What Lies Beneath – Barnegat Bay

2015 BARNEGAT BAY RESEARCH FORUM

OCEAN COUNTY COLLEGE

Kean Ocean Gateway Building, Lecture Hall Room 104

Tuesday, November 17, 2015

9:00 a.m. – 3:30 p.m.

Sponsors: Barnegat Bay Partnership and New Jersey Department of Environmental Protection

AGENDA

Check-in:	Registration	8:30
Welcome:	Stan Hales, Director, BBP	9:00
Welcome:	Gary Buchanan, NJDEP Director DSREH	9:05
Meeting Goals and Org.:	Thomas Belton, NJDEP Barnegat Bay Research Coordinator	9:10

I. WATER QUALITY MONITORING AND MODELING

- **Water Quality Monitoring and Assessment in Support of Model Development** 9:20
  - *Patricia Ingelido, NJDEP, Bureau of Environmental Analysis, Restoration and Standards (BEARS)*
- **Hydrodynamic and Water-Quality Modeling** 9:35
  - *Helen Pang, NJDEP BEARS*
- **Phosphorus Dynamics in Barnegat Bay Sediments** 9:50
  - *David Velinsky and Bhanu Paudel, Academy of Natural Sciences of Drexel University (ANSD); Nat Weston, Villanova University*
- **Facilitated Discussion and Questions (Bruce Freidman)** 10:05

II. BIOLOGICAL ENDPOINTS SUPPORTING THE DEVELOPMENT OF ESTUARINE NUTRIENT CRITERIA

- **Benthic Invertebrate Community Monitoring and Indicator Development** 10:25
  - *Gary Tagon, Judith P. Grassle, Charlotte M. Fuller, and Rosemarie F. Petrecca, Rutgers University*
- **Diatoms as Environmental Indicators in Barnegat Bay** 10:40
  - *Marina Potapova, Nina Desianti, David Velinsky, Paul Kiry, Linda Zaoudeh, Roger Thomas, Paula Zelanko, ANSD; Mihaela Enache and Thomas Belton, NJDEP*
- **Baseline Characterization of Phytoplankton and Harmful Algal Blooms** 10:55
  - *Ling Ren and Don Charles, ANSD; Thomas Belton and Mihaela Enache, NJDEP*
- **Facilitated Discussion and Questions (Thomas Belton)** 11:10

LUNCH (on your own - view posters) 11:30

III. CHARACTERIZING ENVIRONMENTALLY SENSITIVE AREAS (ESAs)

- **Ecological Evaluation of Sedge Island Marine Conservation Area** 12:30
  - *Paul Jivoff, Rider University*
- **Salt Marsh Nutrient Histories and Ecosystem Services (Denitrification)** 12:45
  - *David Velinsky, ANSD; Tracy Quirk, ANSD and Louisiana State University; Jeff Cornwell and Mike Owens, University of Maryland*
- **Evaluation of Environmentally Sensitive Areas (ESAs) to Water Craft Impacts** 1:00
  - *Richard G. Lathrop Jr., Eden Buenaventura and Edwin Green, Rutgers University*
- **Facilitated Discussion and Questions (Joseph Bilinski)** 1:15

IV. NATURAL RESOURCE ASSESSMENT AND MANAGEMENT (SUSTAINABLE FISHERIES)

- **Hard Clam Survey in Barnegat Bay – Little Egg Harbor Estuary** 1:35
  - *Kira Dacanay, NJDEP Bureau of Shellfisheries*
- **Benthic-Pelagic Coupling: Hard Clams Indicators of Suspended Particulates** 1:50
  - *Monica Bricelj, John Kraeuter and Gef Flimlin, Rutgers*
- **Assessment of the Distribution and Abundance of Stinging Sea Nettles** 2:05
  - *Paul Bologna and Jack Gaynor, Montclair University*
- **Baseline Characterization of Zooplankton in Barnegat Bay** 2:20
  - *Ursula Howson and James Nickels, Monmouth University*
- **Facilitated Discussion and Questions (Stan Hales)** 2:35

V. ECOSYSTEMS-BASED MANAGEMENT

- **Assessment of Fishes and Crabs Responses to Human Alteration of Barnegat Bay** 2:55
  - *Thomas Grothues, Kenneth Able, Jessica Valenti, Rutgers; and Paul Jivoff, Rider University*
- **Multi-Trophic Level Modeling of Barnegat Bay** 3:10
  - *Olaf Jensen, Heidi Fuchs and Jim Vasslides, Rutgers University*
- **Facilitated Discussion and Questions (James Vasslides)** 3:25

CONCLUDING REMARKS (Gary Buchanan and Stan Hales) 3:35

NOTES:

What Lies Beneath - Barnegat Bay 2015 Research Forum

Dr. Gary A. Buchanan, Director
Division of Science, Research, and Environmental Health
New Jersey Department of Environmental Protection

November 17, 2015

Ocean County College, Toms River New Jersey
Kean Ocean Gateway Building
Lecture Hall (Room 104)

Governor's Comprehensive Plan of Action: 10 Point Plan

http://www.nj.gov/dep/barnegatbay/

1. Close Oyster Creek Nuclear Power Plant
2. Fund Stormwater Runoff Mitigation Projects
3. Reduce Nutrient Pollution from Fertilizer
4. Require Post-Construction Soil Restoration
5. Acquire Land in the Watershed
6. Establish a Special Area Management Plan
7. Adopt More Rigorous Water Quality Standards
8. Educate the Public
9. Fill in the Gaps on Research
10. Reduce Water Craft Impacts

Plan 9: Comprehensive Research

Produce More Comprehensive Research to:

- Support water quality improvement (nutrient criteria)
- Establish the baseline conditions of the bay
- Fill in critical data gaps
- Advance habitat restoration on the Bay
- Provide data to address management questions

Support for Other Plans (7, 8 and 10)

BARNEGAT BAY COMPREHENSIVE RESEARCH – OBJECTIVES *

	BBay Research Projects	Bio-Criteria	Water Quality Model	Power Plant	Tourism & Recreation	Food Safety	Comprehensive/ Baseline/Data Gaps
1	Benthic Invertebrate Community Monitoring and Indicator Development for Barnegat Bay	X	X	X			X
2	Algal Diatoms as Environmental Indicators in Barnegat Bay	X	X				X
3	Assessment of Hard Clam in Barnegat Bay			X	X	X	X
4	Assessment of Fishes and Crabs Responses to Human Alteration of Barnegat Bay			X	X		X
5	Assessment of the Distribution and Abundance of Stinging Sea Nettles (Jellyfishes) in Barnegat Bay			X	X		X
6	Baseline Characterization of Phytoplankton Communities and Harmful Algal Blooms (HABs)	X	X		X	X	X
7	Baseline Characterization of Zooplankton Communities			X			X
8	Multi-Trophic Level Modeling of Barnegat Bay			X	X		X
9	Tidal Freshwater and Salt Marsh Wetland Studies of Changing Ecological Function and Adaptation Strategies		X		X		X
10	Ecological Evaluation of Sedge Island Marine Conservation Area in Barnegat Bay				X		X

* BARNEGAT BAY PROSPECTUS: MONITORING, ASSESSMENT, AND RESEARCH PRIORITIES FOR THE BARNEGAT BAY-LITTLE EGG HARBOR ECOSYSTEM TO SUPPORT SCIENCE-BASED WATERSHED MANAGEMENT SEPTEMBER 24, 2010 By: Barnegat Bay Partnership STAC http://www.nj.gov/dep/barnegatbay/docs/bbp_prospectus20100924.pdf

Plan 9 Status

- 10 projects/3 years - total budget: $3.75 M
- Years 1 & 2 Reports Posted

  http://nj.gov/dep/dsr/barnegat/final-reports/
- Year 3 Final Reports (soon)
- Communication – get the science out!
  - Science Outreach: BBP/DEP Public Forum; Universities, Others (suggestions).
  - Looking for input on the results!

What Lies Beneath - Barnegat Bay
2015 Research Forum

Thomas Belton
Barnegat Bay Research Coordinator

Division of Science, Research, and Environmental Health
New Jersey Department of Environmental Protection

November 17, 2015

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WHY RESEARCH?

To understand, separate out effects, and manage human impacts to estuary!

Potential Stressors to Barnegat Bay

1. Eutrophication (Nutrients: Harmful Algal Blooms, Low DO, Ecosystem Effects)

2. Power Plant Operation (Impingement & Entrainment, Thermal Discharge)

3. Habitat Loss and Alteration (Estuary and Watershed)

4. Storm water/Pathogens (bacteria, viruses)

5. Hardened Shorelines (bulkheads, sea walls)/Reduced Biodiversity

6. Reduced Freshwater Input (Altered Salinity/Species Susceptibility)

7. Invasive Species (Phragmites Reeds, Chinese Mitten Crabs)

8. Dredging/Boating/Jet Skis (damages animal habitats)

9. Marina Operations (Oil, solvents, anti-fouling paint)

10. Climate Change/Sea-Level Rise (warmer/higher water)

11. Chemical Contaminants (oil, anti-fouling paints, pesticides)

12.Trash/Floatables (plastics, wood, shells)

Change in Barnegat Bay Land Use at Forked River and Oyster Creek (1931 and 2011)

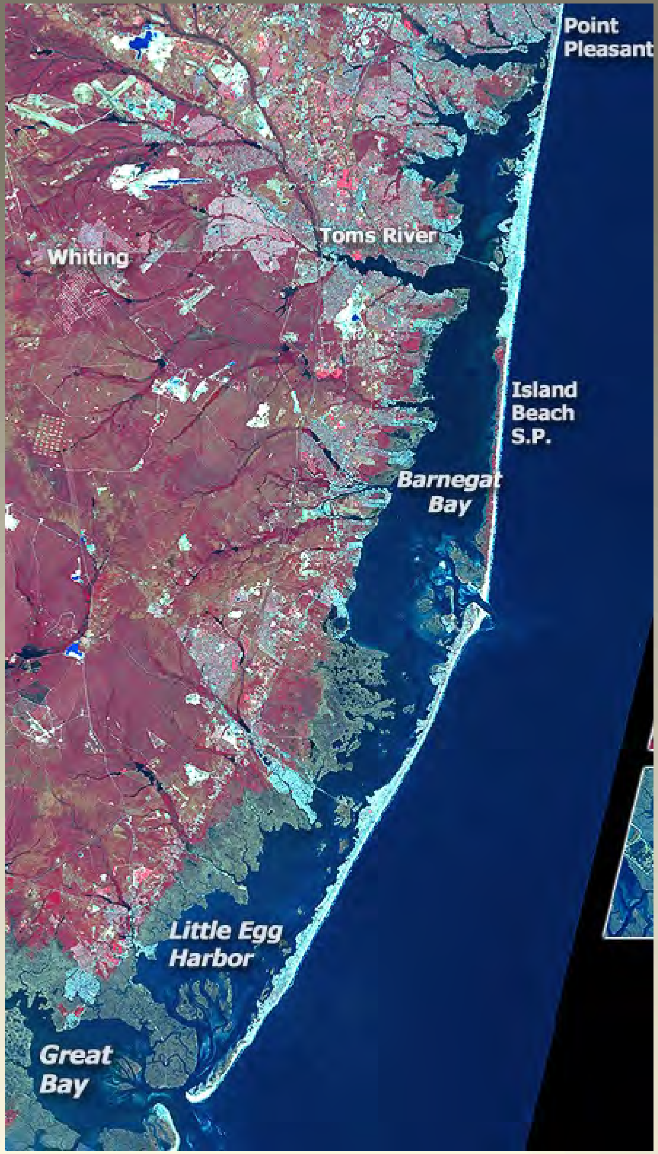
RESEARCH PROJECTS WERE AGGREGATED INTO ENVIRONMENTAL FOCUS AREAS FOR THIS FORUM

1. Water Quality Monitoring and Modeling
2. Aquatic Life Use Assessment and Site-Specific Water Quality Criteria Development
3. Characterizing Environmentally Sensitive Areas (ESAs)
4. Natural Resource Assessment and Management (Sustainable Fisheries)
5. Ecosystem-Based Management

Ultimate Goal
Develop a Barnegat Bay Management and Action Plan

Governor's Comprehensive Plan of Action:
10 Point Plan
http://www.nj.gov/dep/barnegatbay/

Years 1 & 2 Research Reports Posted
http://nj.gov/dep/dsr/barnegat/final-reports/



Contact Info
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Barnegat Bay Water Monitoring Program, Assessment and Model Development

Helen Pang P.E., Patricia Ingelido, Patricia Gardner
in cooperation with:
NJDEP, Division of Water Monitoring and Standards
And
USGS NJ Water Science Center, USGS Woods Hole, USGS St. Petersburg

Presented By: Trish Ingelido
NJDEP, Division of Monitoring and Standards
November 17th, 2015

Barnegat Bay Plan Action Item 7…
How will we get there?

“Adopt More Rigorous Water Quality Standards”

What: Identify appropriate water quality endpoints to inform restoration of Barnegat Bay which may include:

- review of existing criteria
- criteria for nutrients
- loading targets for nutrients

How: Comprehensive assessment and modeling tools

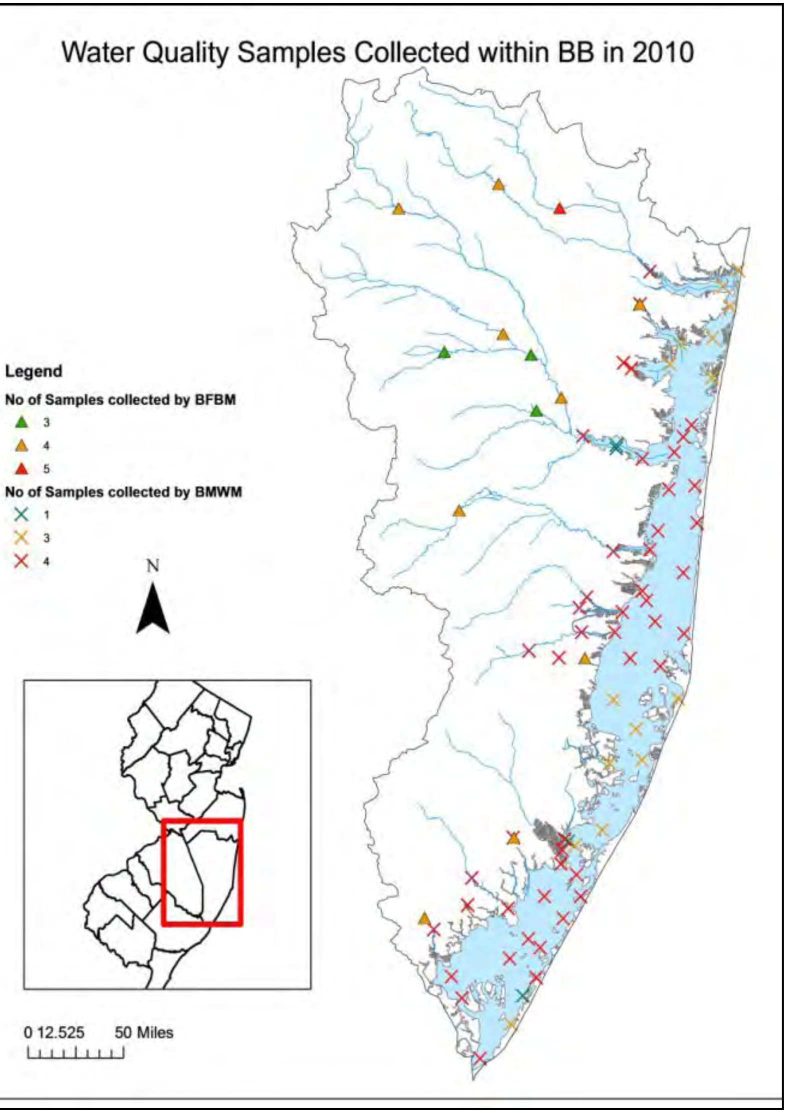
- what is the existing condition
- how do chemical, physical and biological processed interact

Making the Linkages

- Development of restoration measures requires an understanding of the relationships between environmental responses and pollutants.

- To identify restoration measures we need to know linkages between
  - Land use and water quality
  - Tributary water quality and bay water quality
  - Hydrodynamics and water quality

NJDEP Barnegat Bay Monitoring Programs Pre 2011



Freshwater

- 14 stations in BB Watershed
- 4 times a year
- Chemical parameters

Coastal

- 50 stations in the Bay (including tidal tributaries)
- Surface samples
- 4 times per year
- Nutrients, chlorophyll & physical

Flow Monitoring

- 3 Tributary gages

Why More Data ?

- Existing data sets have varied time frames, parameter, sets, spatial extents, field collections and analytical methods etc.

- Modeling relationships between pollutants and observed water quality requires comprehensive, contemporaneous data.

- The Targeted Water Monitoring project plan created a unique data set which meets the needs of both water quality assessment and model development

Objectives of Targeted Water Monitoring Program

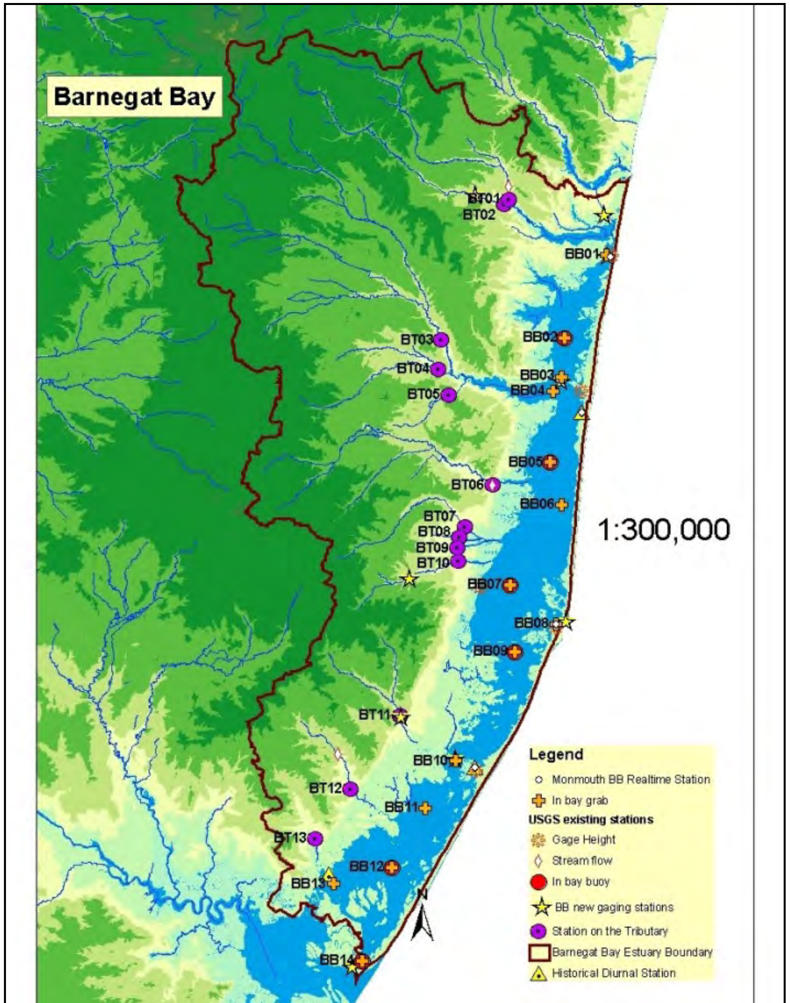
June 2011- July 2013

- Determine the locations and extent of water quality impairments
  - 2012 BB Assessment
  - 2013 BB Assessment (poster)
  - 2014 BB Assessment- In progress

- Calibrate and validate modeling tools
  - Identify numeric criteria or loading targets for nutrients
  - Simulate the effect of potential future conditions
  - Direct water quality restoration for the bay

NJDEP Barnegat Bay Targeted Monitoring Program

June 2011– June 2013



Freshwater

- 13 Tributary Stations- above head of tide
- Varied frequency at least 2 X a month

Coastal

- 13 In bay stations established
- Samples taken at 2 depths
- Varied frequency at least 2X a month

Flow Monitoring

- 3 gages at inlets
- 2 in bay gages
- 7 Tributary gages

Continuous Water Quality

- 4 in bay buoys
- 2 fixed locations

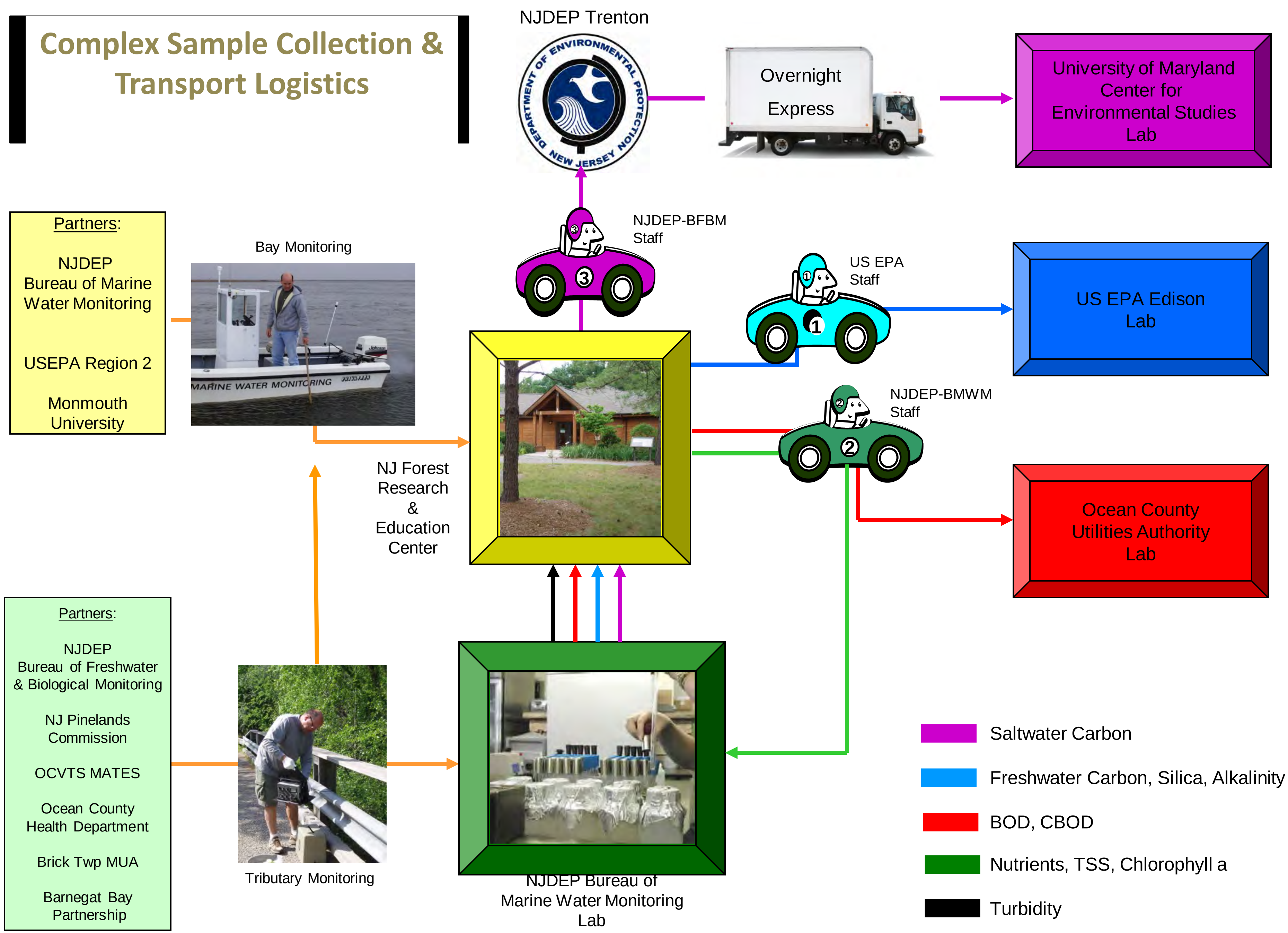
Intensive Sampling Events

- July 2012, August 2012 and June 2013

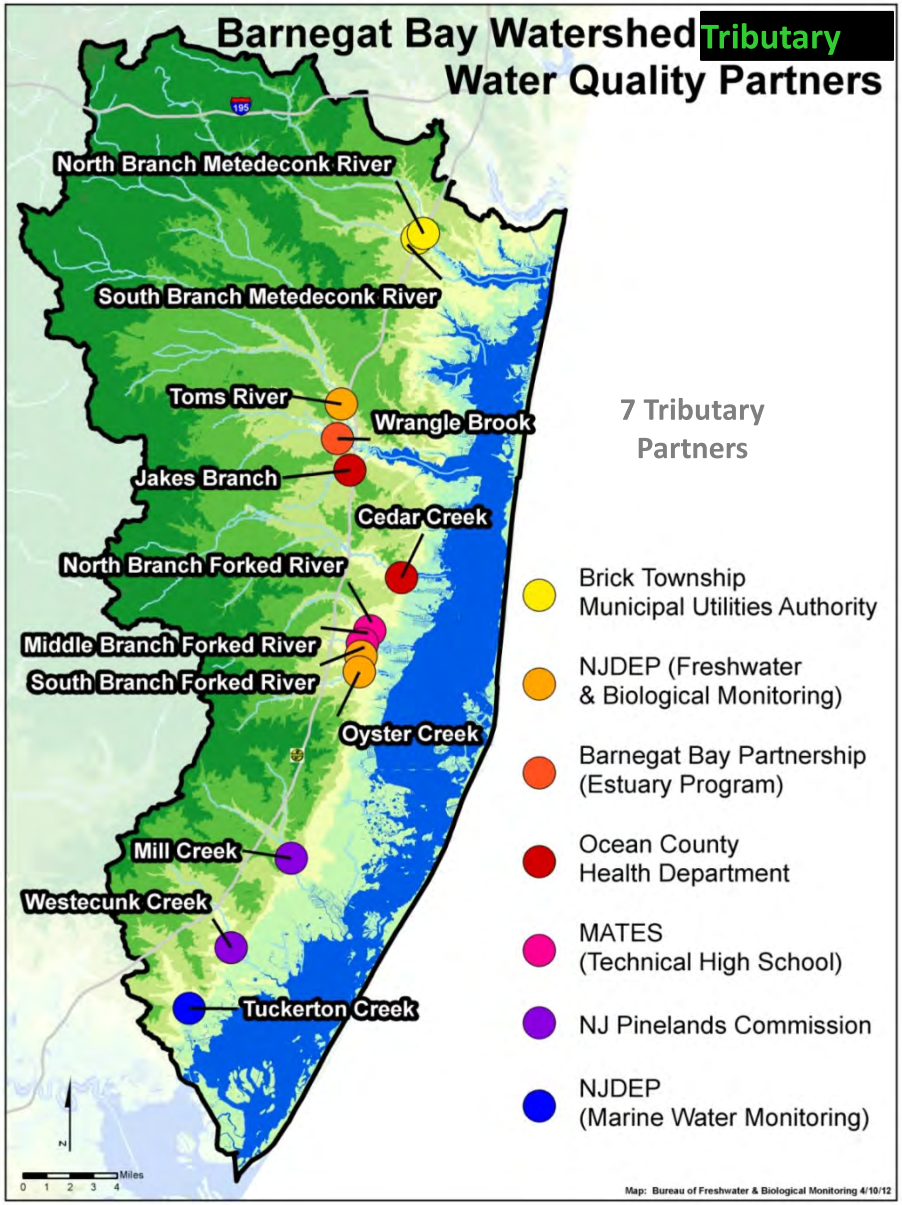
We Need Help!

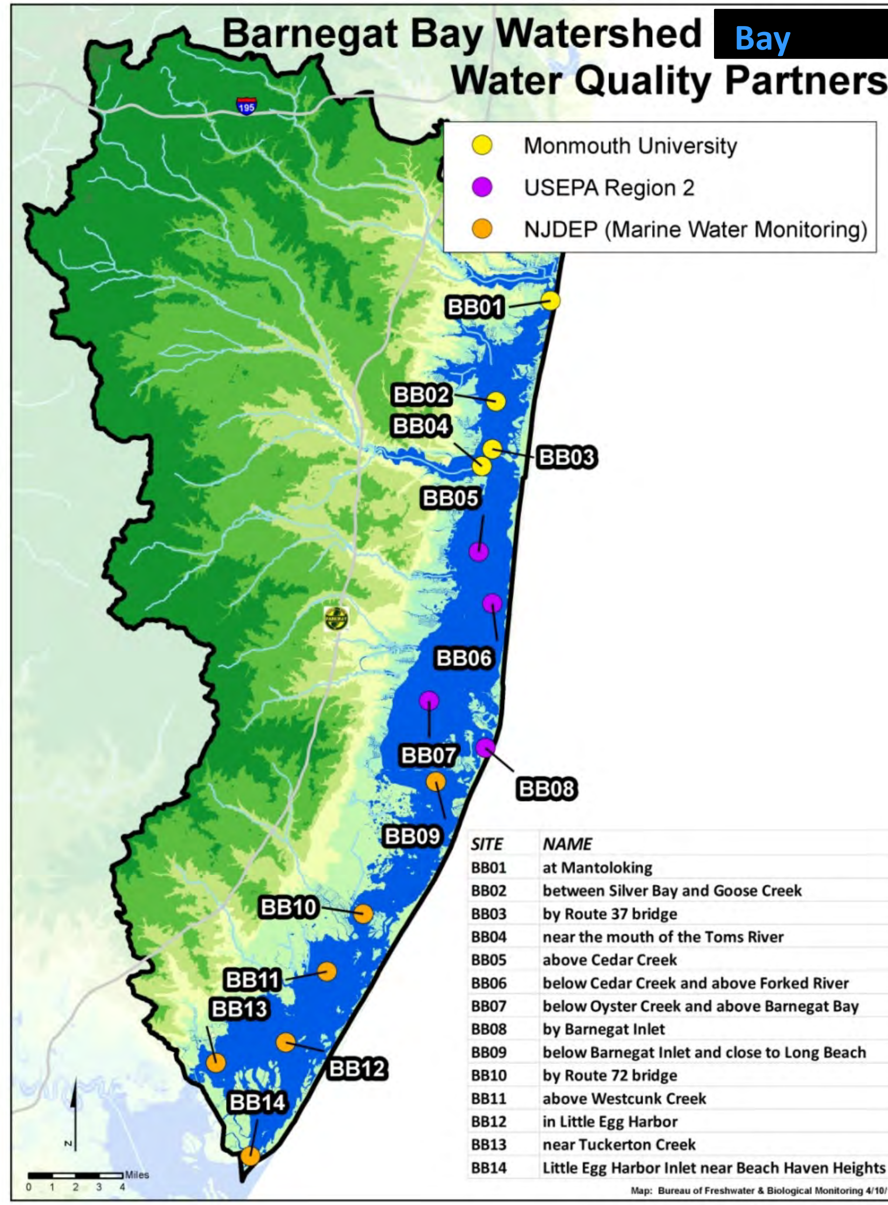
- Simultaneous sampling tributary and bay sites
- Monitoring and sample prep exceeds DEP-DWMS capacity
- First 6 Months:
  - 75,000 field measurements
  - 10,000 bottles, going to 4 different labs
  - > 100 flow measurements

Complex Sample Collection & Transport Logistics



7 Tributary and 3 Bay Monitoring Partners





The Partner Approach

- **17** partner organizations beyond DEP:
  - BBP, EPA, Brick Twp MUA, OCHD, Pinelands Commission, USGS, OCMUA, Monmouth Univ, MATES, NJDHSS, ReClam the Bay, Cattus Island, Brick Twp Marina, Gilford Park Marina, Barnegat Bay Municipal Dock, Causeway Marina, Shelter Cove Marina

- Samples collected and delivered to **2** field labs for filtration and preservation
  - DEP Marine Water Laboratory
  - DEP Forest Resource Education Center

- Preserved samples to **5** laboratories for analysis
  - DEP Marine Water Laboratory, OCUA, EPA Region 2 Edison, Maryland University Laboratory , NJDHSS

Intensive Monitoring Events

- Ambient samples all taken between 8:00-10:00
- How does the chemistry change throughout the day?
- 27 samples locations, 6 samples a day…

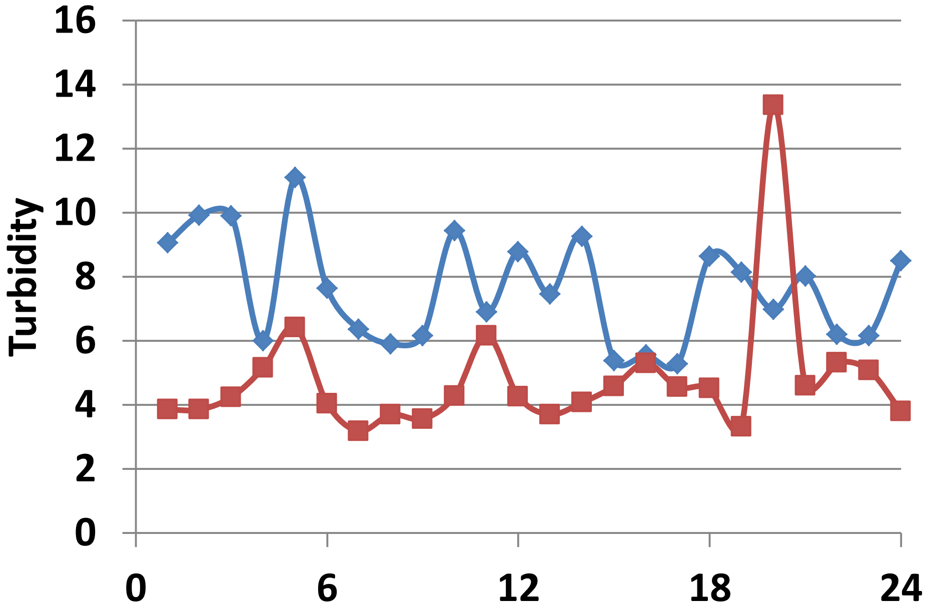


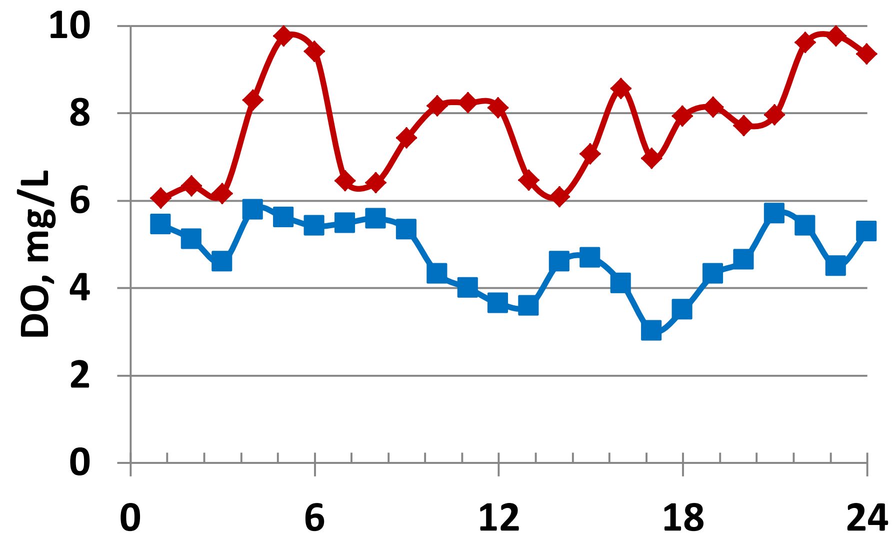
Intensive Monitoring
(July & Aug 2012 and June, 2013)

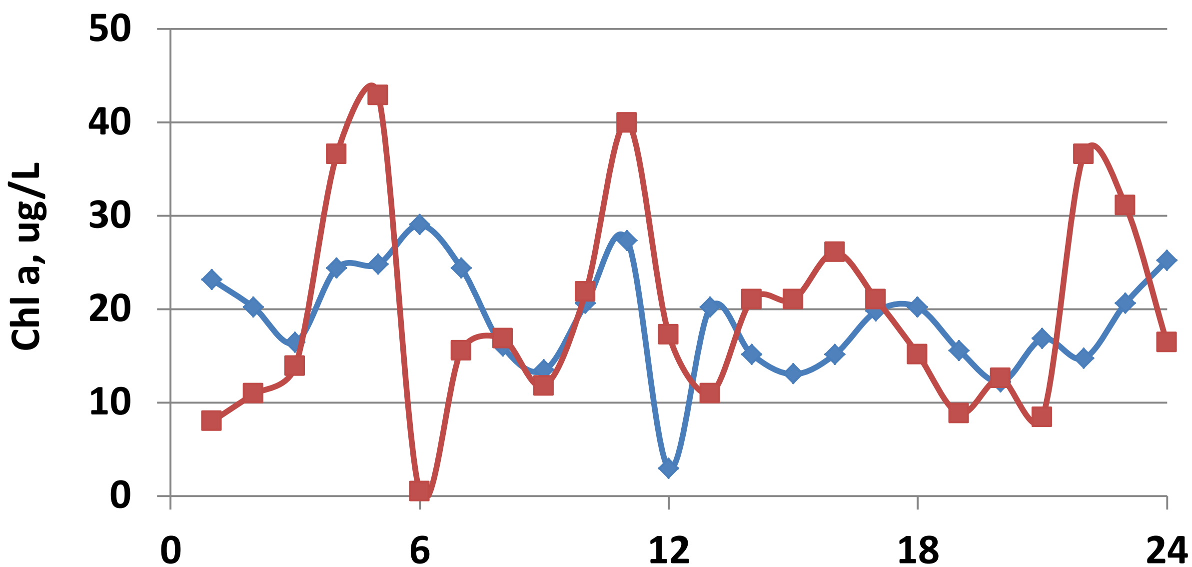
- 27 sampling locations
- 6 boats
- 13 sampling teams
- 30 runner routes
- 75 people per day
- Over 140 NJDEP staff involved
- 4332 total samples


PARAFILM

BB04a (by Toms River) 8/13/12 – 8/16/12 (cont.)





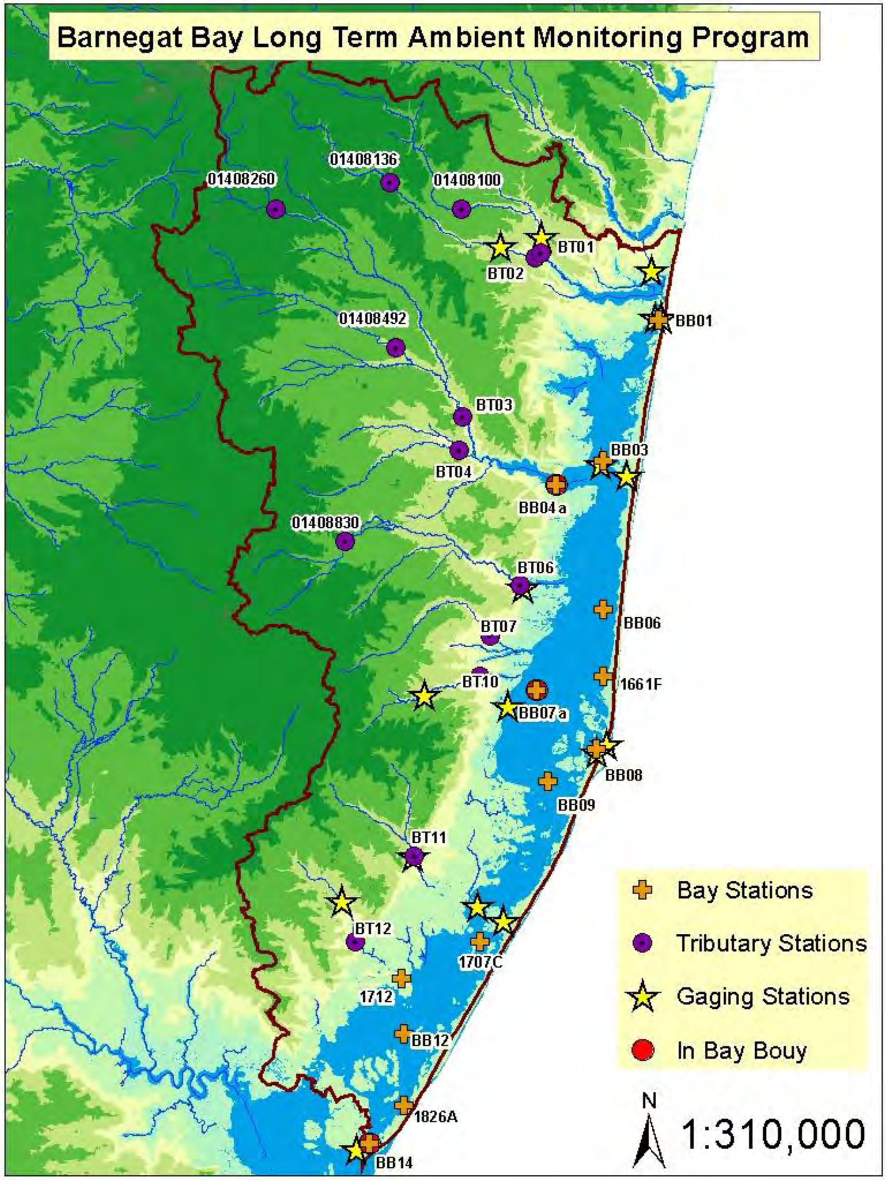


Long Term Ambient Monitoring

June 2013– Ongoing

What's Different:

- Sampling Locations
- Sampling frequency
- Parameters



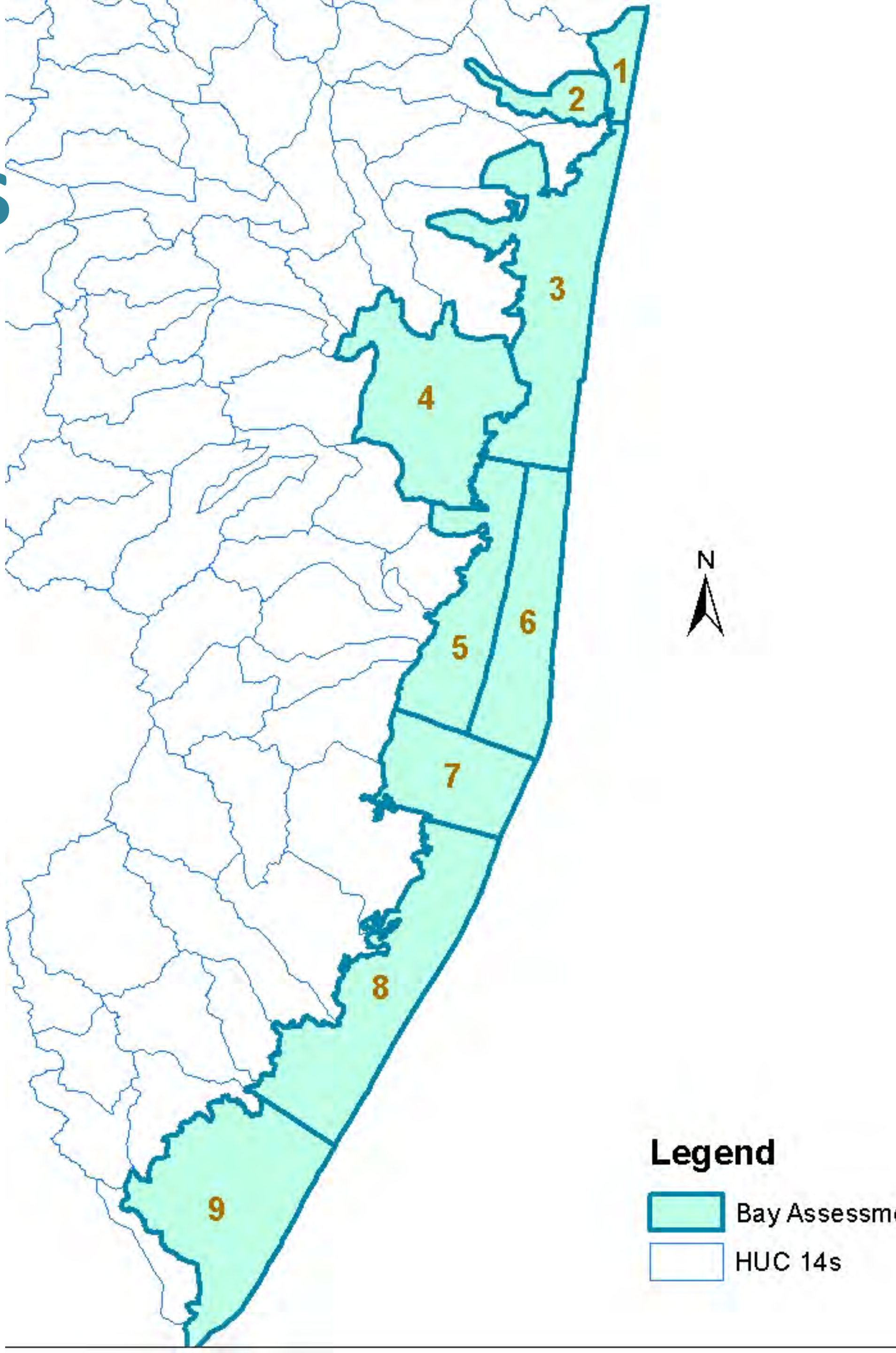
http://www.nj.gov/dep/barnegatbay/docs/BB2QAPPRevision3.pdf

Barnegat Bay Water Quality Assessment

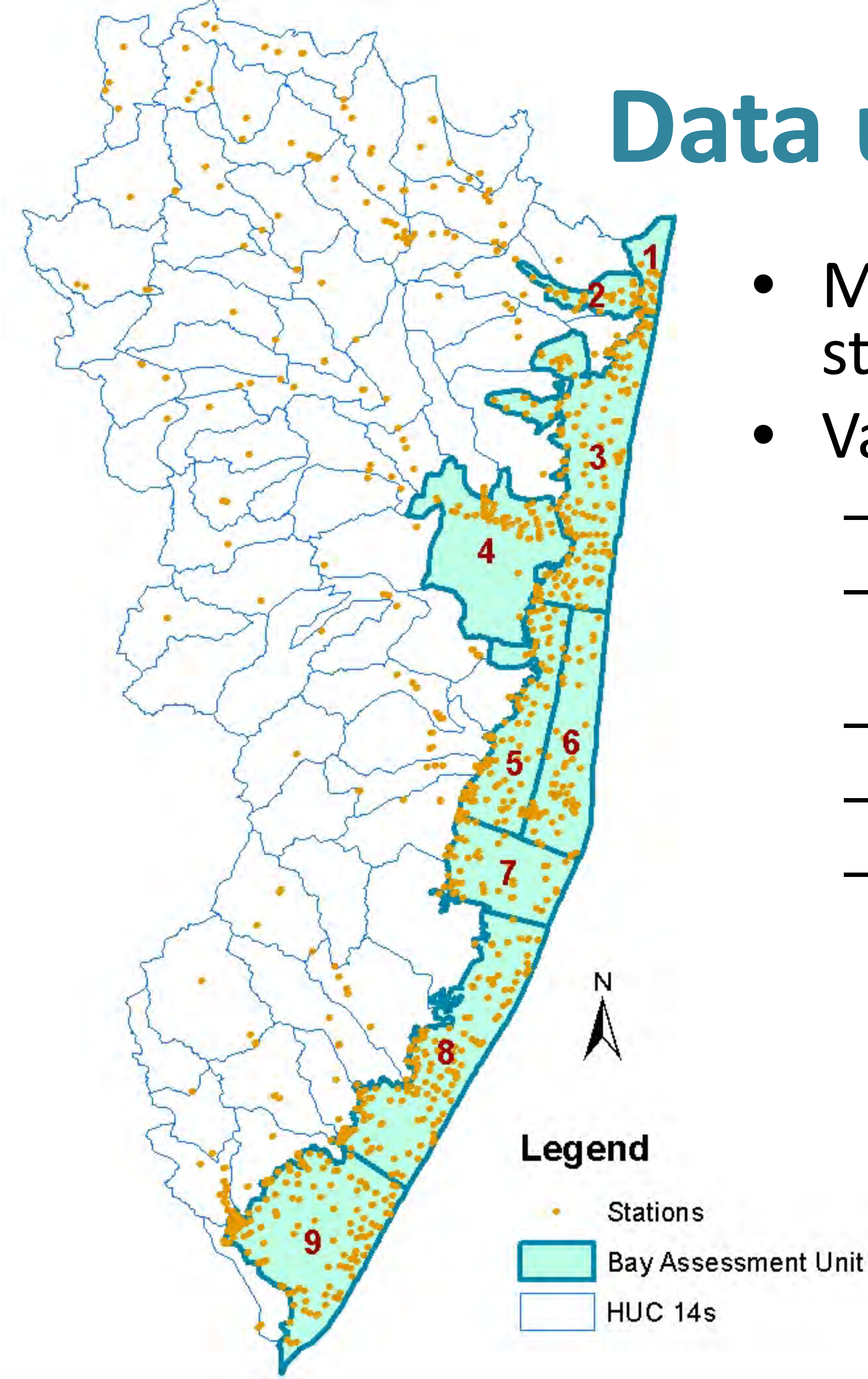
- New Assessment units in the Bay
- Comparison to the threshold values used by other estuary programs *(Poster)*
- Portions of the Bay do not meet standards for Dissolved Oxygen and Turbidity
- Plan 9 research fills the gap and provides a method of evaluating the Macroinvertebrate community, which enables the biological assessment of the Bay.

Assessment Units

- SubWatersheds
  - HUC14s
- Bay
  - Water Quality Similarity
  - Hydrodynamic features



Data use for Assessment



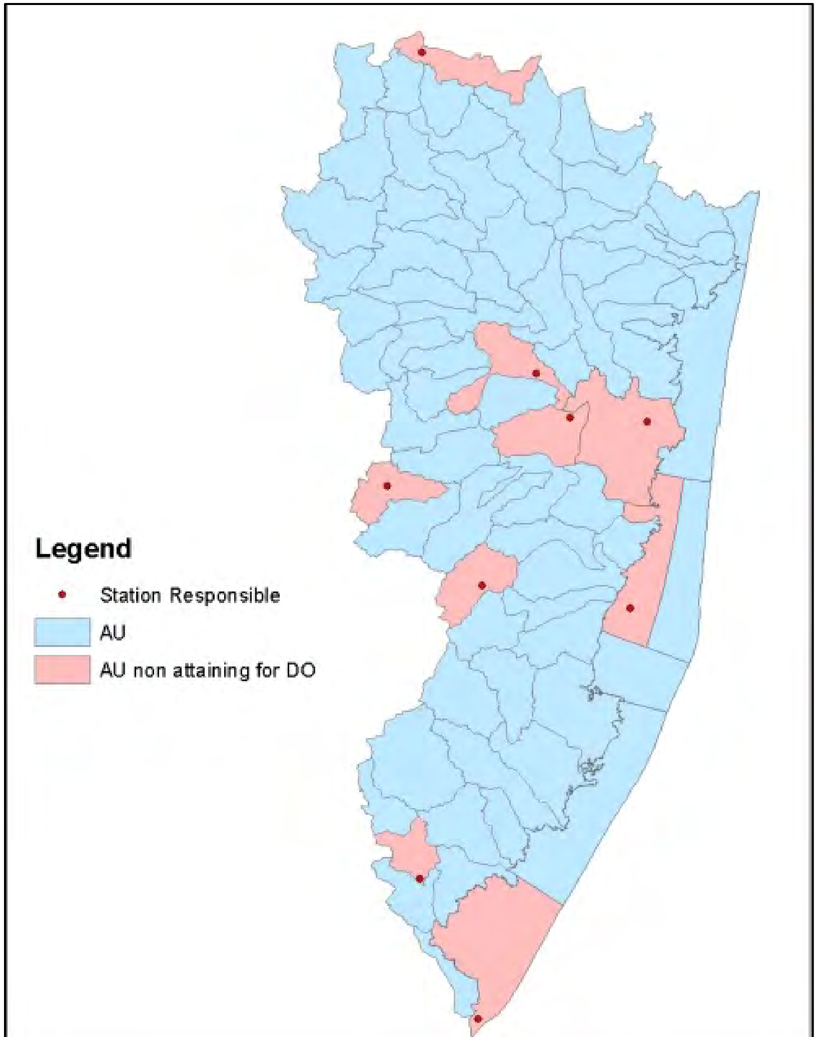
- More than 1000 sampling stations
- Various Sampling Organizations
  - BTMUA
  - Monmouth County Health Department
  - Pineland
  - USGS
  - NJDEP
    - OS Research Projects
    - BFBM
    - BMWM
    - BB

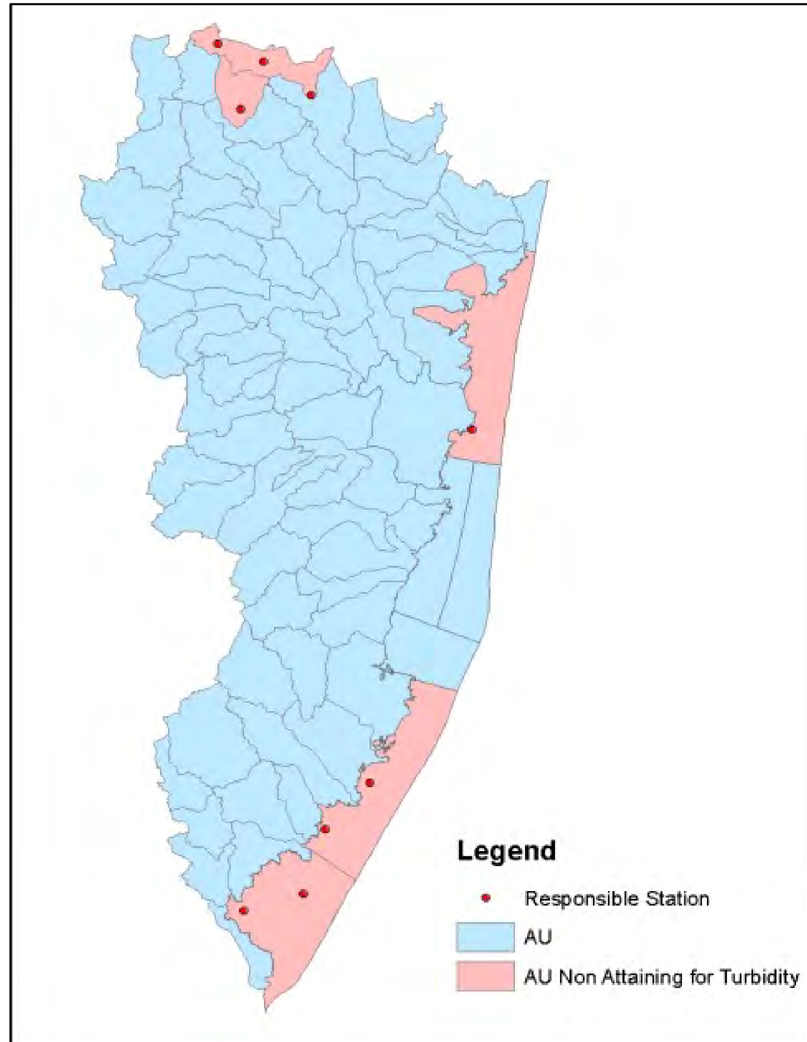
Excursion from the Existing Standards

- Dissolved Oxygen (mg/L)
  - Minimum DO > 4
  - 24-hr average DO > 5

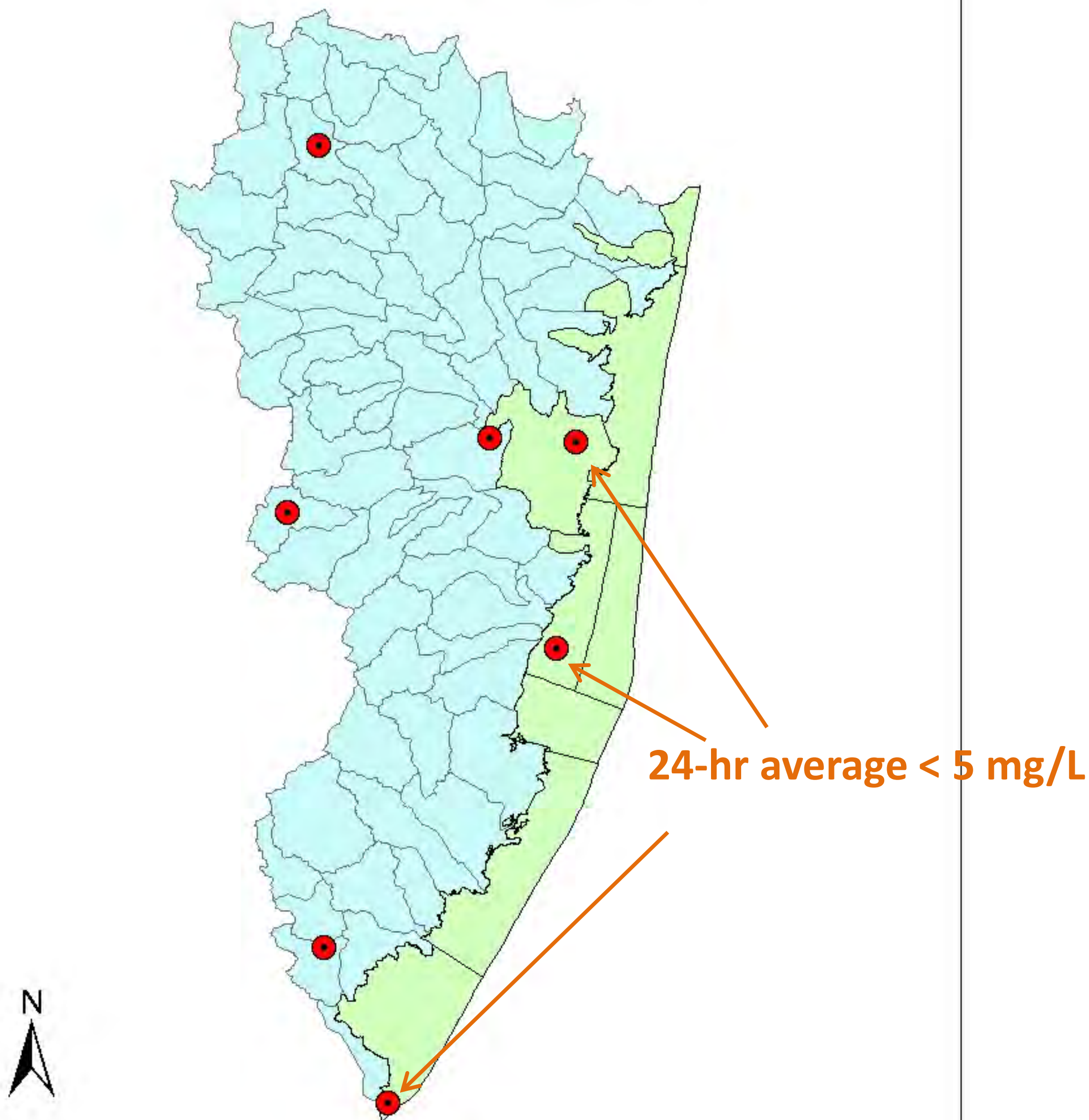
- Turbidity (NTU)
  - Single sample < 50 FW, <30 SE
  - 30-day average < 15 FW, < 10 SE

Barnegat Bay Assessment Results

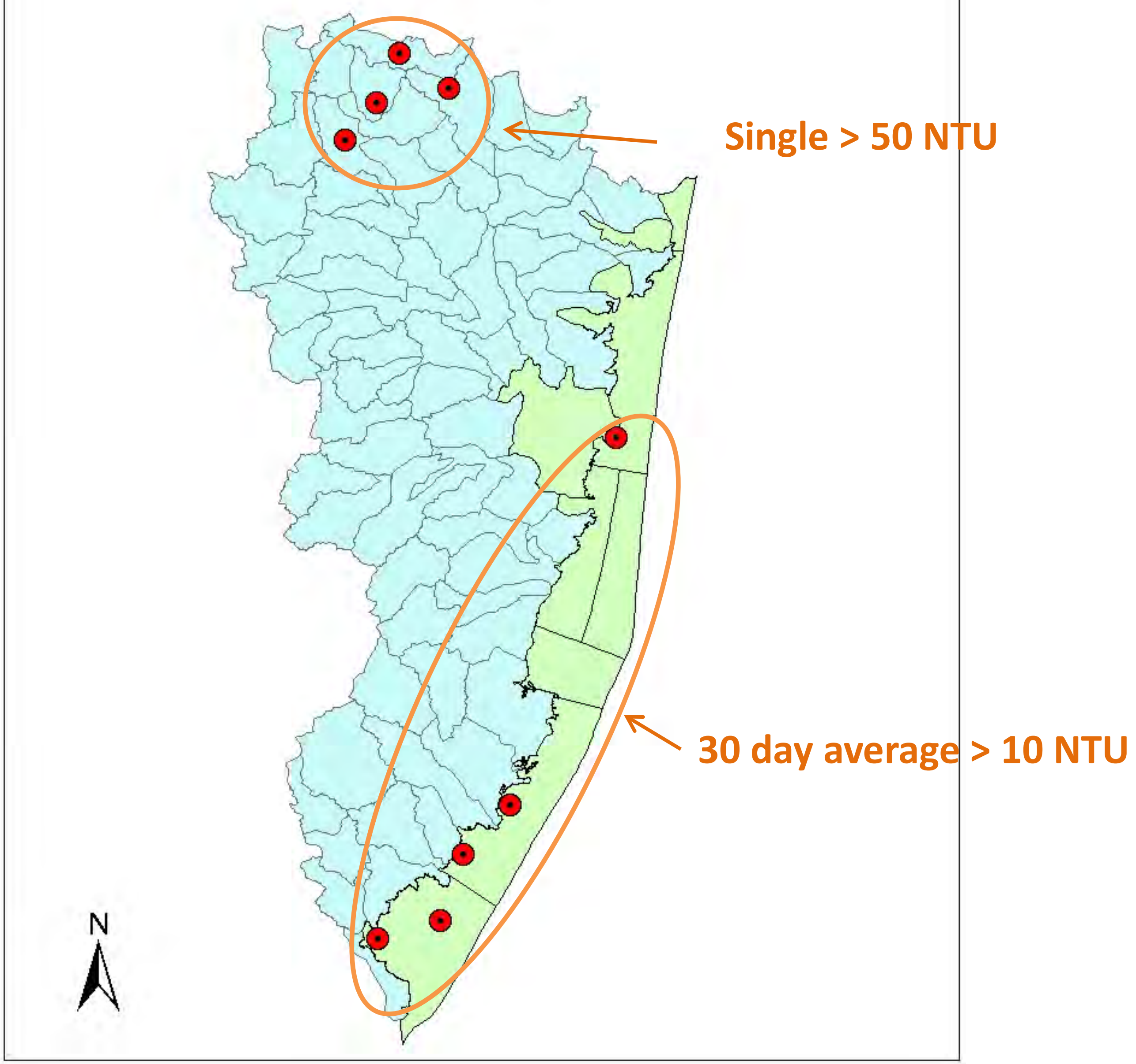




BB 2013 Assessment Stations Non Attaining
DISSOLVED OXYGEN

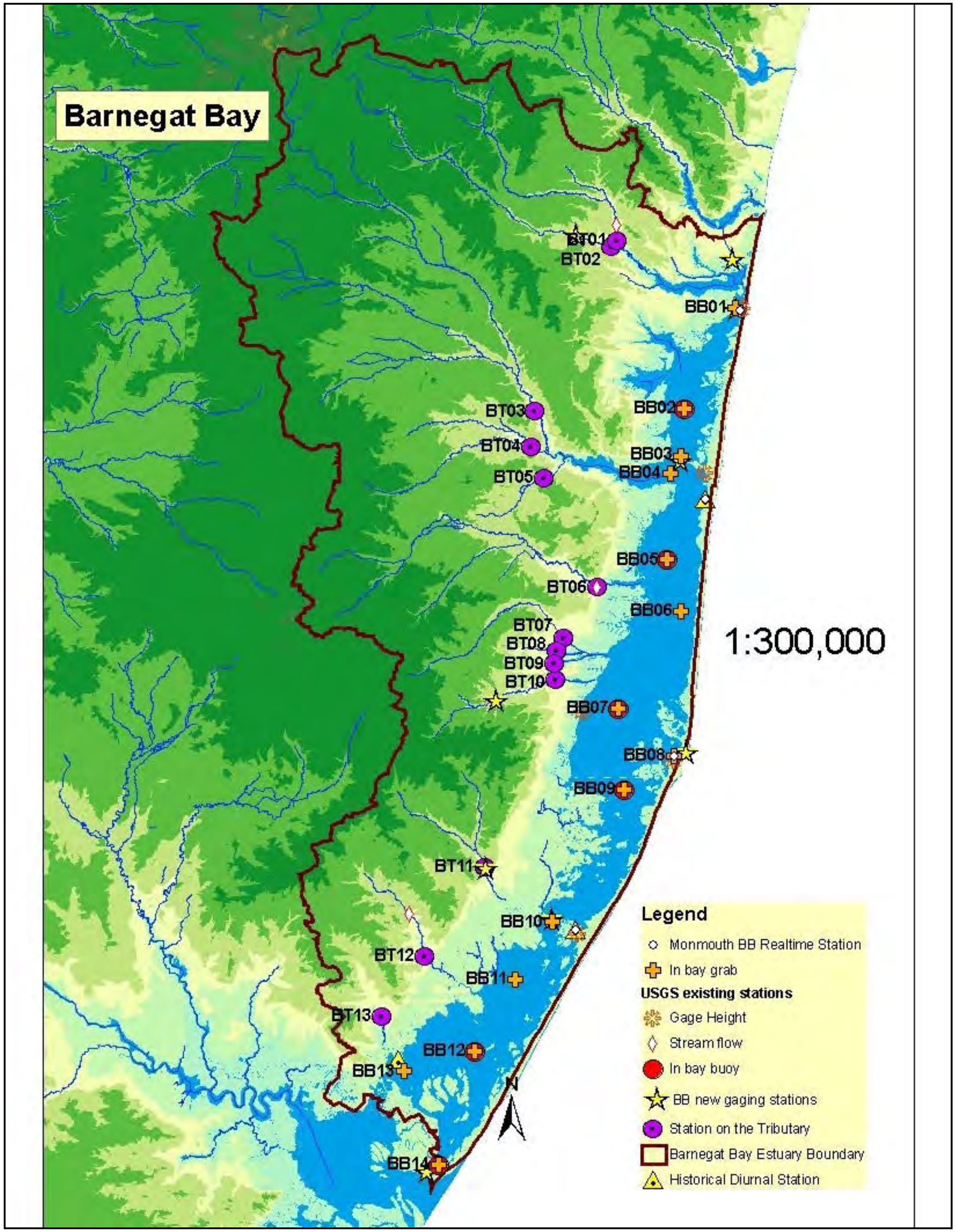


BB 2013 Assessment Stations Non Attaining TURBIDITY



DATA

Modeling Tool

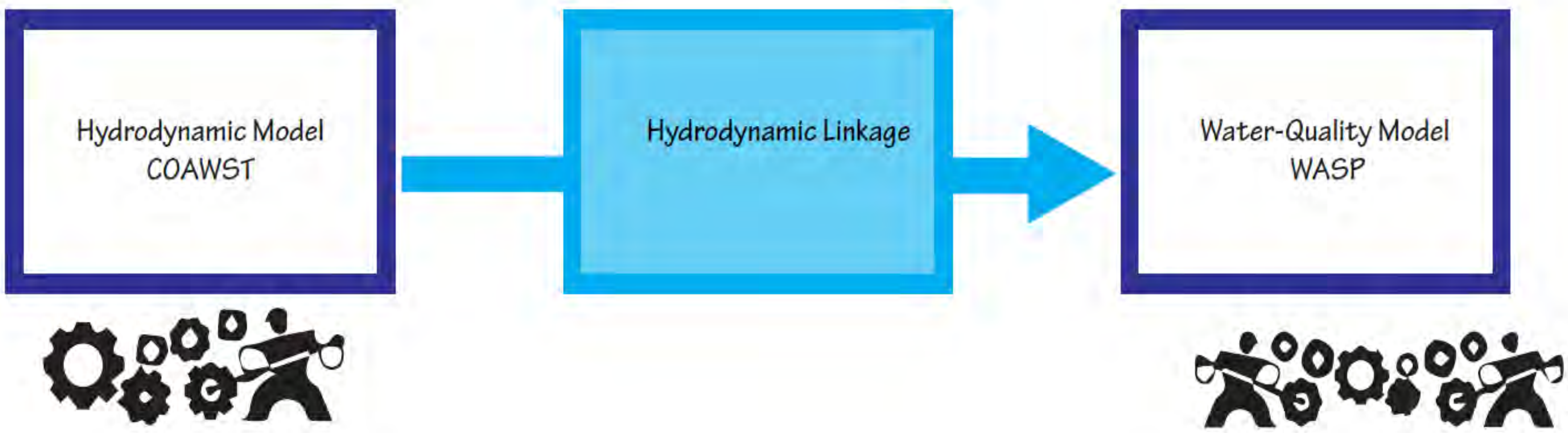


Two Phases of Modeling Development

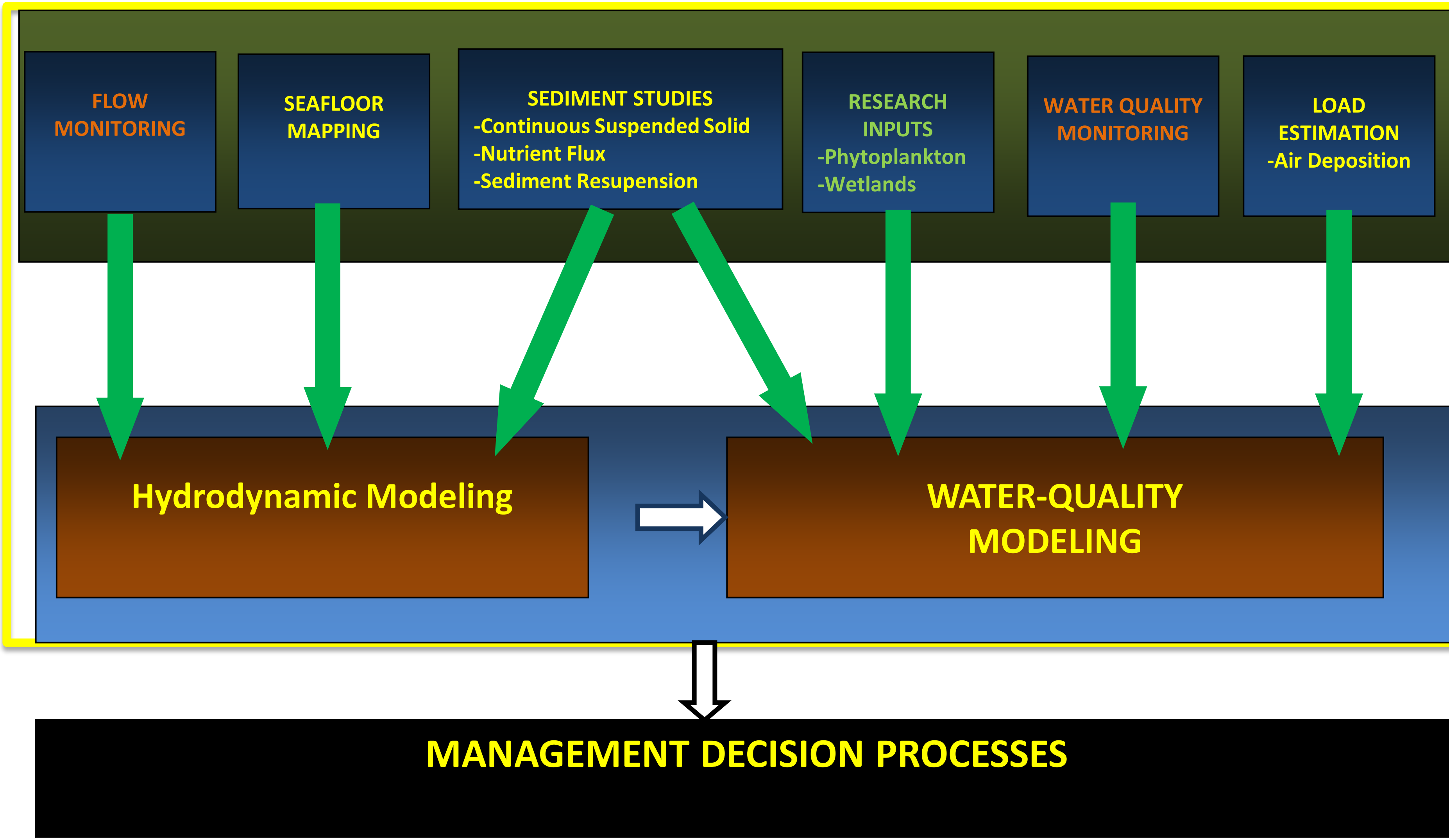
I. Construct and calibrate the model - “current” condition

II. Predict the future conditions using the calibrated model by varying the inputs.

Core Components of BB Model



INTEGRATION OF BARNEGAT BAY WORK AND ITS RELATION TO MODELING AND MANAGEMENT



Hydrodynamic Model

What we have learned

Characterization of Bay Conditions

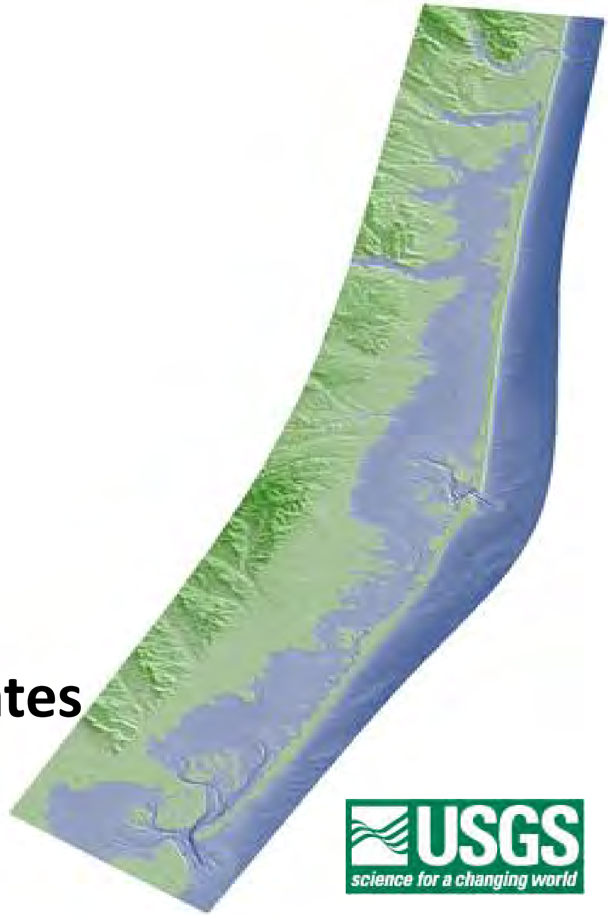
- ~4°C higher than ocean in shallow bay water
- Lower salinity in the northern Barnegat Bay

Residual Circulation

- Residual current from south to north
- Dominant force tidal

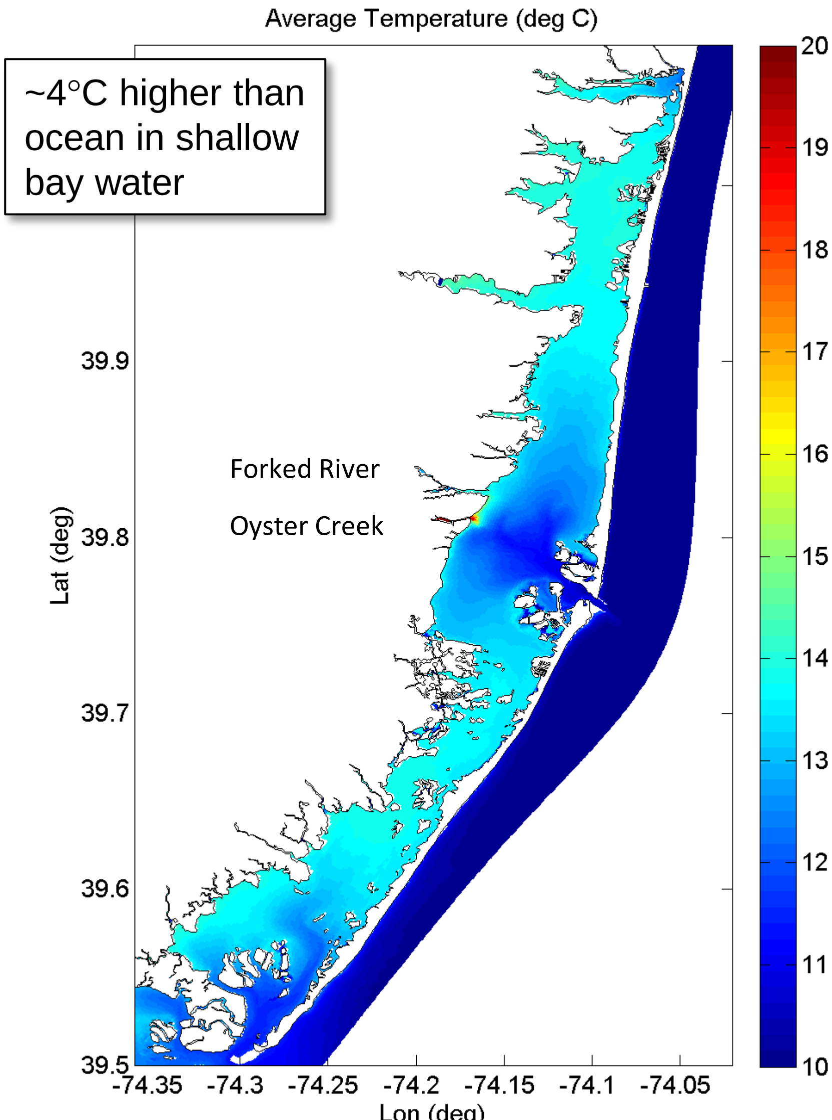
Particle Tracking Model/Residence Time Estimates

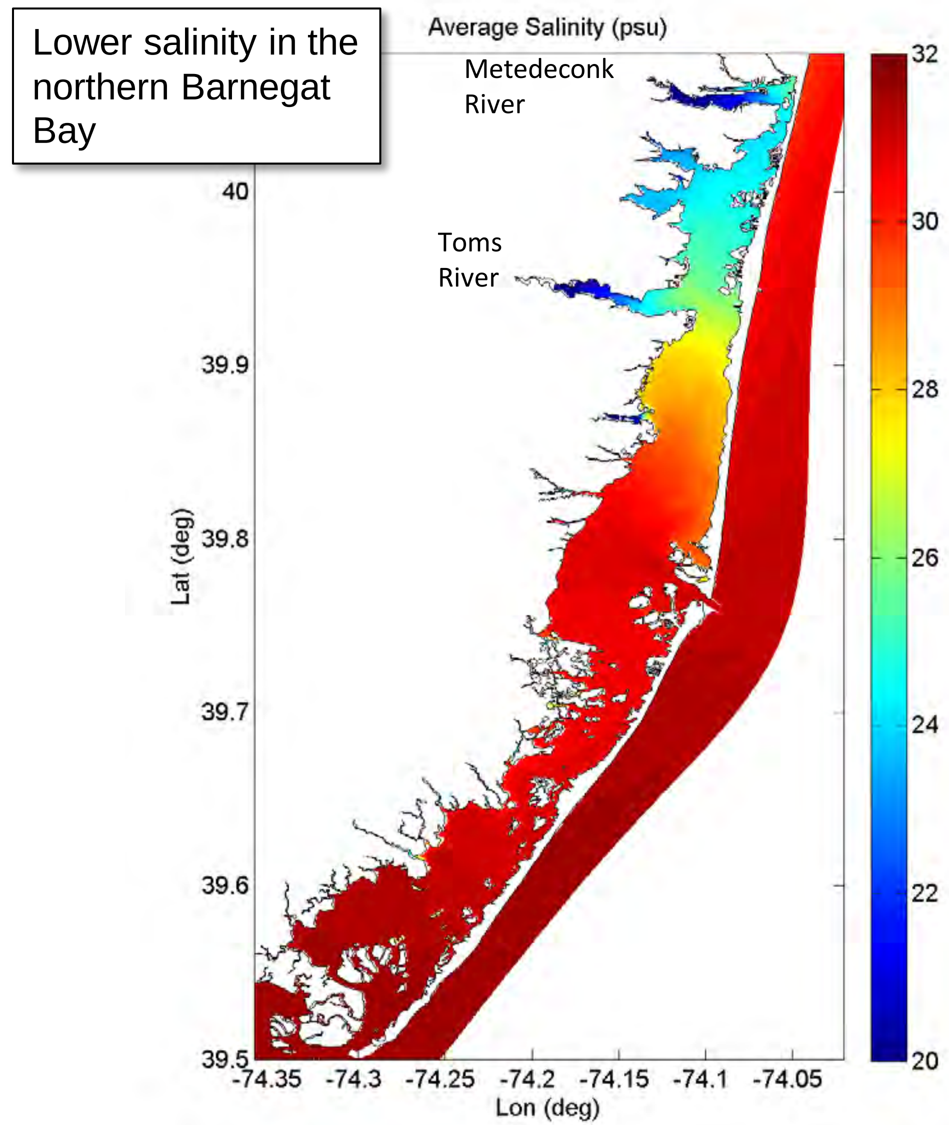
- Mean residence tome : 13 days
- Largest residence time:
  - ✓ <u>NORTH</u>: Toms River, Kettle Creek and Silver Bay Sedge Island
  - ✓ <u>SOUTH</u>: Manahawkin and Little Egg Marshes Mordecai Island



Hydrodynamic Model Results:

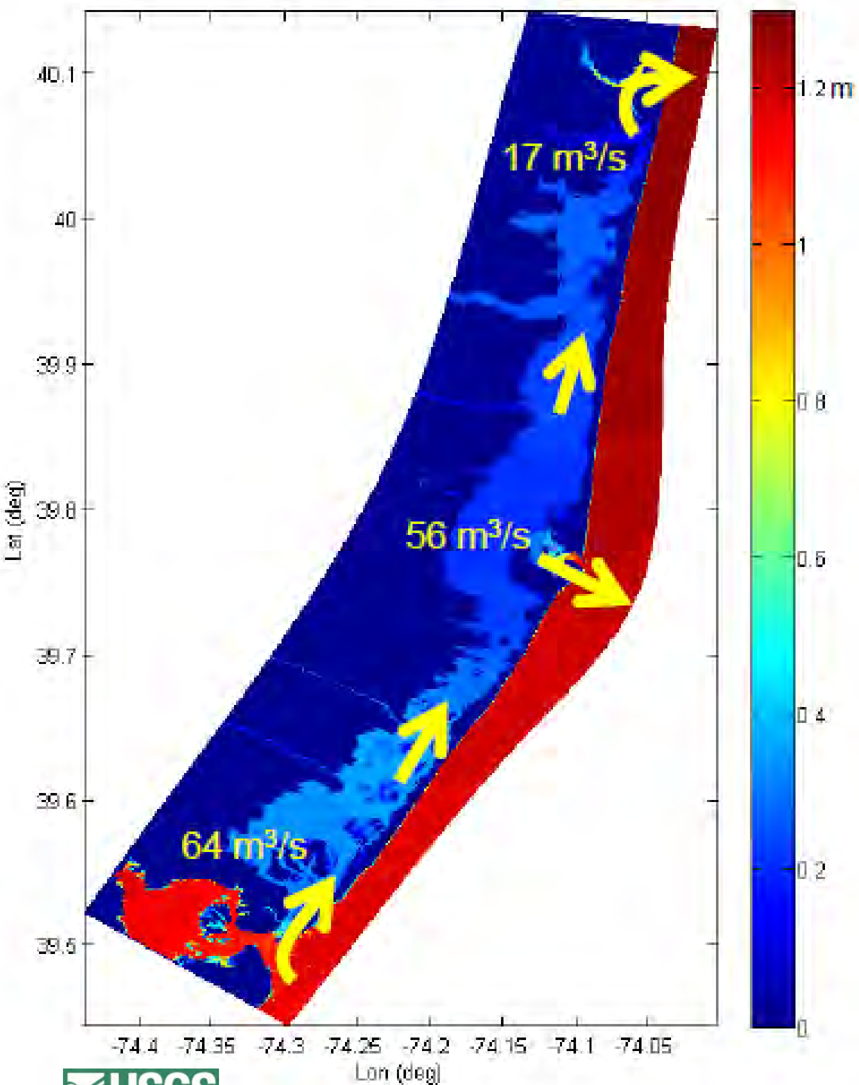
Average Bay Conditions: Temp and Salinity March-April 2012





Hydrodynamic Model Results:

Tidal Range and Residual Circulation



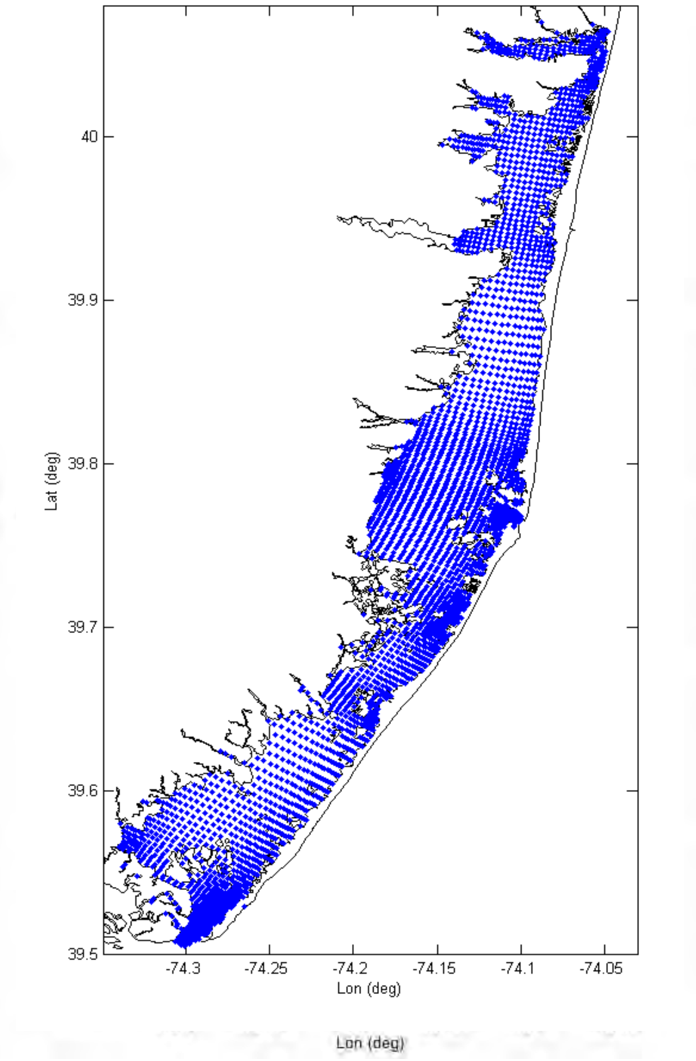
- Tides attenuate rapidly through Barnegat Inlet
- Residual current from south to north
- Driving force behind the residual circulation
  ~75% from tides
  ~20% from local winds
  ~5% from rivers
  ~5% offshore subtidal forcing

(*1 m^3/s = 22.8MGD)

USGS science for a changing world

Hydrodynamic Model Results:

Particle Tracking Model- *Lagrangian TRANSport (LTRANS*)*



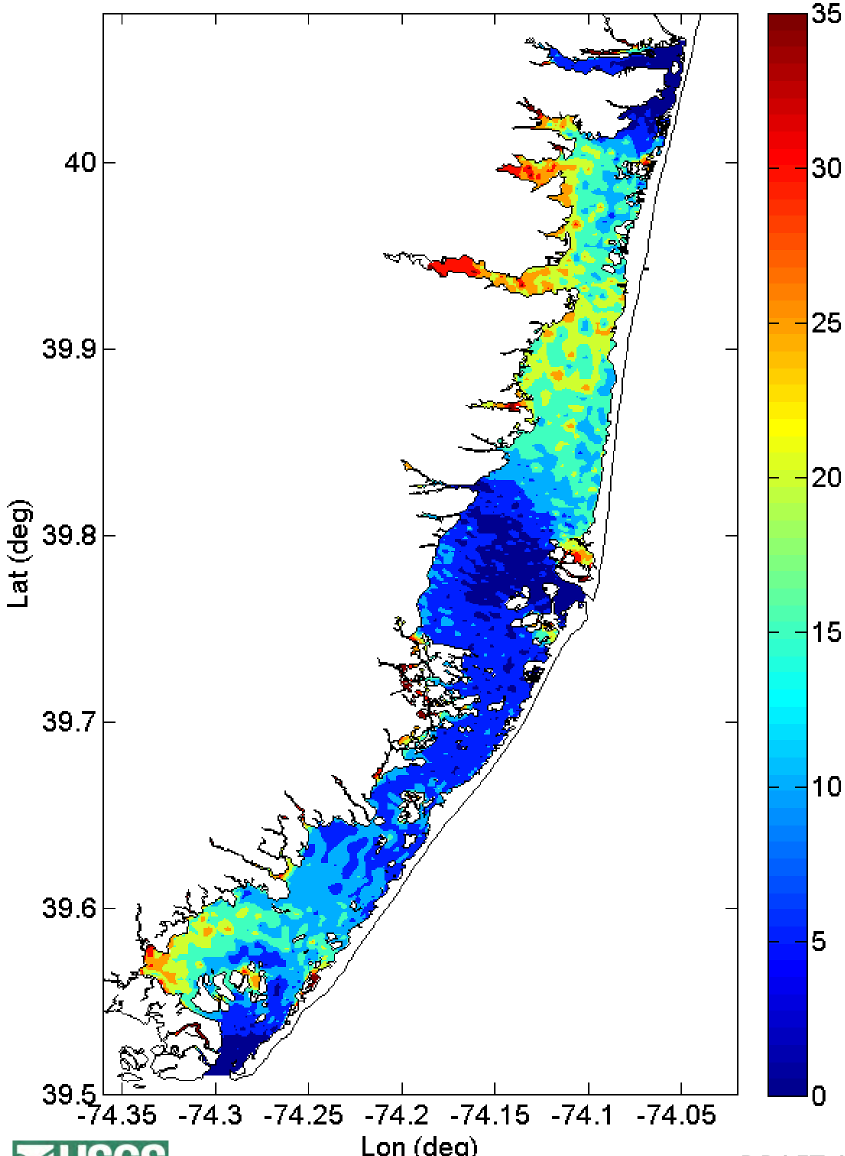
- Released particles ~ 80 k particles uniformly in top layer
- Tracked for 2 months
- Stop tracking particles once they exit the bay

Uses:

- Calculate residence time
- Useful tool to model larval dispersion

* North, E. W., E. E. Adams, S. Schlag, C. R. Sherwood, S. Socolofsky, R. He. 2011. *Simulating oil droplet dispersal from the Deepwater Horizon spill with a Lagrangian approach.* AGU Book Series: Monitoring and Modeling the Deepwater Horizon Oil Spill: A Record Breaking Enterprise 195: 217-226.

