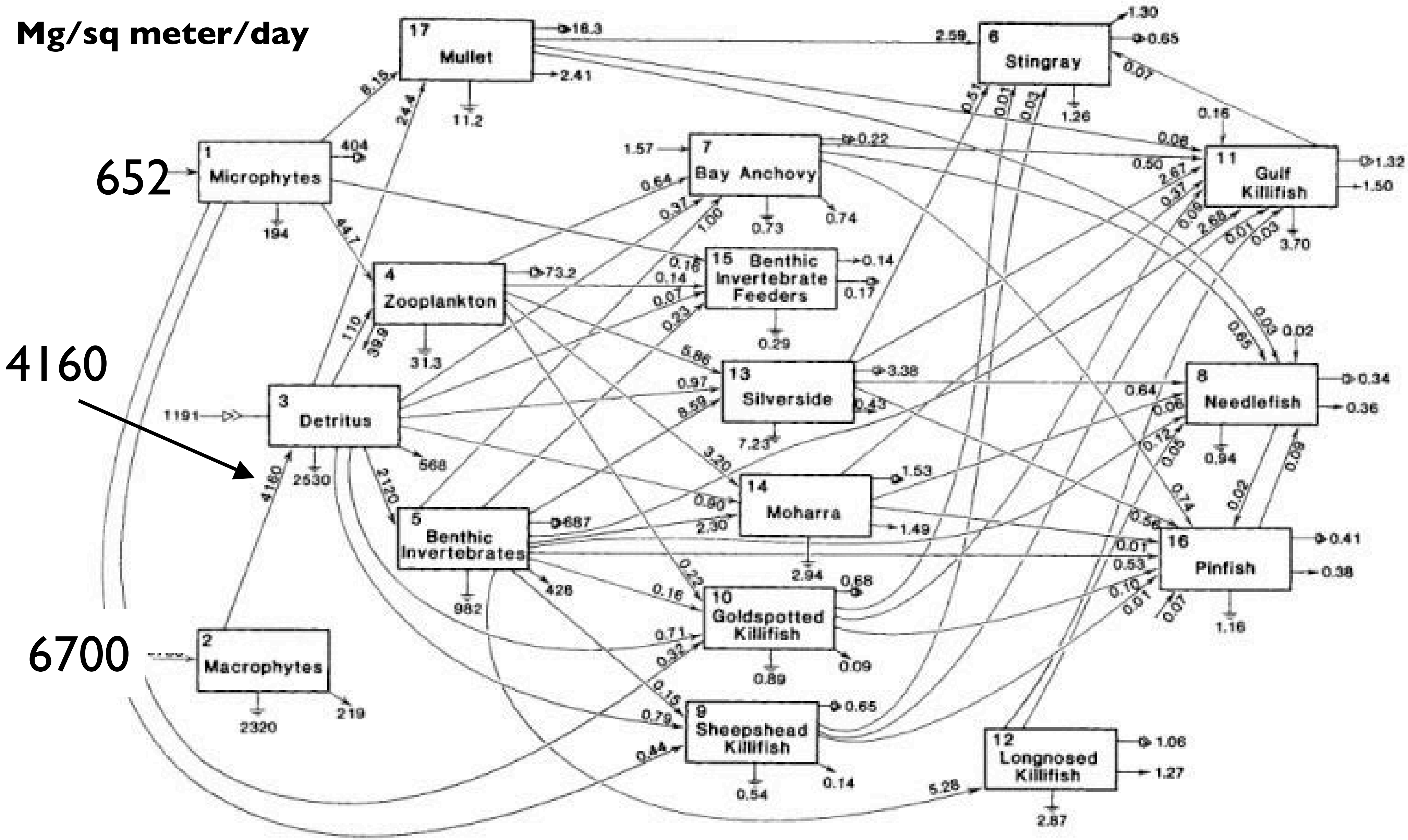
sMean free-diffusion pathways for oxygen to rhizosphere may clog, suppressing plant growth

Nutrients, P & N, have been shown to increase carbon breakdown in soils & sediments

But, breakdown of polyphenolics and lignocellulose is oxygen dependent, and does not occur under low oxygen tensions

Marsh growth and develoment is dependant on an integration of sediment and root growth and development

