THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

RUTGERS UNIVERSITY
COASTAL OCEAN OBSERVATION LAB
OPERATIONS CENTER

Effects of Global Change on Coastal Environments and the Rutgers Research Potential

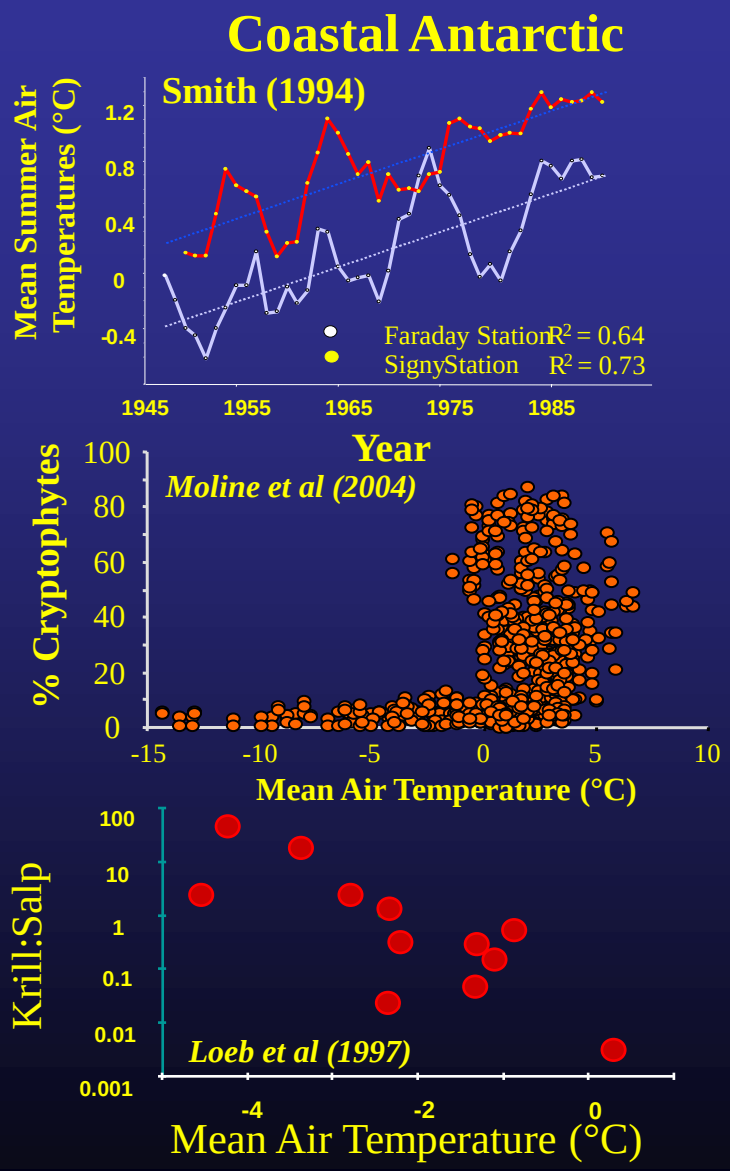
MY CHARGE FROM THE ORGANIZERS

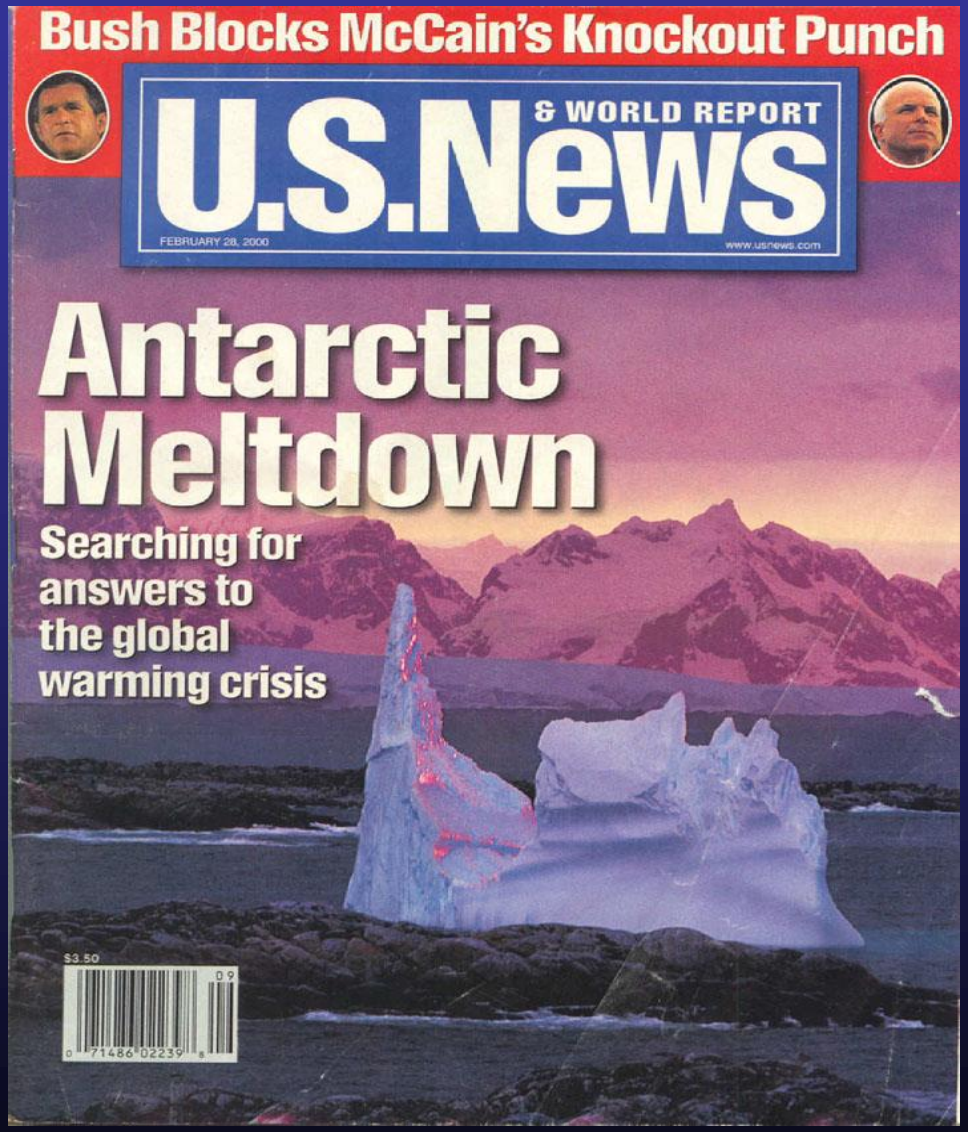
URGENCY

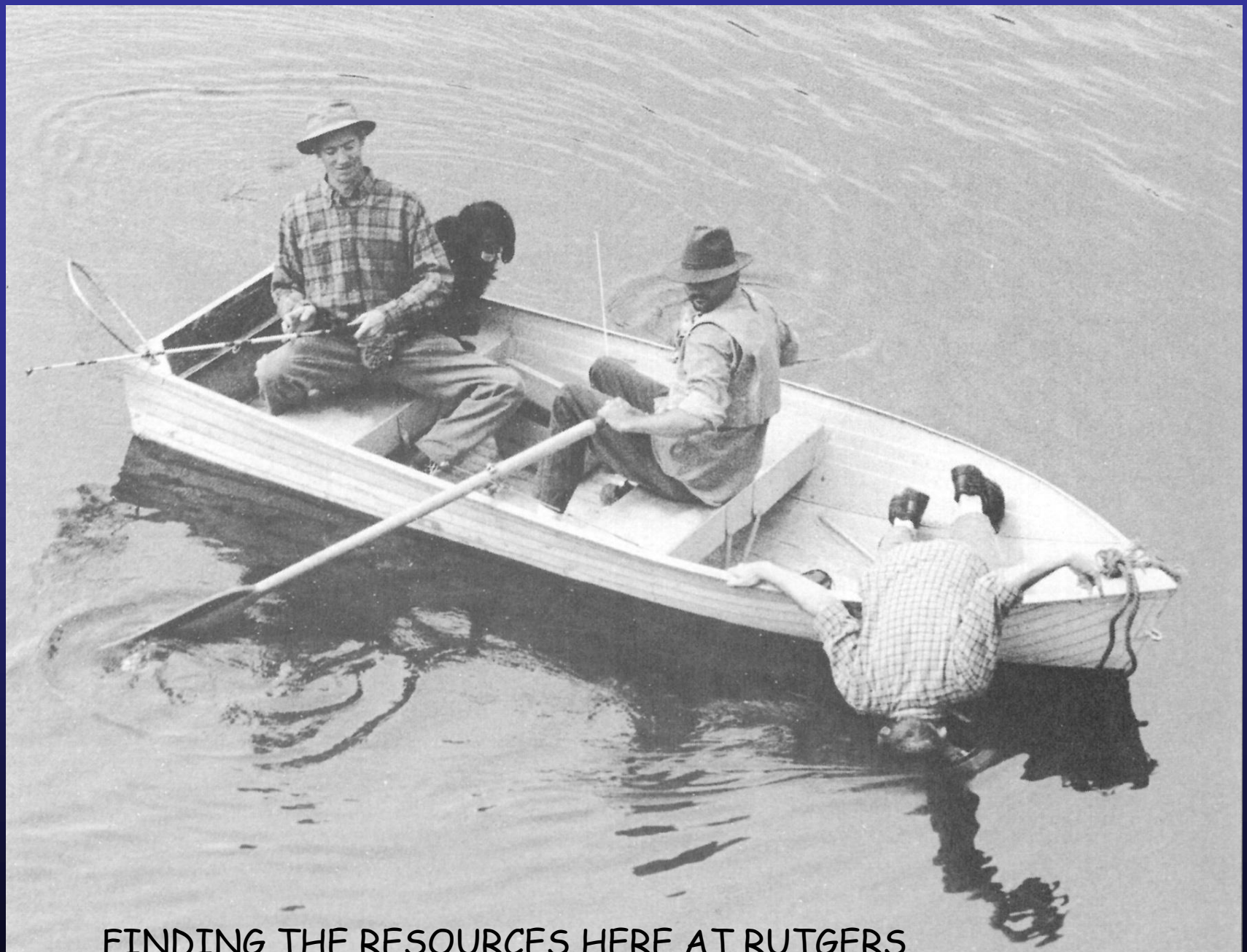
ISSUES ASSOCIATED WITH CHANGING COASTS

UNIQUE CHALLENGES UNDERSTANDING POTENTIAL FOR OUR COASTS & THE *SOME* RESOURCES THE RUTGERS BRINGS TO TABLE

THE PROBLEM: MY EXPERIENCE







FINDING THE RESOURCES HERE AT RUTGERS

The are no organized shopping aisles at this one stop shop

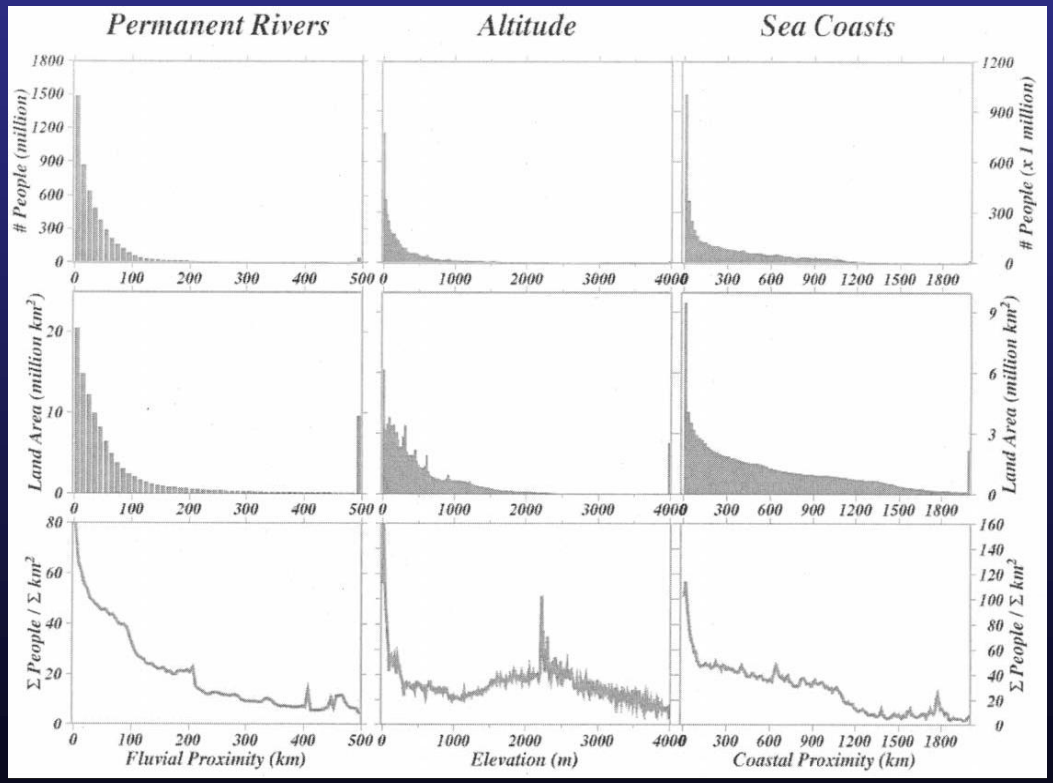
The coasts are disproportionately important to humans

1.2 billion people (23% of human population) live within 100 m of sea level and 100 m from coast line

Population densities at 20 m above sea level are on average 3x the global average

Populations at coasts will increase dramatically over the next 50 years*

- In USA from 1960-1990, coastal population density increased from 275 to 400 /kilometer
- In China 56% of population lives in 13 coastal provinces, with current estimates suggesting 20-40 million on the move (population of Spain) to coastal areas



Small and Cohen 2004, Current Anthropolgy vol 45

* Hinrichesen aaas, 2005

Coastlines importance will increase due to projected human & associated economic growth

China: All 14 "economic free zones" and 5 "special economic zones" are coastal provinces and over 65% of China's cities that have municipal status are coastal

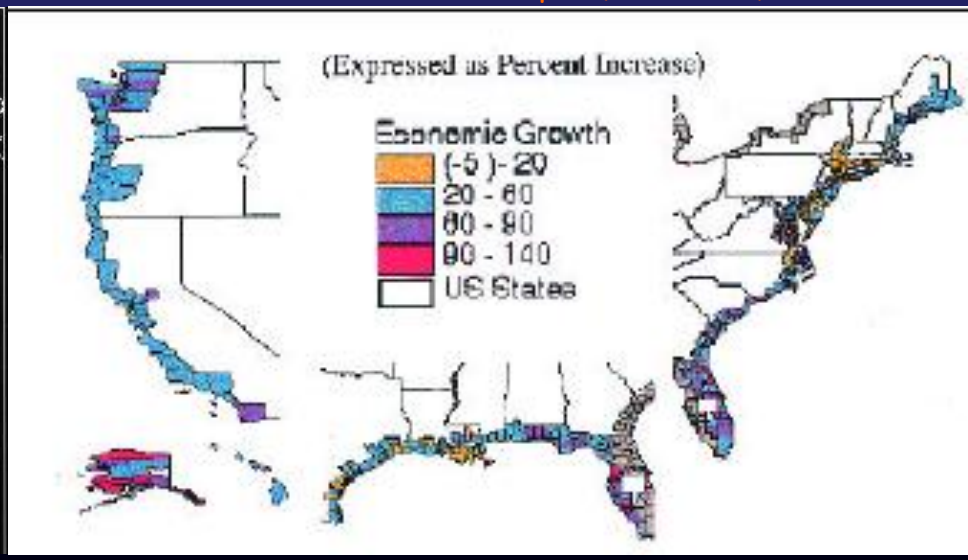
Southeast Asia: ~65% of the major cities (2 million or more) are coastal

Latin American and the Carribean 57 out of 77 cities are coastal and current projections have 75% of the populations living in urban centers in the next 10 years

Mediterranean basin has current population of 380 million (146 at coasts) with projections of 555 million within years (176 living at the coast itself)

Night-time radiance of the United States

Projected economic growth between 2000 & 2025 as % current economic output (NPA 1999)