Hydrodynamic Model Results:
Residence Time (d) in BB

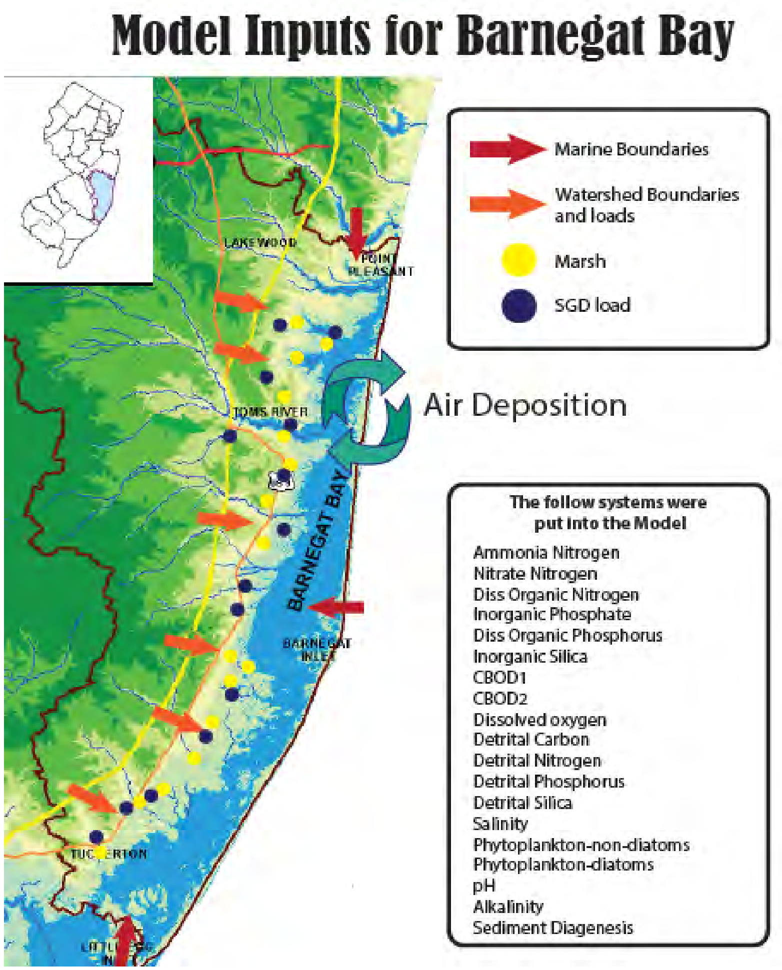


- **Mean residence time:** 13 days
- **Largest residence times**
  - **The north:**
    - Toms River, Kettle Creek and Silver Bay Sedge Island
  - **The south:**
    - Manahawkin and Little Egg Marshes Mordecai Island

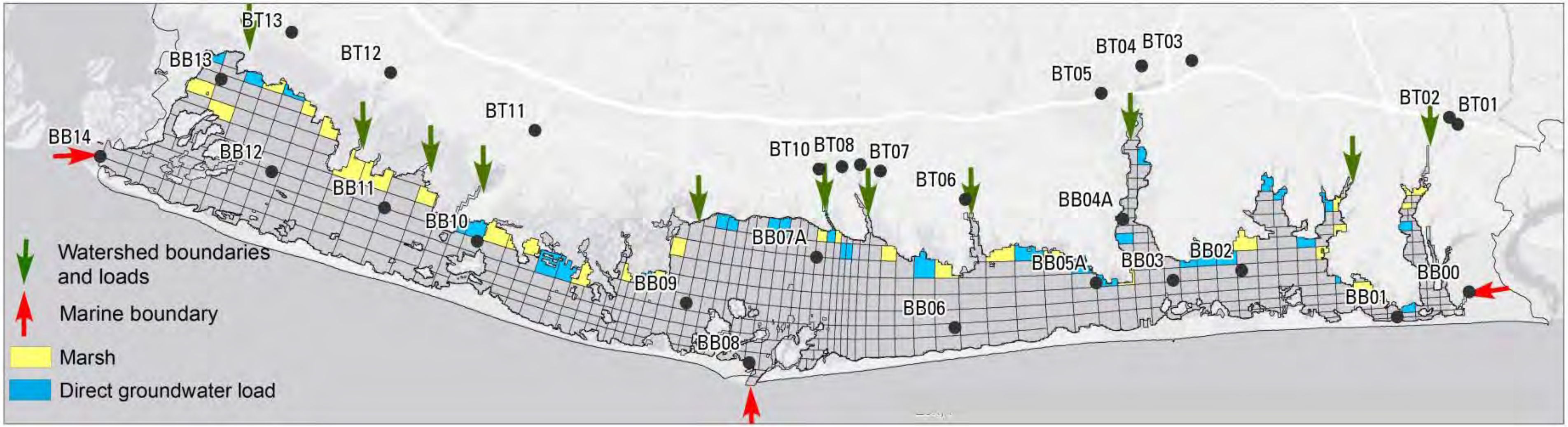
Water Quality Model

Current Status

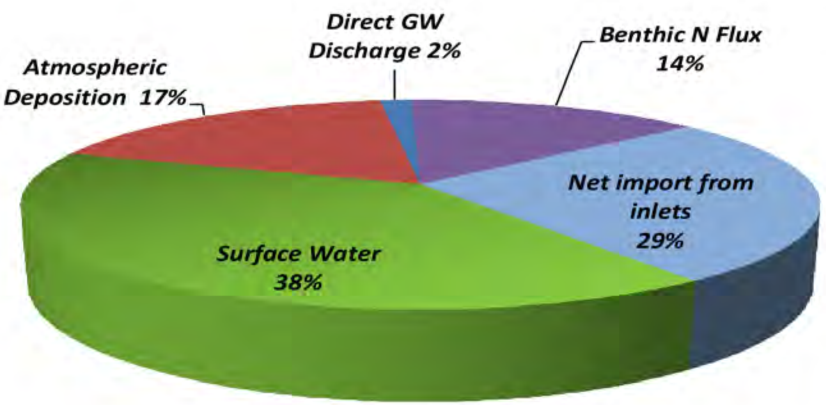
- Built and to be fully calibrated
- 3 Layers, 1827 segments
- Linked to Hydrodynamic Model
- Loading estimates completed



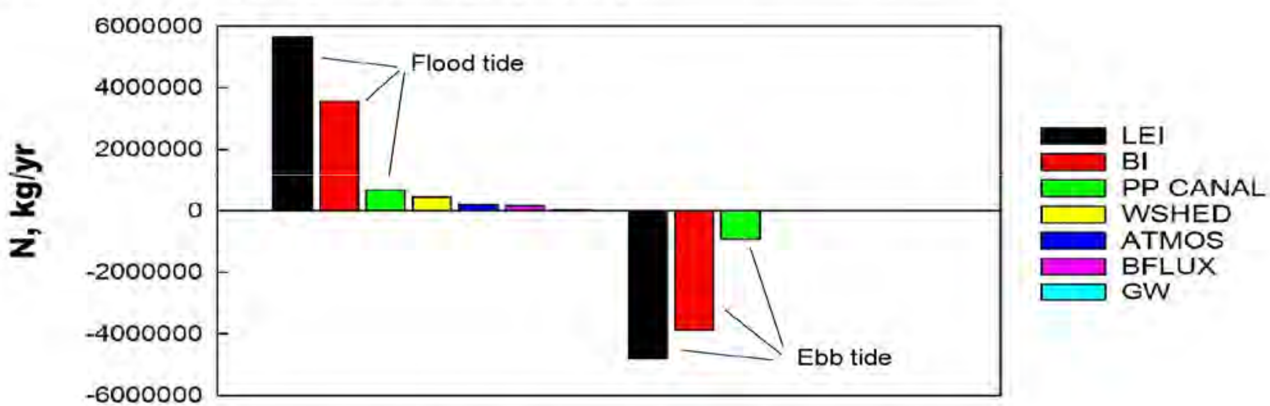
WQ Model Input Location and Calibration Segments



Water Quality Model Preliminary DRAFT Loading Estimates



Relative contribution of nitrogen inputs by source to the Barnegat Bay-Little Egg Harbor Estuary [*Surface water includes stream baseflow plus storm runoff; kg N/yr, kilograms of nitrogen per year*]

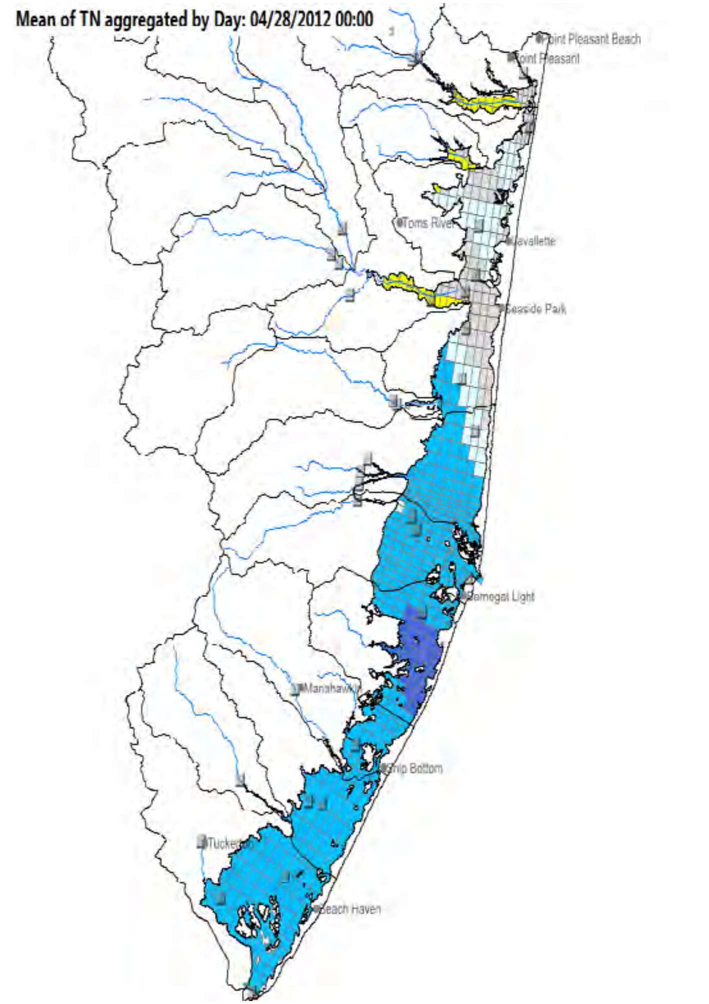


Nitrogen inputs by source to the Barnegat Bay-Little Egg Harbor Estuary.

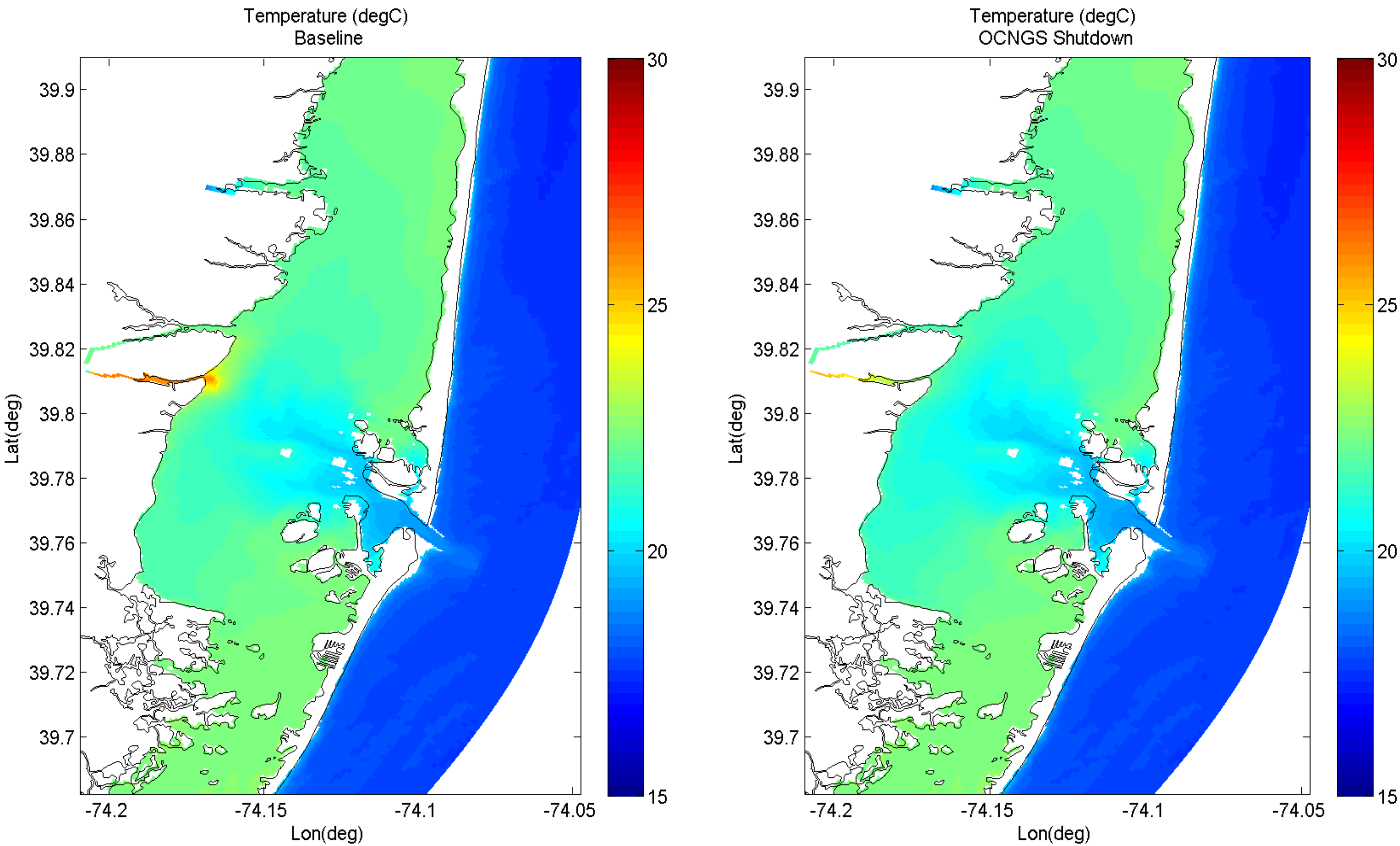
USGS science for a changing world

Water Quality Model Simulation

- Dissolved Oxygen (mg/L)
- Total Nitrogen (mg/L)
- Total Chl a (ug/L)
- TP (mg/L)
- Total Inorganic Silica (mg/L)
- Total Silica (mg/L)
- Inorganic Nitrogen (mg/L)



Example Hydrodynamic Model Results:
OCNGS Shut Down



Next Steps

- Continue Long Term Monitoring
- Complete Calibration of Water Quality Model
- Run Additional future condition scenarios
- Model runs will be complete Summer 2016
- Results will inform the development of water quality standards and loading targets

Barnegat Bay Website:
www.state.nj.us/dep/barnegatbay/

Contributors:

NJDEP: Pat Gardner, Lynette Lurig, Chris Kunz, Leigh Lager, Leslie McGeorge, Jill Lipoti, Tom Vernam, Bob Schuster, Barb Hirst, Jeff Reading, Alena Baldwin-Brown, Bruce Friedman, Jack Pflaumer, Anne Witt, Ariane Giudicelli, Amanda Lotto

USGS: Neil Ganju, Zafar Defne, Fred Spitz, Vince DePaul, Brian Andrews, Jen Miselis

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CLEAN WATER
NEW JERSEY

BRICK UTILITIES
THE BRICK TOWNSHIP MUNICIPAL UTILITIES AUTHORITY

STATE OF NEW JERSEY · PINELANDS COMMISSION

OCEAN COUNTY · NEW JERSEY
Ocean County Health Department

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ReClam the Bay
RCTB
Barnegat Bay, NJ

NJ Health
New Jersey Department of Health

NEW JERSEY DEPARTMENT HEALTH SENIOR SERVICES

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Division of Parks and Forestry
FREC
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BARNEGAT BAY PARTNERSHIP
RESEARCH · EDUCATE · RESTORE

Phosphorus Dynamics in Barnegat Bay Sediments

or

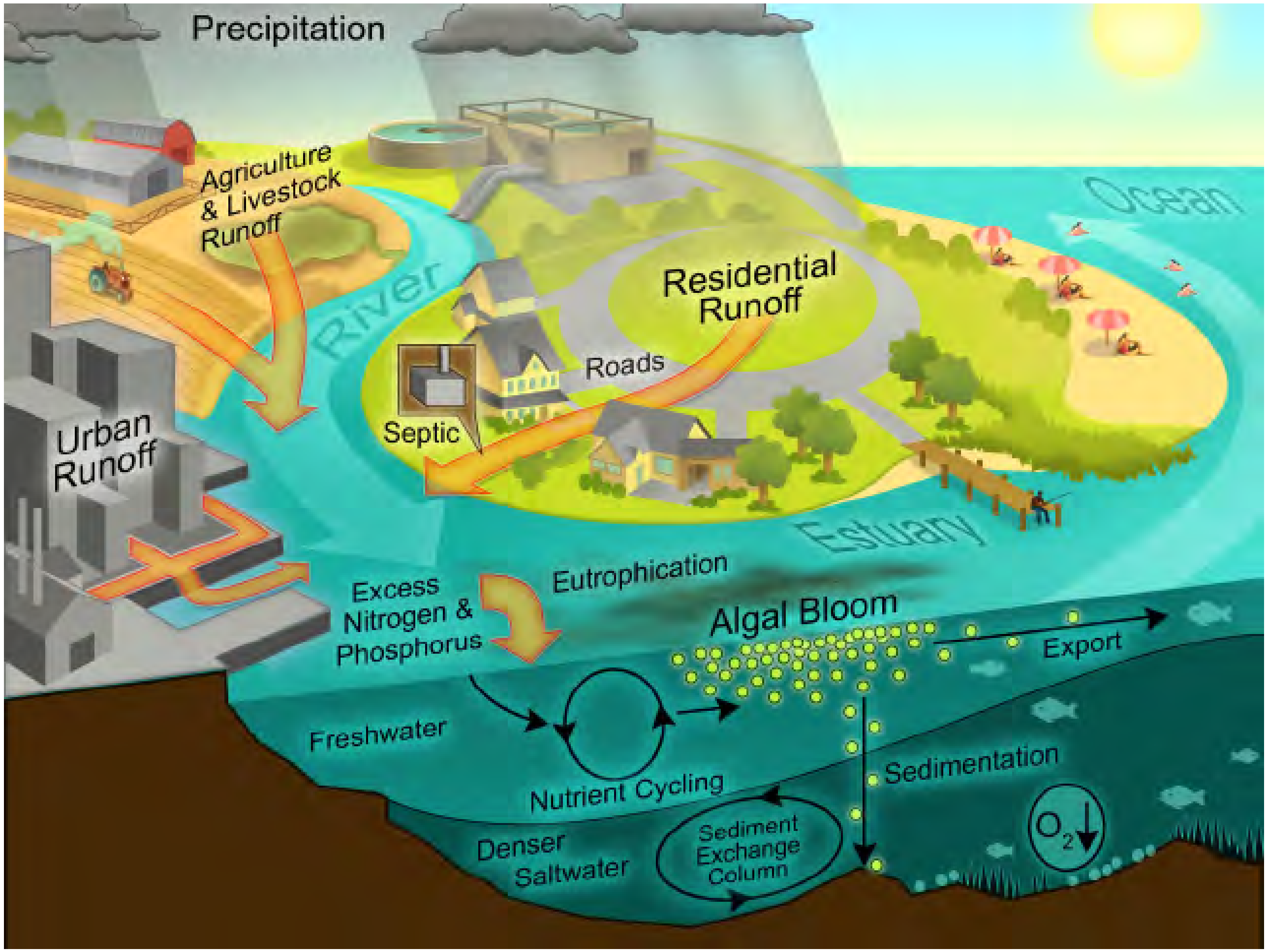
Whodunit? The Barnegat Bay Phosphorus Mystery

Nathaniel Weston
(Villanova Department of Geography & the Environment)
David Velinsky, Bhanu Paudel
(Drexel University, Academy of Natural Sciences)

Phosphorus

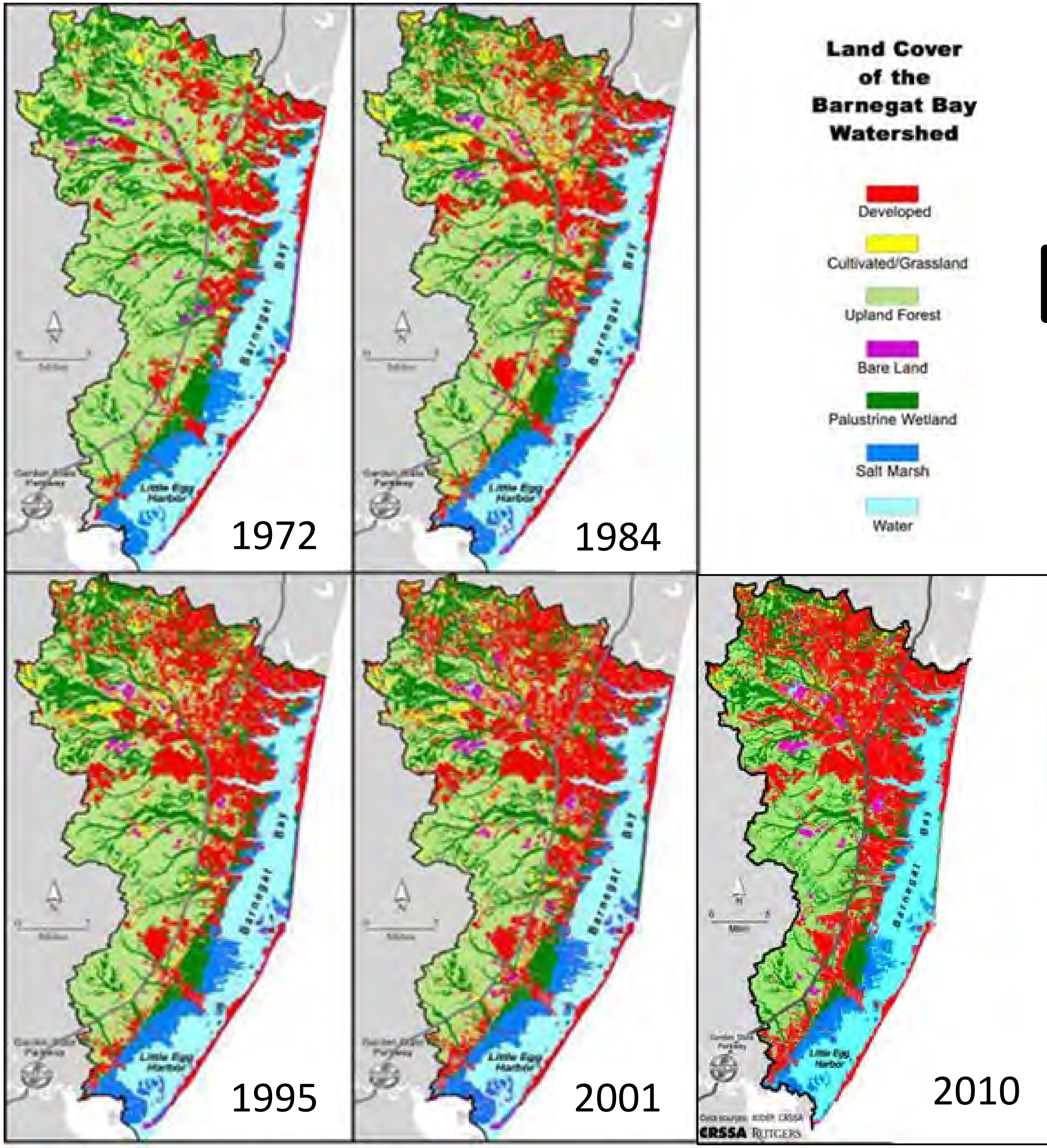
THE CRIME: PHOSPHORUS

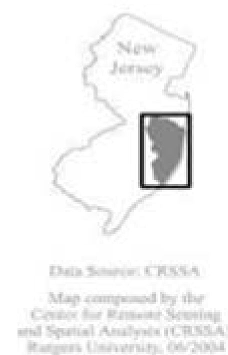
Coastal Eutrophication



University of North Carolina

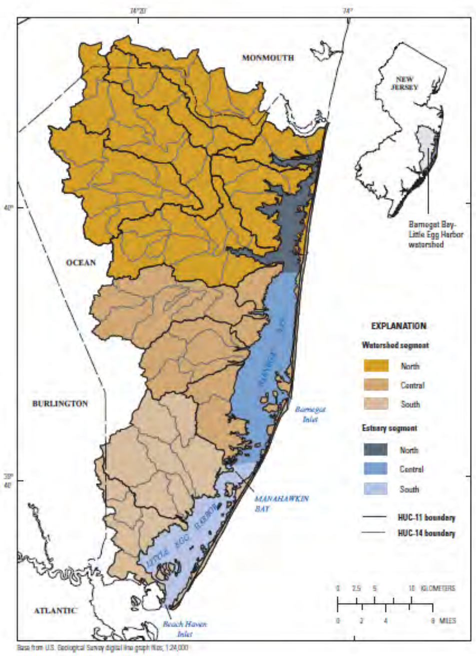
Land Use Change in Barnegat Bay Watershed

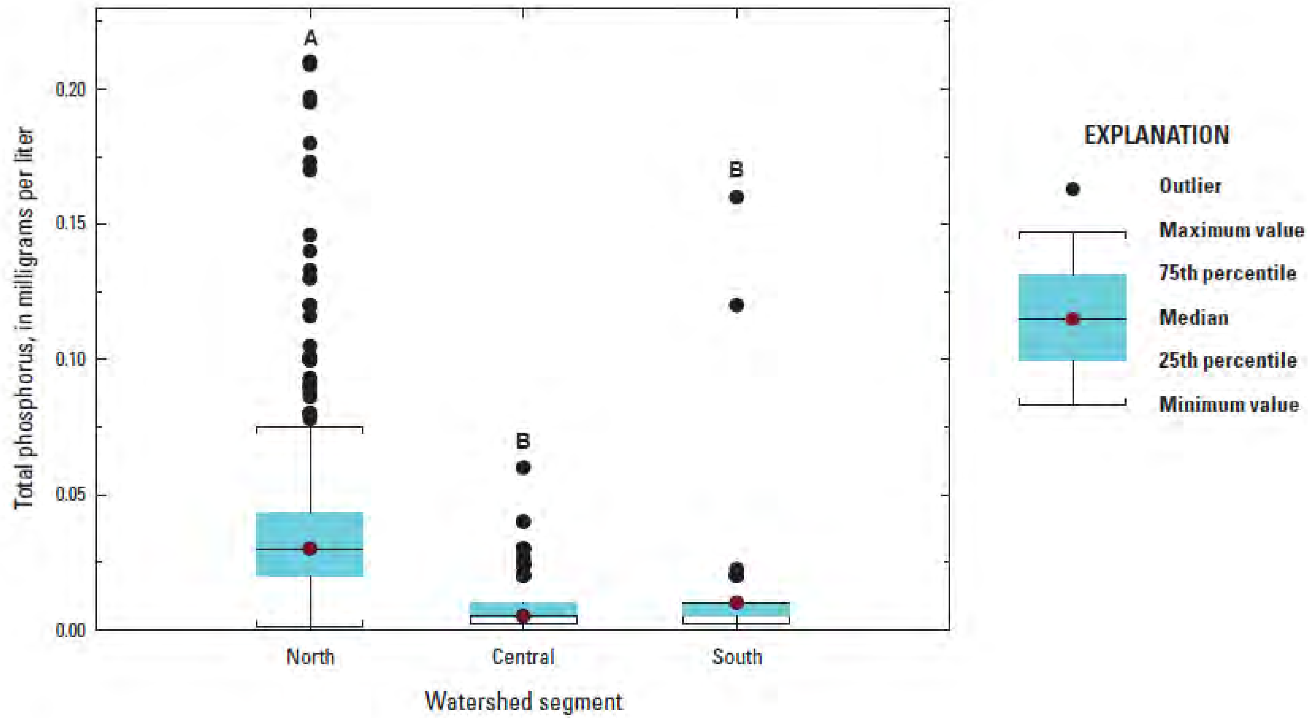




Center for Remote Sensing and Spatial Analysis
Rutgers University

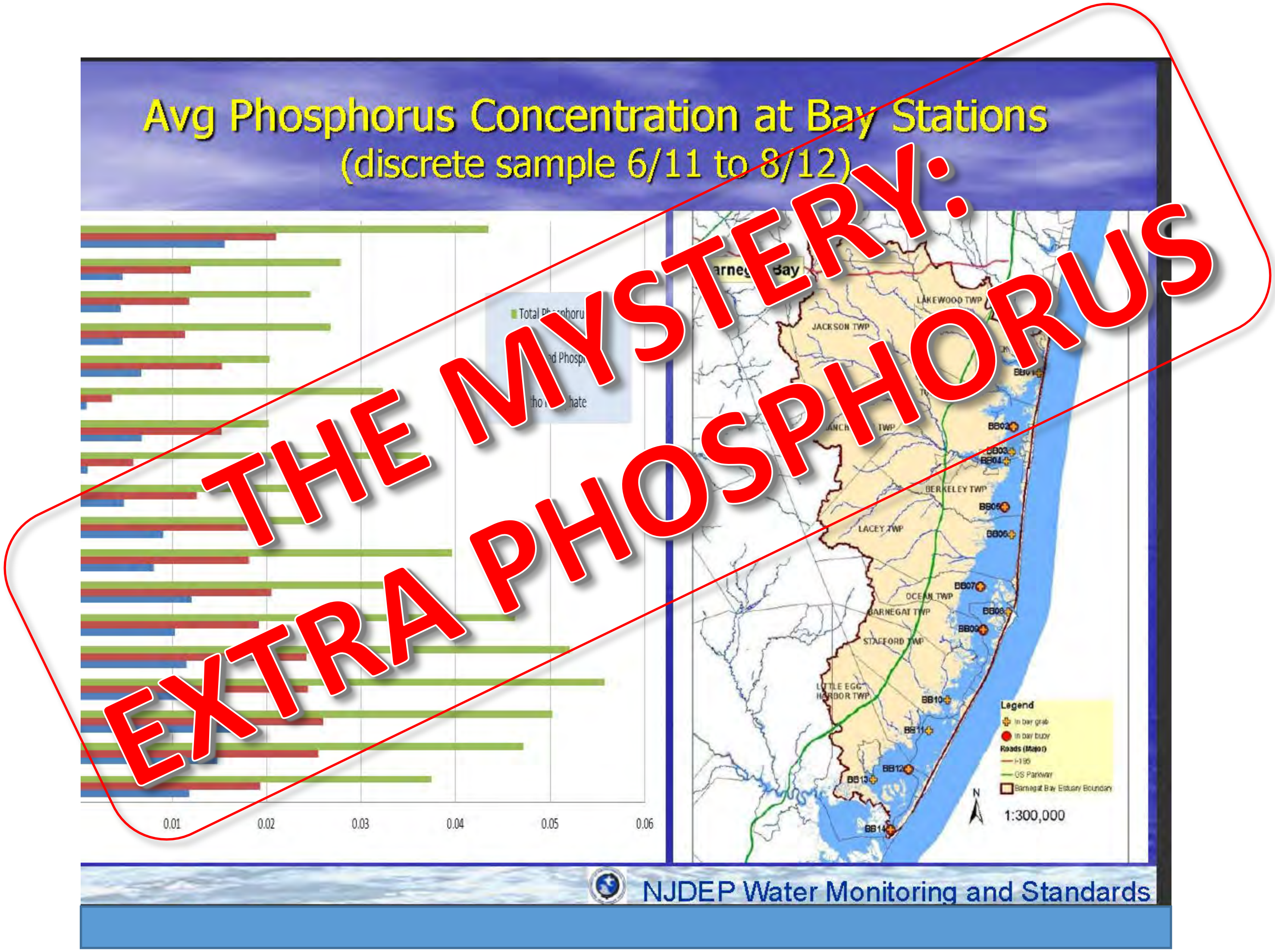
Phosphorus Inputs to the Bay



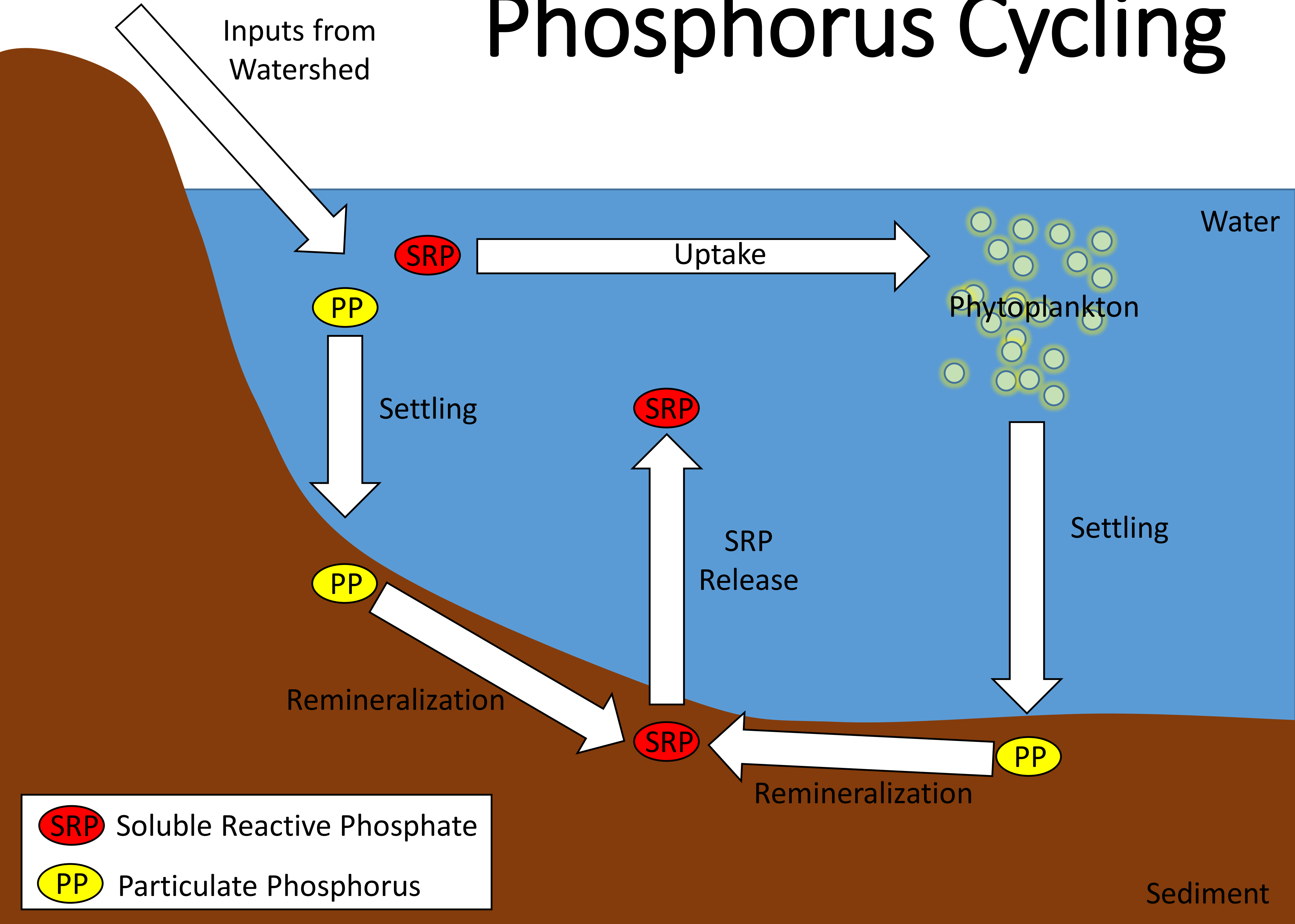


Baker et al. (2014)
USGS Report 2014-5072

Phosphorus in the Bay Itself



Phosphorus Cycling



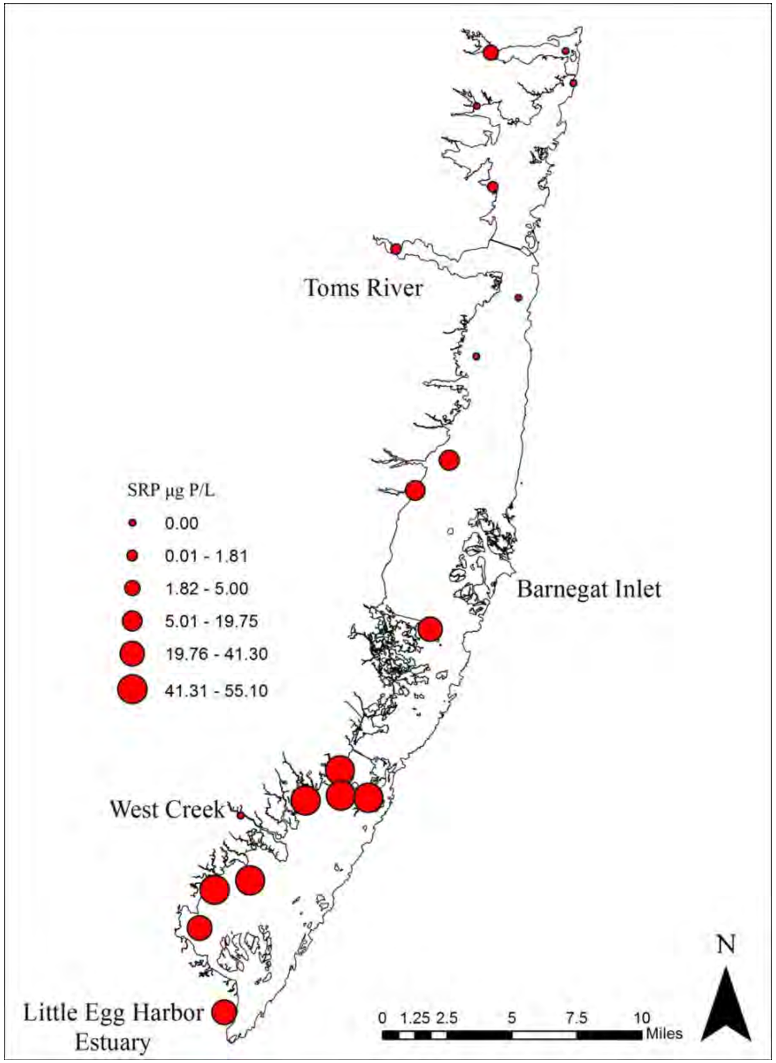

SUSPECT #1:
THE MUD

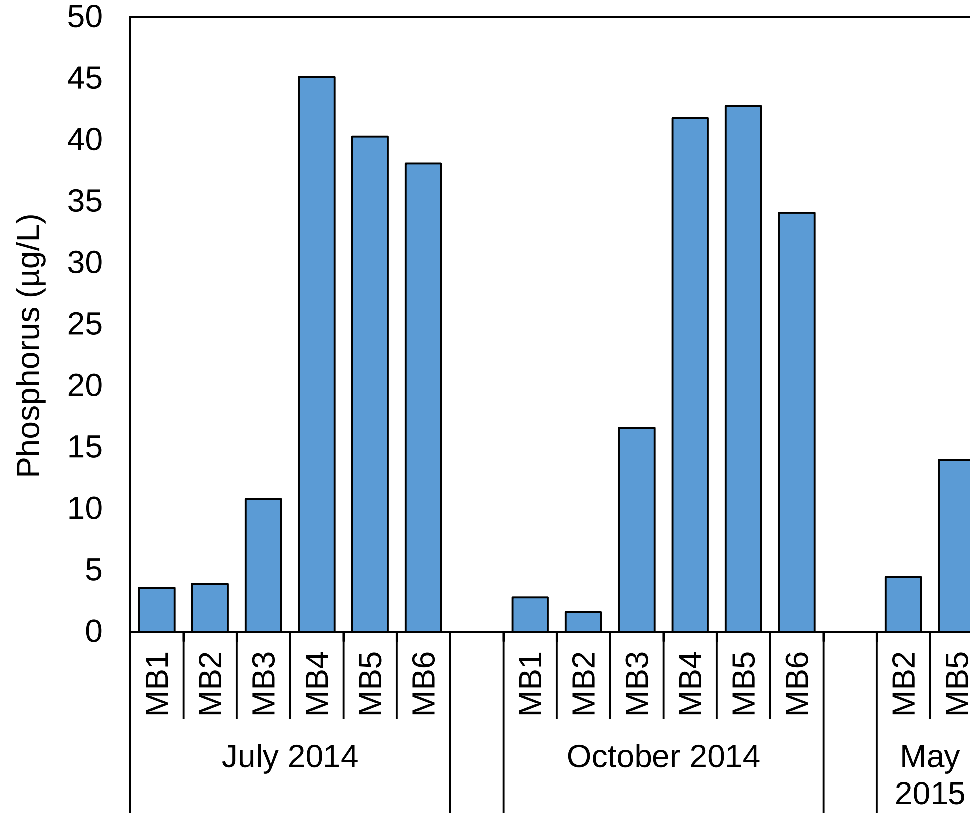
Sampling Locations

Sampling Bay Sediments & Water

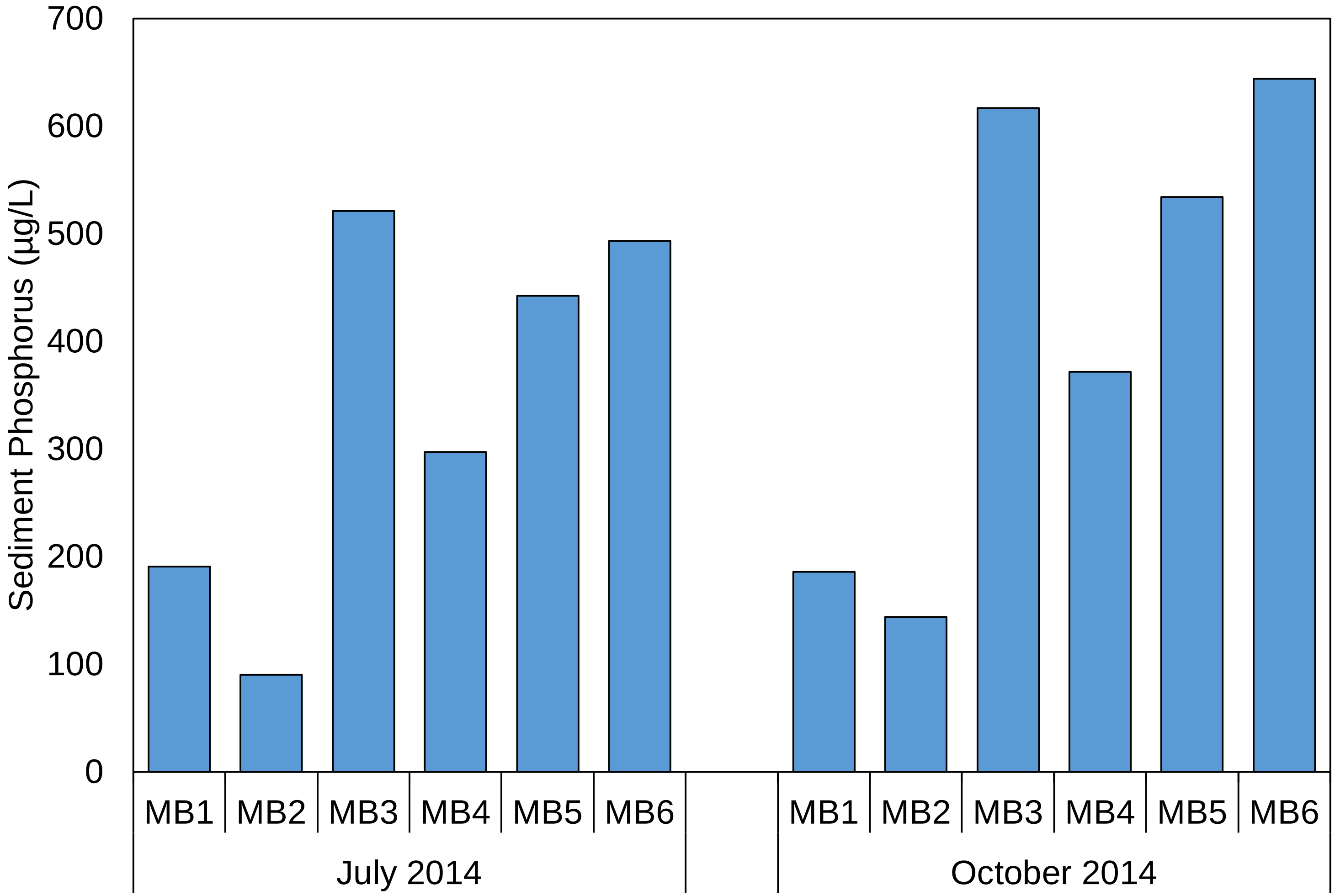
July 2014, October 2014, May 2015

Barnegat Bay Phosphorus

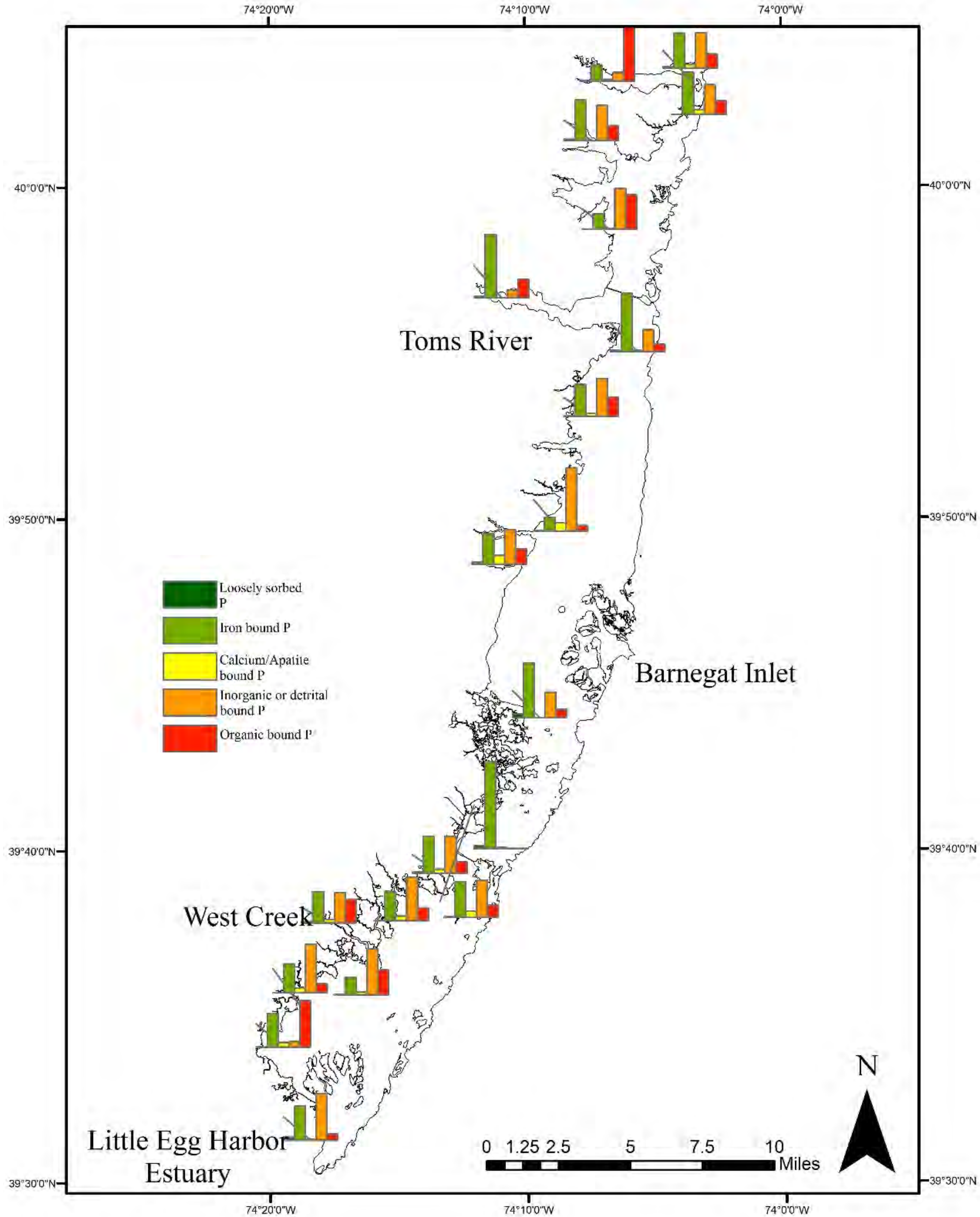


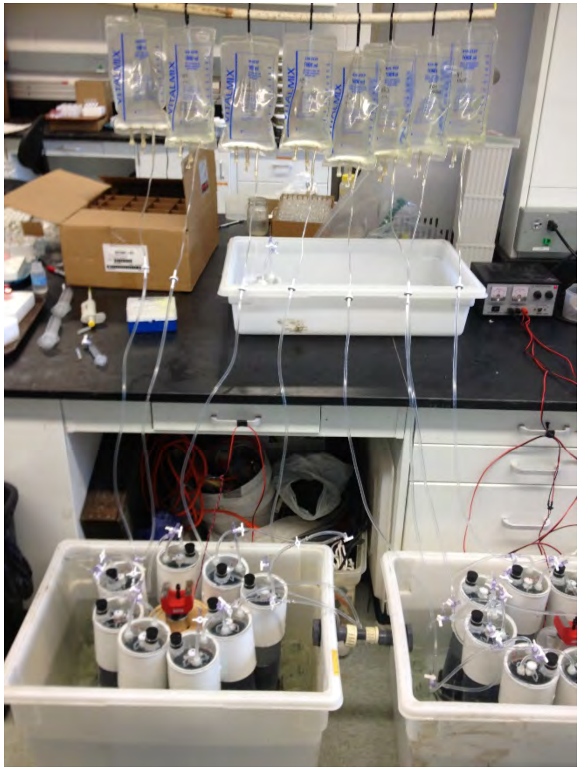


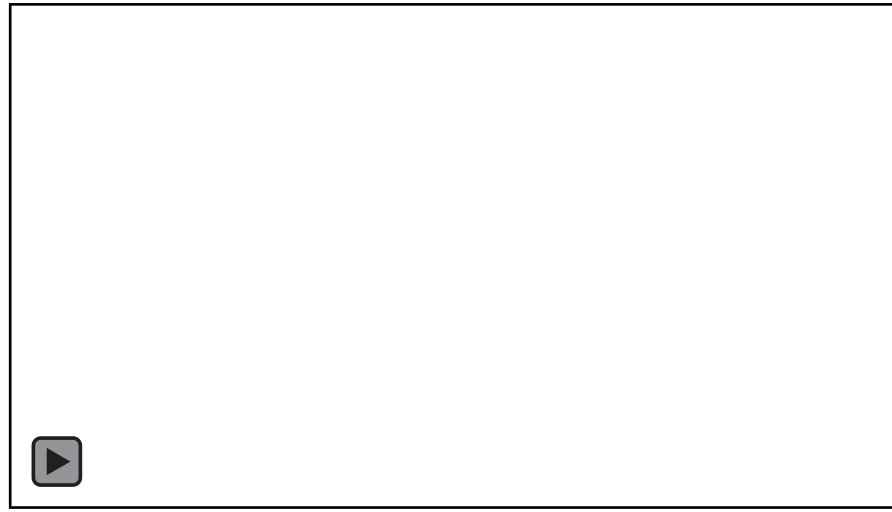
Barnegat Bay Sediment Phosphorus



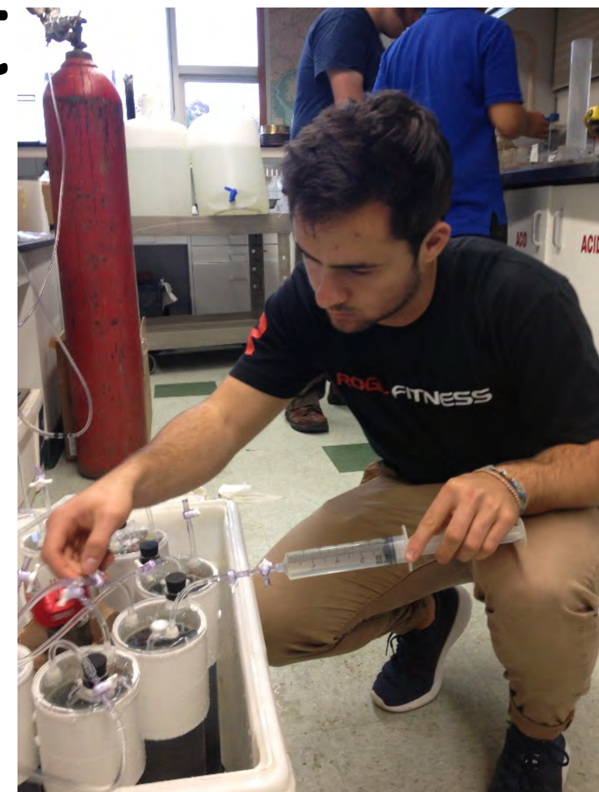
Sediment Phosphorus Minerology



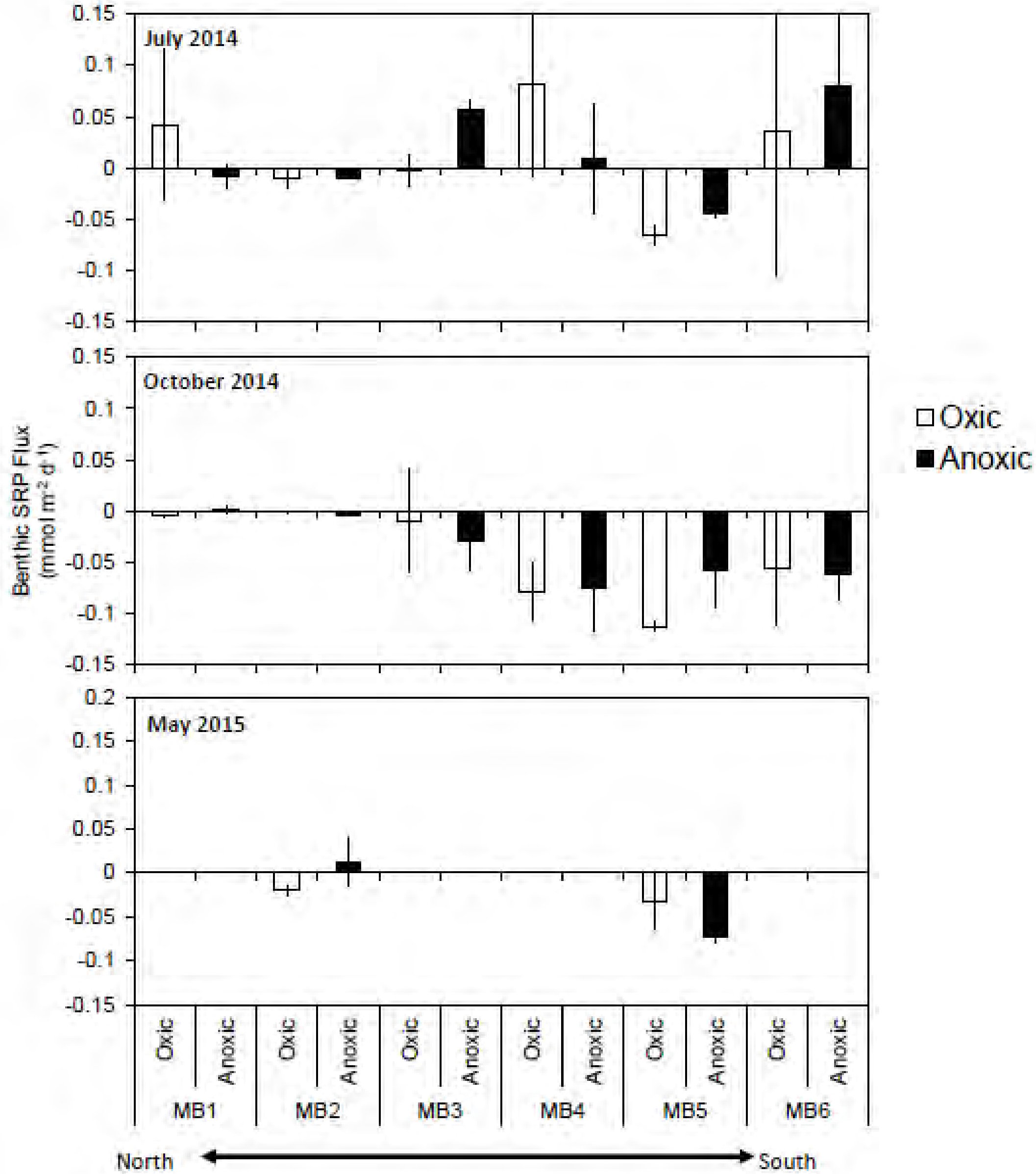


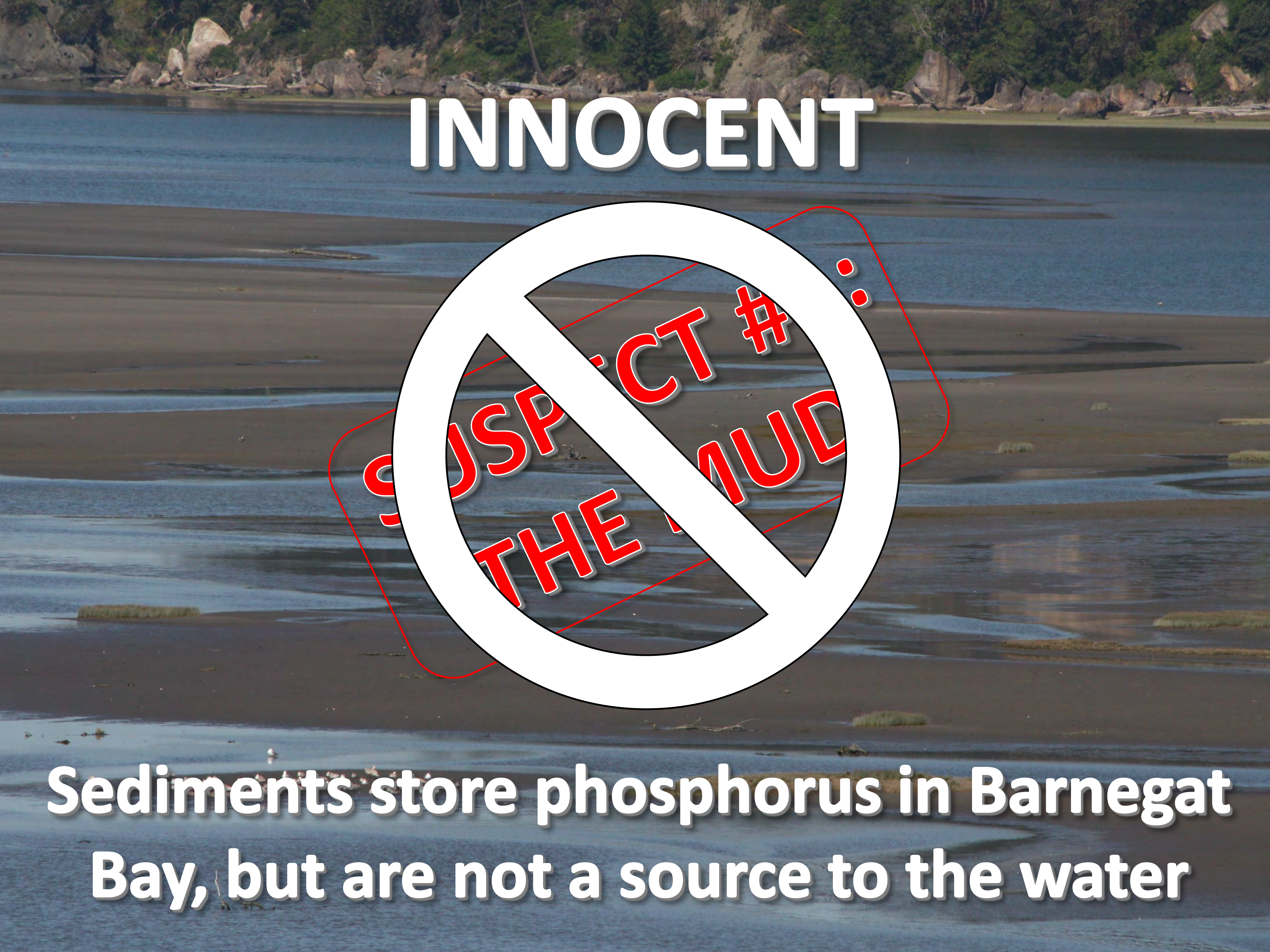


Sediment Flux

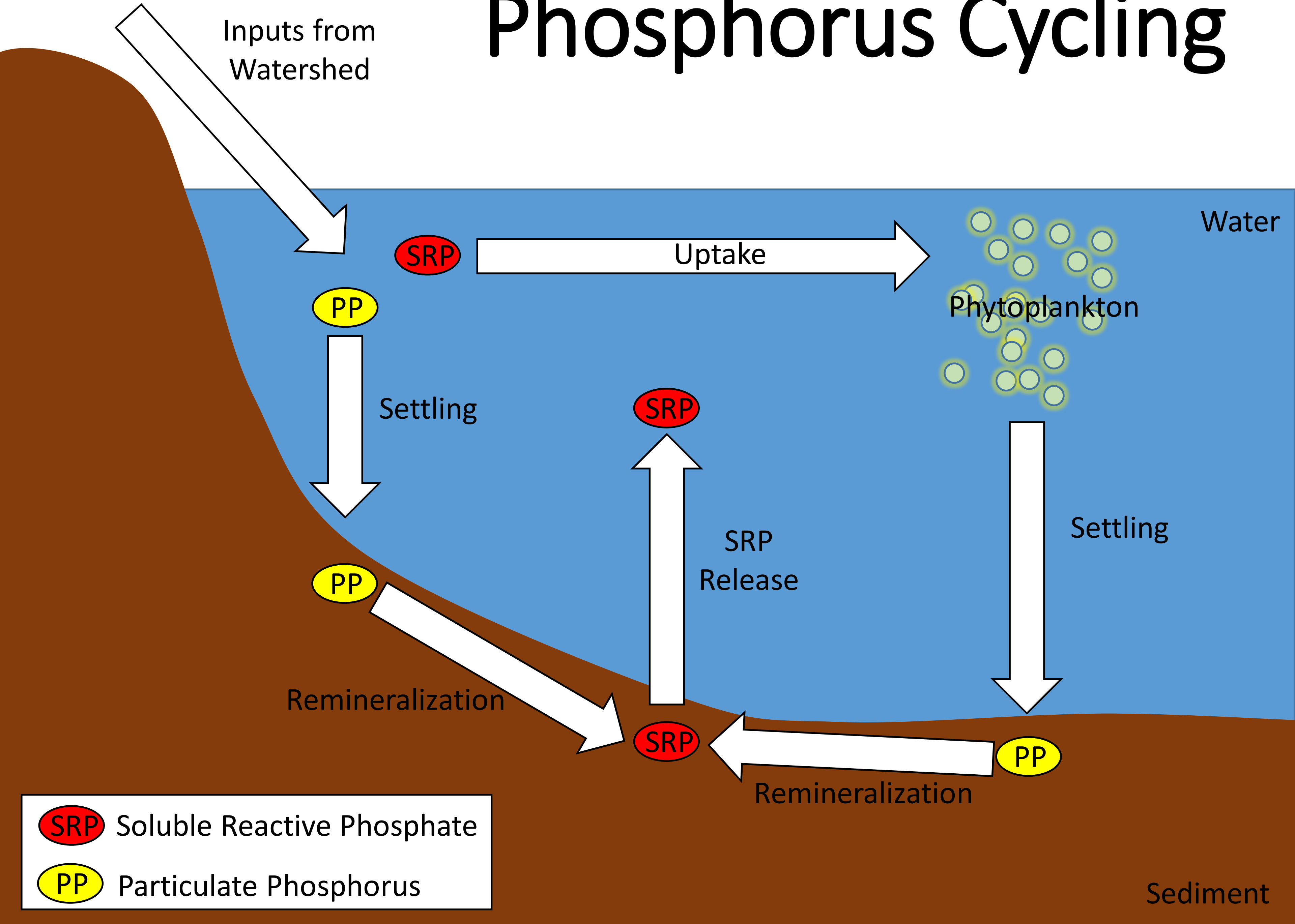


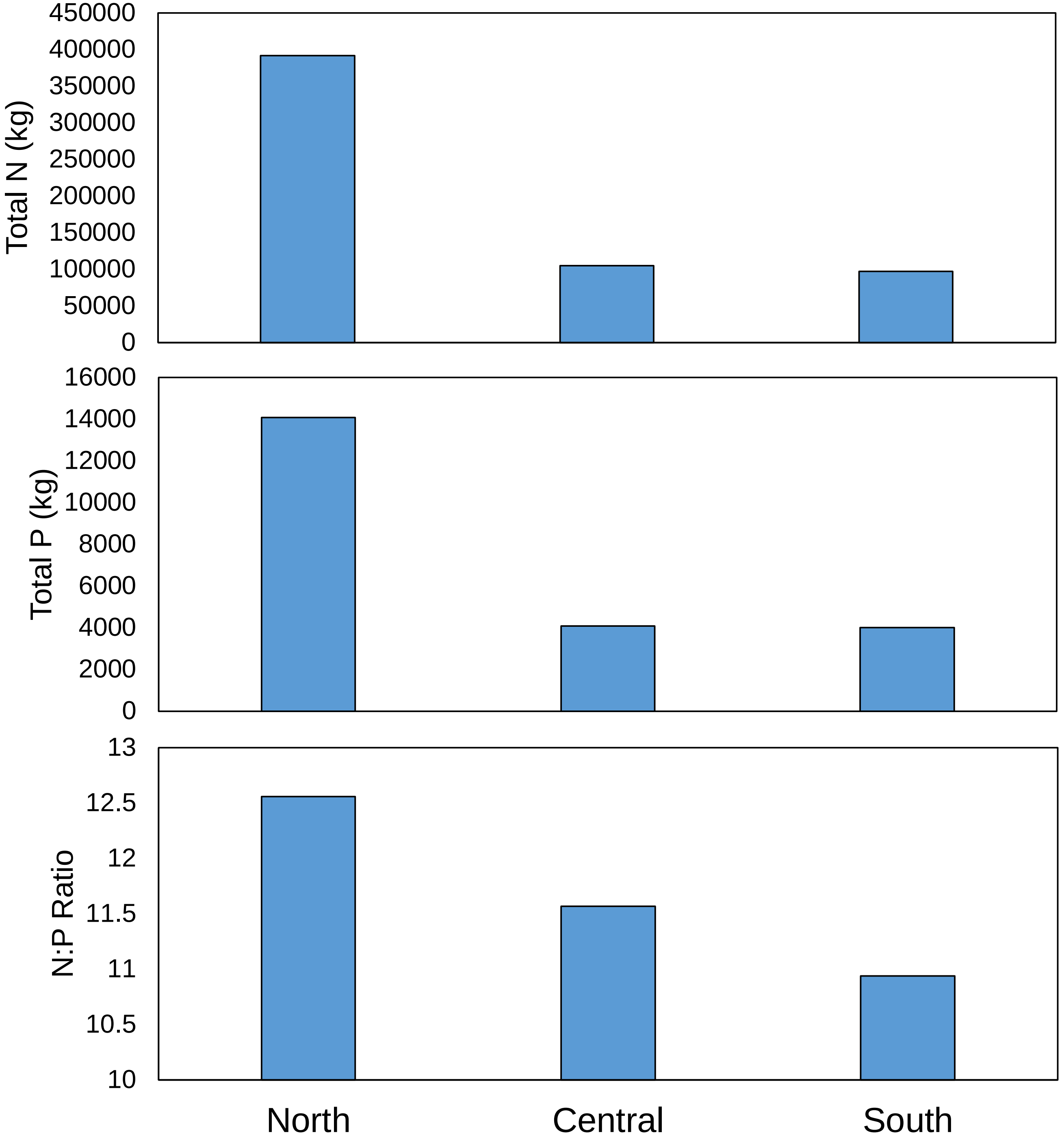
Sediment Phosphorus Exchange

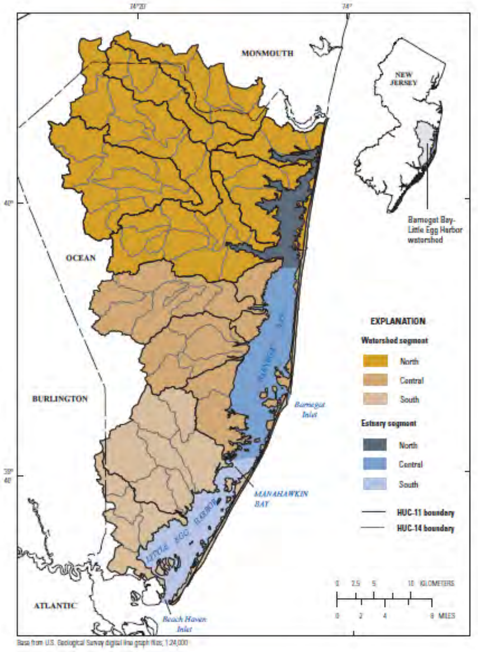



INNOCENT
Sediments store phosphorus in Barnegat Bay, but are not a source to the water

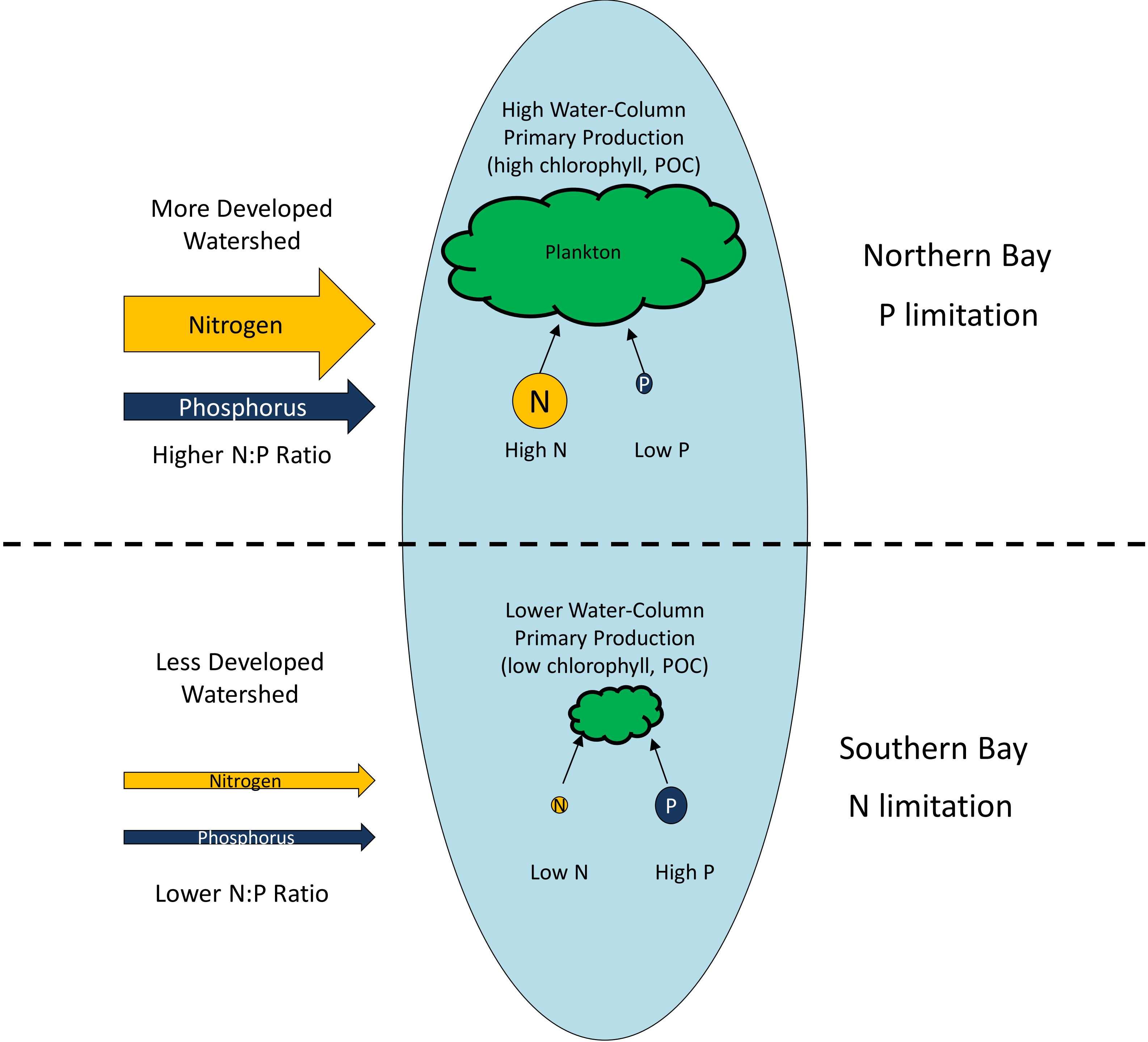
Phosphorus Cycling



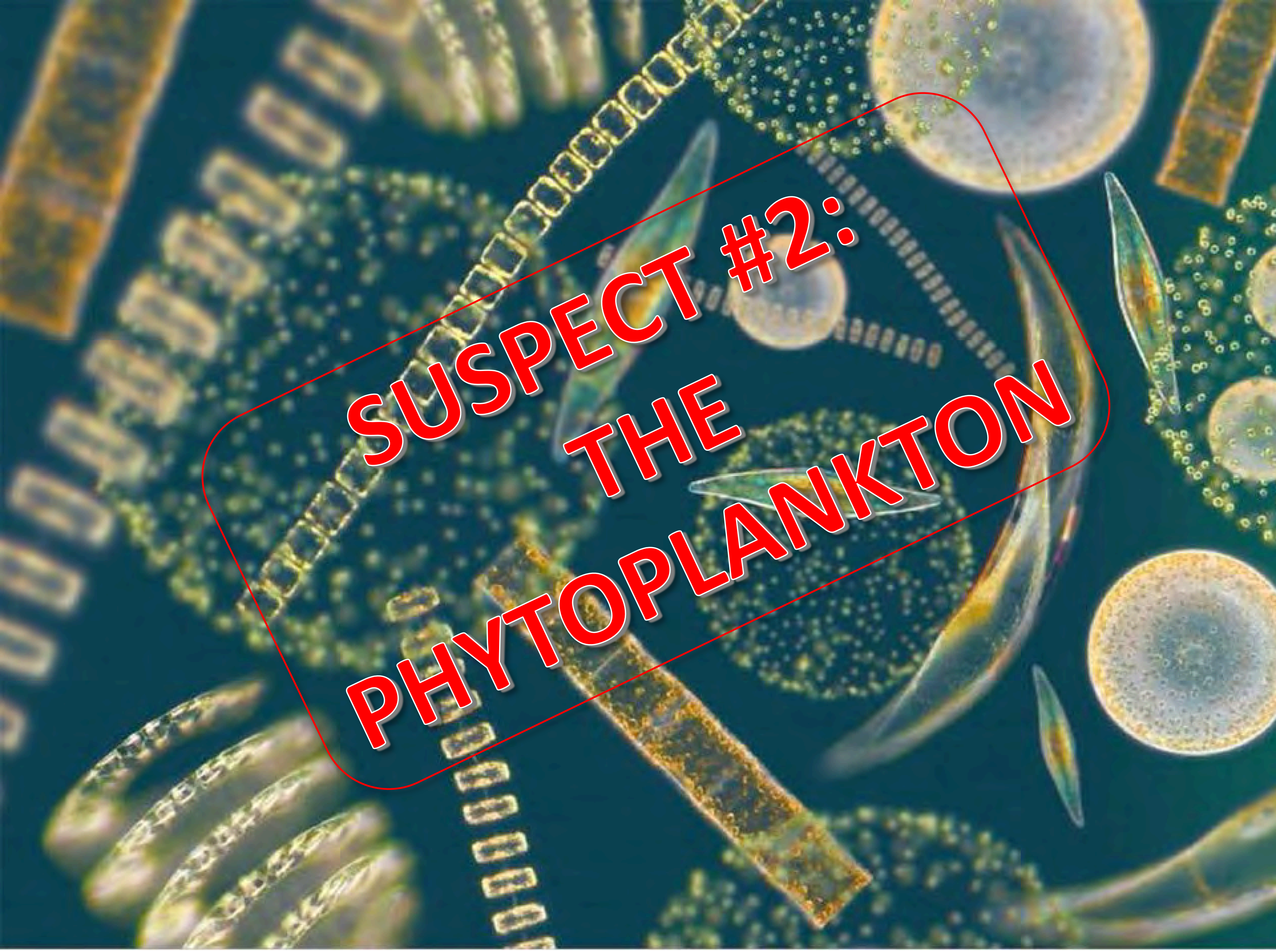




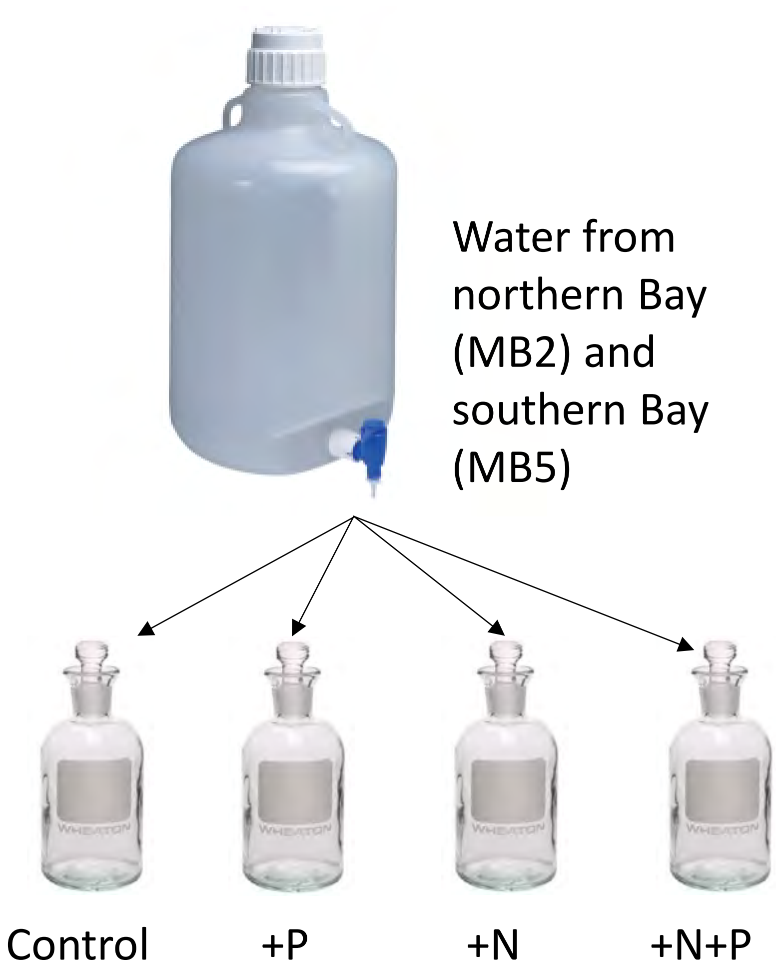
Data from:
Baker et al. (2014)
USGS Report 2014-5072



High Water-Column
Primary Production
(high chlorophyll, POC)
More Developed
Watershed
Plankton
Northern Bay
P limitation
Nitrogen
Phosphorus
N
P
High N
Low P
Higher N:P Ratio
Lower Water-Column
Primary Production
(low chlorophyll, POC)
Less Developed
Watershed
Southern Bay
N limitation
Nitrogen
Phosphorus
N
P
Low N
High P
Lower N:P Ratio


SUSPECT #2:
THE
PHYTOPLANKTON

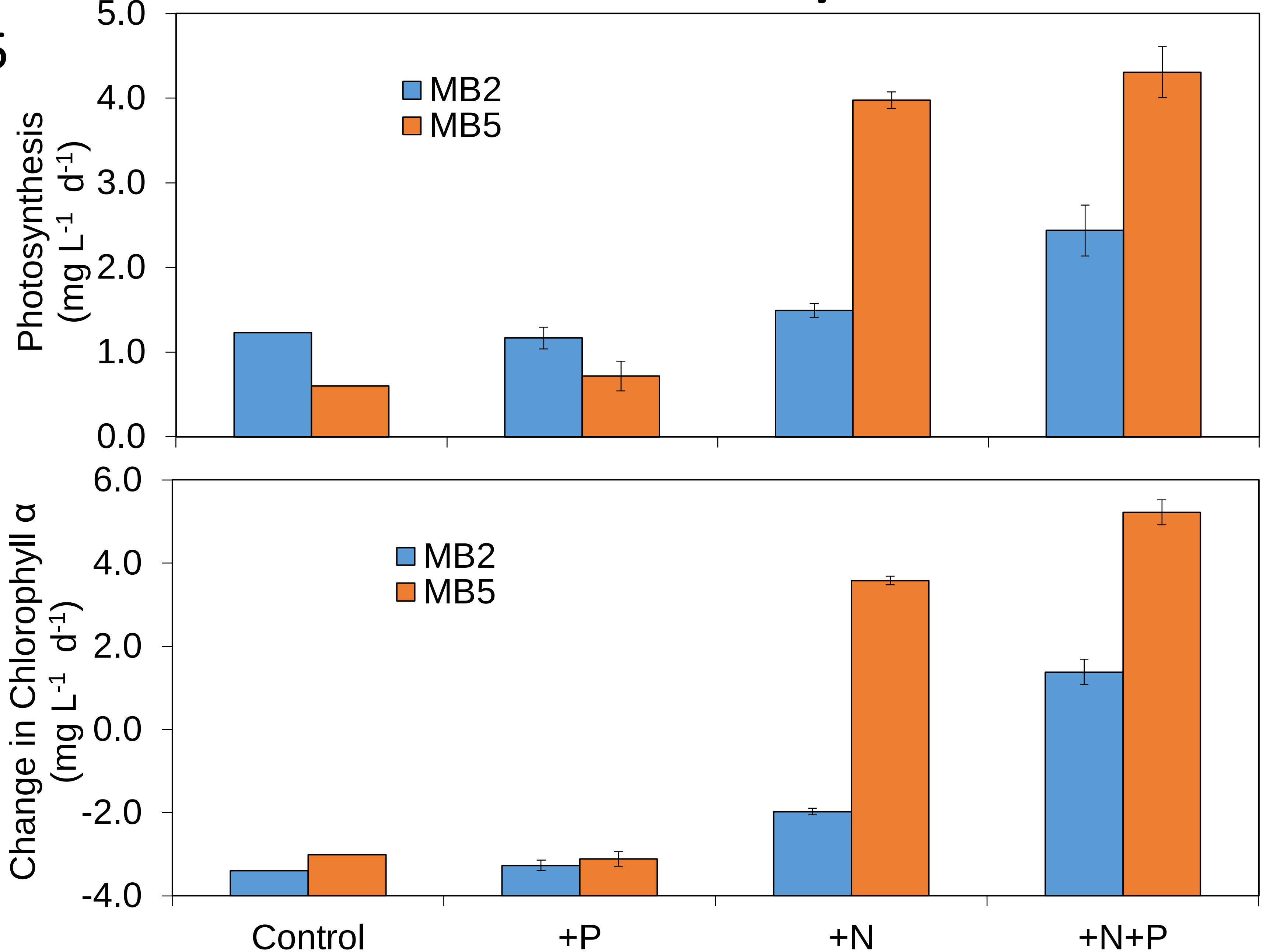
Bay Water Photosynthesis Rates & Chlorophyll α Production



May 2015

Water Column Photosynthesis

May 2015




GUILTY
SUSPECT #2:
THE
PHYTOPLANKTON
Phytoplankton respond to nutrient inputs to
the Bay, leading at least in part to observed
patterns in phosphorus and other nutrients

THE REAL CRIME: NUTRIENT POLLUTION


THE CRIME BOSS:
COASTAL
DEVELOPMENT
Effective management of nutrient inputs to
Barnegat Bay is required

Acknowledgments

- Funding from New Jersey Department of Environmental Protection

- Tom Belton
- Roger Thomas
- Paul Kiry
- George Keighton
- Sylvan Klein
- Kate Henderson
- Gerard Ondrey
- Stef Dantos
- Ashley Siefried
- John O’Connor
- Gavin Lewis

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THE ACADEMY OF NATURAL SCIENCES of DREXEL UNIVERSITY

Bottom-Dwelling Animal Community as an Indicator of Habitat Quality in Barnegat Bay

Gary Taghon, Judith Grassle, Charlotte Fuller, Rosemarie Petrecca
Department of Marine and Coastal Sciences

Bottom-dwelling animals: worms, clams, crustaceans, etc.

Conclusions

Based on the kinds and abundances of bottom-dwelling animals, habitat quality in Barnegat Bay-Little Egg Harbor is good to high

Based on limited (older) data, largely unchanged from 40 years ago

Abundance of species sensitive to environmental stressors may be a useful indicator of water quality

Why use bottom-dwelling animals to infer habitat quality?