Mg/sq meter/day



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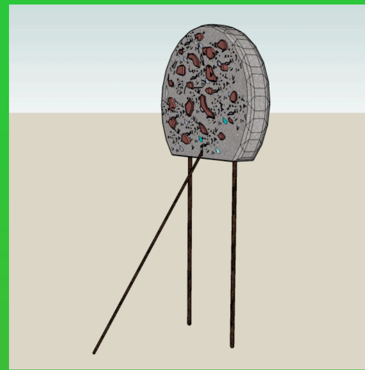
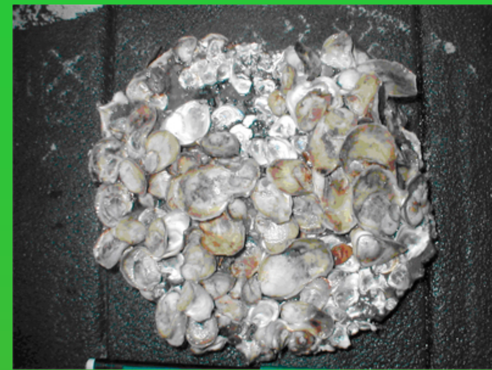
Productivity

veg type	**gC/sq meter/yr**
Laminaria	1200 to 1900
Macrocystis pyrifera	800-1000
Macrocystis integrifolia	1300
Seagrasses	500-1000
Fucus Ascophyllum	300-600
benthic diatoms	100-400
phytoplankton	100-200

Clasons Point/East River


Decrease the quantity of water enters treatment plants and is discharged as stormwater runoff

Increase the quantity and surface area of structures the provide estuarine habitat.

Couple outfalls with structures that can be colonized by suspension feeders and seaweeds.

Create refugia for keystone species

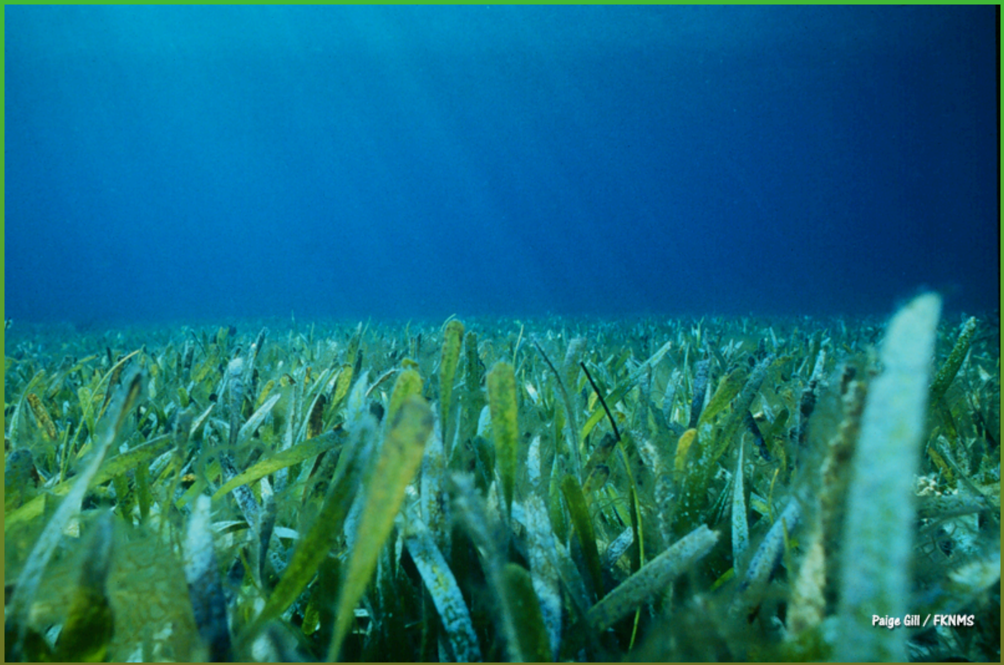
Scale saltmarsh, eelgrass beds, oyster reefs, mussel beds, seaweed habitat & biogeochemical filters to approximate and match or exceed nutrient inputs

A single oyster can filter up to 5 liters of water per hour (up to 50 gallons per day); removing nutrients, pollutants, and algae from the water column.

Healthy oyster and mussel beds have a surface area 50 times greater than a flat bottomed seabed.

Seaweeds & Eelgrasses provide shelter and habitat for juvenile mollusks, crustaceans and fishes.