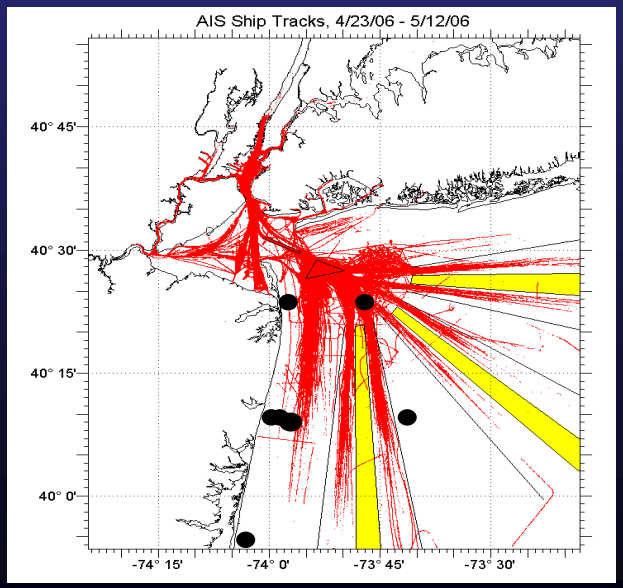
Elvidge et al. 1997

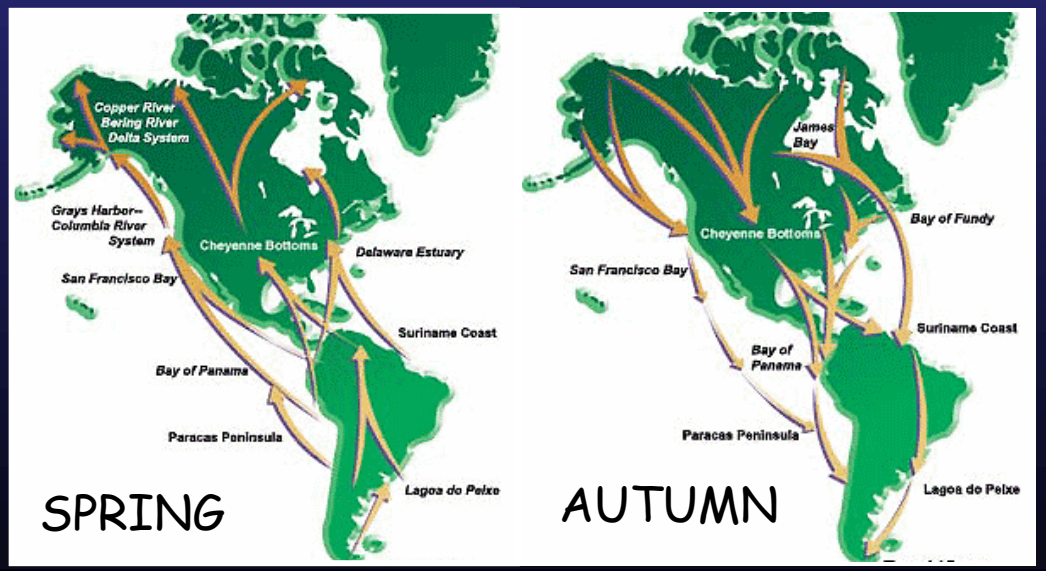
Coasts are critically important to New Jersey

PEOPLE: NJ has ~ 8.6 million people, 60% are located in coastal counties

MONEY: Coasts critical to the state economy ($16 billion tourism industry, $50 billion maritime industry, $100 million commercial fishing industry)

ENVIRONMENT: Diverse habitats that include bays, estuaries, wetlands, and dunes. State coastal ecosystems are home to at least 24 endangered or threatened wildlife species. It is a global stopover point 1.5 million migratory shorebirds, home to world's largest population of horseshoe crabs, and many of the fisheries are migratory.

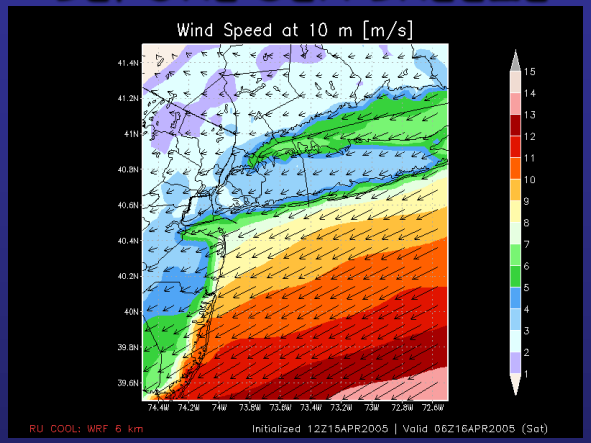




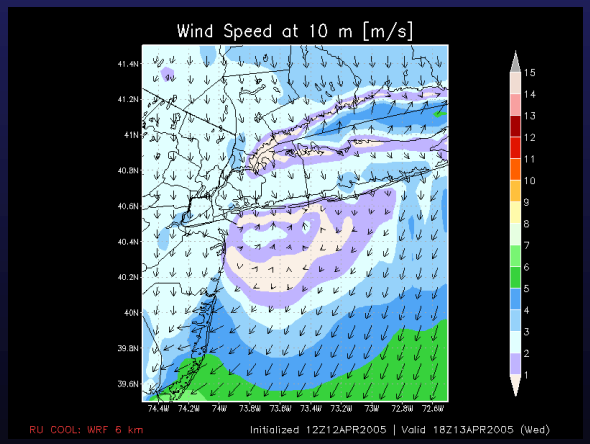
Cooper, Beevers, and Oppenheimer 2005

Coastal influences extend far inshore

BEFORE SEA BREEZE



SEA BREEZE KICKS UP



SEA BREEZE CARRIES MATERIAL ACROSS THE LAND IMPACTING THOSE ECOSYSTEMS

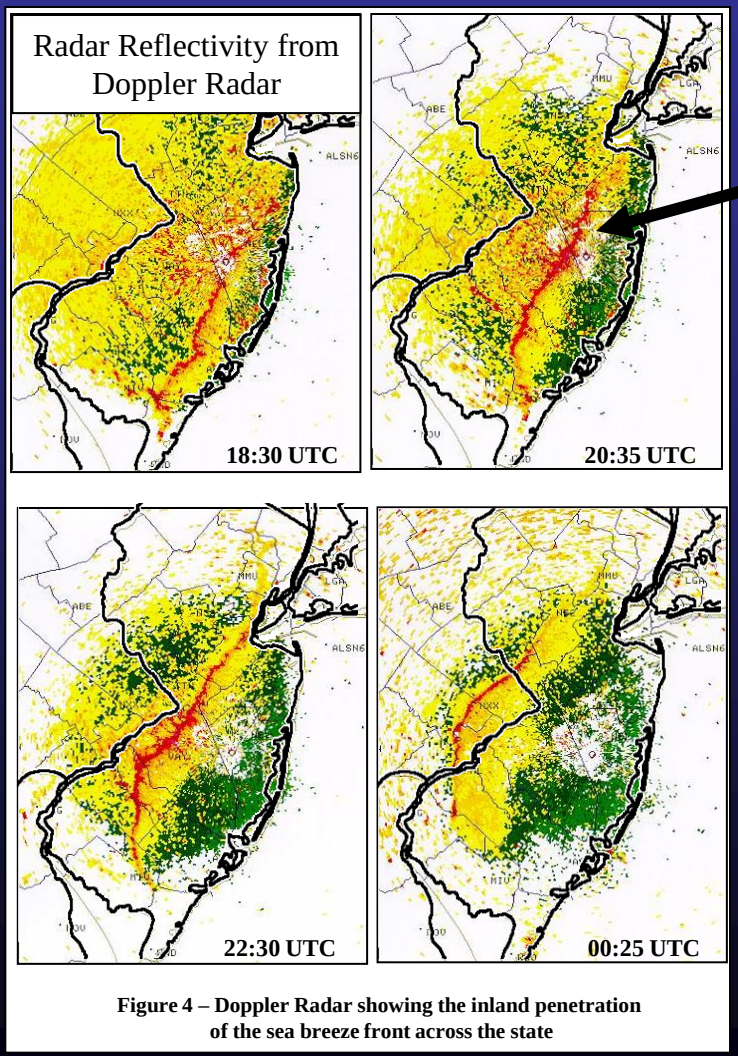
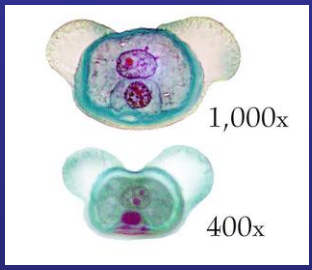
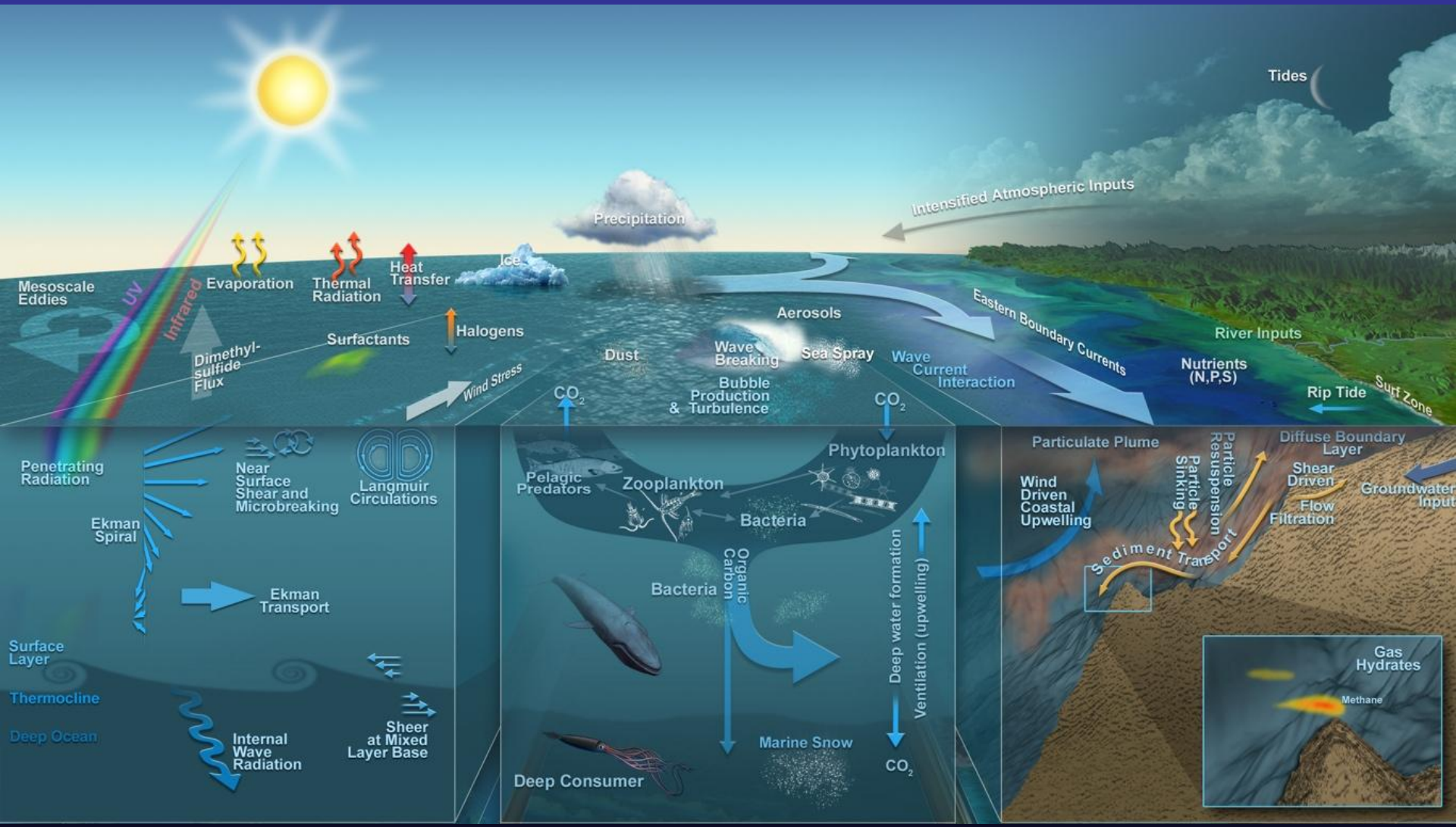


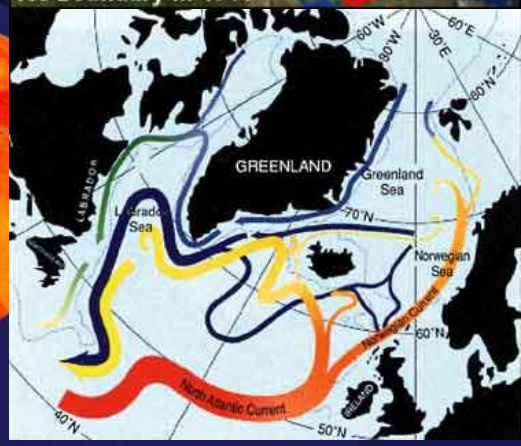
Figure 4 – Doppler Radar showing the inland penetration of the sea breeze front across the state

Human Health & Asthma Fronts




Tides
Intensified Atmospheric Inputs
Precipitation
Mesoscale Eddies
UV
Infrared
Evaporation
Thermal Radiation
Heat Transfer
Ice
Aerosols
Eastern Boundary Currents
River Inputs
Dimethyl-sulfide Flux
Surfactants
Halogens
Dust
Wave Breaking
Sea Spray
Wave Current Interaction
Nutrients (N,P,S)
Wind Stress
Bubble Production & Turbulence
CO_2
CO_2
Rip Tide
Surf Zone
Penetrating Radiation
Near Surface Shear and Microbreaking
Langmuir Circulations
Ekman Spiral
Ekman Transport
Surface Layer
Thermocline
Deep Ocean
Internal Wave Radiation
Sheer at Mixed Layer Base
Phytoplankton
Pelagic Predators
Zooplankton
Bacteria
Bacteria
Organic Carbon
Deep water formation
Ventilation (upwelling)
Marine Snow
Deep Consumer
CO_2
Particulate Plume
Particle Resuspension
Particle Sinking
Diffuse Boundary Layer
Shear Driven
Flow Filtration
Groundwater Input
Wind Driven Coastal Upwelling
Sediment Transport
Gas Hydrates
Methane

CLIMATE CHANGE WILL IMPACT NJ DRIVEN BY THE CHANGES IN LAND, ATMOSPHERE, AND OCEAN



CLIMATE CHANGE WILL IMPACT

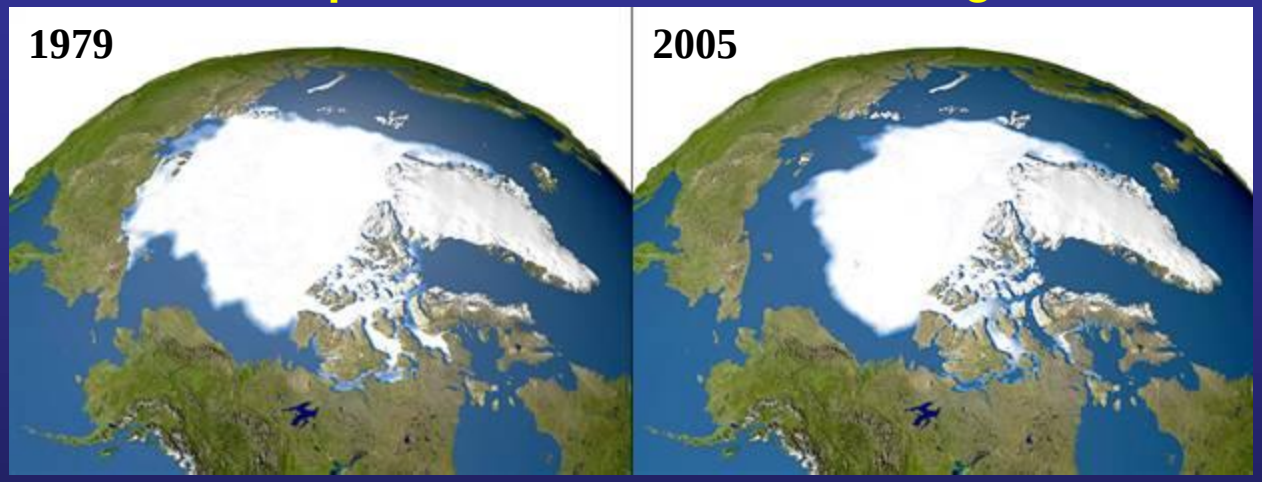
sea level rise, extreme weather, ecosystems structure/productivity, air quality, human health, agriculture

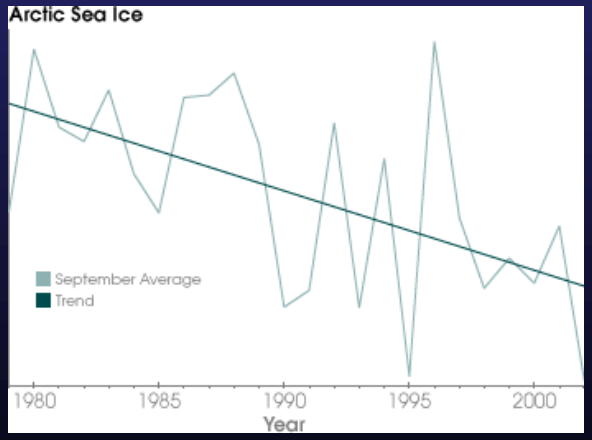
Jim Miller

GLOBAL CHANGE: IMPACT ON NEW JERSEY

Over the next 50 years, the oceans off New Jersey will change, will we as a state be prepared for those changes?