Most species are relatively sedentary

Relatively long-lived

Species differ in tolerances to stress

Important ecological roles

The types of species and how abundant they are can be used as an “index” of habitat quality

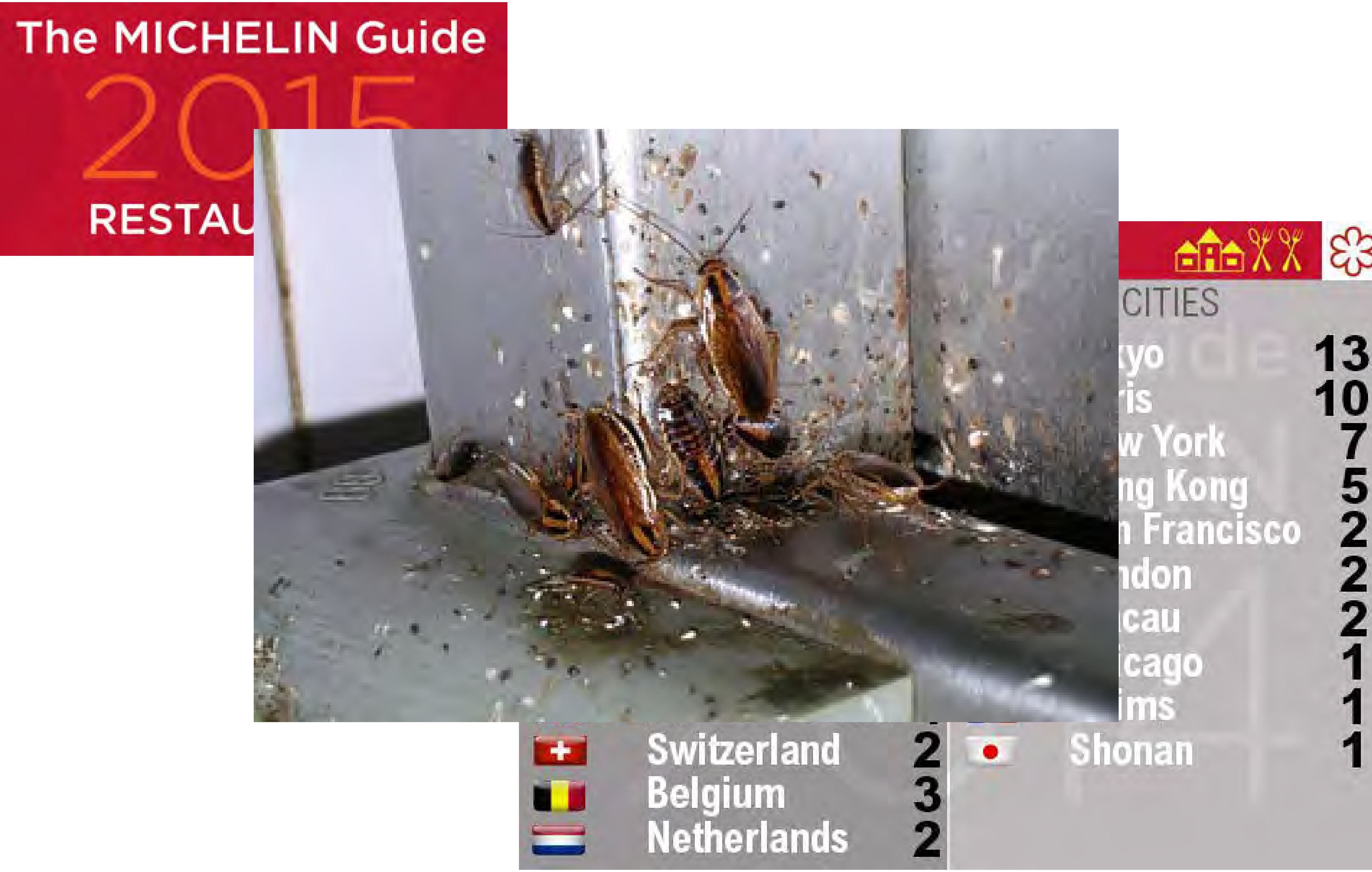
An analogy: rating restaurants

The MICHELIN Guide
2015
RESTAURANTS

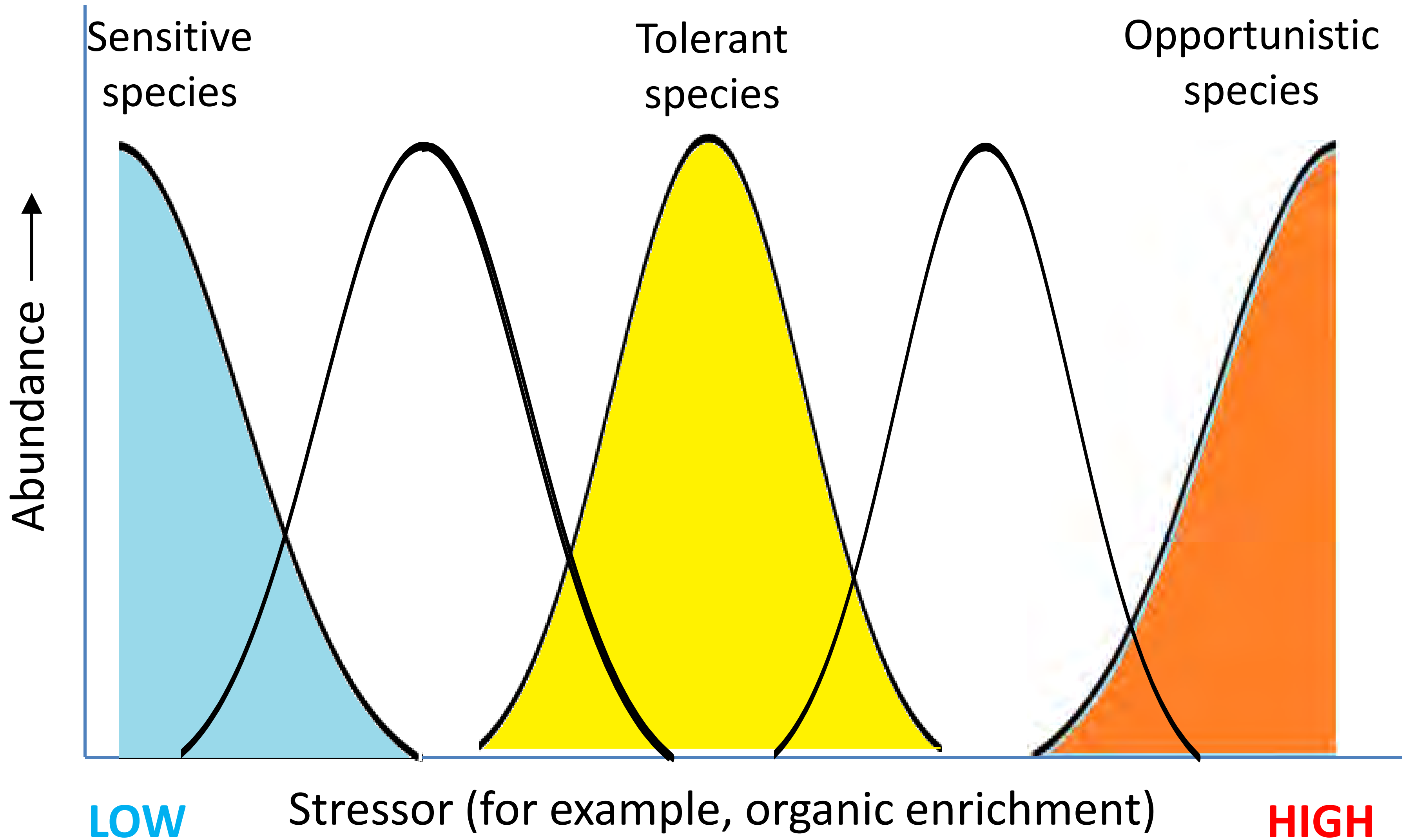
3-Star restaurants worldwide

COUNTRY		CITIES	
Japan	28	Tokyo	13
France	27	Paris	10
Germany	11	New York	7
US	10	Hong Kong	5
Spain	8	San Francisco	2
Italy	8	London	2
China	7	Macau	2
Spain	7	Chicago	1
The UK Ireland	4	Reims	1
Switzerland	2	Shonan	1
Belgium	3		
Netherlands	2		

An analogy: rating restaurants



A commonly observed response: Species differ in their sensitivity or tolerance to stress



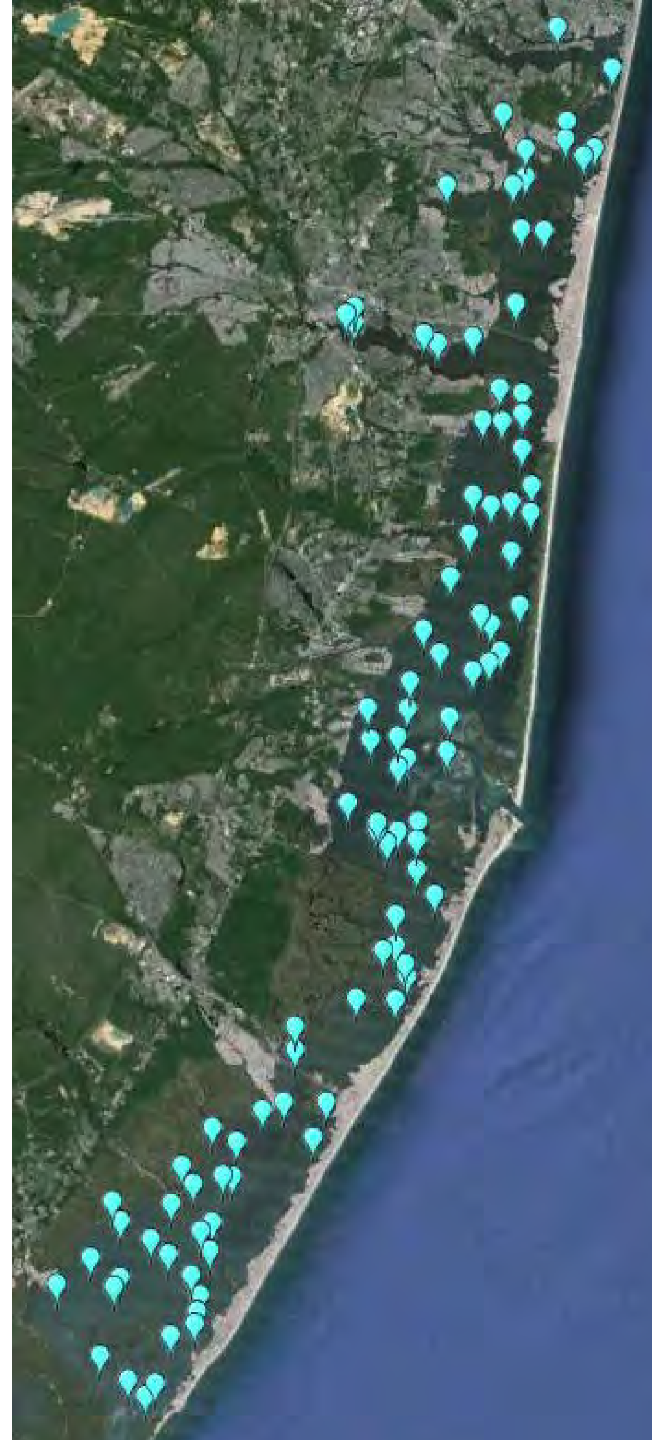
What we did

Sediment sampling at 100 locations in July 2012, 2013, 2014

Total of 600 samples

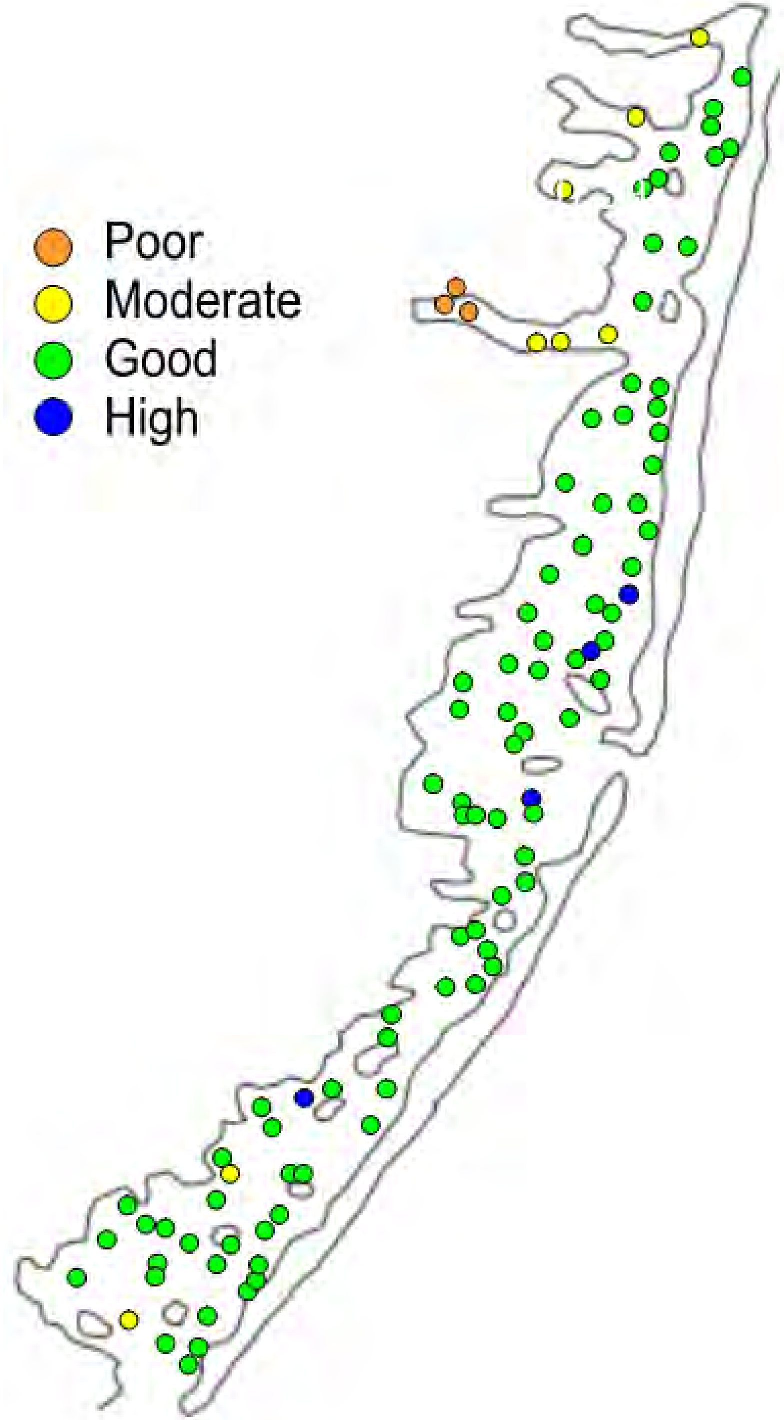
Total of 184 species

Total of 156,527 individuals



What we conclude

Most of Barnegat Bay-Little Egg Harbor (89 of 100 stations) is in 'good' or 'high' condition

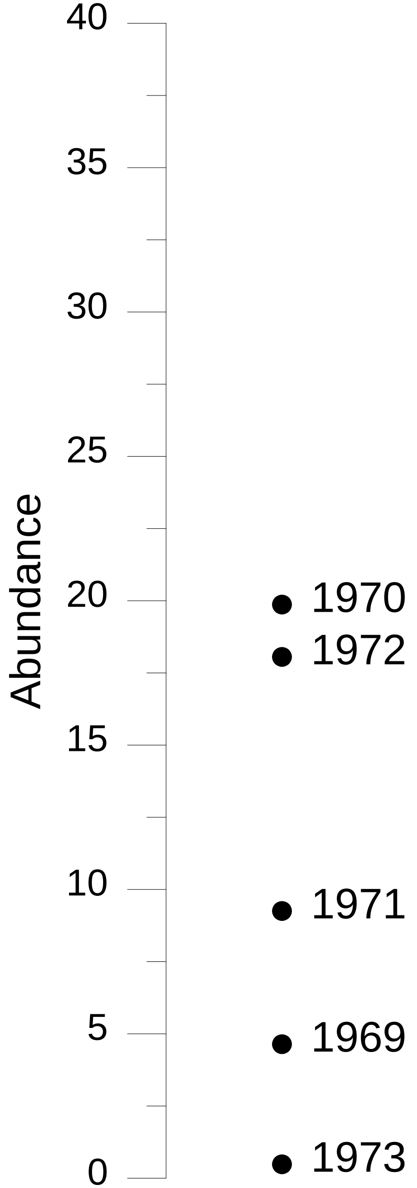


How does animal community in the past compare with the present?

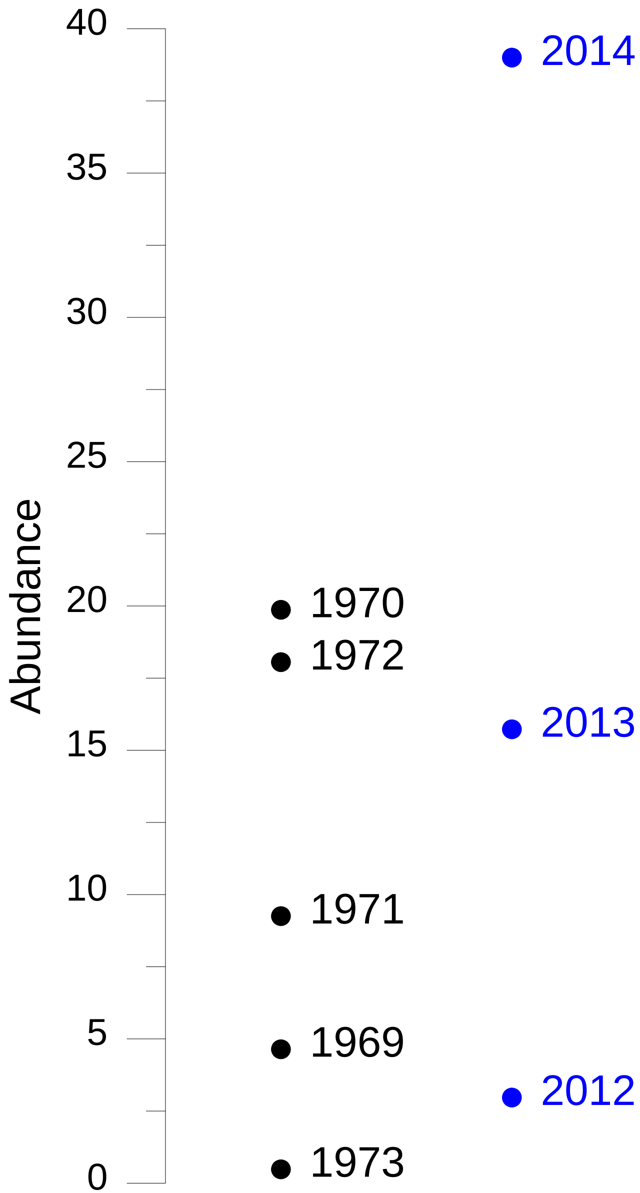
Five years of sampling, 1969-1973

Three years of sampling, 2012-2014

How do abundances in the past compare with the present?

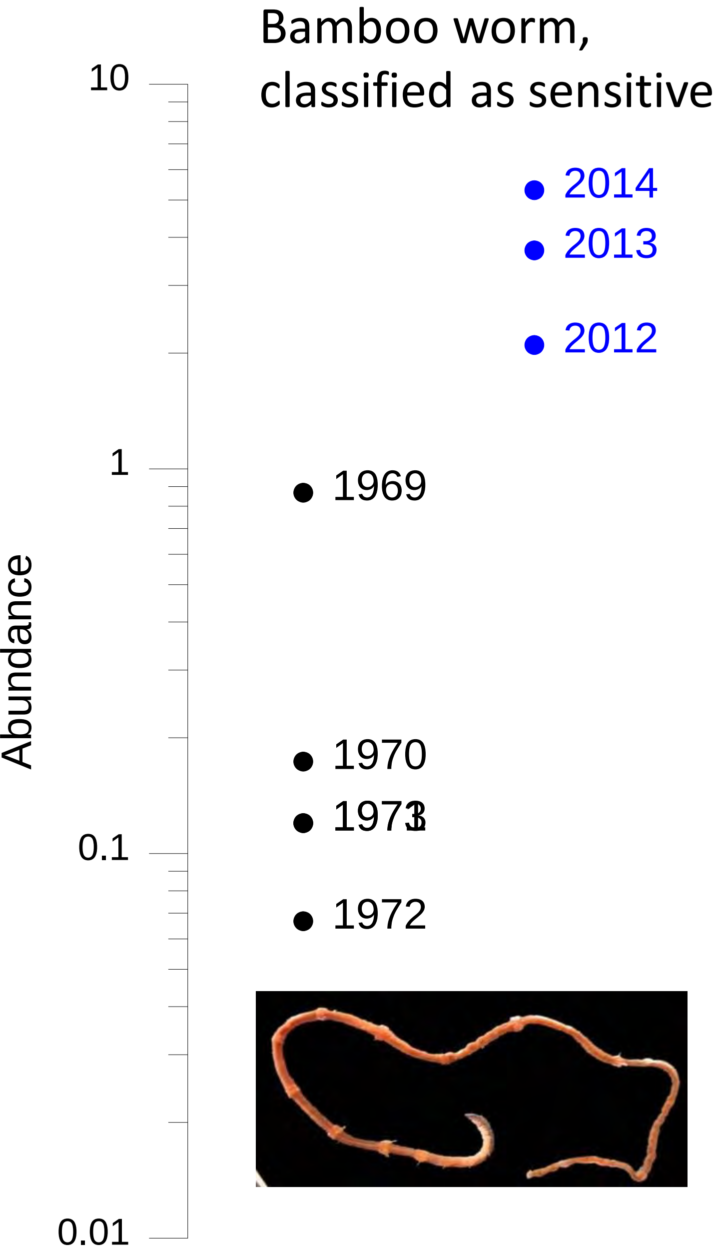


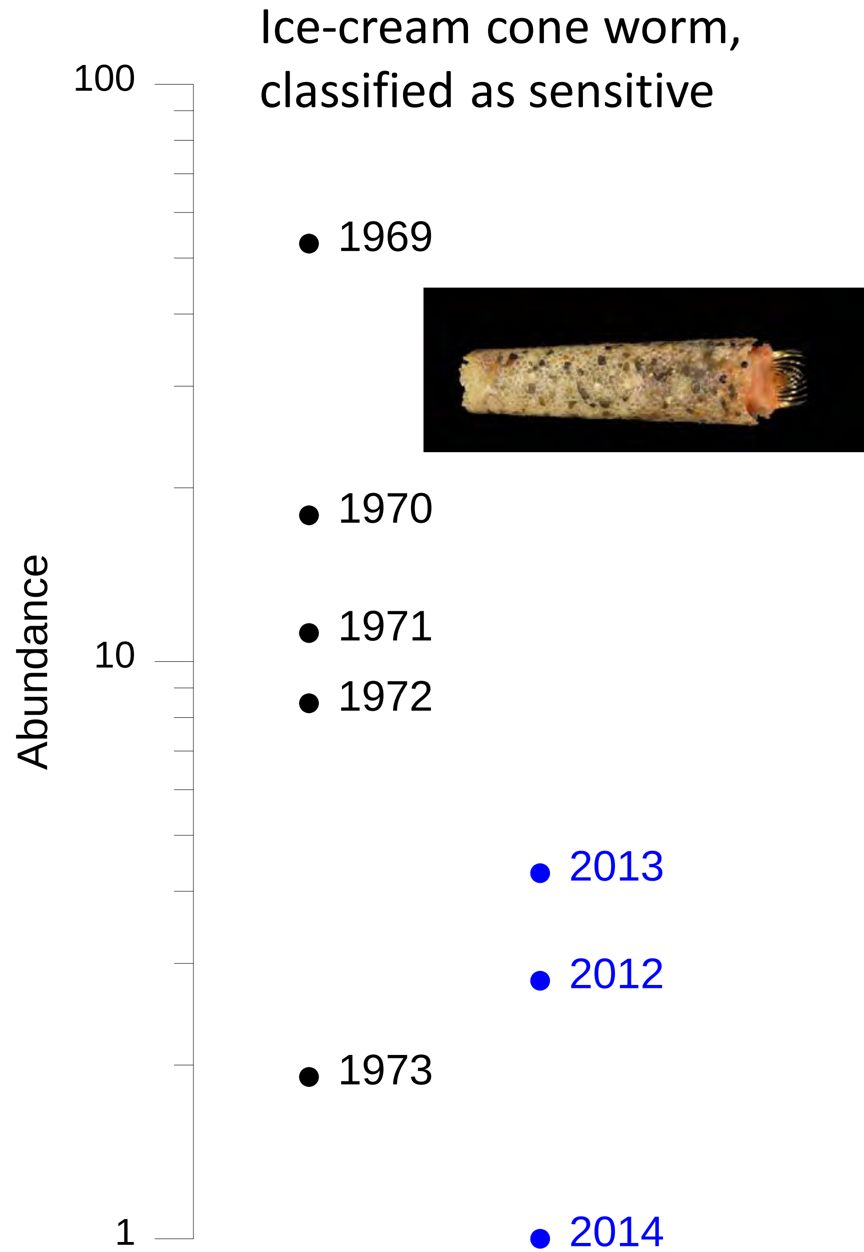
Four-eyed amphipod, classified as sensitive-to-tolerant



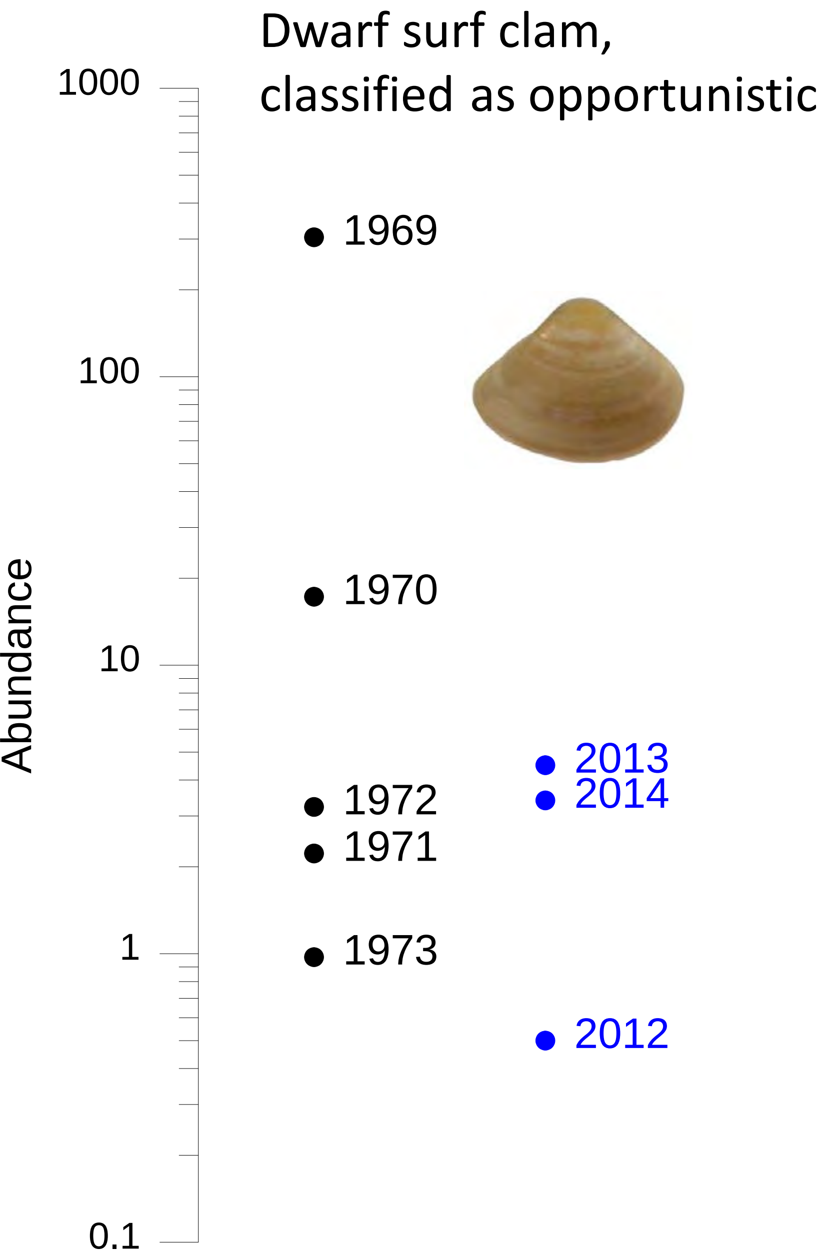
Four-eyed amphipod, classified as sensitive-to-tolerant

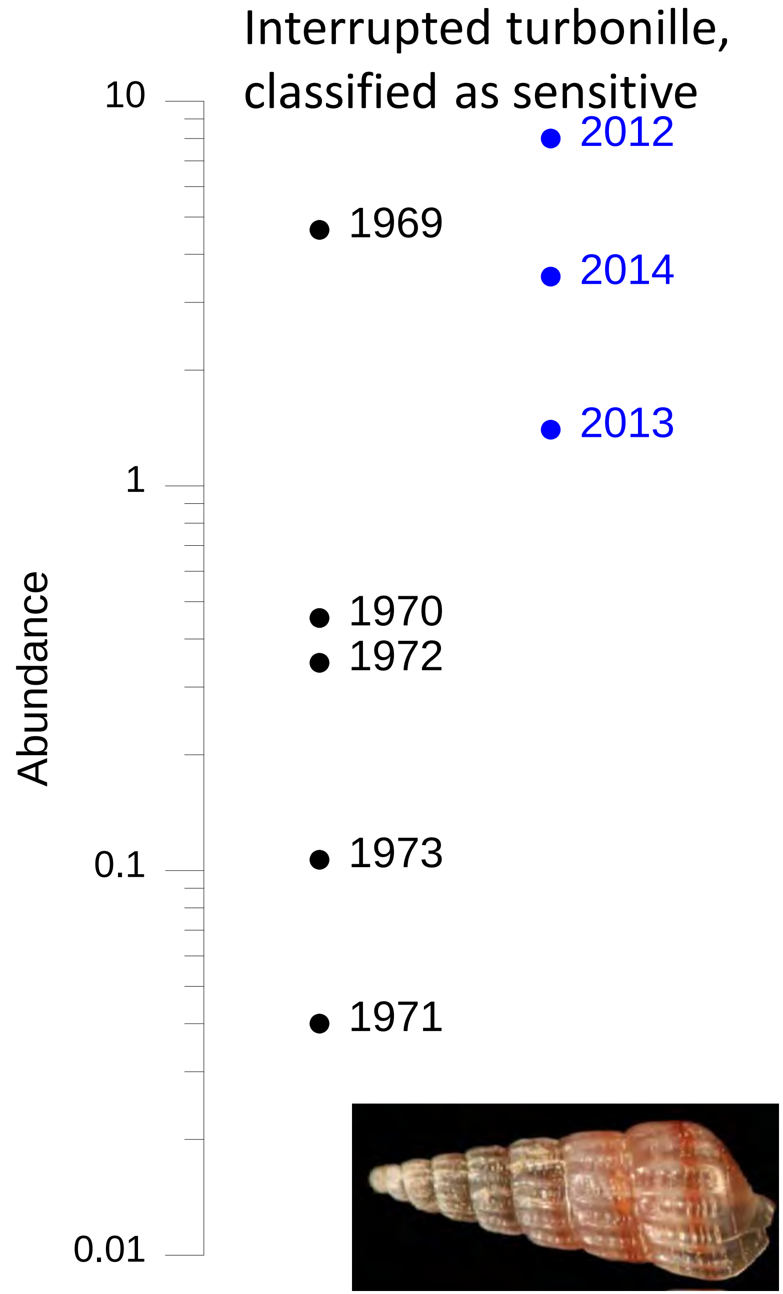
How do abundances in the past compare with the present?



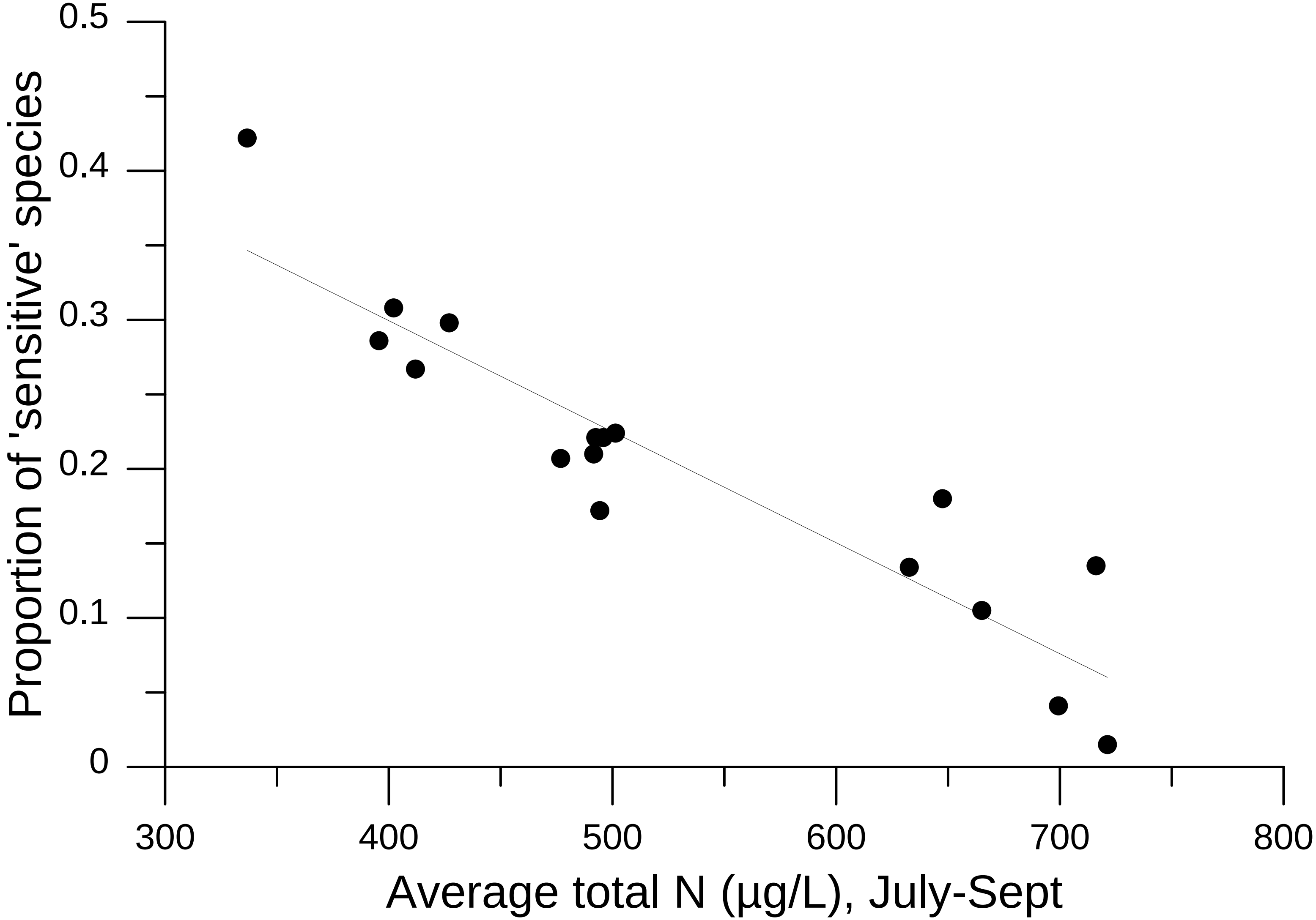


How do abundances in the past compare with the present?





The proportion of ‘sensitive’ species decreases as total nitrogen concentration in the water increases



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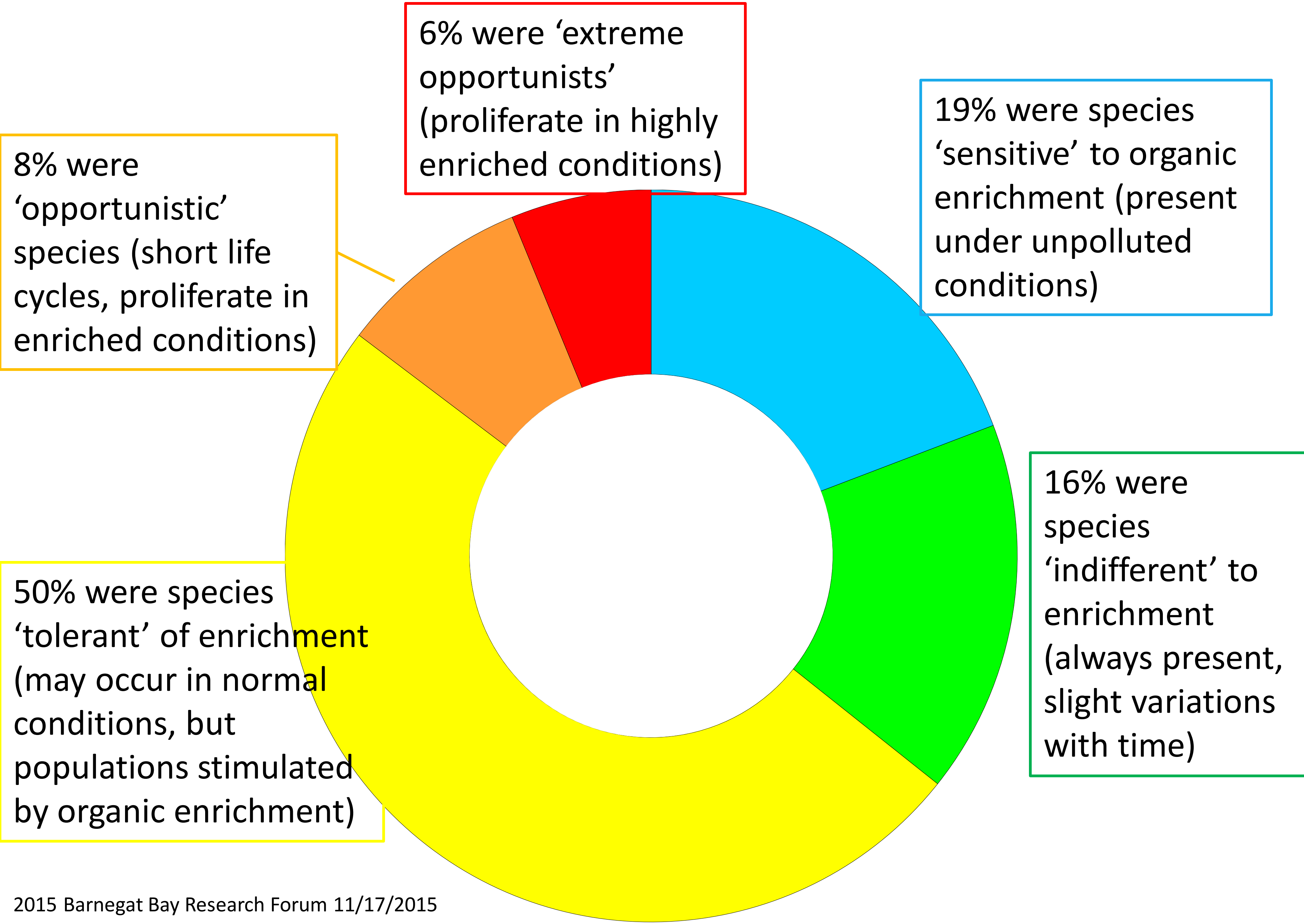
Based on limited (older) data, largely unchanged from 40 years ago

Abundance of species sensitive to environmental stressors may be a useful indicator of water quality

Classification of benthic invertebrates in BB-LEH on basis of sensitivity to enrichment



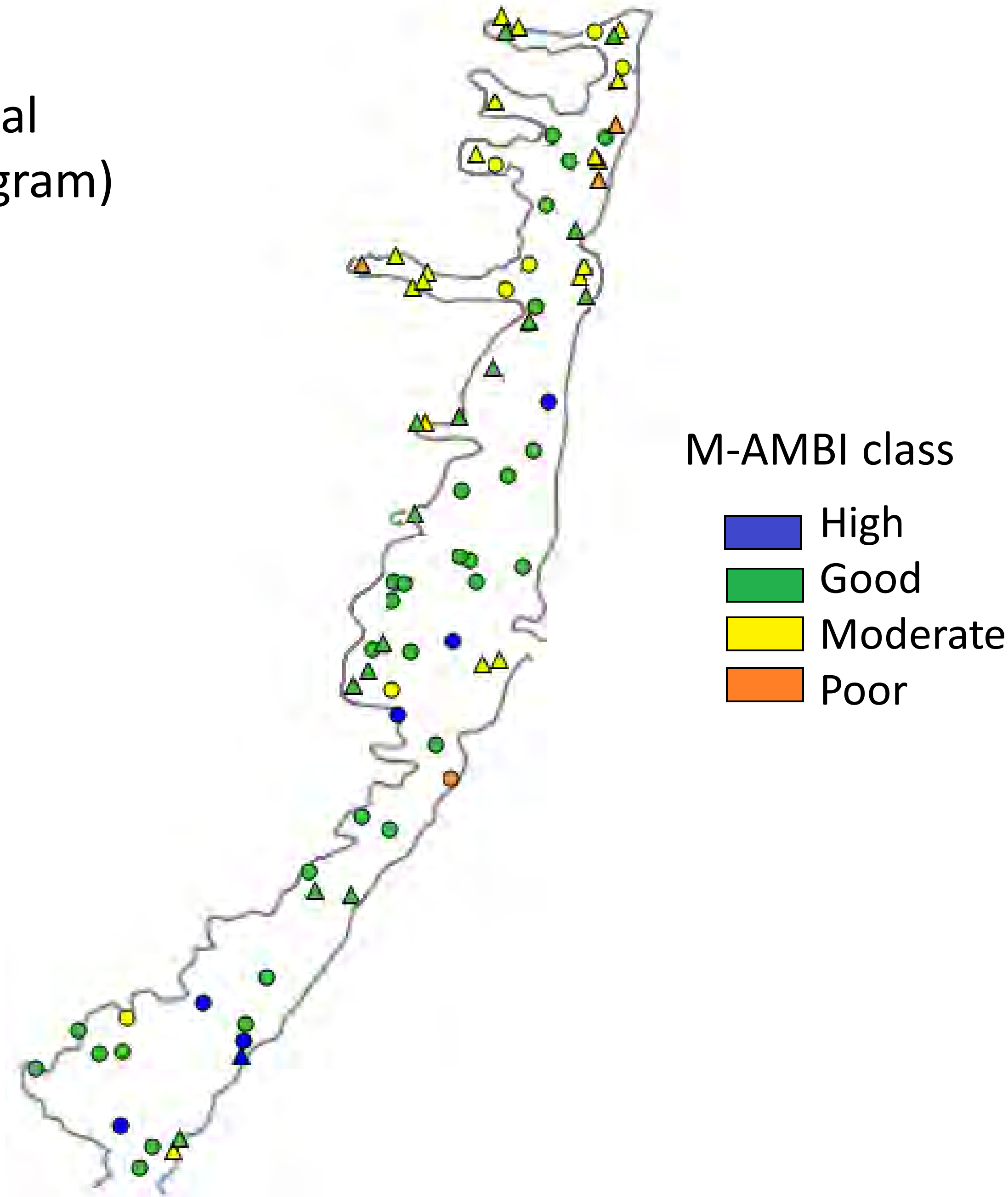
How does benthic community today compare with the past?

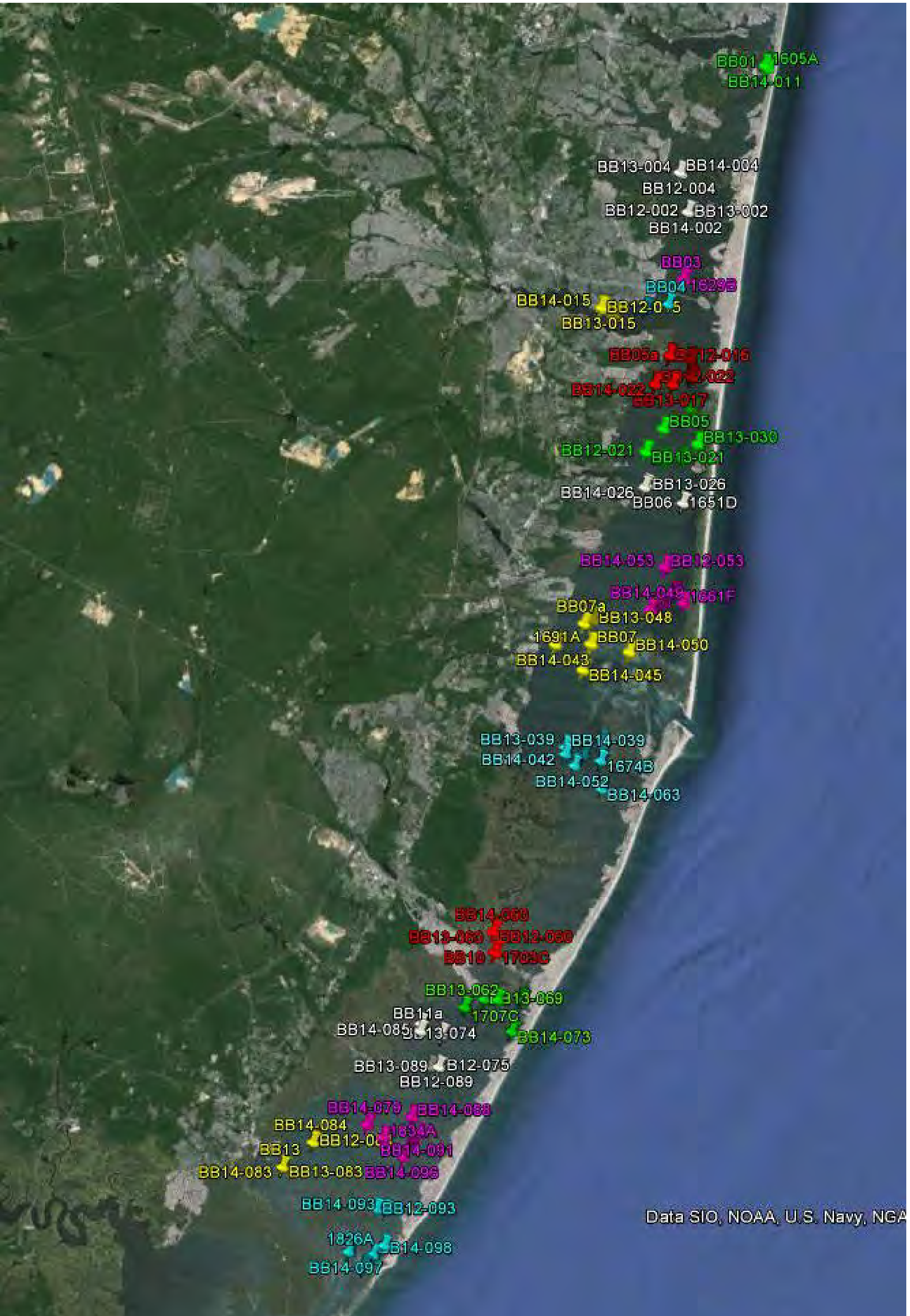
2001 (EPA Regional Environmental Monitoring and Assessment Program)

Not random sampling design

○ 'Open bay' stations

△ 'Marina' stations



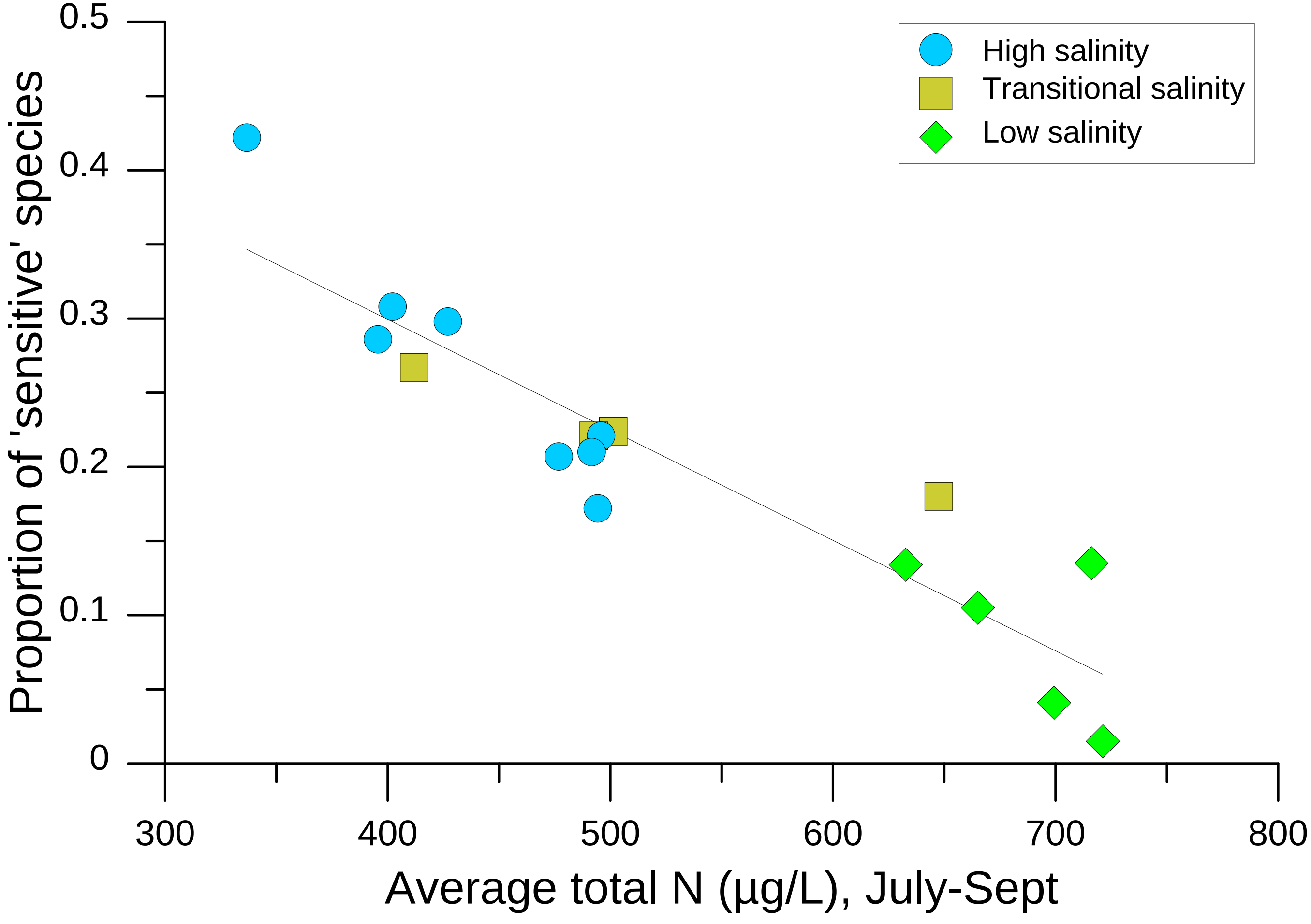


Are benthic community composition and water quality related?

Approach: Focus on water quality properties that might correlate with abundance of 'sensitive' species

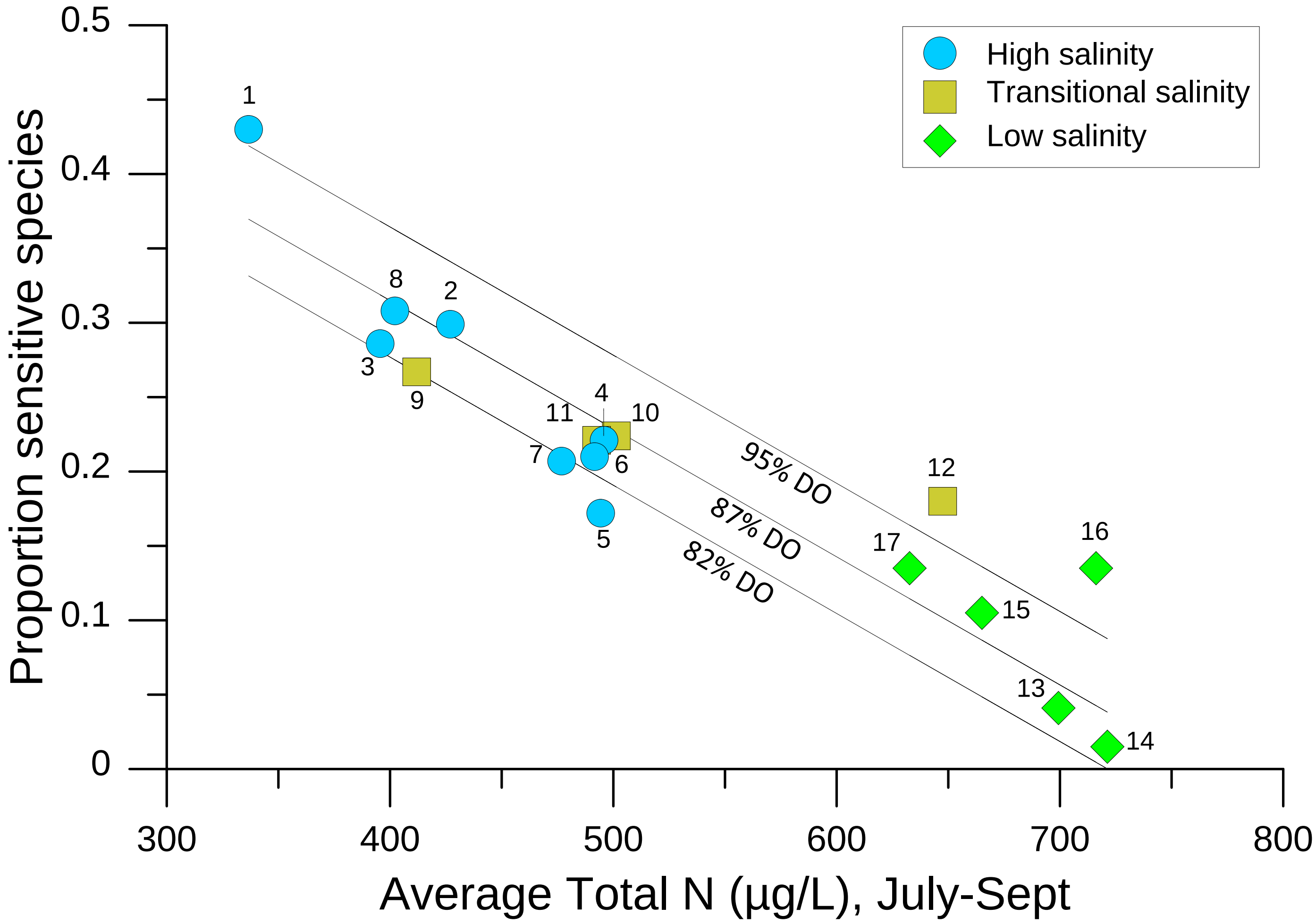
Approach: Select locations within 2 km of each other with data on water quality and benthic community composition.

Result: 17 groups (total of 25 water quality, 59 benthic stations)

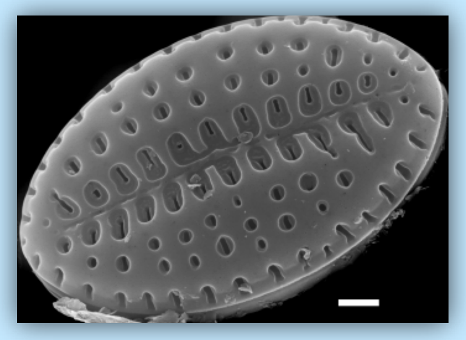

Proportion of 'sensitive' species
0.5
0.4
0.3
0.2
0.1
0
300
400
500
600
700
800
Average total N (µg/L), July-Sept
High salinity
Transitional salinity
Low salinity

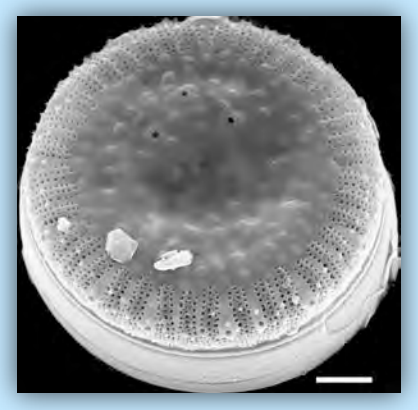
The summertime concentration of total N 'explains' 84% of the variation in the relative abundance of Sensitive species

Proportion EG1 taxa = 0.074 – 8.62E-4*Total N +6.68E-3*DO saturation



TRACKING EUTROPHICATION OF NEW JERSEY COASTAL LAGOONS WITH DIATOMS





Marina Potapova, Nina Desianti, Paul Kiry, Roger Thomas, David Velinsky, Paula Zelanko
Academy of Natural Sciences of Drexel University

Mihaela Enache and Tom Belton
New Jersey Department of Environmental Protection

Barnegat Bay-Little Egg Harbor estuary, NJ: a highly eutrophic lagoonal estuary

Questions:

- Can we use diatoms as indicators of nutrient enrichment in coastal lagoons?
- How diatom assemblages changed in the last few hundred years as a result of eutrophication?

What previous studies have shown?

Classifications of diatoms in respect to nutrient content

- Vos & DeWolf (1993), Stachura-Suchoples (2001)…

Core and historical data

- Baltic Sea: Andrén (1999, 2000), Lesniewska & Witak (2011) and others: shift towards planktonic diatoms in recent decades; “anthropogenic assemblage” includes *Cyclotella chocktawhatcheeana, C. atomus, Thalassiosira proschkinae*
- Chesapeake Bay: Cooper et al (1995): shift towards small planktonic species (*C. chocktawhatcheeana*) since 1800
- Gulf of Mexico: Rabalais et al. (1996):): shift towards small and lightly silicified planktonic species; Parsons et al. (2006): Louisiana salt marsh diatoms associated with N loading
- Sea of Okhotsk/Japan: Katsuki et al. (2008): increase of small *Cyclotella*, decrease of *Paralia sulcata* and benthic diatoms

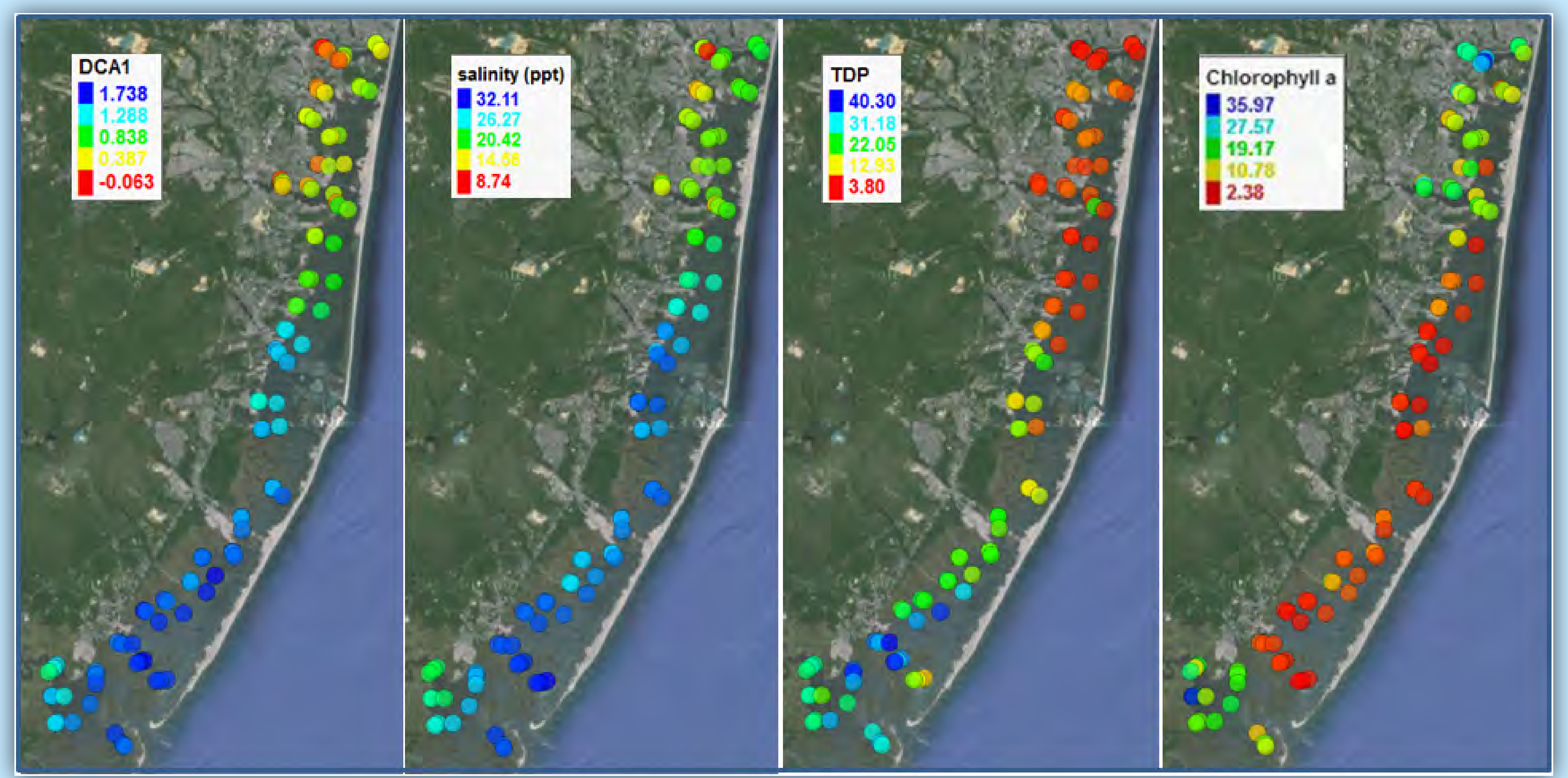
Inference models

- Gulf of Finland: Wekström et al. (2006) R^2_{jack}: TDN= 0.73, TDP= 0.50
- Florida: Wachnicka et al. (2010) Florida Bay R^2_{jack} : TN = 0.46; TP= 0.49, Sal= 0.95;
  Wachnicka et al. (2011) Biskayne Bay R^2_{jack} : TN= 0.51, TP= 0.72, TOC= 0.62,
  Salinity = 0.85 (highly inter-correlated)

"Calibration" dataset of 110 samples surface sediment samples collected in 2012 from 100 sampling sites in the Barnegat and Great Bays, NJ

603 species found

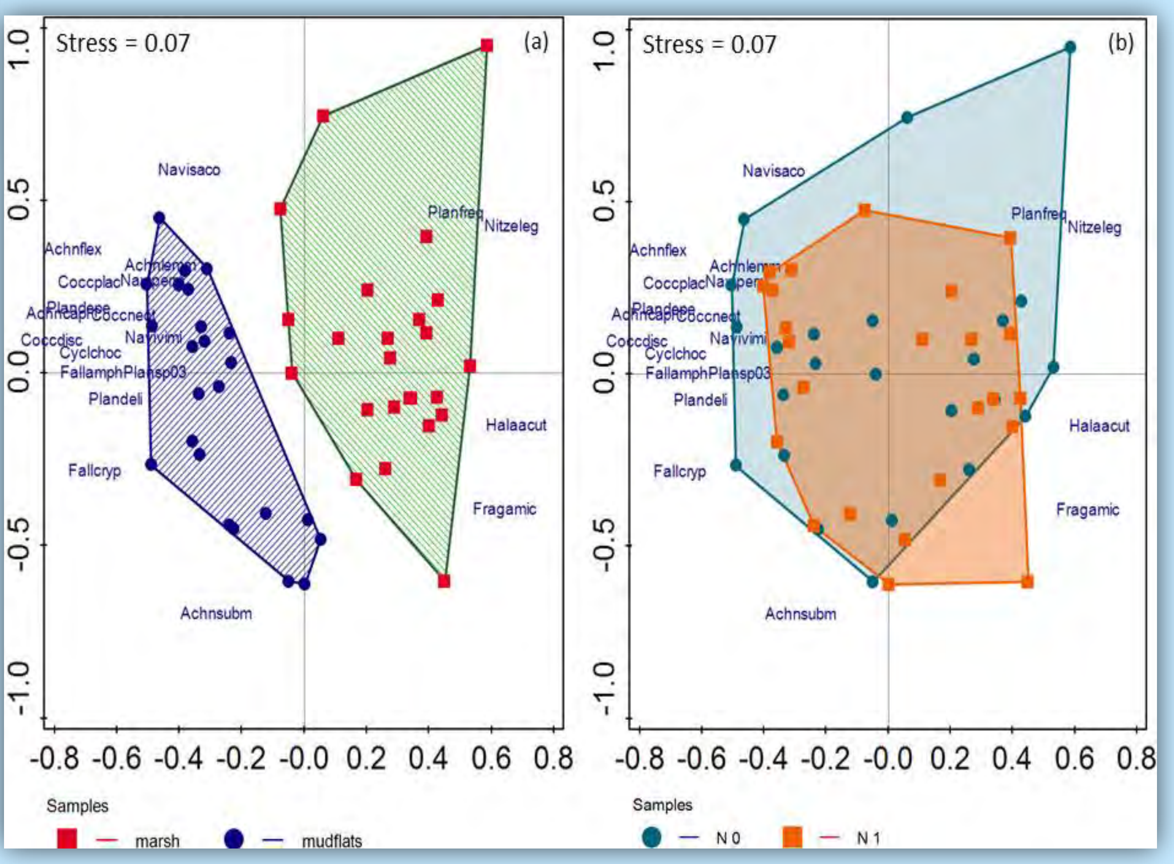
North- to South salinity gradient masks diatom response to nutrients



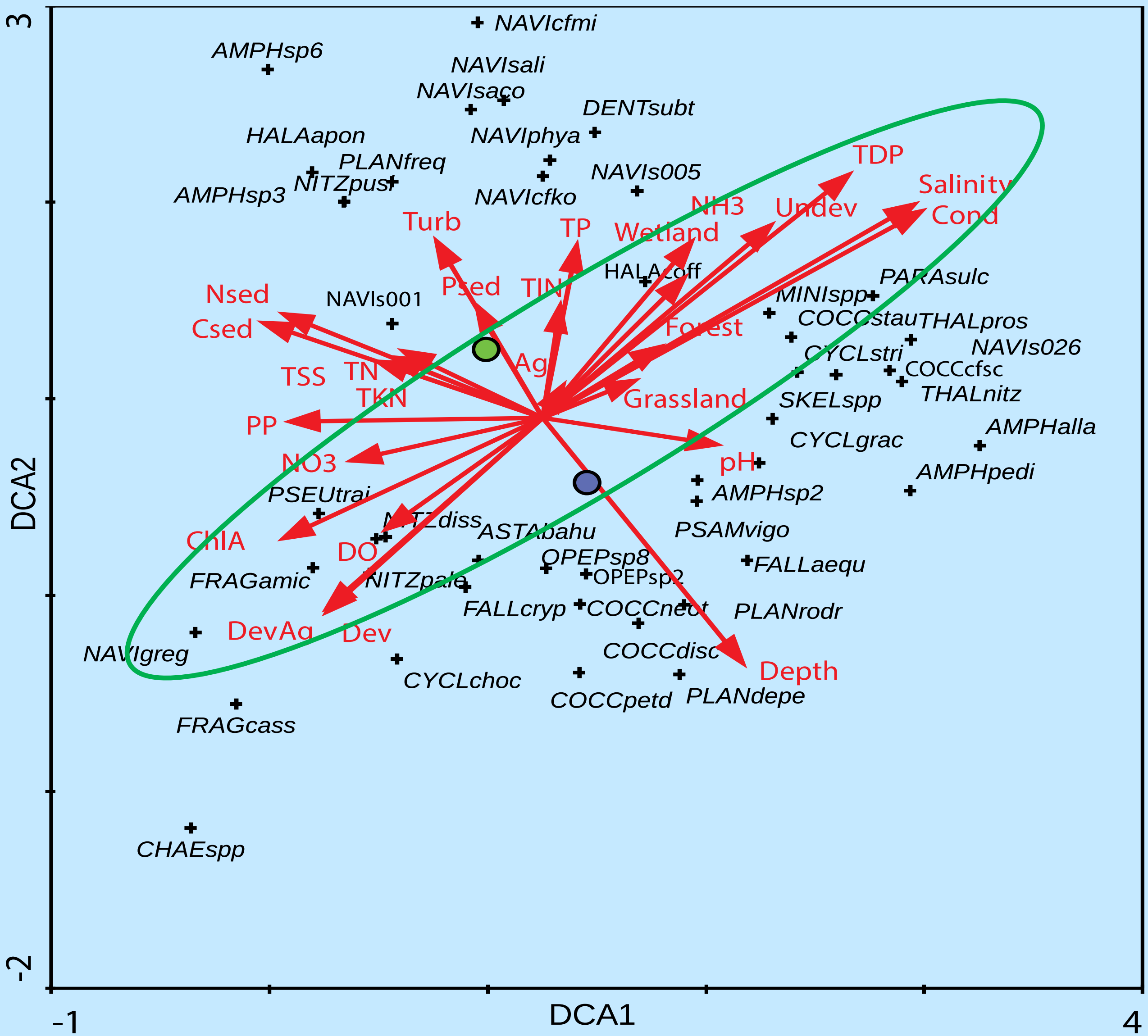
Nutrient addition experiments: no response

- Nutrient-diffusing substrates installed in two kinds of habitat (mudflat / vegetated marsh) at two sites (North/South of the bay)

- nMDS plots show considerable difference in species composition between habitats and no effect of nitrogen additions



High correlations between salinity and most nutrient characteristics, but not with sediment N and C



Strength of the relationships between diatom assemblage composition and environmental variables as measured by the significance of the first CCA axes

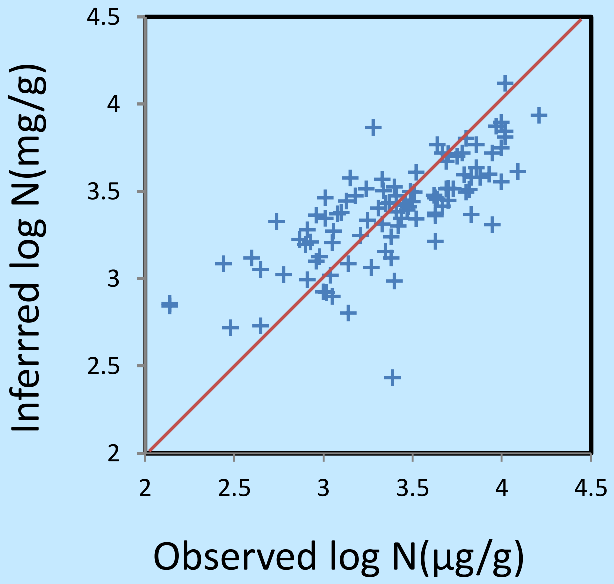
Environmental variable	F-ratio	P-value
Chlorophyll A, Log µg/L	**2.5**	**0.001**
Particulate Phosphorus, Log µg P/L	2.4	0.002
Total Dissolved Phosphorus, Log µg P/L	**3.5**	**0.001**
Total Phosphorus, Log µg P/L	**3.1**	**0.001**
Ammonia, Log µg N/L	2.0	0.006
Nitrate + Nitrite, Log µg N/L	2.5	0.004
Total Inorganic Nitrogen, µg N/L	2.3	0.002
Carbon sediment, Log µg/g	**4.2**	**0.001**
Nitrogen sediment, Log µg/g	**4.7**	**0.001**
Phosphorus sediment, Log µg/g	**3.3**	**0.001**
"Developed" land-use, sqrt %	**2.5**	**0.001**

* The effect of salinity is taken out

WAPLS inference model for salinity, 2nd component:
R^2 = 0.94, R^2_{boot}= 0.81, RMSEP = 2.7ppt

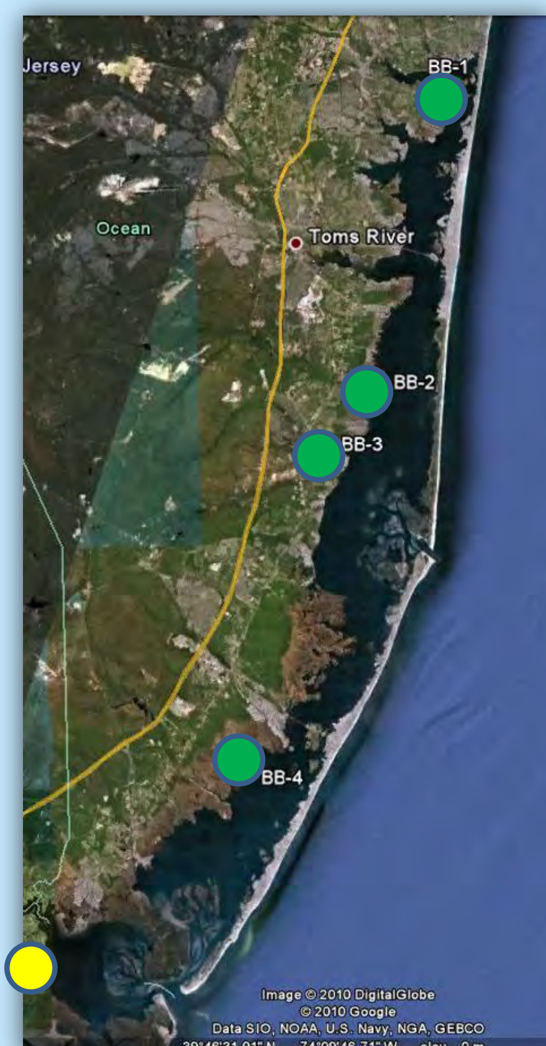
Weighted-averaging partial-least square inference model for sediment N, 2nd component:

R^2 = 0.87,
R^2_{boot}= 0.55
RMSEP = 0.30 (log µg/g)



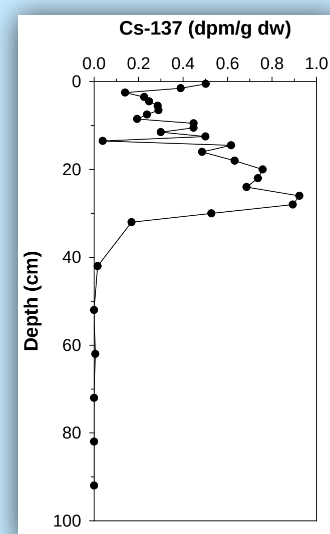
Diatoms from 5 marsh sediment cores

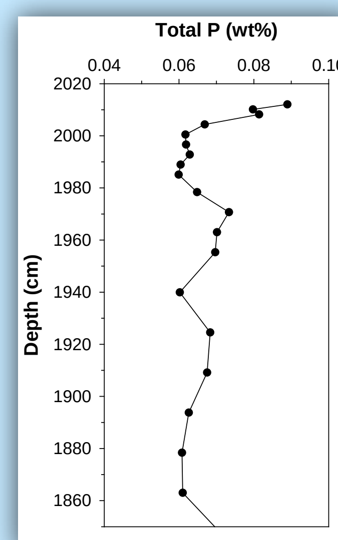
Four cores from Barnegat Bay



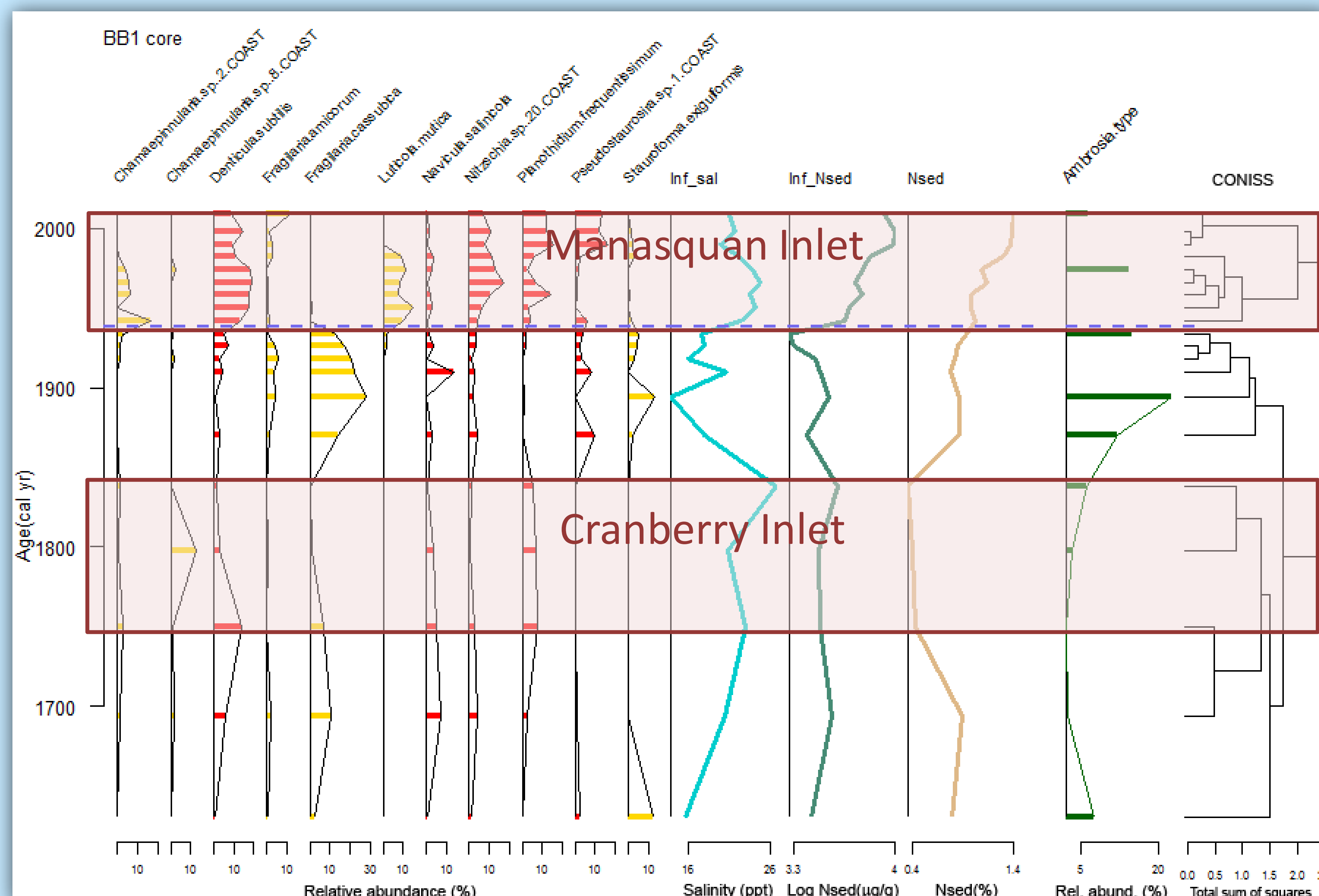
Great Bay core

Core dating, chemistry, pollen and diatom analyses

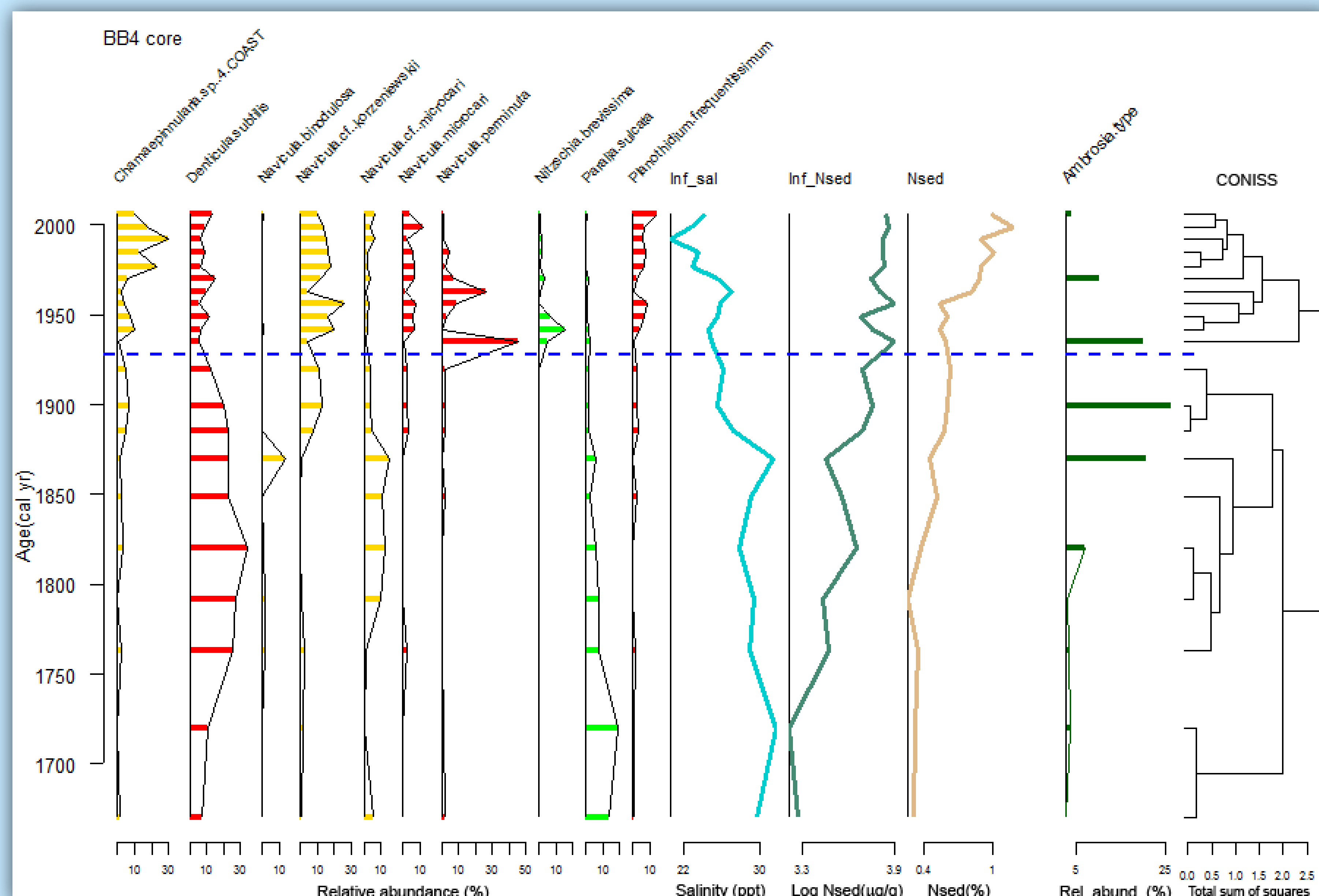




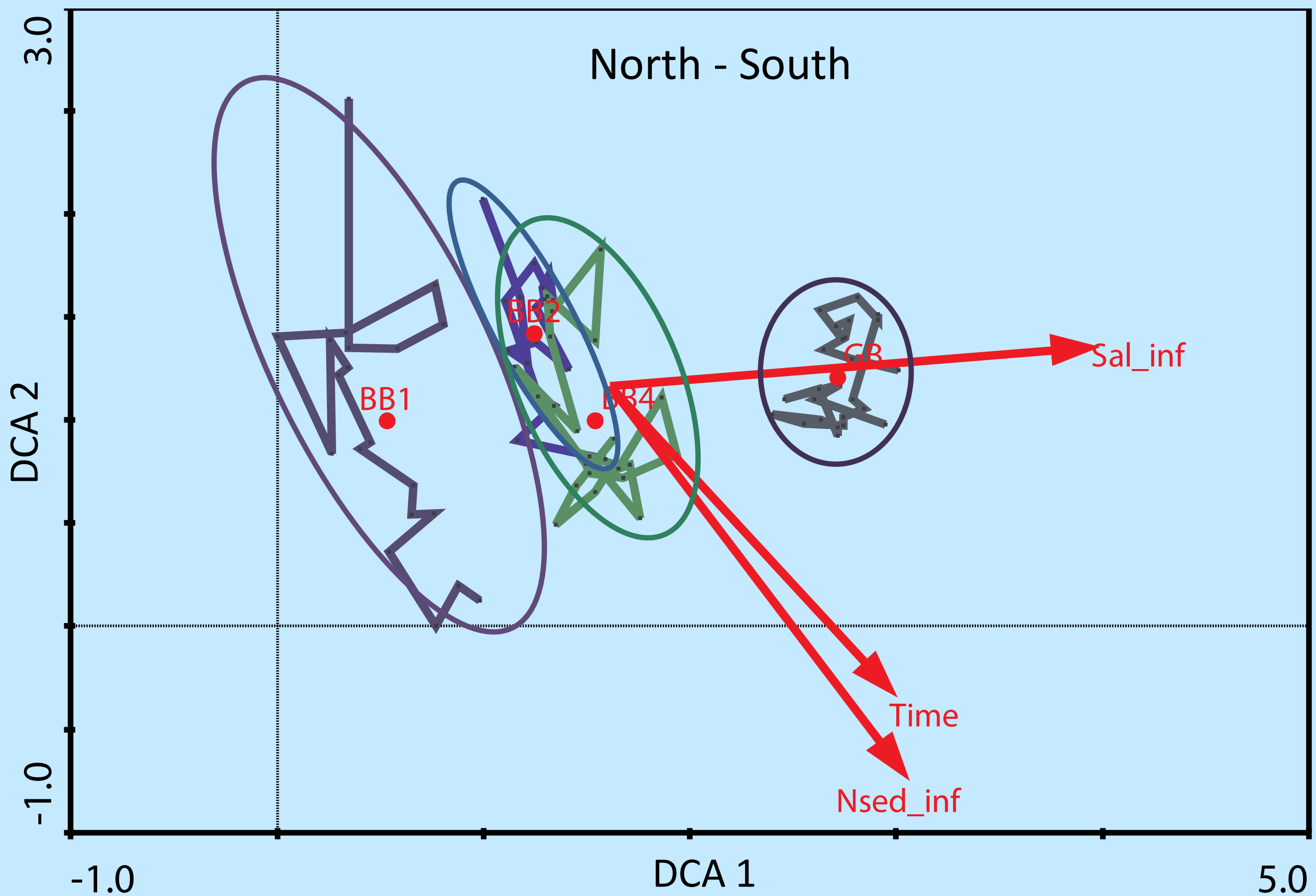
Core BB1: diatom-based inference shows strong N enrichment starting from 1940s



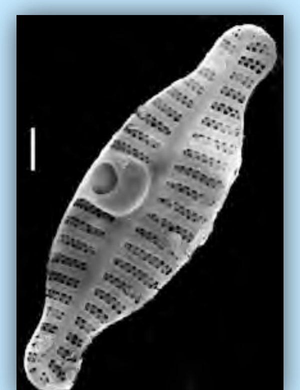
Core BB4: some N increase starting from 1800s

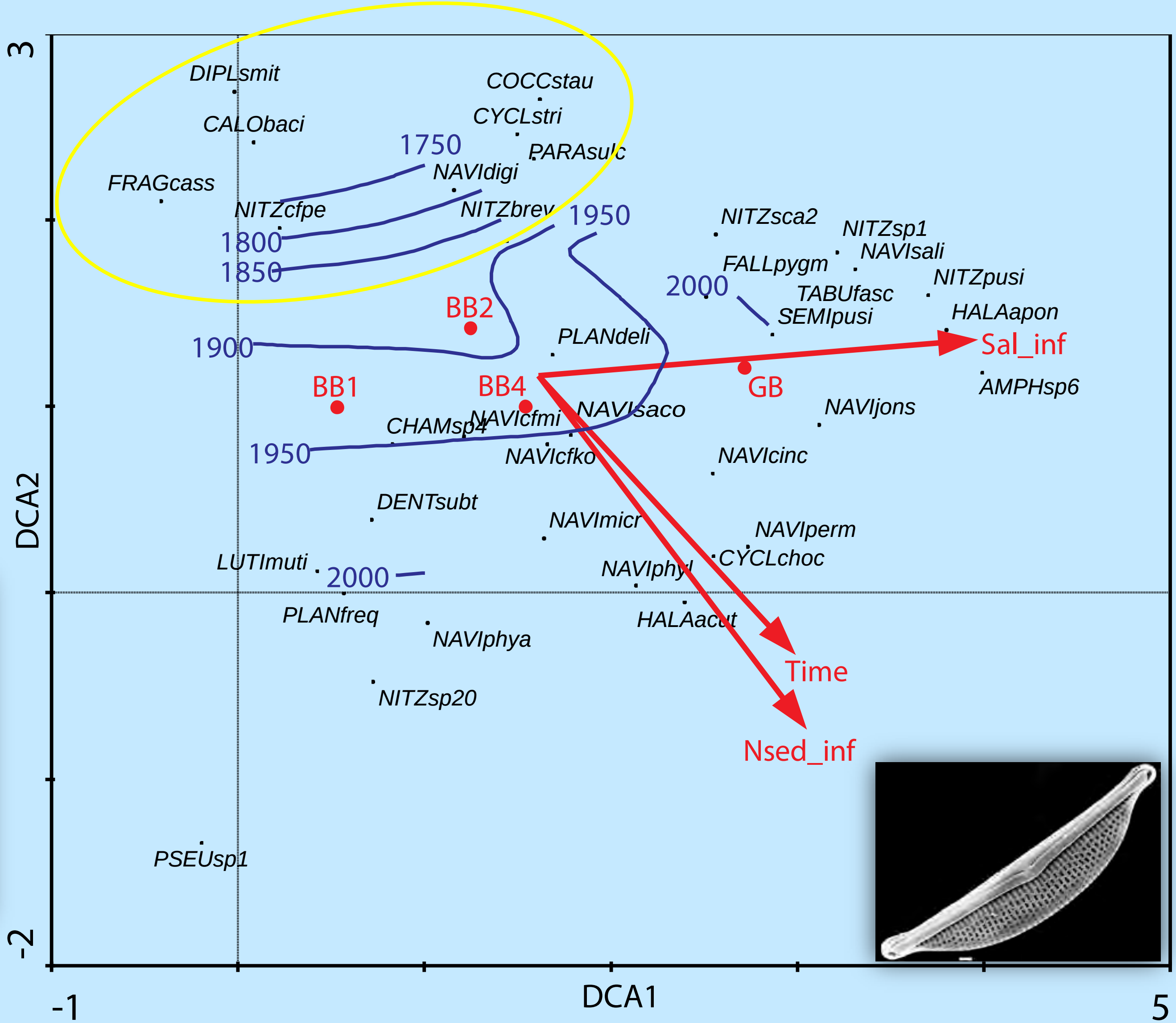


Temporal shift in diatom assemblage composition as revealed by indirect ordination: increase in species associated with high sediment nitrogen; similar trends in Barnegat Bay cores, but slightly different in Great Bay core



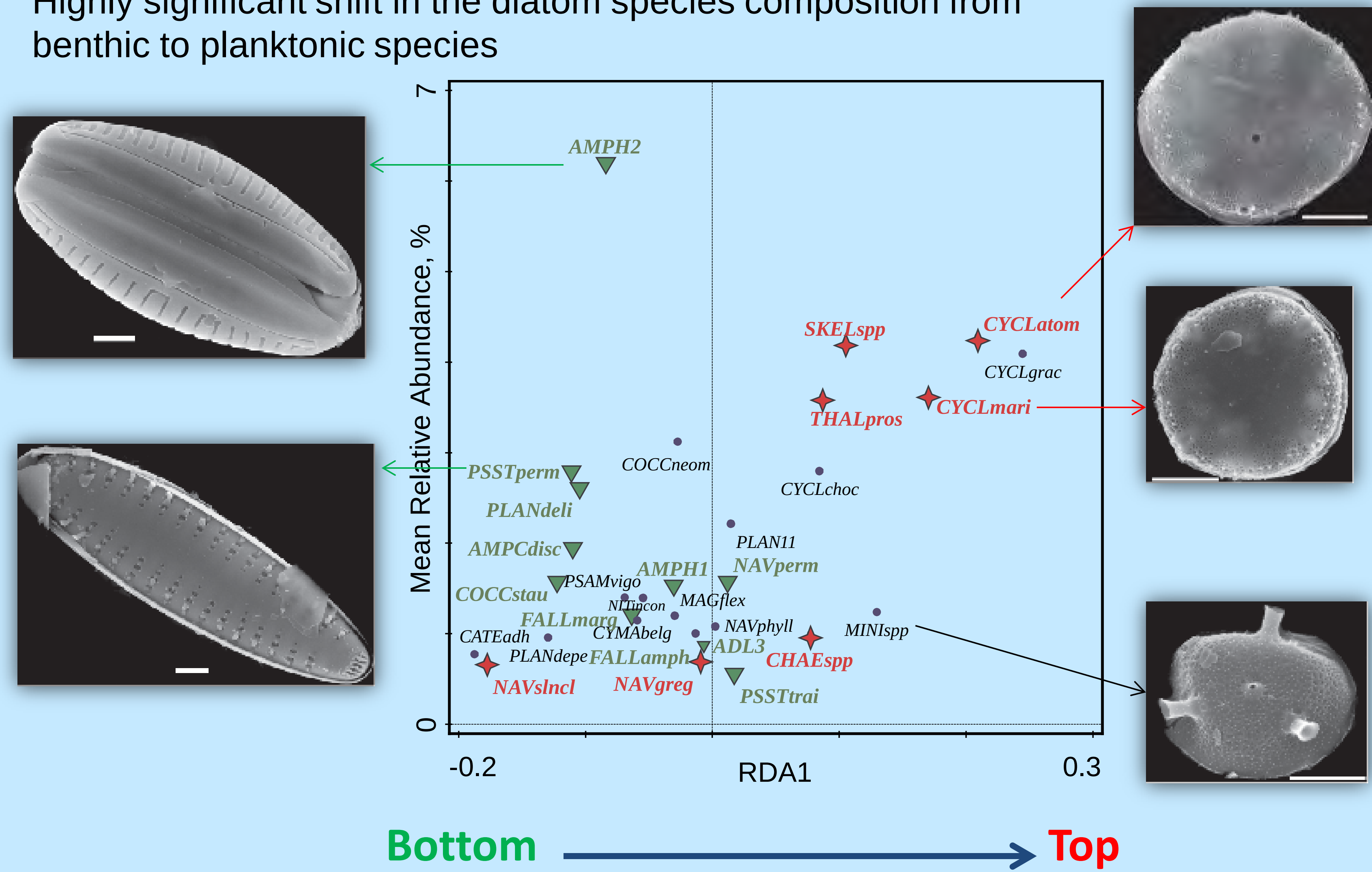
The same ordination, but plot showing species and time isolines: rate of diatom assemblage change in accelerates with time





USGS contaminant " dataset: 50 sampling locations in NJ NY. Diatoms analyzed in the top and bottom layers of each grab sample

Highly significant shift in the diatom species composition from benthic to planktonic species



Conclusions

1. Difficult to separate effects of water column nutrients from overriding effects of salinity
2. Diatom assemblage composition correlated with sediment N and/or C content
3. Analysis of the diatom assemblages from marsh sediment cores showed that in the course of the last 400 years they were evolving towards higher abundance of species indicative of high N content and that the rate in the change has been accelerating over last 150 years.
4. A temporal trend towards the dominance of small planktonic diatoms was found; comparison with other coastal studies points out at the eutrophication as the most likely cause
5. Next steps: explore indicative properties of benthic diatoms using long-term nutrient enrichment experiments and studying diatom assemblages in the subtidal cores.