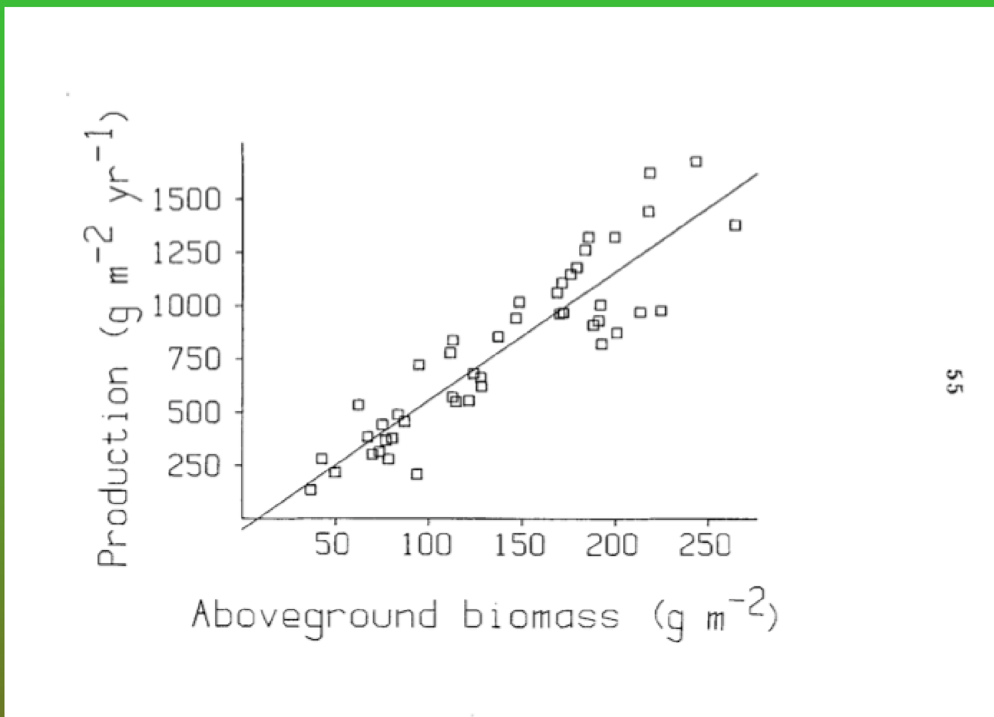
They also act as transformers, moving water column nutrients, N, P, Fe, etc., into food chains, food webs, and fisheries.