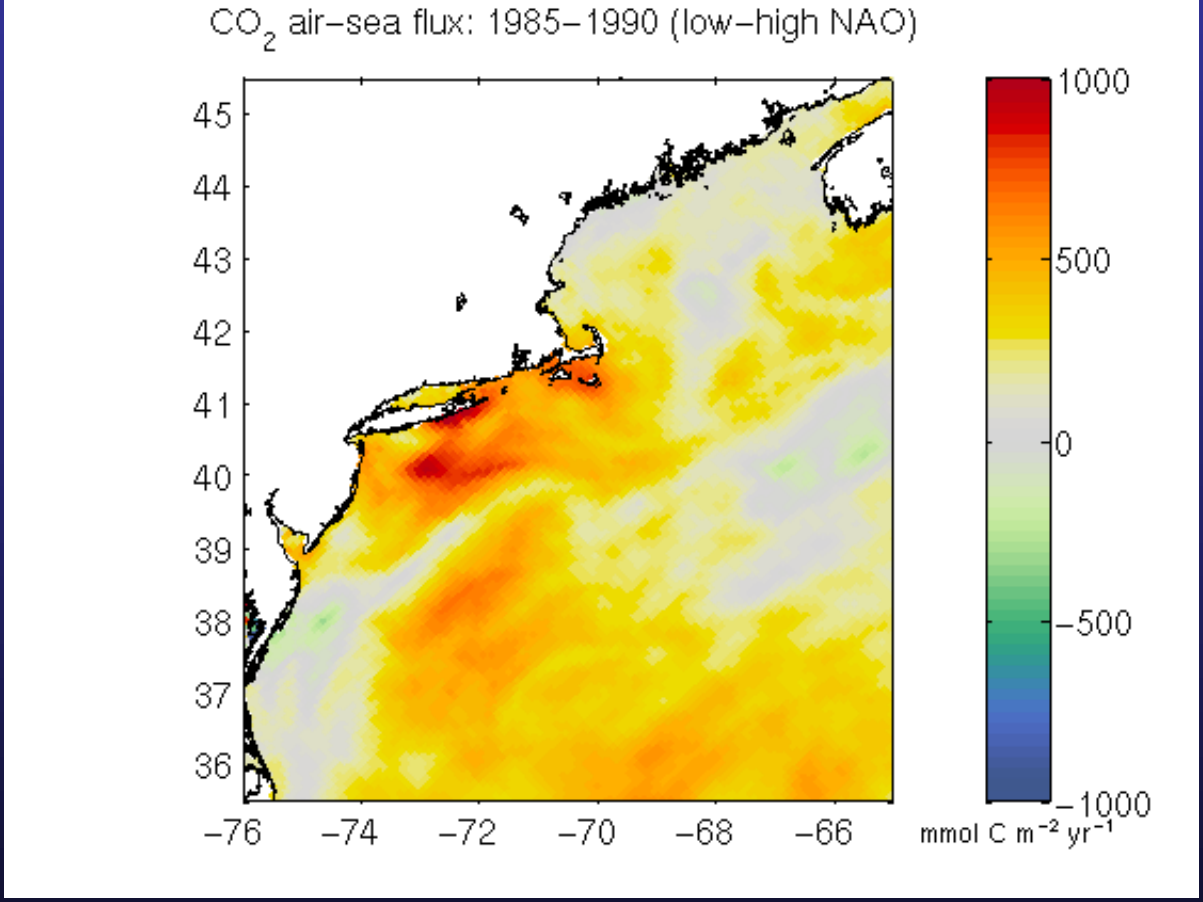
Polar Amplification of Global Warming





Francis et al.

Understanding the role of long term secular and cyclical impacts on our region



Previdi

Changes in our local waters during the 1990's

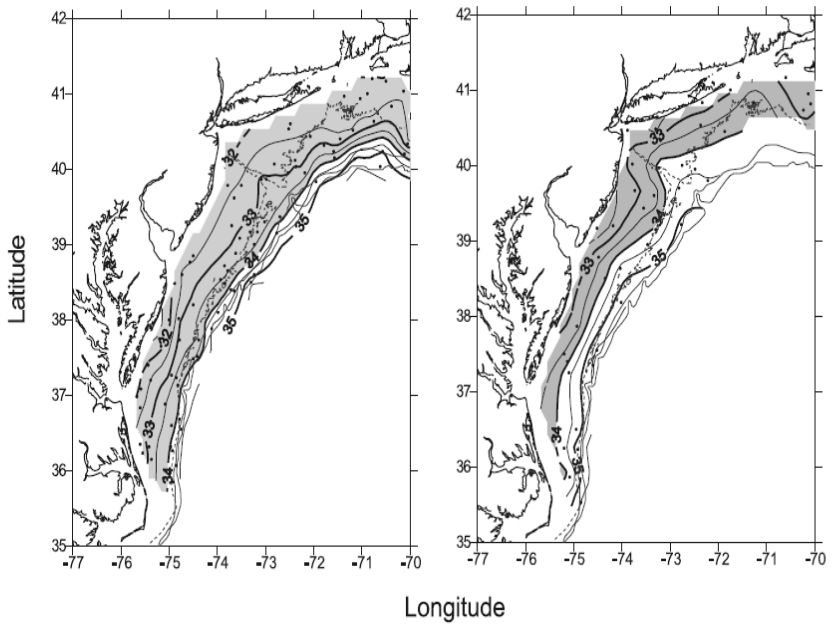
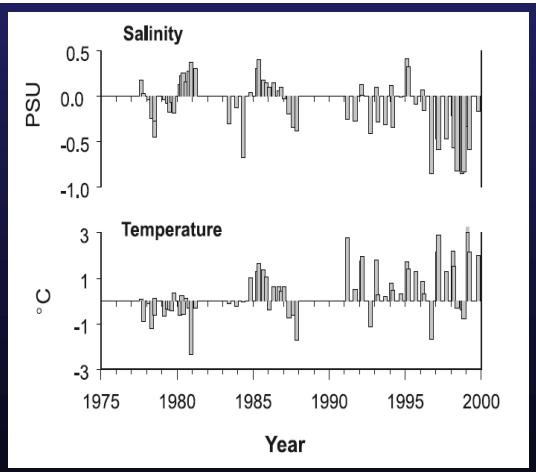


Figure 7. Bottom salinity distribution during (a) February 1993 and (b) February 1995.



Mountain JGR 2002

These changes could not be explained by increases in precipitation

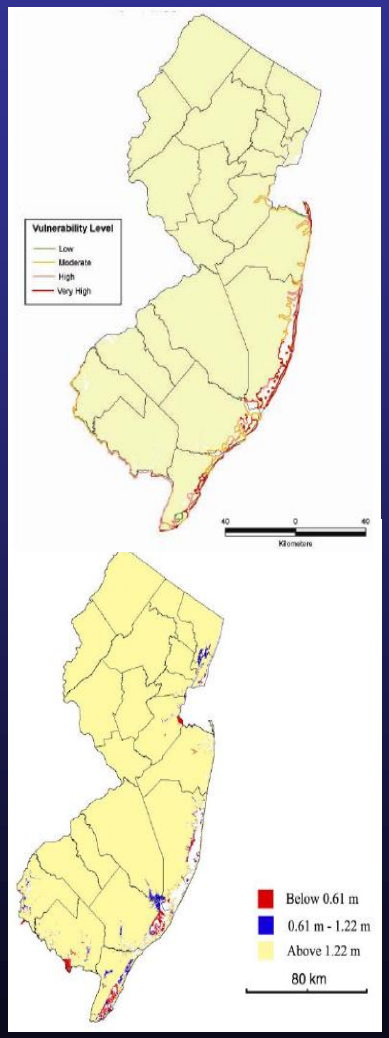
Variability in Shelf waters during 1990's due largely from transport of Scotian Shelf water and Slope waters.

On Decadal averages the Shelf waters in the 1990's was about 1 degree warmer, 0.25 salinity units fresher

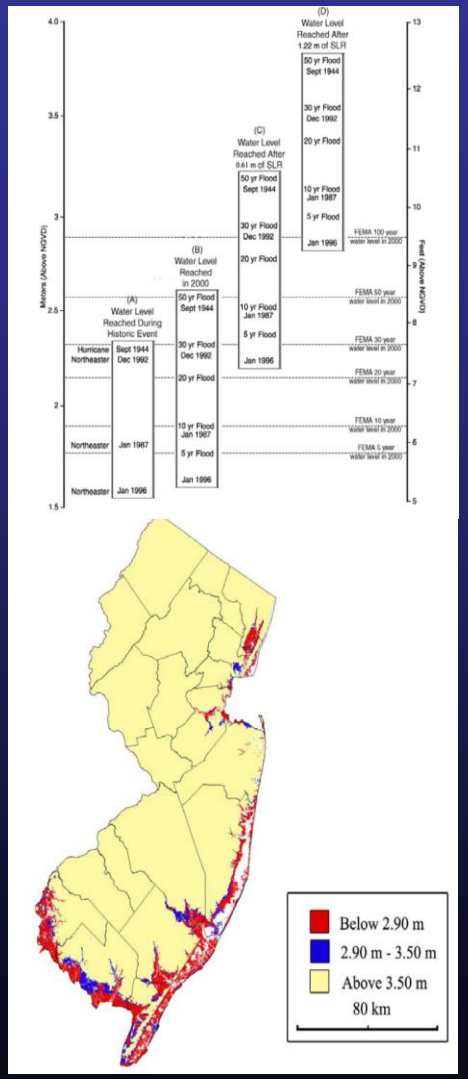
SEA LEVEL

Impact of sea level rise on New Jersey

We will lose some land. Miller talk 1.22 m rise, 3% loss



As sea level rises so does the potential flood impact



	Sea level rise (m)		
	0.61	1.22	2.90
	Area lost (km²)		
Total	171	442	1251
Wetlands	83%	83%	72%
Forest	2%	2%	5%
Beach	3%	3%	5%
Urban	10%	10%	16%
Industrial	1%	1%	2%
Agriculture	0.2%	0.2%	4%

What will be the economic and environmental impacts? What should NJ do?

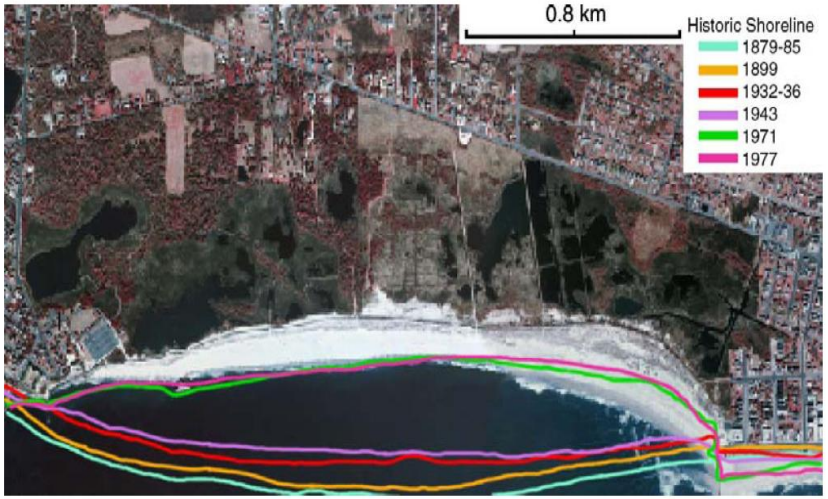
Cooper, Beevers, and Oppenheimer 2005

LAND-USE

GEOGRAPHY: Research focuses on human-environment relations affecting patterns and processes of land-use land-cover change. Monitoring and modeling land transformation, biophysical remote sensing and ecological dynamics of plant invasions.

IMCS: Research focuses on geomorpholgy of NJ and the impacts of land use and accelerated sea level rise.

DAFARE: Rsearch on New Jersey's changing ecology and human political responses in the realm of land use policy. They also look at the connection between energy consumption patterns and settlement patterns.



Cape May Point, New Jersey

Cooper, Beevers, and Oppenheimer 2005

LAND-USE cont.

DAFRE has worked on the economics of carbon sequestration when land use changes from agriculture to forest.

DAFRE is assessing how government research investments and technology policy could lead to sustainable agricultural growth, reduced greenhouse gas production, and poverty reduction. It uses the framework of the global change scenarios based on the findings of the Intergovernment Panel on Climate Change and Millennium Ecosystem Assessment.

DAFRE is working on documenting the reductions in greenhouse gases and resulting climate change benefits from diverting food waste away from the landfill. Also it is working with a statewide initiative to have mayors sign on to the Climate Protection Agreement.

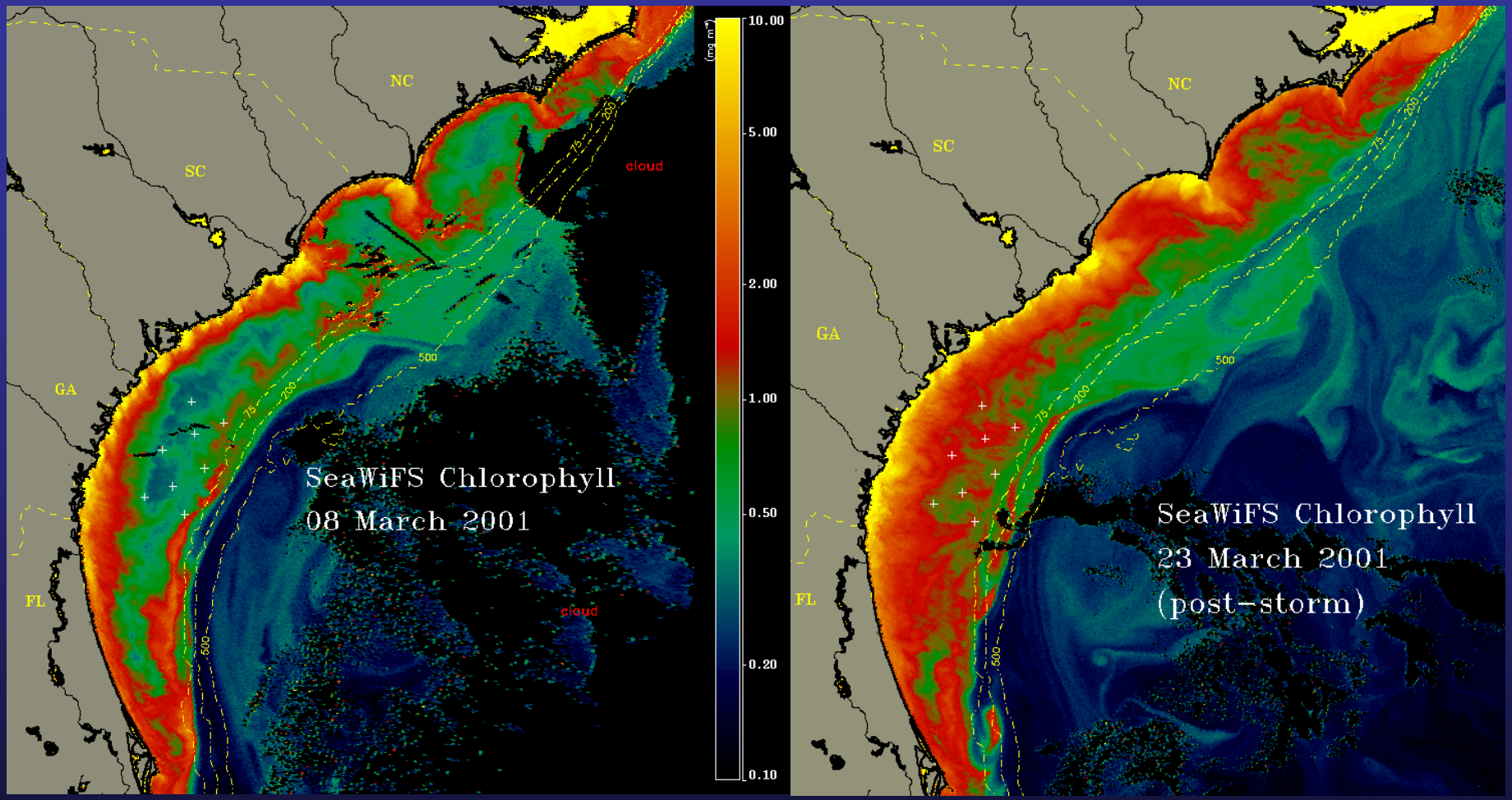
DAFRE has conducted research on a number of research projects looking at the economics of waste management – leaf composting, food waste – and land use policies such as the Pine Lands conservation project which provide ecosystem services.