Baseline Characterization of Phytoplankton and Harmful Algal Blooms in BB-LEH

Ling Ren and Donald Charles
Patrick Center for Environment Research
Academy of Natural Sciences of Drexel University

Thomas Belton and Mihaela Enache
Division of Science, Research and Environmental Health
New Jersey Department of Environmental Protection

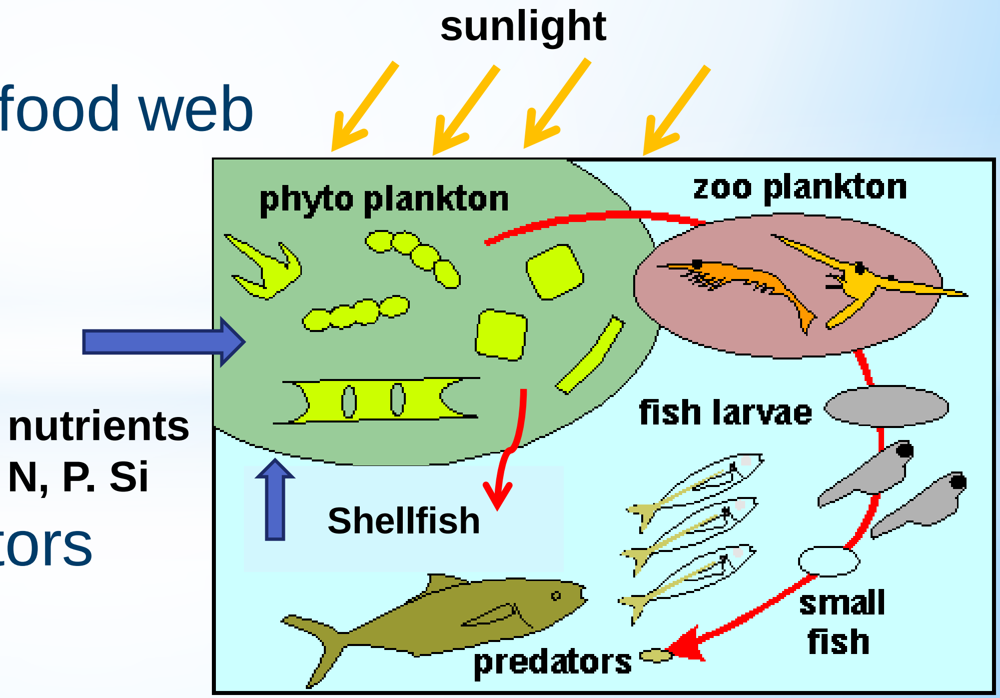
What are phytoplankton?

- *Phyto* (plant) + *plankton* (wanderer or drifter)

- Microscopic organisms

They are important

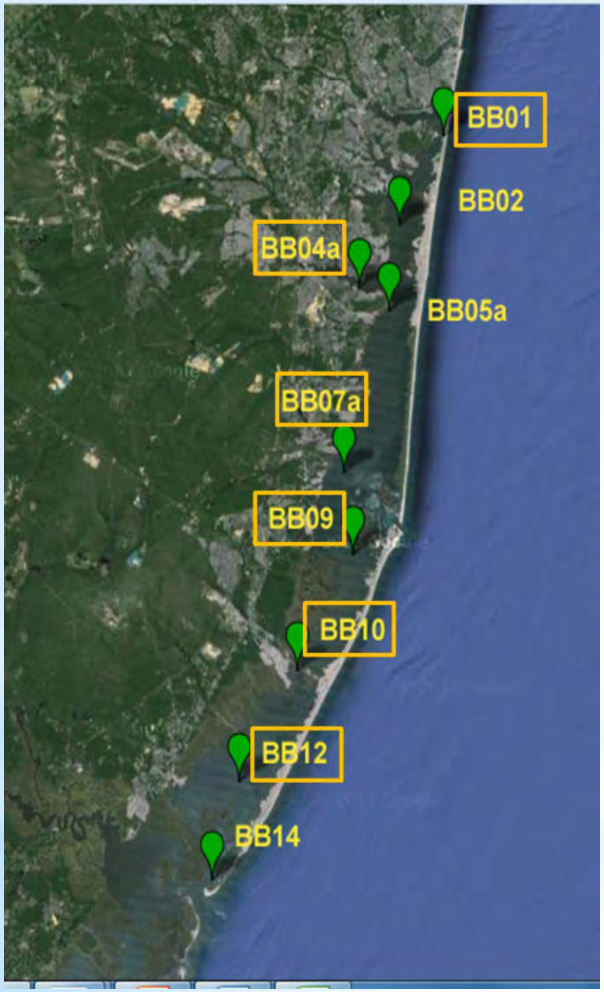
- Primary producers
- Base of the aquatic food web
- Excessive growth & Harmful algal blooms
- Water quality indicators



Project Objectives

- To document phytoplankton species composition and succession, occurrence of HABs
- To characterize their temporal and spatial changes
- To understand the relationships between the changes of species composition and environmental variables
- To develop season-salinity specific phytoplankton index of biotic integrity (P-IBI) for BB-LEH

Sample Collection and Analysis



Map of Sites

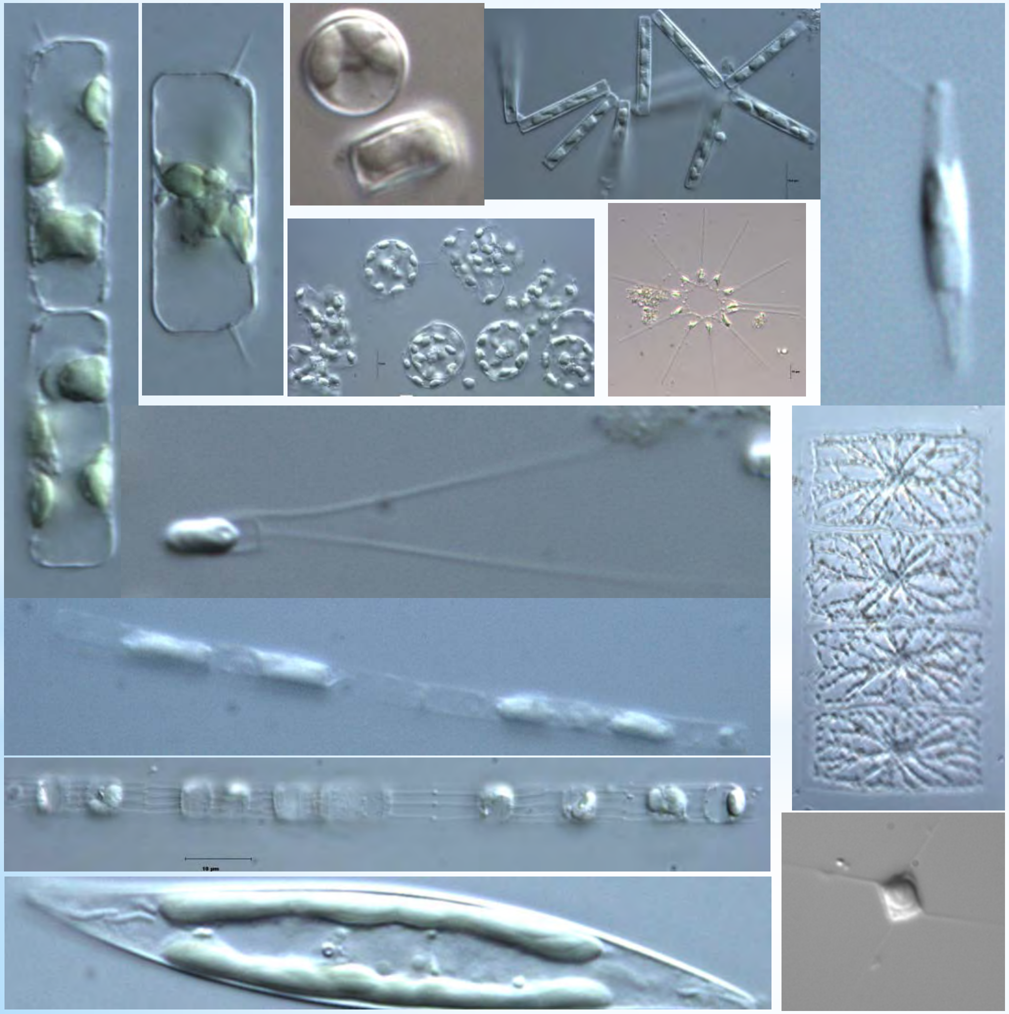
- Year-one: Aug 2011-Sept 2012
  Year-two: Oct 2012-Aug 2013
  Year-three: Apr 2014-Apr 2015
- Frequency:
  monthly (October-March)
  biweekly (April to August)
- Synchronized with the NJDEP water quality monitoring
- 282 samples were analyzed for species composition and cell density, biovolume and carbon biomass for major groups

In This Talk

- Species composition and major phytoplankton groups
- Harmful algal blooms and HAB species
- Temporal and spatial changes of phytoplankton and relationships with environmental variables
- Development of phytoplankton index of biotic integrity (P-IBI)

Major Groups of Phytoplankton

Diatoms

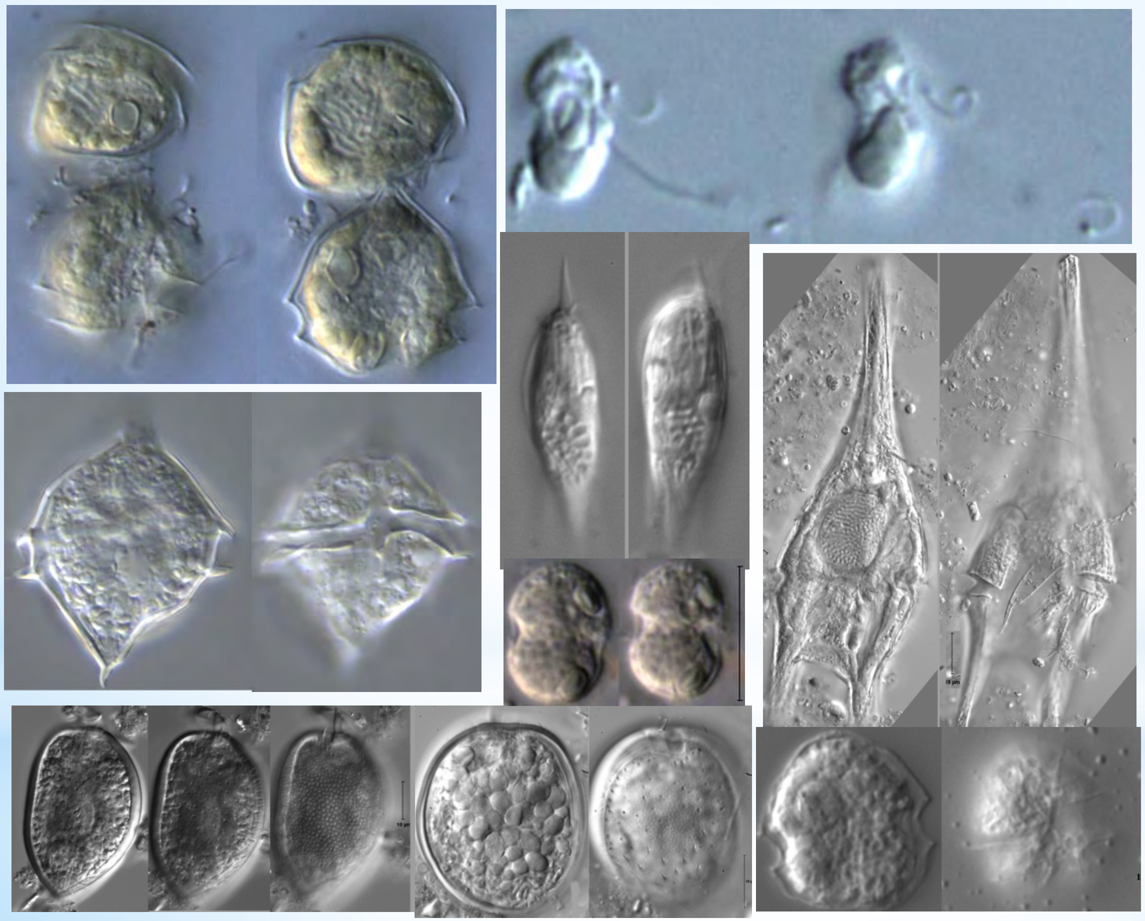


> 50% of total taxa (158)

Dominant from late fall through spring

Major Groups of Phytoplankton

Dinoflagellates



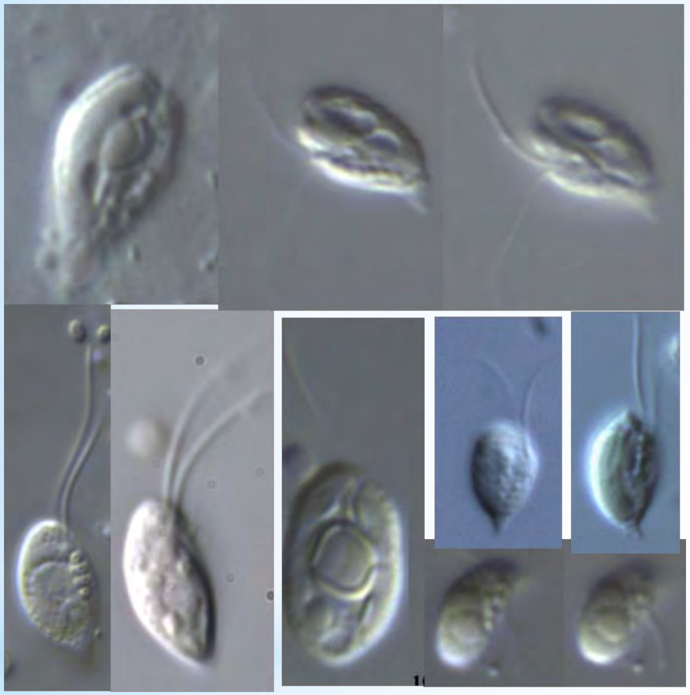
"Red tide" species

More in summer

Southern BB and LEH

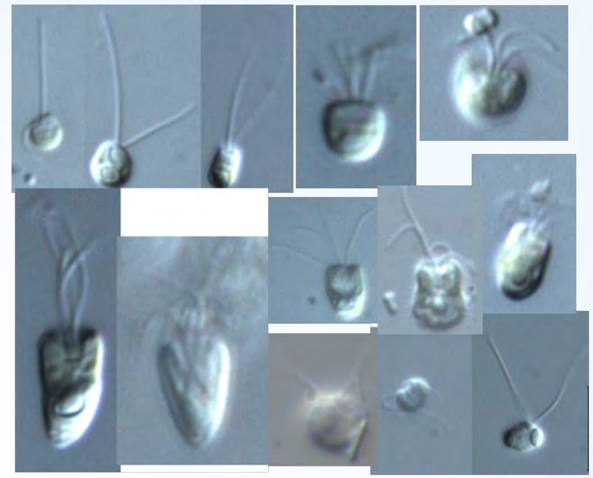
Major Groups of Phytoplankton

Cryptophytes

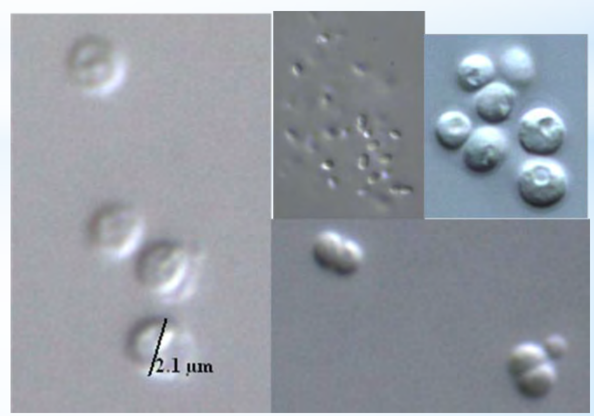


Cell size: 5~20 um
Late spring through summer

Other flagellates



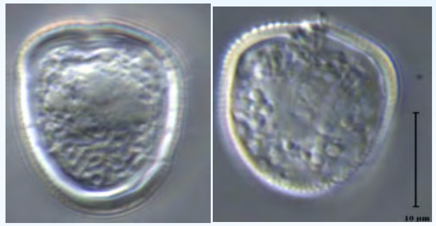
Picoplankton



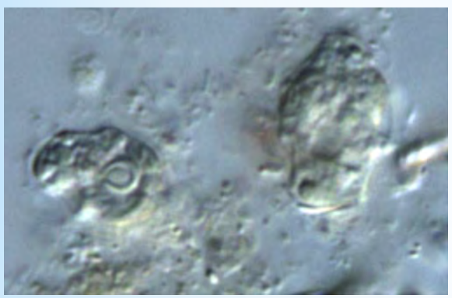
Dominant in summer

Harmful Algal Blooms and HAB Species

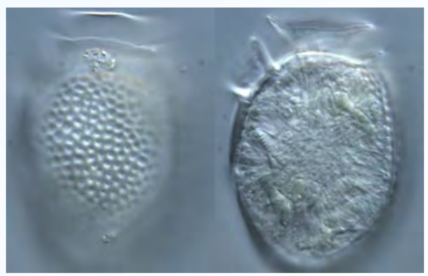
Aureococcus anophagefferens



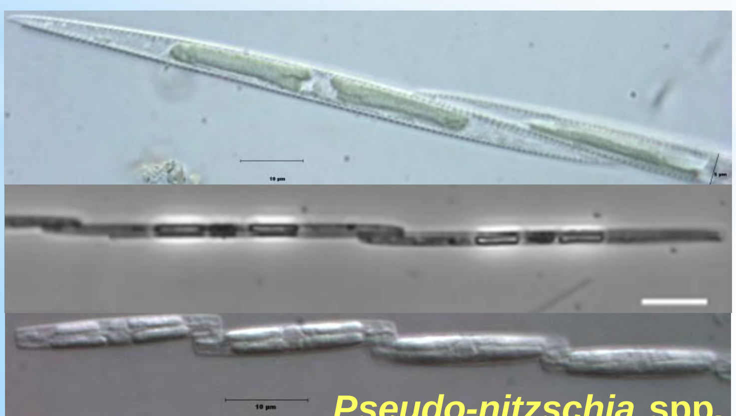
Prorocentrum minimum



Heterocapsa rotundata



Dinophysis acuminata

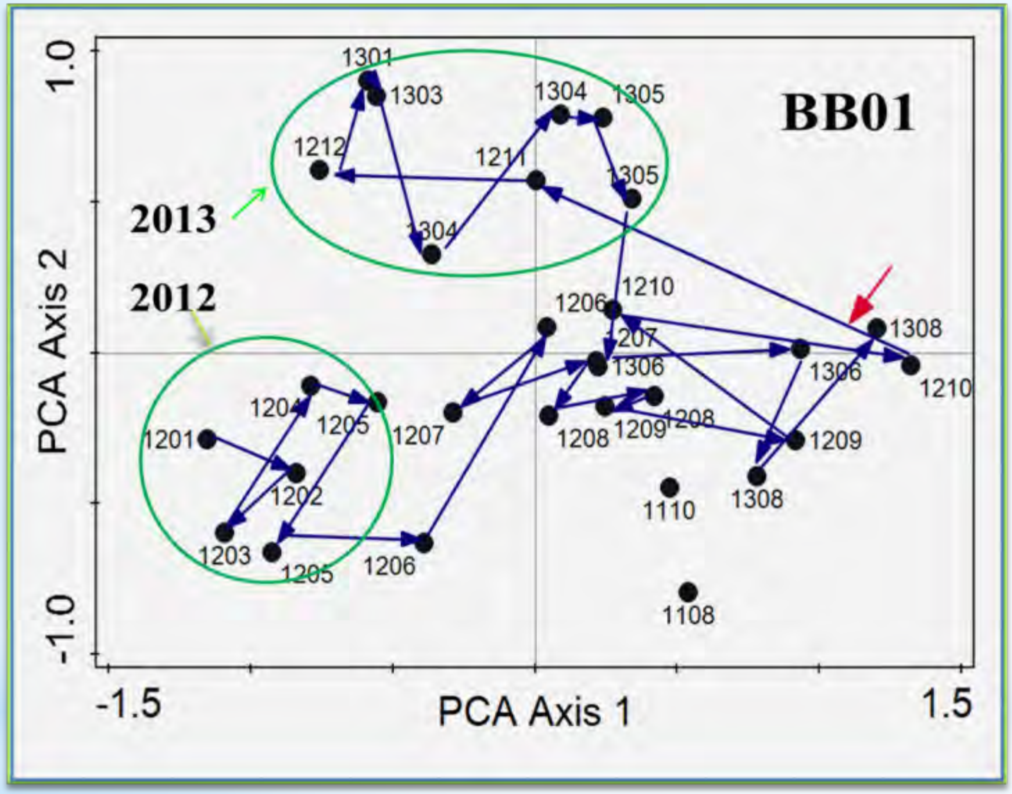


***Pseudo-nitzschia* spp.**

- Brown tide alga, *Aureococcus anophagefferens* (AA), at low density (10^5-10^6 cells/L) in southern BB. An incidence of AA bloom was detected near Sedge Island on June 19, 2013 (4.5 x10^8 cells/L, Bricelj et al. unpublished data
  - *Prorocentrum minimum:* up to 2.5 x10^6 cells/L, in Year 1 from northern BB
  - *Heterocapsa rotundata:* up to 1.0 x10^6 cells/L, in Year 2&3 in north
- *Dinophysis acuminata*: up to 1.0 x10^6 cells/L, in Year 2 in Little Egg Harbor
- *Pseudo-nitzschia* spp.: up to 6.0 x10^6 cells/L, in Year 1&3, near BB inlet and in Little Egg Harbor

Temporal Changes and the Effects of Hurricane Sandy

Nonmetric Multidimensional Scaling (NMDS)

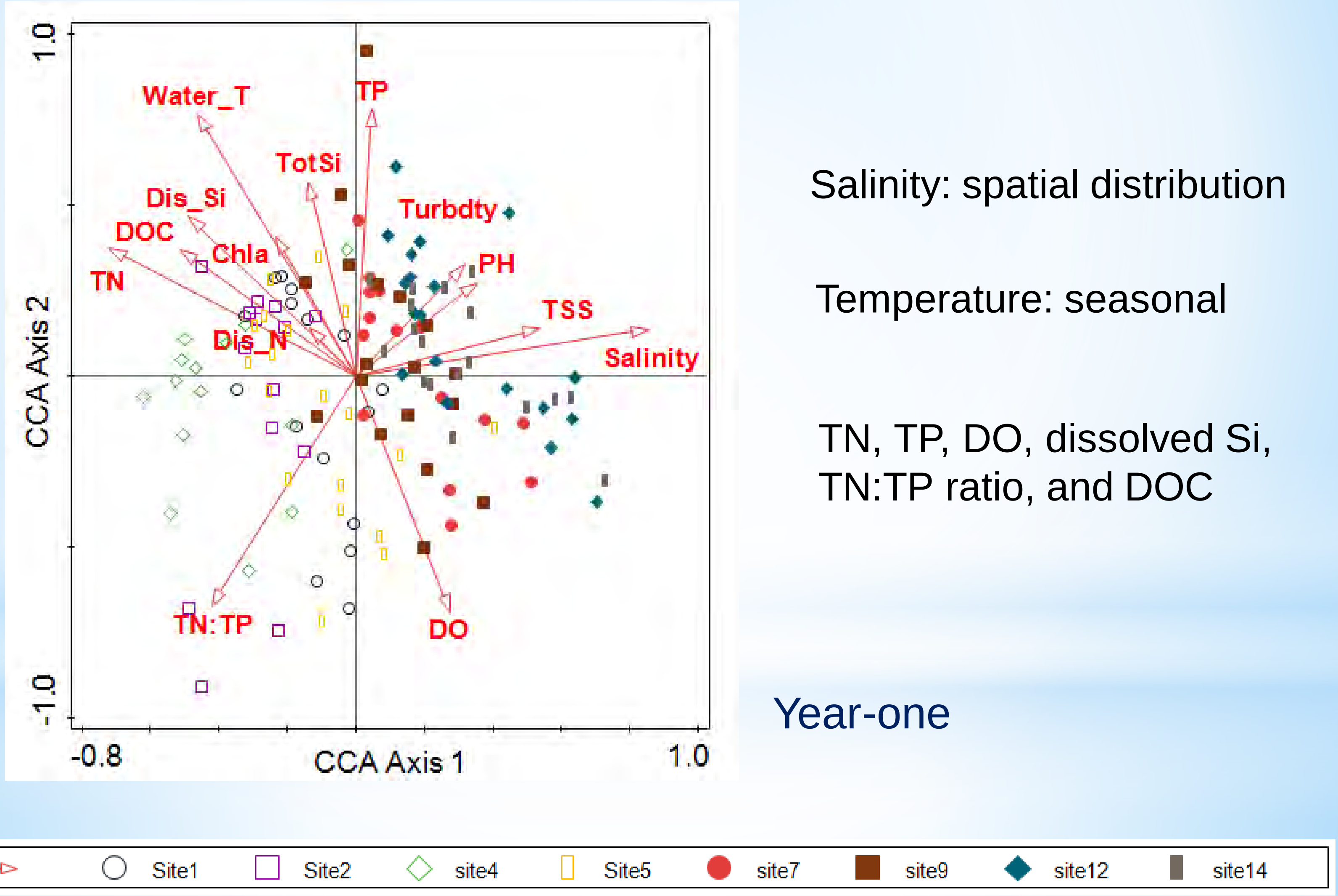


Data: Aug 2011 to Aug 2013

- Large dissimilarity before and after the Hurricane
- Winter and spring assemblages in 2013 was distinct from 2013
- Summer assemblages were similar

Phytoplankton Changes in Relation to Environmental Variables

Canonical Correspondence Analysis (CCA)



Salinity: spatial distribution

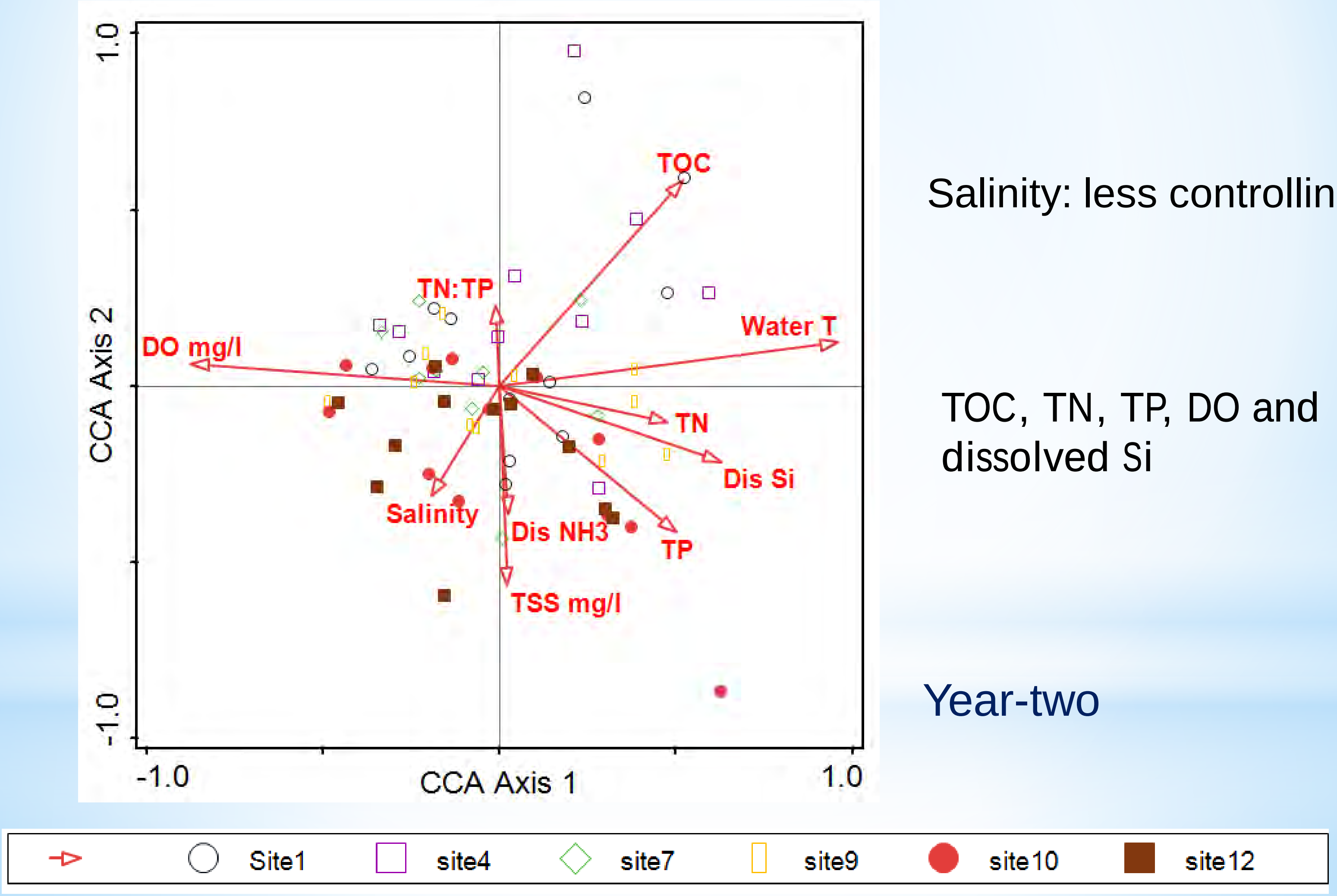
Temperature: seasonal

TN, TP, DO, dissolved Si, TN:TP ratio, and DOC

Year-one

Phytoplankton Changes in Relation to Environmental Variables

Canonical Correspondence Analysis (CCA)



Salinity: less controlling

TOC, TN, TP, DO and dissolved Si

Year-two

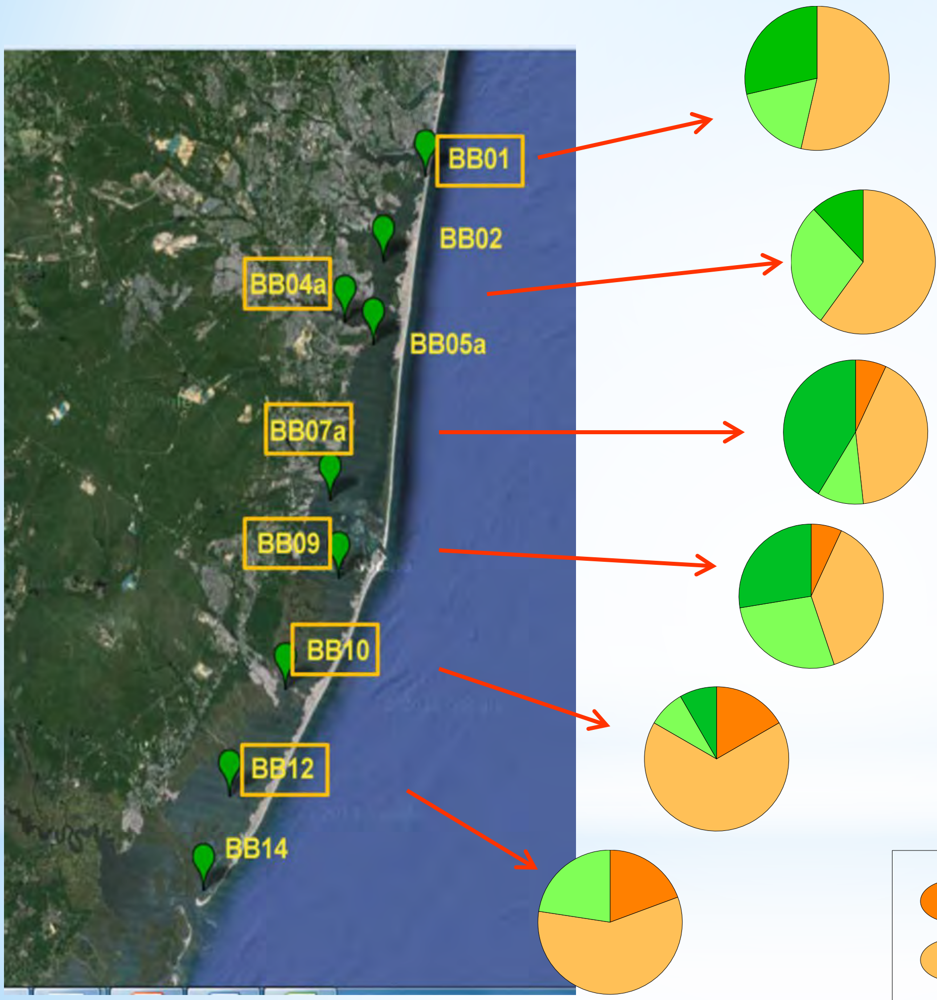
Phytoplankton Index of Biotic Integrity (P-IBI)

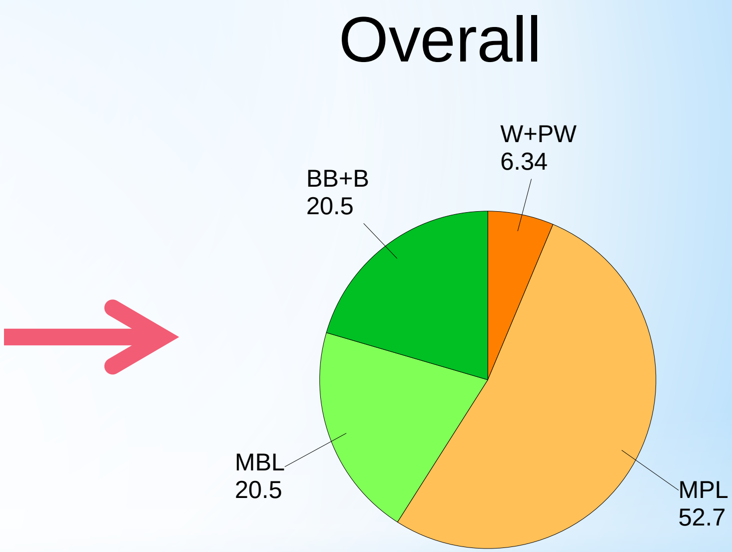
- Biotic index goes one step beyond bioindicators
- It is multimetric, comprised of several phytoplankton and physiochemical metrics
- Incorporates features of different elements of the ecosystem into a single value
- Is more sensitive than individual indicators
- Methods similar to those for the Chesapeake Bay

Buchanan et al. 2005, Estuaries 25: 138-159
Lacouture et al 2006, Estuaries and Coasts 29: 598-616
Gibson et al. 2000

Habitat Classification Based on Light, DIN and ortho-P

205 samples





	W+PW	Worst+Poor Worst
	MPL	Mixed-Poor Light
	MBL	Mixed-Better Light
	BB+B	Better-Best+Best

P-IBI Metrics

W+PW	Worst+Poor Worst → **Impaired (or degraded)**
MPL	Mixed-Poor Light
MBL	Mixed-Better Light
BB+B	Better-Best+Best → **Least-Impaired (or Reference)**

- 34 metrics were tested for their discriminatory ability between least-impaired and impaired communities.

9 Phytoplankton metrics:
Chl*a*
Chl*a* : C ratio
Total nano-micro plankton abundance
Average NM plankton cell size
% diatoms biomass
% dinoflagellate biomass
% cryptophyte biomass
Summer % picoplankton
% cyanobacteria biomass

\+

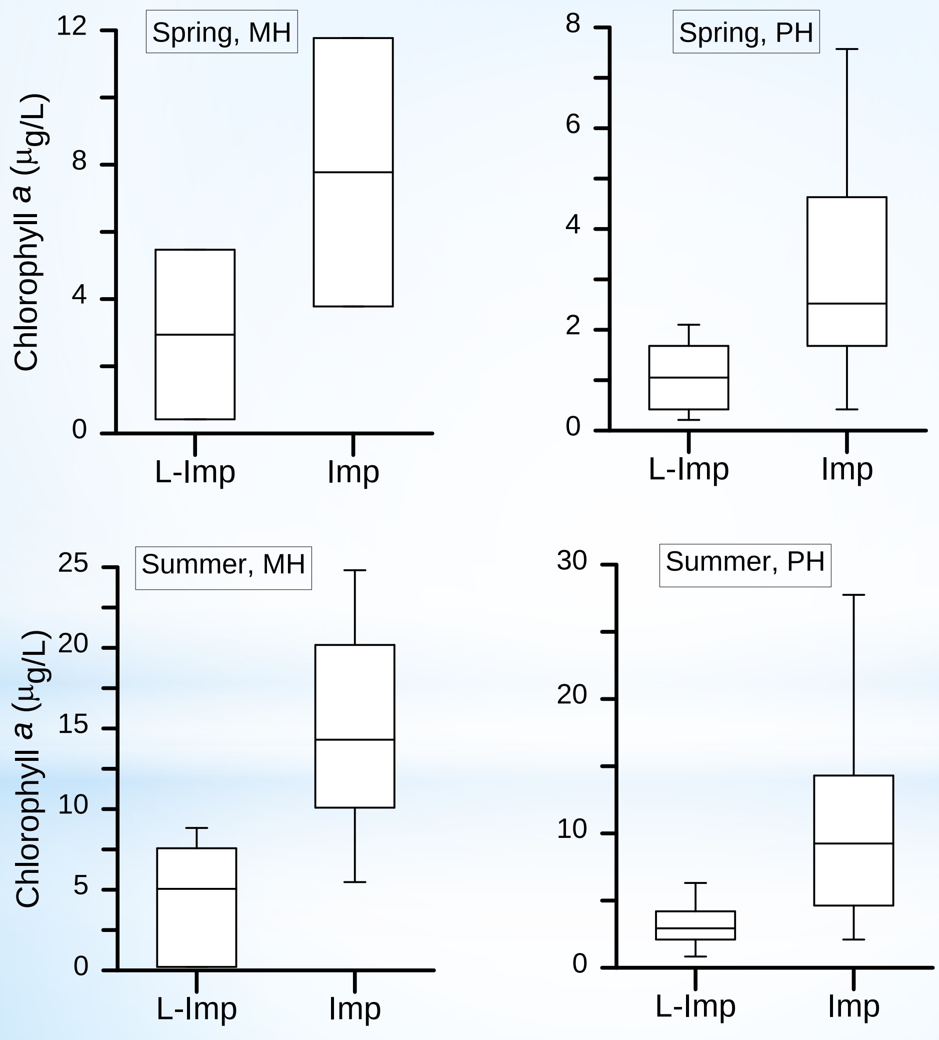
3 Physiochemical metrics:
DO, DOC/TOC, and TSS

↓

P-IBI for
Spring MH and PH
Summer MH and PH
MH: (mesohaline, 5-18 ppt)
PH: (polyhaline, >=18 ppt)

Least-impaired vs. Impaired

Chlorophyll *a*



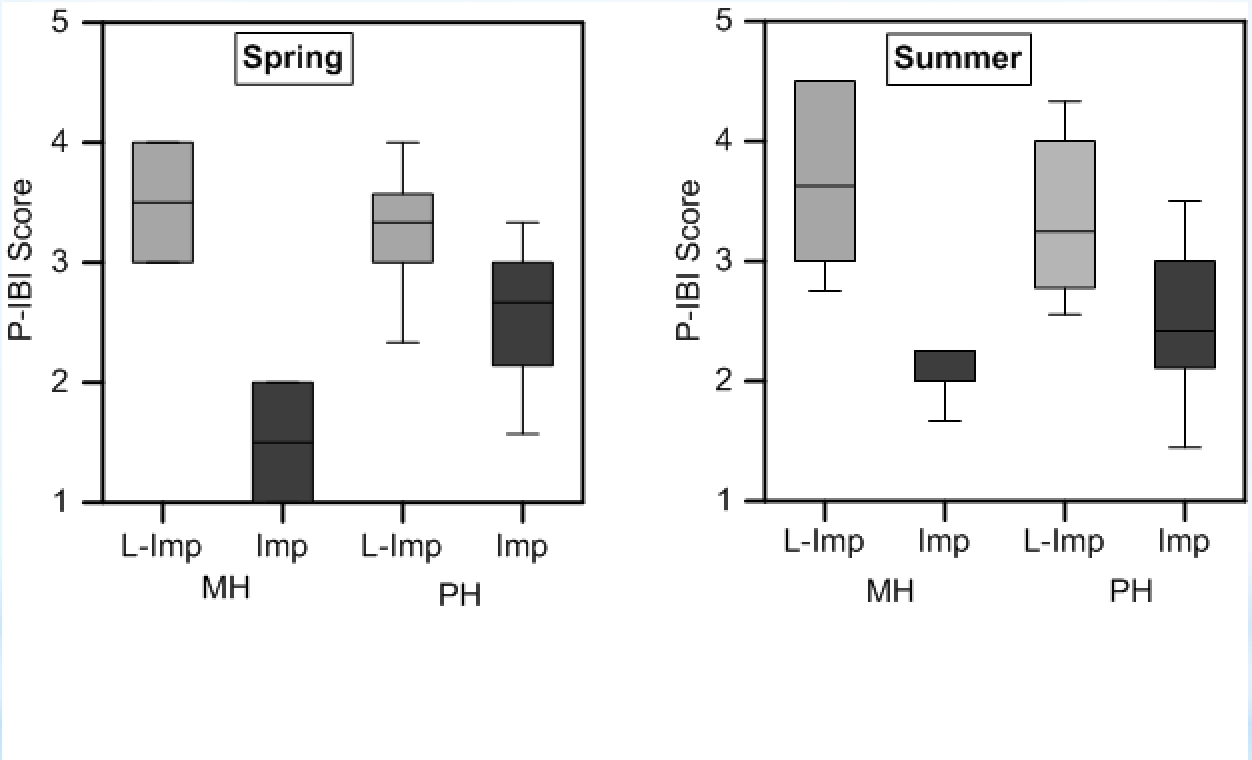
Classification efficiency of P-IBI for least-impaired (L-imp) and impaired (Imp) conditions, and overall

Season-salinity zones	Habitat conditions	# of Samples	Reference vs. Degraded	Overall
Spring MH	L-imp	4	50%	67%
	imp	2	100%	
Spring PH	L-imp	23	48%	57%
	imp	30	53%	
Summer MH	L-imp	4	50%	81%
	imp	12	92%	
Summer PH	L-imp	12	64%	68%
	imp	38	71%	

L-imp: 48-64%
Imp: 53-100%
Overall: 57-81%

MH: Mesohaline zone, salinity 5-18 ppt
PH: Polyhaline zone, salinity >=18 ppt

Actual separation of P-IBI scores for impaired (gray bar) and least-impaired (black bar) communities.



MH: Mesohaline zone, salinity 5-18 ppt
PH: Polyhaline zone, salinity >=18 ppt

Summary

- Inter-annual change in the phytoplankton community varied among sites. Species composition in northern Barnegat Bay was more affected by Hurricane Sandy due to salt water intrusion and long residence time.
- Seasonal and spatial changes of phytoplankton were generally controlled by temperature and salinity, but also significantly related to TN, TP, dissolved silica, TN:TP ratios, DO, and TOC/DOC.
- The developed P-IBI correctly classified 57-81% of the samples in the calibration data set. P-IBI scores showed good separation between impaired and least-impaired for most season-salinity zones.
- Our work is the first attempt to develop a P-IBI for BB-LEH estuary. The calculated phytoplankton reference communities and water quality criteria are scientifically based and region specific, and are expected to facilitate assessment and restoration efforts in water quality management of BB-LEH.

Uncertainties and Recommendations

- Phytoplankton communities were largely disturbed by Hurricane Sandy. As a result, use of the calculated P-IBI, which is based on the first two years of data, should take into account this additional source of uncertainty.
- HAB species did not show significant discriminatory ability due to limited data points. For the same reason, P-IBI is also constrained for the fall and winter mesohaline zones.
- More investigation of the phytoplankton community, along with water quality monitoring, are essential to refine the reference communities and strengthen the P-IBI.
- Pheophytin, a degradation product of Chl*a*, is regarded as a good metric for P-IBI (Lacouture et al. 2006), and should be included in the water quality monitoring.

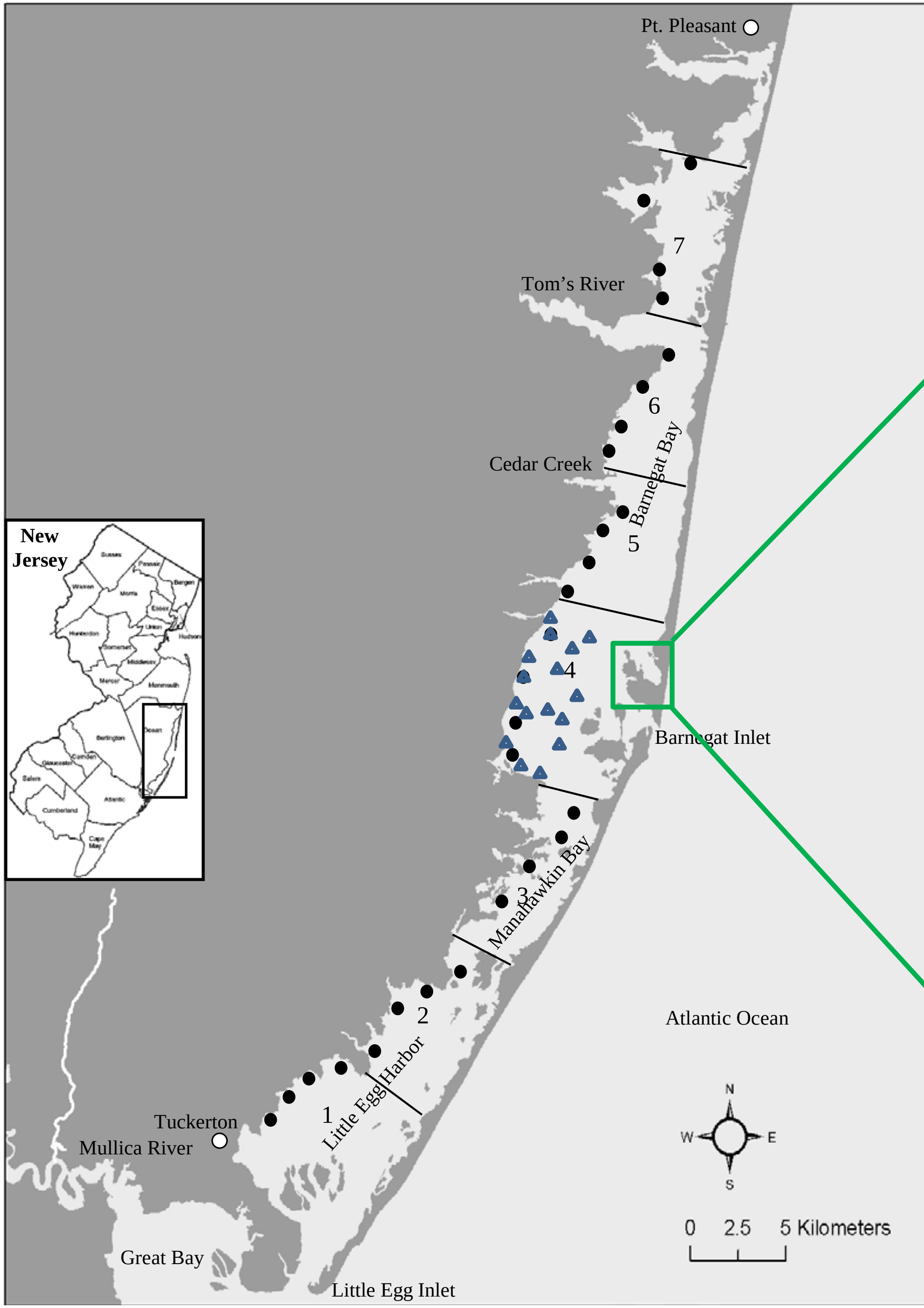
Acknowledgements

- NJDEP for the funding
- Bob Schuster, Bill Heddendorf and field crew at Bureau of Marine Water Monitoring for sample collections
- Elena Colon for laboratory assistance

2015
Barnegat Bay Research Forum

Ecological Evaluation of the Sedge Island Marine Conservation Zone

Paul Jivoff
Department of Biology
1865 RIDER UNIVERSITY



Rationale

-NJ's First Marine Conservation Zone….
for preserving diversity of essential habitats and species-especially of economic importance

-Little work to assess habitats present or evaluate effectiveness for organisms

Objectives

-Are habitats inside SIMCZ equivalent to those outside?

-Use blue crab as one indicator species for evaluating relative effectiveness of SIMCZ

Methodology

(1) abundance and diversity of fish, crabs and shrimp
cylinder sampling in 3 habitats: SAV, algae, open
inside versus outside SIMCZ

(2) abundance, size, and sex ratio of adult blue crabs
blue crab trap sampling in 3 areas:
SIMCZ & central bay & western shore

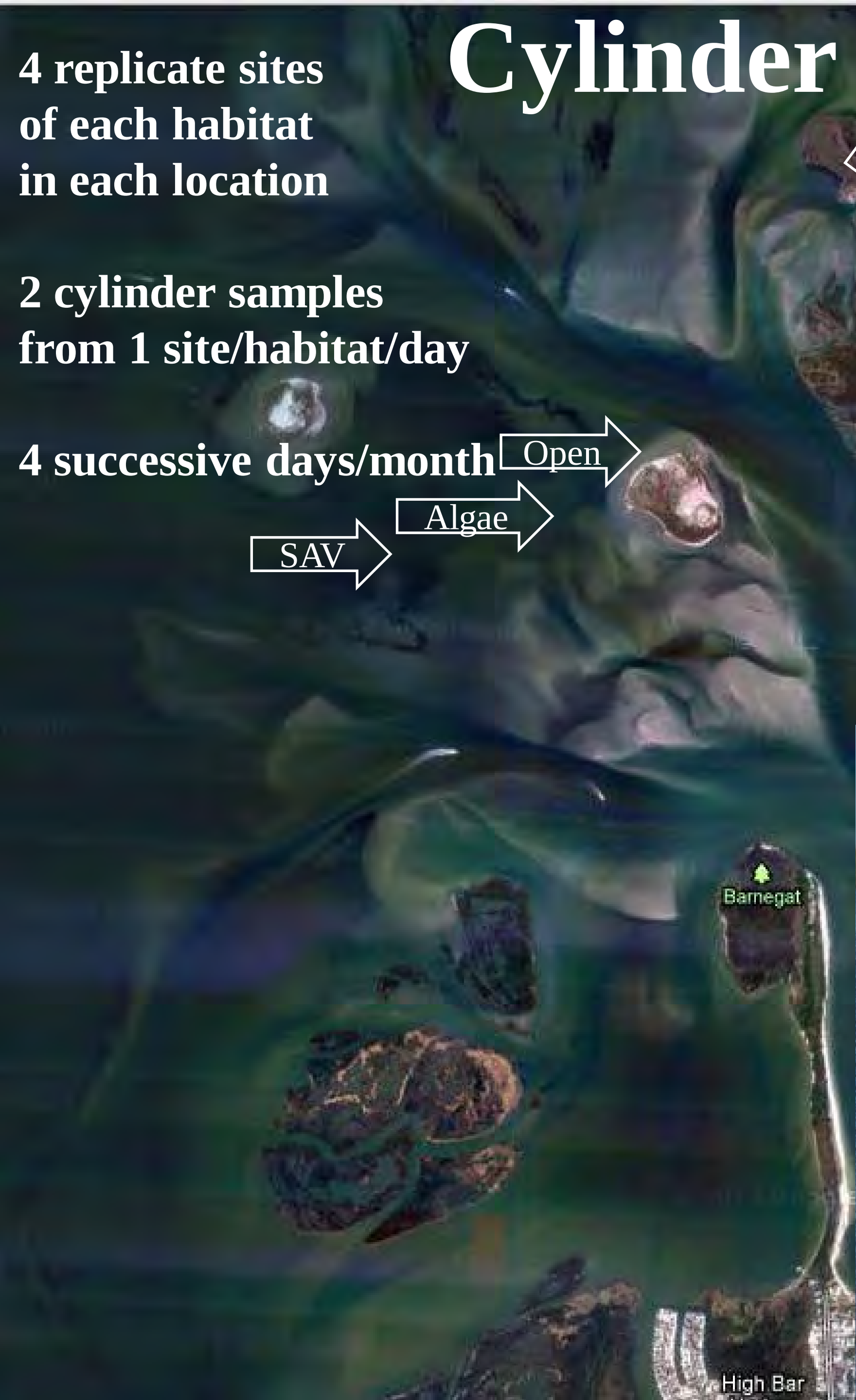
(3) abundance, size, and sex ratio of adult blue crabs
blue crab trap sampling
SIMCZ versus other SAV-dominated areas in the bay

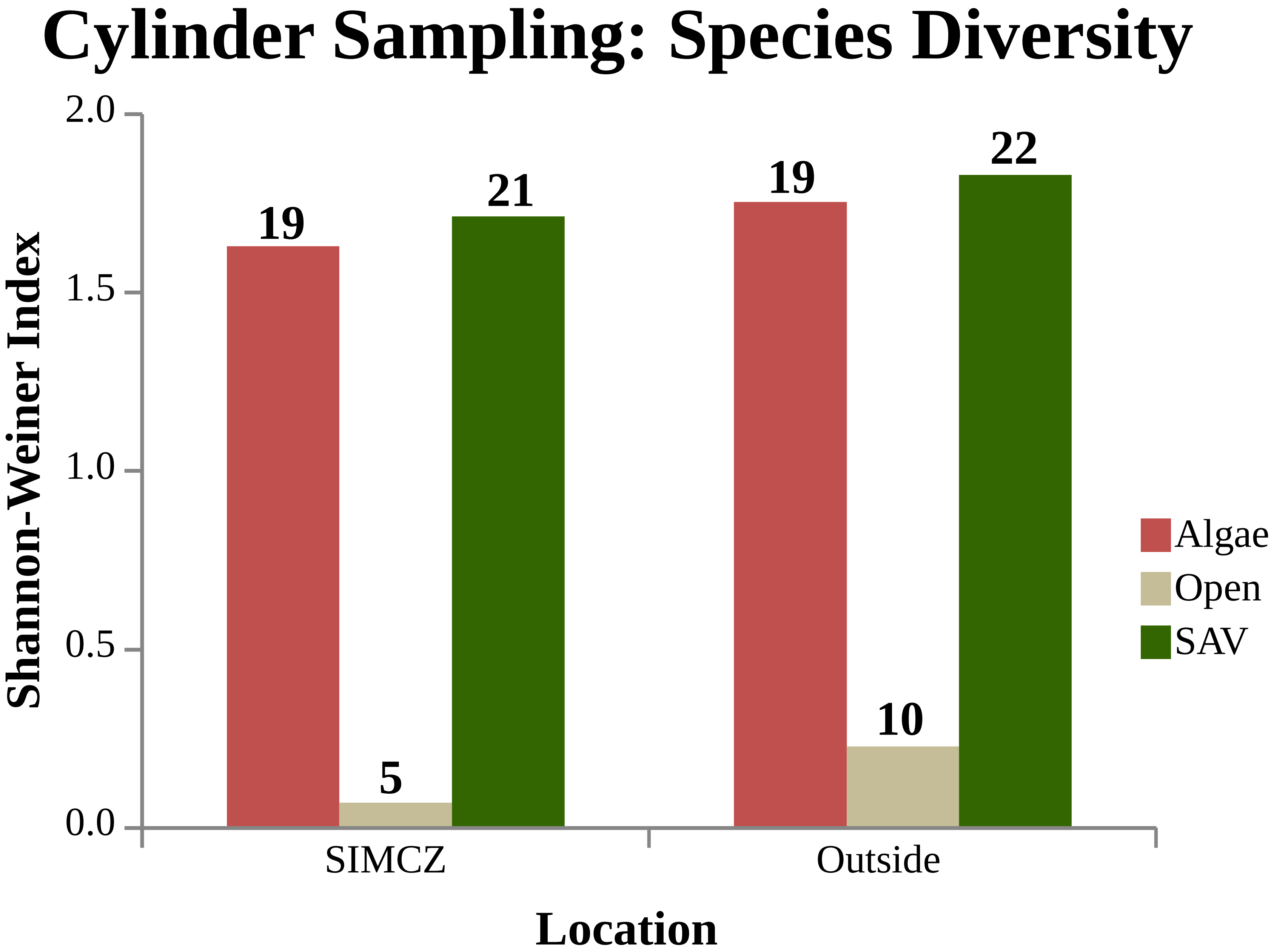
Cylinder Sampling

4 replicate sites of each habitat in each location

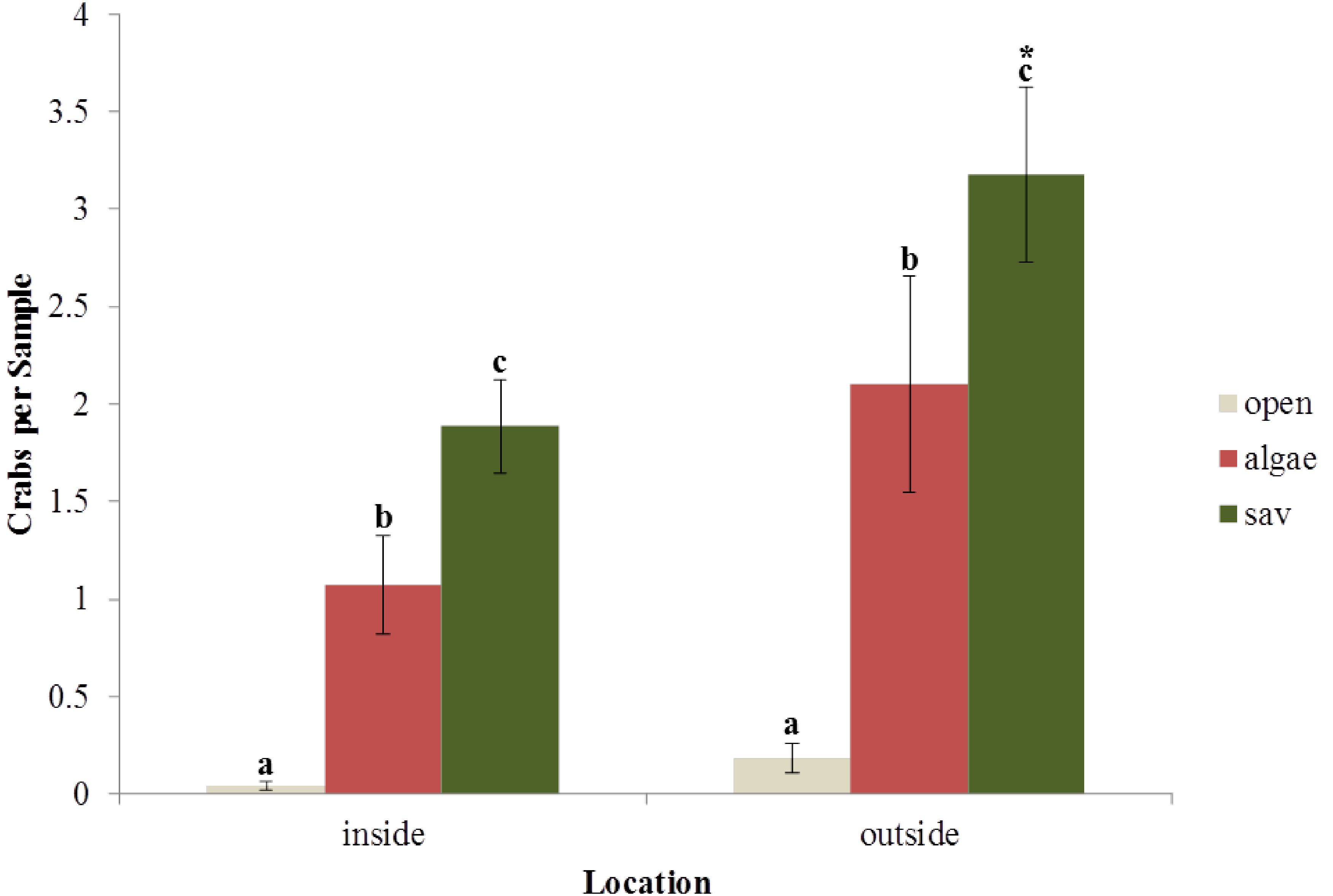
2 cylinder samples from 1 site/habitat/day

4 successive days/month




Cylinder Sampling: Species Diversity
Shannon-Weiner Index
2.0
1.5
1.0
0.5
0.0
19
5
21
19
10
22
SIMCZ
Outside
Location
Algae
Open
SAV

Cylinder Sampling: Blue Crab Abundance

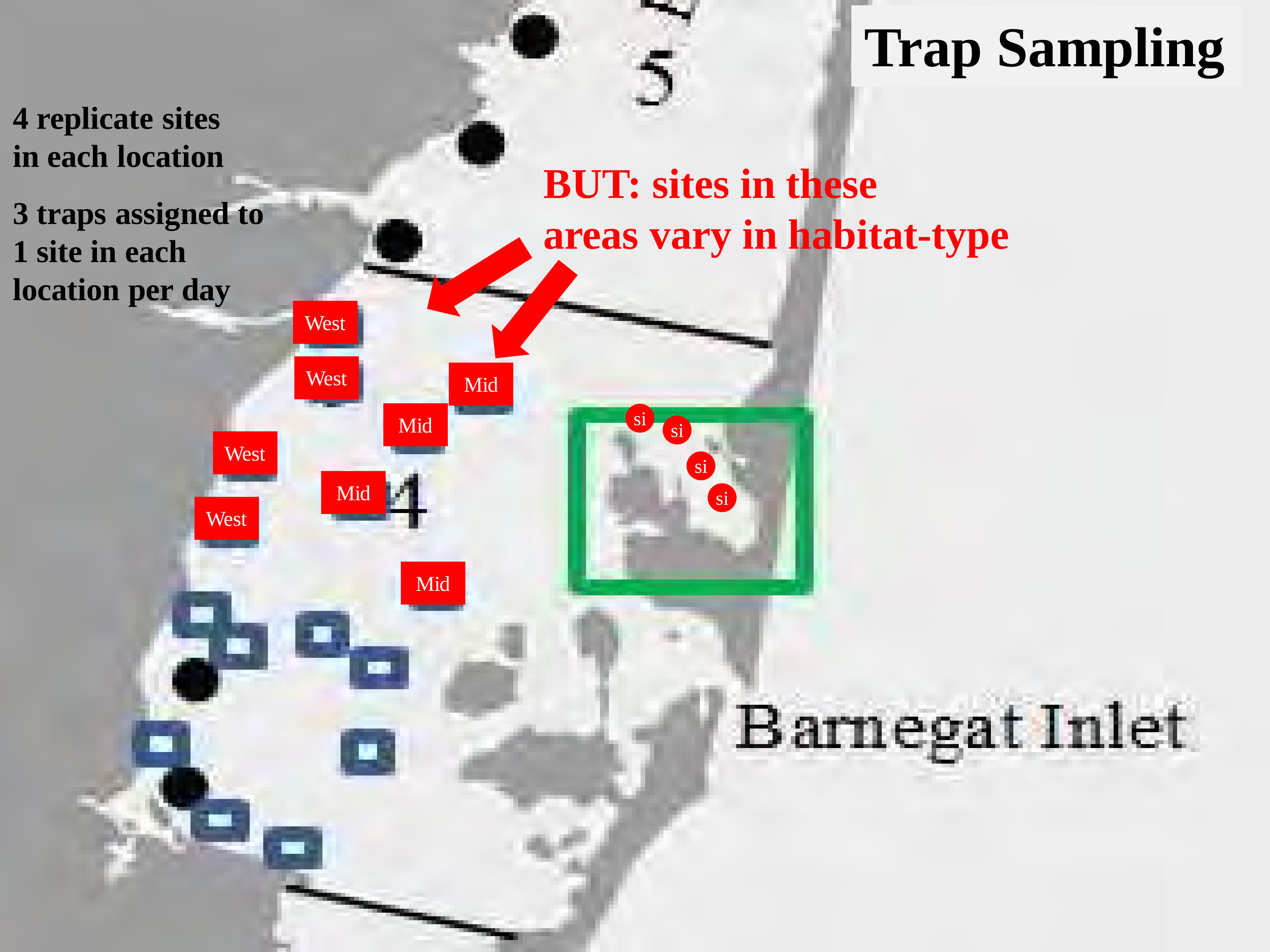


Trap Sampling

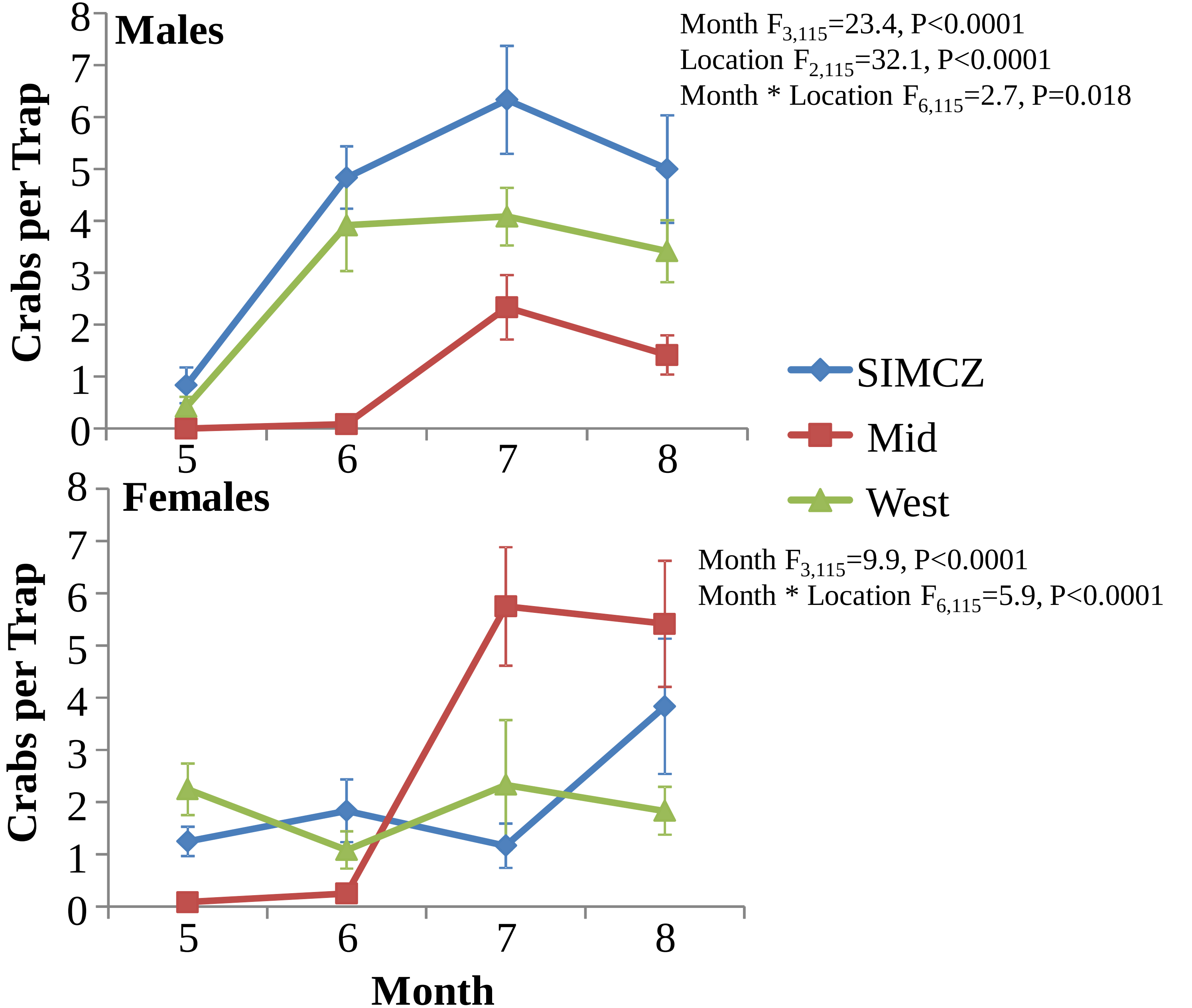
4 replicate sites in each location

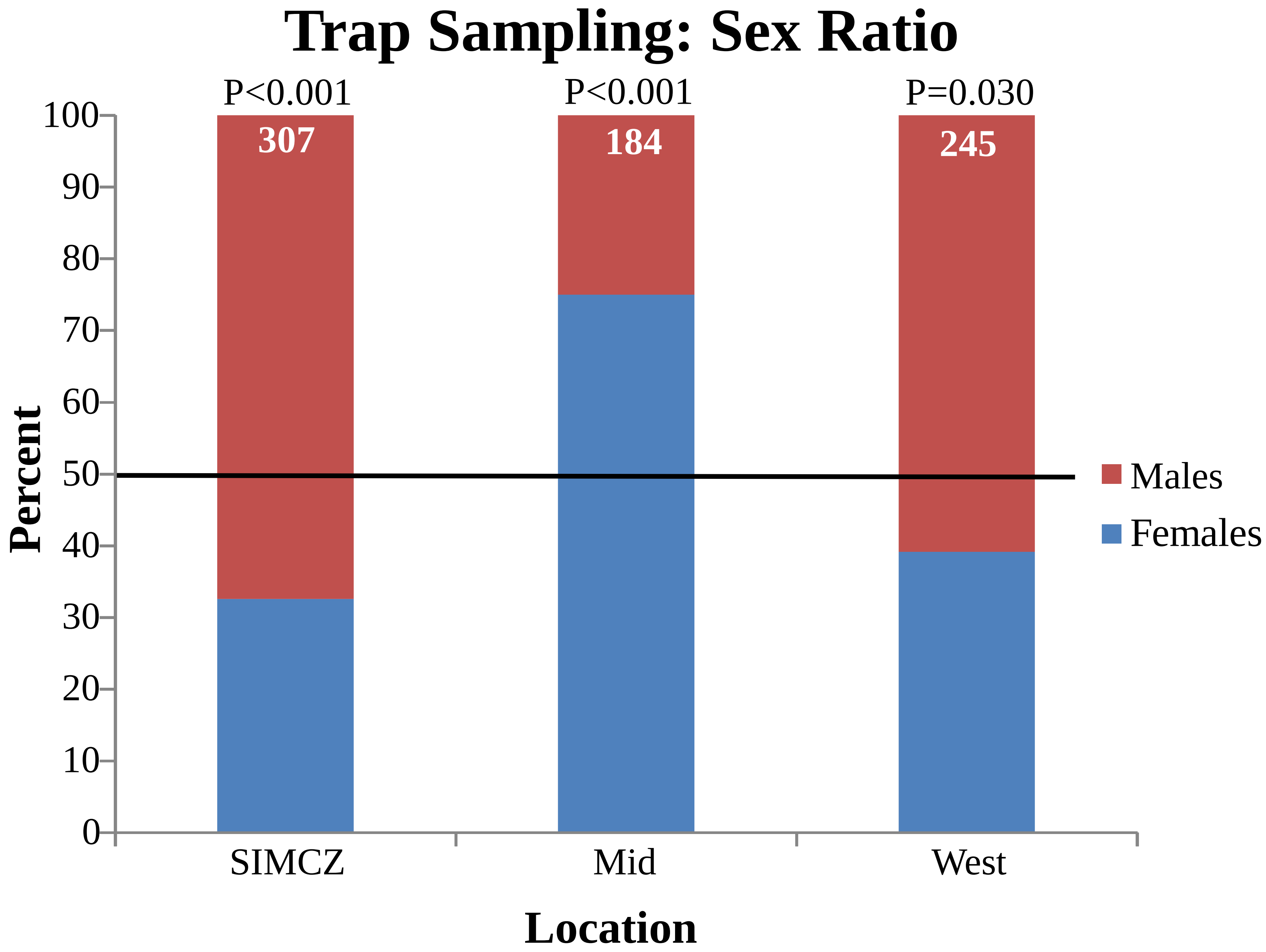
3 traps assigned to 1 site in each location per day

BUT: sites in these areas vary in habitat-type



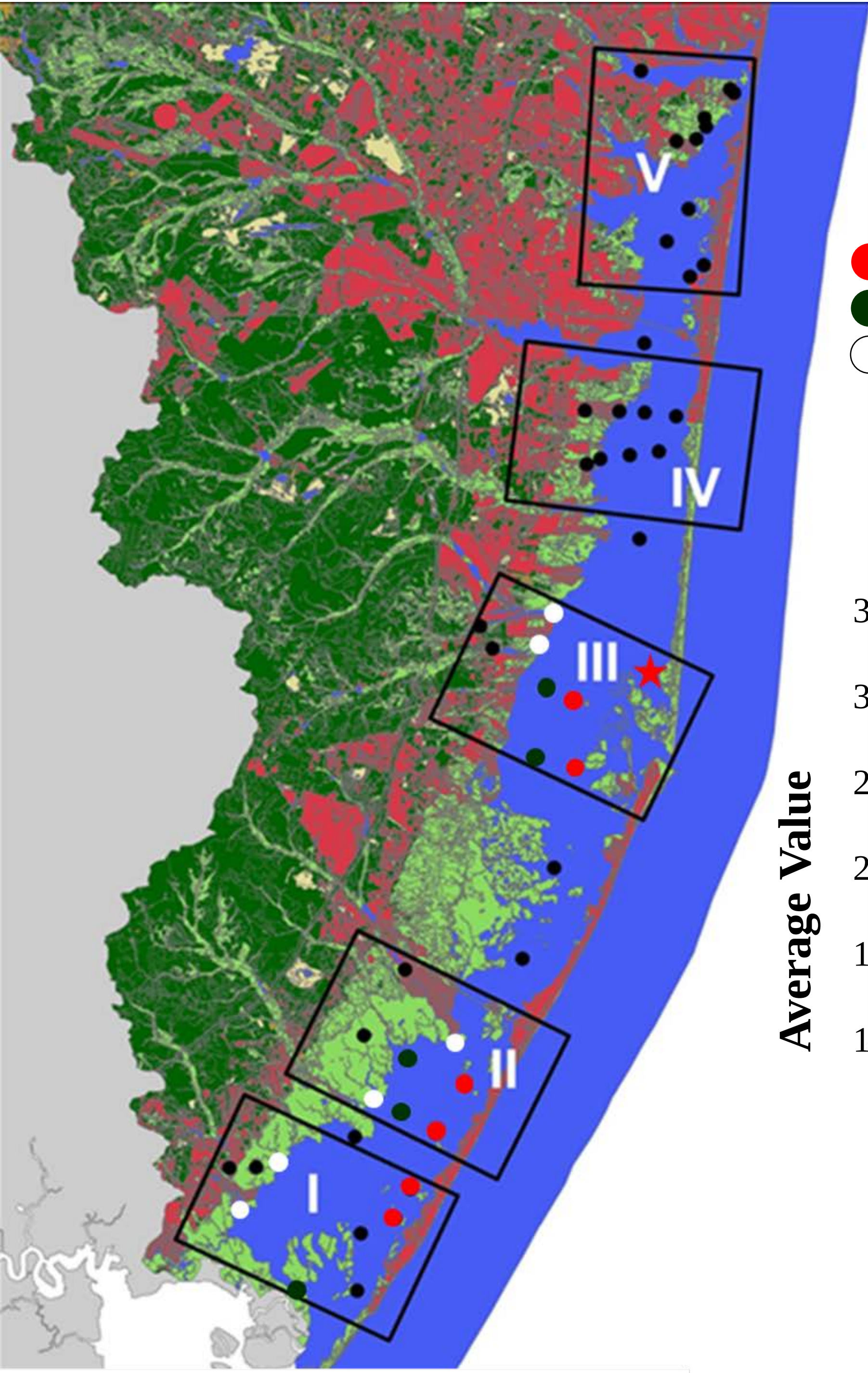
Trap Sampling: Abundance





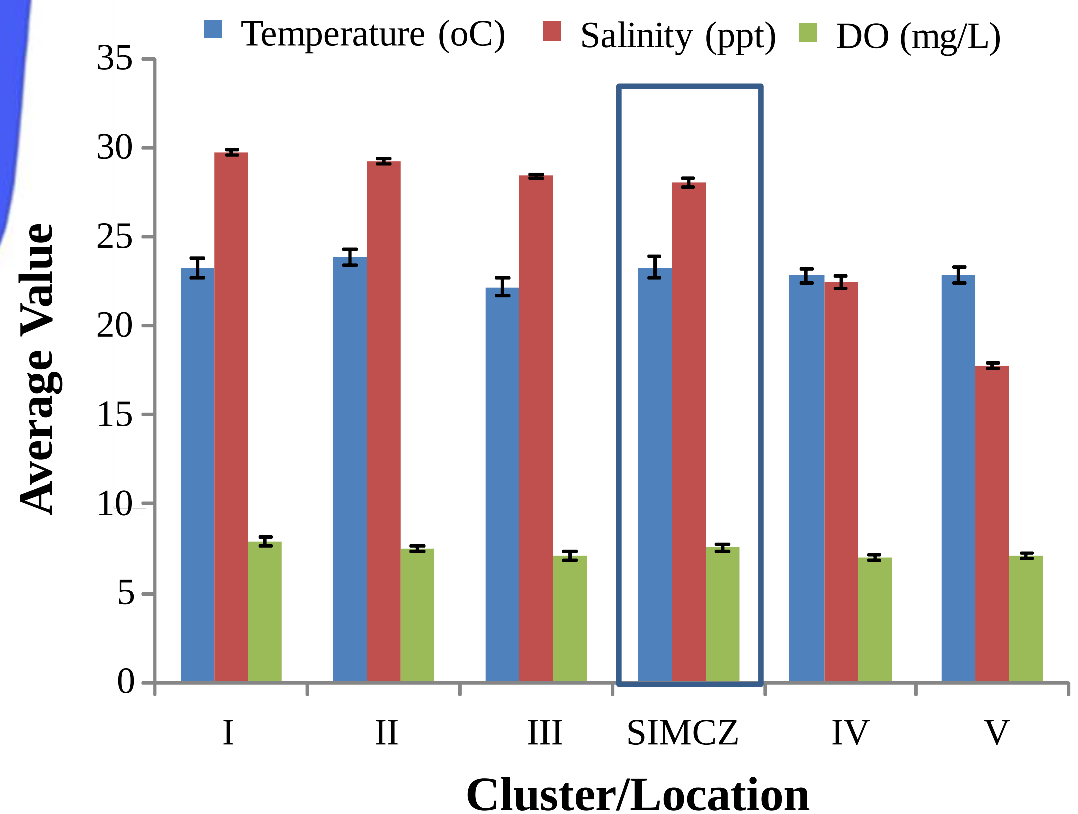
Trap Sampling: Sex Ratio
P<0.001
P<0.001
P=0.030
307
184
245
100
90
80
70
60
50
40
30
20
10
0
Percent
SIMCZ
Mid
West
Location
Males
Females

SIMCZ vs Other SAV-dominated areas….

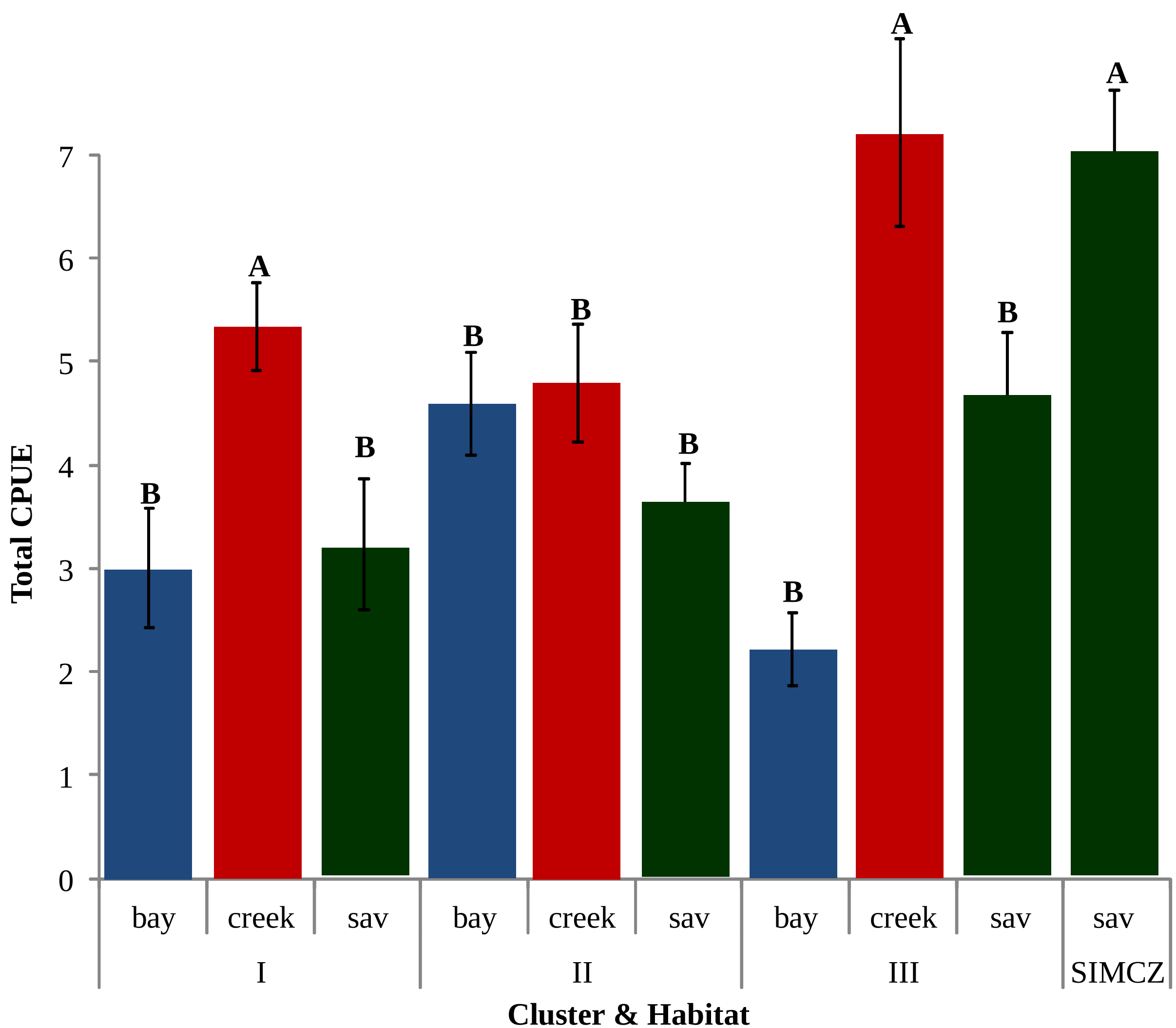


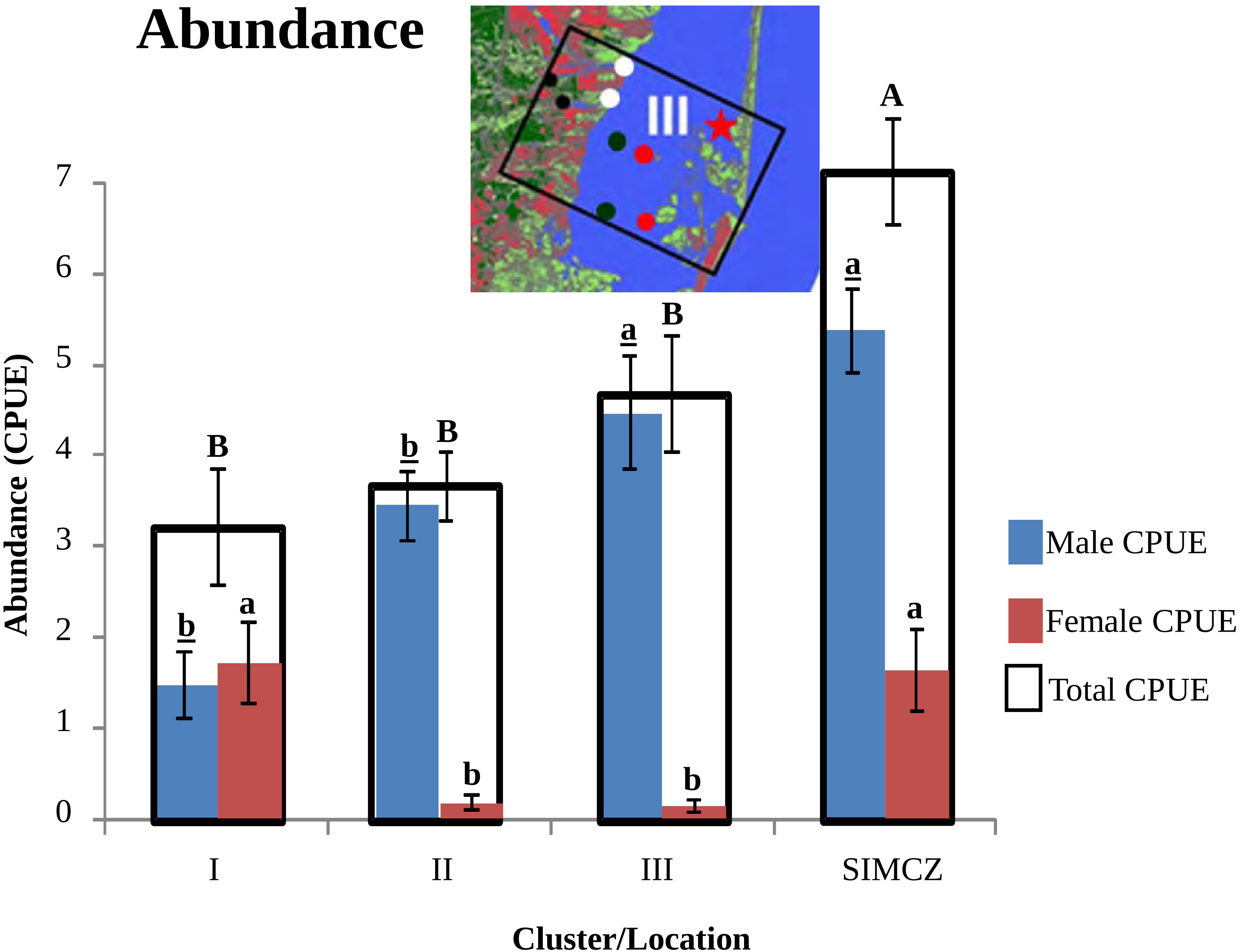
SAV
Bay
Creek Mouth

which clusters to use?....