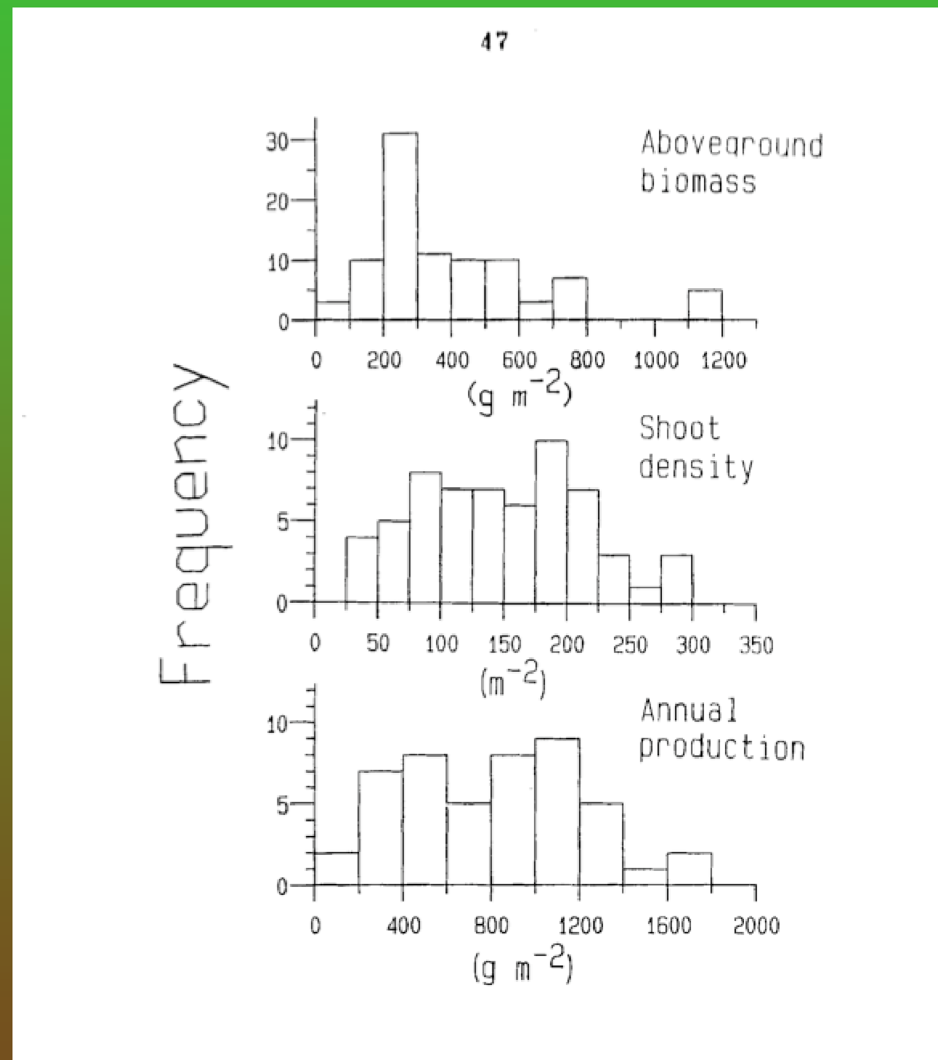


Oysters and eelgrass are growing together in this Ninagret Bay on Rhode Island

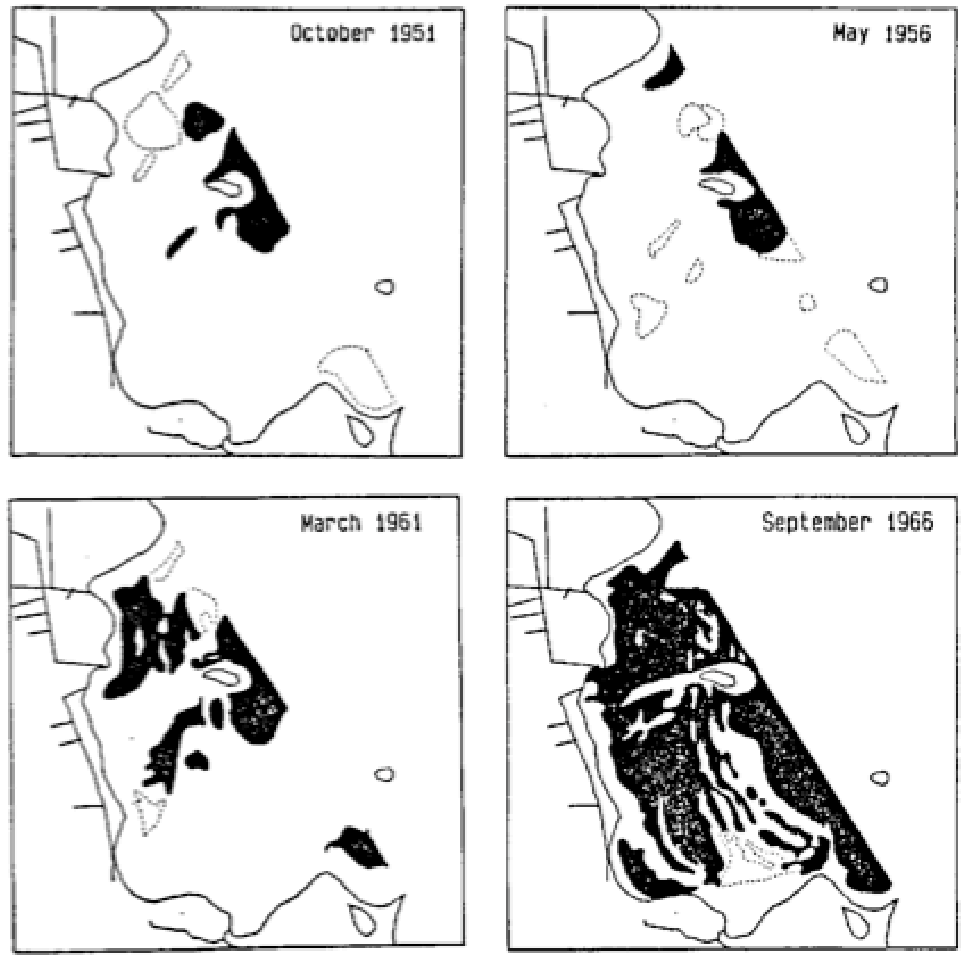
Eelgrasses invest about a kilogram per square meter into primary productivity, with a tenth to a fifth of that, ≈ 100 to 200 g/m2/yr invested in above grade structure

Eelgrass structure invests nutrients in food chains and entrains flow, enhancing biodiversity