EXTREME EVENTS

A GLOBAL RESPONSE THAT HAS VERY SIGNIFICANT LOCAL EFFECTS

CLIMATE AND WEATHER: EXTREME EVENTS

Improve storm model intensity models by measuring in the events. Measure impact on marine ecosystem


NC
SC
GA
FL
cloud
cloud
SeaWiFS Chlorophyll
08 March 2001
(mg m⁻³)
10.00
5.00
2.00
1.00
0.50
0.20
0.10
SeaWiFS Chlorophyll
23 March 2001
(post-storm)

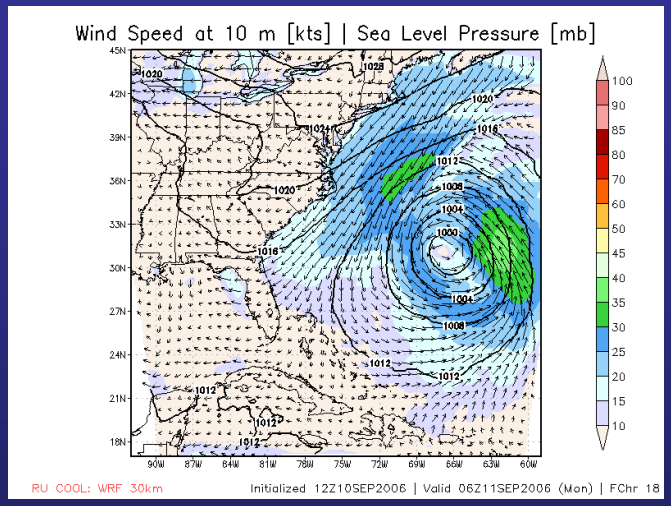
EXTREME WEATHER

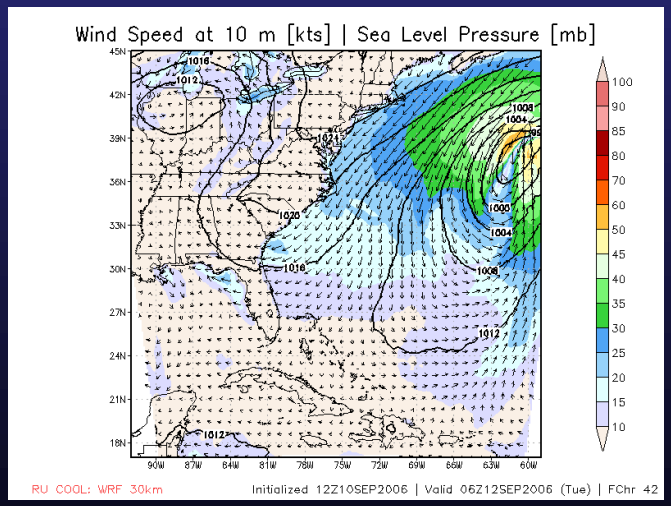
FORECASTING

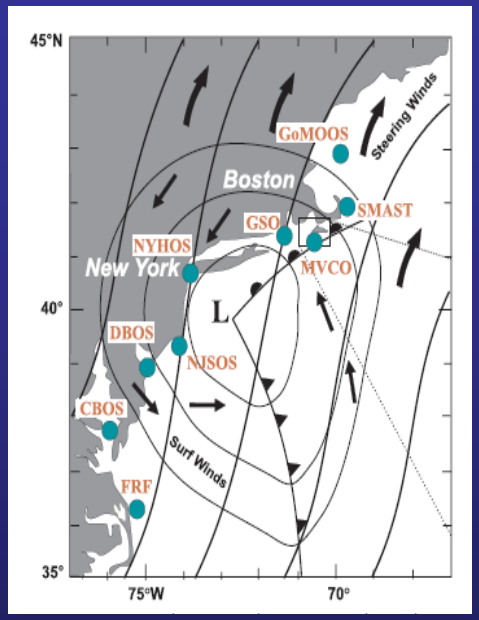
ATM-OCEAN INTERCATIONS

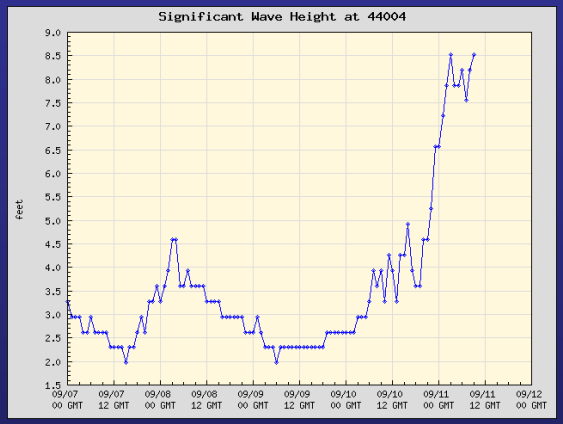
OCEAN RESPONSE

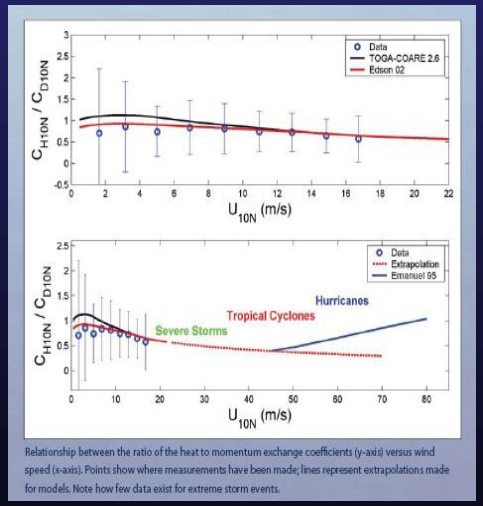
FLORENCE SEPT. 11 2006

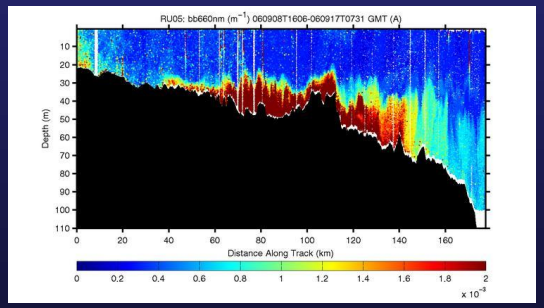










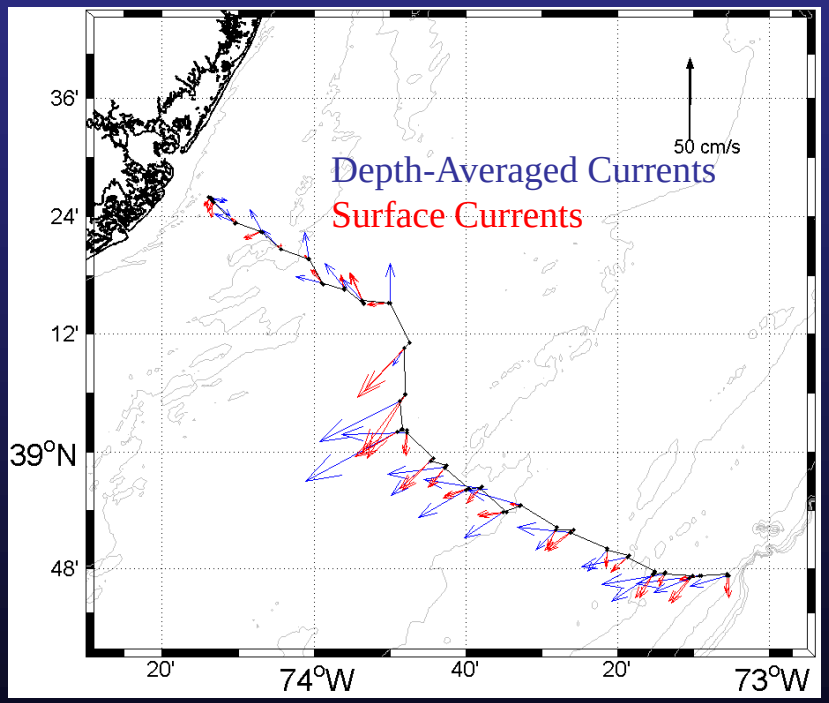


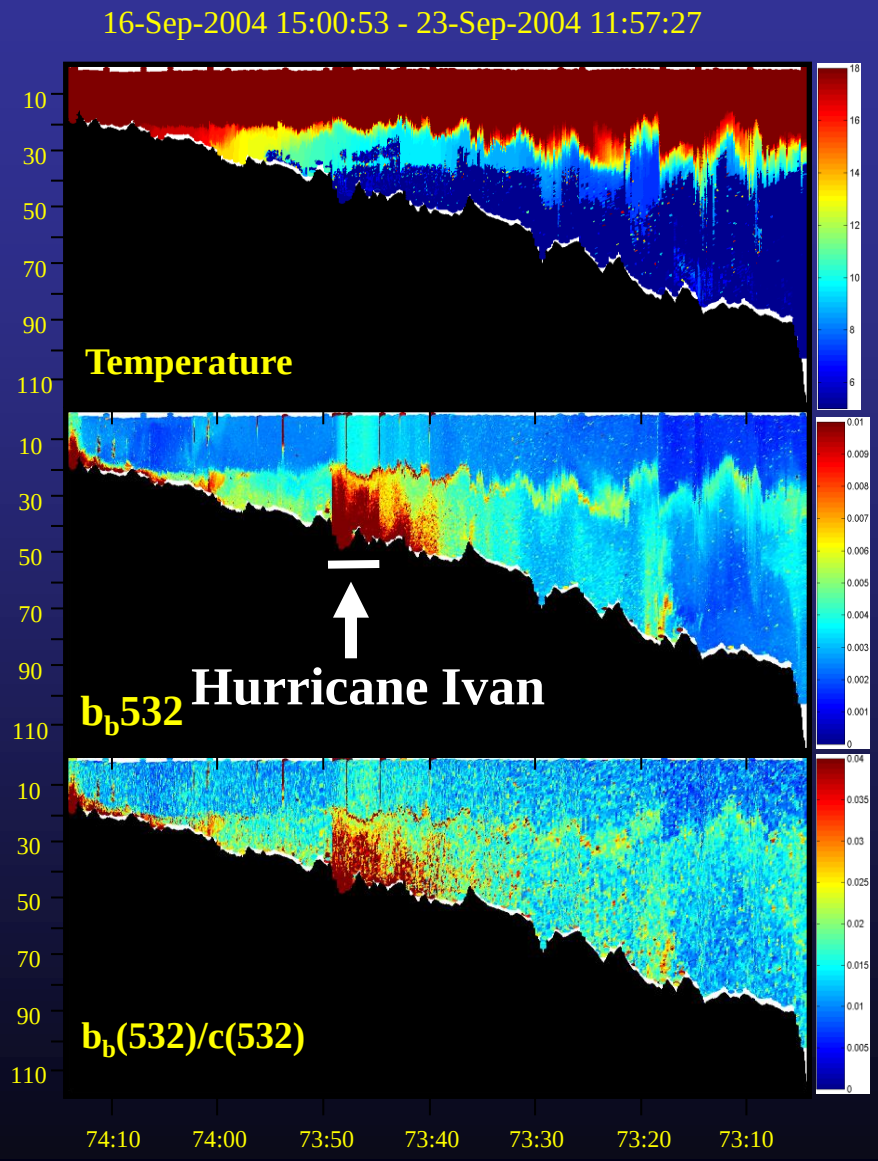
Atmospheric and marine sciences

IMCS

CLIMATE AND WEATHER: EXTREME EVENTS

Improve storm model intensity models by measuring in the events. Measure impact on marine ecosystem

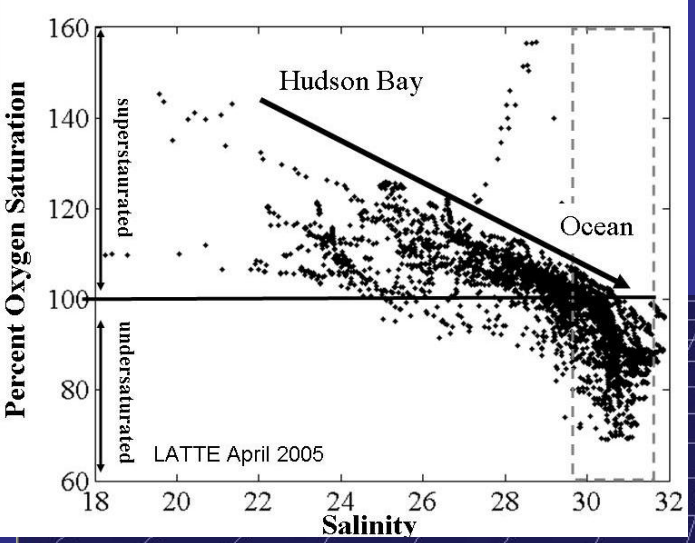




EXTREME WEATHER cont.

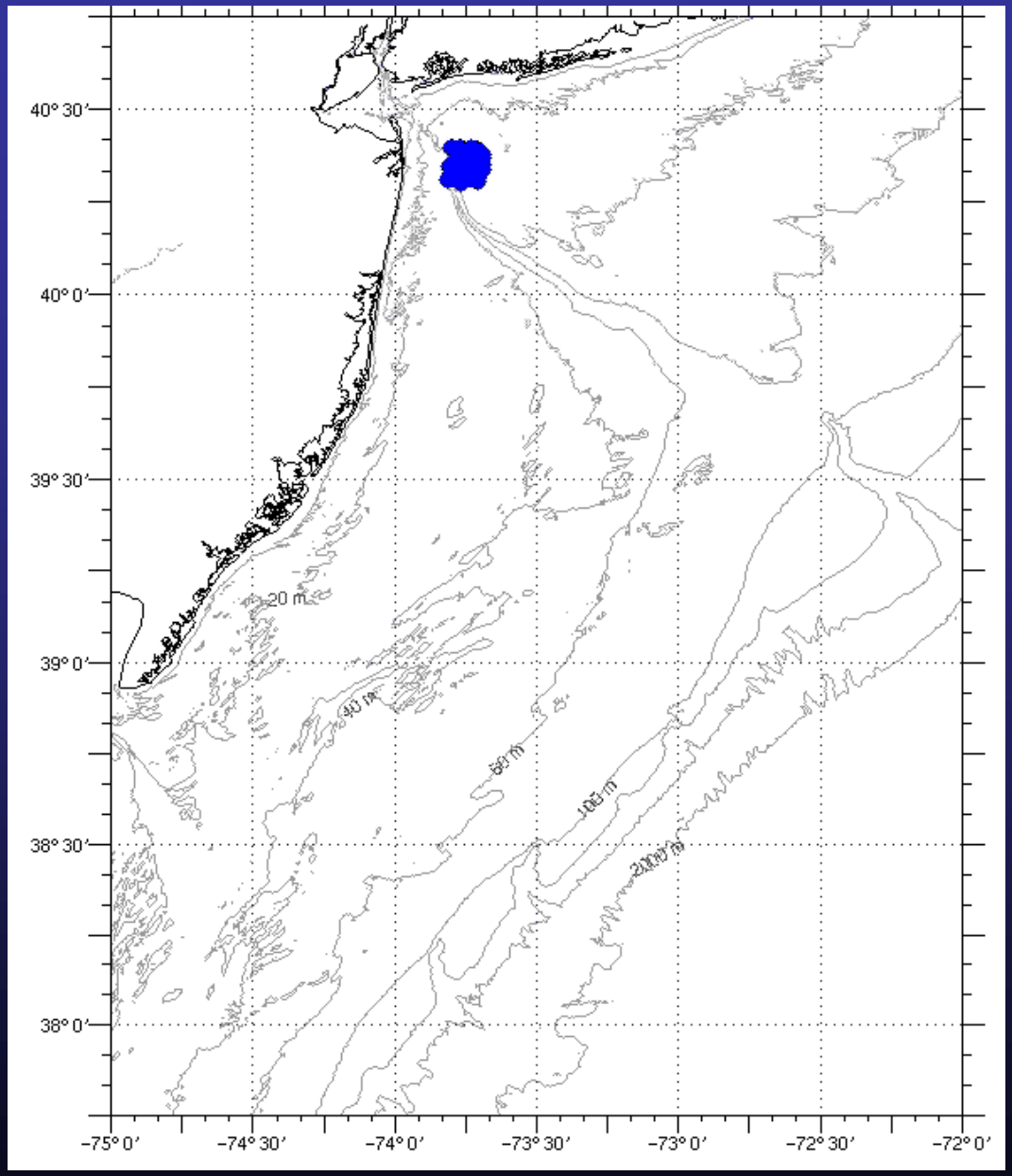
Department of Geography: Research examines human responses to environmental hazards, particularly naturally occurring events that impact mega cities.

Department Ecology and Evolution: Looking at storm surge retreat zones have been mapped and areas where coastal development is vulnerable to estimated storm surge.



Geography studies hydrology and water resources in urbanizing watersheds.