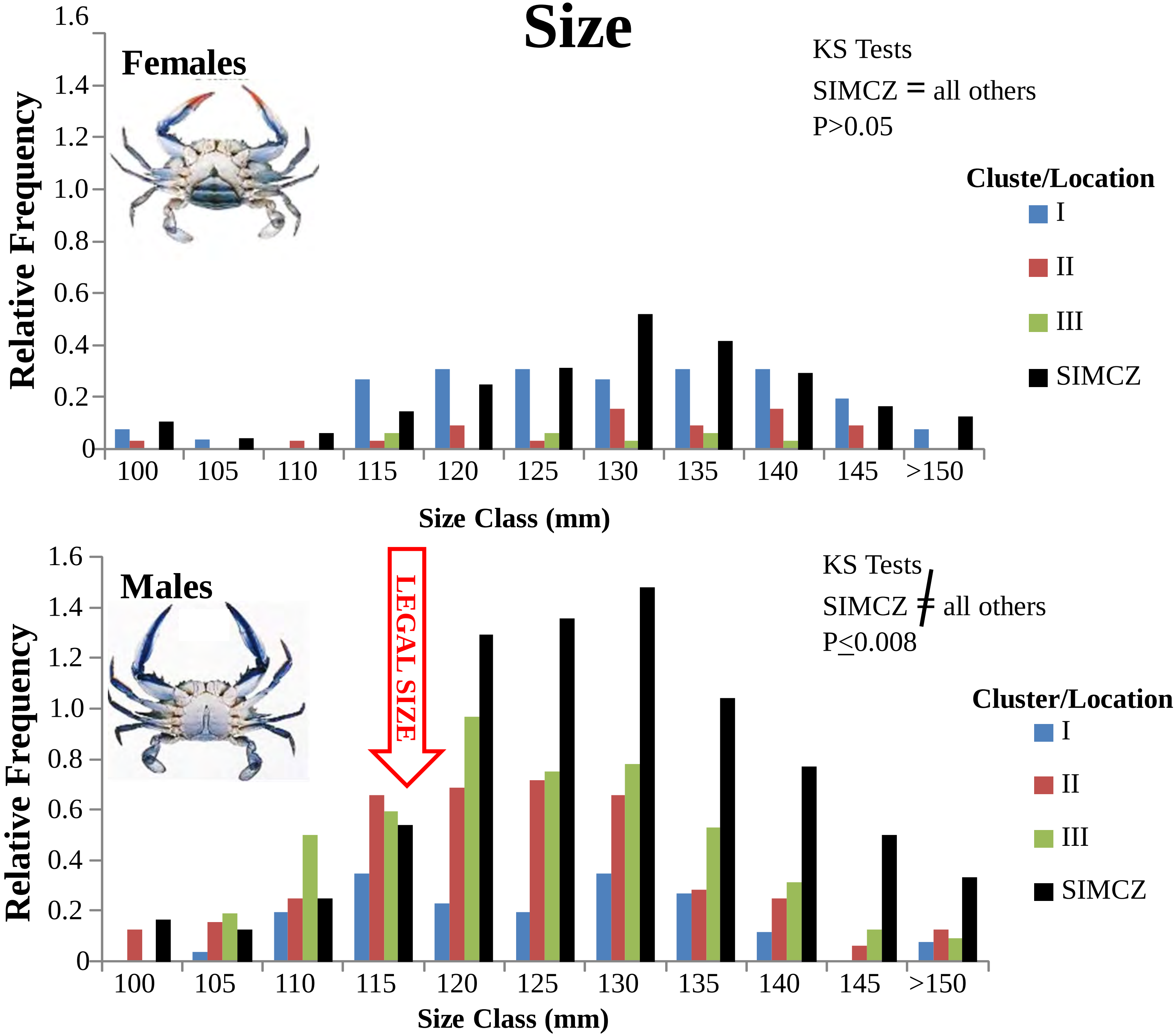
Abundance: Other Habitats



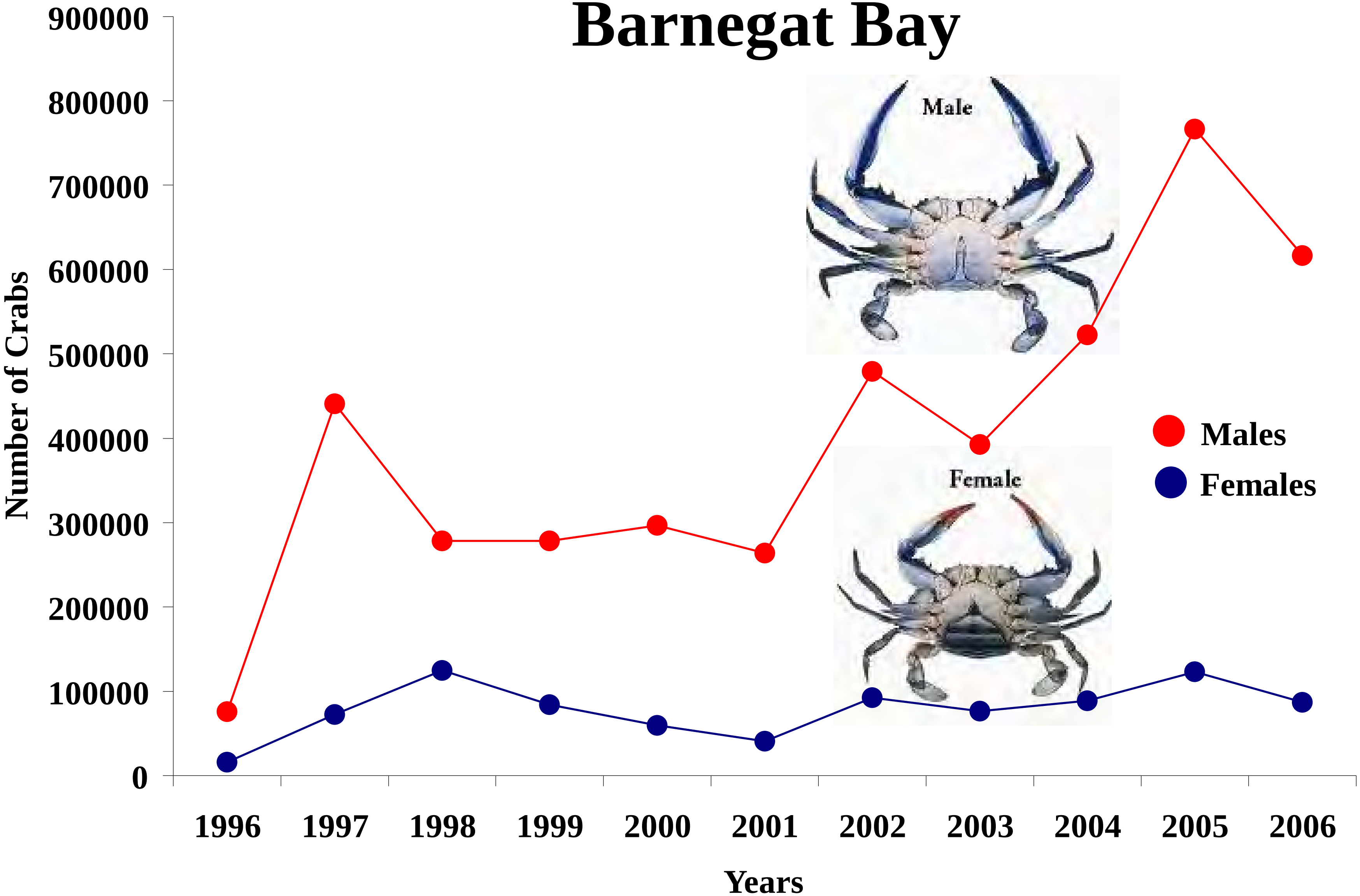


Abundance
III
Abundance (CPUE)
0
1
2
3
4
5
6
7
B
b
a
b
B
b
a
B
b
A
a
a
I
II
III
SIMCZ
Cluster/Location
Male CPUE
Female CPUE
Total CPUE

Size


Females
KS Tests
SIMCZ = all others
P>0.05
Cluste/Location
I
II
III
SIMCZ
Relative Frequency
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
100
105
110
115
120
125
130
135
140
145
>150
Size Class (mm)
Males
LEGAL SIZE
KS Tests
SIMCZ ≠ all others
P≤0.008
Cluster/Location
I
II
III
SIMCZ
Relative Frequency
Size Class (mm)

Sex-Biased Fishing (summer)
Barnegat Bay



Summary

(1) Species diversity (H') & Richness

habitat effect (low in open) but no location effect….

habitats inside SIMCZ are similar to those outside the SIMCZ

(2) Juvenile blue crab abundance

habitat effect (low in open) but no location effect….

habitats inside SIMCZ are similar to those outside the SIMCZ

(3) Adult blue crab population structure

more abundant in SIMCZ

relatively more males in SIMCZ

abundance and sex ratio different inside SIMCZ than outside

(4) SIMCZ versus other SAV-dominated areas

more males in SIMCZ

more larger (legal sized) males in SIMCZ

no fishing?

abundance and size different inside SIMCZ than other SAV areas

Thanks to…

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Chelsea Tighe

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NJ-Department of Environmental Protection

Rider University

Tidal Marshes of Barnegat Bay: Nutrient History and Ecosystem Services

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[1]Patrick Center for Environmental Science
The Academy of Natural Sciences of Drexel University

[2]Department of Oceanography and Coastal Sciences, Louisiana State University
[3]Center for Environmental Science, University of Maryland-Horn Point

November 2015

Barnegat Bay Comprehensive Research
NJ Department of Environmental Protection

Outline

- Tidal wetlands of Barnegat Bay
- Processes in tidal wetlands
- Sediment history and burial
- Nitrogen removal in wetlands
- Mass Balance of N in the Bay
- Summary

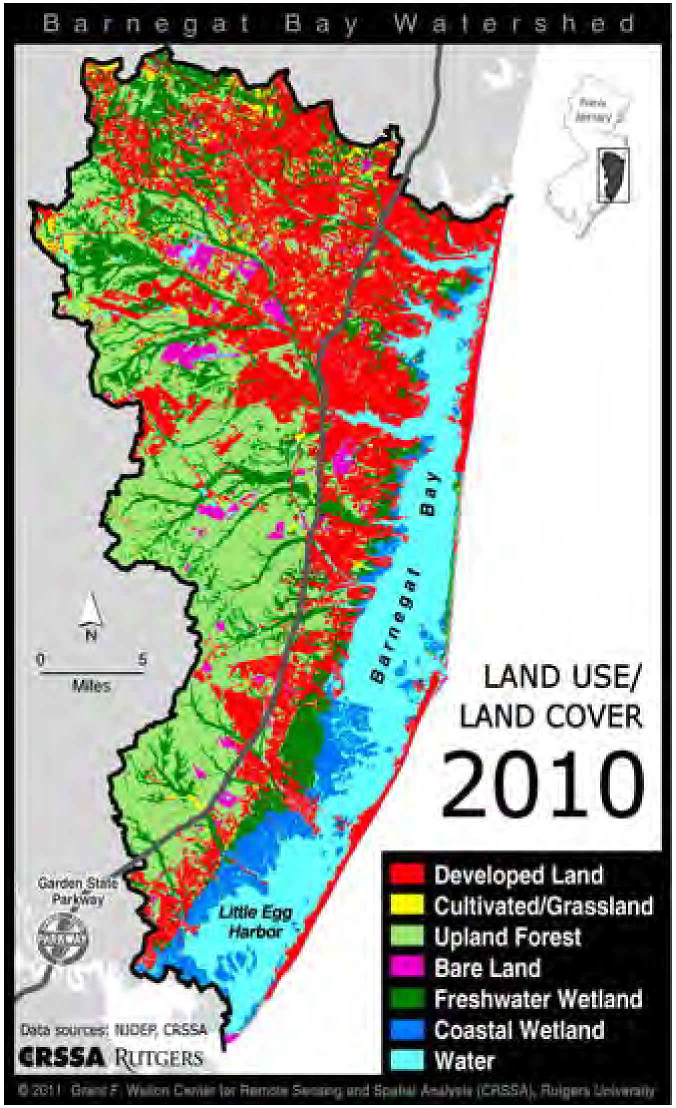
Barnegat Bay

Watershed N load: 4.6 to 8.6 x 10^5 kg N yr^{-1}

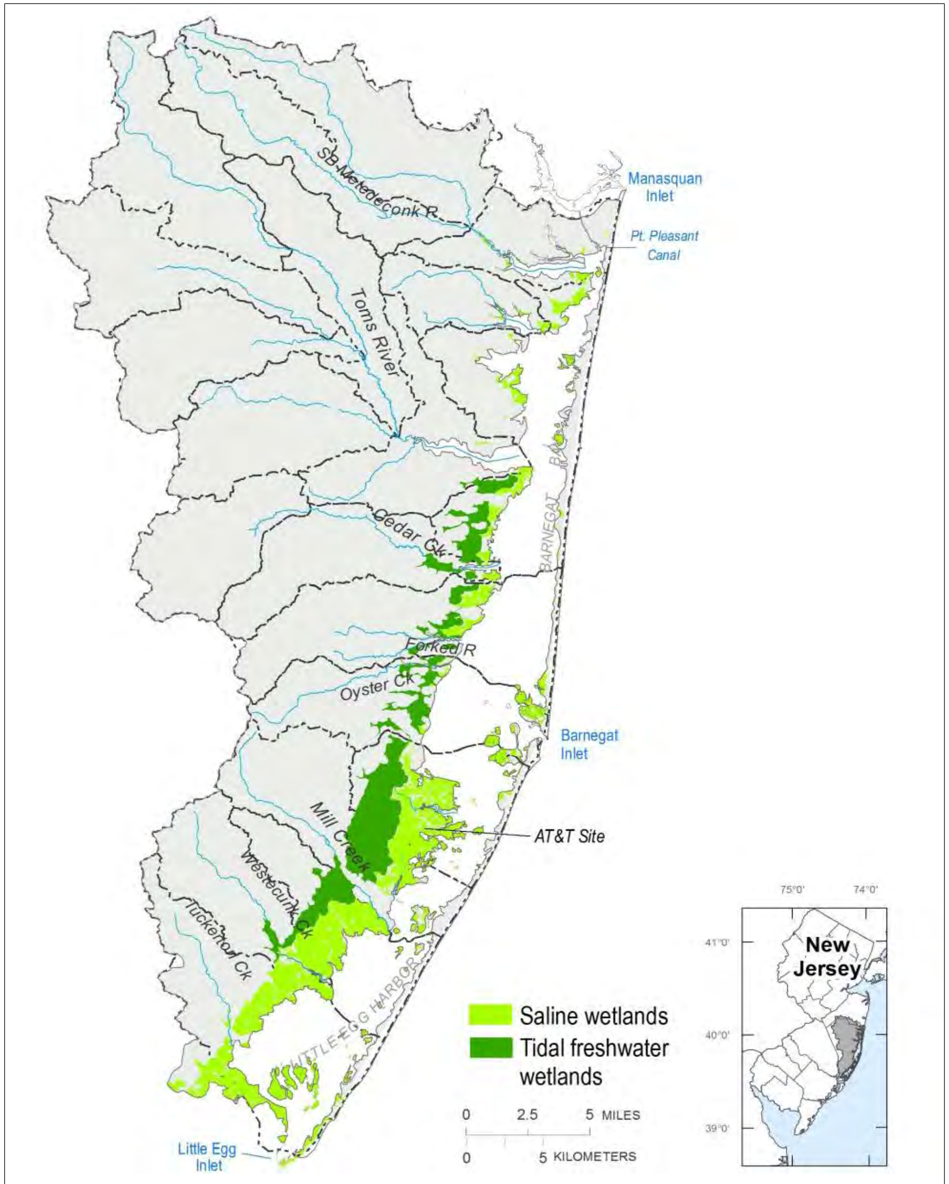
(from 1998 to 2011; Baker et al. 2014)

Symptoms of Eutrophication

- phytoplankton and macroalgae blooms
- brown tide and HABs
- alteration of benthic communities
- loss of seagrass and shellfish beds



Wetlands of Barnegat Bay



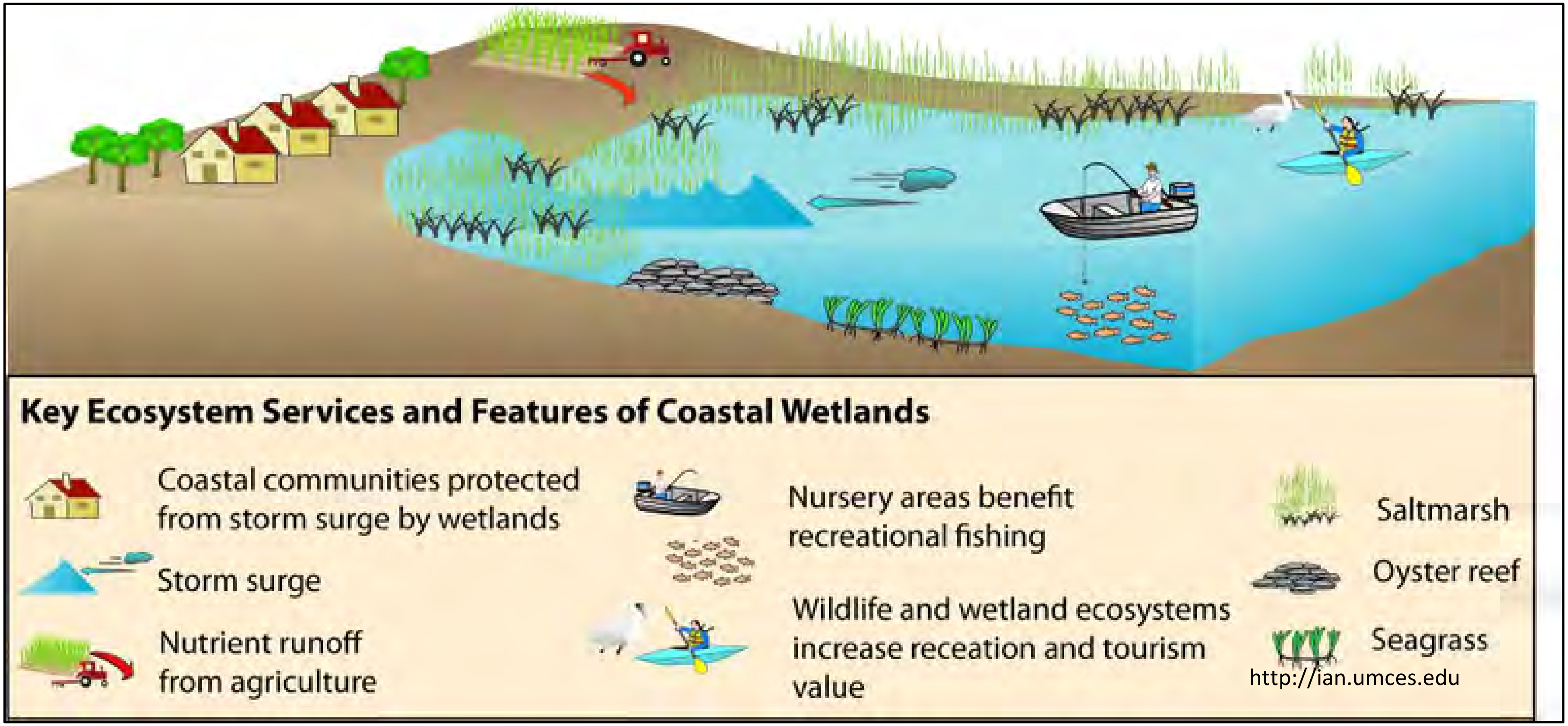
Saline Wetlands: 21,800 acres

Tidal Freshwater: 5,100 acres

Total Areal Extent: 26,900 acres

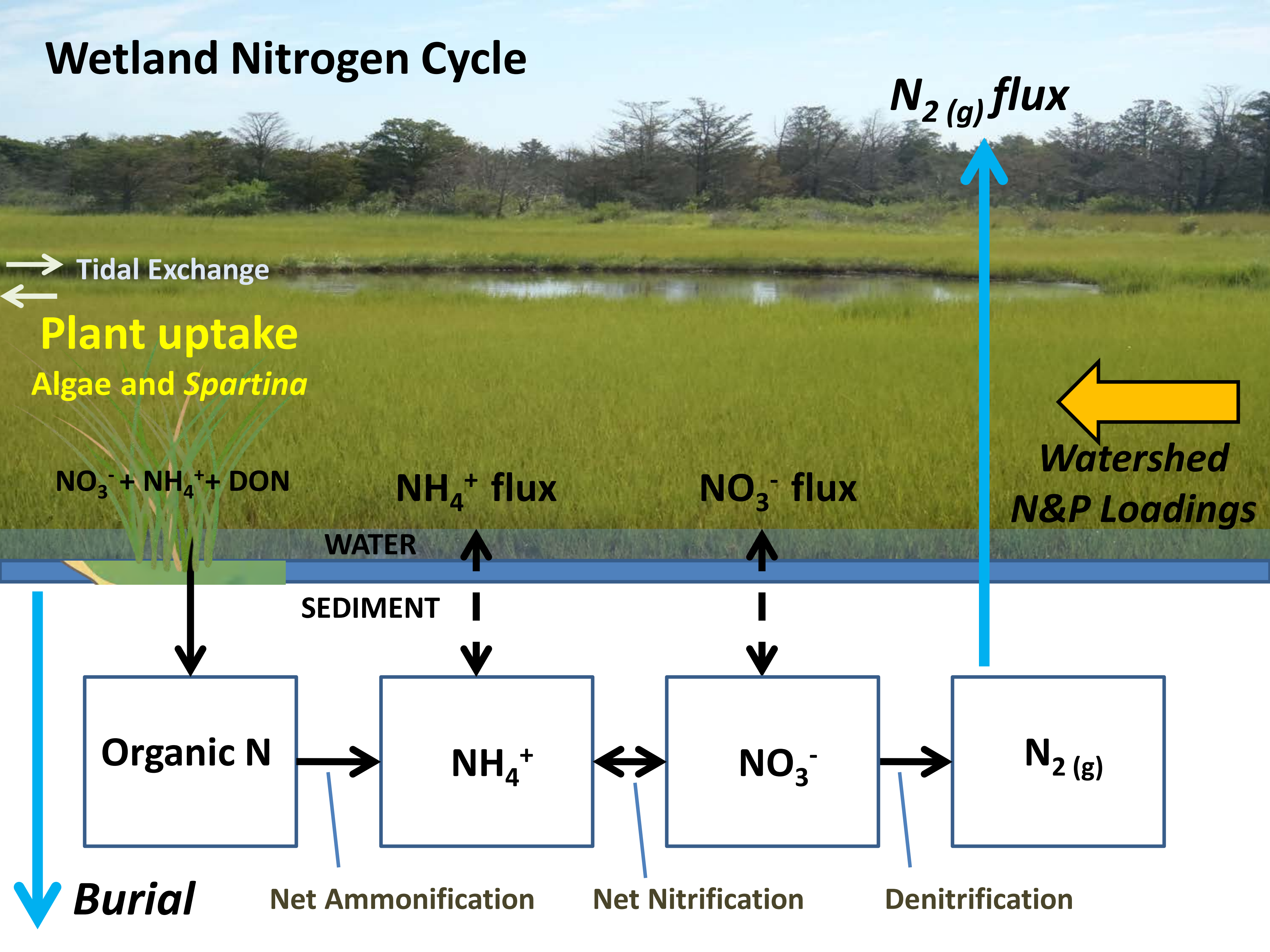
Data from V. Depaul (USGS)

Wetlands provide valuable ecosystem services!



- Water quality improvement (e.g. chemical transformation)
- Floodwater retention and protection
- Biodiversity islands and corridors
- Carbon, nitrogen, phosphorus (i.e., chemical) removal
- Locations for recreation and nature observation/education

Wetlands services located around the bay


Wetland Nitrogen Cycle
N2 (g) flux
Tidal Exchange
Plant uptake
Algae and Spartina
Watershed
N&P Loadings
NO3- + NH4+ + DON
NH4+ flux
NO3- flux
WATER
SEDIMENT
Organic N
NH4+
NO3-
N2 (g)
Burial
Net Ammonification
Net Nitrification
Denitrification

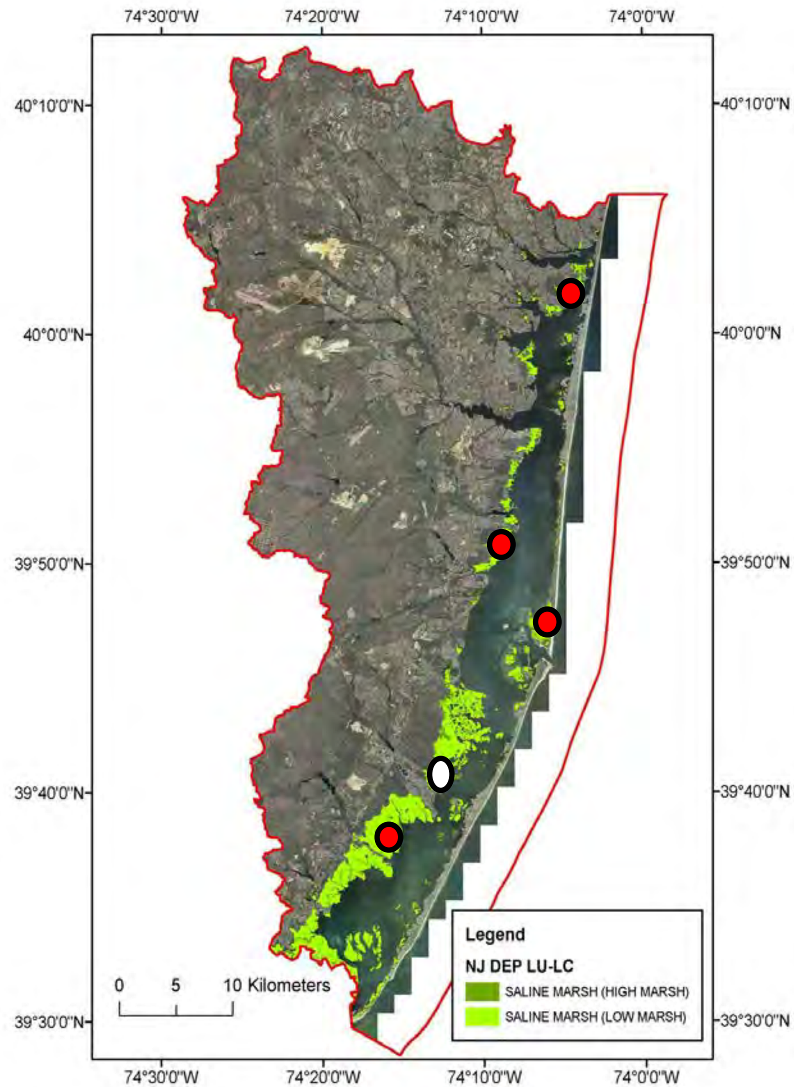
NJDEP Barnegat Bay Comprehensive Research

Objectives of Projects:

1. Evaluate permanent nitrogen (N) removal services provided by Barnegat Bay coastal wetlands:
   - Sediment burial of nitrogen, carbon and phosphorus (Yr 0)
   - *Bay-wide* seasonal denitrification rates in salt marshes (Yr 1)
   - Mosquito control (OMWM) ponds impact on denitrification (Yr 2)
     - How do OMWMs impact ecosystem services?
2. Combine data to obtain an overall estimate of N removal services provided by Barnegat Bay wetlands.

Q: What is the fate of nitrogen and other nutrients in the Bay?

Barnegat Bay



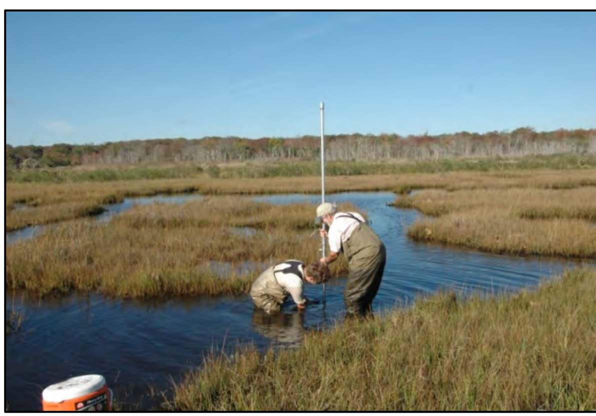
Spatial coverage of the bay

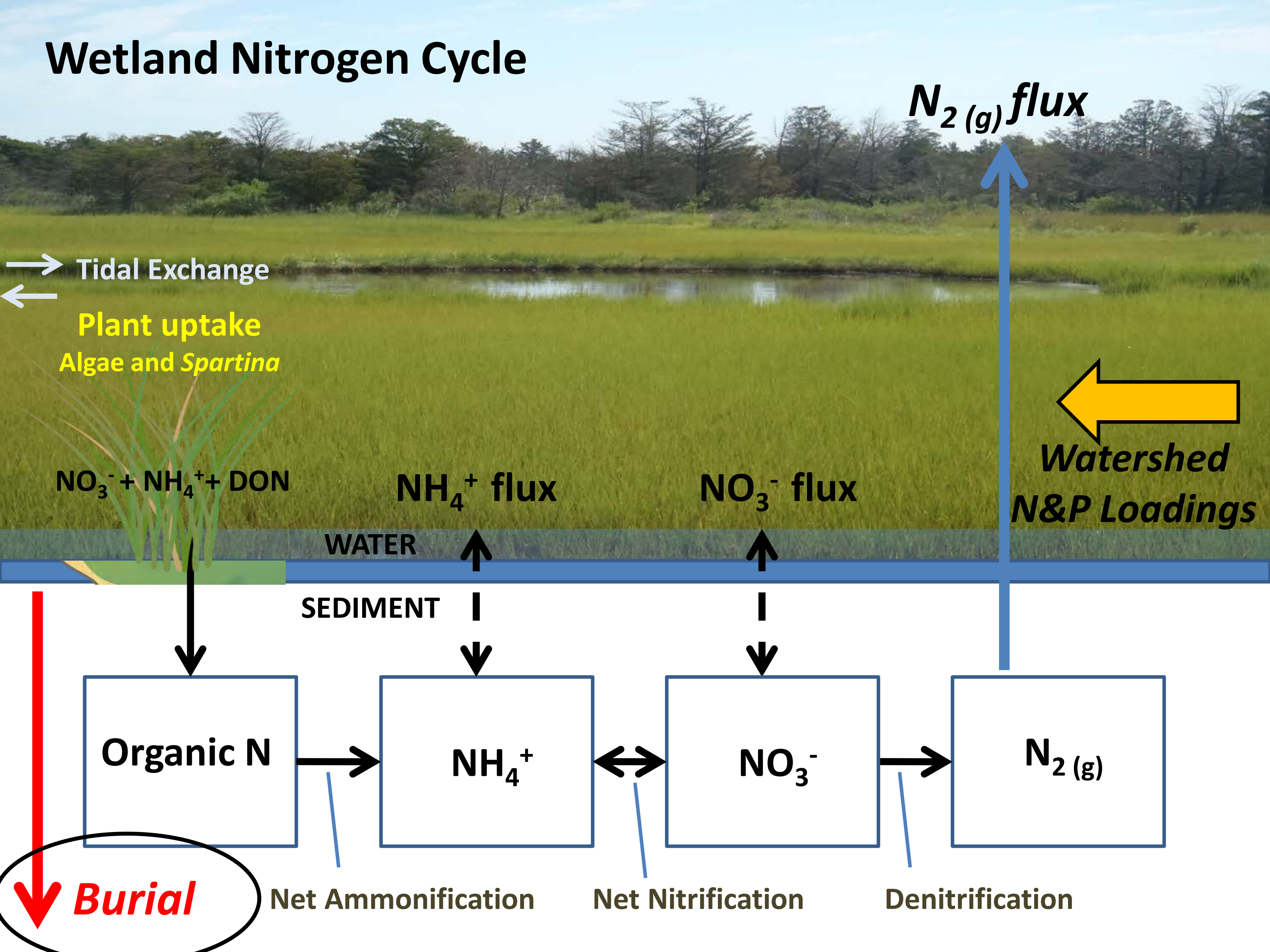
- North
  - High nutrient input
  - Lower salinity
- Mid-bay Barrier Island
  - Mid gradient of salinity/nutrients
- South
  - Lower nutrient input
  - Higher salinity

Year 0 and 1 Sites

Year 2 Sites

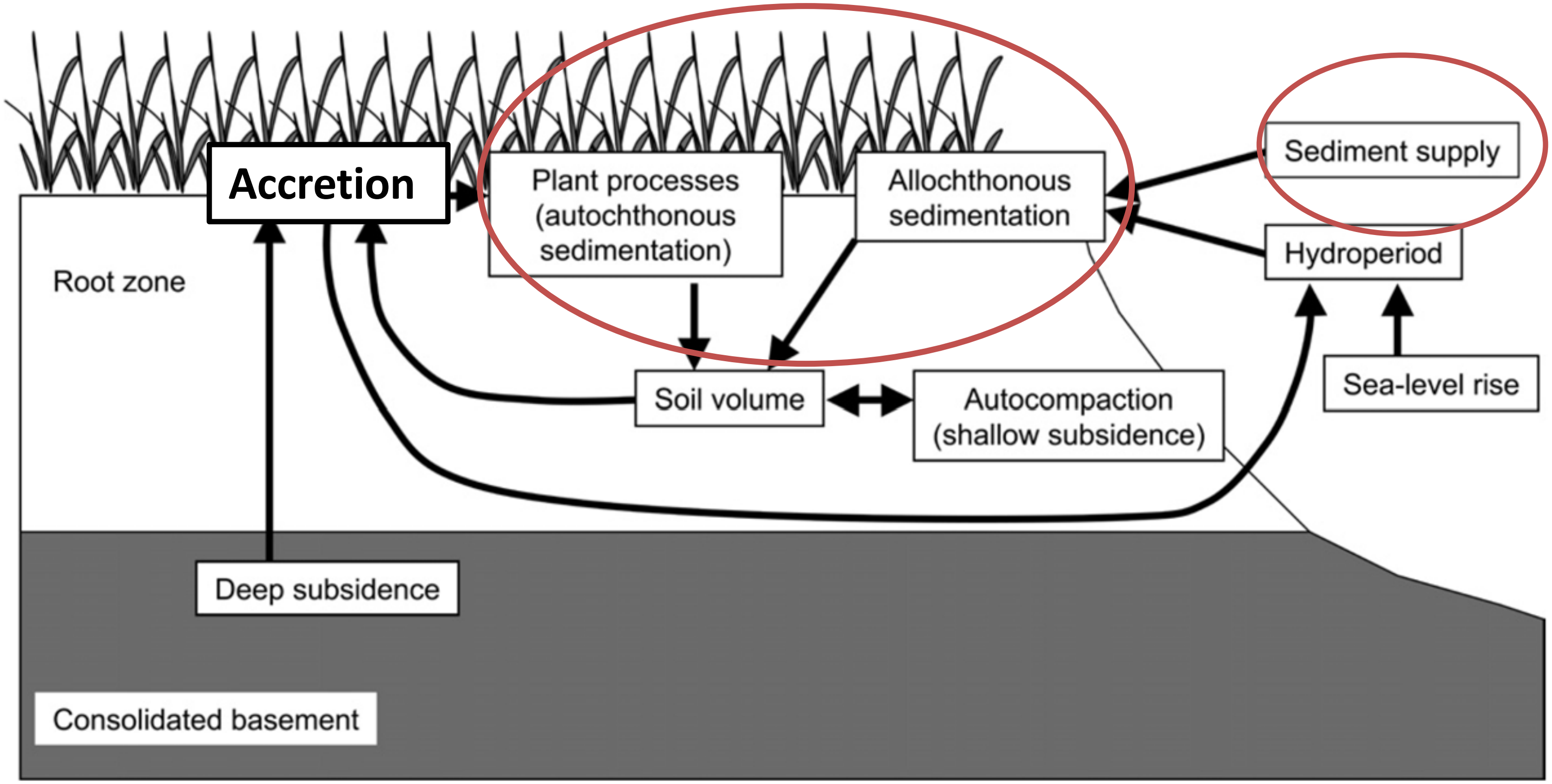
Photos from the Field





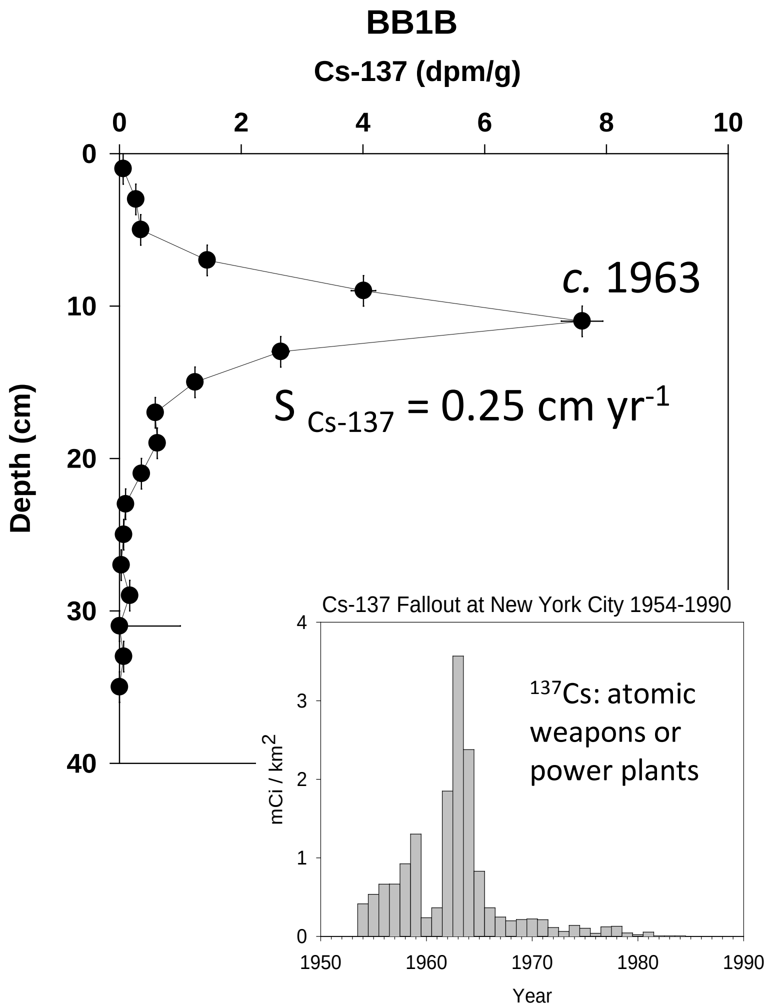
Wetland Nitrogen Cycle
$N_{2\ (g)}$ flux
Tidal Exchange
Plant uptake
Algae and *Spartina*
$NO_3^- + NH_4^+ +$ DON
NH_4^+ flux
NO_3^- flux
Watershed N&P Loadings
WATER
SEDIMENT
Organic N
NH_4^+
NO_3^-
$N_{2\ (g)}$
Burial
Net Ammonification
Net Nitrification
Denitrification

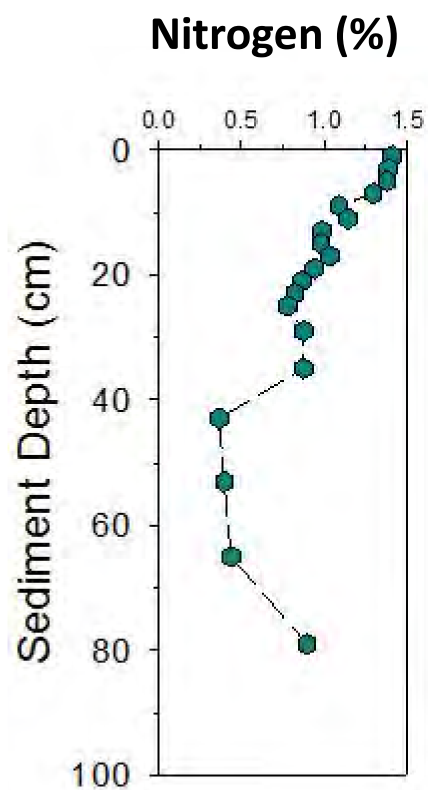
Wetland accretion and erosion

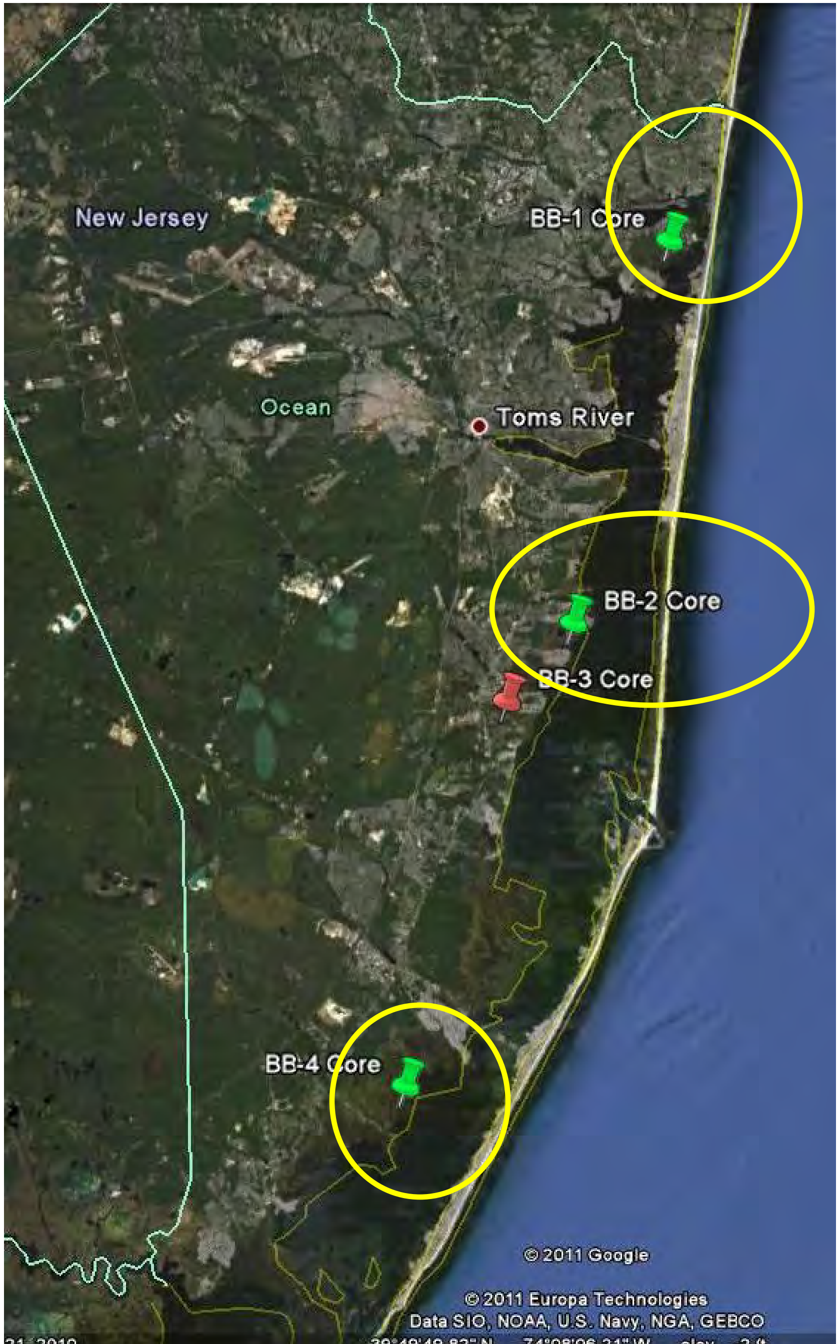


- Plant biomass and input of sediment from tidal flow = sediment supply to marsh
- Absolute accretion = local accretion + subsidence

Nitrogen Burial in Barnegat Bay Wetlands







Sampling Locations

- Reedy Creek (BB-1)
- Mid Bay-Wire Pond (BB-2)
- Oyster Creek (BB-3)
  - discharge canal
- West Creek (BB-4)

Analytical Parameters

– Organic Carbon, Total Nitrogen and Total Phosphorus

– Diatom Species Composition

– Stable Isotopes of Carbon ($\delta^{13}C$) and Nitrogen ($\delta^{15}N$)

– Grain size (< 63 μm; clay + silt)

– Radioactive Isotopes: ^{210}Pb and ^{137}Cs

Comparison Between Delaware and Barnegat Bays: Accretion Rates

Tidal fresh and salt marsh accretion rates in Delaware Estuary:

All Sites

Mean 0.72 ± 0.21 cm/yr, n=29

Max 1.1 cm/yr

Min 0.39 cm/yr

Salt Marshes

Mean 0.65 ± 0.17 cm/yr, n=17

Max 1.0 cm/yr

Min 0.39 cm/yr

Tidal Freshwater Marshes

Mean 0.85 ± 0.24 cm/yr, n=12

Max 1.1 cm/yr

Min 0.60 cm/yr

Barnegat Bay Sites:

All Sites

Mean 0.25 ± 0.06 cm/yr, n= 4

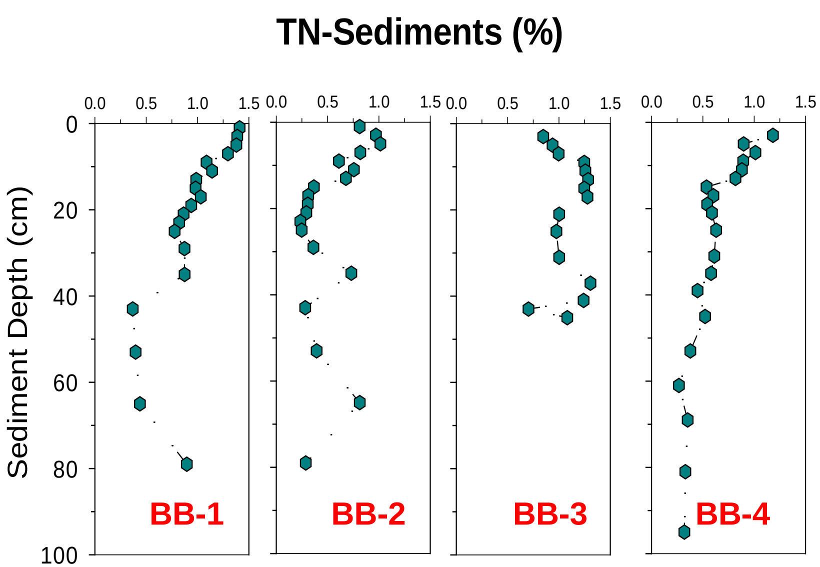
Max 0.29 cm/yr

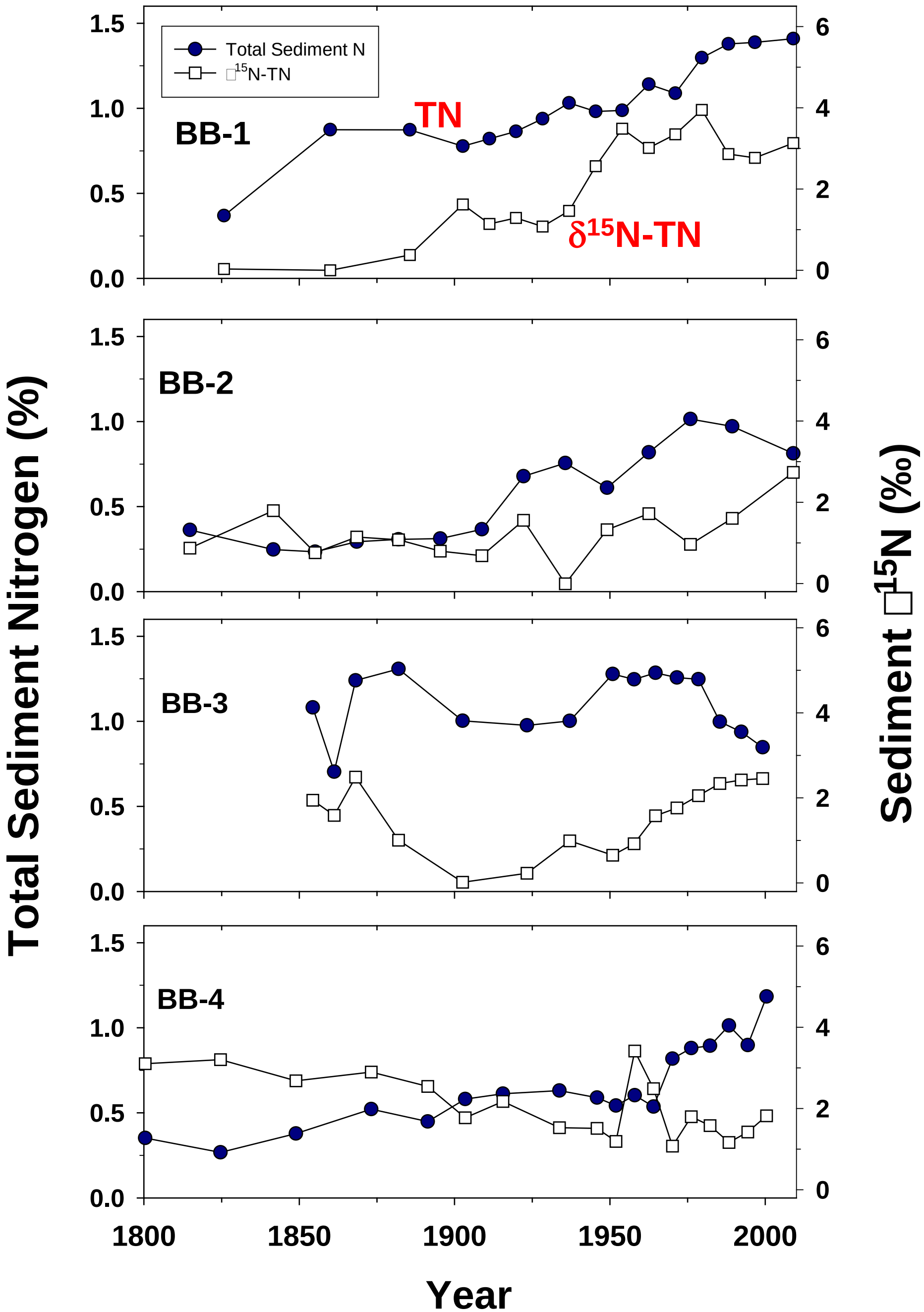
Min 0.16 cm/yr

Barnegat Bay -Relative Sea Level Rise (RSLR) in Barnegat Bay = ~0.4 cm/yr

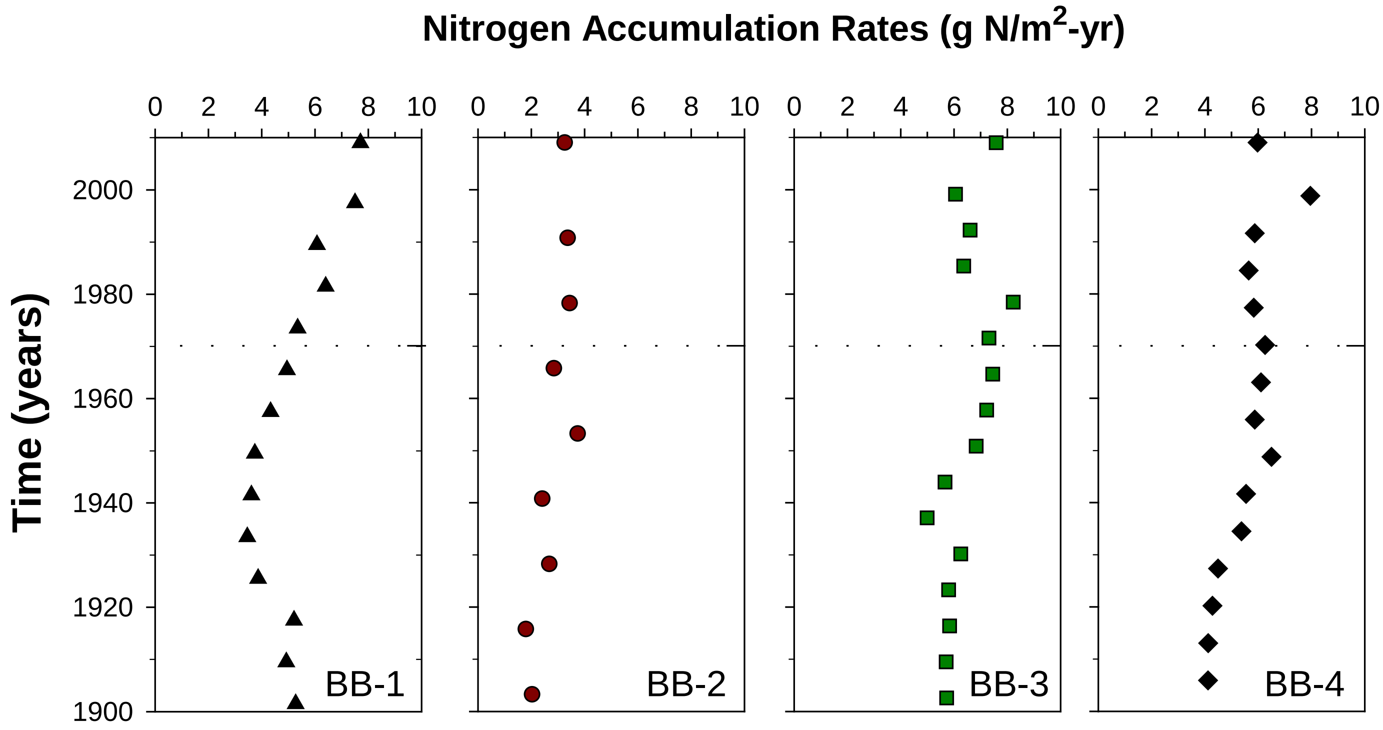
Changes in N with Time

- Increased N concentrations starting around the 1940s
- The δ^{15}N-TN increased from 0-1 per mill to ~ 4 per mill at the surface
- Suggests more land and sewage-derived N was/is being introduced to the bay (..has it changed?)



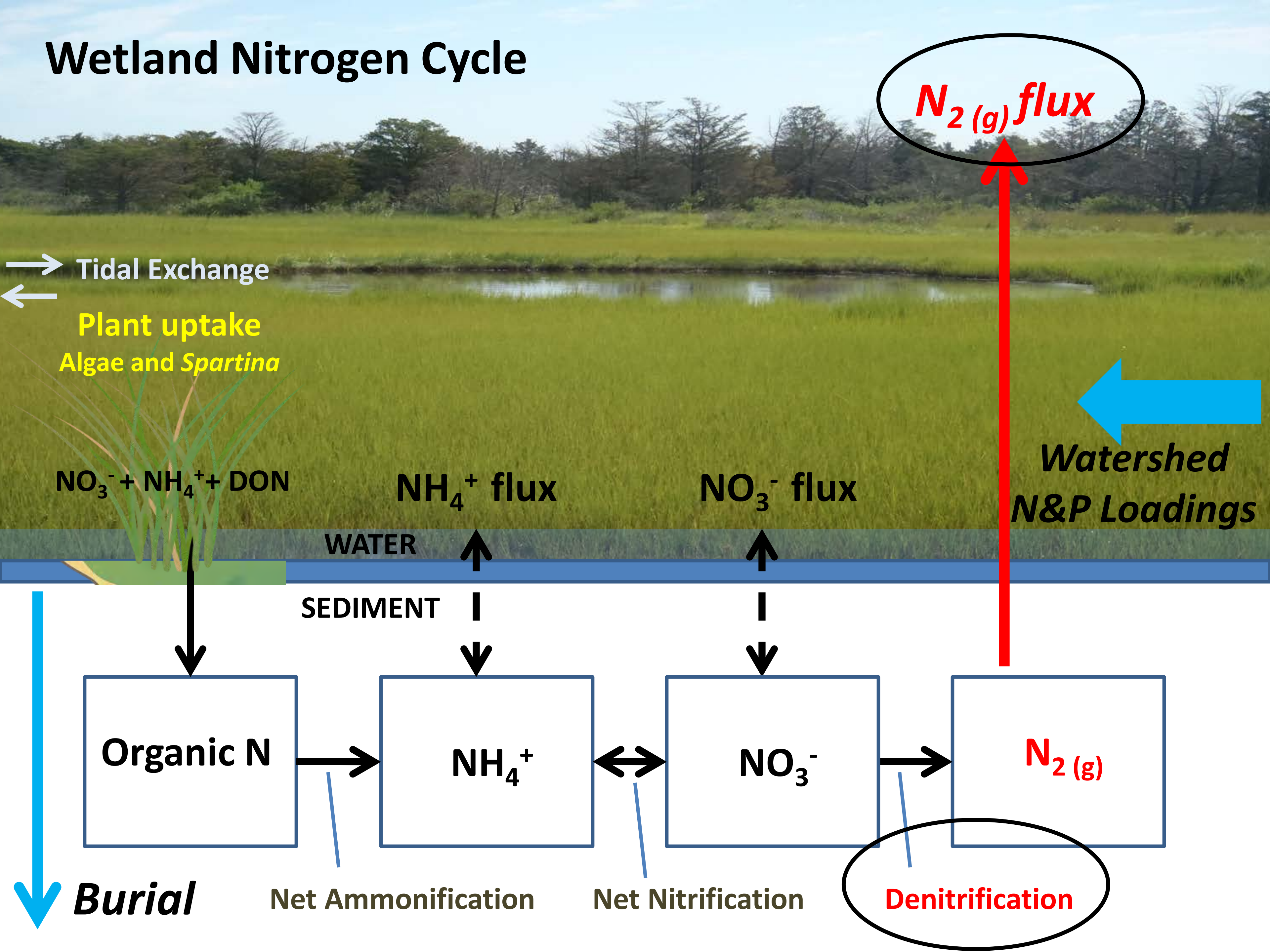


How much N is Buried in the Marshes of Barnegat Bay?



- Using [N or P], sediment mass, and accretion rates to calculate accumulation rates over time
- Rates change with time, with a general increase in most cores starting in the ~1950s/1960s
- Can use rates over time (past 50 years) to estimate sequestration of N from wetland sediments

Results in a Burial rate = 5.2 ± 0.7 g N m^{-2} yr^{-1} (n = 4)



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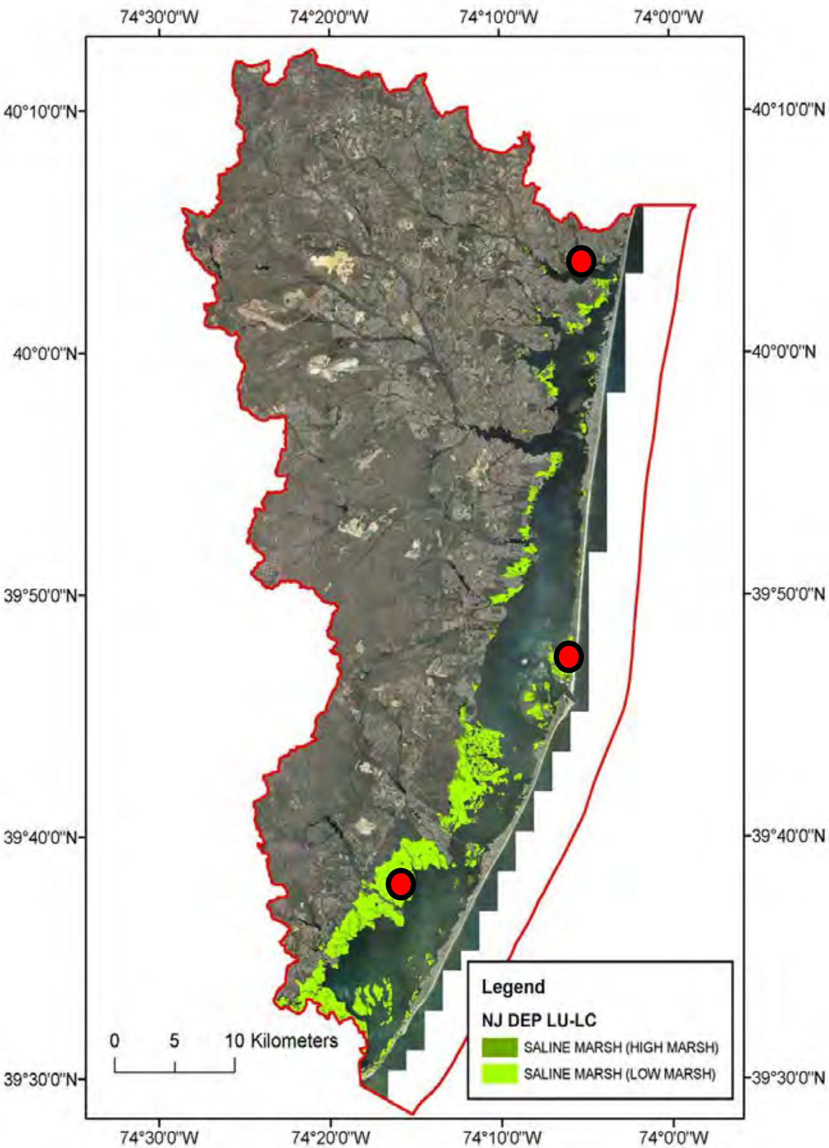
Watershed N&P Loadings
WATER
SEDIMENT
Organic N
NH_4^+
NO_3^-
$N_{2\,(g)}$
Burial
Net Ammonification
Net Nitrification
Denitrification

Barnegat Bay Marshes: Denitrification

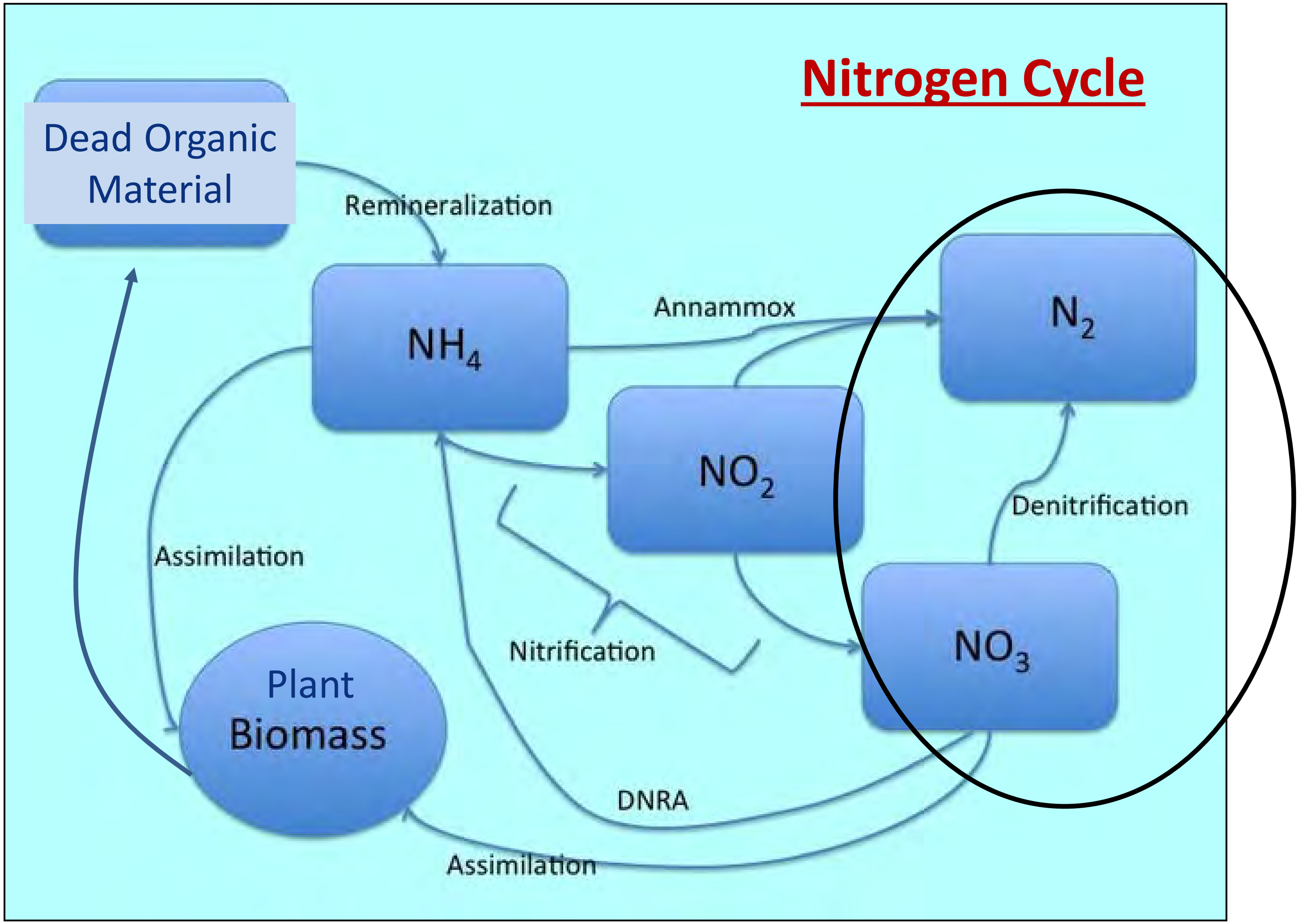


<u>Seasonal denitrification rates</u>

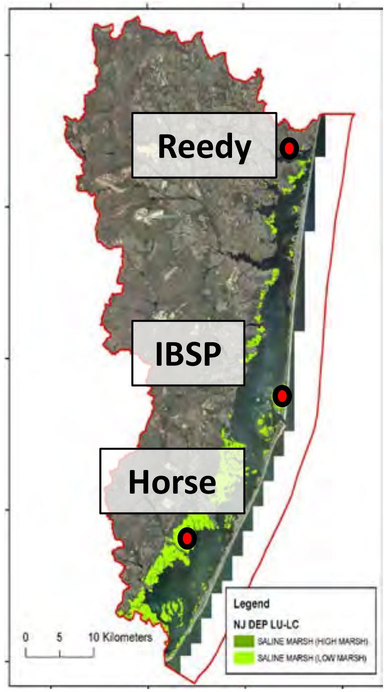
- 3 salt marshes in north, mid-, and south bay
- 6 cores per marsh
- 3 times per year (May, July, October)
- Analyze cores for N- fluxes, oxygen demand, sediment carbon and nitrogen
- Determine average bay-wide flux rates (g N m^{-2} d^{-1})

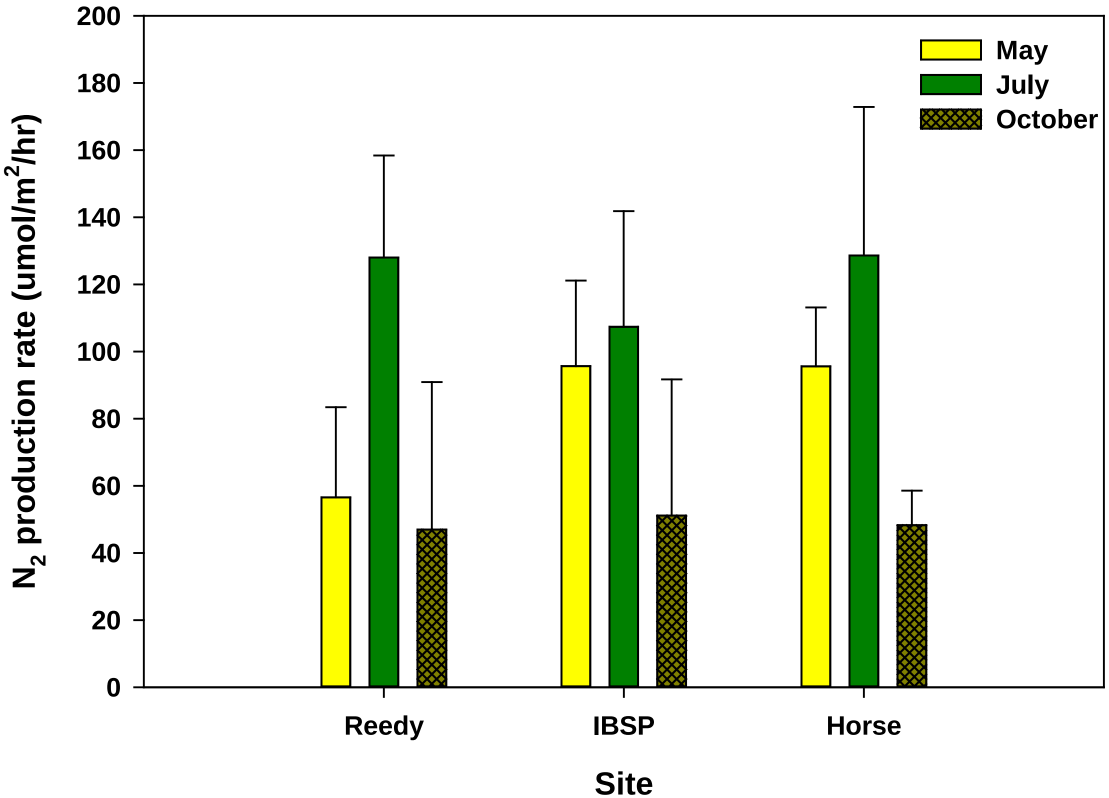
What is Denitrification?

Denitrification is a microbial process that converts nitrate to nitrogen gas



Denitrification Rates in Three Salt Marshes in Barnegat Bay





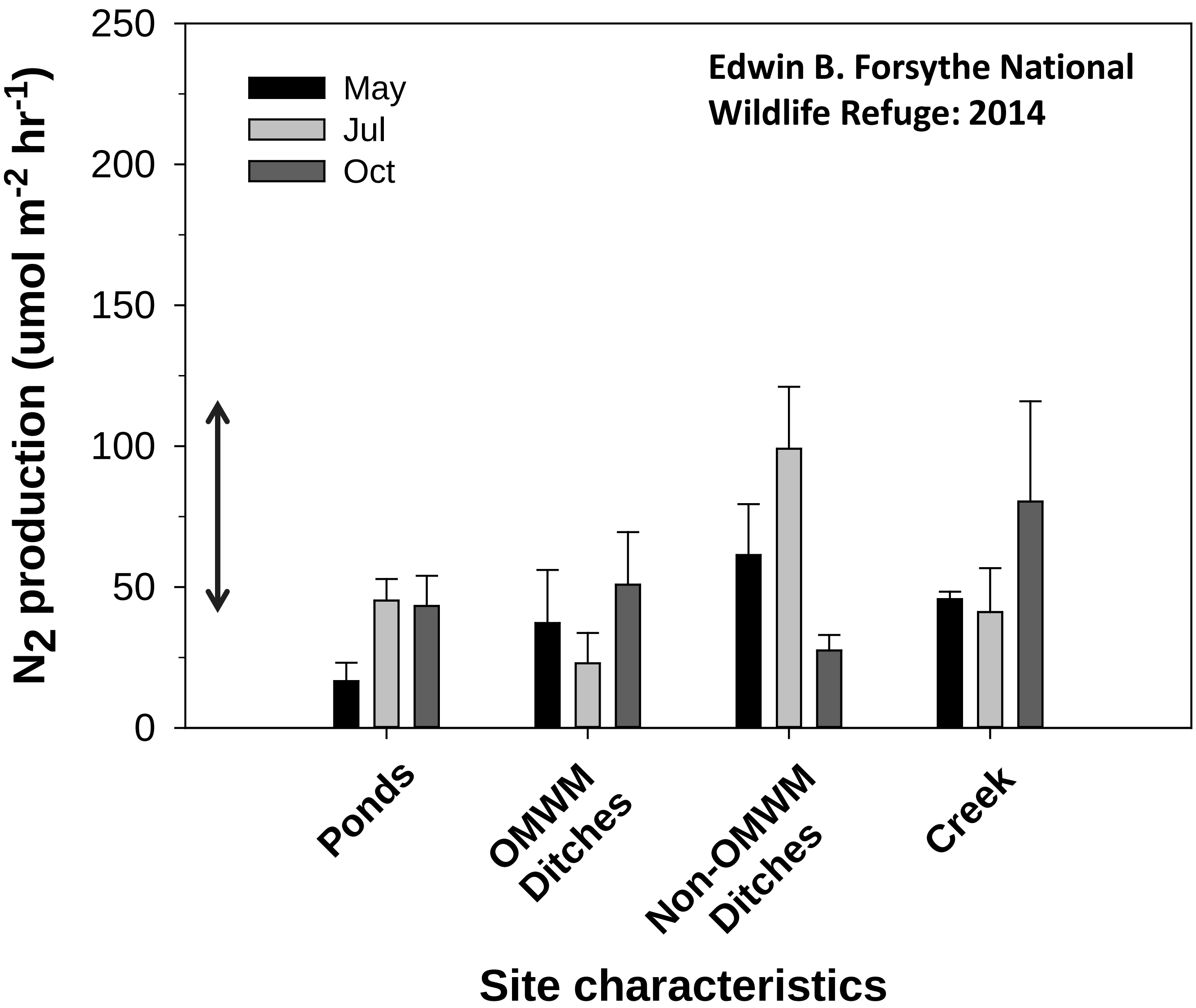
MONTH	N_2 Production (μmol/m^2/hr)
May	83 ± 14^{ab}
July	121 ± 20^{a}
October	49 ± 19^{b}

What are Open Marsh Water Management (OMWM) Systems?

Mosquito control: since the 1970's the Ocean County Mosquito Extermination Commission has created over 9,000 ponds across 12,000 acres of salt marsh in Barnegat Bay, NJ.

- **Limited amount of information about how it affects marsh accretion and ecosystem services**
- **How much is enough?: Balance between human health and ecosystem health**

Comparison of N_2 Production Among Study Sites

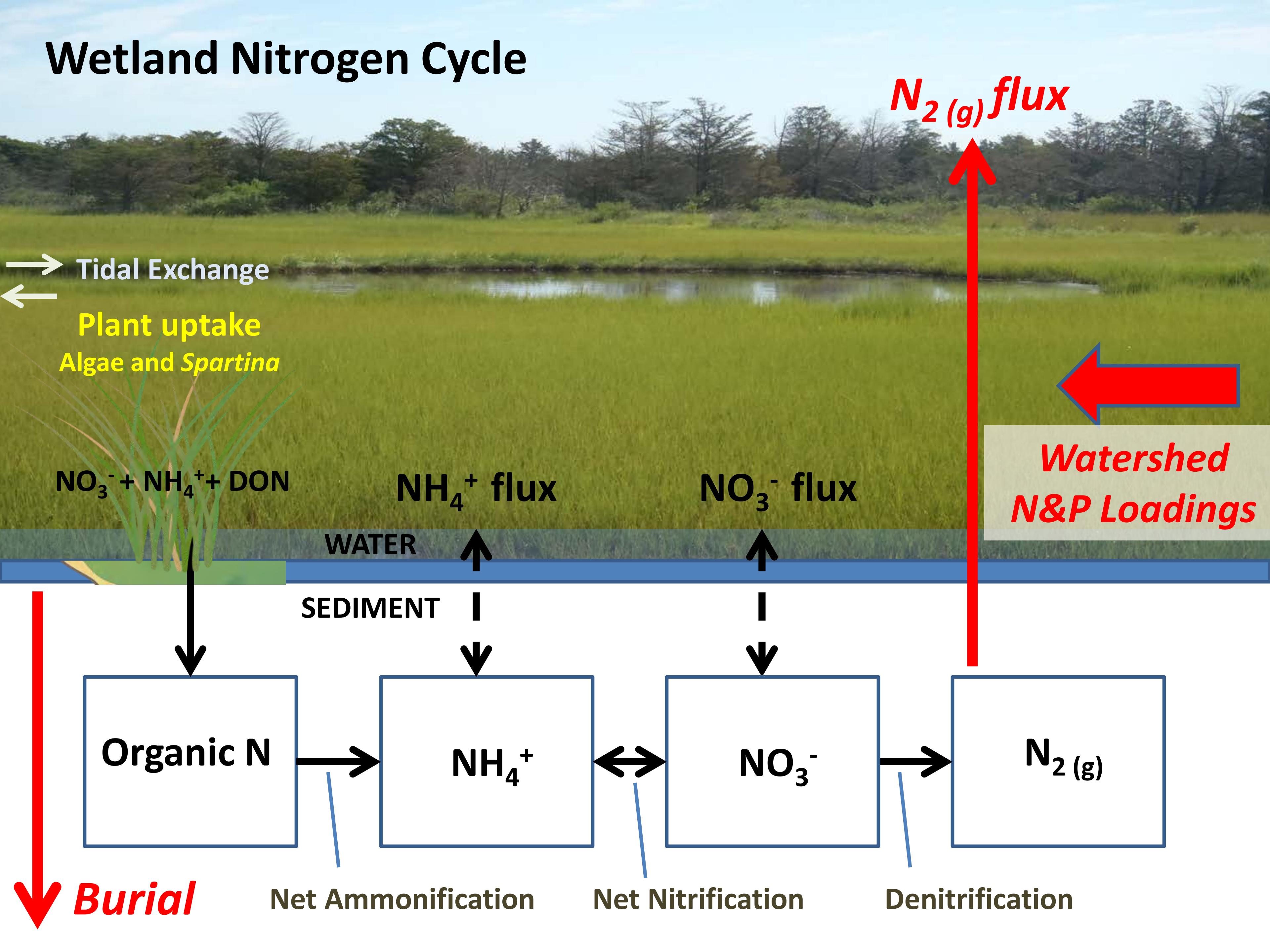


Summary of Denitrification Study

<u>Open water (OMWM) vs Vegetated marsh</u>

- Denitrification was variable in vegetated marsh
- Much less variable in open water compared to interior marsh sites
- No substantial difference between marsh open water and vegetated sites
- No relationship between pore water sulfide and N_2 production

Open Marsh Water Management (*OMWM*)



Wetland Nitrogen Cycle
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NO_3^- flux
WATER
SEDIMENT
Organic N
NH_4^+
NO_3^-
$N_{2\,(g)}$
Burial
Net Ammonification
Net Nitrification
Denitrification

Comparison of Barnegat Bay Marsh Nitrogen Removal Rates Measured to Rates of Nitrogen Inputs to Barnegat Bay

	Nitrogen (kg/yr X 10^5)
Watershed Inputs (1989-2011; Median)	6.7
Marsh Burial	
Using 50yr average	5.2±0.71
Burial as a % of Inputs	77%
Marsh Denitfication:	0.49±0.20
Denitrification as a % of Inputs	7.3%
Total Removal	**71% to 97% (avg ~84%)**

Nitrogen inputs ranged from 4.6 to 8.6 X10^5 kg/yr (1989-2011; Baker et al., 2014). Wetland area (26,900 acres or 1.1 X10^8 m^2) are obtained from www.crssa.rutgers.edu/ projects/lc/ and V. Depaul (USGS)

Summary and Conclusions

- Remaining wetlands play ***critical role*** in nutrient cycles in Barnegat Bay
- Plant uptake and sediment burial can remove carbon, nitrogen and phosphorus from the water column
- Denitrification is an important process for nitrogen removal in wetlands
- OMWM sites have similar rates in whole marsh
- Studies showcase the importance of maintaining ***and increasing area*** of Barnegat Bay wetlands

Acknowledgements

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OF NATURAL SCIENCES
of DREXEL UNIVERSITY

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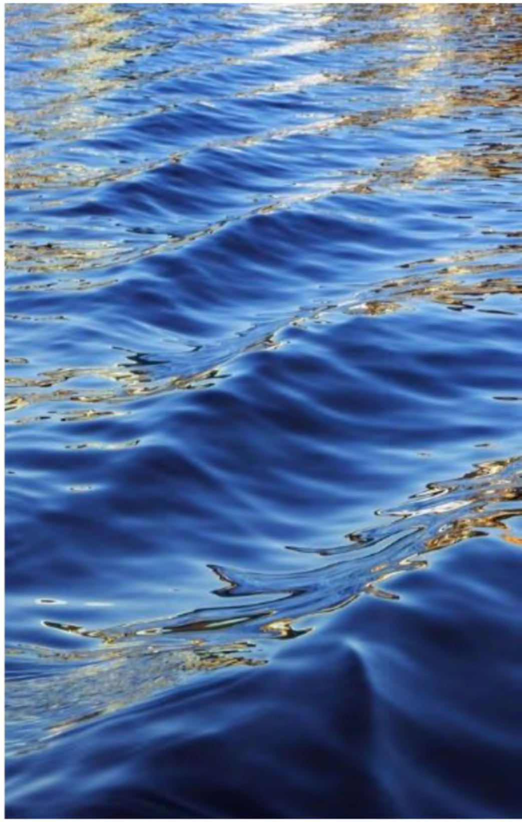
NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Assessment of Ecologically Sensitive Areas (ESAs) in Barnegat Bay

November 17, 2015



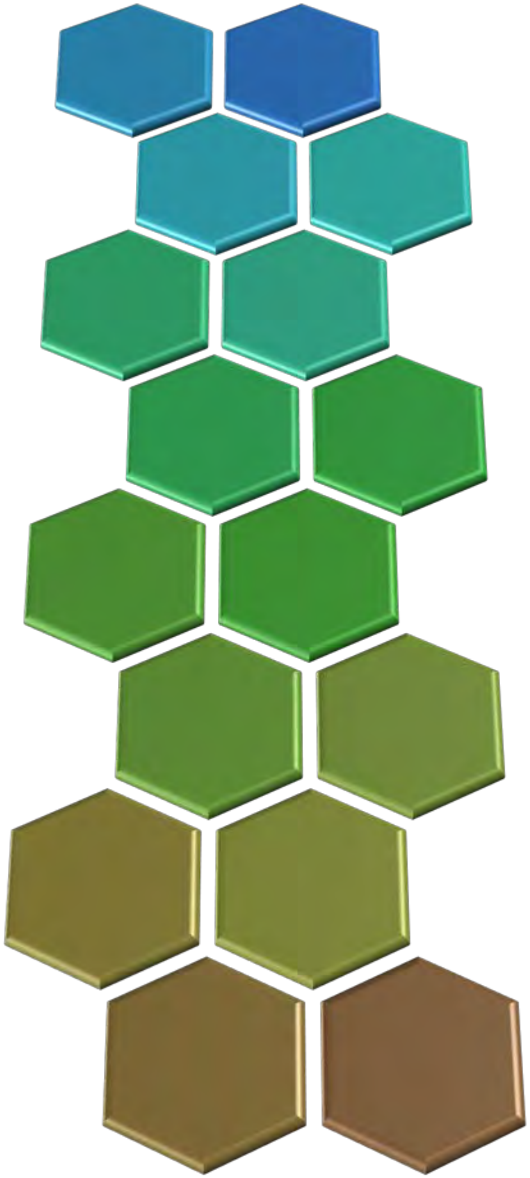
Principal Investigator
Dr. Richard G. Lathrop

Co-Principal Investigator
Dr. Edwin Green

CRSSA Staff Analyst
Eden Buenaventura

Photo: Microsoft Office and Chronicles of Zostera

10 Point Action Plan

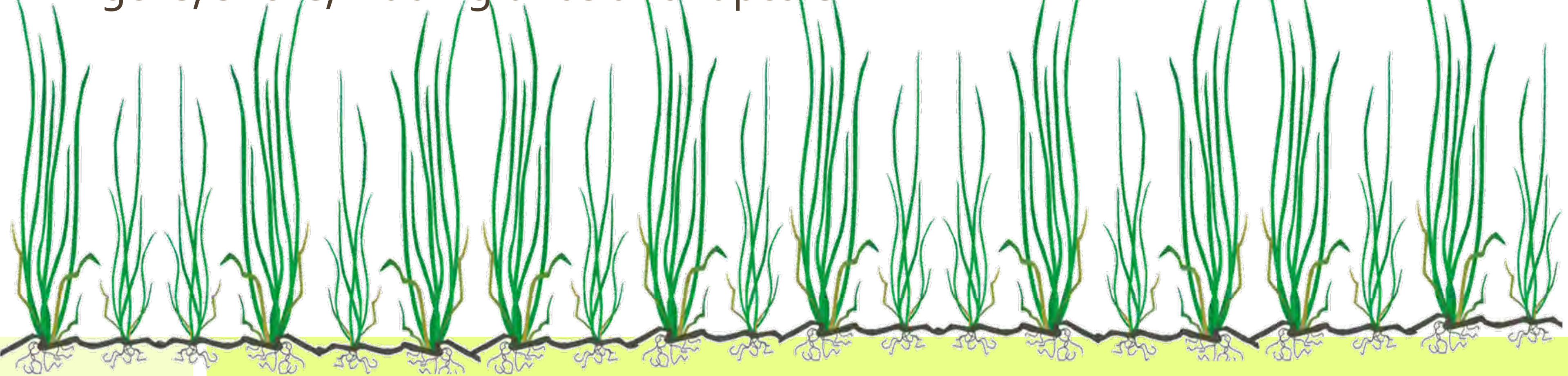


1. Close Oyster Creek Nuclear Power Plant
2. Fund Stormwater Runoff Mitigation Projects
3. Reduce Nutrient Pollution from Fertilizer
4. Require Post-Construction Soil Restoration
5. Acquire Land in the Watershed
6. Special Area Management Planning
7. Adopt More Rigorous Water Quality Standards
8. Educate the Public
9. Fill in the Gaps on Research
10. Reduce Water Craft Impacts

Watercraft impacts to Barnegat Bay

Barnegat Bay is a playground for recreational activities, such as boating.

- As motorboat and personal watercraft cross through seagrass meadows, the propellers and pro/jet wash can cut SAV leaves and uproot rhizomes, leaving propeller or boat scars.
  - Due to their ecological importance and sensitivity to eutrophication, seagrasses are considered as an important ecological indicator of overall estuarine health. Barnegat Bay contains >75% of NJ's seagrass habitat.
- Boat wakes can erode salt marsh shorelines.
- In addition, boats and other human activities can disturb nesting terns, gulls, shore, wading birds and raptors.



What is an ESA?

- Due to concern over the impacts of watercraft to Barnegat Bay's shallow water ecosystems and island/marsh nesting habitats, one strategy to address Point 10 was the designation of a series of special Ecologically Sensitive Areas with special use restrictions to protect areas with high ecological value deemed to be especially sensitive to negative effects from boating
  - In 2011, the Rutgers Center for Remote Sensing & Spatial Analysis hosted several working sessions with representatives from the NJDEP, USFWS, State and county parks and other government agency personnel.
  - 16 ESAs were delineated based on the best professional judgment of the group using extant maps of habitat natural features including seagrass meadows, shellfish beds, presence of endangered species, and proximity to bird nesting areas, among others.

Evaluation of Environmentally Sensitive Areas to Water Craft Impacts in Barnegat Bay NJ

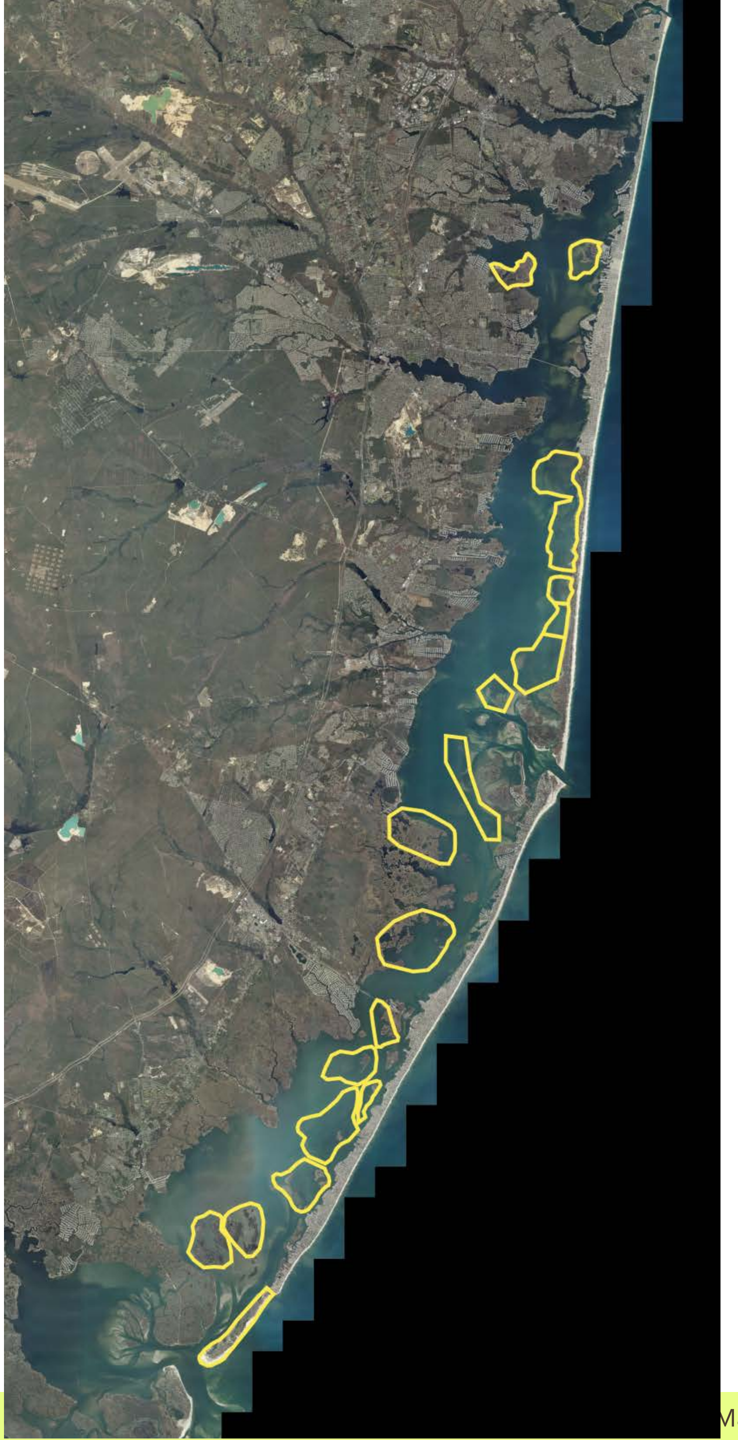
Task 1 Re-evaluate how representative the ESAs are of BB-LEH and their inclusion of sensitive resources.

Task 2 Examine whether there has been a discernible change in ecological or environmental condition since the establishment of the ESA.

Task 3 Assess whether the designated ESAs represent areas of greater risk due to boating impacts.

Task 4 Determine whether Superstorm Sandy changed any of the habitat features in a way that could obscure or magnify the detection and characterization of potential boater impacts.

Task 5 Examine whether the development of a multi-metric assessment index is feasible for future monitoring and management of these ESAs.



Map: NJDEP

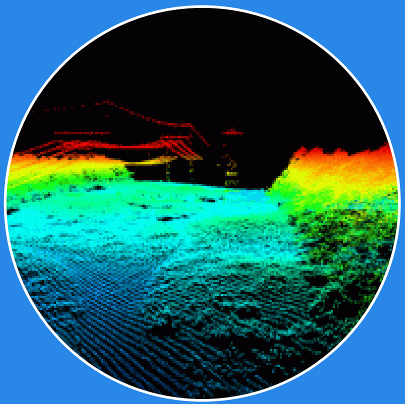
Task 1: Develop a multivariate profile of the 16 ESAs and compare these characteristics to the broader baywide datasets (i.e., inside vs. outside the ESAs) using statistical modeling.