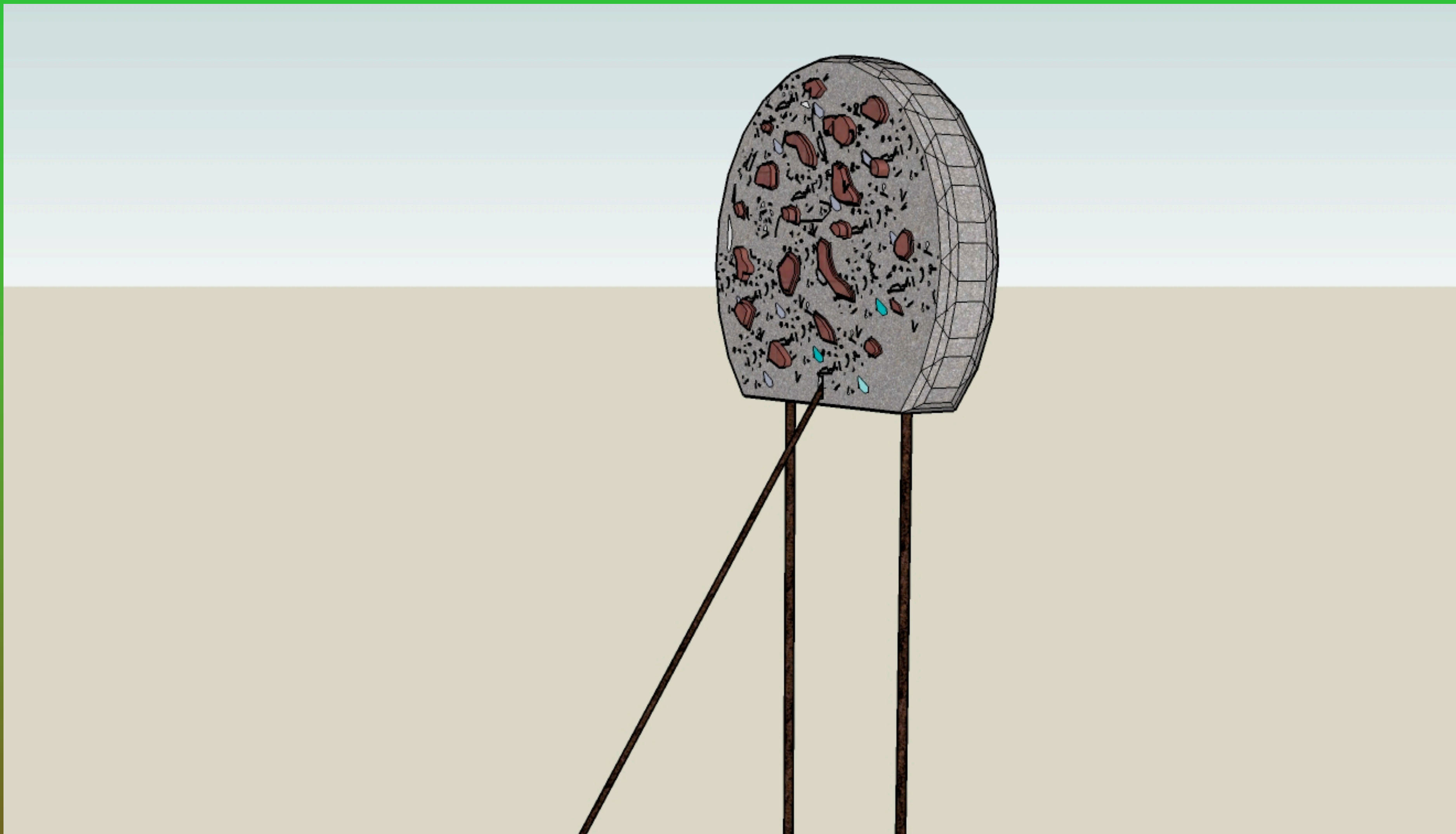




Eel grasses colonize zones around pioneer colonies through both seeds and below grade growth. Costa's 1988 thesis demonstrates population areas doubling in as quickly as about a decade



Increases viable habitat surface area without diminshing existing or potential bottomn habitat.