IMCS and Envir. studies the physics of outflow and implications for biology and chemistry


40° 30′
40° 0′
39° 30′
39° 0′
38° 30′
38° 0′
−75° 0′
−74° 30′
−74° 0′
−73° 30′
−73° 0′
−72° 30′
−72° 0′
20 m
40 m
60 m
100 m
200 m

RUTGERS MARINE & COASTAL SCIENCES

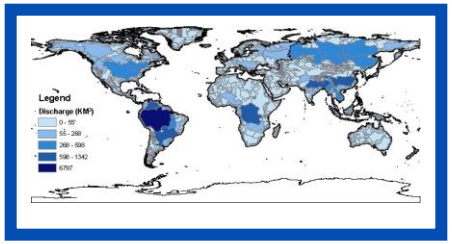
GLOBAL NEWS

Spatially Explicit Global Models Of Nutrient Export To Coastal Systems

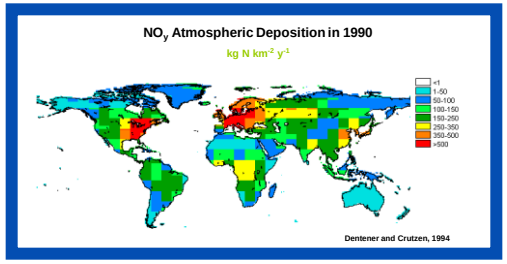
BIOGEOCHEMISTRY
LAND OCEAN ATMOSPHERE

Sybil Seitzinger
John Harrison (Post-doc)

MODEL INPUTS

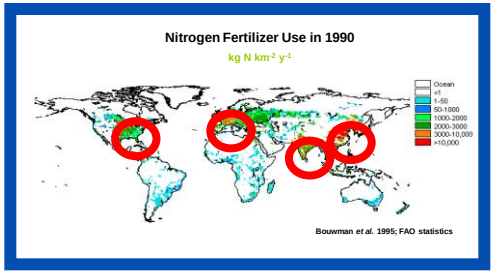


Hydrology



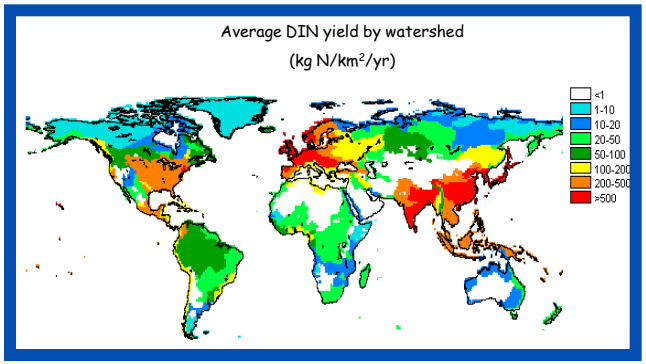
Anthropogenic Activities

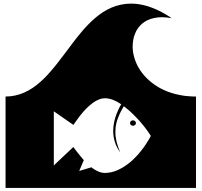
N, P, Si
- dissolved inorganic
- dissolved organic
- particulate



OTHER INPUTS:
- **Slope**
- **Soil C:N**
- **P Fertilizer**
- **Human Population**
- **Animal Manure**
- **Etc.**

MODEL OUTPUT





Effects on Coastal Ecosystems

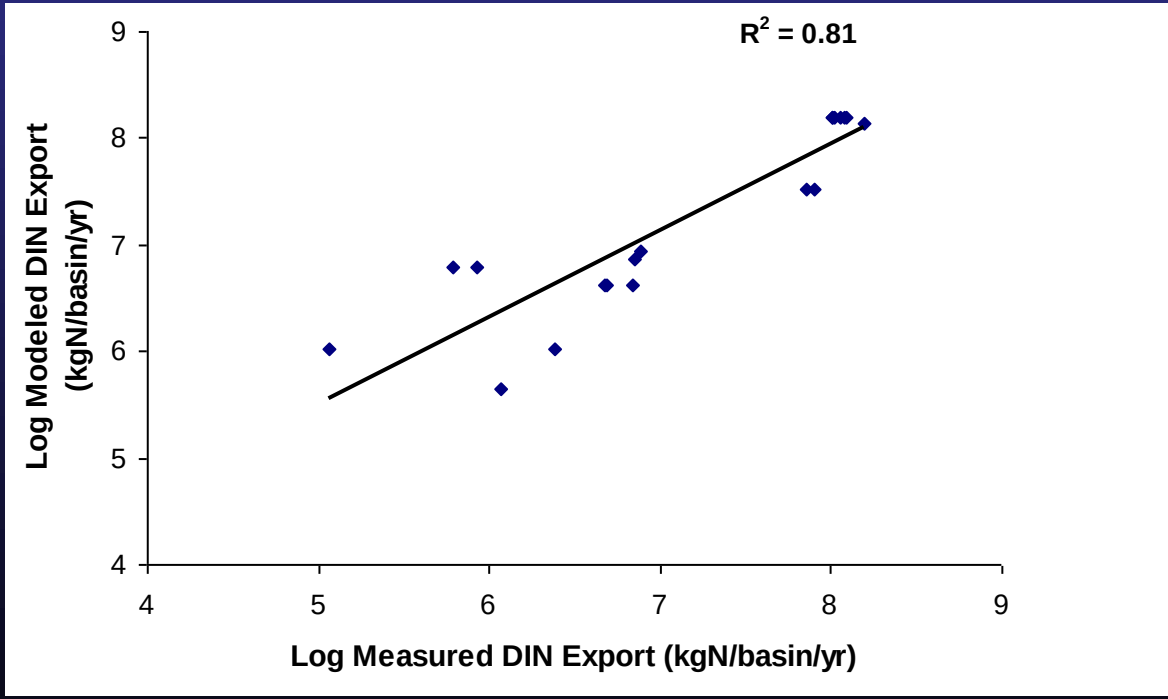
Funding Sources:
UNESCO-IOC
NSF
NOAA
SEAGRANT

Model Calculation of NO_3 Export by Rivers

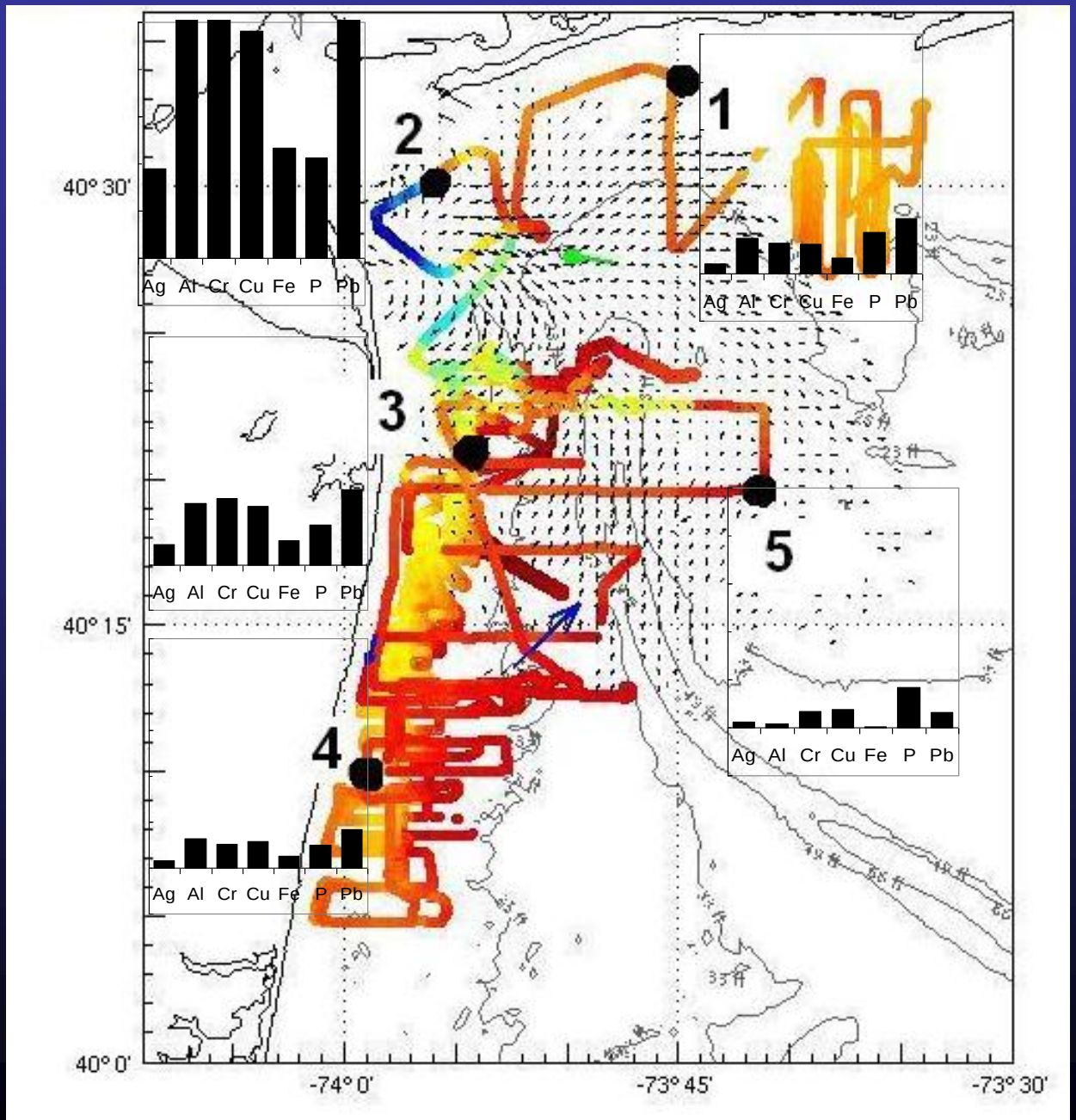
(Modified from Caraco and Cote 1999; Seitzinger and Kroeze 1998)

NO_3 Export = f(Human Sewage , Fertilizer Use, Atmos. Dep.)

[0.4 x Water Runoff $^{0.8}$] x [Fert Use + Atmos. Dep.])

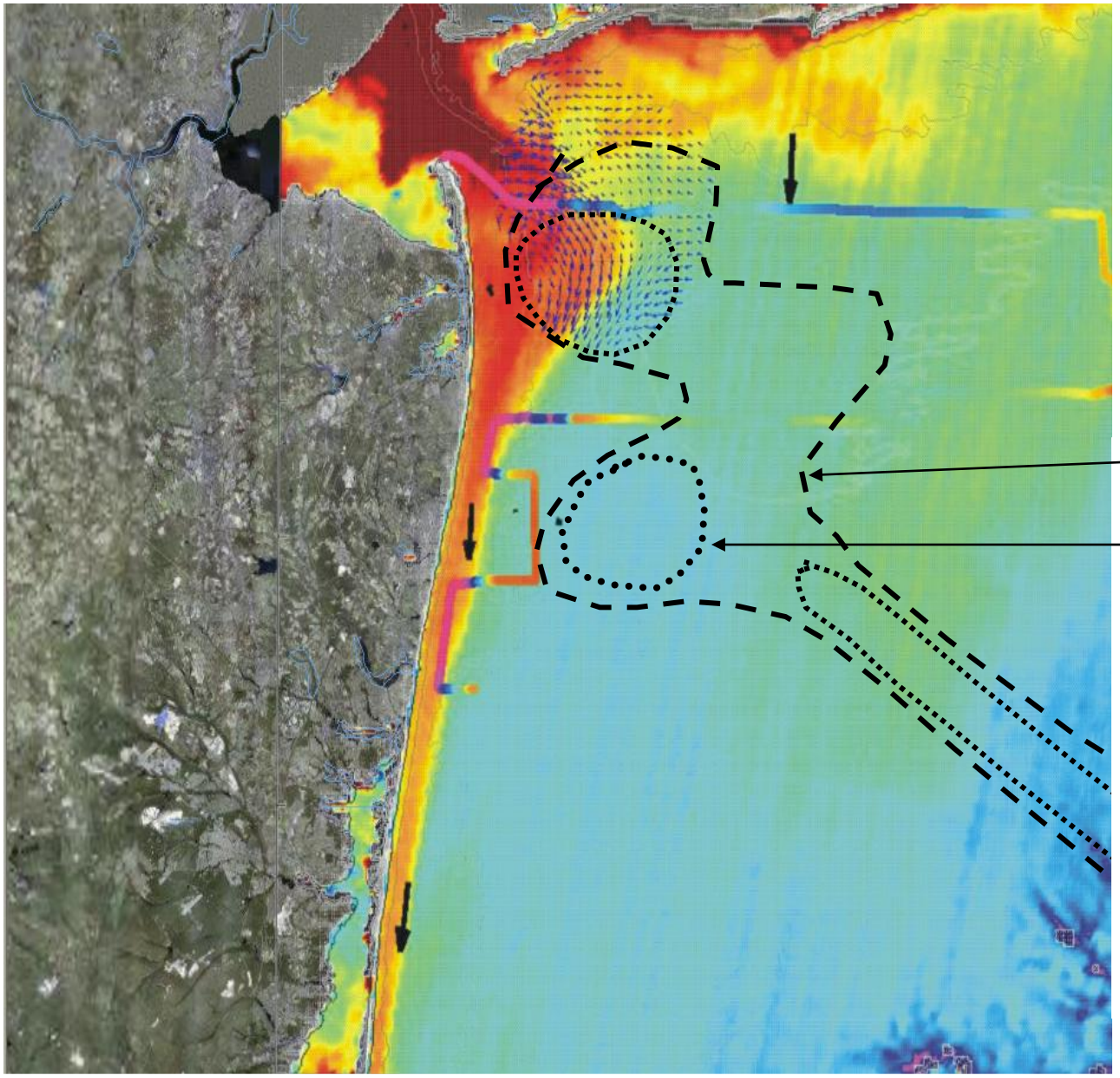


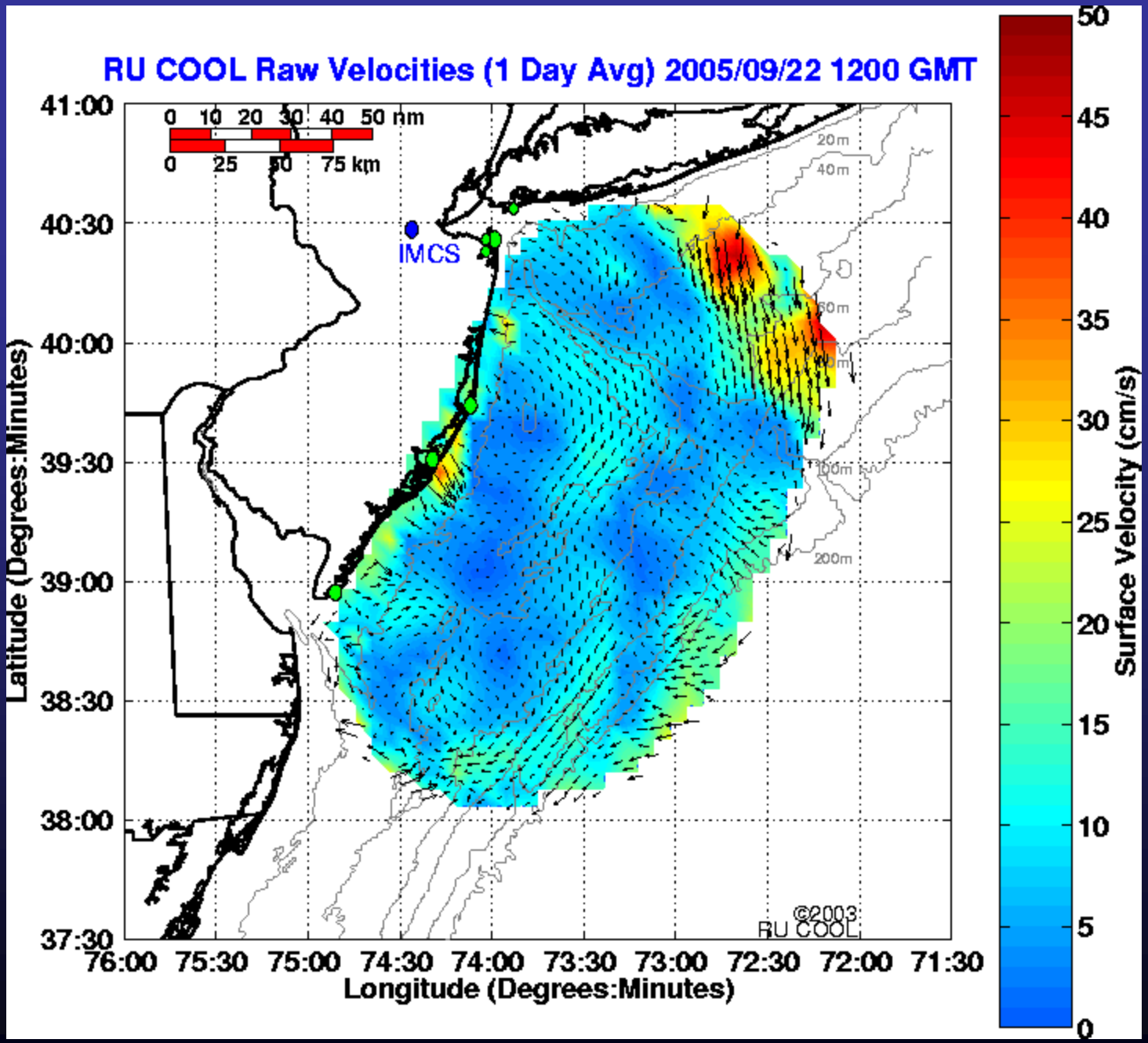
>20 µm particulate trace metals and phosphorus - Ag, Al, Cr, Cu, Fe, P, Pb



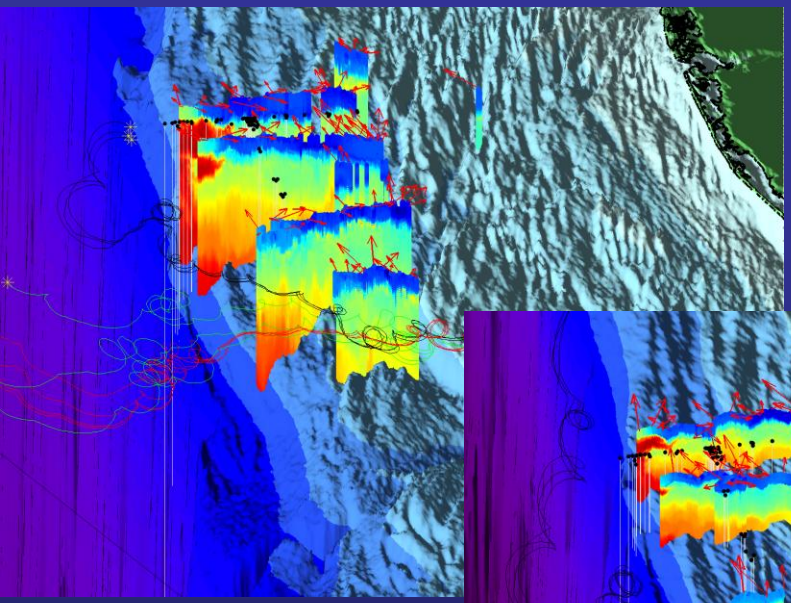
50 ng L^{-1}
(Al, Fe, P µg L^{-1};
Ag x 10, Al x 5, P x 10)

Reinfelder
et al.
Envir. Sci.