Biological Datasets

- Bird nesting data from NJDEP & Rutgers
- Percentages of Seagrass by year
- Percent of bird habitat
- ENSP Osprey nesting/foraging data
- Gary Taghon environmental conditions and species abundance data
- Marina Potapova diatoms data
- Michael Celestino shellfish stock data
- Ken Able fish and crab data

Water Quality Data

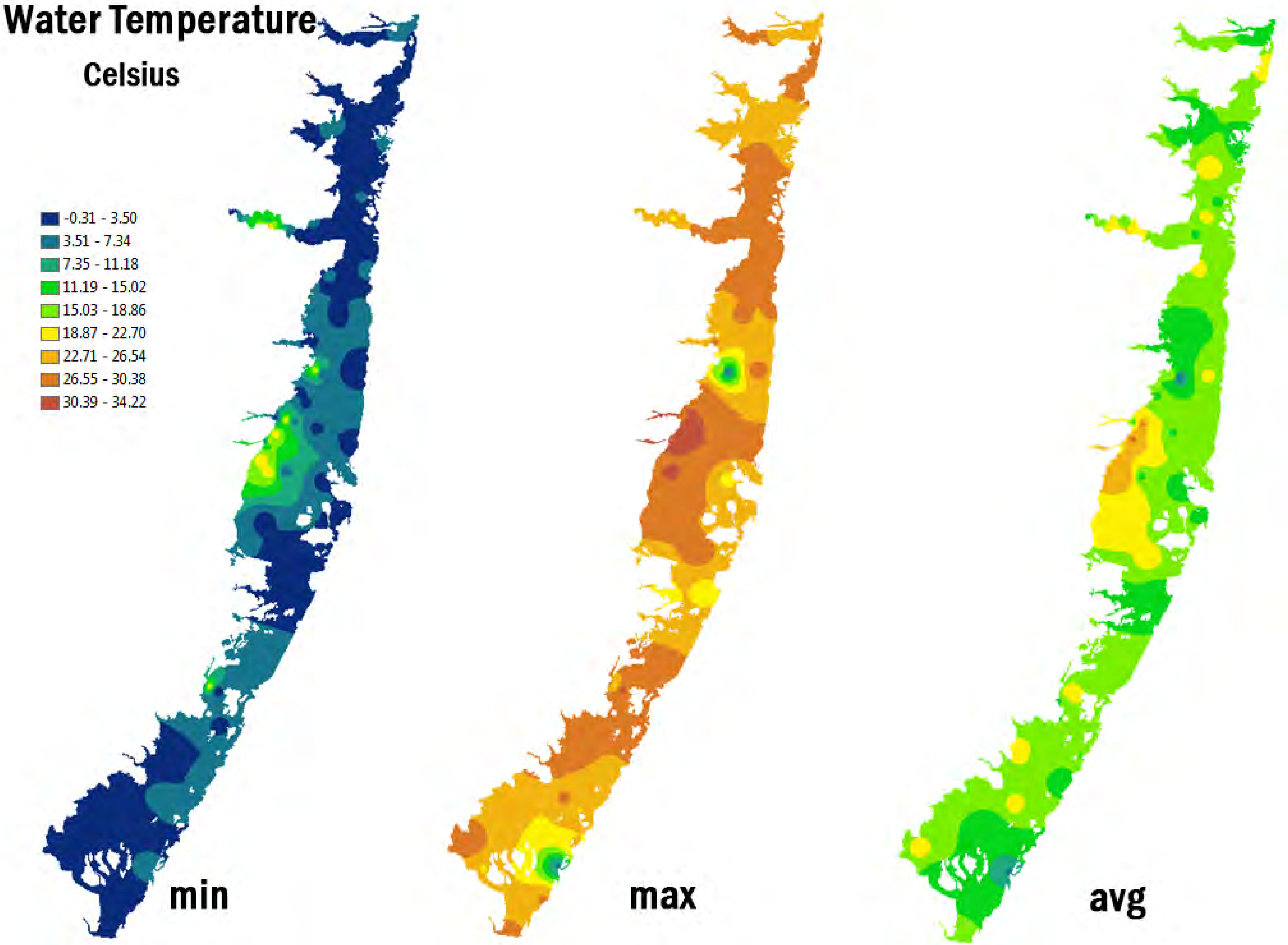
- NJ Estuarine Monitoring Program
- Chlorophyll A
- Depth (Secchi Disk)
- Dissolved Oxygen
- Fecal Coliform
- Nitrogen
- Water Temperature
- pH
- Phosphorus
- Salinity
- Total Coliform
- Turbidity



Environmental Datasets

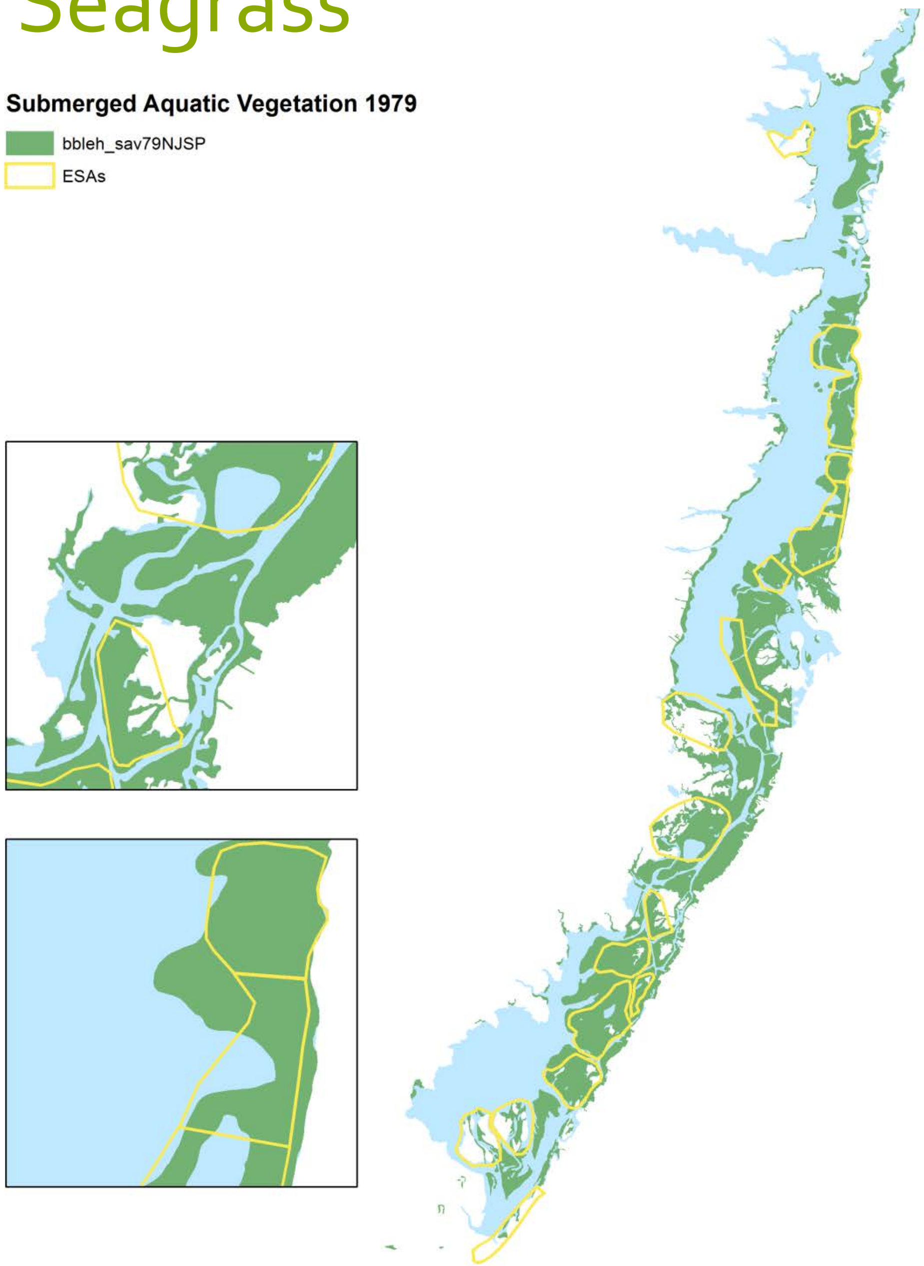
- NOAA Environmental Sensitivity Index
- Experimental Advanced Airborne Research LiDAR
- NOAA Post-Sandy Flyovers
- Trish Long Boater survey data

Photo: Grit.com, Three Rivers Park District, and Accurate Map Survey

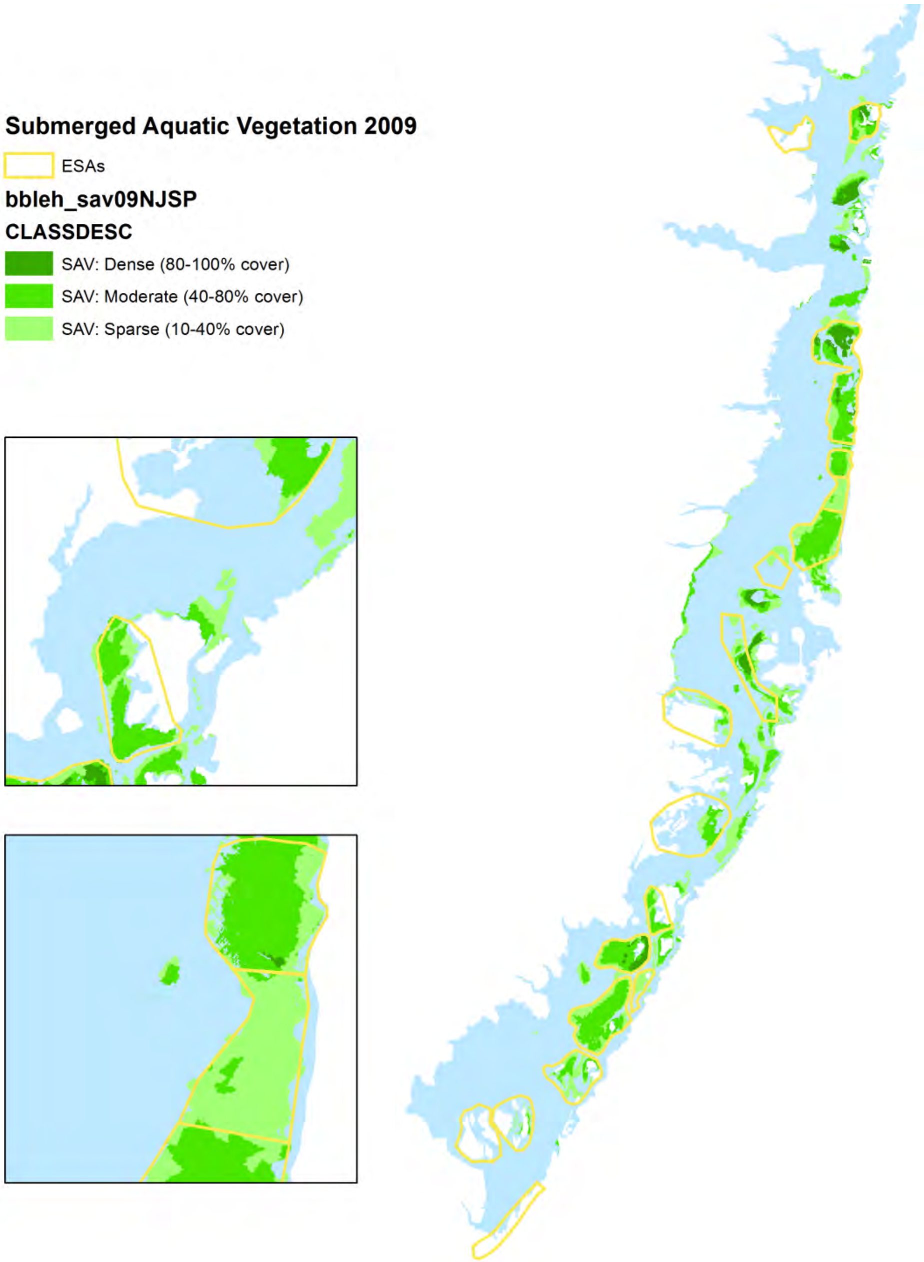


Water Temperature
Celsius
-0.31 - 3.50
3.51 - 7.34
7.35 - 11.18
11.19 - 15.02
15.03 - 18.86
18.87 - 22.70
22.71 - 26.54
26.55 - 30.38
30.39 - 34.22
min
max
avg

Seagrass



Submerged Aquatic Vegetation 1979
bbleh_sav79NJSP
ESAs



Submerged Aquatic Vegetation 2009
ESAs
bbleh_sav09NJSP
CLASSDESC
SAV: Dense (80-100% cover)
SAV: Moderate (40-80% cover)
SAV: Sparse (10-40% cover)

Hierarchical Bayesian model: Comparison of Inside vs. Outside ESAs

The observations were modeled as realizations from a normal distribution with mean if the observations were from an ESA, or with mean if they were from a non-ESA. Vague priors were assigned to all variances and higher level parameters.

2.5 and 97.5 percentiles were used to form a 95% credible interval for the difference. If this included 0 then we concluded that there was no significant difference between the ESA and non-ESA areas for that particular response variable.

No Significant Differences

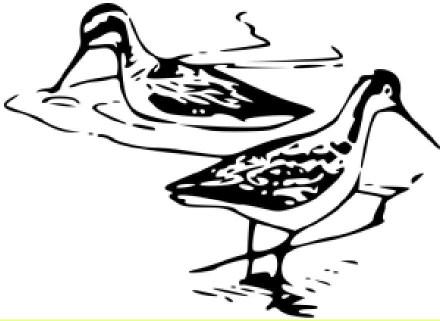
- Chlorophyll A (µg/L)
- Secchi Disk Depth (ft)
- Fecal Coliform (CFU/100mL)
- Salinity (ppt)
- Water Temperature (°C)
- Turbidity (NTU)
- Dissolved Oxygen (mg/L)
- Sediment Grabs
  - Muddy sand
  - Sand
- Water Depth

Significant Differences

- pH (0.07,0.32)
  - Slightly higher pH
- Sediment Grab of Mud (-0.54, -0.05)
  - less mud in ESA
- Seagrass (0.08, 0.42)
  - more seagrass in ESAs

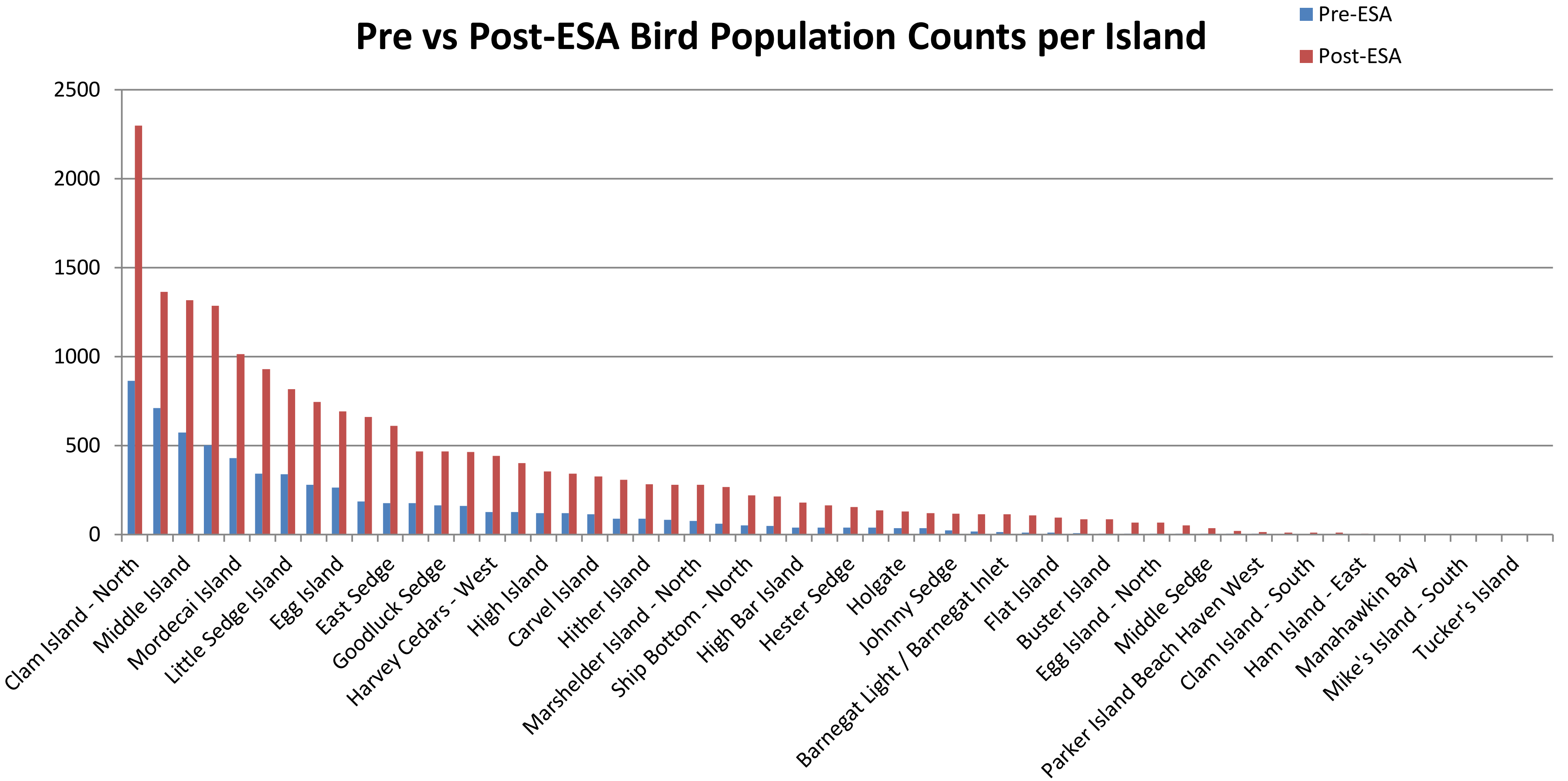
Statistical Analyses in Progress

- Hard Clam Abundance (clams per foot squared)
  - 1985 and 2013 showed no significant decline
  - Significant decline in all other years (1986, 1987, 2001, 2011, 2012)
- RUMFS Survey:
  - Fish
  - Vegetation
  - Arthropods
  - Cnidarians
- Bird Abundance
  - Piping Plover
  - Larids
  - Waders
  - Least Terns
  - Black Skimmers
  - American Oystercatchers
- Osprey nests and foraging areas



<u>Task 2</u> Examine whether there has been a discernible change in ecological or environmental condition since the establishment of the ESA, where there are comparable data sets allowing for a rigorous before vs. after analysis

Pre vs Post-ESA establishment



Pre vs Post-ESA establishment

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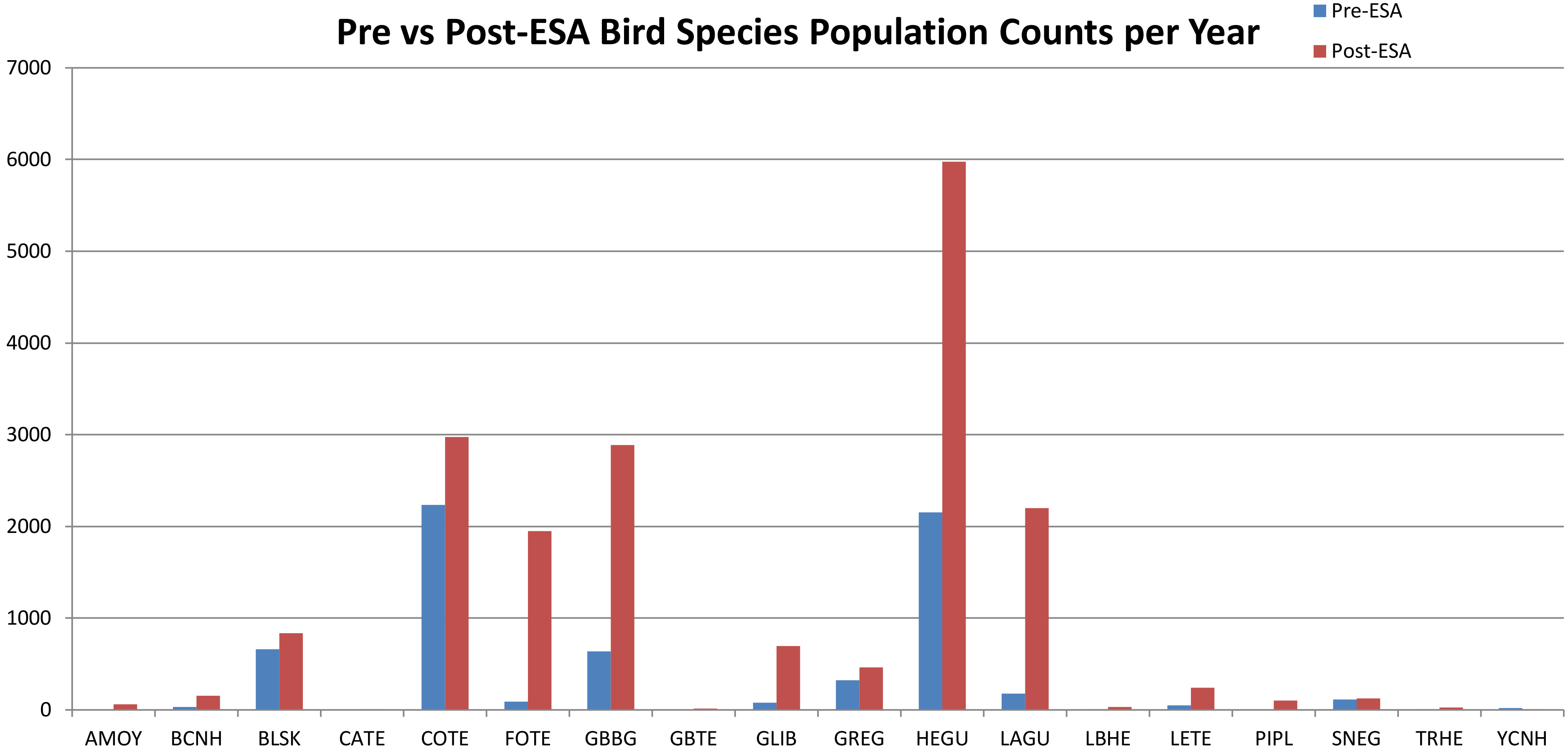
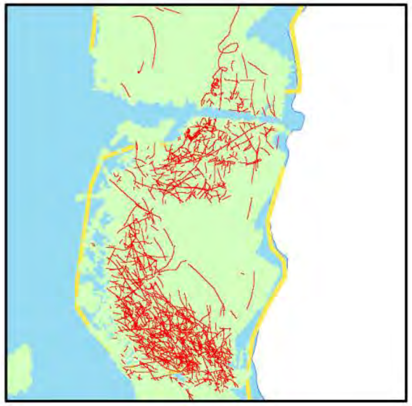
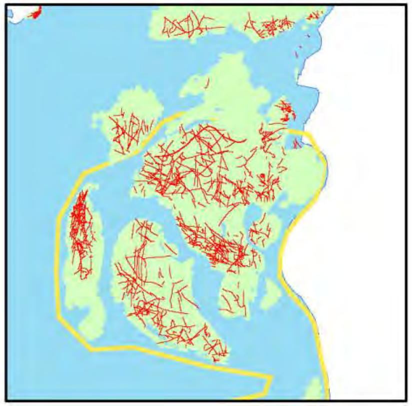


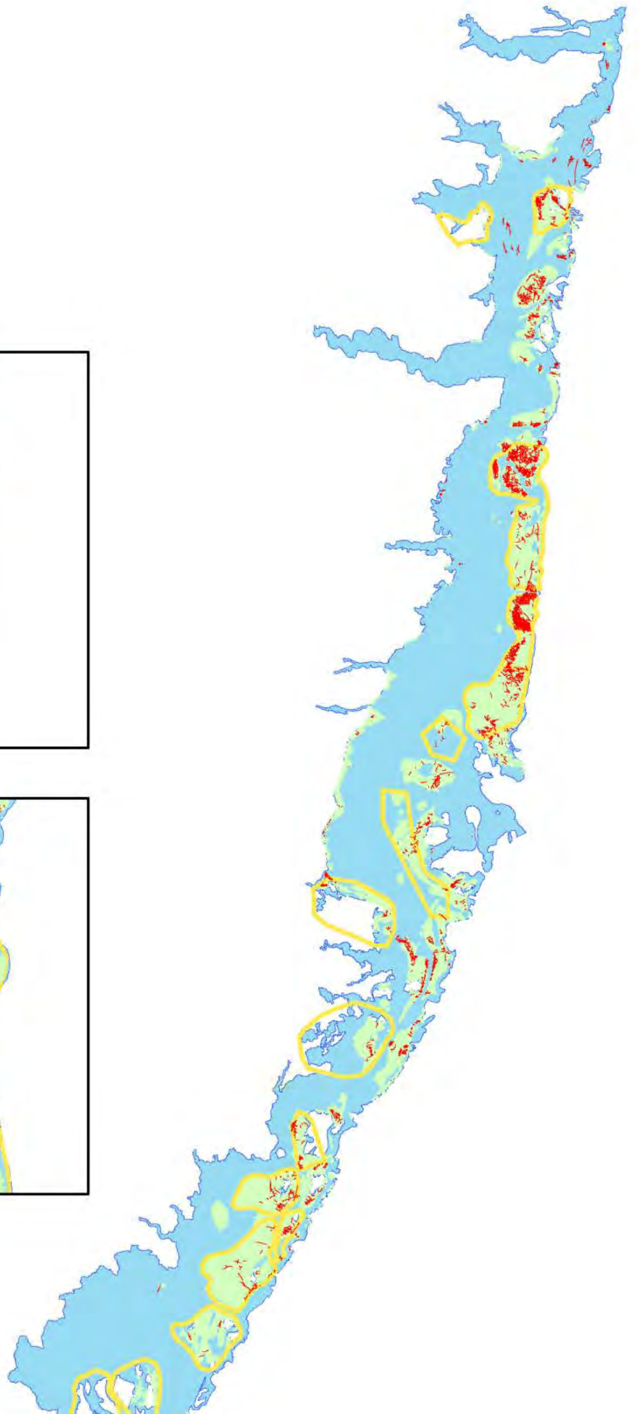
Data provided by Christina Davis of NJDEP Endangered & Nongame species Program

Task 3: Assess whether the designated ESAs represent areas of greater risk due to boating impacts

- Nearly 120 miles of boat scarring were mapped to have occurred within the ESAs over this approximately 10 year period.
- Island Beach South ESA, followed by Island Beach North were identified as major hotspots of boat scarring accounting for over 76% of the boat scarring.
- Much of the scarring in Island Beach South is the result of recreational boats and personal watercraft traversing the ESA on their way to or from Tice's Shoal.

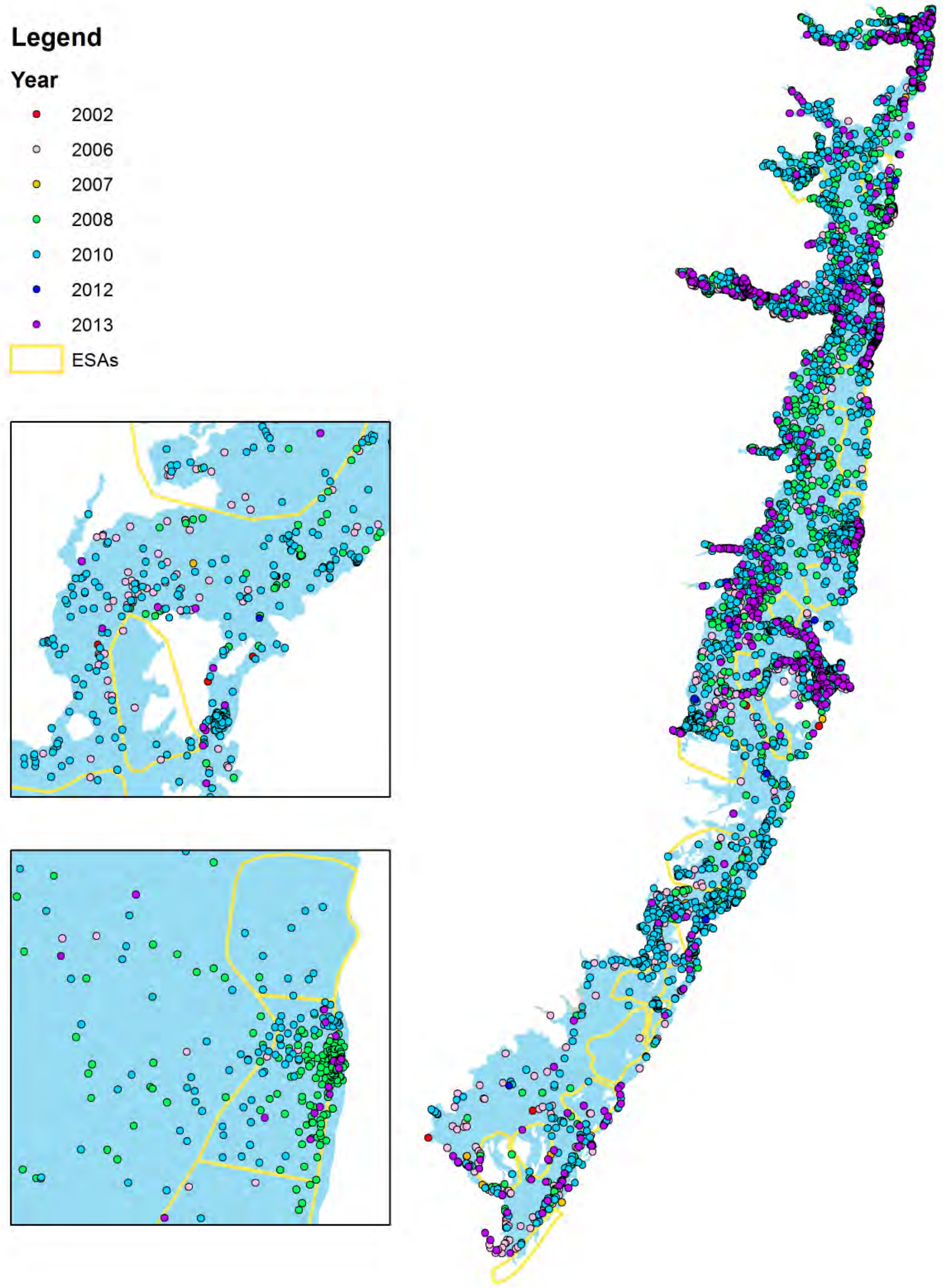




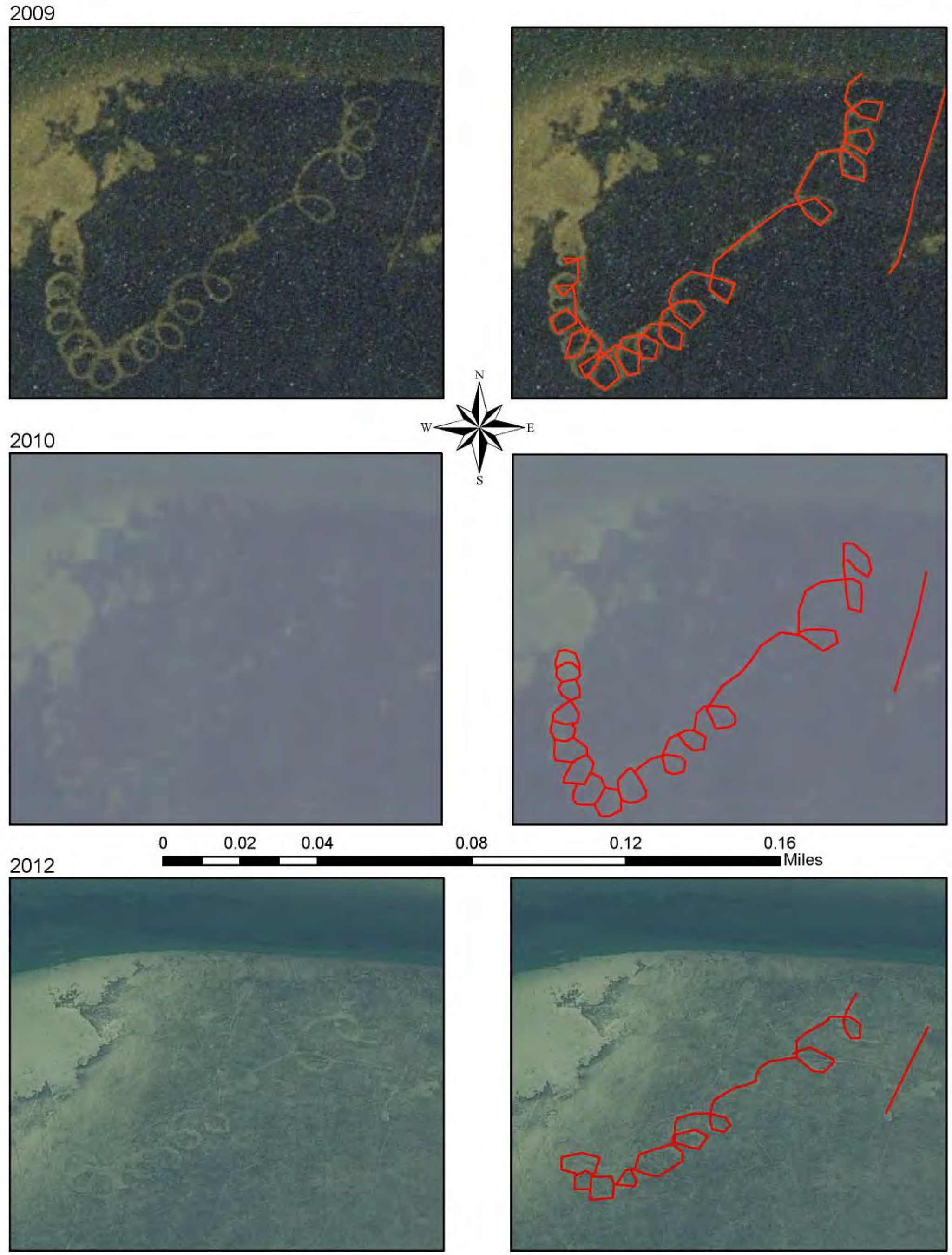


Boating Activity by year

- A few of the ESAs accounted for nearly 90% of the activity: Island Beach South, Island Beach North, Forsythe South, Long Beach North and Forsythe North (ranked from higher to lower).
- Island Beach South alone accounted for nearly 73% of the boating activity with many of those boats moored at what is known as Tice's Shoal. From there boaters can access Island Beach State Park's oceanside beaches.

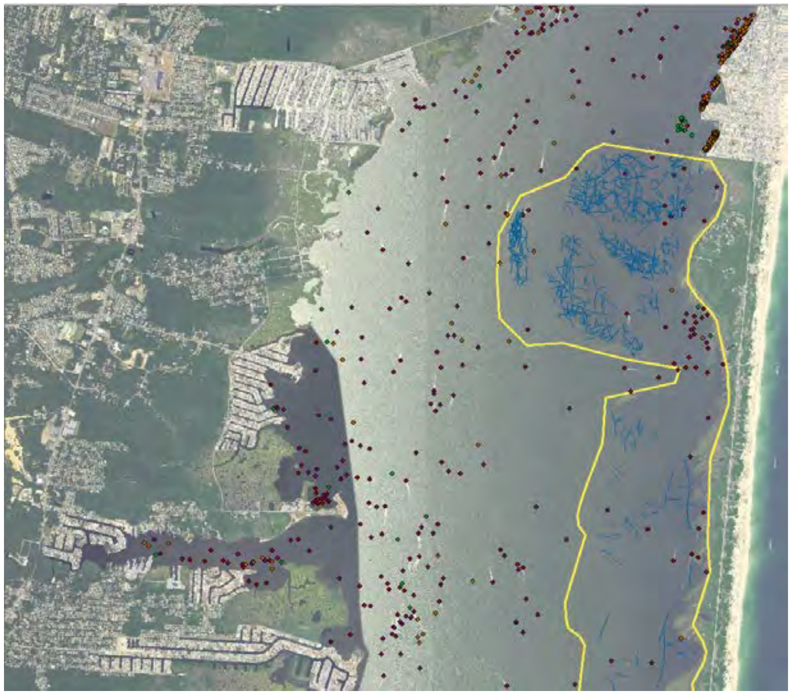


Personal Watercraft Scarring Persistence from 2009-2012



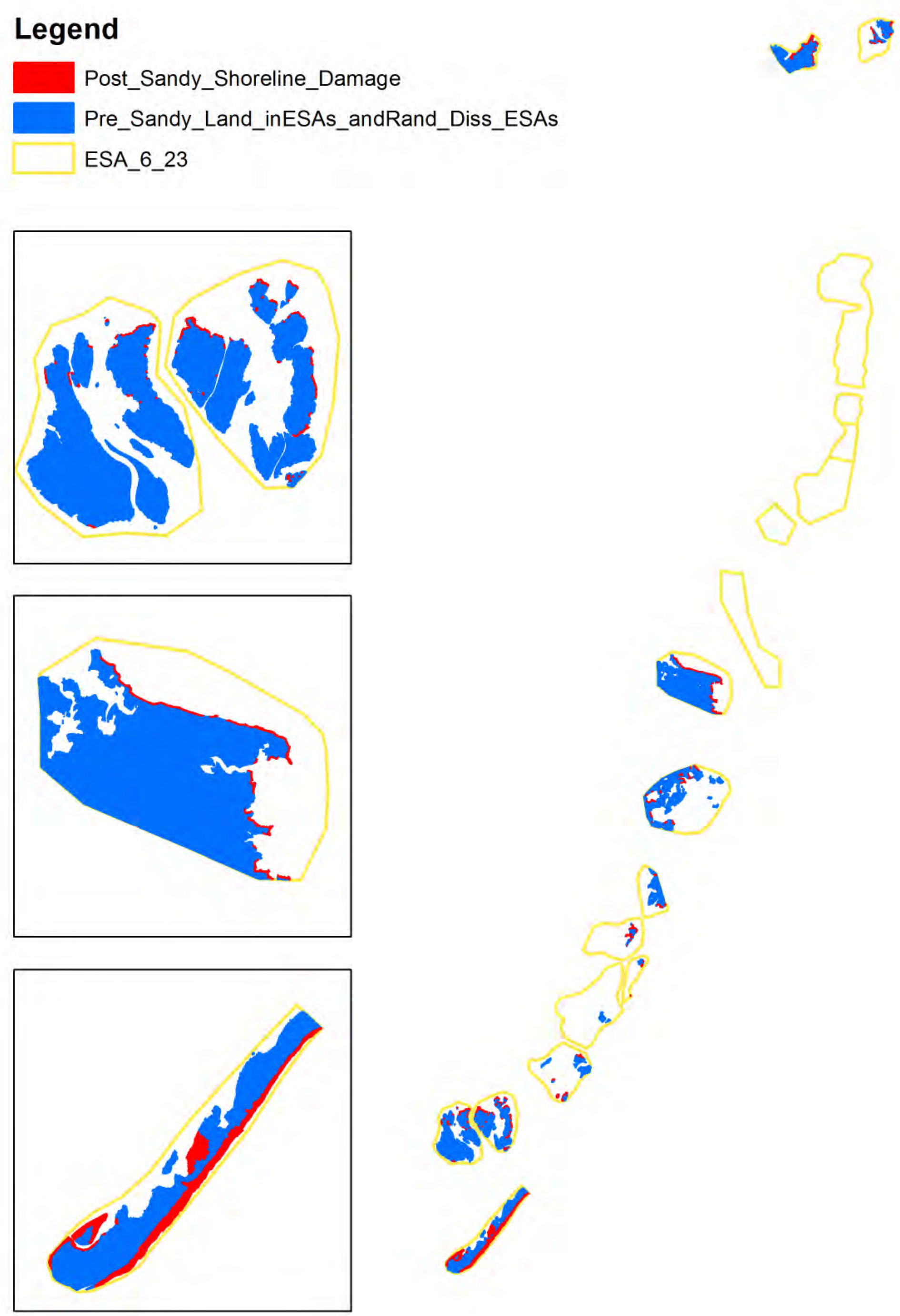
Results

- Nearly 120 miles of boat scarring were mapped to have occurred within the ESAs over this approximately 10 year period.
- Island Beach South ESA, followed by Island Beach North were identified as major hotspots of boat scarring accounting for over 76% of the boat scarring.
- Much of the scarring in Island Beach South is the result of recreational boats and personal watercraft traversing the ESA on their way to or from Tice's Shoal.
- The damage in Island Beach North is concentrated in the northern section of the ESA in close proximity to the developed portion of Seaside Park. In this ESA the seagrass beds occur on a series of sand flats separated by deeper channels. It appears that the damage is due to boats crossing over the beds between channels as well as accessing the backside of Island Beach State Park where there is a secondary locus of boats moored.



Task 4: Determine whether Superstorm Sandy changed any of the habitat features in a way that could obscure or magnify the detection and characterization of potential boater impacts

Post-Sandy Shoreline Damage



Damaged Islands

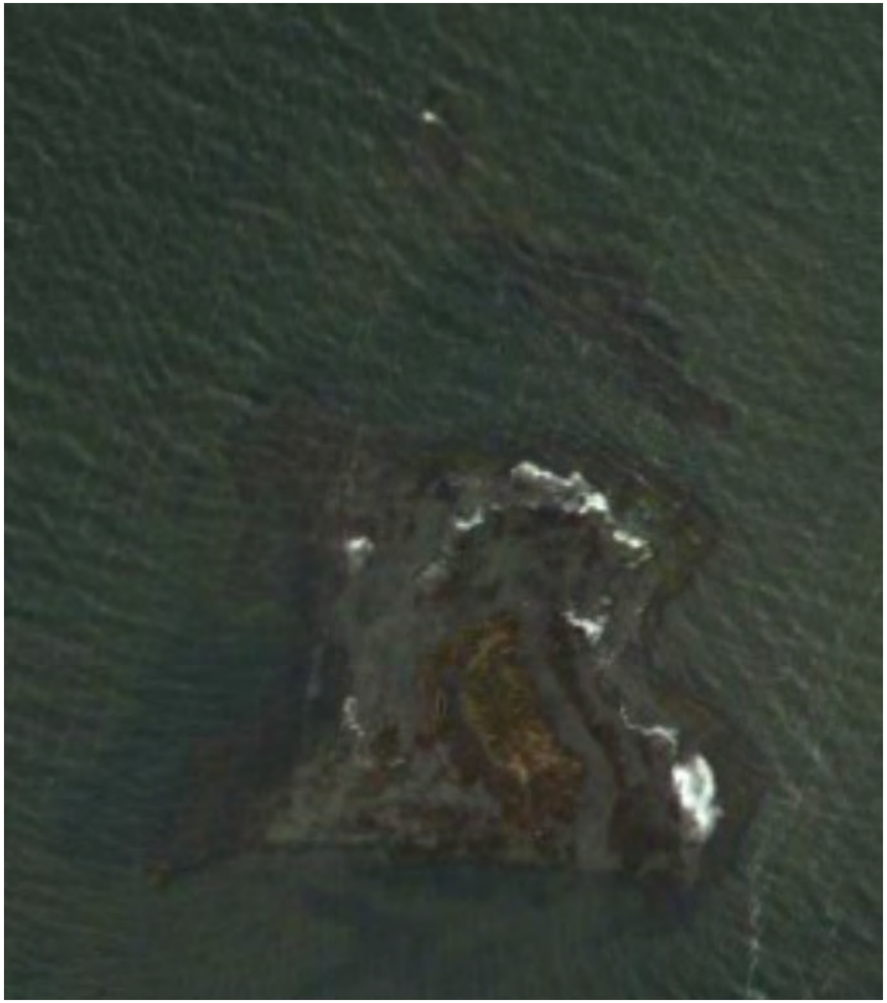
- 1,383.44 hectares Pre-Sandy
- ~55.55 hectares damaged
- ~3.80% of land lost
- highest area of land lost is Holgate at ~20% of that area

Total Area Digitized Lands	NOAA Hurricane Sandy Response Imagery http://storms.ngs.noaa.gov/storms/sandy/ ; NJGIN WMS 2012 http://njgin.state.nj.us/download2/layerfiles/NJ_2012NaturalColor.lyr	Used basemaps to do heads-up digitizing for Pre and Post-Sandy islands and marshes in Barnegat bay at about 1:300 scale

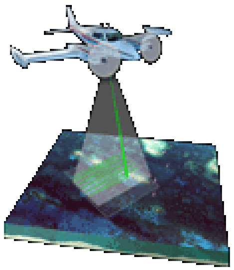
OID	ESA_ID	Islands	Damage (Hectares)	Total Area Pre (Hect)	Percent Damaged
44	18	Tucker Island	4.65	4.28	108.79
10	13	Daniel Island	0.07	0.07	100.00
15	12	Egg Island - North	0.24	0.32	75.58
27	18	Holgate	38.23	207.31	18.44
23	17	Hester Sedge	0.03	0.17	15.15
40	15	Parker Island - Beach Haven West	0.14	1.33	10.77
16	12	Egg Islands	1.02	11.06	9.25
43	17	Story Island East	0.06	0.68	8.09
39	15	Parker Island - Beach Haven East	0.23	5.29	4.31
13	16	East Sedge	0.08	2.03	4.12
2	16	Blake Whale Island	0.06	1.76	3.57
7	11	Cedar Bonnet Island Southwest	0.35	11.32	3.11
46	16	West Sedge	0.24	8.65	2.74
24	13	High Island	0.10	4.10	2.45
32	15	Marshelder Island North	0.31	13.19	2.36
29	15	Little Island	0.02	1.02	2.24
1	16	Barrel Island	0.40	24.51	1.64
38	2	Northwest Point Island	0.06	4.18	1.42
34	16	Middle Island	0.41	35.85	1.15
37	1	Mosquito Cove	1.37	139.43	0.98
9	9	Conklin Island	3.05	336.06	0.91
35	16	Middle Sedge	0.08	14.29	0.58
31	2	Marsh Elder Island - Chadwick	0.04	7.06	0.57
8	11	Cedar Bonnet Islands	0.20	37.08	0.53
14	10	Edwin B. Forsythe National Wildlife Refuge	0.69	155.39	0.45
26	17	Hither Island	0.18	64.66	0.28
11	17	Drag Sedge	0.03	9.92	0.25
36	2	Middle Sedge Island - Chadwick	0.05	28.01	0.16
28	16	Johnny Sedge	0.04	29.24	0.12
42	17	Story Island	0.11	118.90	0.09
3	16	Bunting Sedge - East		11.12	0.00
4	16	Bunting Sedge - West		12.51	0.00
5	10	Carvel Island		1.37	0.00
6	10	Carvel Island - West		0.89	0.00
12	17	Drag Sedge East		0.08	0.00
17	17	Goodluck Sedge		18.63	0.00
18	17	Goodluck Sedge South		0.06	0.00
19	14	Ham Island - East		0.84	0.00
20	14	Ham Island - West		6.37	0.00
21	10	Harvey Sedge Island East		4.21	0.00
22	10	Harvey Sedge Island West		3.85	0.00
25	17	Hither Channel Island North		0.05	0.00
30	10	Log Creek Island		16.94	0.00
33	15	Marshelder Island South		13.83	0.00
41	15	Shelter Island		3.73	0.00
45	10	West Log Creek Island		11.81	0.00

Egg Island North

- Of this, 12.97 hectares had caused visually significant damage on islands, causing them to sink partially or completely, including at Holgate, Egg Island North, Mosquito Cove, and Daniel Island

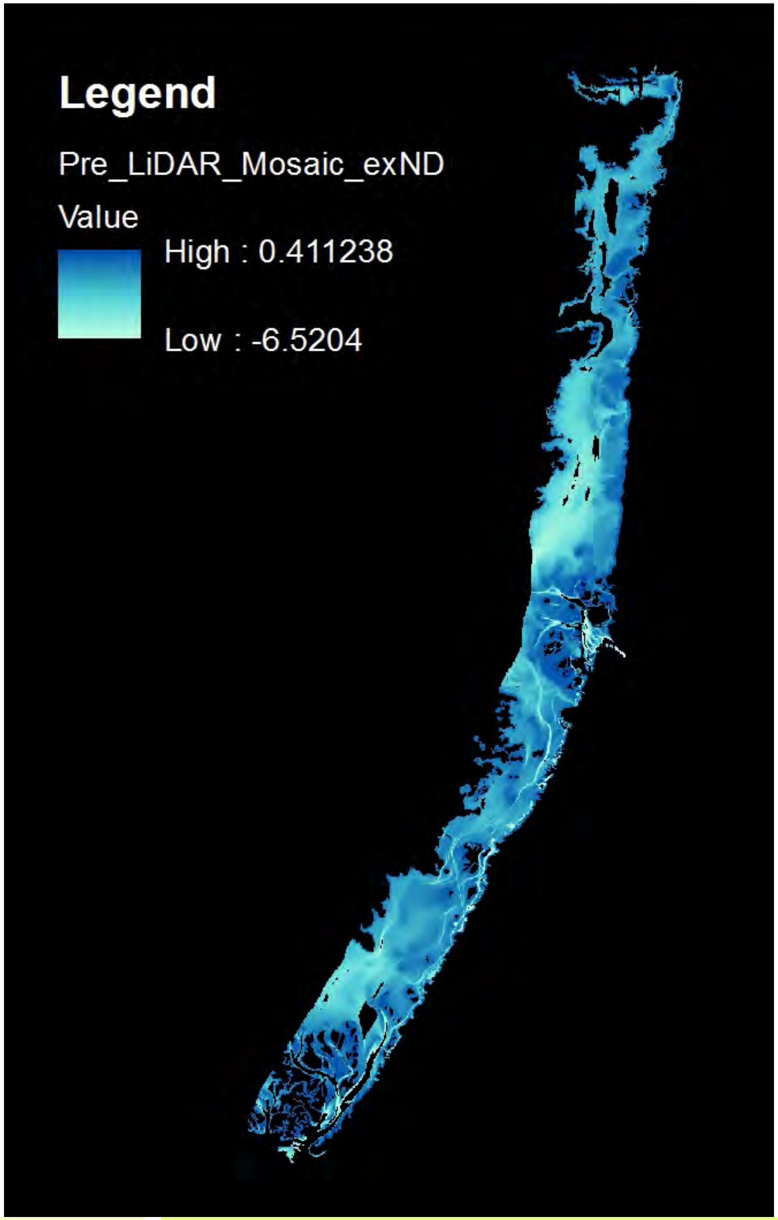


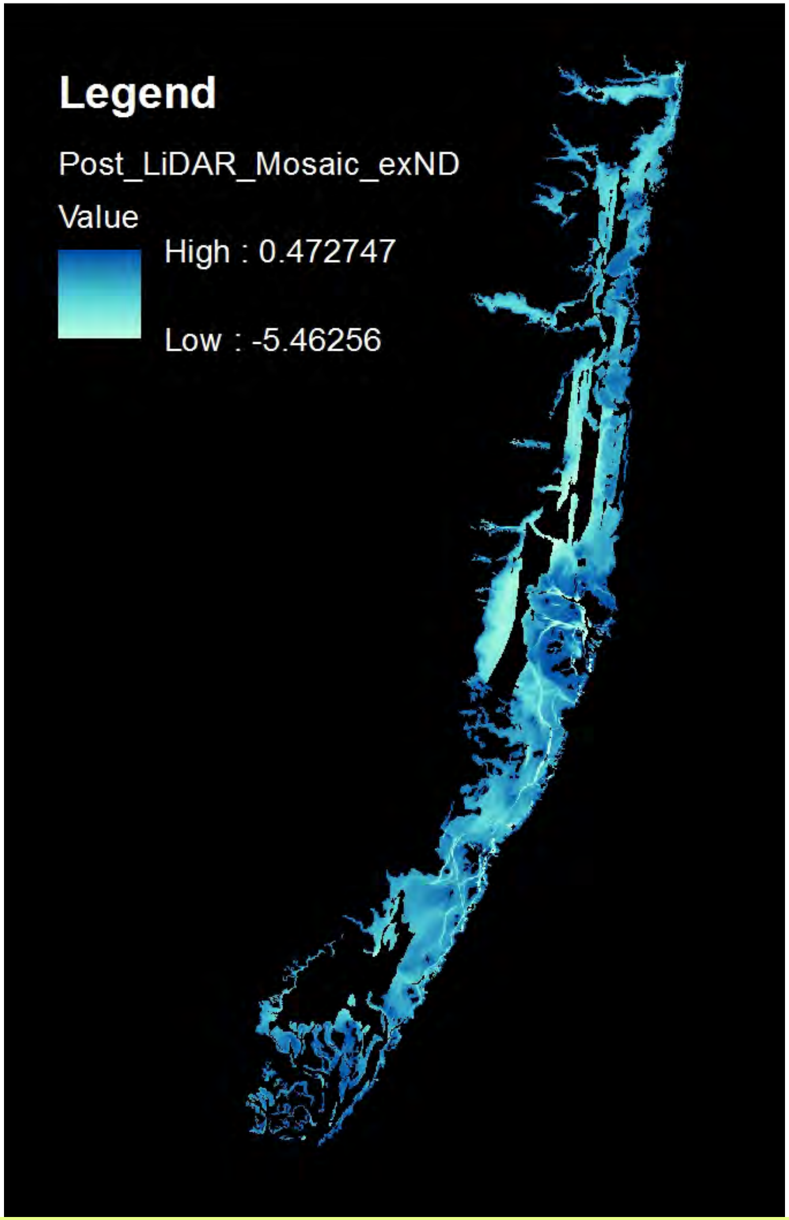
Impacts of SuperStorm Sandy to Bottom Surface Elevation in Barnegat Bay



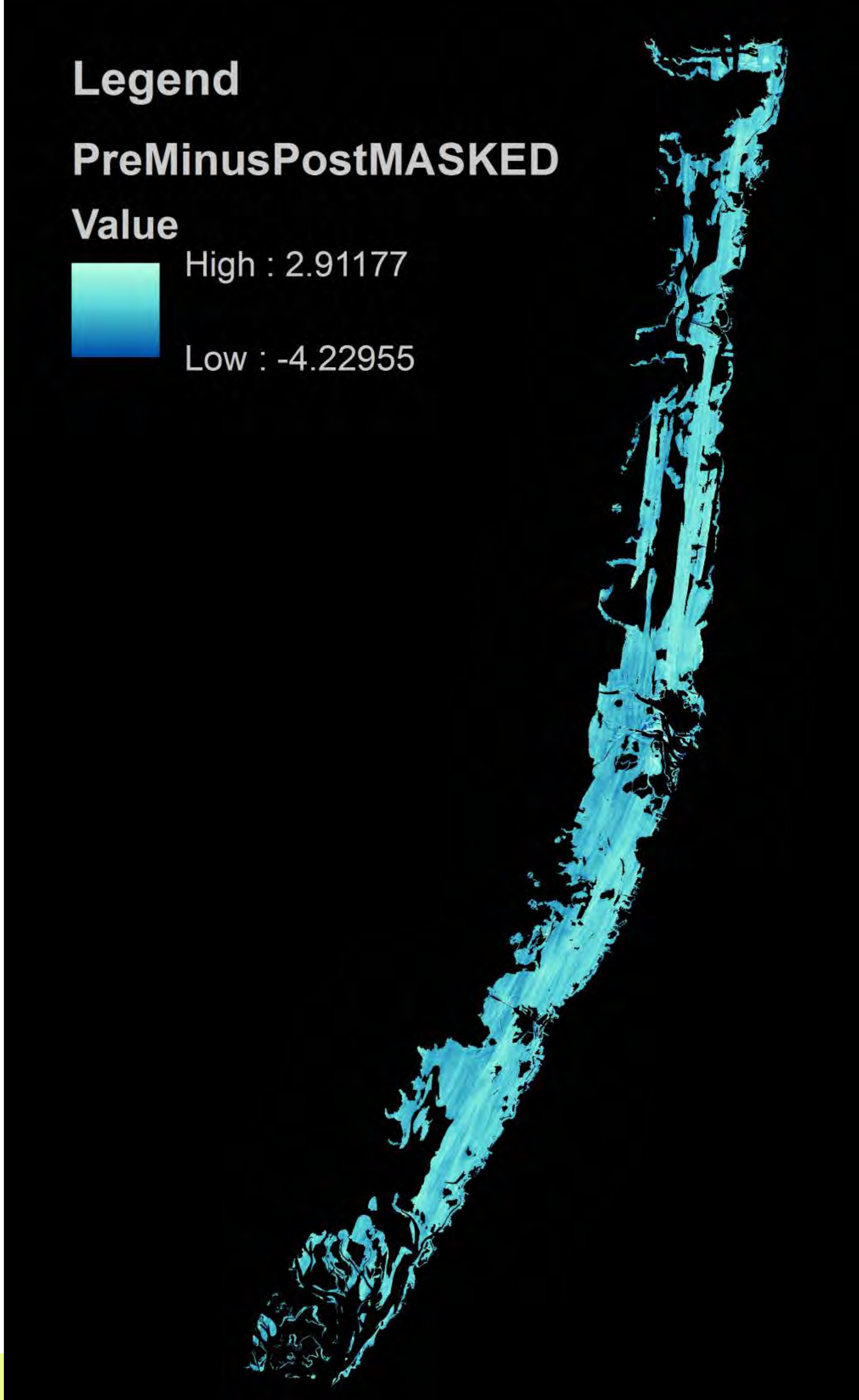
- The US Geological Survey released a digital elevation model dataset of the Pre (October 26, 2012) and Post-Sandy (November 1 & 5, 2012) EAARL-B Coastal Topography.
- The USGS Post-Sandy bathymetric DEM was digitally differenced from the Pre-Sandy DEM. There will always be residual error in this sort of comparison due to errors in both the vertical and horizontal dimensions.
- To differentiate "real" vs. "artifactual" change an elevation threshold was determined. This 0.3m threshold was determined qualitatively by visual examination of areas of known change (e.g., Lyman Ave and Mantoloking Bridge overwash sites vs. background artifactual change). Figure 1d shows the area greater than this 0.3m thresholds over the entire study area colored as red.

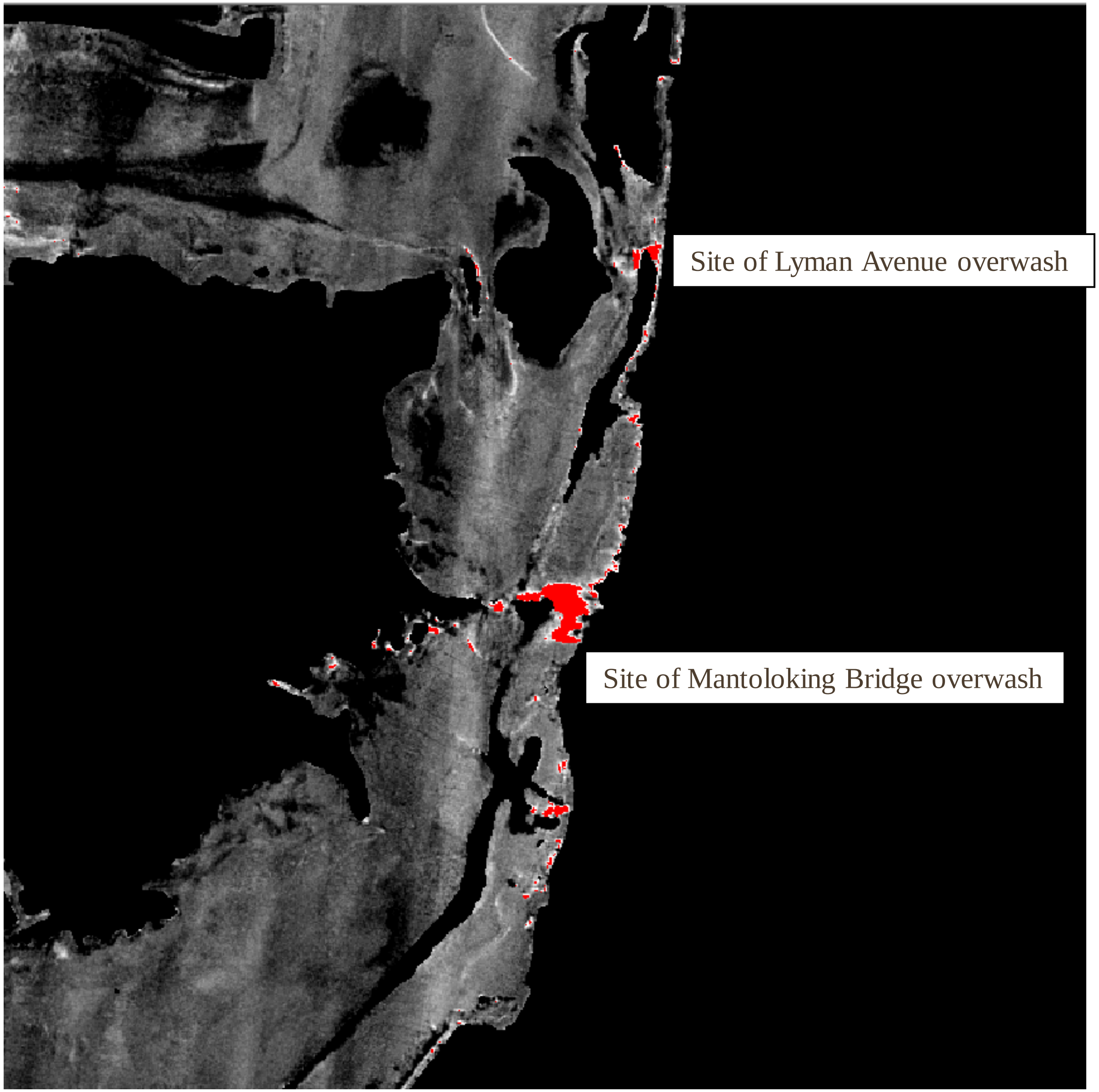
Pre and Post-Sandy EAARL-B Imagery





Change Analysis

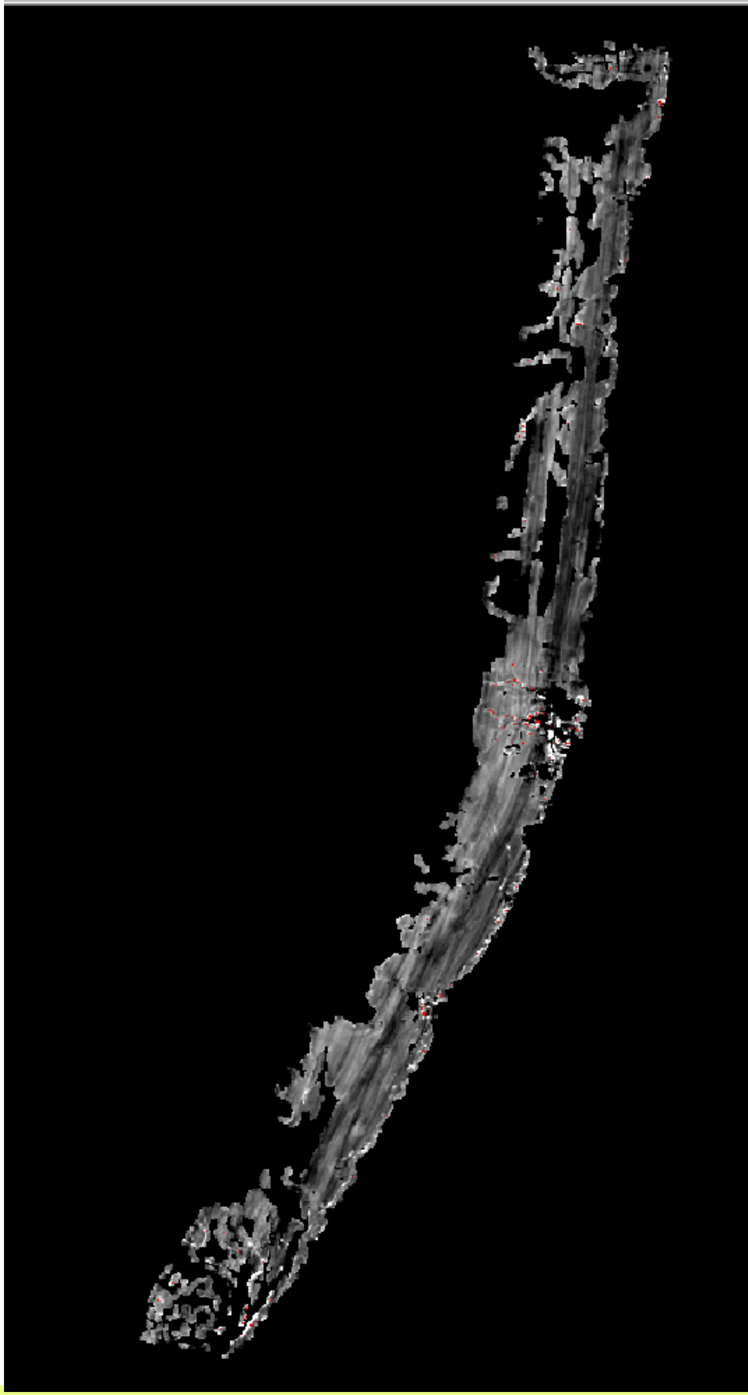




Showing areas with greater than 0.3m difference threshold in red.

Results

- Using a 0.3 meter elevation threshold, those areas that are greater or equal to a +0.3m change are classed as overwash sediment deposit. This overwash area represented only 66 hectares of the Barnegat Bay-Little Egg Harbor study area.
- The only ESAs to show a greater than 0.1% change in area mapped as overwash sediment deposit were
  - ESA 7 Barnegat Light
  - ESA 8 Long Beach North
  - ESA 17 Story Island West
  - ESA 18 Long Beach South
- Based on this analysis, we conclude that SuperStorm Sandy did not deposit a significant amount of overwash sediment to the bay bottoms of the ESAs. Only ESA 14 Barnegat Light has more than 1% area change. This ESA includes the tidal delta interior to Barnegat Inlet and is a naturally dynamic zone. The other ESAs showing slight changes are also associated with the dynamics tidal deltas of Barnegat and Little Egg Harbor Inlets.



Task 5 Examine whether the development of a multi-metric assessment index is feasible for future monitoring and management of these ESAs.

Barnegat Bay-Little Egg Harbor ESA metric

- In Progress: Once we have completed Tasks 1 & 2 we will have a better idea of what parameters will be most useful to incorporate in a multi-metric assessment.
- Most likely will focus on those parameters for which the ESAs are established, relate to boating impact/human disturbance in some fashion and that can be efficiently and effectively monitored:
  - Seagrass meadow % cover and extent, along with incidence of boat scarring
  - Marsh island nesting bird populations: diversity and species composition

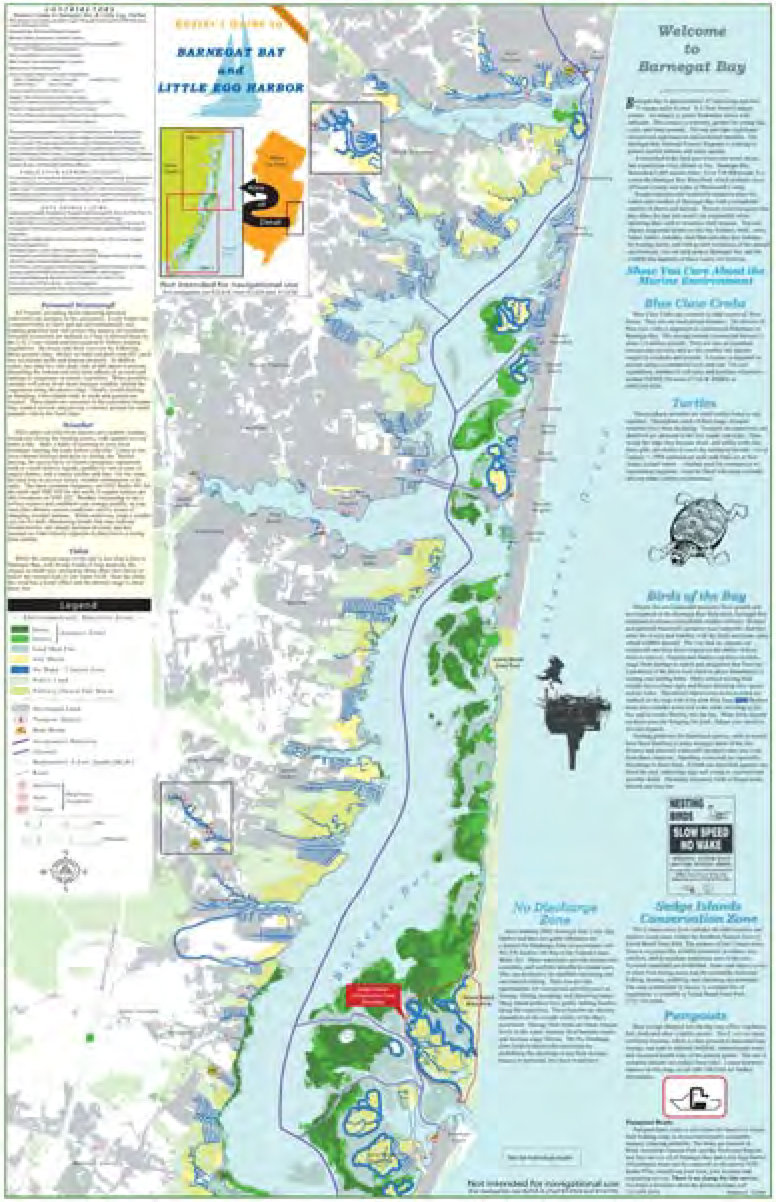
Tips for Clean and Green Boating in Barnegat Bay

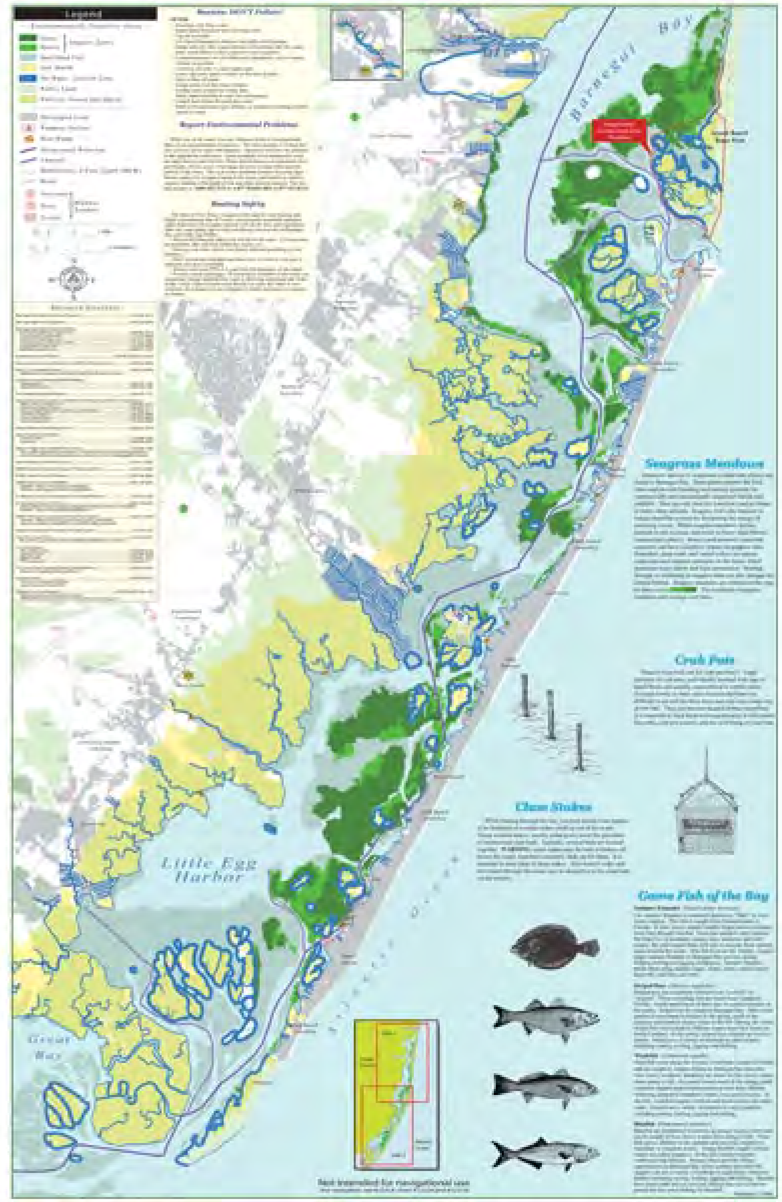
To help keep the Bay vibrant and healthy for all of its residents, please take these actions when you are on the water using a boat (motorized or un-motorized) or personal watercraft:

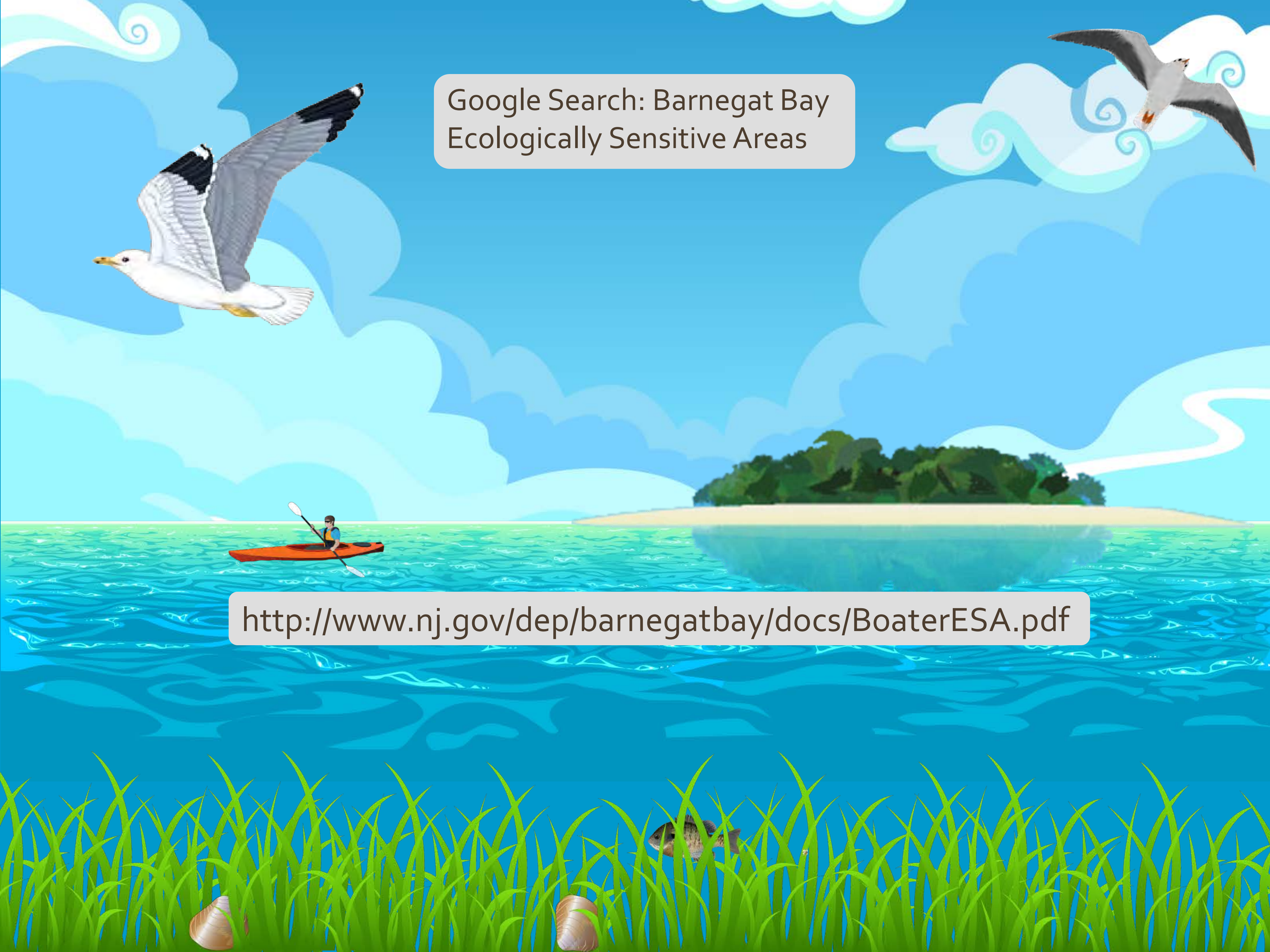
- Stay out of restricted areas set aside for wildlife. Do not harass nesting birds and other animals.
- Buoy mooring chains and lines to prevent them from scraping on the Bay bottom and harming submerged aquatic vegetation and animals.
- Use pump-out boats and facilities. Do not discharge wastewater holding tanks into open water.
- Maintain 100' distance (about the length of six cars) from natural shorelines, Bay islands and sensitive ecological areas, and use marked navigational channels for travel.
- Minimize wakes in all shallow areas to help reduce erosion and harm to aquatic plants and animals.
- Appreciate wildlife from a distance.
- Help reduce air pollution by cutting the engine and not idling in open water.
- Keep trash, recyclables, hooks and lures in secure containers and dispose of them properly on land. Recycle used monofilament fishing lines instead of throwing them away.
- Avoid giving invasive aquatic plants and animals a ride. Thoroughly clean boats, personal watercraft and equipment when transferring them from one water body to another
- Keep the engine leak-free and well-tuned in order to minimize the discharge of fuel and oil into the water. Use a pillow or oil absorbent pad in the bilge to absorb any spilled oil.

For more information: www.barnegatbay.nj.gov

Two-sided 22"x34" fold-out map : To obtain a copy of the Boater's Guide, call the New Jersey Division of Fish & Wildlife at 609-748-2056 or The Marine Trades Association of New Jersey at 732-206-1400. CRSSA, 2004.



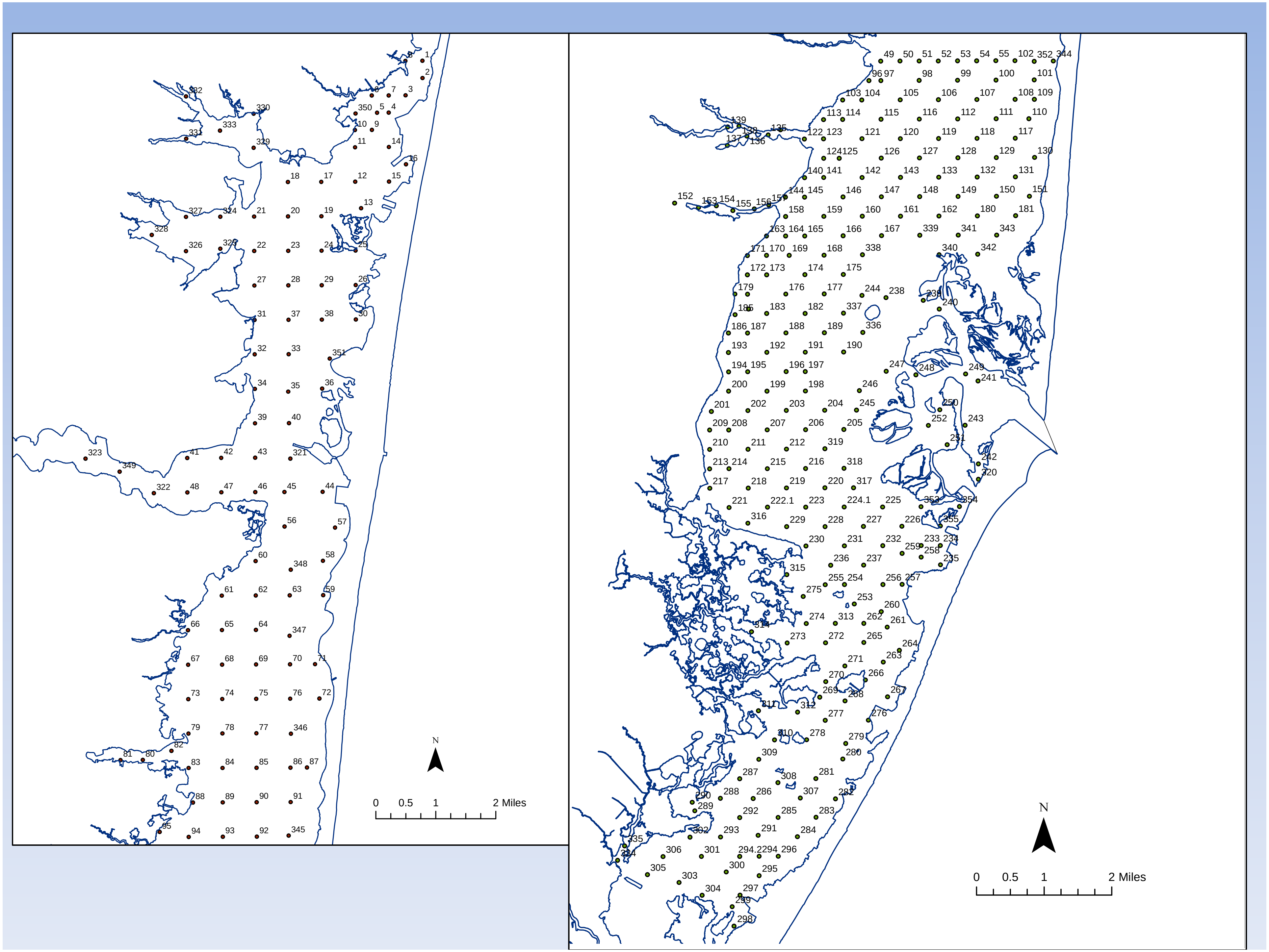



Google Search: Barnegat Bay Ecologically Sensitive Areas
http://www.nj.gov/dep/barnegatbay/docs/BoaterESA.pdf

Hard Clam Stock Estimate of Barnegat Bay (2012)
&
Little Egg Harbor Bay (2011)

with Pre-and Post-Sandy Investigation (2013)

Kira Dacanay
Michael Celestino
NJ Marine Fisheries Administration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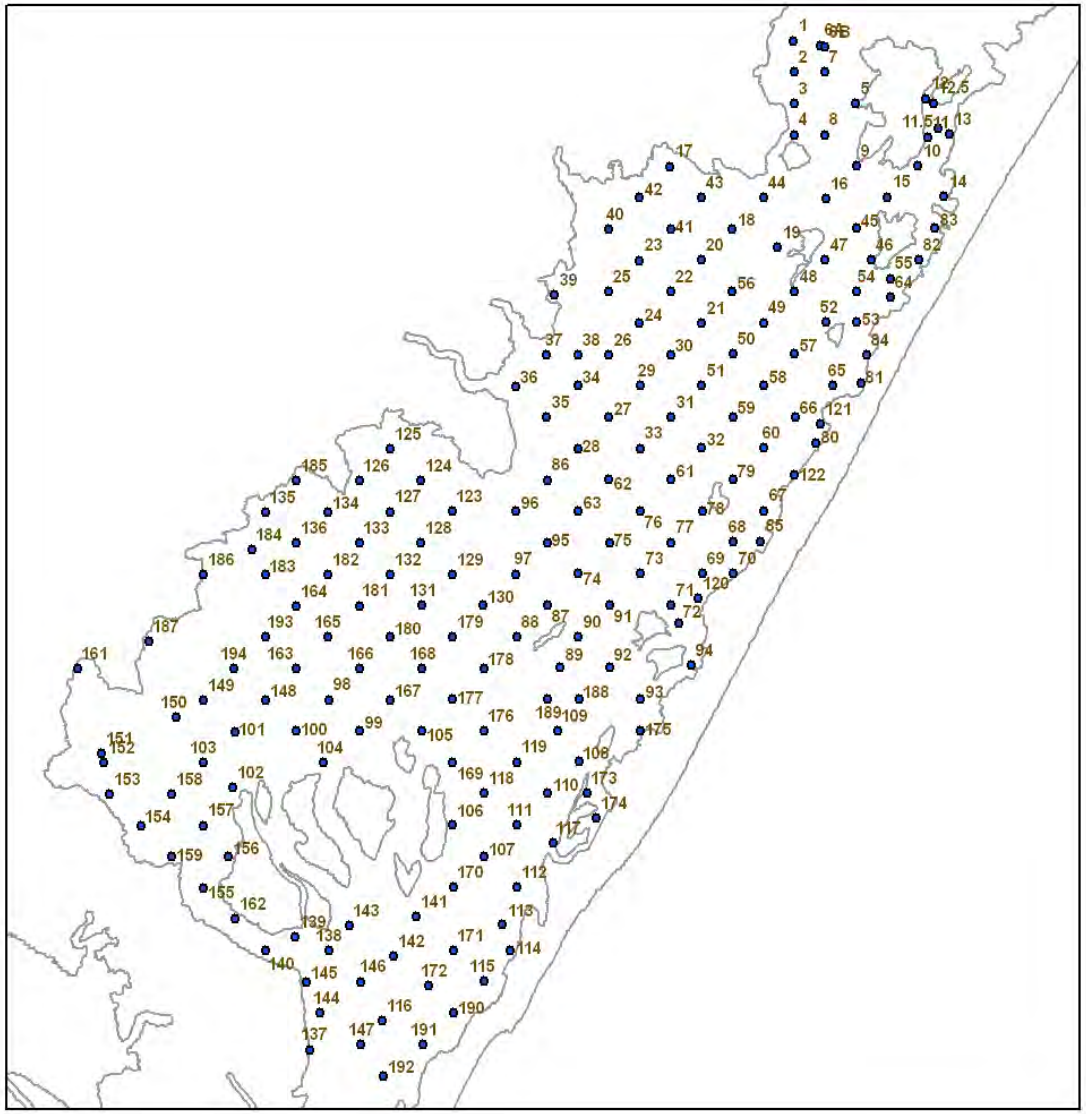
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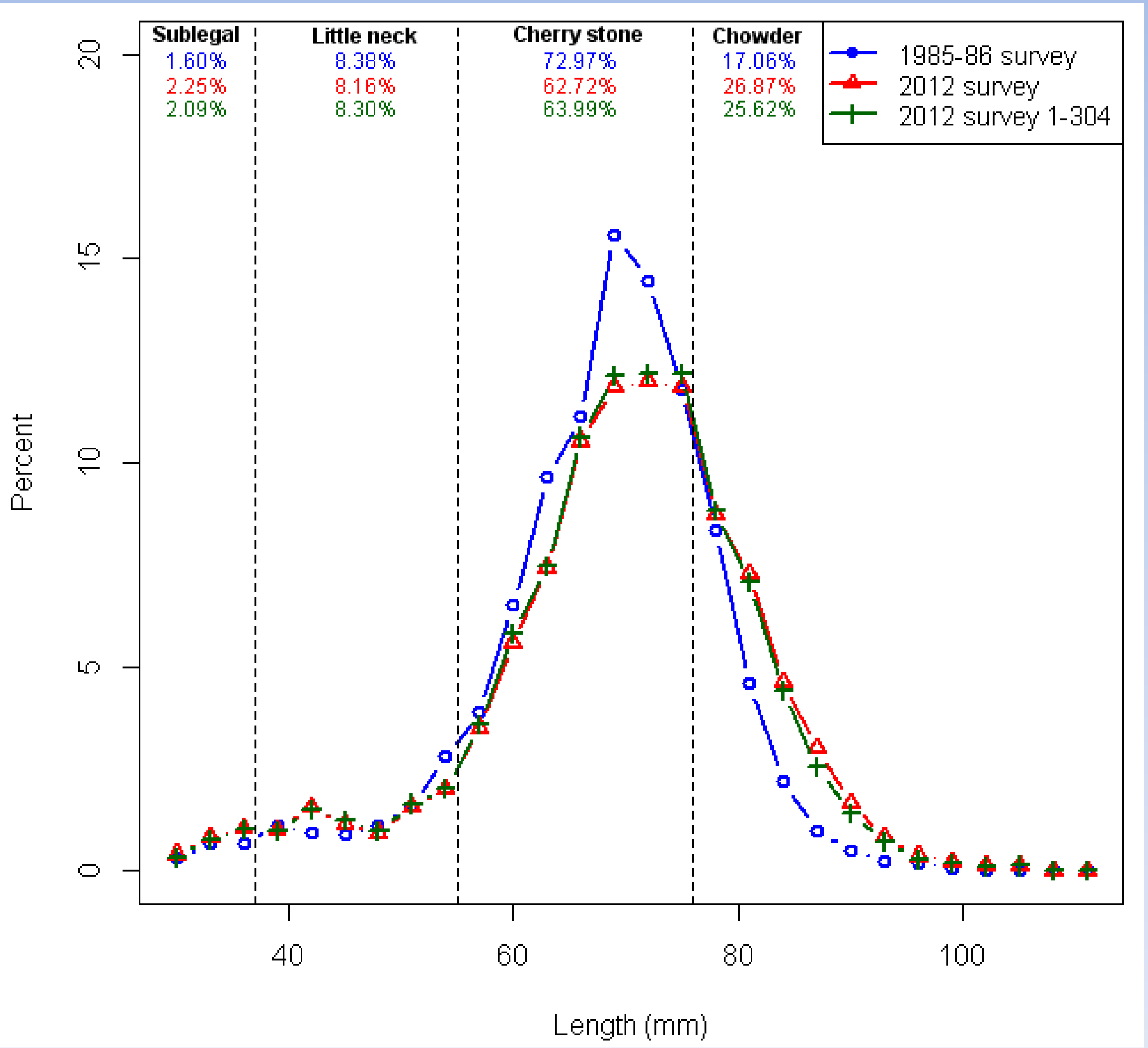
Stock Estimate

- Barnegat Bay 2012 → 138.2 million clams
  - 136.7 million clams if using only stations sampled in both surveys
  - 23% decline since 80s survey (using 136.7M estimate)

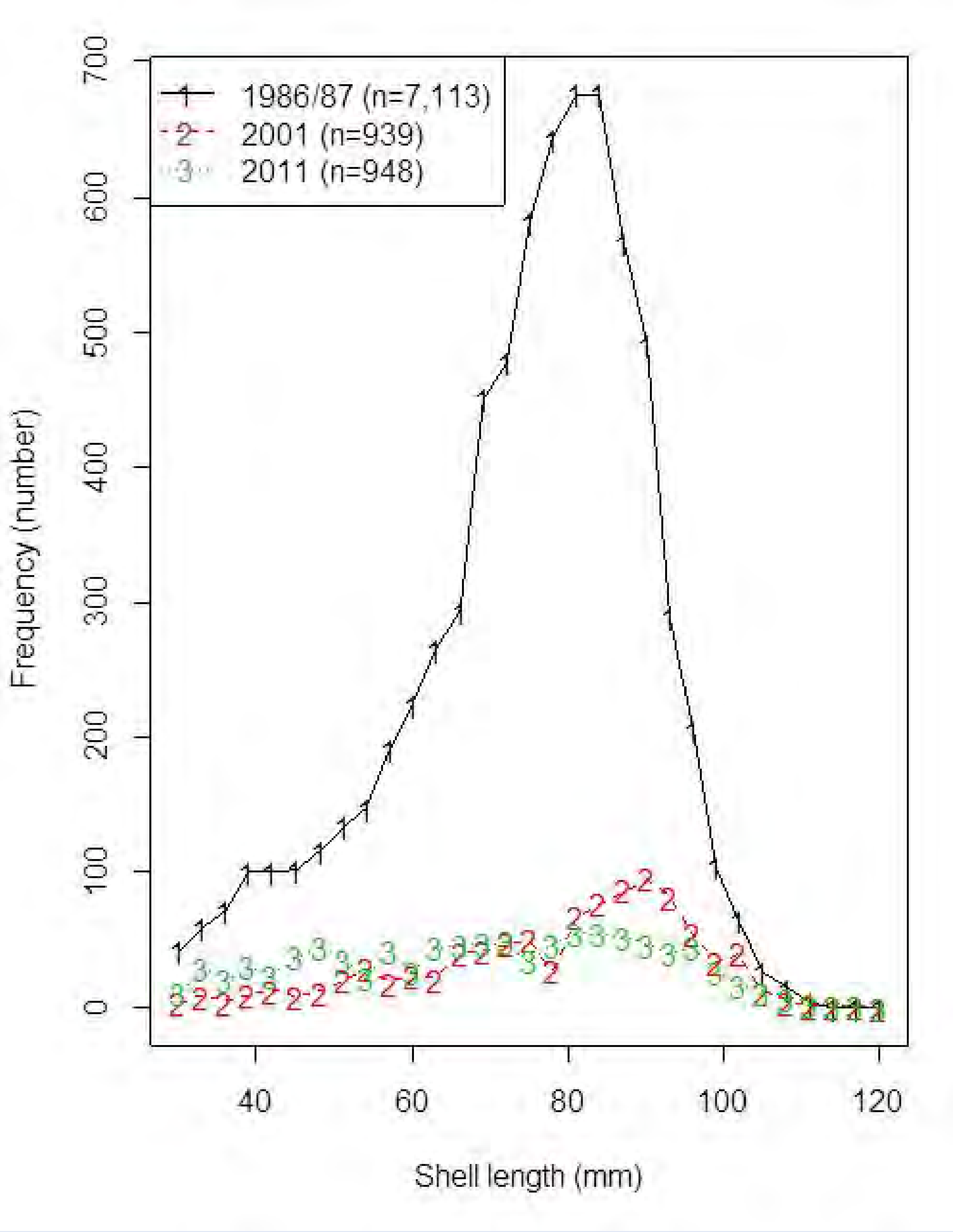
- Little Egg Harbor Bay 2011 → 86 million clams
  - 32% increase from 2001, but still 57% decline from 80s