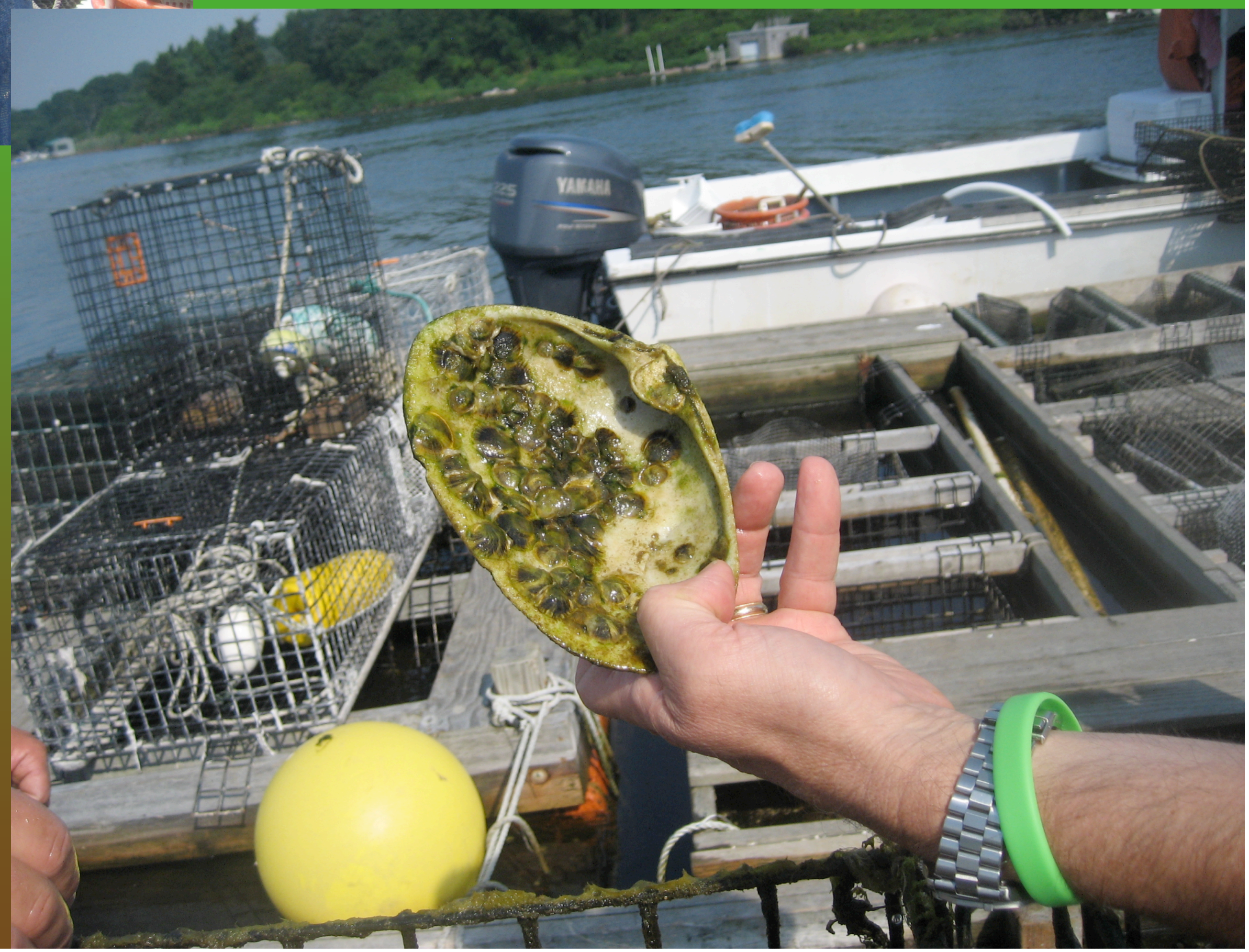


Estuary Habitat

“Lollypop” Substrate with little impact on on the continuity of benthic habitat

Approximately 1.4 million oysters are growing in the oyster farm pictured here.

It it hypothsized that a similar structure could removed between 10% and 50% of the nitrogen flowing from the 26th Ward Waste Water Control Plant, at a cost of approximately $50,000



Approximately 5 million mussels could be grown along a few hundred linear feet of an estuary creek, like the one flowing from the 26th Ward WWTP

It it hypothsized the structues pictured here, properly scaled, could filter approximately 100,000,000 gpd for a cost of less than $20,000

Salt Marsh at 50 lbs per acre/yr = 400 sq.mi.

Salt Marsh with ribbed mussels at 200 lbs/acre/yr = 100 sq.mi.

Mussel & Oyster reefs at 1500 lbs per acre per year = 13 sq.mi.

An Ecological Paradox:

Managing for Selforganization?