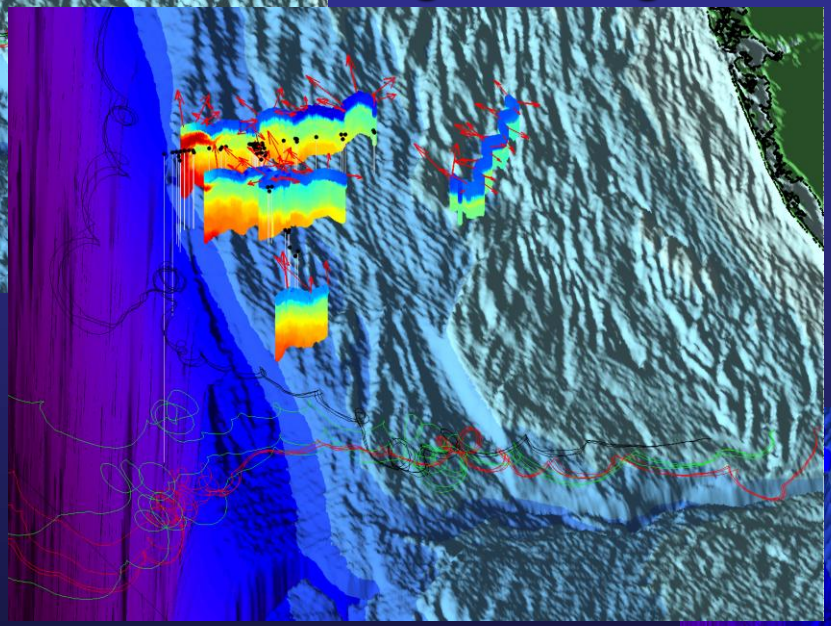

20-30%
80%
% weight of organic carbon in surficial ooze


RU COOL Raw Velocities (1 Day Avg) 2005/09/22 1200 GMT
0 10 20 30 40 50 nm
0 25 50 75 km
IMCS
20m
40m
60m
100m
200m
©2003
RU COOL
41:00
40:30
40:00
39:30
39:00
38:30
38:00
37:30
Latitude (Degrees:Minutes)
76:00 75:30 75:00 74:30 74:00 73:30 73:00 72:30 72:00 71:30
Longitude (Degrees:Minutes)
Surface Velocity (cm/s)
0 5 10 15 20 25 30 35 40 45 50

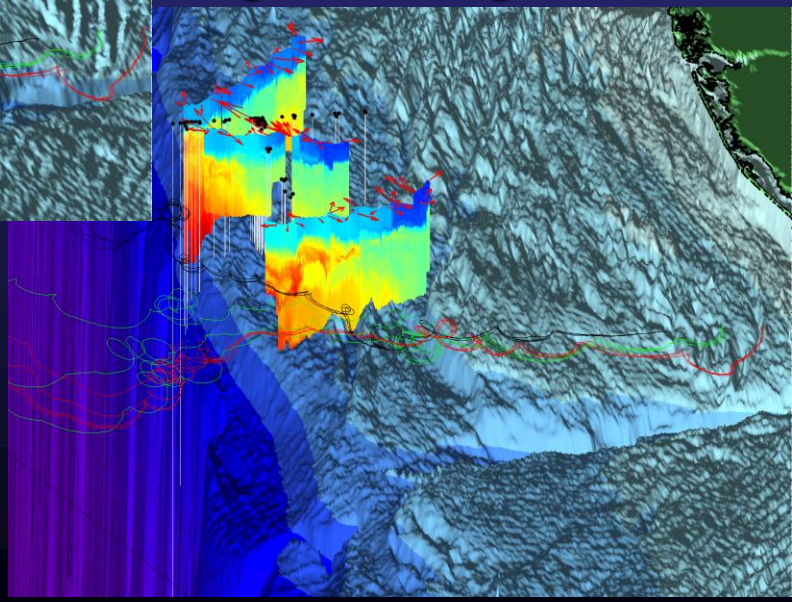
August 6-August 9 2006

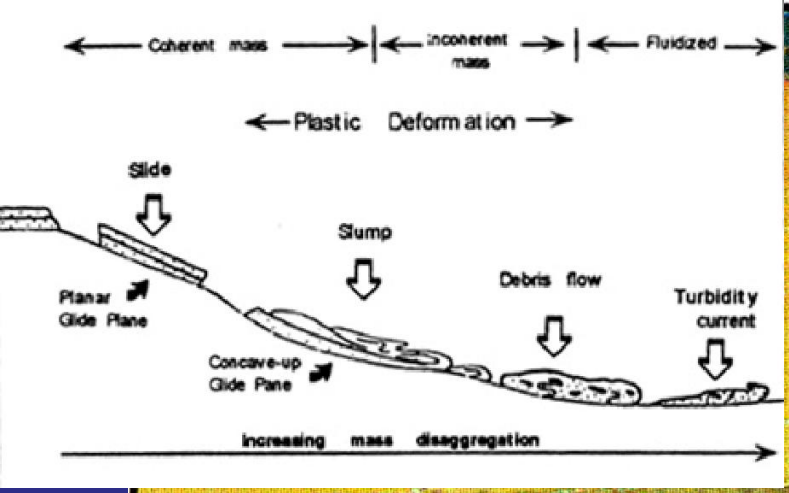


August 9-August 12 2006



August 13-August 16 2006





Hudson Canyon

2002 Multibeam Survey and Proposed Study Area

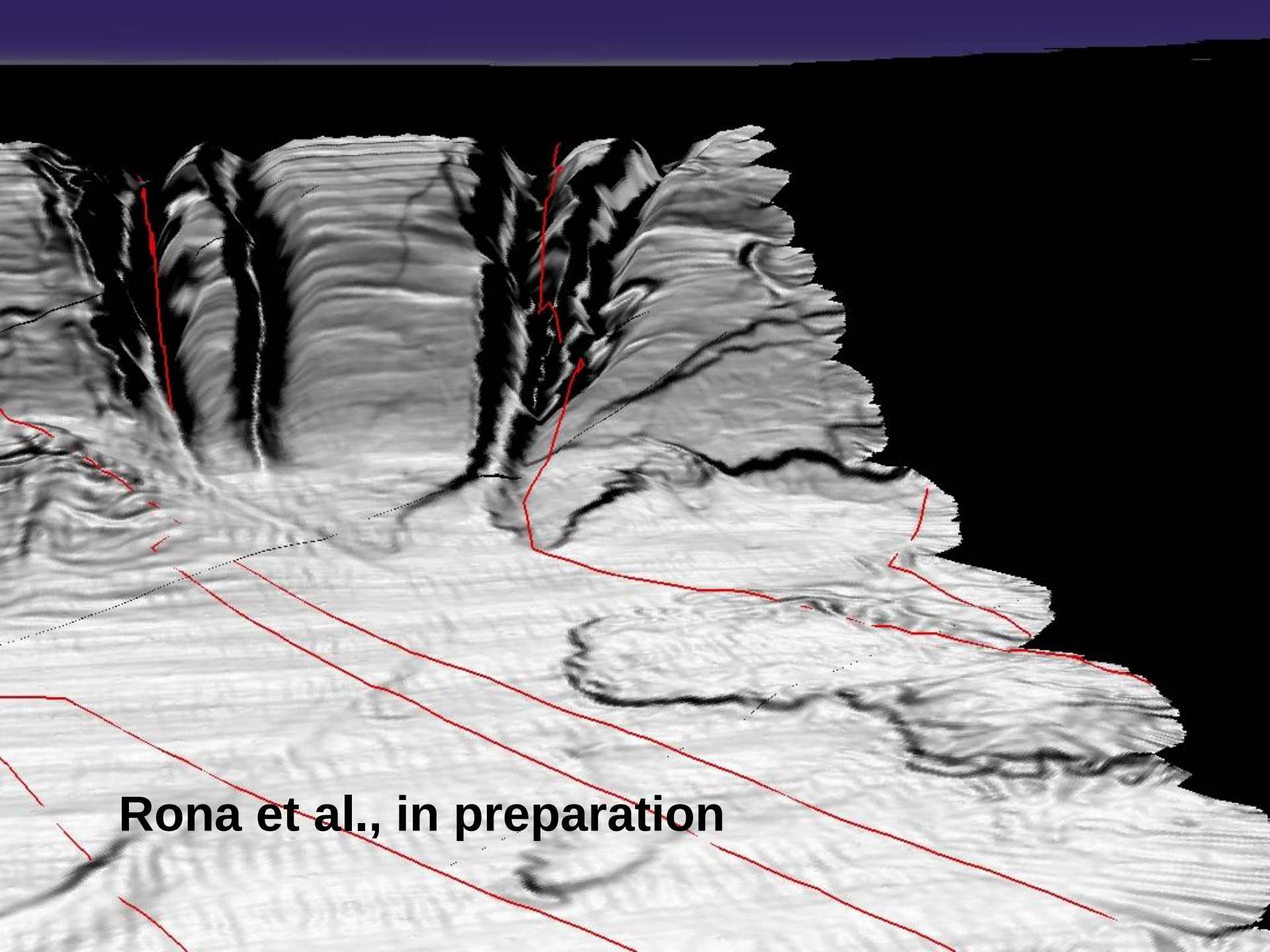
0

-100 m

-500 m

-2000 m

-4000 m


Rona et al., in preparation

Changing biological communities with changing environment

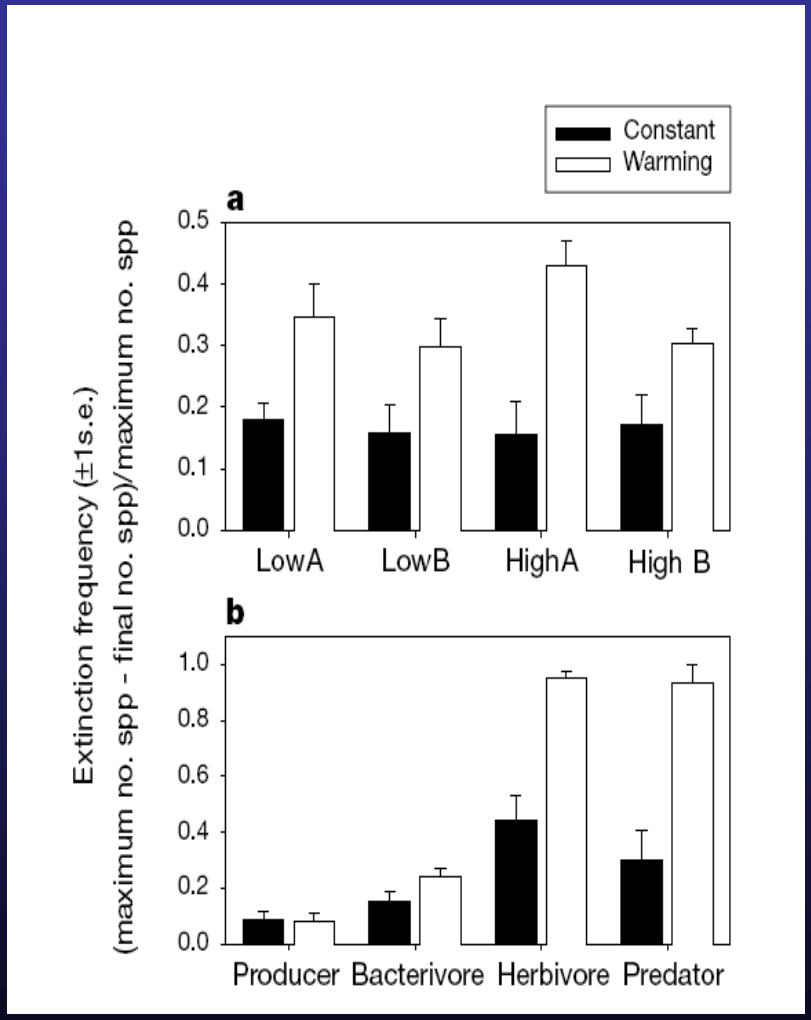
What are the potential impacts of the climate change on coastal ecosystems?

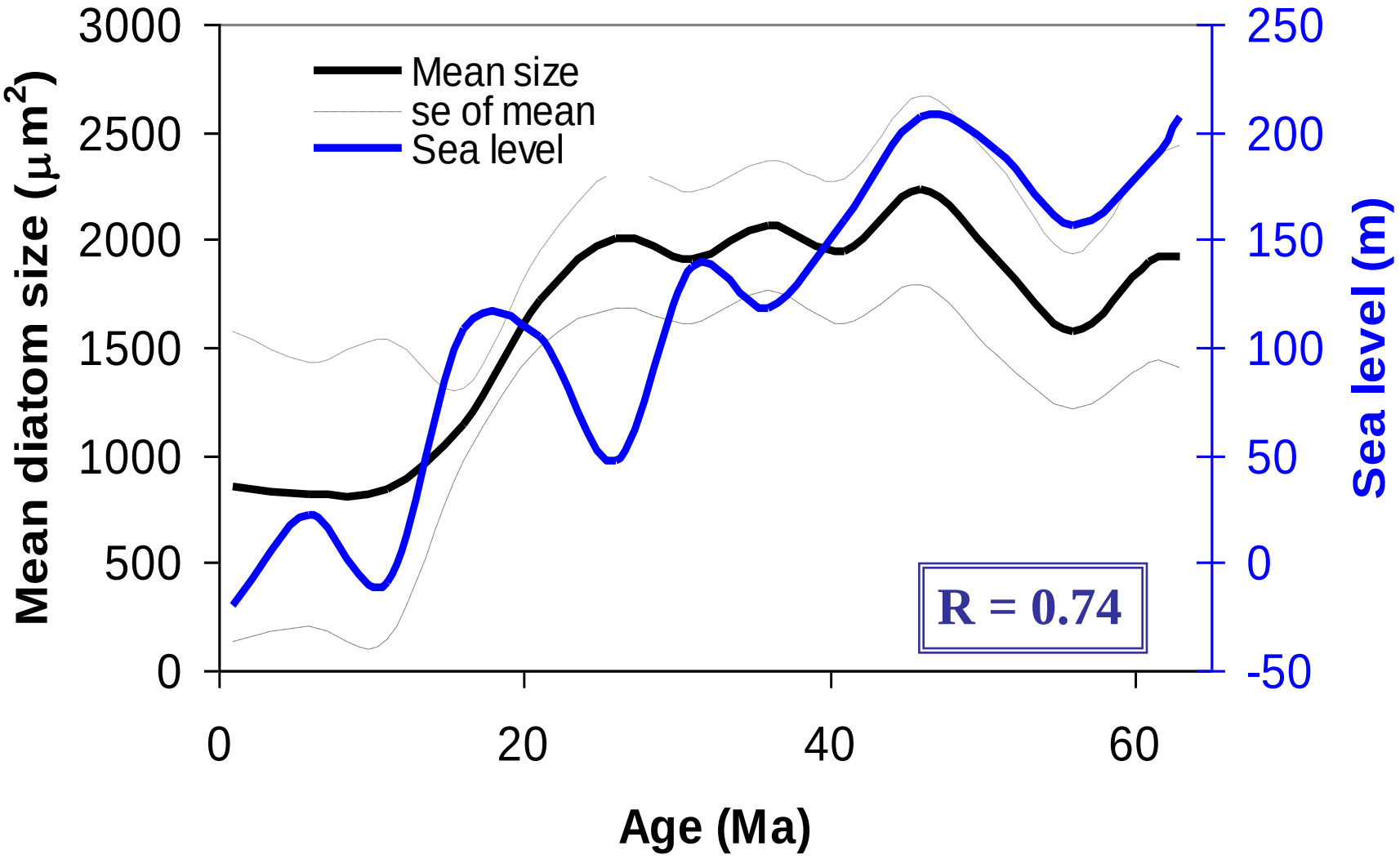
Environmental warming alters food-web structure and ecosystem function