Population Structure

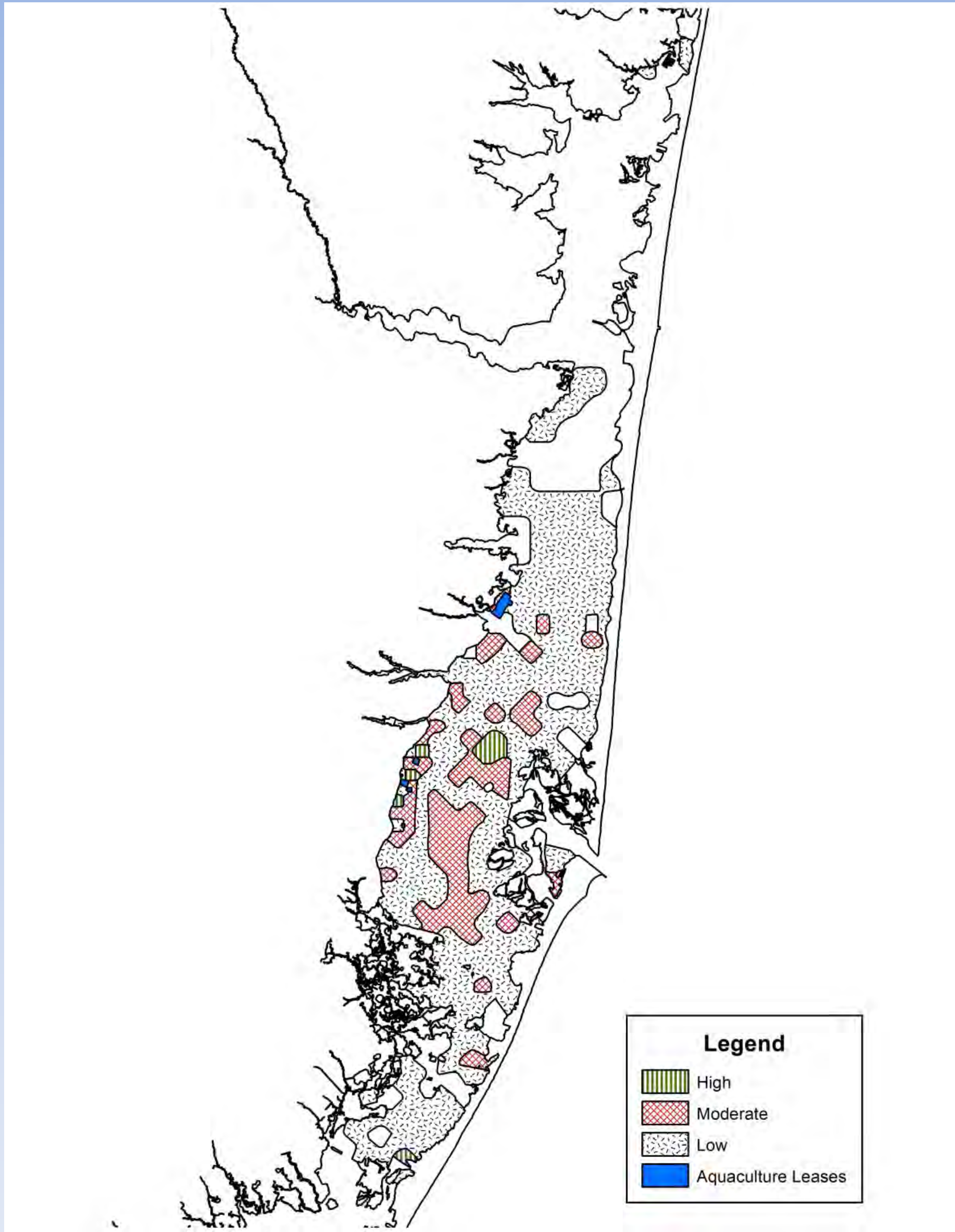
- Barnegat Bay dominated by cherrystone-sized clams, 56-76mm

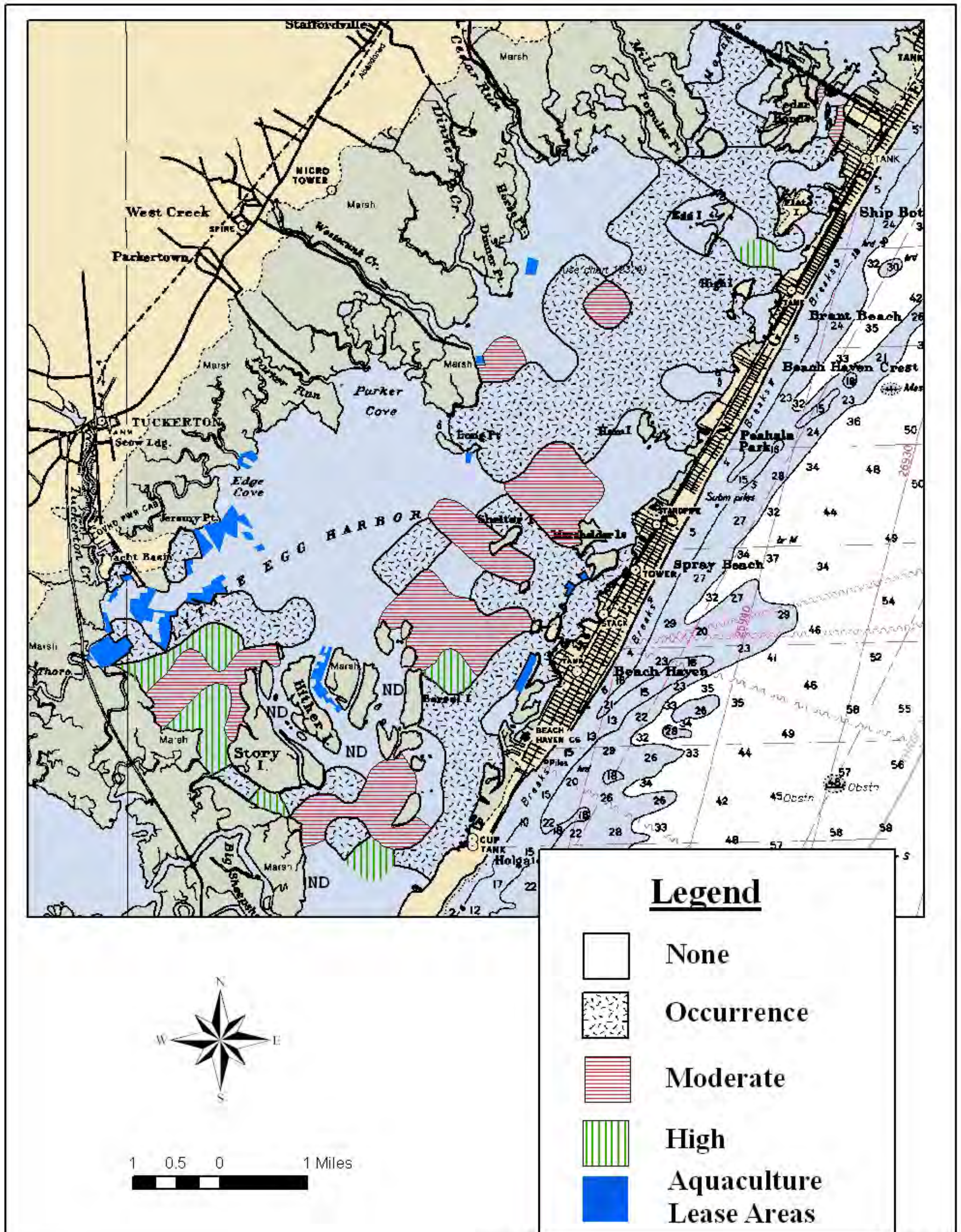


- LEHB changes over time to include more smaller clams



Distribution

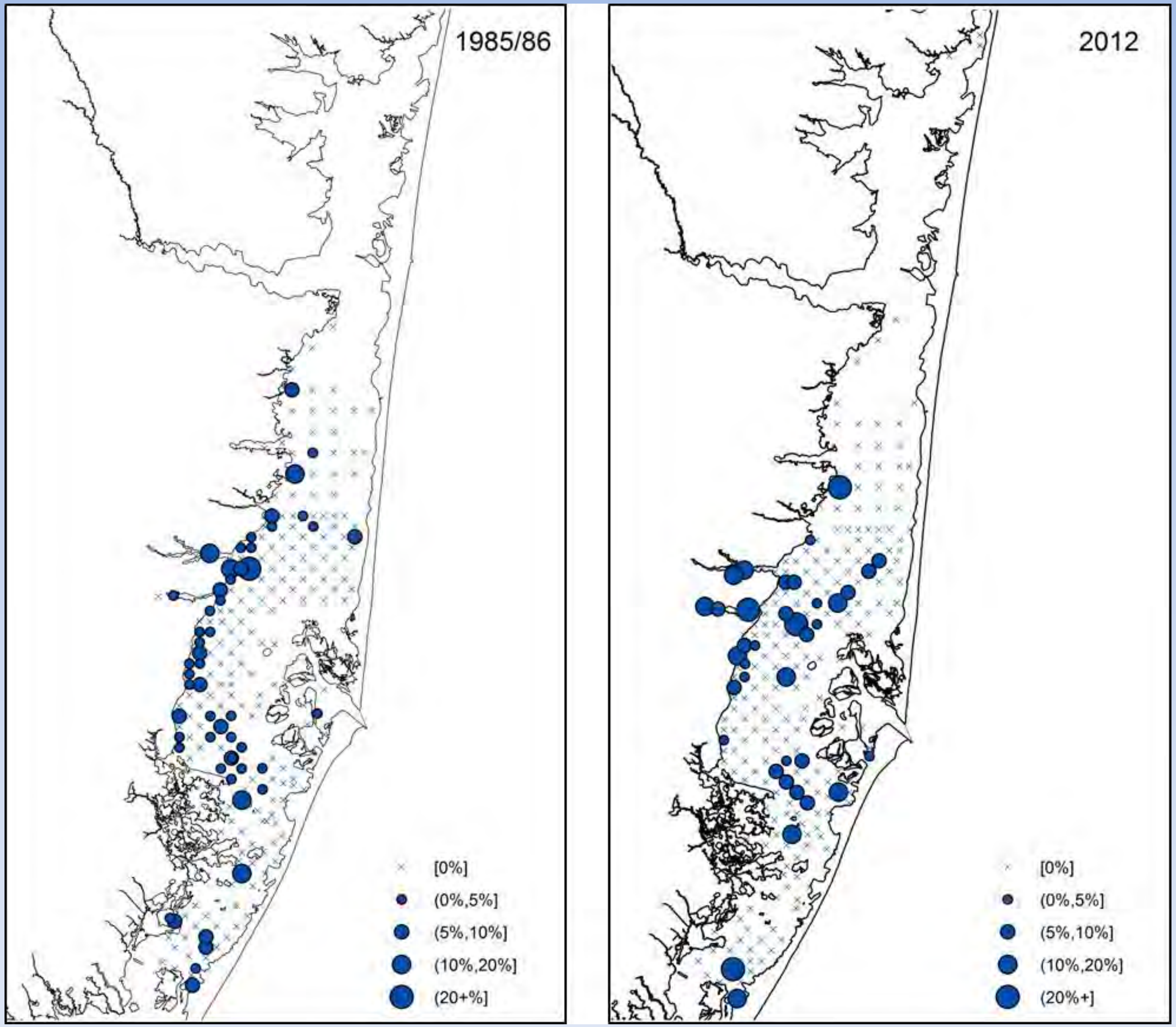


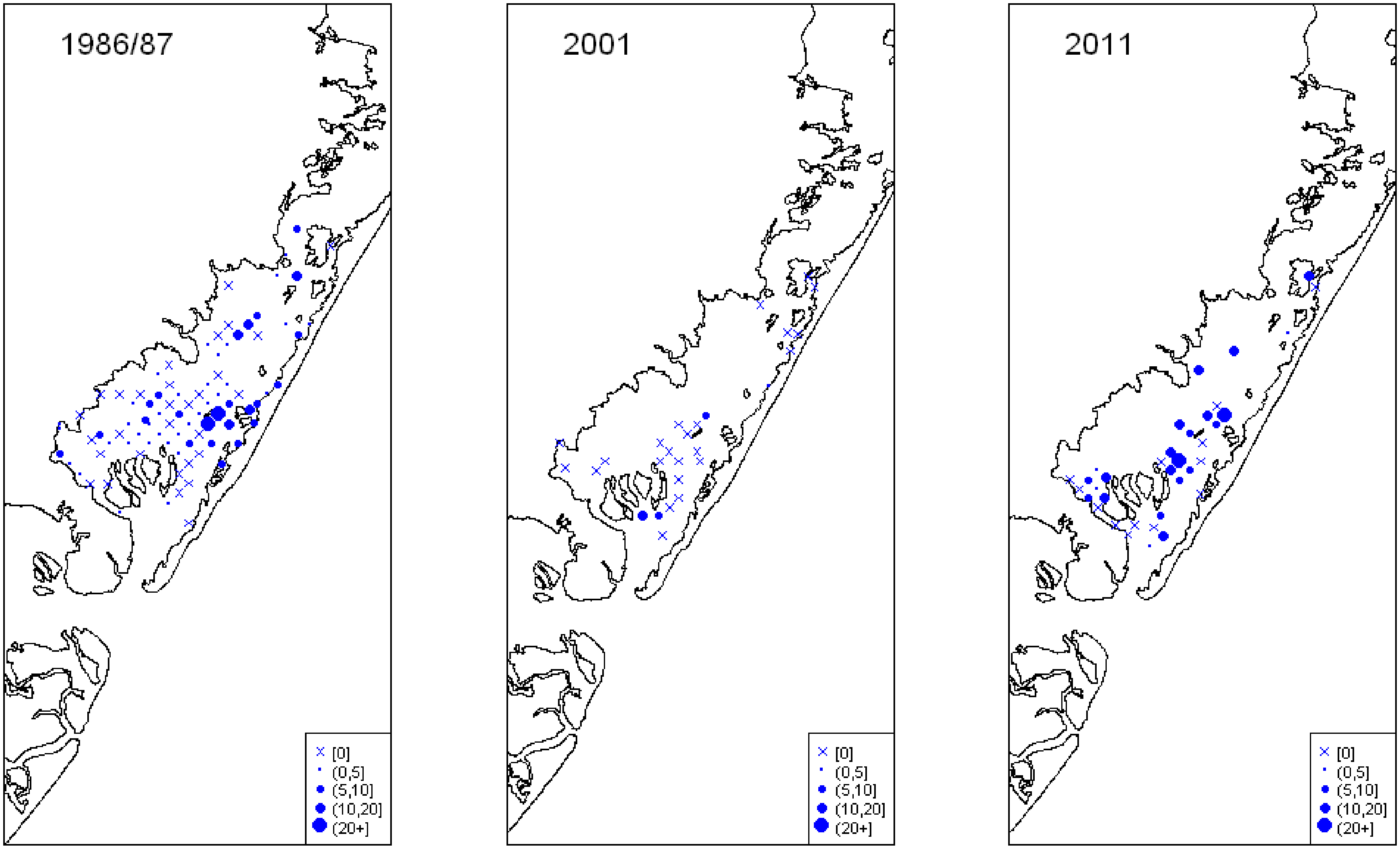


Staffordville
West Creek
Parkertown
TUCKERTON
Parker Run
Parker Cove
Edge Cove
Jeremy Pt.
Yacht Basin
Story I.
ND
Brant Beach
Beach Haven Crest
Peahala Park
Spray Beach
Beach Haven
N
S
E
W
1 0.5 0 1 Miles
Legend
None
Occurrence
Moderate
High
Aquaculture Lease Areas

Recruitment

- Percent of sublegal clams (30-37mm) at each station

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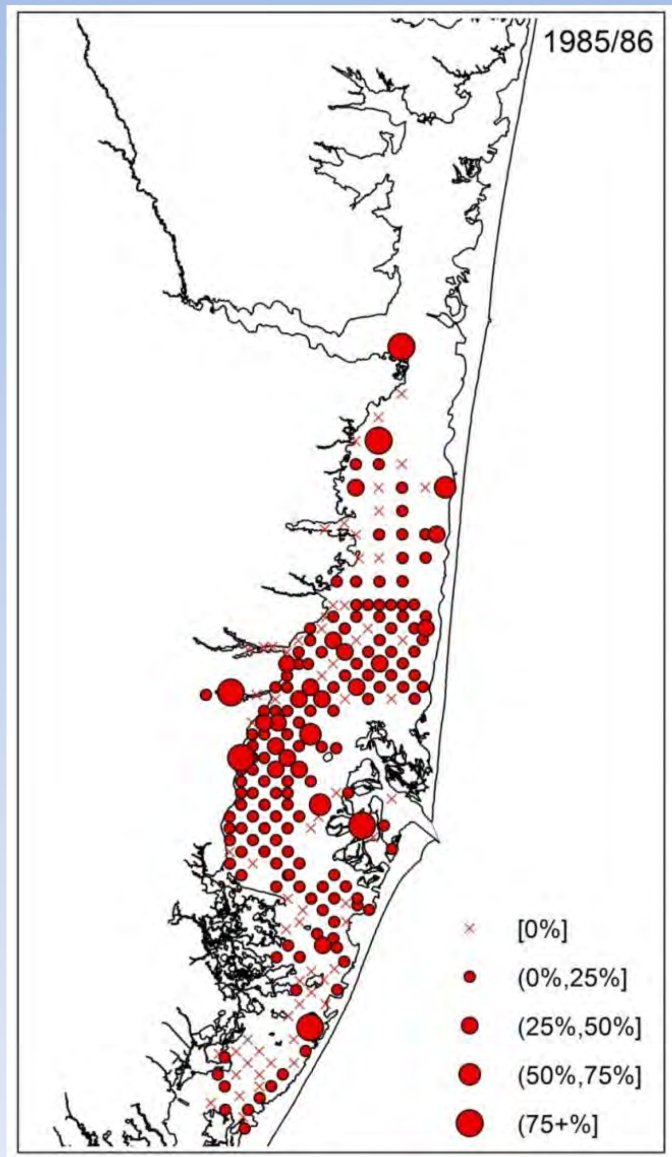
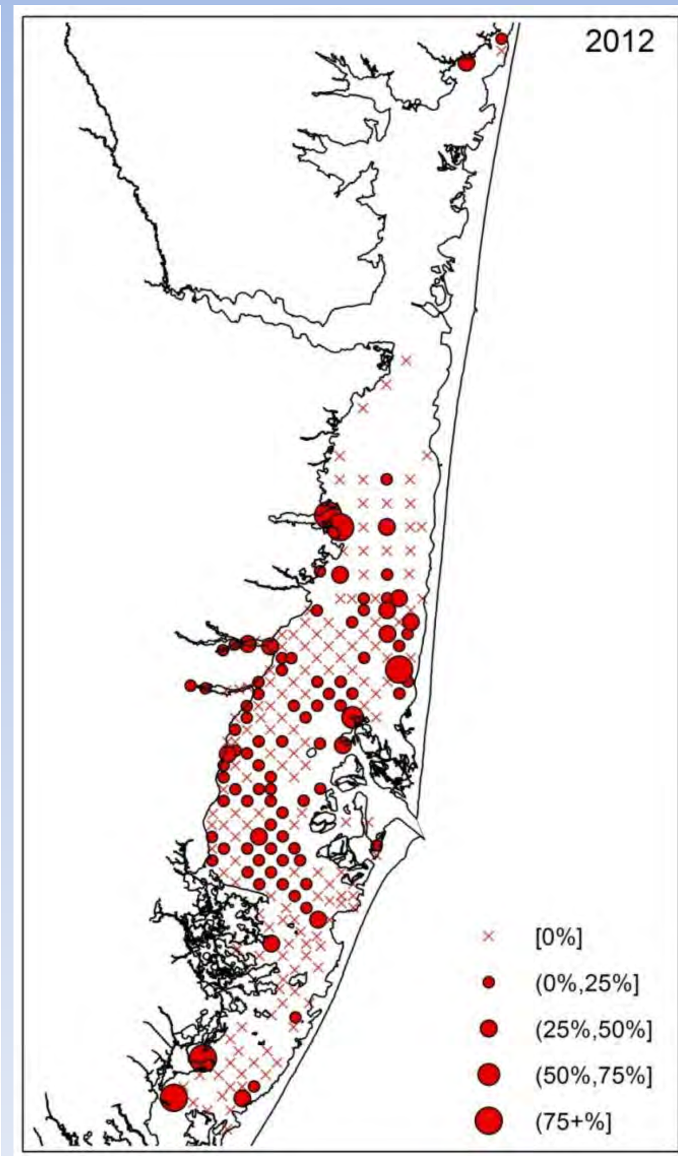
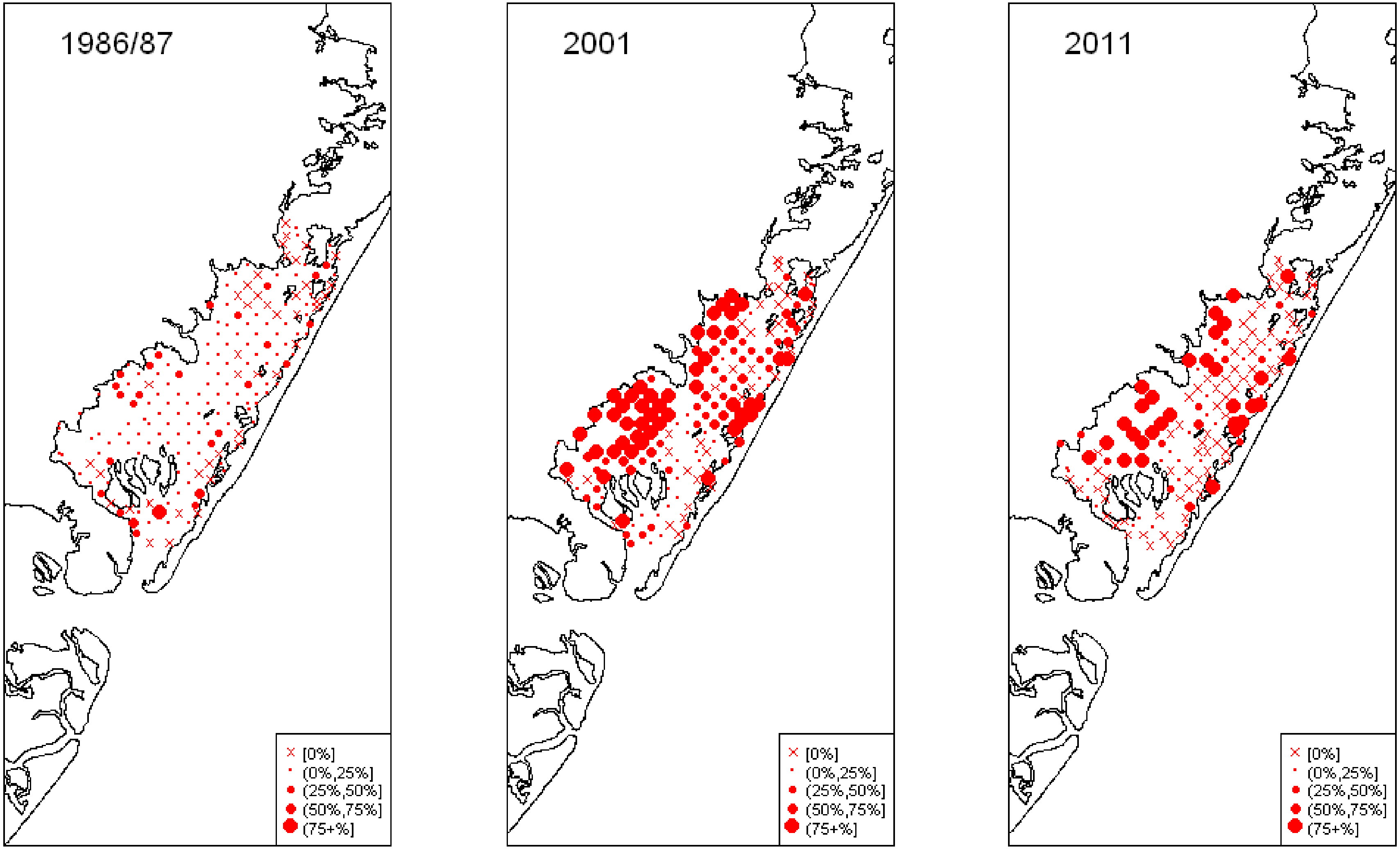
(10,20]
(20+]

Mortality

- Natural mortality estimate based upon boxes (paired valves) relative to live clams



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(0%,25%]
(25%,50%]
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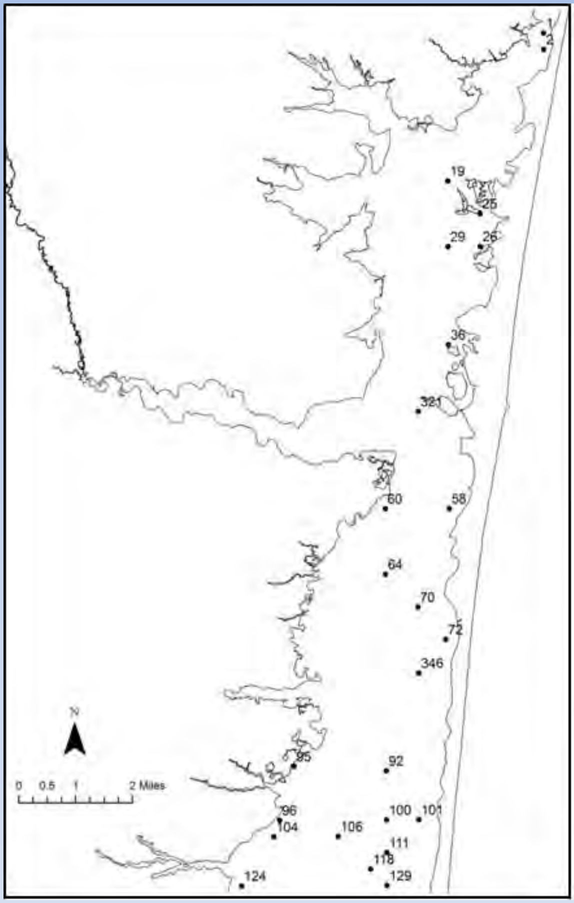
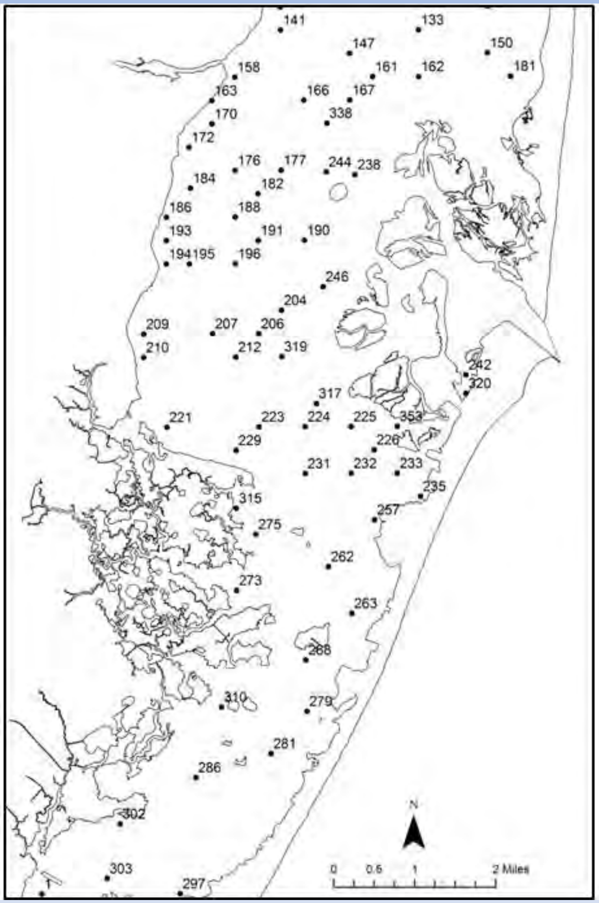
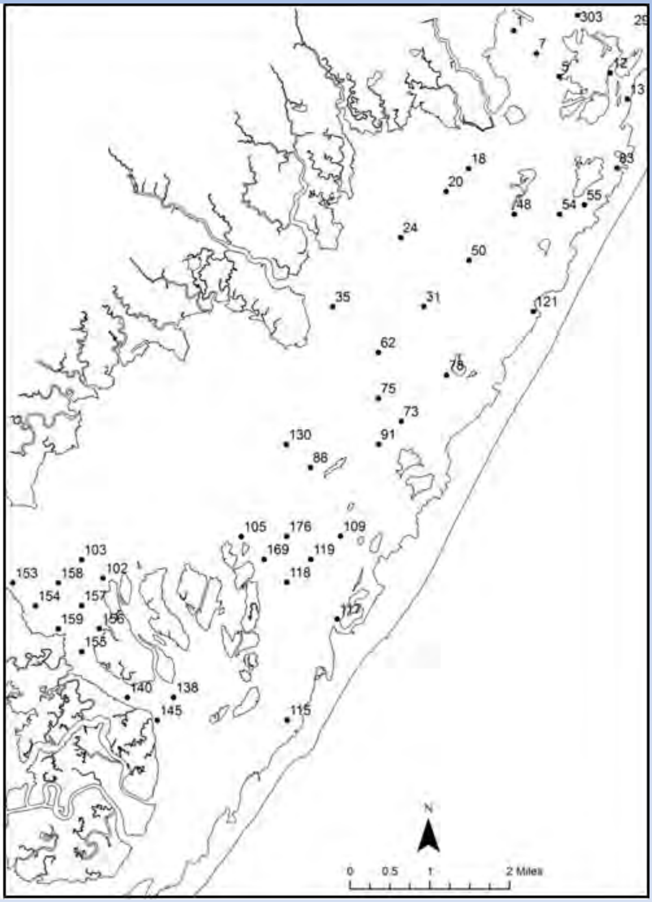
(75+%]

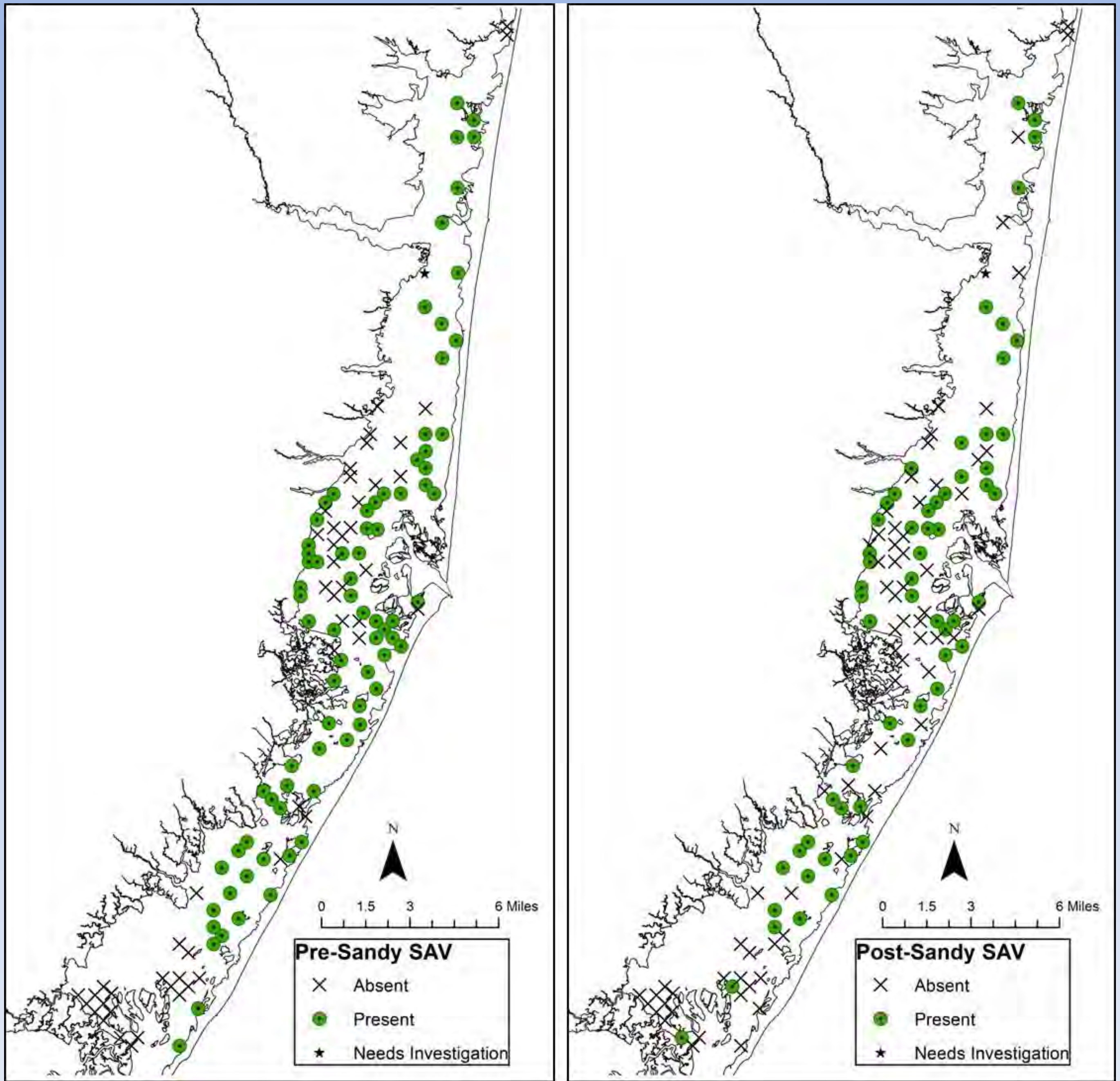
Post-Sandy Investigation
2013



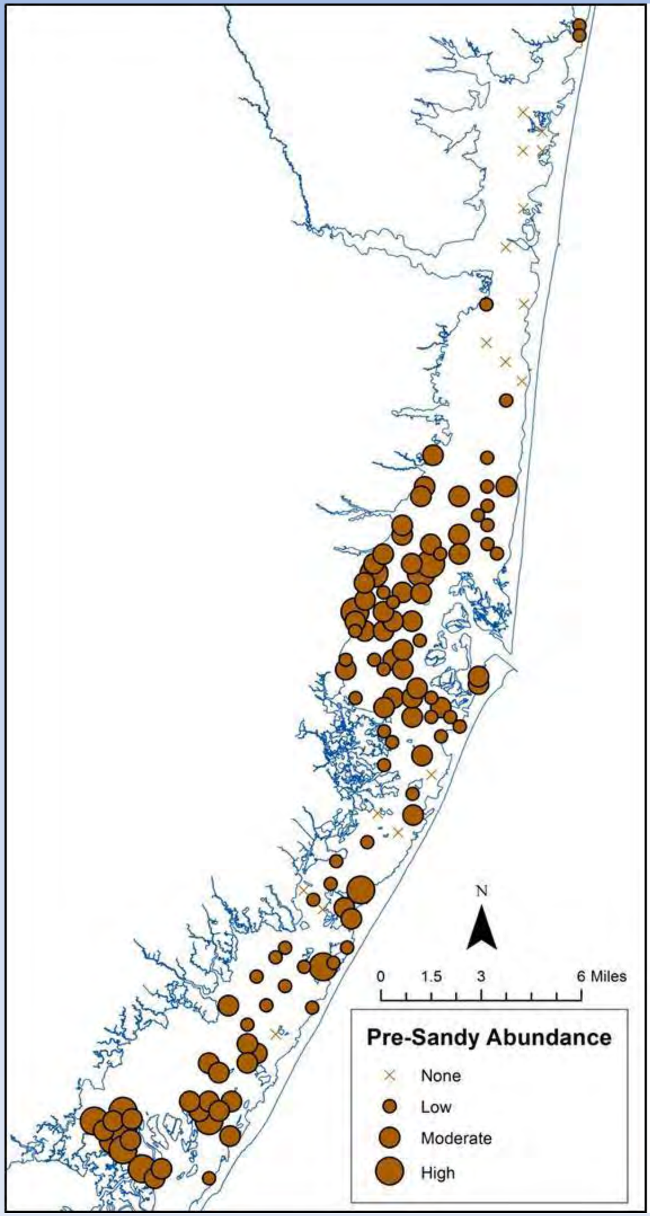


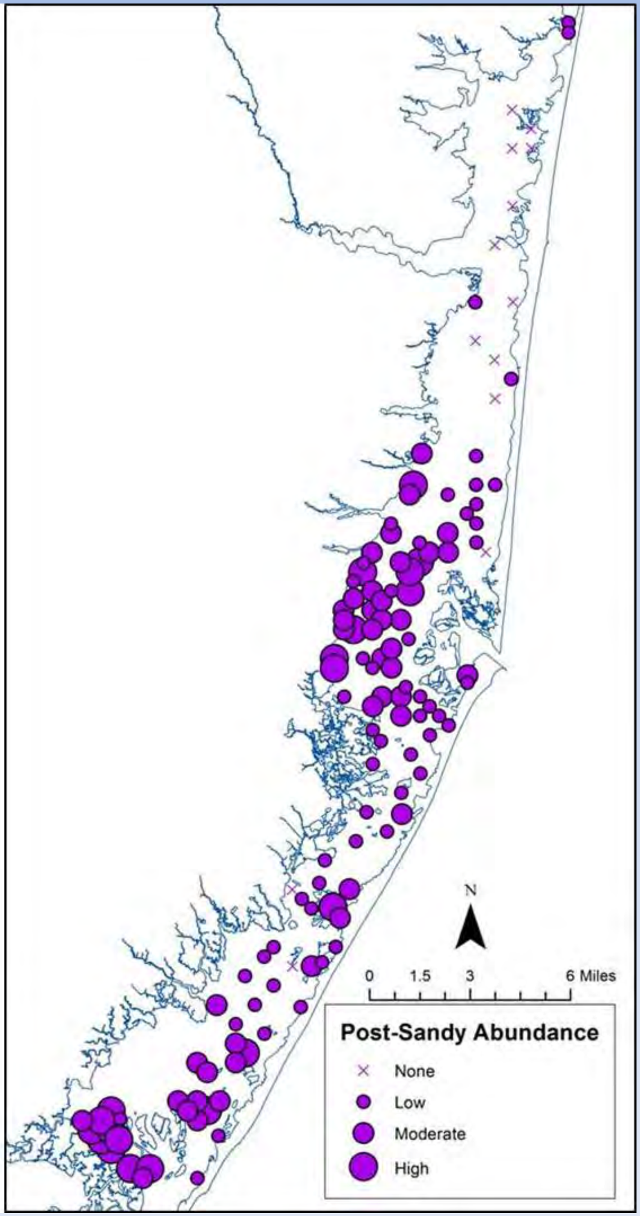


Significant difference in SAV pre and post Sandy

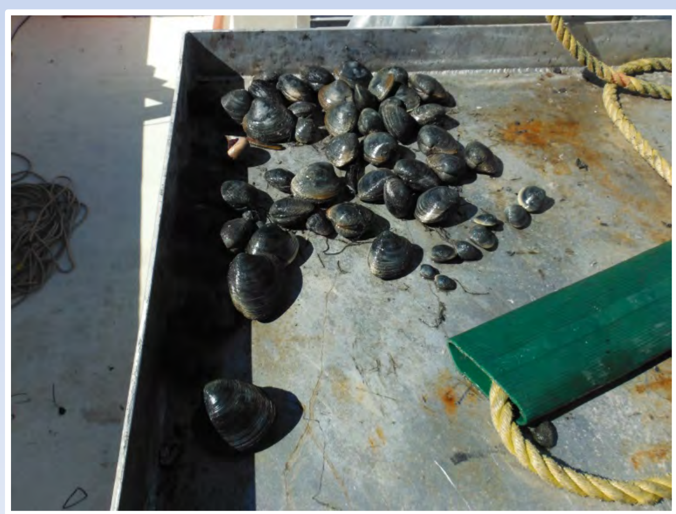


- No significant difference in shellfish densities
- No significant difference in mortality estimates

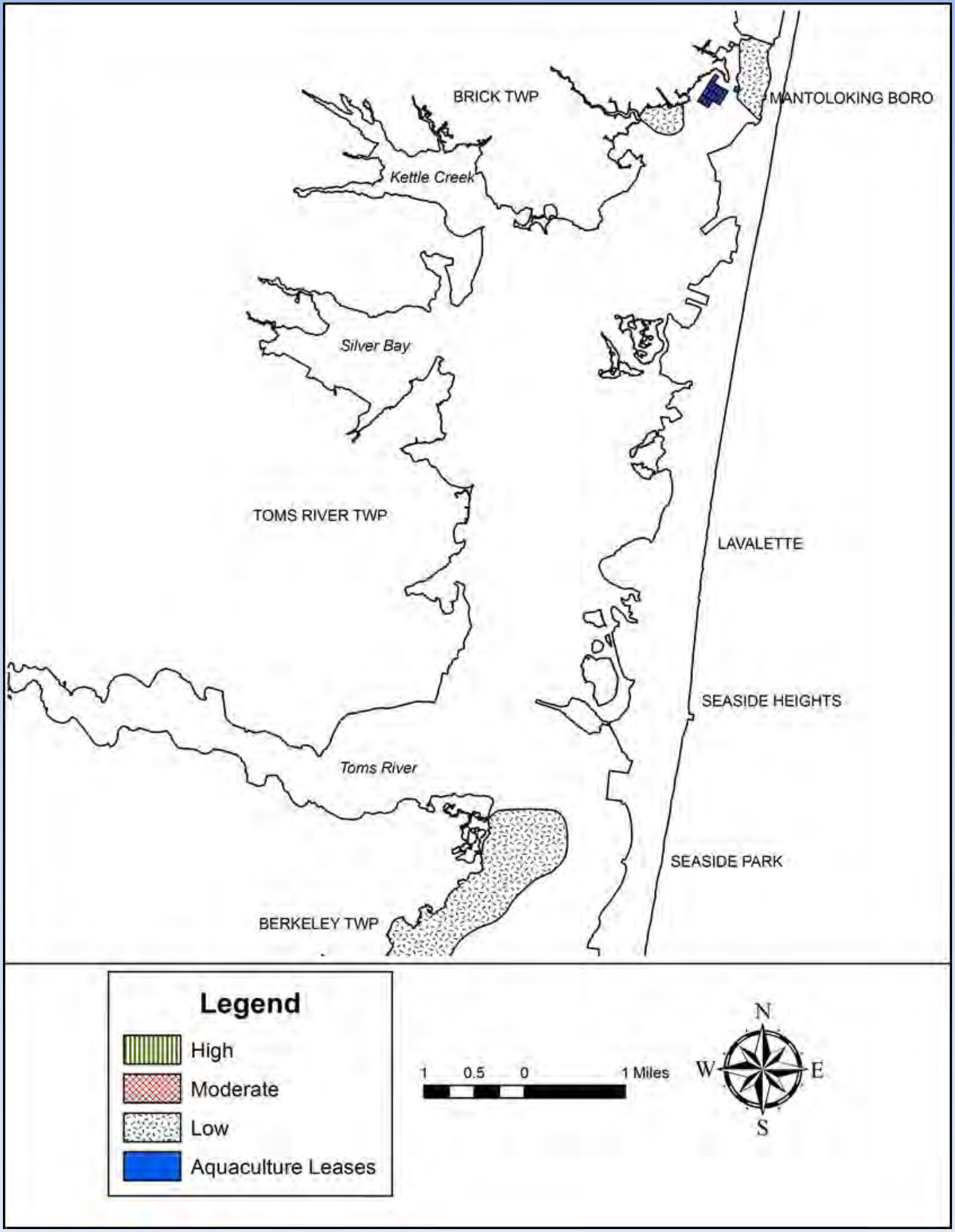


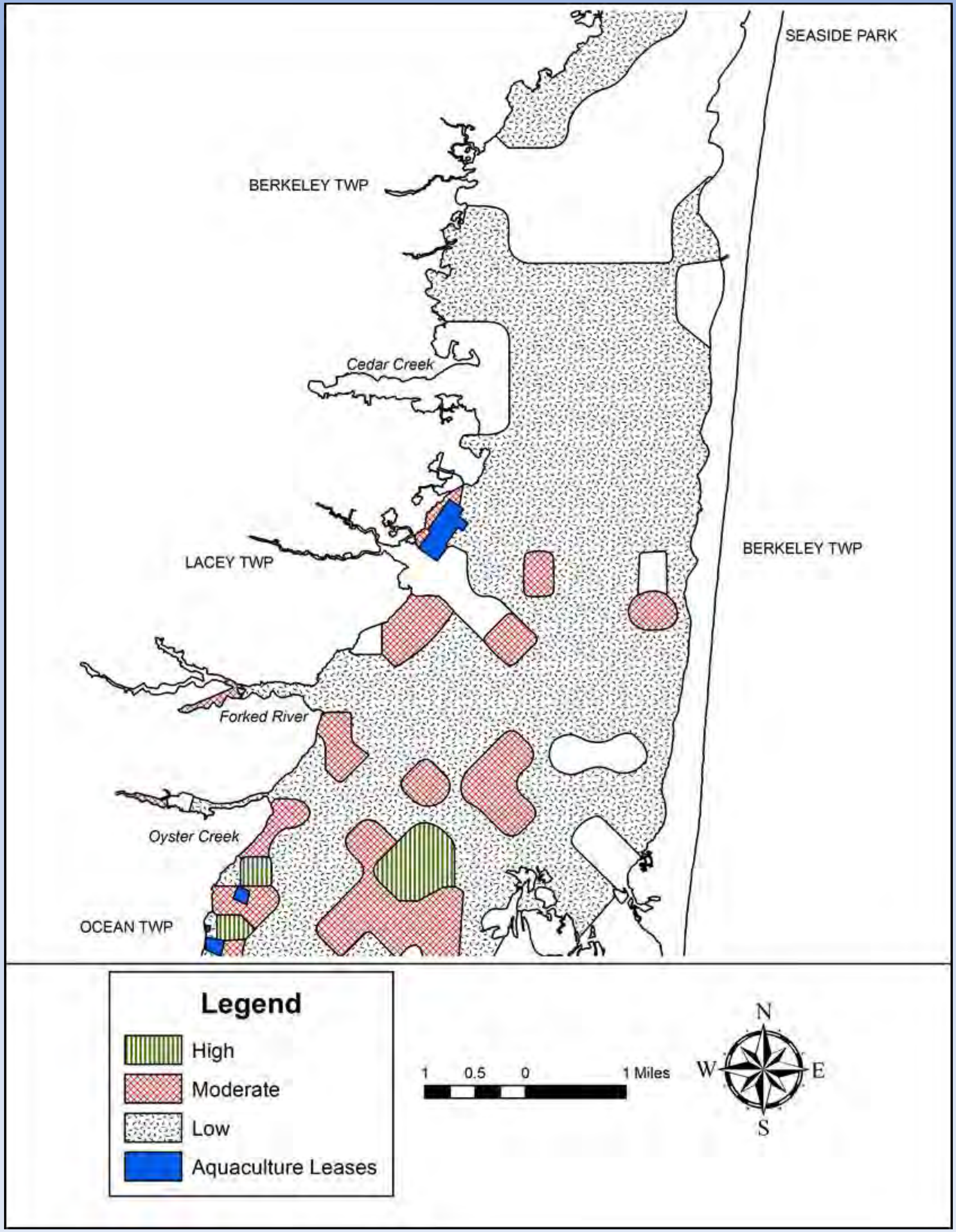


kira.dacanay@dep.nj.gov
609-748-2021



Distribution





SEASIDE PARK
BERKELEY TWP
Cedar Creek
LACEY TWP
BERKELEY TWP
Forked River
Oyster Creek
OCEAN TWP
Legend
High
Moderate
Low
Aquaculture Leases
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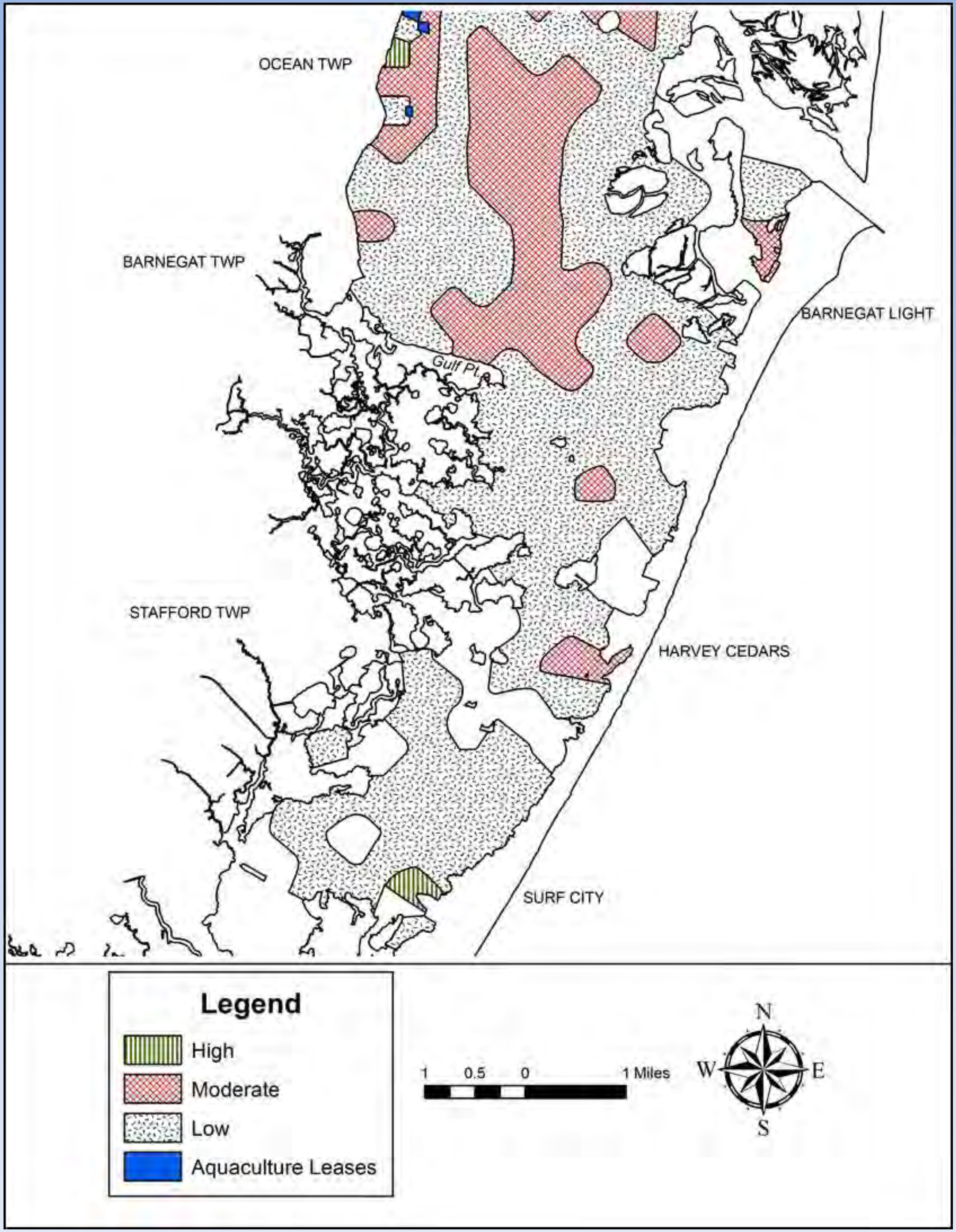
OCEAN TWP
BARNEGAT TWP
BARNEGAT LIGHT
Gulf Pt.
STAFFORD TWP
HARVEY CEDARS
SURF CITY
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Moderate
Low
Aquaculture Leases
1 0.5 0 1 Miles
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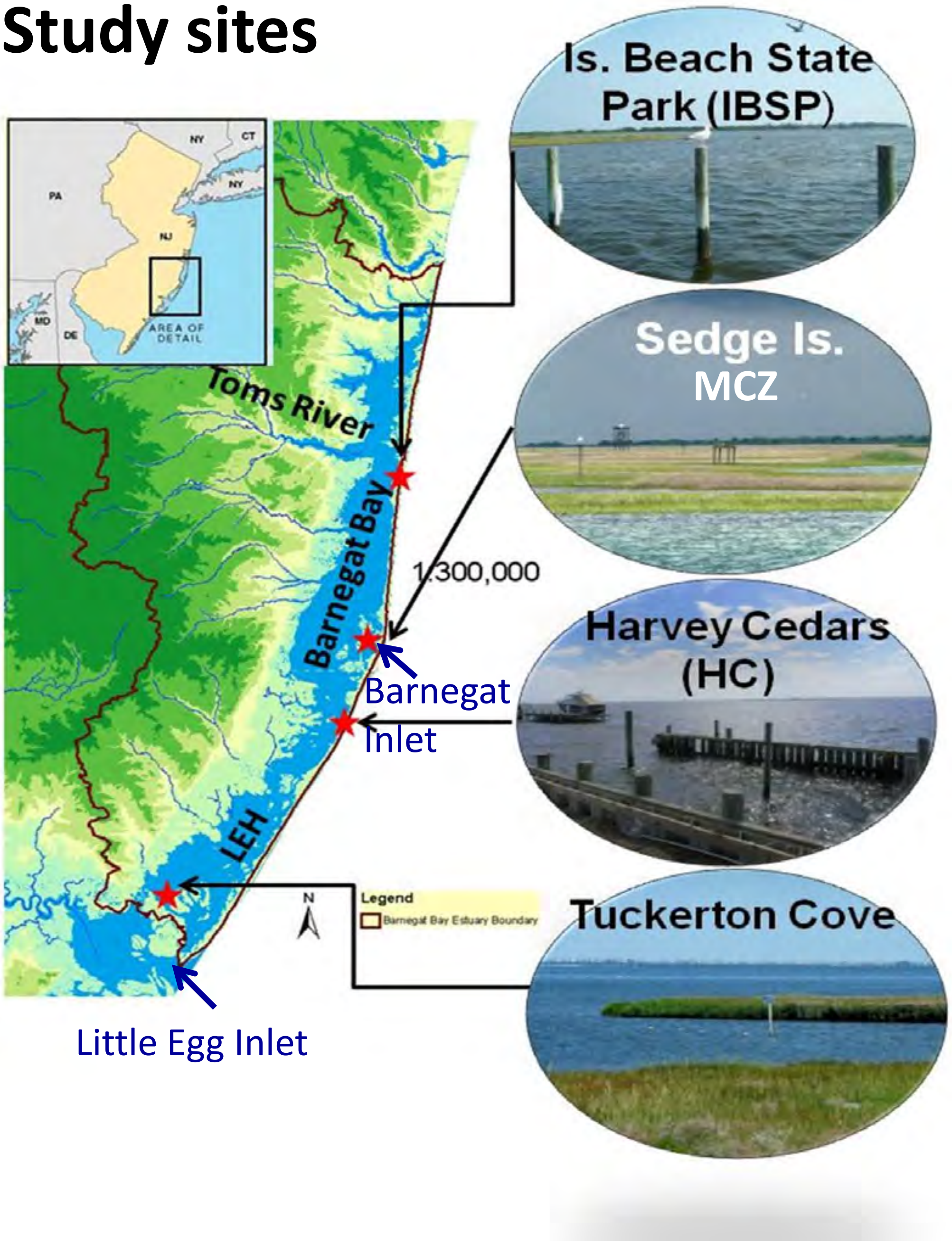
Benthic-pelagic coupling: hard clams, *Mercenaria mercenaria*, as indicators of environmental conditions in Barnegat Bay

Monica Bricelj[1,2], John Kraeuter[2], Gef Flimlin[3] Ryan Fantasia[1], Carola Noji[1], Ling Ren[4], Emily McGurk[2]

[1]Department of Marine & Coastal Sci., Rutgers University (RU), New Brunswick, NJ; [2]Haskin Shellfish Res. Lab./RU, Port Norris, NJ; [3]RU Cooperative Extension of Ocean County; [4]Philadelphia Academy of Science at Drexel

Study sites



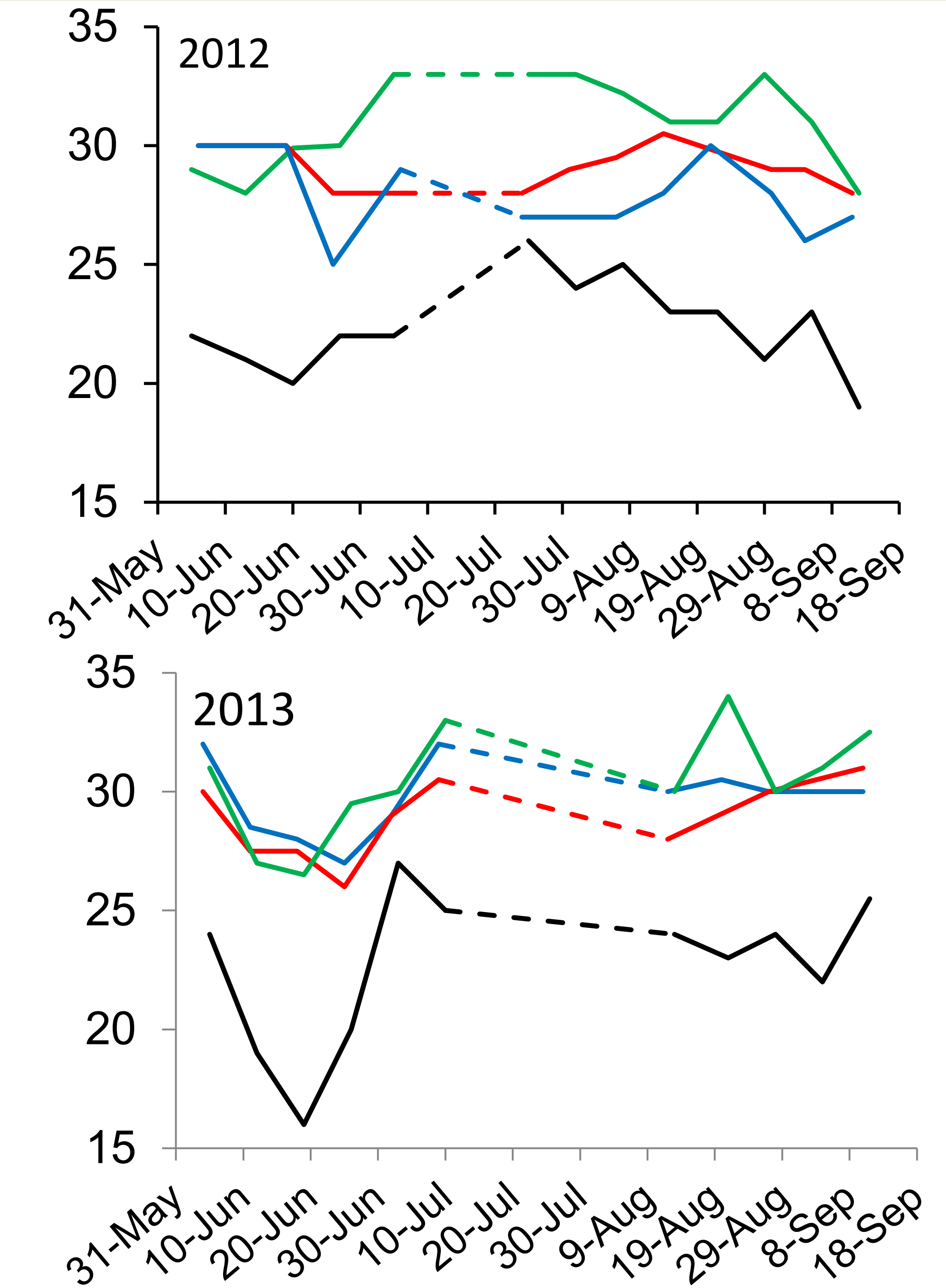
Objectives

Determine:

1. Growth & mortalities of juvenile clams in cages at 4 contrasting sites in 2012-2013
2. Size-specific reproductive condition and mortalities at the 2 northern sites in 2014

In relation to environmental factors: temperature, salinity & food quality/quantity *(determined from phytoplankton pigments at the 4 sites & validated microscopically at 2 sites)*

Salinities at the 4 Study Sites



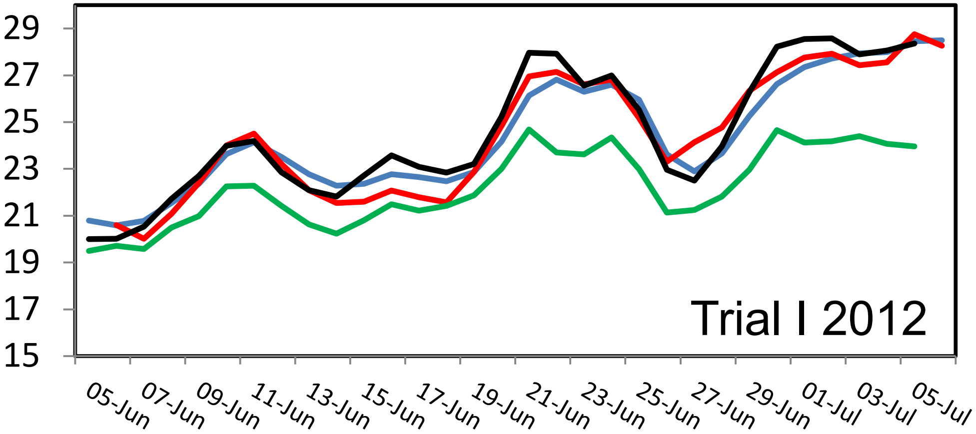
Mean	Range	Site
22.5	16-27	IBSP
30.5	26.5-33	Sedge
29.5	27-32	Tuckerton
28.5	26-30.5	Harvey Cedars

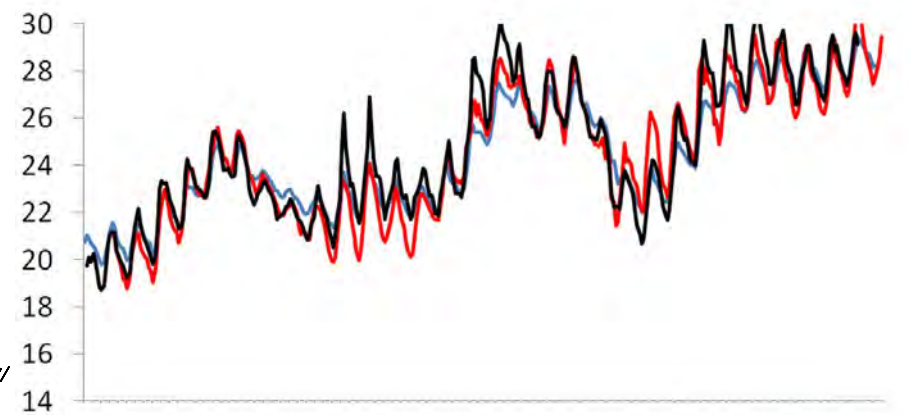
- Highest salinities at Sedge Is. due to exchange through Barnegat Inlet

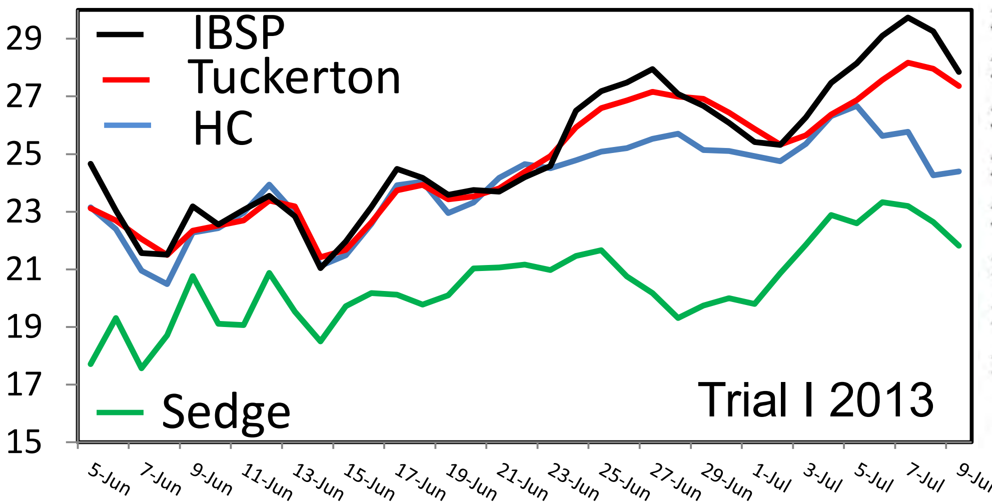
- Lowest salinities at IBSP due to influence of the Toms River plume - *minimum of 16 in 2013 & 2014 is close to the limit of tolerance of hard clams*

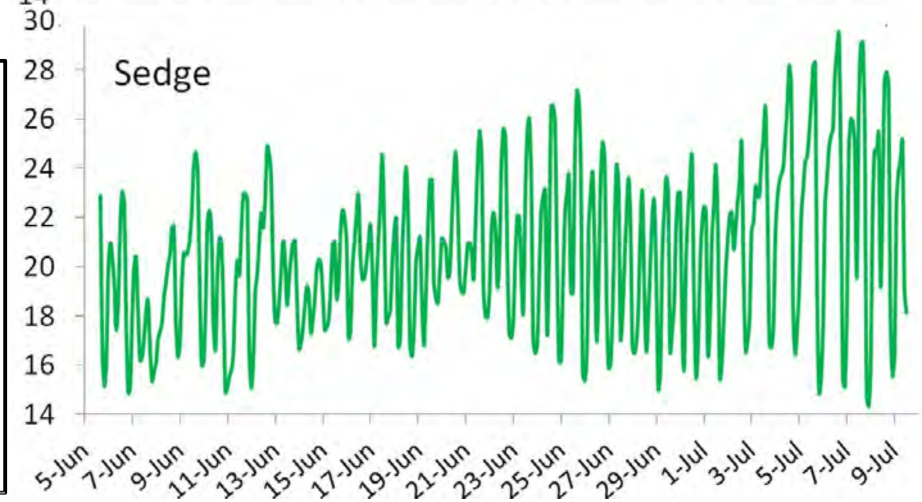
Daily mean temperatures

2 hr-fluctuations 2013 (^oC)

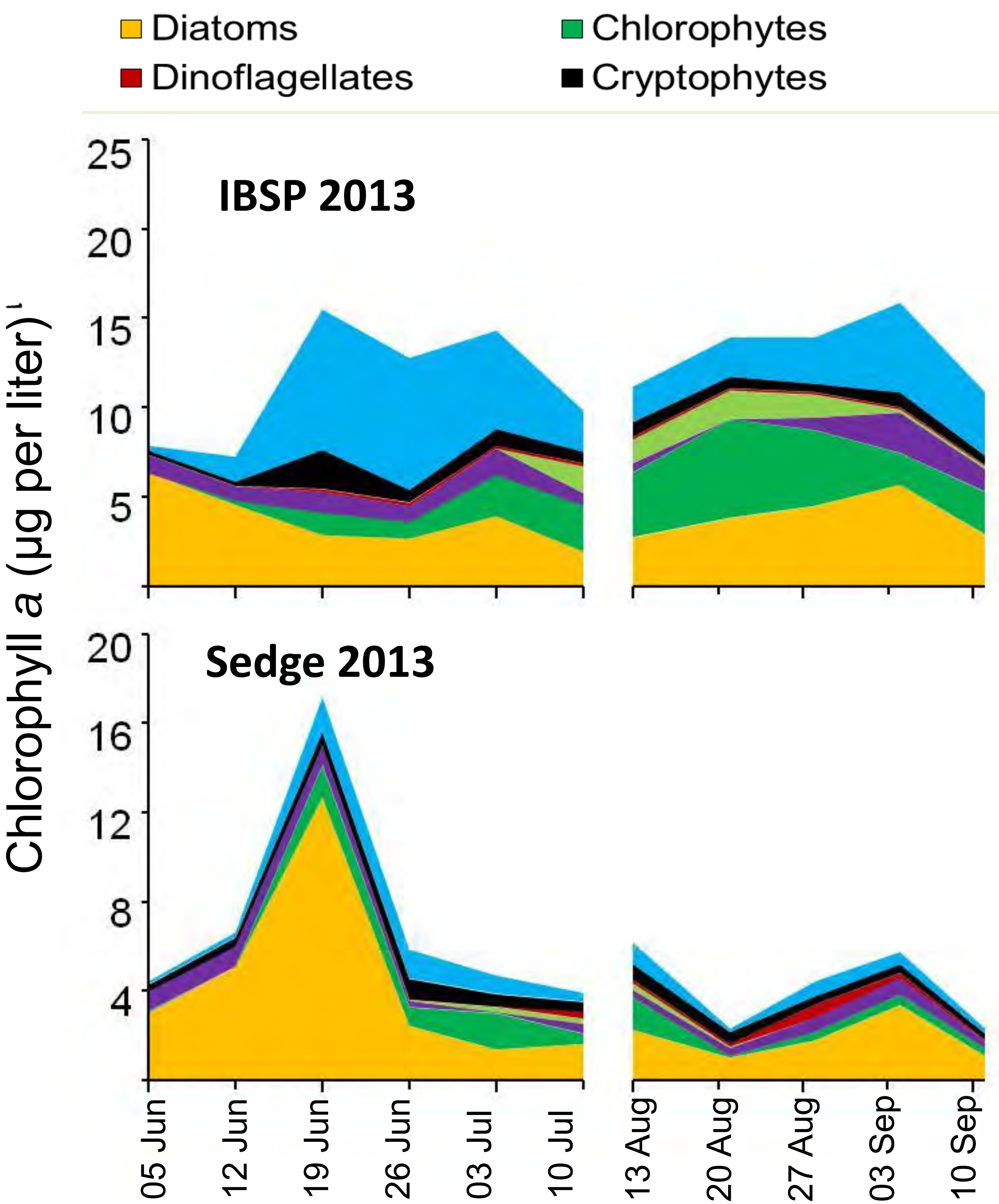








- Consistently lower temperatures at Sedge Is. over 3 yrs, especially in June-July
- Higher temperature fluctuations at Sedge - up to 16^{o}C (50^{o}F)/day in 2013 – may affect clam spawning that is triggered by temperature change



Both food quantity & quality are important to support clam production

- High % of green & blue-green microalgae (chlorophytes & cyanobacteria) at IBSP
  These 2 groups are typically a poor food source for clams

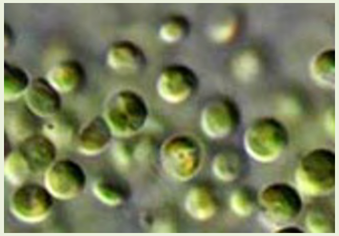
- High % of diatoms at Sedge but often low total chlorophyll *a*, a measure of total food quantity
  Diatoms are typically a good food source for clams

METHODS

Water column sampling and filtration to characterize natural suspended particulates

- Significant relationships (+ or -) found between growth of juvenile clams & phytoplankton characteristics

\+ -



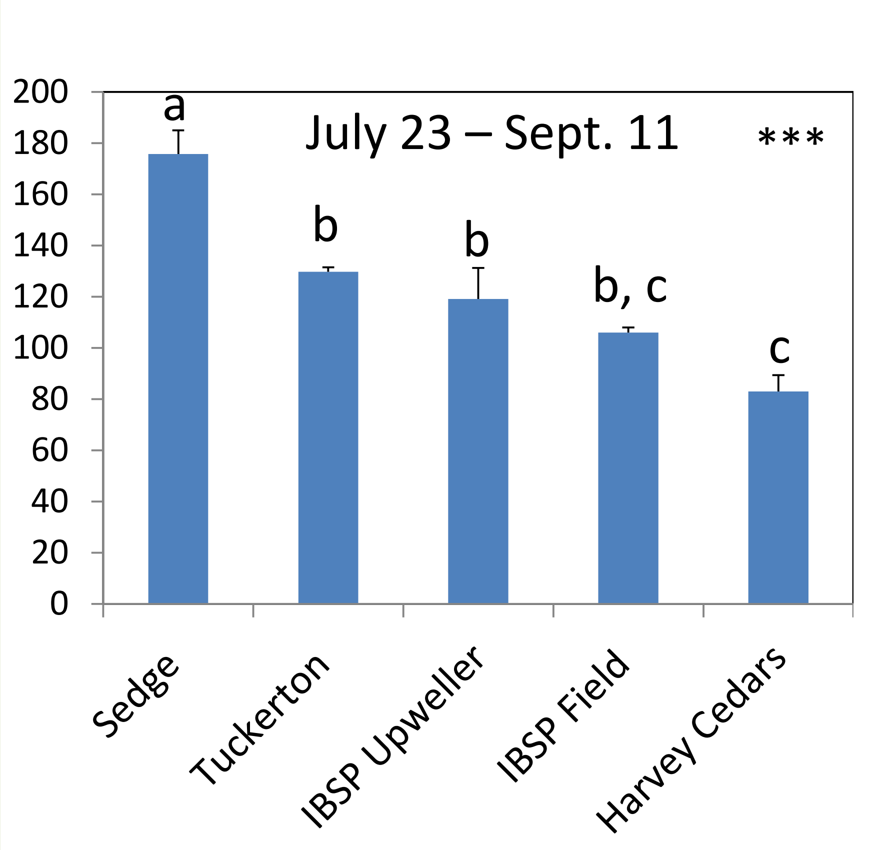
- Significant + relationship between total Chl *a* & clam growth only at Sedge Is. in 2013 and HC 2012.

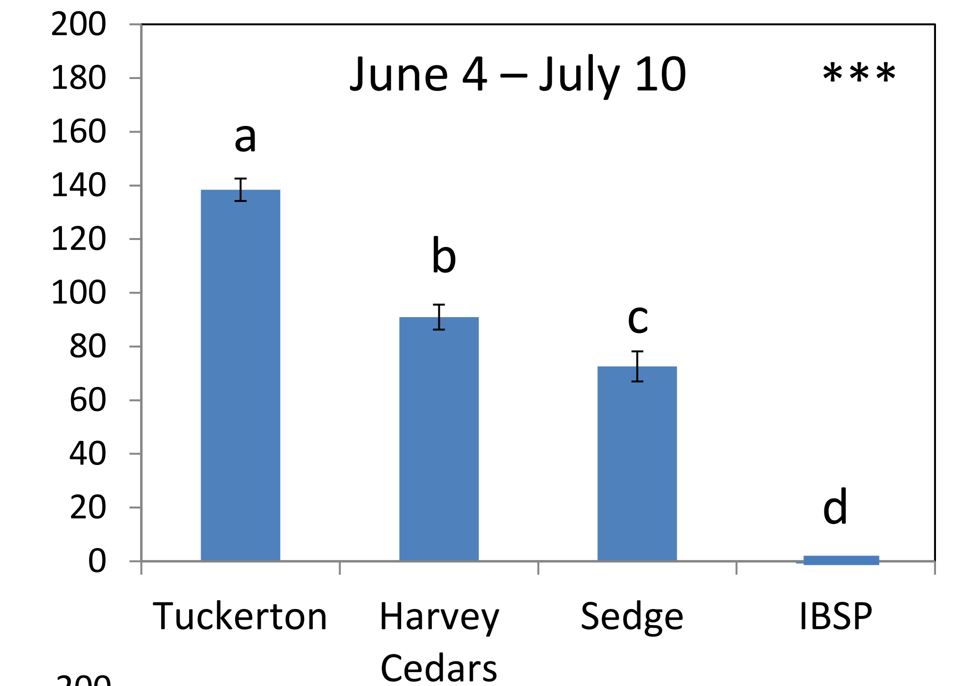
Food quality often more important than food quantity to predict clam growth

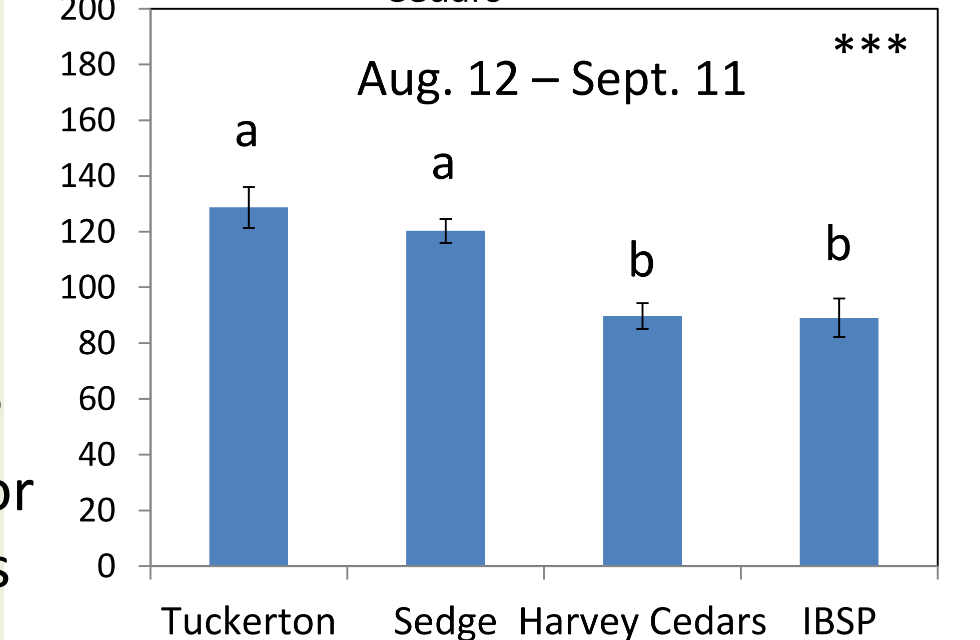
Ranking of time-integrated shell growth rate in µm/day

2013

2012

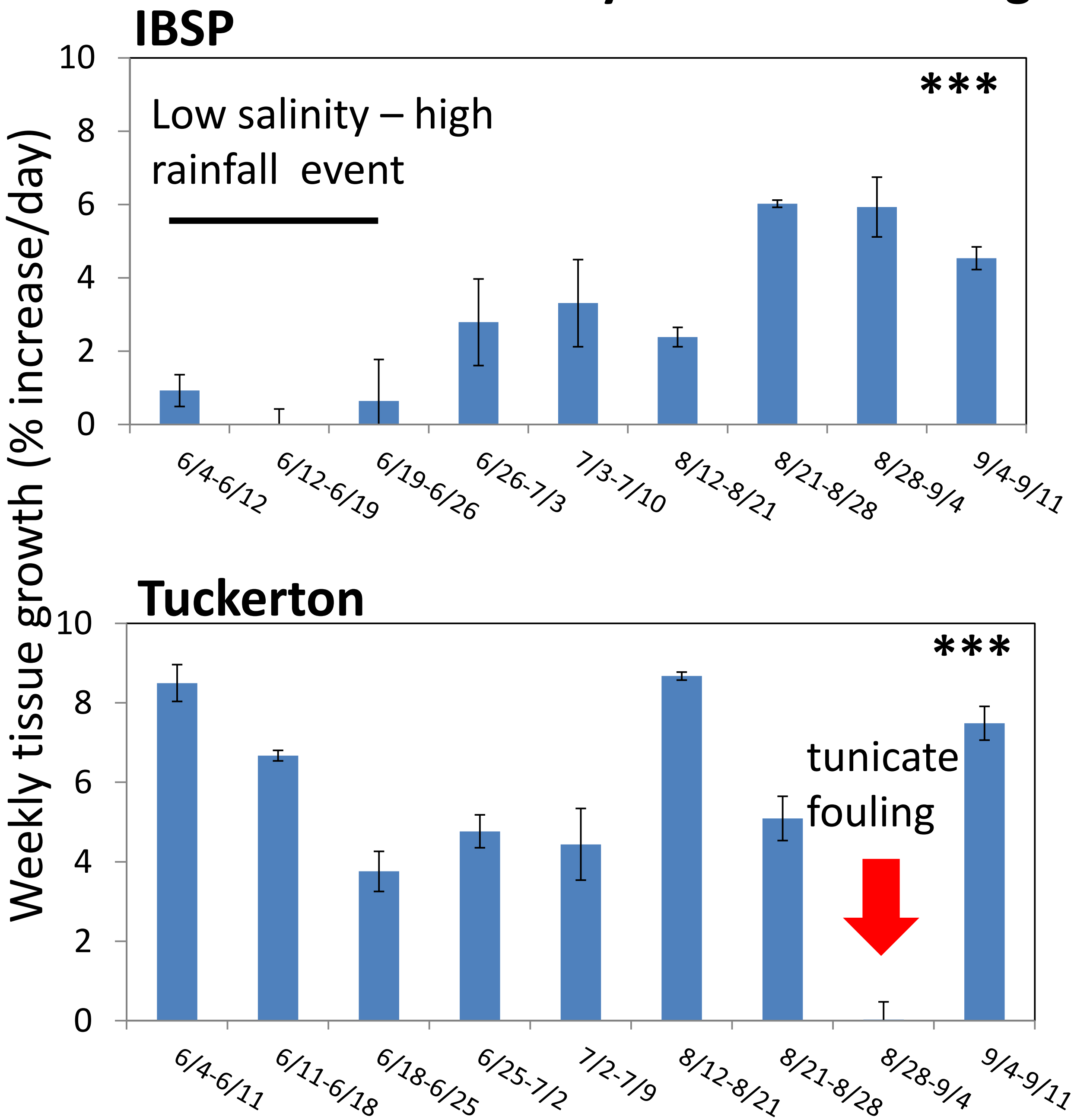


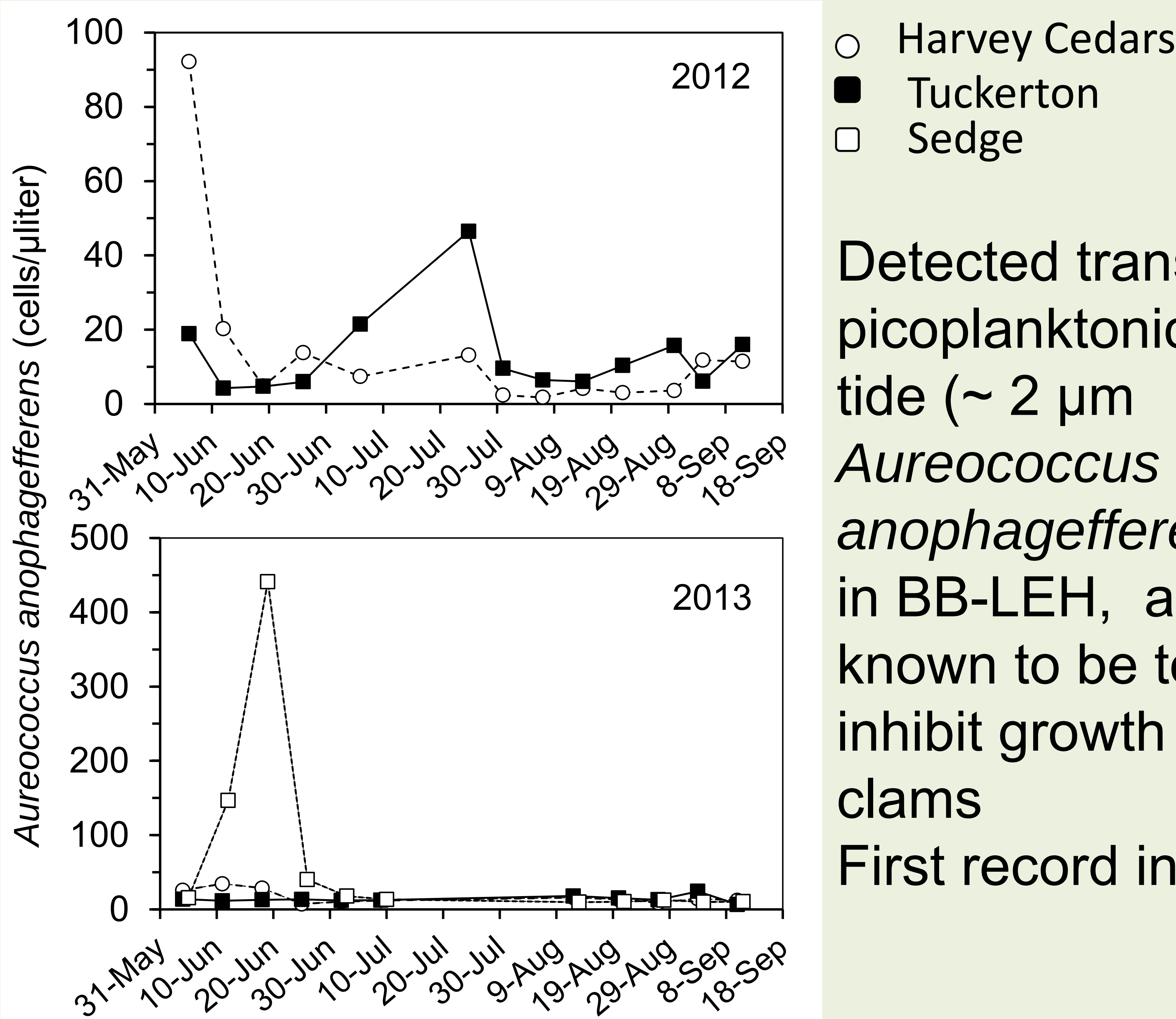


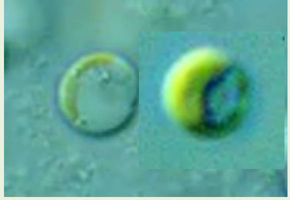


- Clam growth typically low at IBSP
- Growth greater at Sedge (2012) or Tuckerton (2013), protected areas

2013 Weekly clam soft tissue growth rates







Detected transient picoplanktonic brown tide (~ 2 µm *Aureococcus anophagefferens* cells) in BB-LEH, at levels known to be toxic & inhibit growth of hard clams

First record in the MCZ

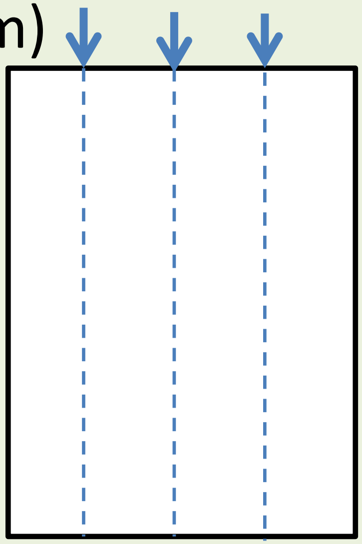
Conclusions

- Maximum weekly clam shell growth in 2012 & 2013 = 175 & 144 µm/day, respectively, approach maxima in other mid-Atlantic estuaries (~ 200 µm/day)
- Clams at Tuckerton showed the highest (3 out of 4 trials) or 2nd highest shell growth rates
- Clam growth at Sedge generally greater than at IBSP despite lower temperatures, high temp. fluctuations & lower food quantity (Chl *a* & Particulate Organic Matter) at Sedge

  Attributed to high food quality at this site (high diatom contribution)
- Lower clam growth at IBSP caused by early summer low salinity events, &/or poor food quality despite relatively high food quantity
- Confirmed presence of brown tide in the estuary in 2012 & 2013 at densities that can inhibit growth of clams but do not cause discoloration of the water

Size-specific Reproduction in 2014

- 2 sites: **IBSP & Sedge**
- 4 plots covered with a ½" mesh screen
- 3 size classes: **Necks** (38-55 mm); **Cherrystone** (56-76mm); **Chowders** (>76 mm)



14 ft x 20 ft

~234 clams/plot (78/size class)

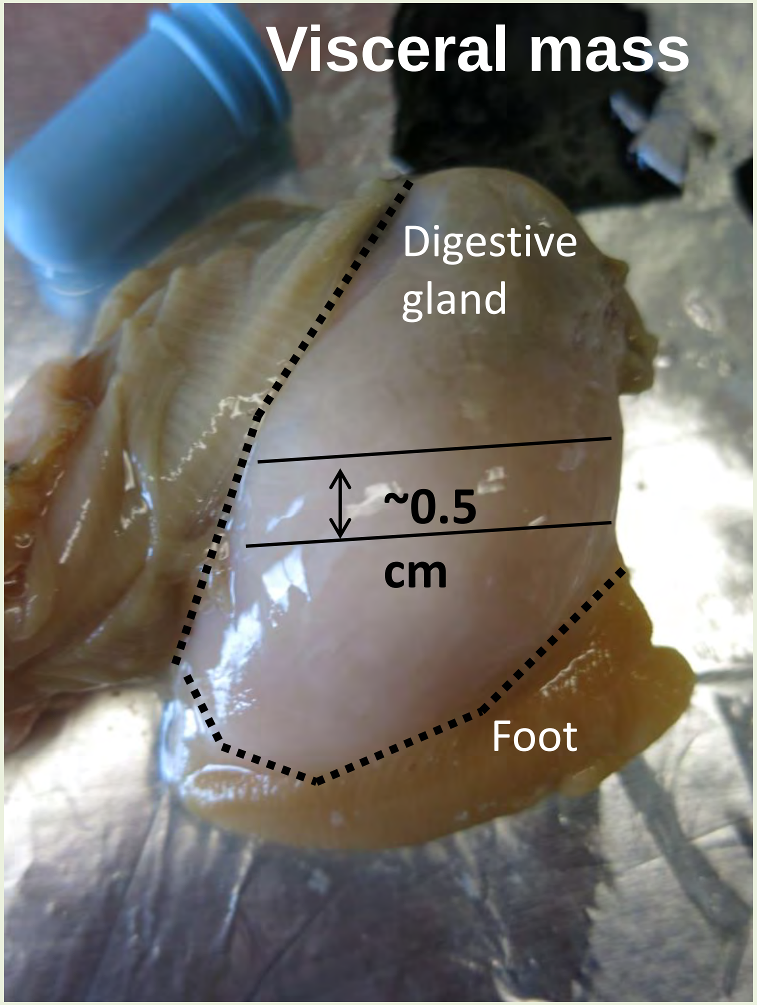
~ 0.84 clams/ft^2 = 9 clams/m^2

Sampled ~ 20-24 clams/size/date

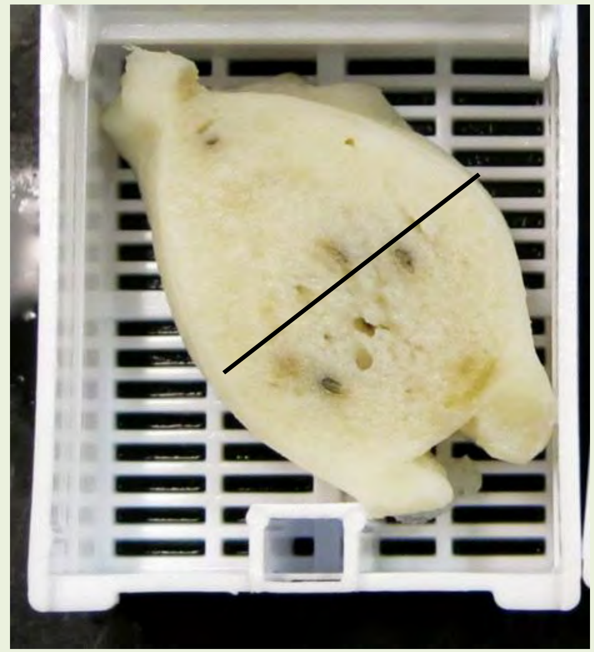
Deployed color-coded wild clams, collected from Tuckerton, in mid-April 2014 before gonadal development (temperature ~ 11 ^{o}C)

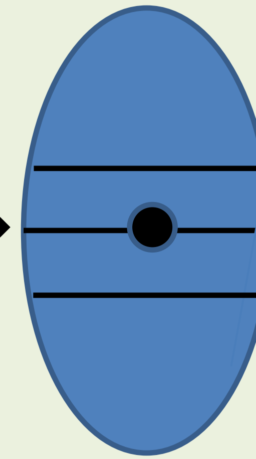
Sampled clams and determined food, temperature & salinity every 2 wks from mid-June to late-Oct.