Owen L. Petchey, P. Timon McPhearson, Timothy M. Casey & Peter J. Morin

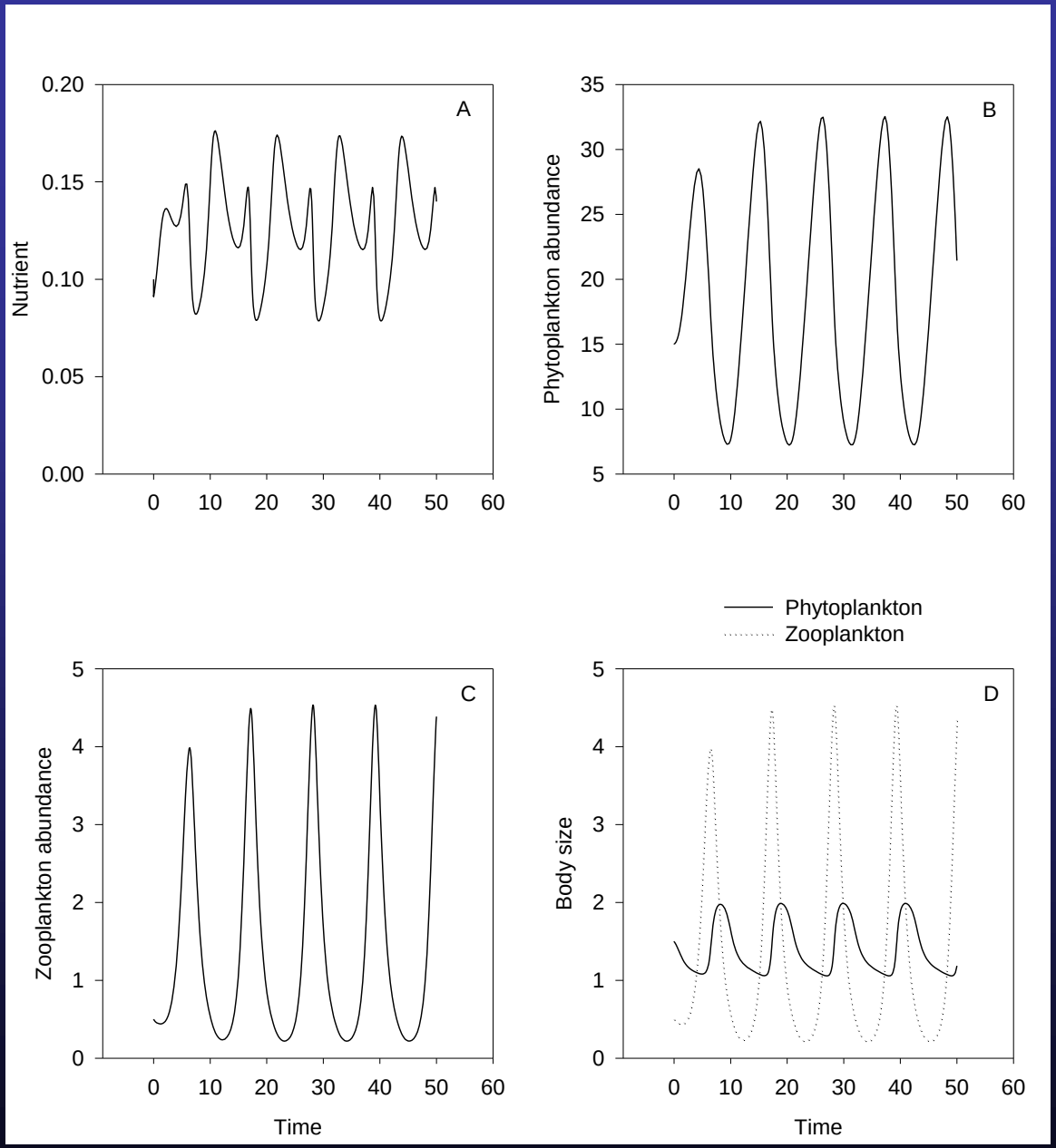
Microcosm studies assessing how changing environments impact the trophodynamics.

Results show the changes in the environment do not impact all trophic levels equally due to numerous feedbacks within food webs. What are the implications for coastal ecosystems?





Finkel, Katz, & Falkowski


A
Nutrient
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
B
Phytoplankton abundance
35
30
25
20
15
10
5
Phytoplankton
Zooplankton
C
Zooplankton abundance
5
4
3
2
1
0
Time
D
Body size
Time

DEENR & IMCS

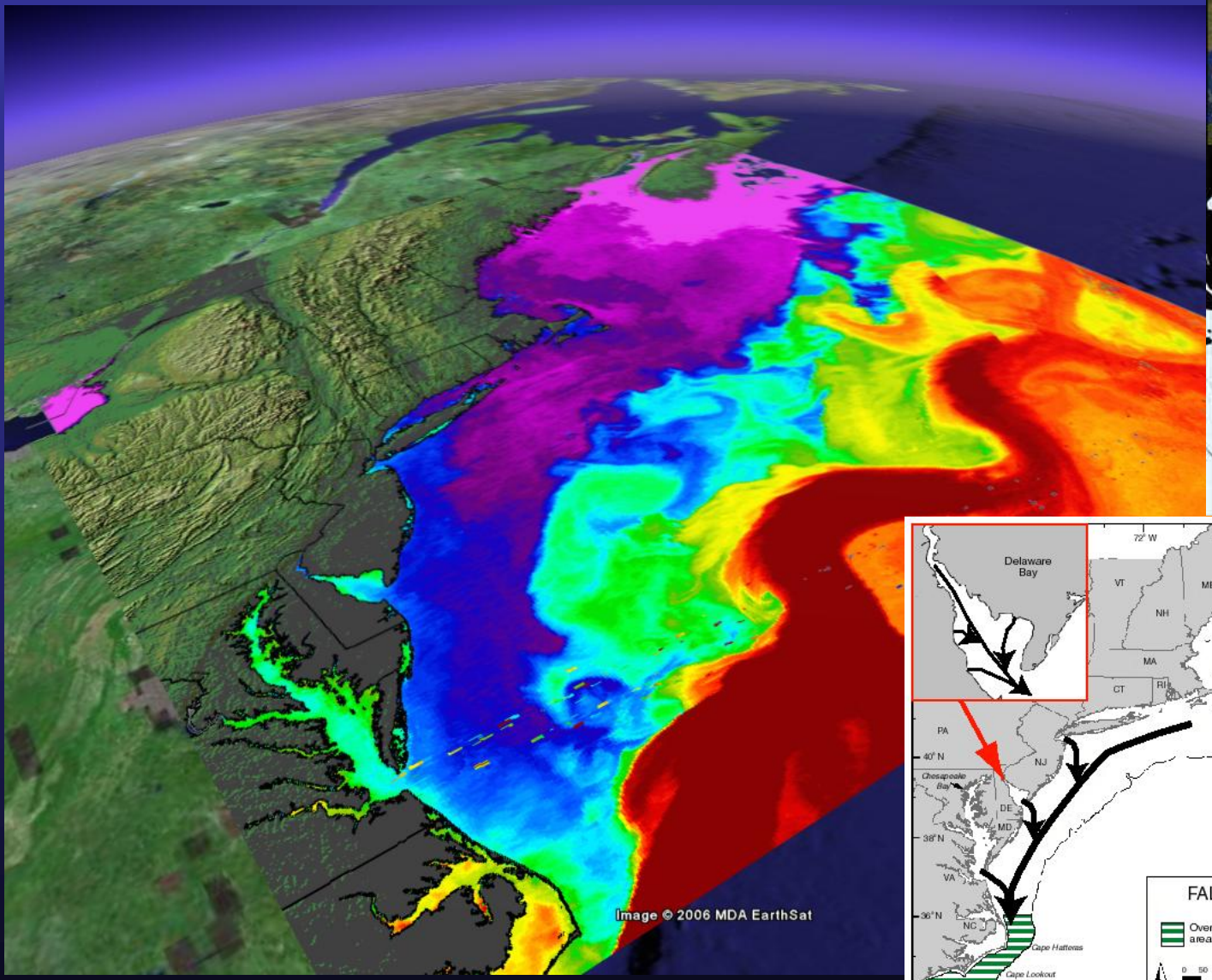
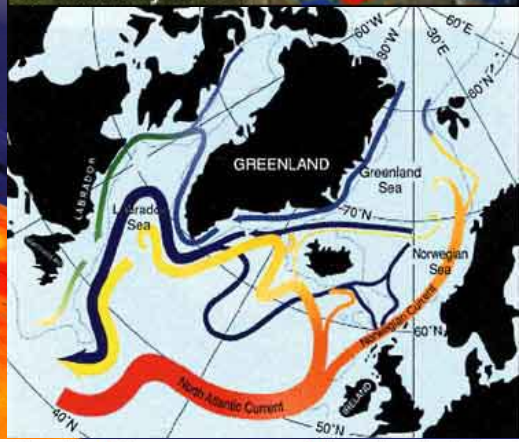
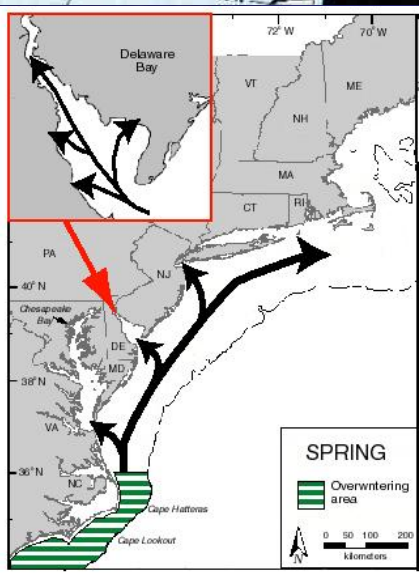


Image © 2006 MDA EarthSat


North Pole
Summer Arctic Sea
Ice Boundary in 1979

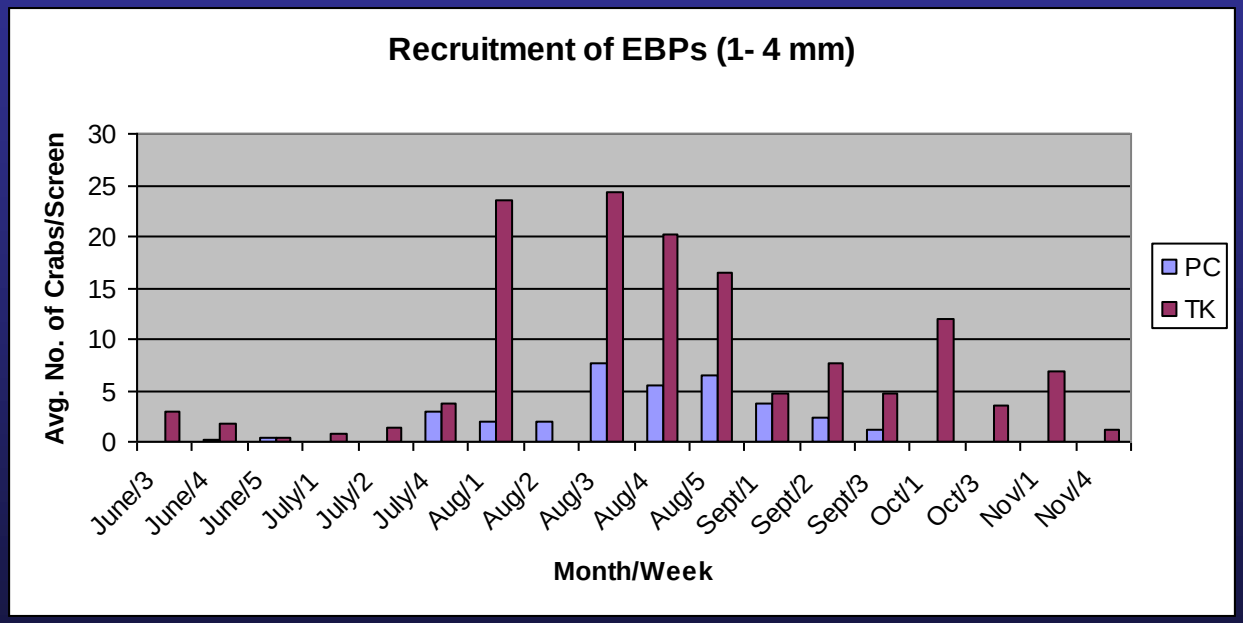

GREENLAND
Greenland Sea
Labrador Sea
Norwegian Sea
North Atlantic Current
60°W
30°W
0°
30°E
60°E
70°N
60°N
50°N
40°N

Delaware Bay
72° W
70° W
VT
ME
NH
MA
CT
RI
PA
NJ
40° N
Chesapeake Bay
DE
MD
38° N
VA
36° N
NC
Cape Hatteras
Cape Lookout
FALL
Overwintering area
0 50 100 200
kilometers

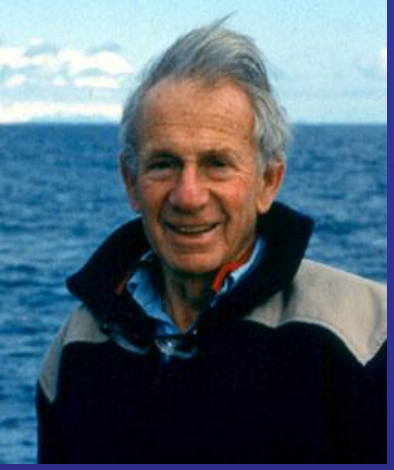

Delaware Bay
72° W
70° W
VT
ME
NH
MA
CT
RI
PA
NJ
40° N
Chesapeake Bay
DE
MD
38° N
VA
36° N
NC
Cape Hatteras
Cape Lookout
SPRING
Overwintering area
0 50 100 200
kilometers

Impacts on the NJ Fauna?

Recruitment impact of Fiddler crabs: Warming trends may impact the breeding season



Lauren L. Bergey and Judith S. Weis



Walter Munk, SIO

A Look Back

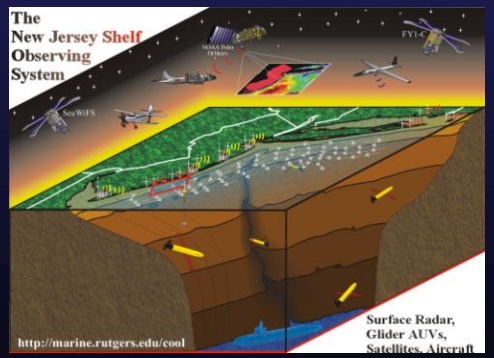
"If I were to choose a single phrase to characterize the first century of modern oceanography, it would be a century of under-sampling."

Walter Munk, 2000

A Look Forward

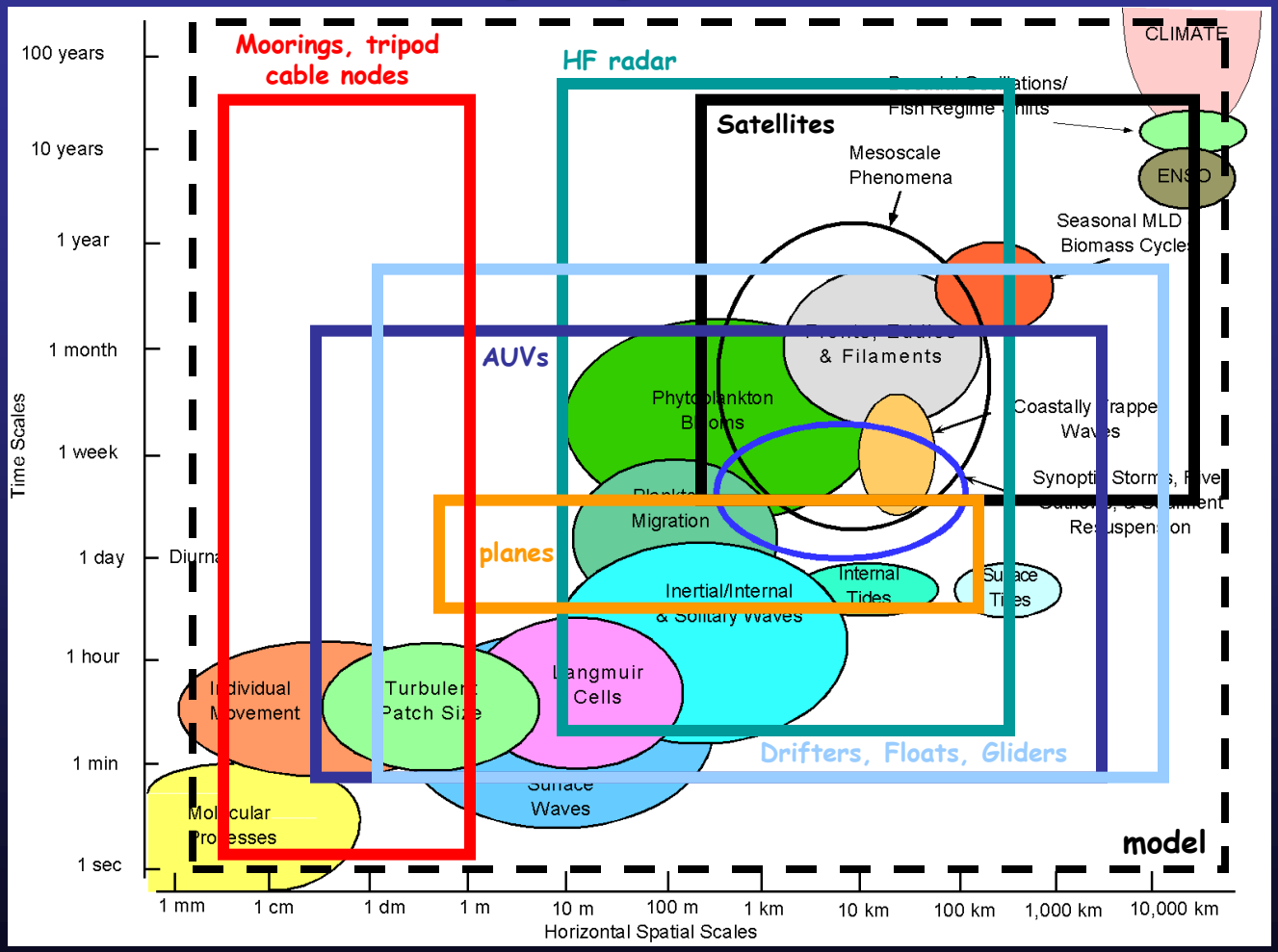
Technology is Enabling Scientists to Improve The View

1	Satellites in Space (Beginning in 1980's)
+1	+ In the Field Arrays (Now!)
----	----------
3	Well Sampled Environment



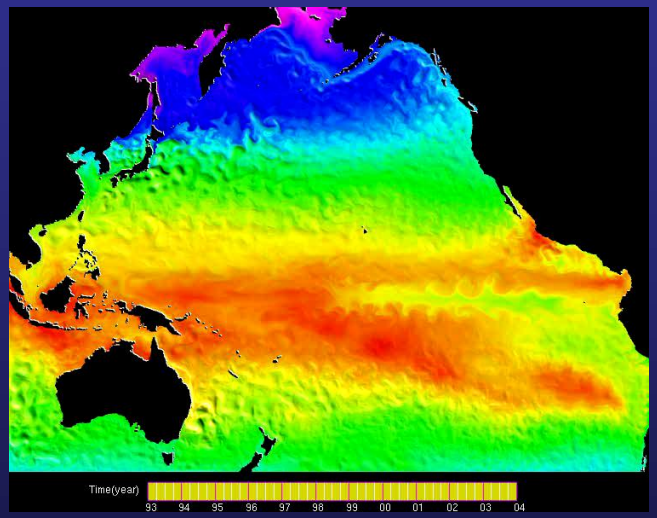
Walter Munk, 2000. Oceanography Before, and After, the Advent of Satellites.

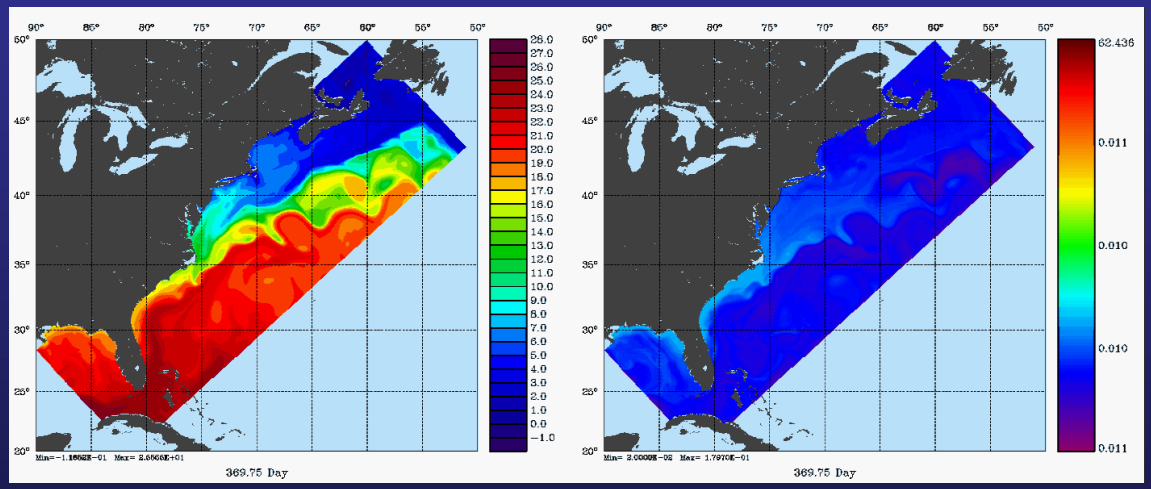
The coastal ecosystem is nonlinear, so the evolution of a processes at any one scale is dependent on all other scales. Given this, how does the physics select for the individual organisms? Given a specific ecosystem response, how does it feedback on the physics over geologic time?



This figure does not even adequately address the important role of episodic events

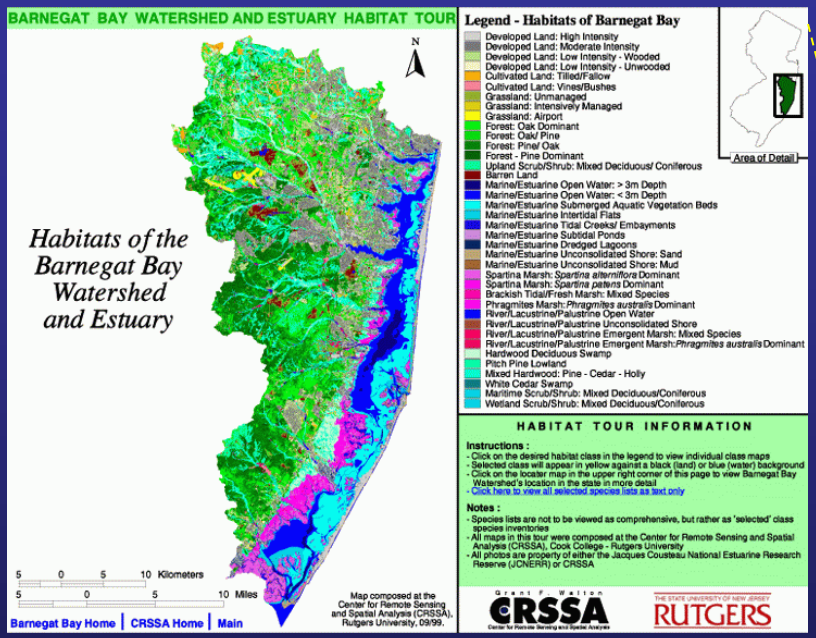
AT RUTGERS WE HAVE MODELS

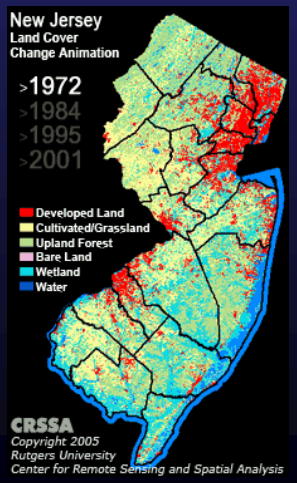


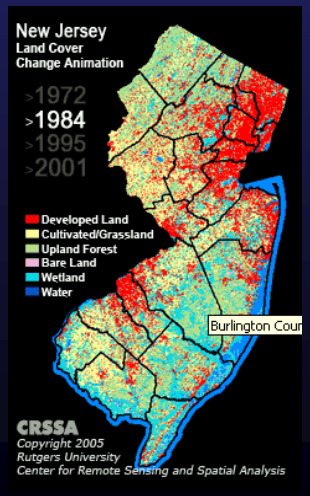


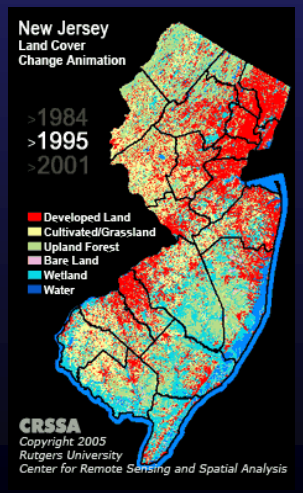
Thanks to Dale Haidvogel, John Wilkin, and Enrique Curchitser

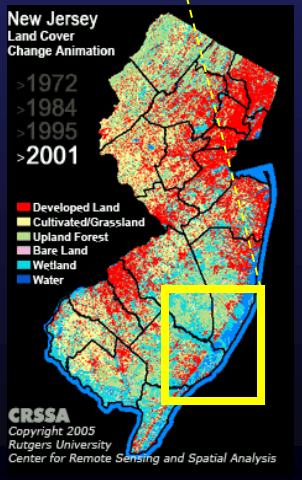
Observing the changing landscape Terrestrial Systems





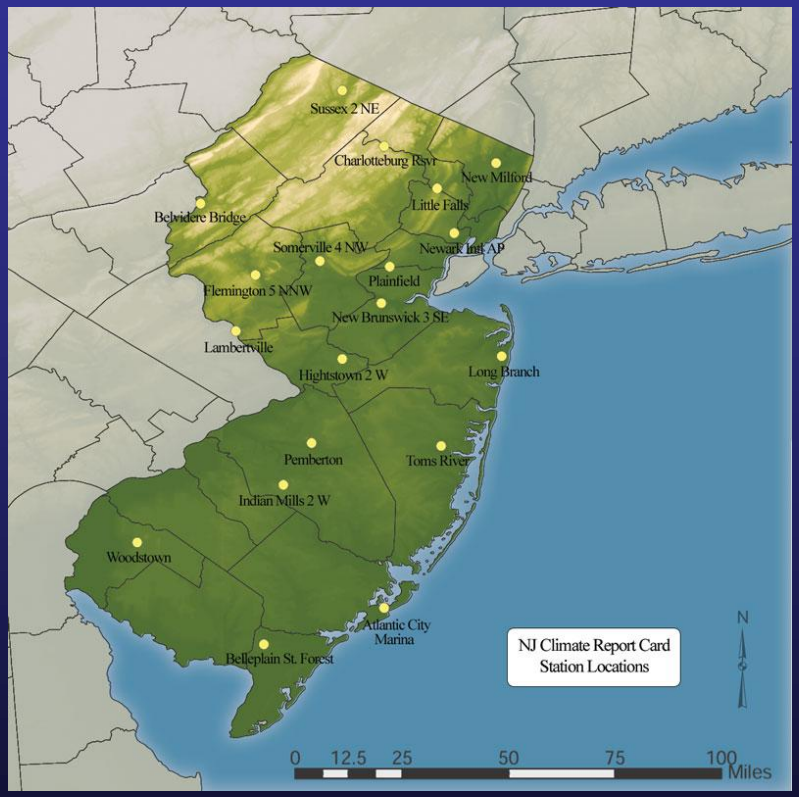


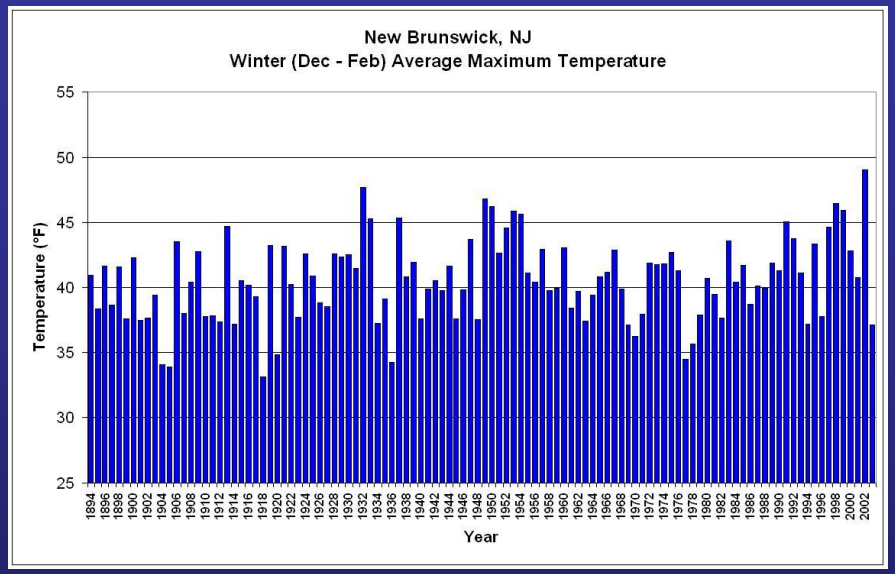


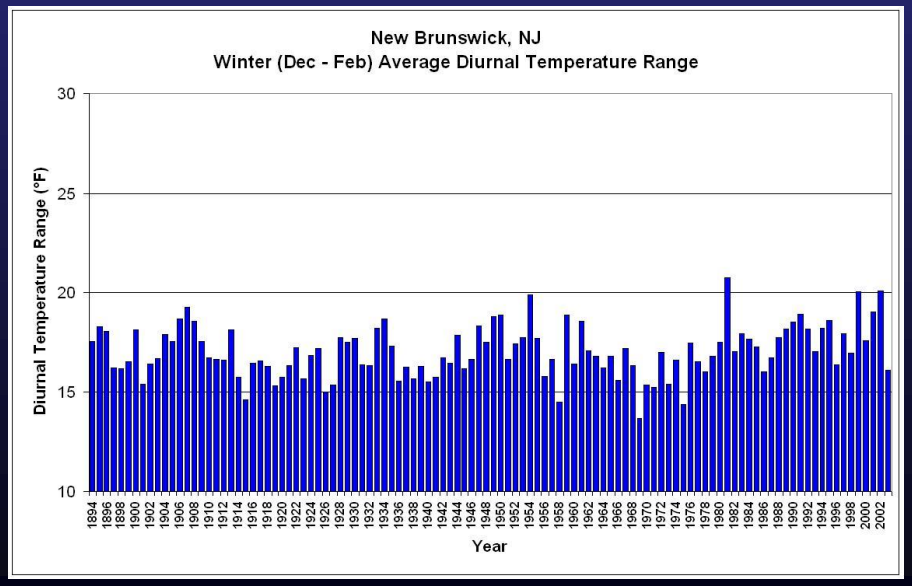


ONJSC
at Rutgers University
Office of the New Jersey State Climatologist · Rutgers University · 54 Joyce Kilmer Avenue · Lucy Stone Hall B224 · Piscataway, NJ 08854

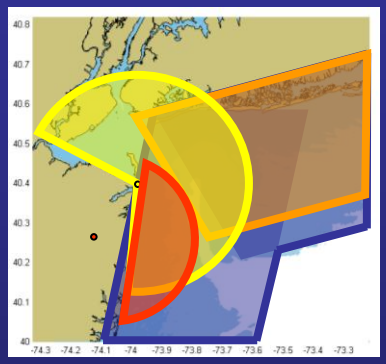
OBSERVATIONS RESOURCES AT RUTGERS







OBSERVATIONS RESOURCES AT RUTGERS



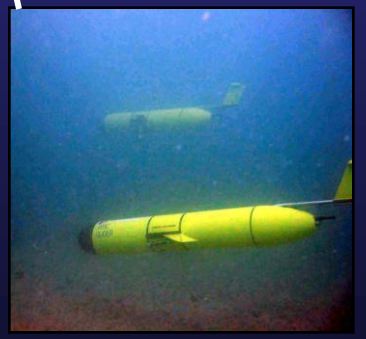
Ship-to-Shore Communications

CODAR Network

L-Band

X-Band

Cable



Glider Fleet

Mission: Sustained Operations of Key Observing Technologies for Scientific Research, Technology Development, Education and Outreach

Given that change is coming how will Rutgers help NJ to adjust and thrive in the coming landscape?

Will NJ be the top of the economic food chain?

Or……

ENERGY POLICY

DAFRE working on connections between New Jersey's changing ecology and human political responses in the realm of land use policy. It looks at the connection between energy consumption patterns and settlement patterns. Does low density suburban living involve high levels of energy consumption?

IMCS is studying sea breezes and the potential energy that might be harvested.

Rutgers et al. lead by Falkowski et al., what will be the fuels of the future?



Plant, Animal, Microbe & Food Systems

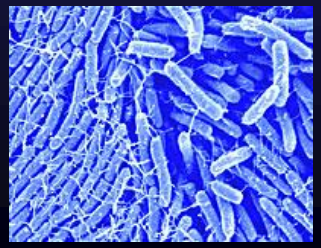
How Will NJ profit and create jobs given projected changes? What might the agriculture products that NJ should produce given the projected landscape and climate changes (drought and/or coastal inundation)? Which products will be profitable given demographic projected changes in NJ? How might economic crops within NJ be protected?

Department of Agricultural, Food & Resource Economics *Support society's agricultural, agribusiness, food, environmental and natural resource needs for economic analysis through an integrated program of teaching, research and outreach activities designed to improve the quality of public and private decisions.*

animal sciences

The research mission of the Department of Animal Sciences is to develop and enhance excellence in basic and applied research in focused areas within Animal Science.

Plant biology and Pathology building and supporting sustainable plant industries in New Jersey and is seeking to have positive transformative impacts locally, nationally, and internationally in areas of Plant Agriculture, Biotechnology, Horticulture, and basic Plant Biology and Pathology.



Microbial Prospecting microorganisms represent the largest pool of untapped genetic and biochemical diversity on Earth. Less than 0.1 per cent of all microbes are currently in cultivation. Thus, the potential for discovery of new biochemical pathways, new genetic capabilities, and new enzymes is tremendous.

Agriculture & Food Systems cont.

Given analysis, how will Rutgers NJ prepare for the prospective changes?

Optimizing traditional NJ agriculture products

Equine Science Center
Boosting Return on Investment in the Shellfish Industry
Cranberry Health
Center for Turfgrass Science
Sustainable Agriculture
Integrated Pest Management (IPM)

New products for the changing landscape in NJ

Phytomedics, Inc.
The New Use Agriculture and Natural Products Program (NUANPP)
WellGen, Inc.