Visceral Mass Index = [Viscera Wet Weight (g) $*10^5$] / Shell Length $(mm)^3$



Mid-cross section for histology

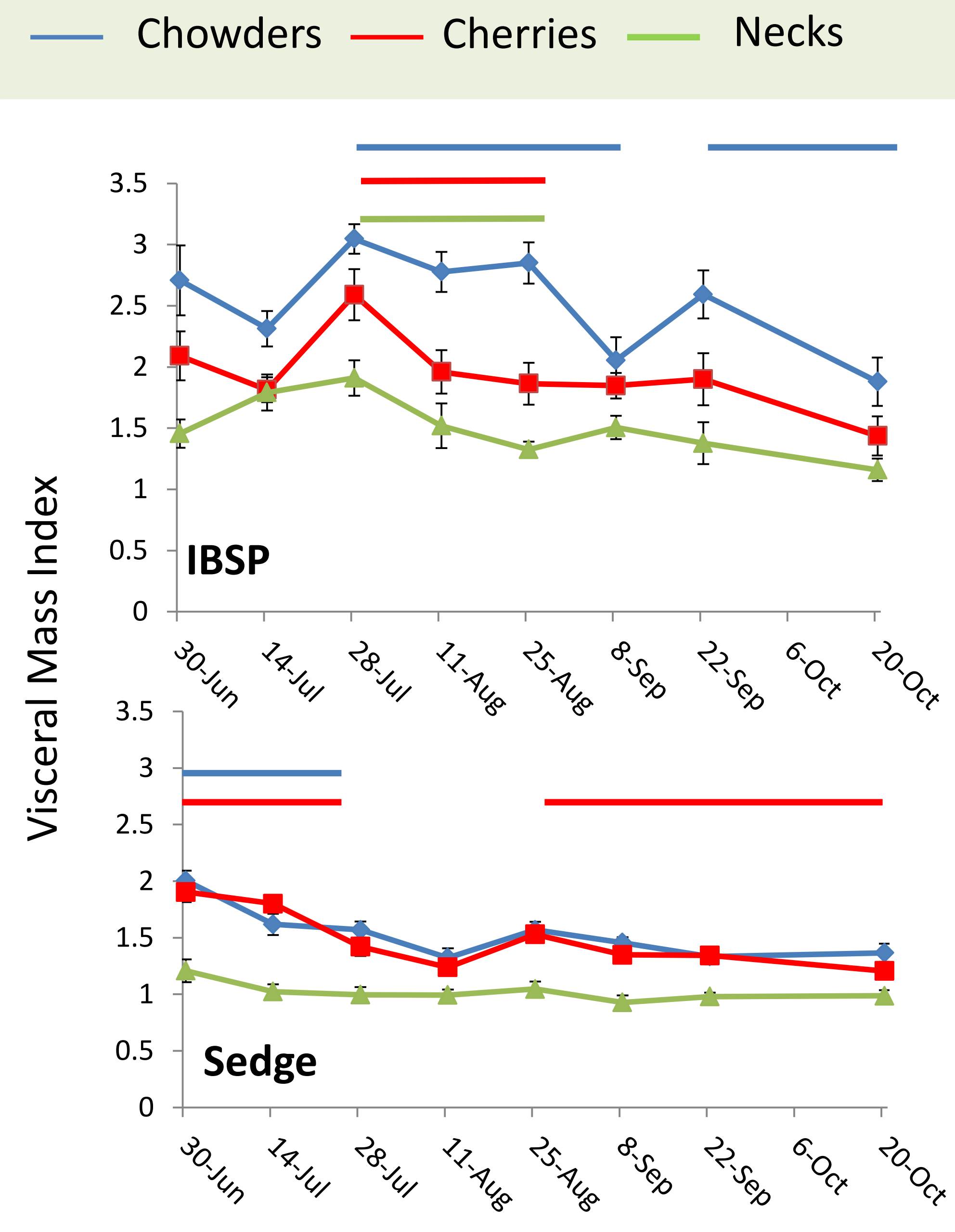




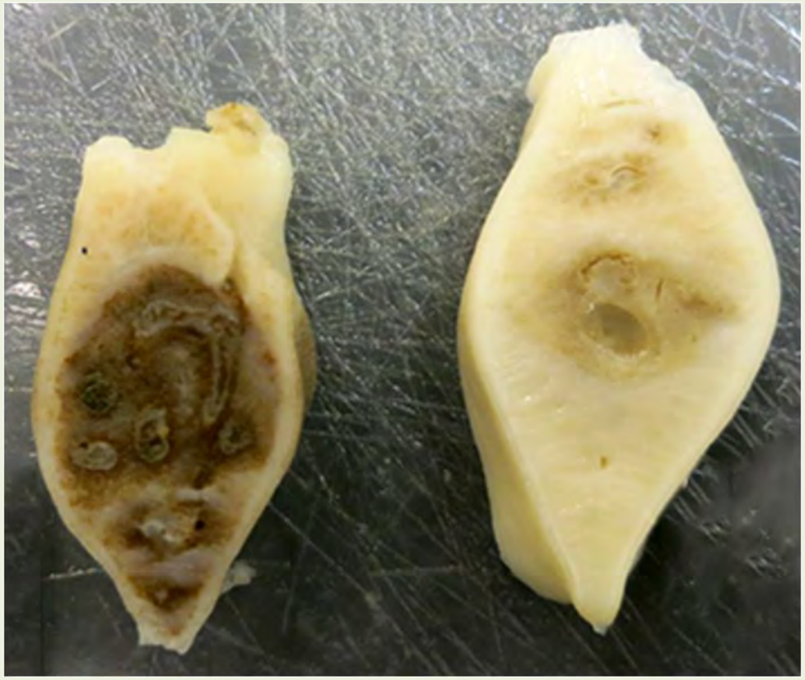
% gonadal tissue also determined microscopically

- Developed a new method to measure clam reproductive condition

Temporal changes in Visceral Mass Index (VMI)

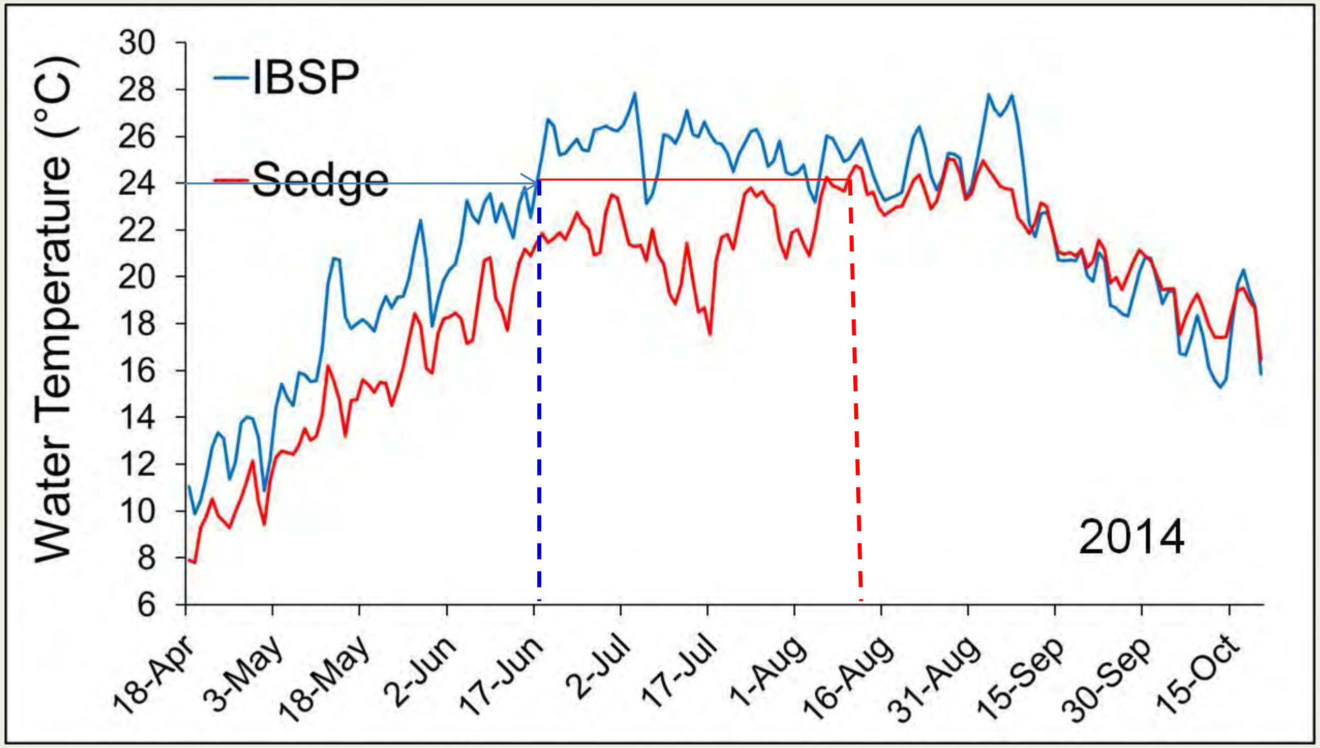


- VMI at IBSP >> Sedge
- VMI of necks << larger clams at both sites
- Drop in VMI, shown by horizontal bars (July 29-Sept 8) indicates spawning, that in Oct. likely gamete resorption
- Histology showed that necks spawned earlier than larger clams

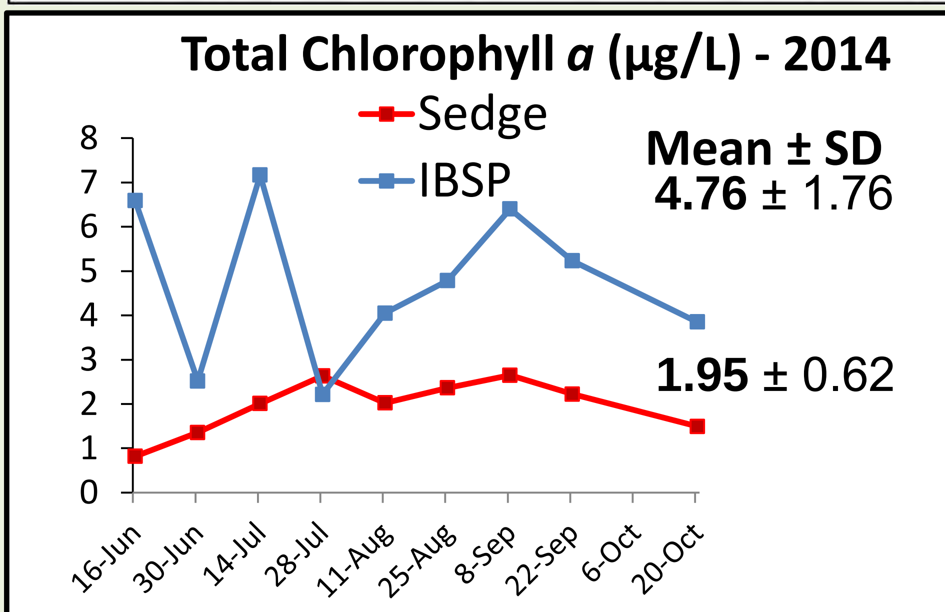


- Documented clams with grey viscera, mainly at Sedge & only in larger clams
- Up to 9% of large clams at any sampling date
- This condition affects market quality. The cause remains uncertain & requires further study

Temperature and food levels at the 2 study sites in 2014



- Minimum temperature for hard clam spawning = 24°C did not occur until mid August at Sedge



- Low food supply at Sedge in 2014 2.5x lower Chl *a* concentration than at IBSP

Conclusions

- Reproductive condition in 2014 significantly < at Sedge than at IBSP for all 3 adult clam size classes, yet Sedge supported good to moderate growth of juveniles in 2012-2103

- Necks made a limited contribution to reproduction. They also spawned at a different and narrower window of time than larger clams

- Adult clams showed relatively high cumulative mortalities at both sites: up to 7.1% for cherries & 6.0% for necks over ~4.5 months

Is poor reproduction at Sedge Is. a common, annual occurrence? Does it occur throughout the MCZ? This may affect use of this area as a potential broodstock sanctuary

In 2014 it may have been caused by particularly low food levels & the characteristic temperature regime of this site (low temp., high fluctuations)

Acknowledgements

- Jeffrey Silady, ReClam the Bay
- Lisa Izzo, Shaila Huq, Romi Patel, Jennifer Tomko, Rutgers University
- Conor MacDonnell, College of William & Mary, VA
- Larry Murphy (waterfront access at Harvey Cedars)
- Staff at the IBSP Forked River Interpretive Center
- Staff at the Sedge Is. Education Center – Jim Merritt

Funding from NJDEP, Barnegat Bay Partnership & NSF

Characterization of Gelatinous Zooplankton

Paul Bologna, John Gaynor, Robert Meredith

Department of Biology

Montclair State University

Background on 'Jellyfish' Species

- We have 'True Jellyfish', Siphonophores, and Comb Jellies
- True Jellyfish and Siphonophores have Stinging Cells
- Comb Jellies do not

- All are Vicious and Voracious Predators
  - Fish and Fish Larvae
  - Crab Larvae
  - Clam Larvae

True Jellyfish



- Sea Nettle
- Moon Jellyfish
- Lion’s Mane
- *Obelia*
- Mushroom Jelly
- *Aequora*
- Box Jellyfish

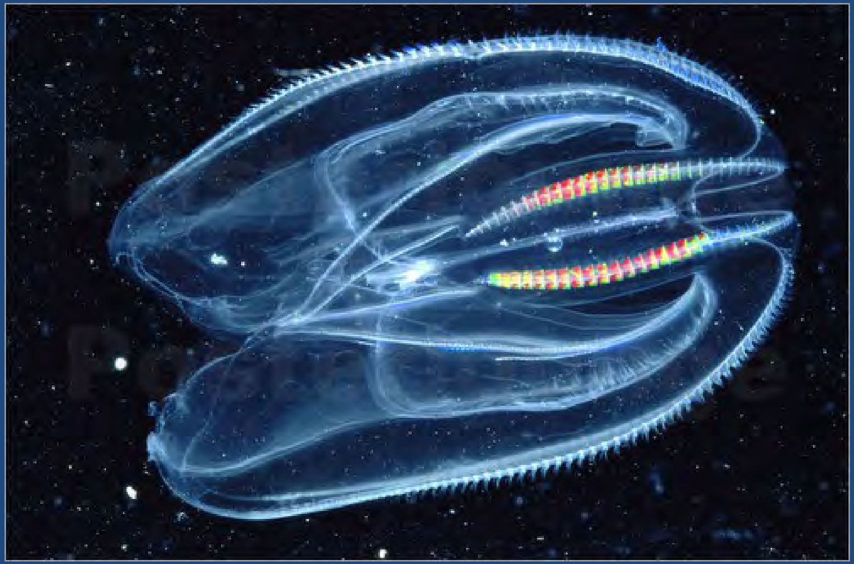


Siphonophores
aka Portuguese Man-of-War

Colonial Organism:
Cloned individuals work together to make the whole

Comb Jellies (Ctenophores)

- **Don't have Stinging Cells**
- **Some are Bioluminescent**
- **Sea Walnuts (*Mnemiopsis*)**
- **Sea Gooseberry**



Salps

- Lower Chordates
- Asexually Bud to create a Colony (not colonial!)
- Off-shore

http://www.thecollectiveint.com/2013/02/sea-salps.html

Rise in jellyfish swarms hints at oceans' decline

By ELISABETH ROSENTHAL
The New York Times

Fact Checks

- Simple Organisms
- High physiological tolerance
- Venomous
- Voracious Predators
- Introduced Accidentally throughout the world

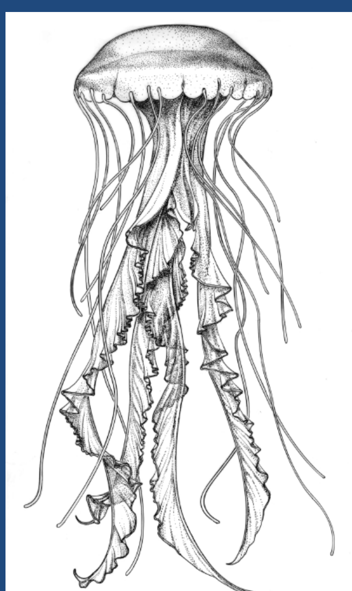
http://www.thedailymarvel.com/1/post/2012/04/scientists-say-global-jellyfish-numbers-on-the-rise.html

What Role to Jellyfish Play?

Predators

Competitors

Nutrient and Carbon recyclers and sinks

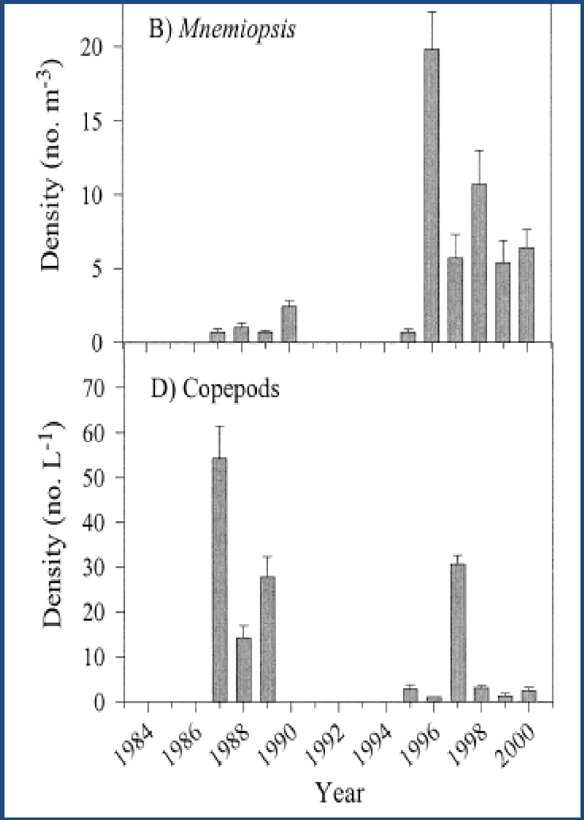


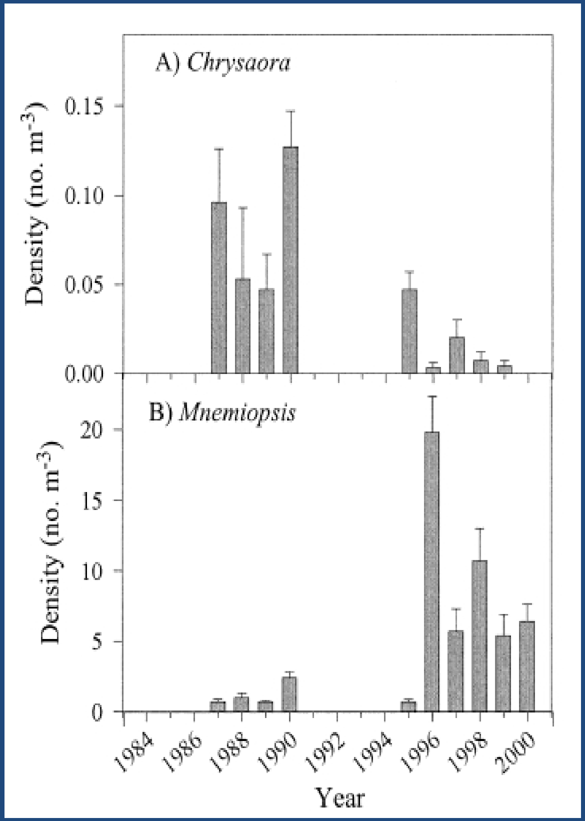
Research Questions

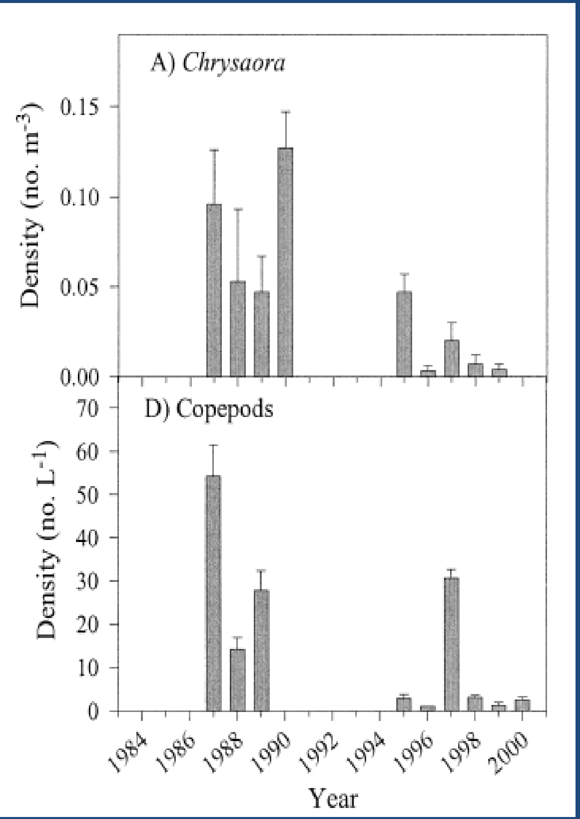
- Density of 'Jellyfish' in Barnegat Bay
- Types of Jellyfish in the Bay
- Spatial Distribution Patterns
- Monthly Distribution Patterns
- Where do Sea Nettles Settle

What Role might Sea Nettles Play?

Chesapeake Bay
Nettles are top GZ predators





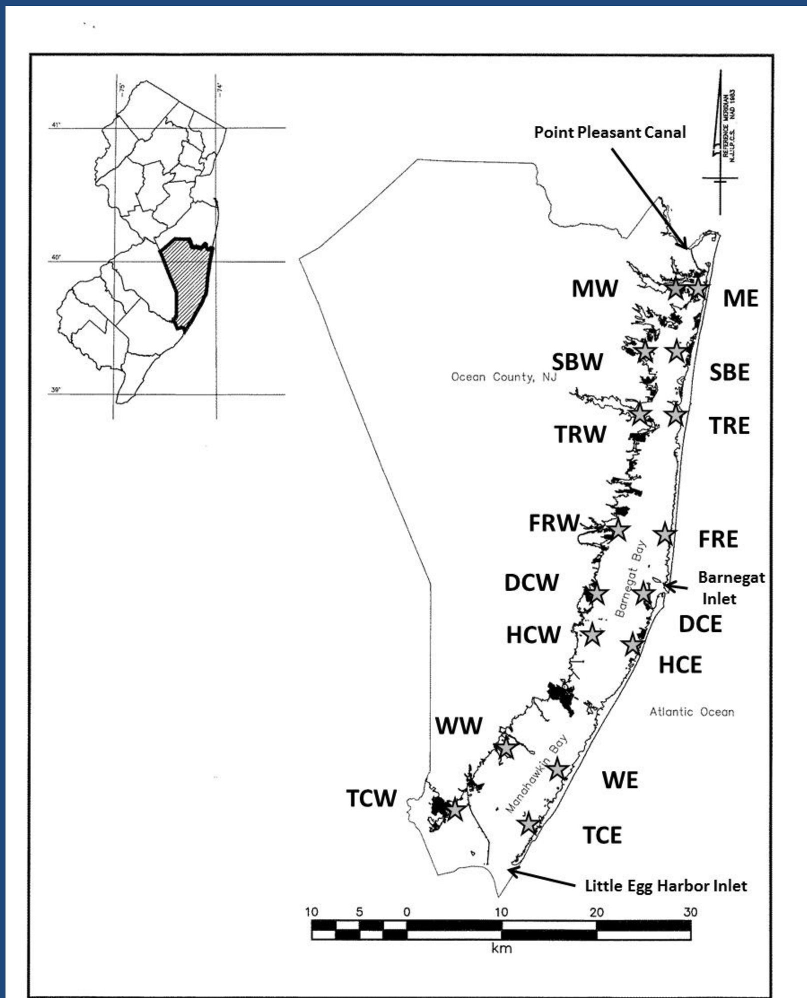


(Purcell & Decker, Limnol. Oceanogr., 50(1), 2005, 376–387)

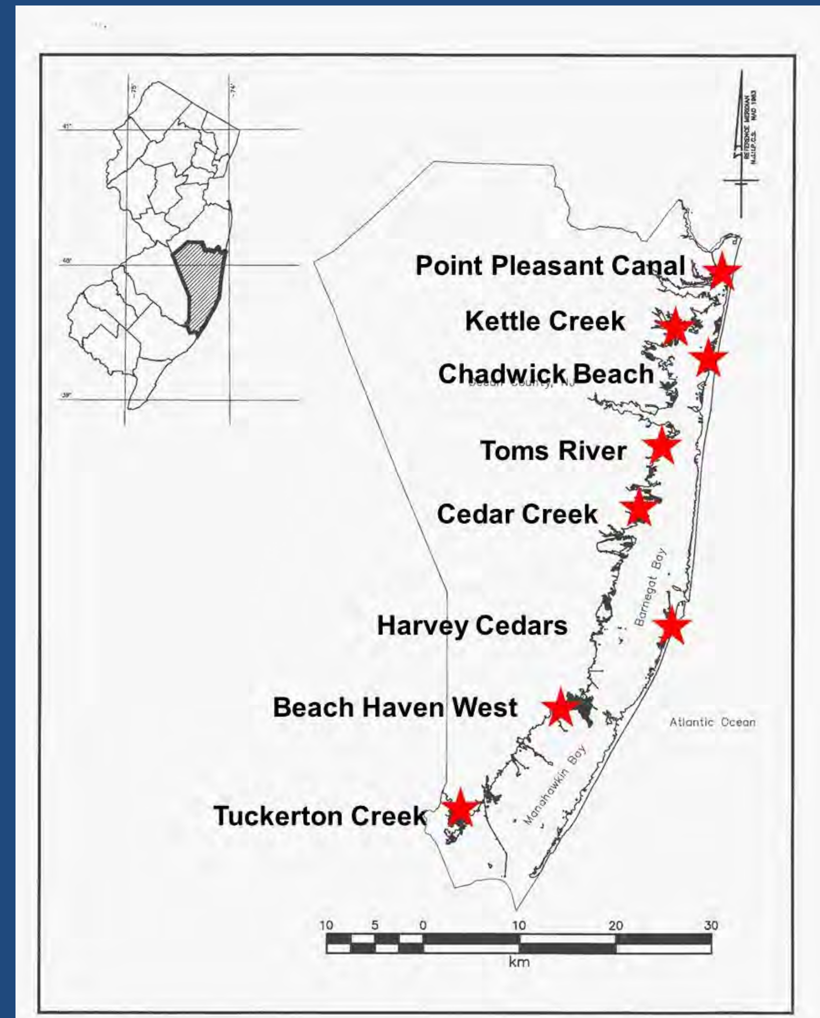
Top-down Control and Trophic Cascades

ZOOPLANKTON

Past Spatial and Temporal Distribution

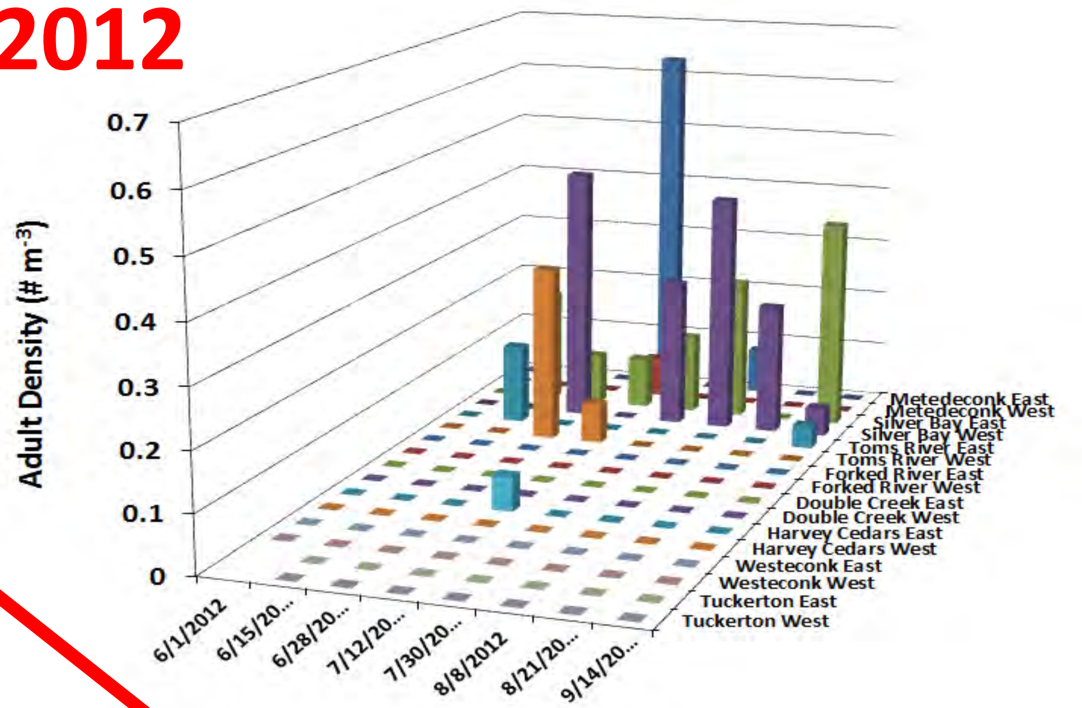


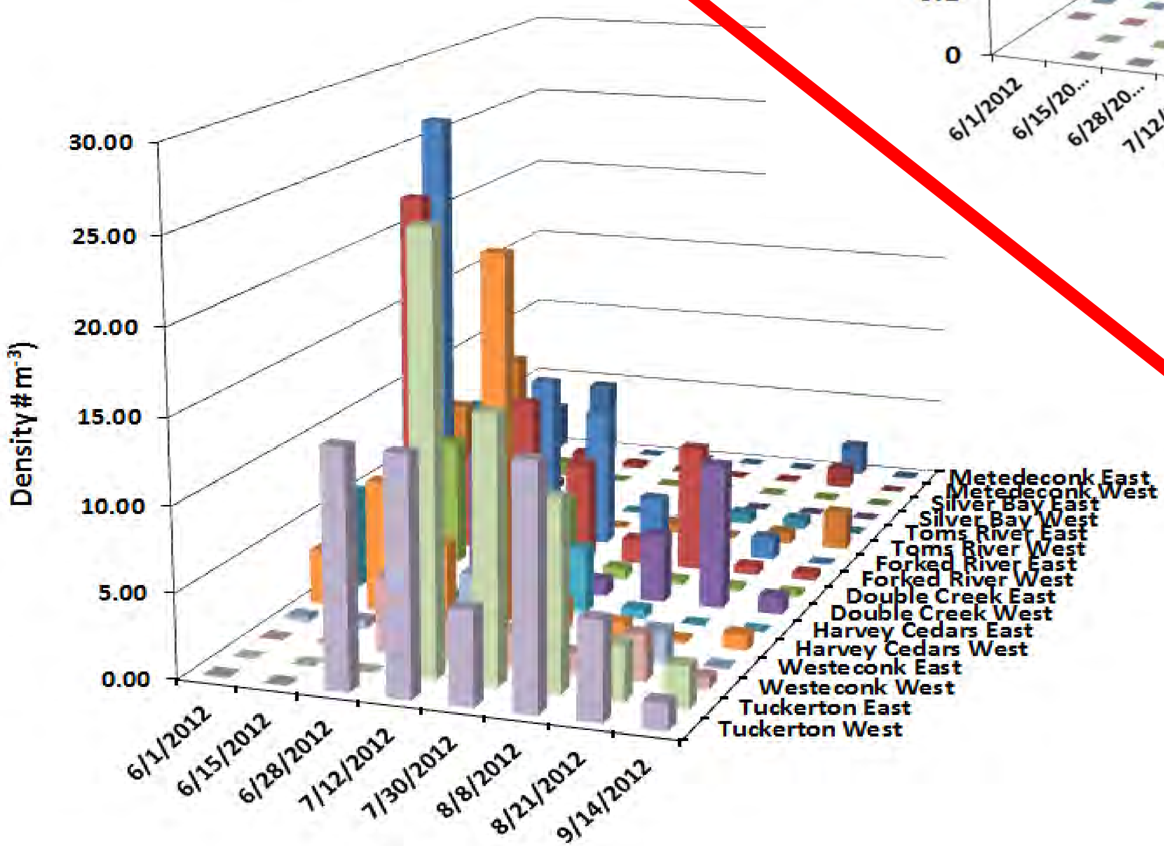
Bay Wide Sampling Stations



Lagoon Sampling Stations

2012





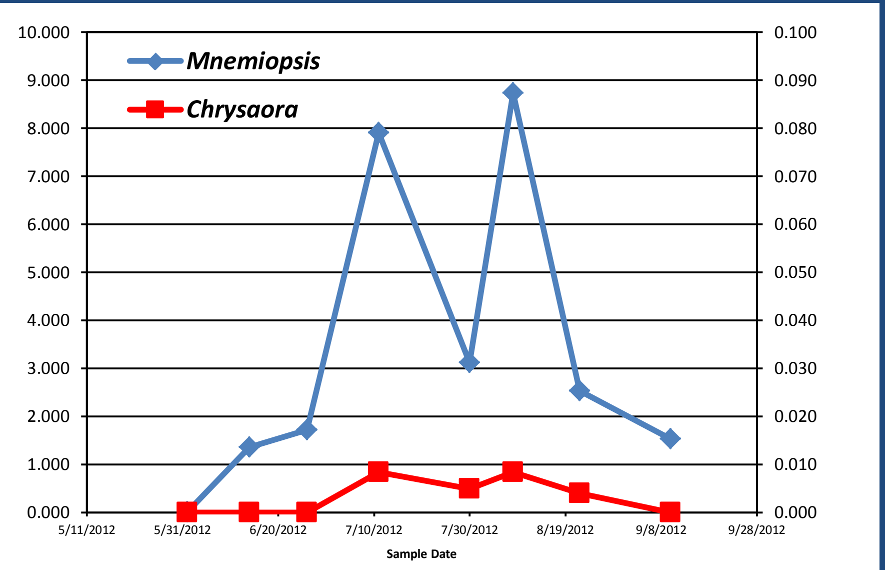
Significant disjoint populations

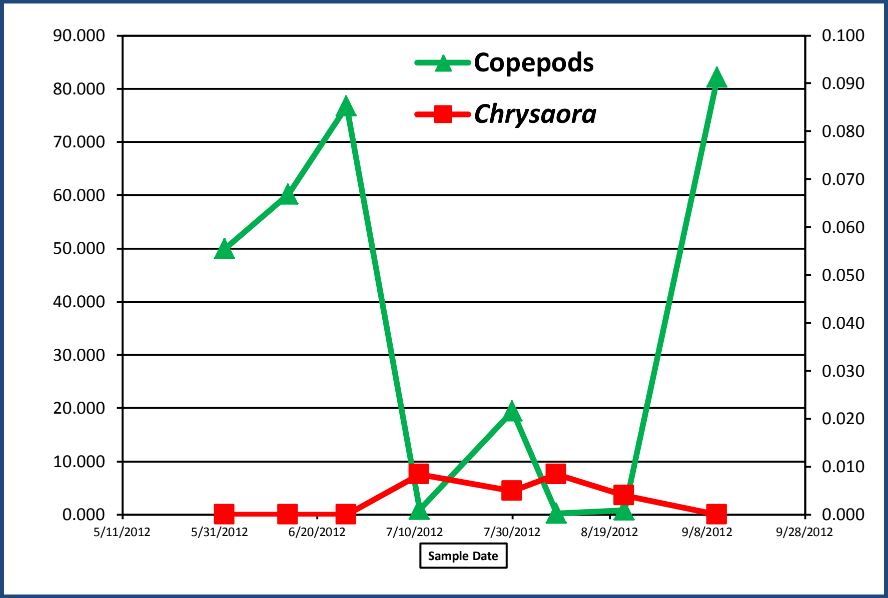
Food Web Impacts

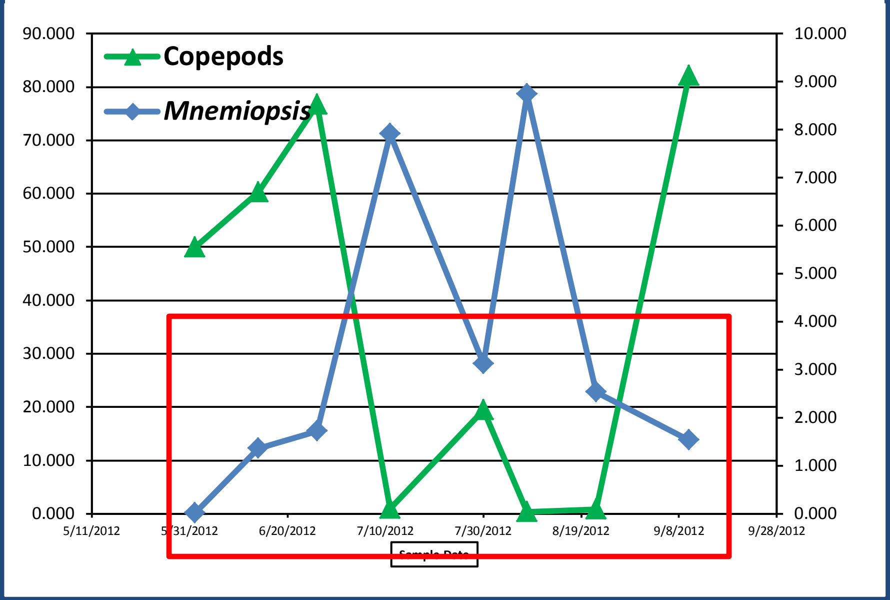
Southern Barnegat Bay

Sea Nettles ‘absent’
No Top-down impacts on *Mnemiopsis*

***Mnemiopsis* directly impacts copepod densities → Top-down predation**







Food Web Impacts

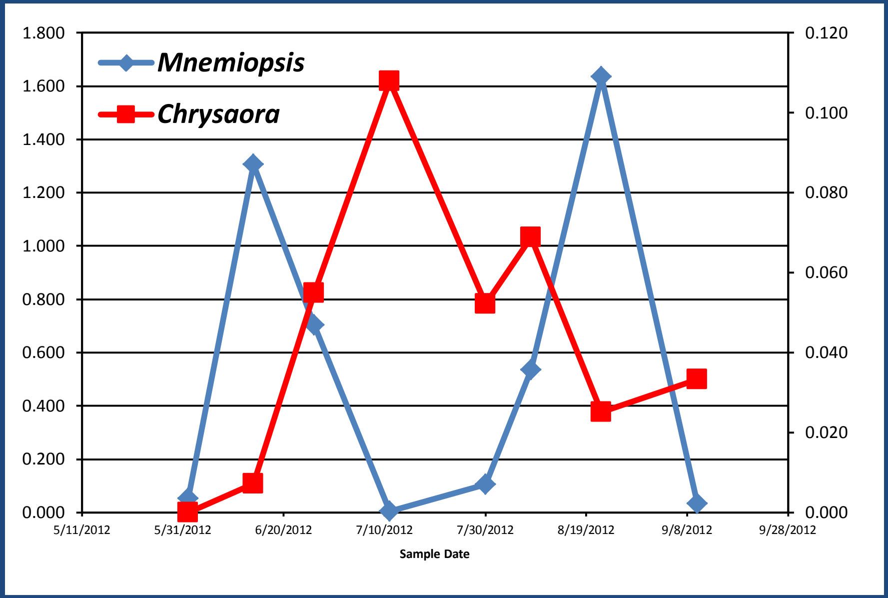
Sea Nettles 'abundant'

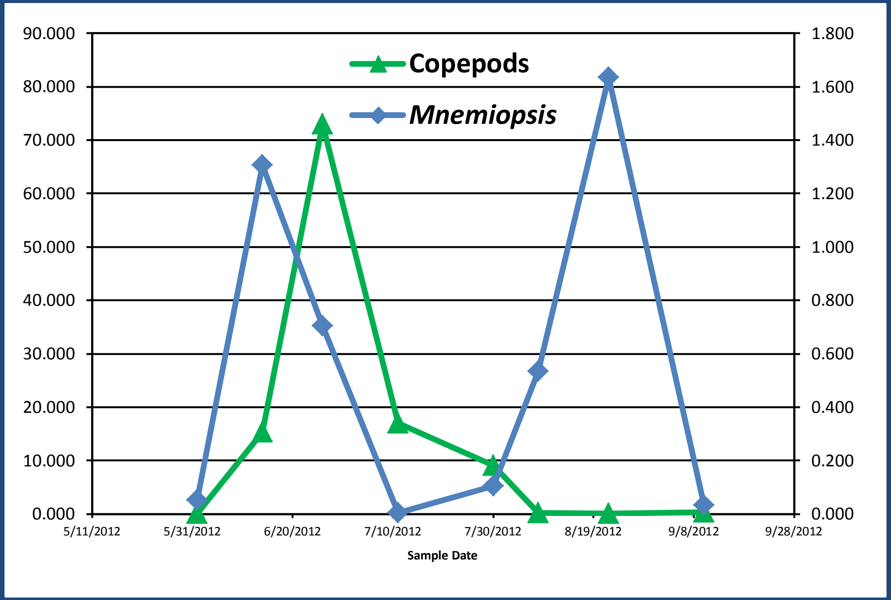
Top-down impacts on *Mnemiopsis*

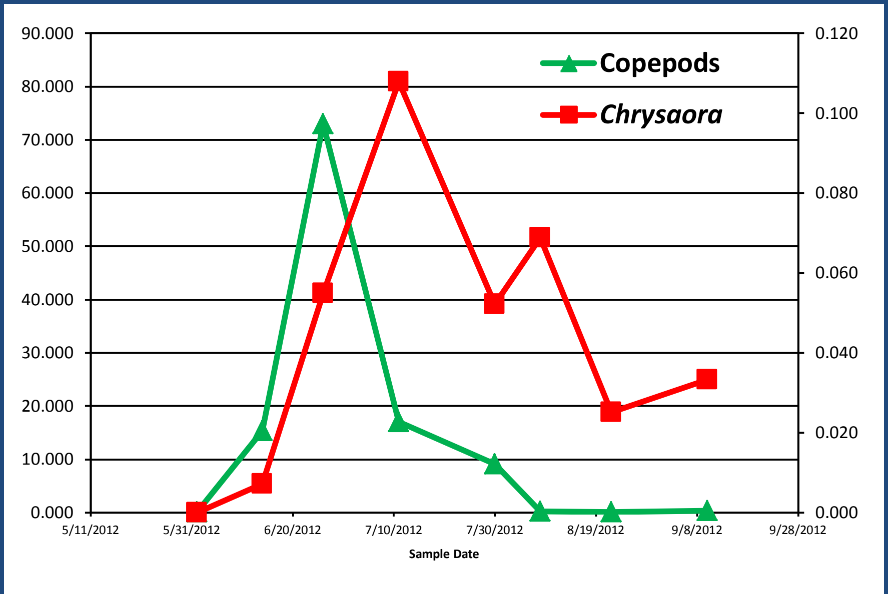
***Mnemiopsis* no impacts copepod densities, but**

***Chrysaora* → top-down pressure on copepods**

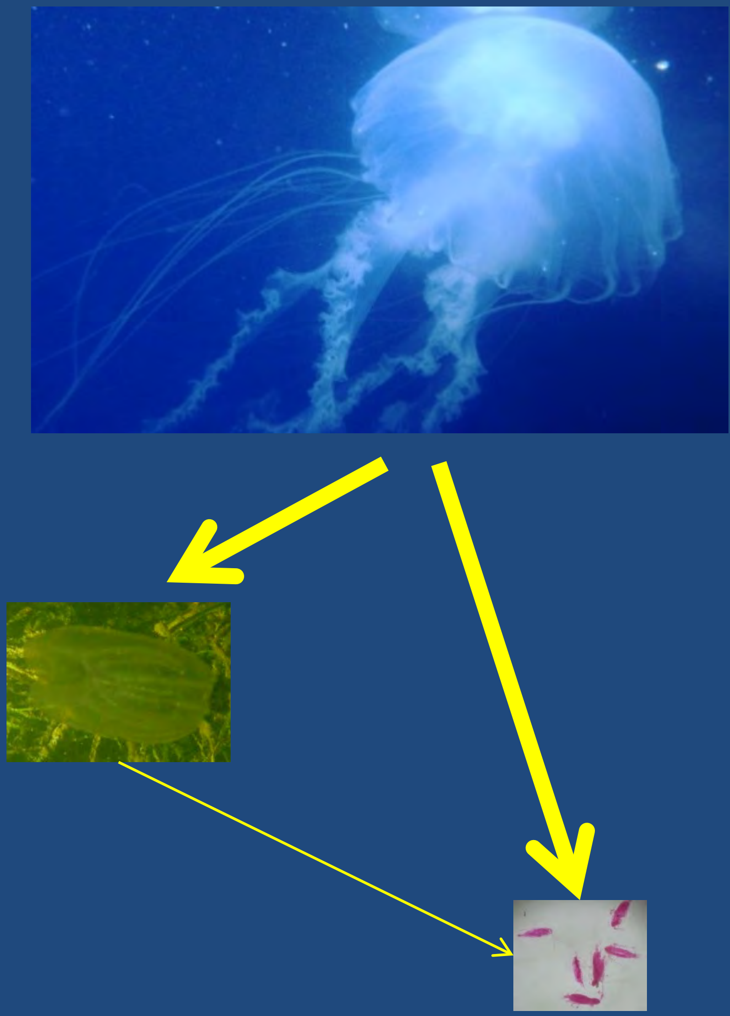
Northern Barnegat Bay

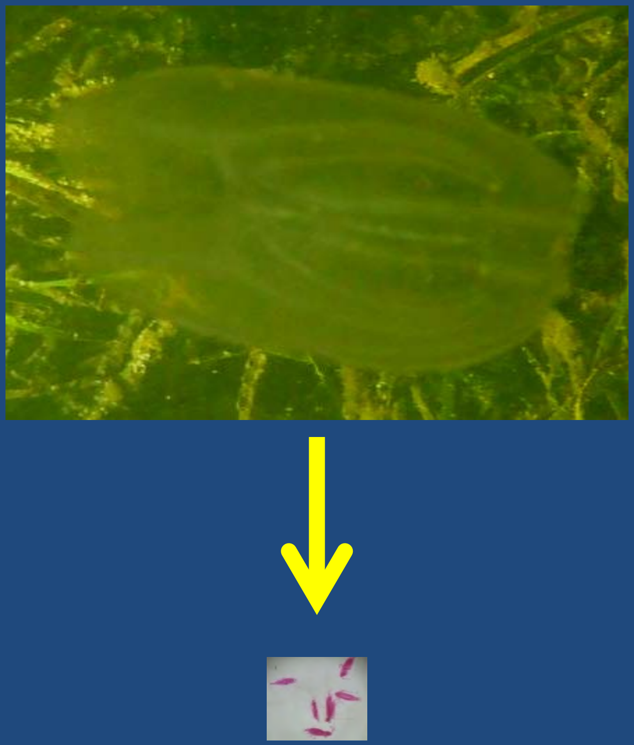






Top-down Control, but no Trophic Cascades

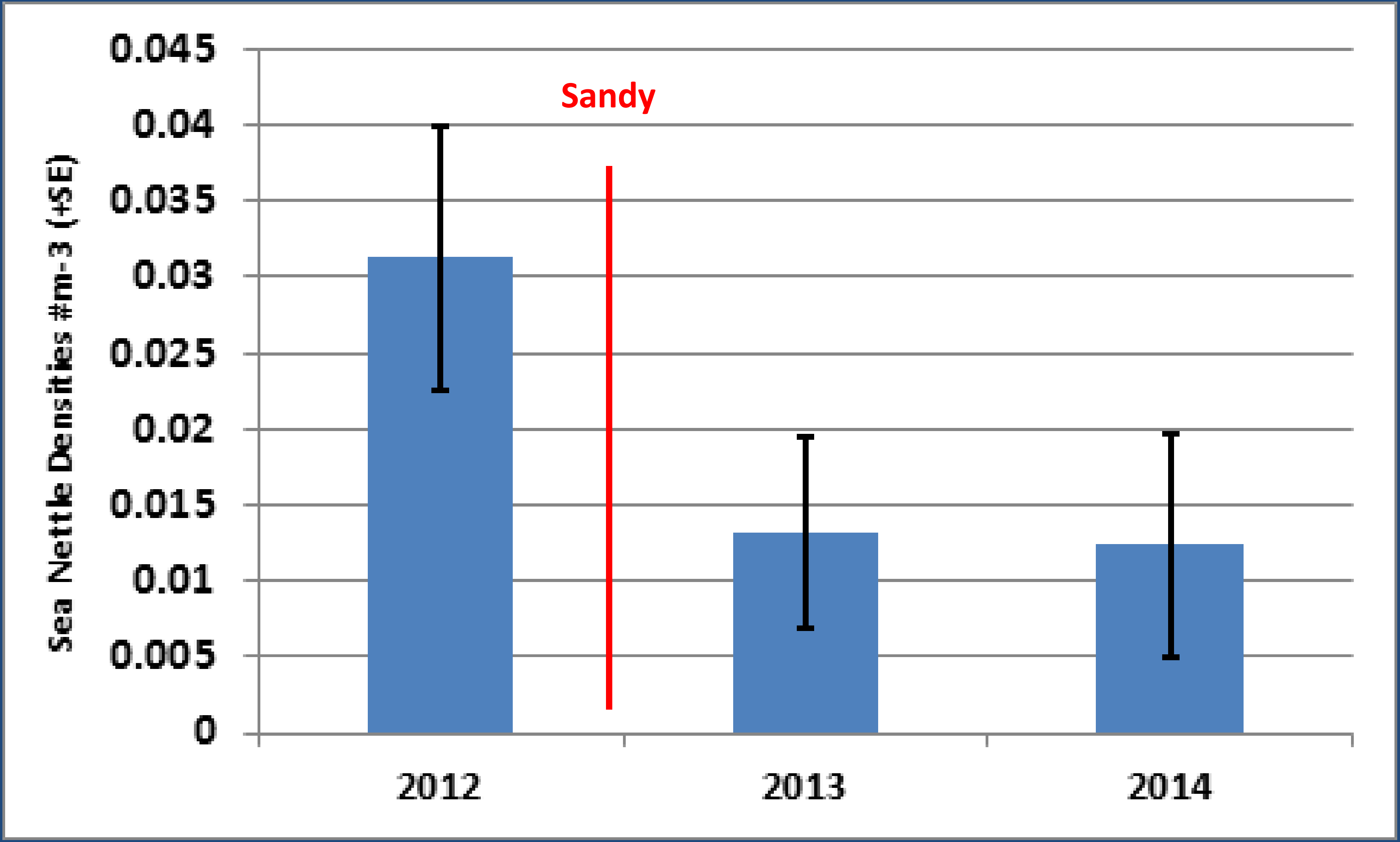




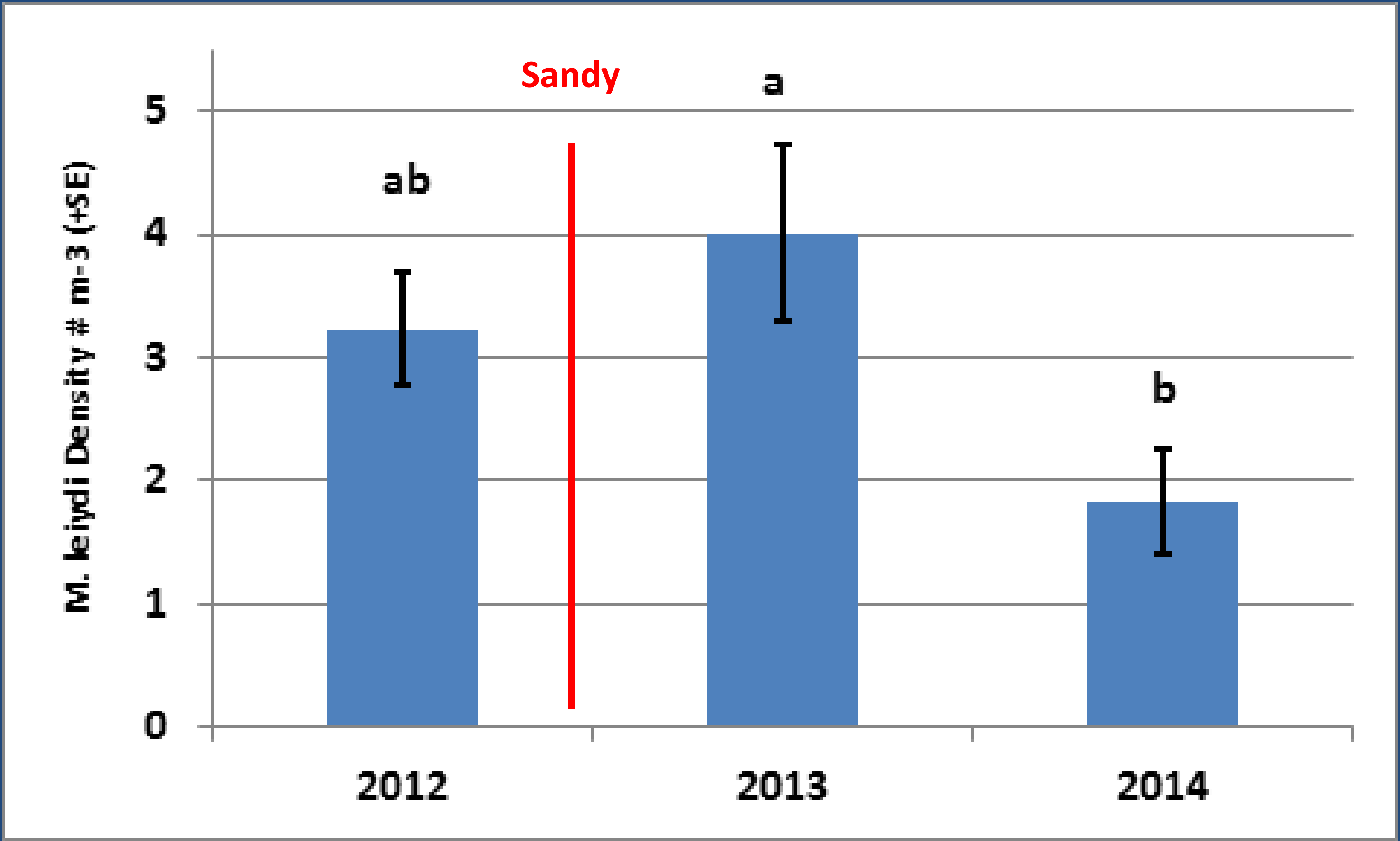
ZOOPLANKTON

Changes in Communities due to Sandy

Sea Nettle Density

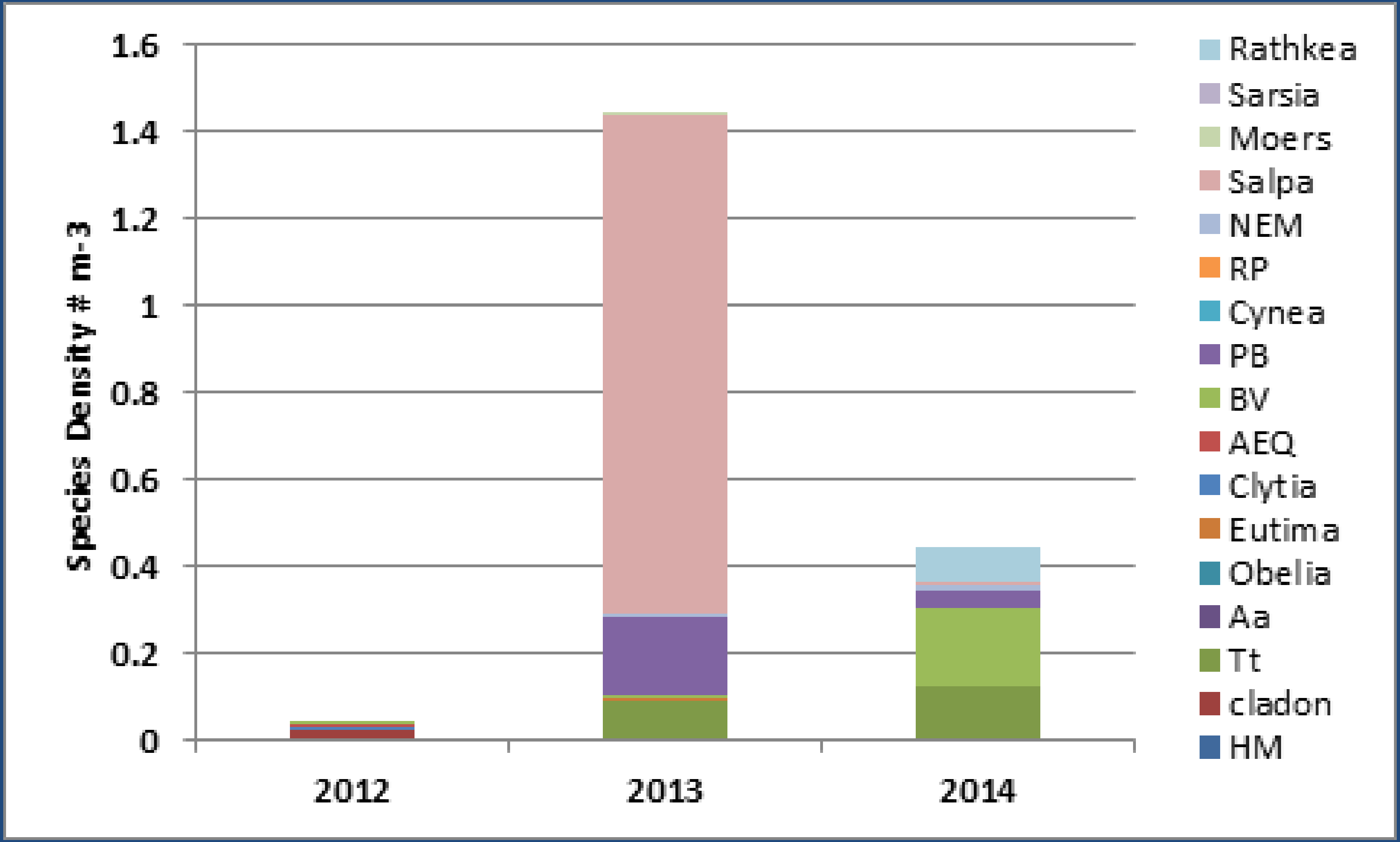


Sea Walnut Density

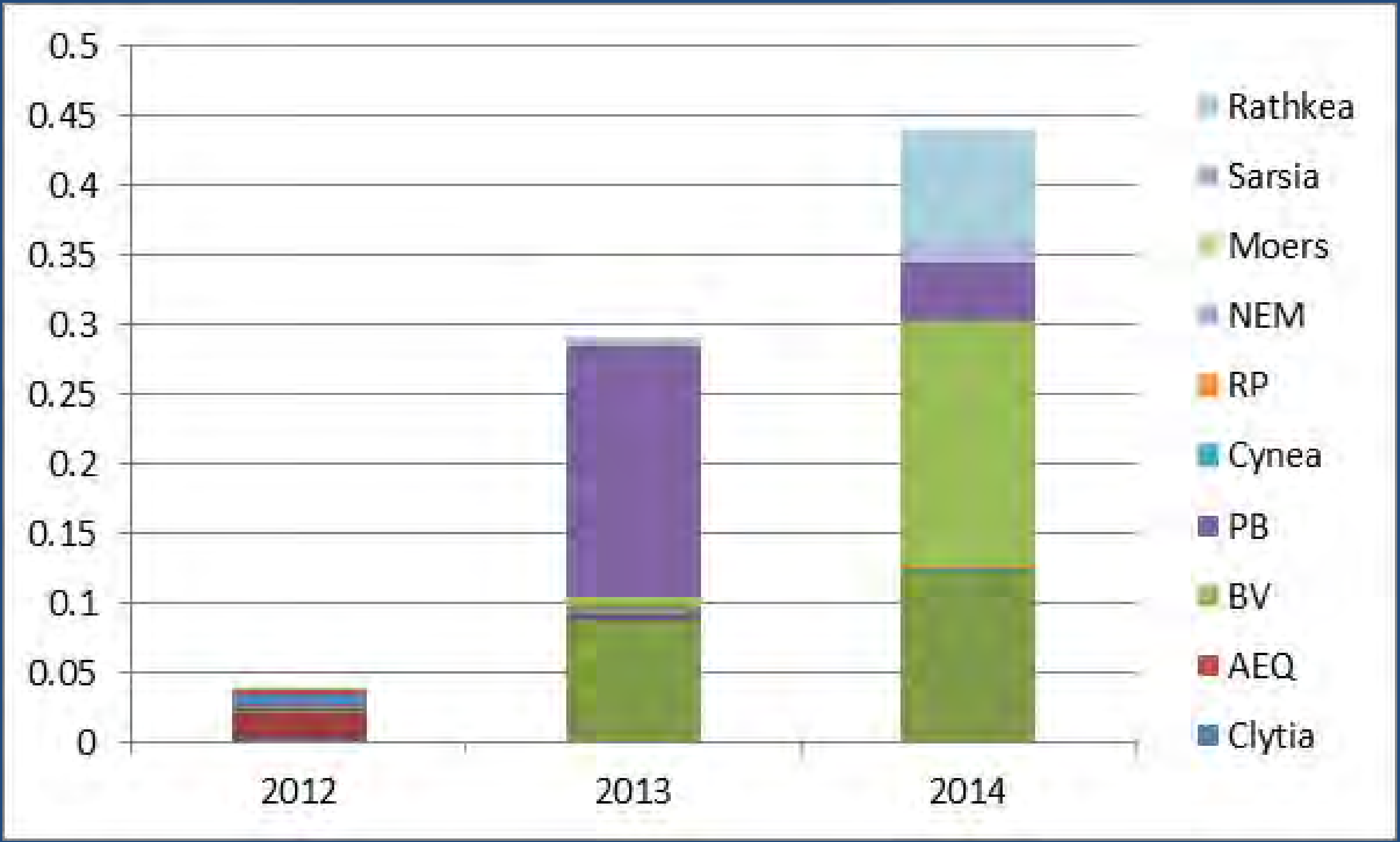


Sea Nettles have little impact post Sandy

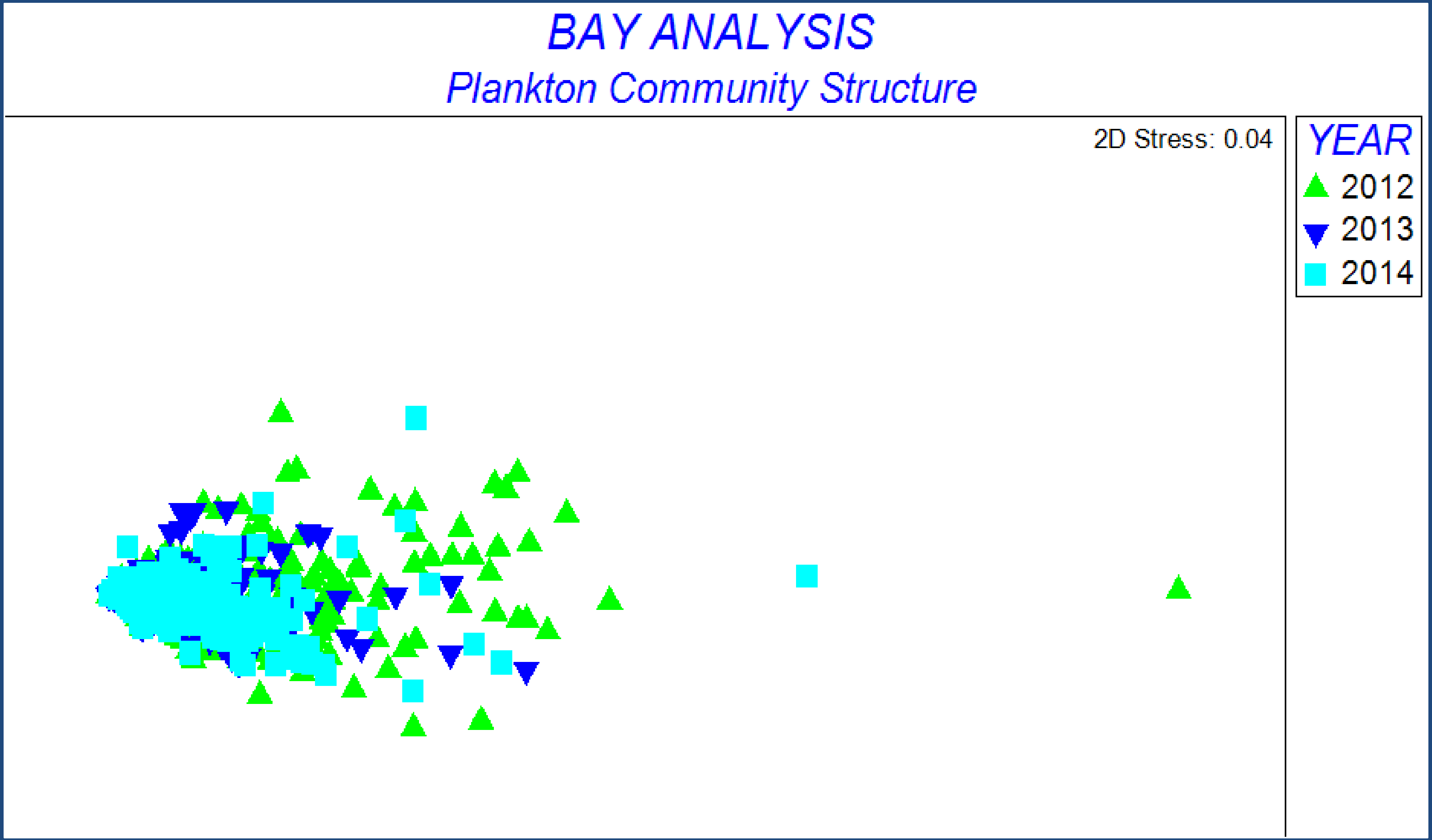
Change in Other Jellyfish Densities



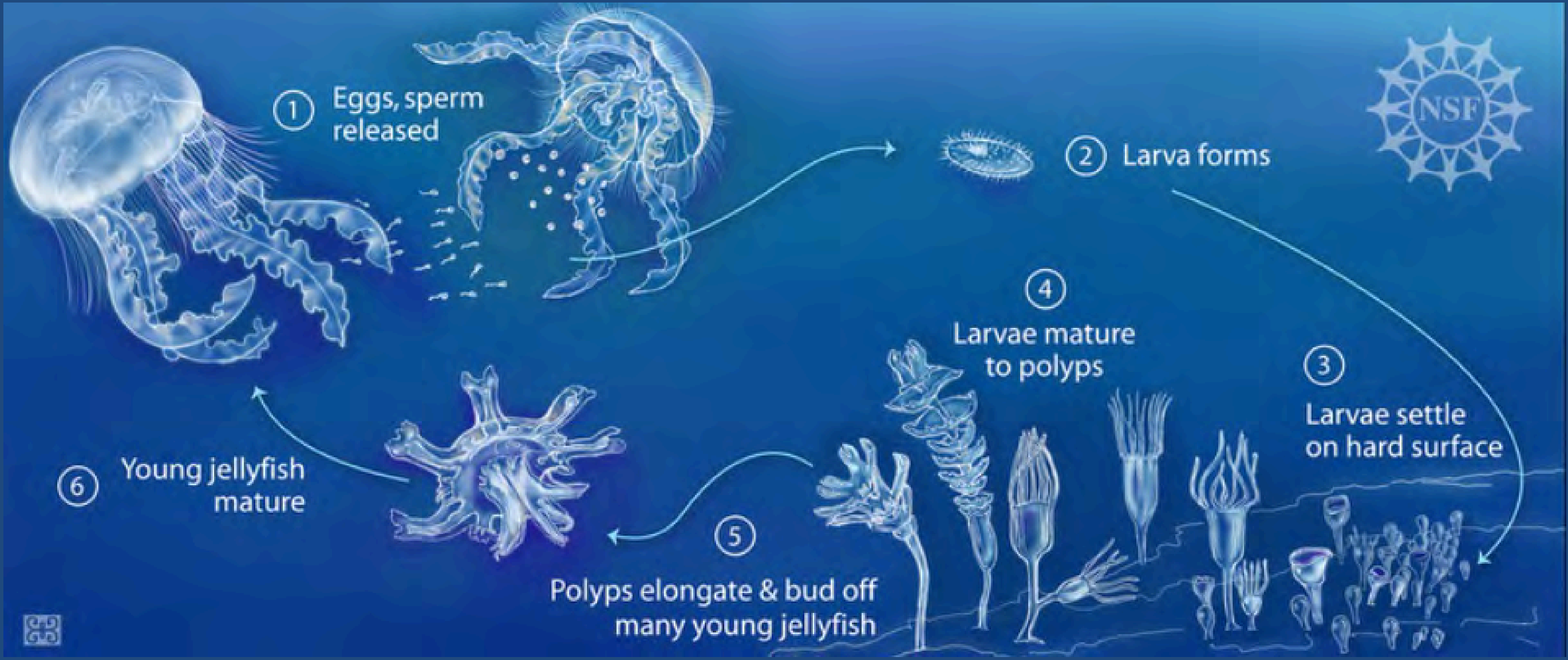
Change in Other Jellyfish Densities
Salps Removed



Overall Pelagic Community Structure Pre-Sandy differs from Post-Sandy



Assessing Settlement of Polyps



Settlement Requires Hard Substrates
Jellyfish survive in poor water quality

Shoreline Modification

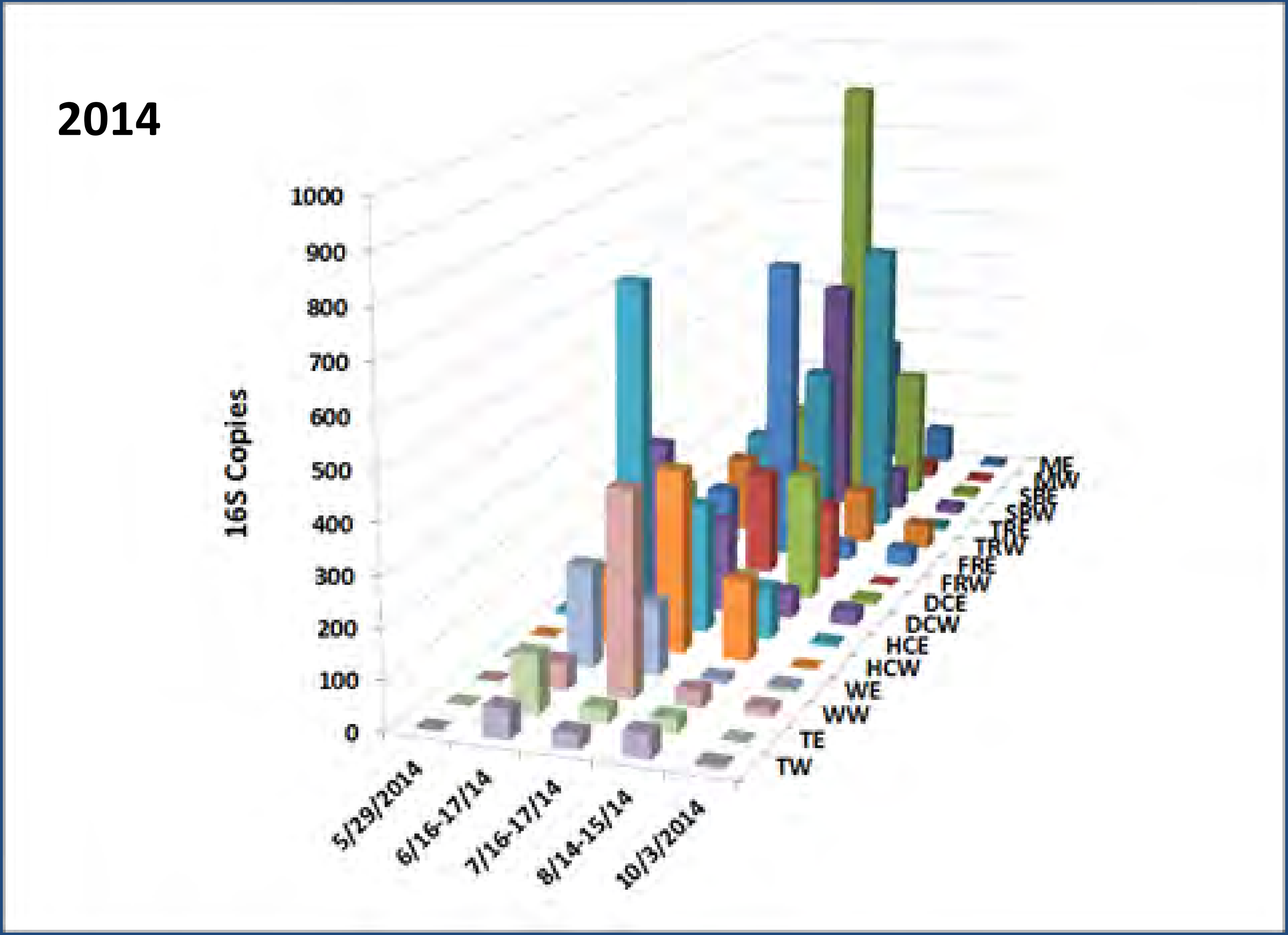
Lagoon Communities

- Restricted Tidal Flow
- Storm Water Run-off
- Hard Substrates
    - Docks, Bulkheads, etc…
- Replacing toxic materials with ‘green’ building materials

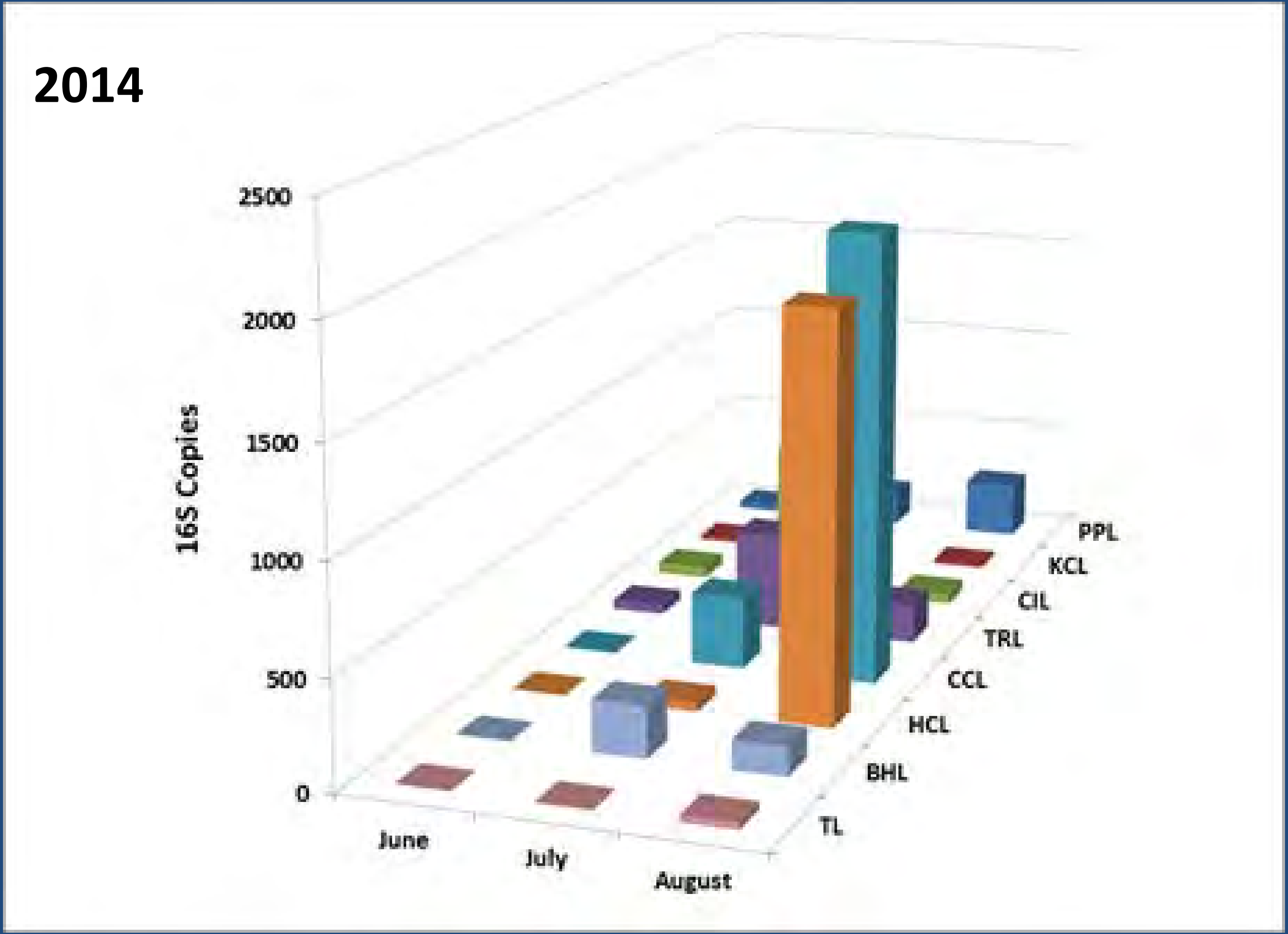
- Increases Settlement Habitat with limited ‘competition’

- Jellyfish polyps win by default

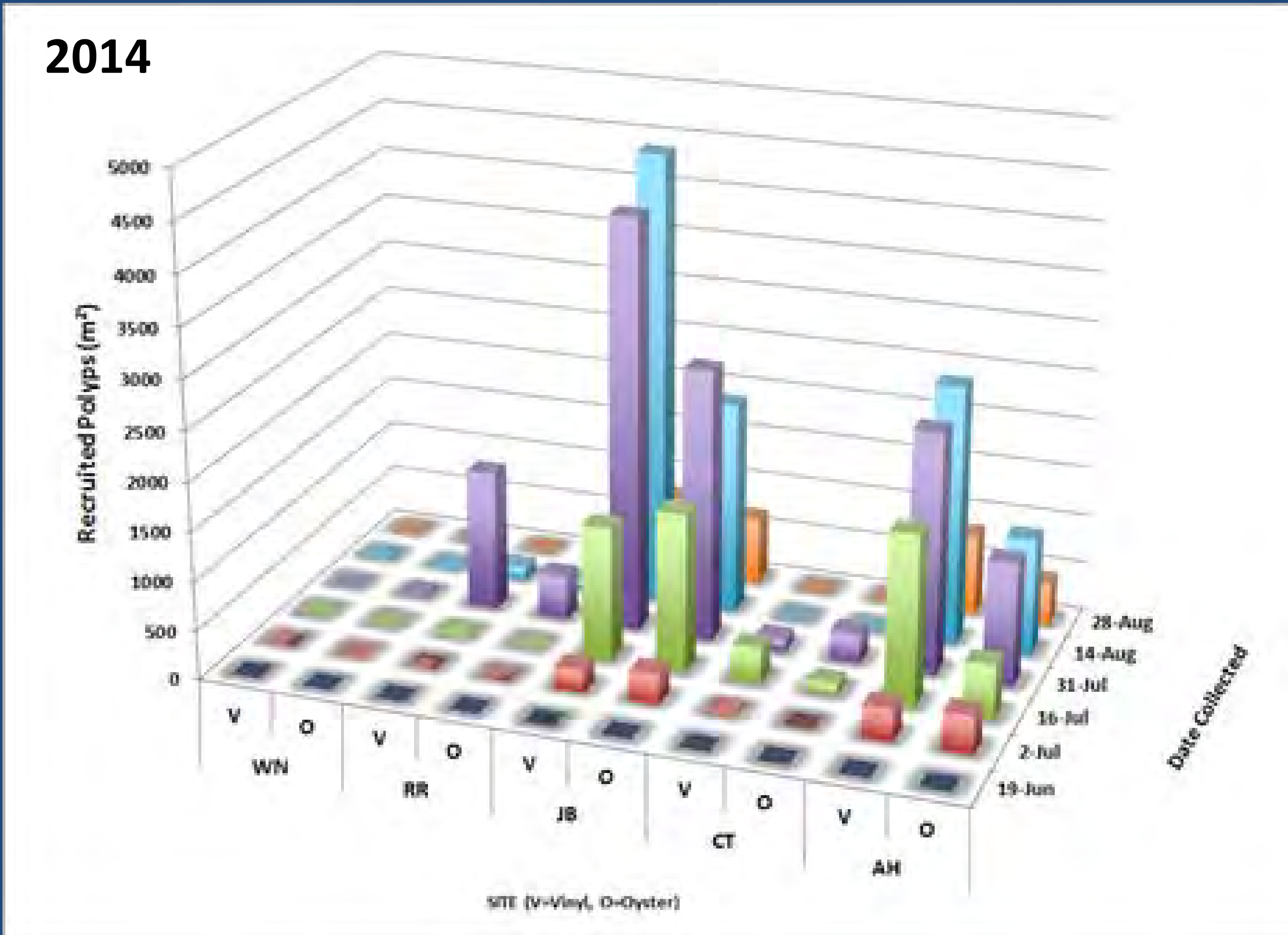
Tracking Larval Sea Nettle DNA in the Bay



Tracking Larval Sea Nettle DNA in Lagoons



Tracking Settling Polyps



Houston, we don't have a jellyfish problem, we have a polyp problem

http://jellieszone.com/scyphomedusae/

Sandy Impacts

- Destroyed Sea Nettle Polyp habitat
  – Docks, bulkheads, etc…
- Sea Walnuts Increase
- Jellyfish Diversity Increased
- Pelagic Community Structure Changed

- So, what does the future hold?
- Address and Manage the polyp populations

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Acknowledgements

Christie Castellano, Dena Restaino, Marco Finocchiaro, George Shchegolev, Victoria Lussier, Meghan Prahdt, Brian Neilan, Steve Connolly, Weston Scholars

Sea Nettles
Montclair State University

Questions?

BASELINE CHARACTERIZATION OF ZOOPLANKTON IN BARNEGAT BAY

James Nickels and Ursula Howson

Supported by New Jersey Department of Environmental Protection

Zooplankton

- Near base of estuarine food web
  - Grazers and predators
- Most microscopic
- Motile not mobile
- Bloom patterns
- Holoplankton and meroplankton

- Holoplanktonic Zooplankton

Comb jelly

Copepod

Cladocerans

- Meroplanktonic Zooplankton

Crab zoea

Bivalve veliger

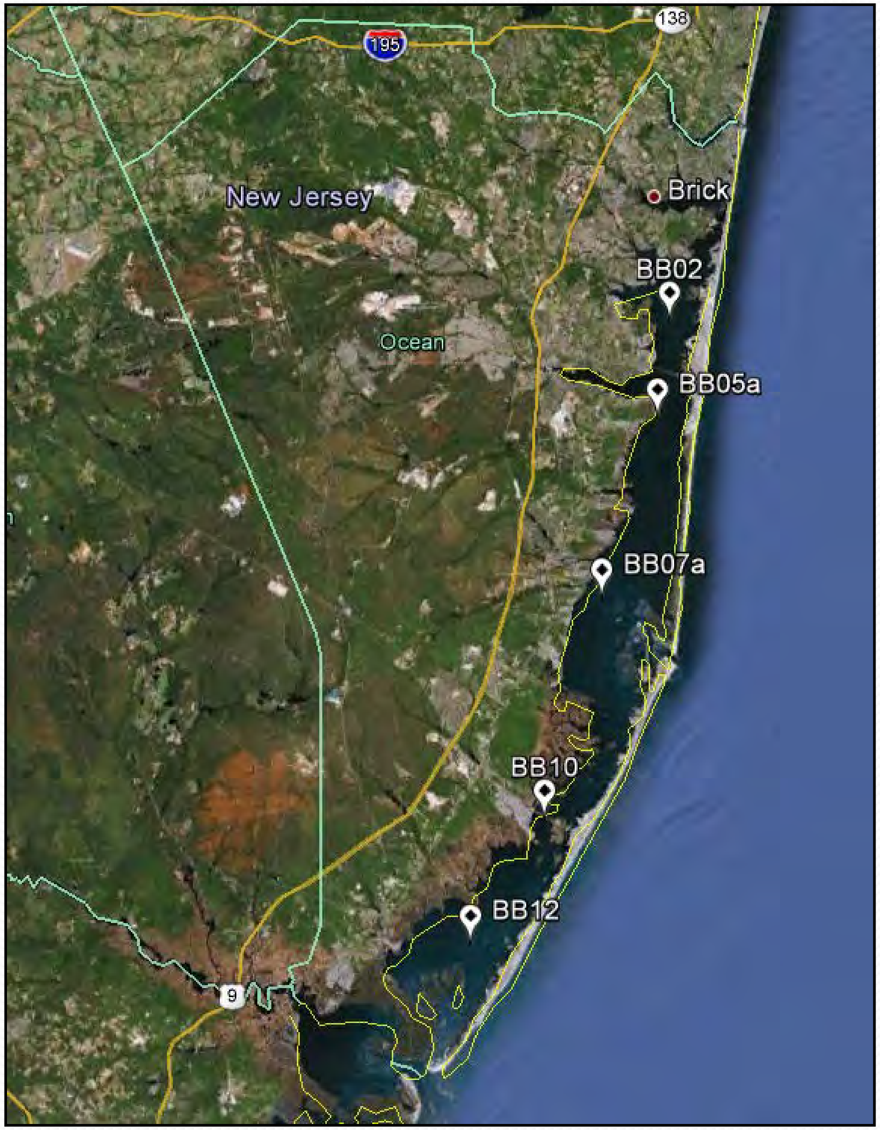
Winter flounder larva

Goals

- Characterize zooplankton distribution and abundance
  - Spatially and temporally
- Correlate zooplankton community w/ water quality data
- Quantify gelatinous macrozooplankton – target species
  - Additional – ichthyoplankton (distribution, abundance, aging with otoliths)

Methods

- Sites selected based on water quality parameters
- Bongo net – surface tows
  - Paired 200 µ samples
  - Paired 500 µ samples
- 24 hour intensive sampling

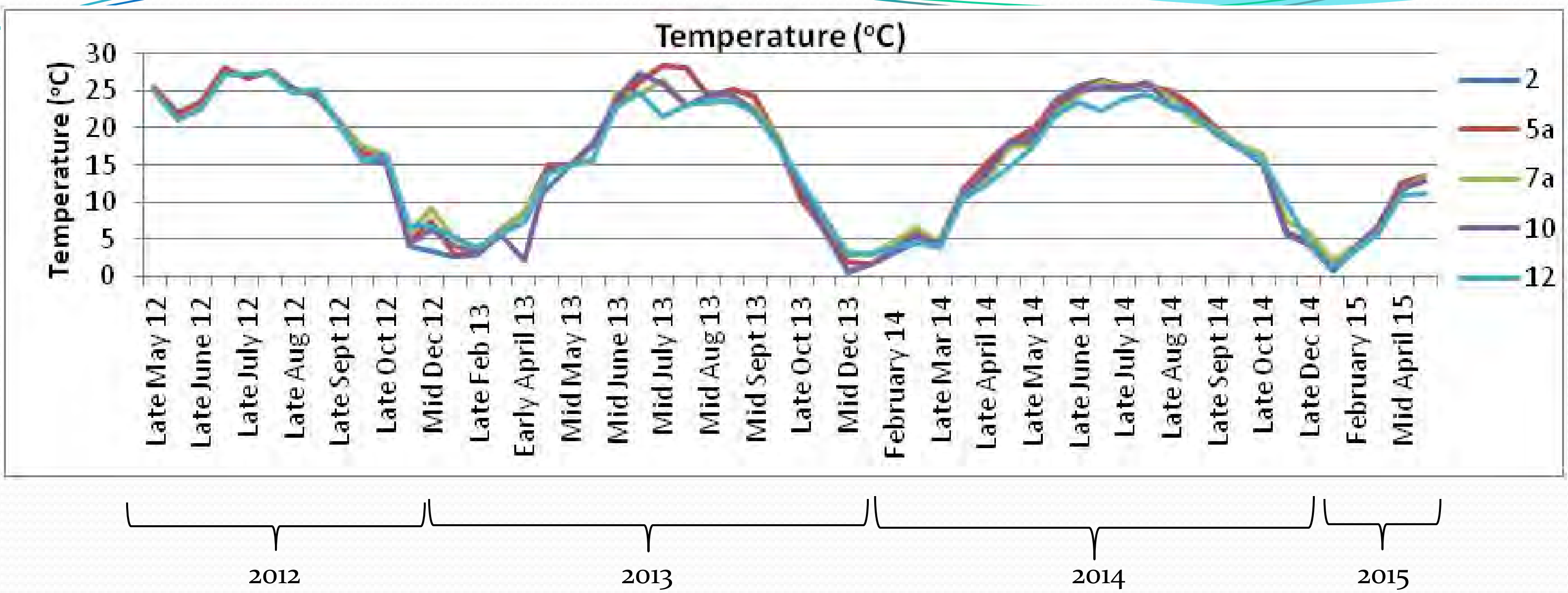


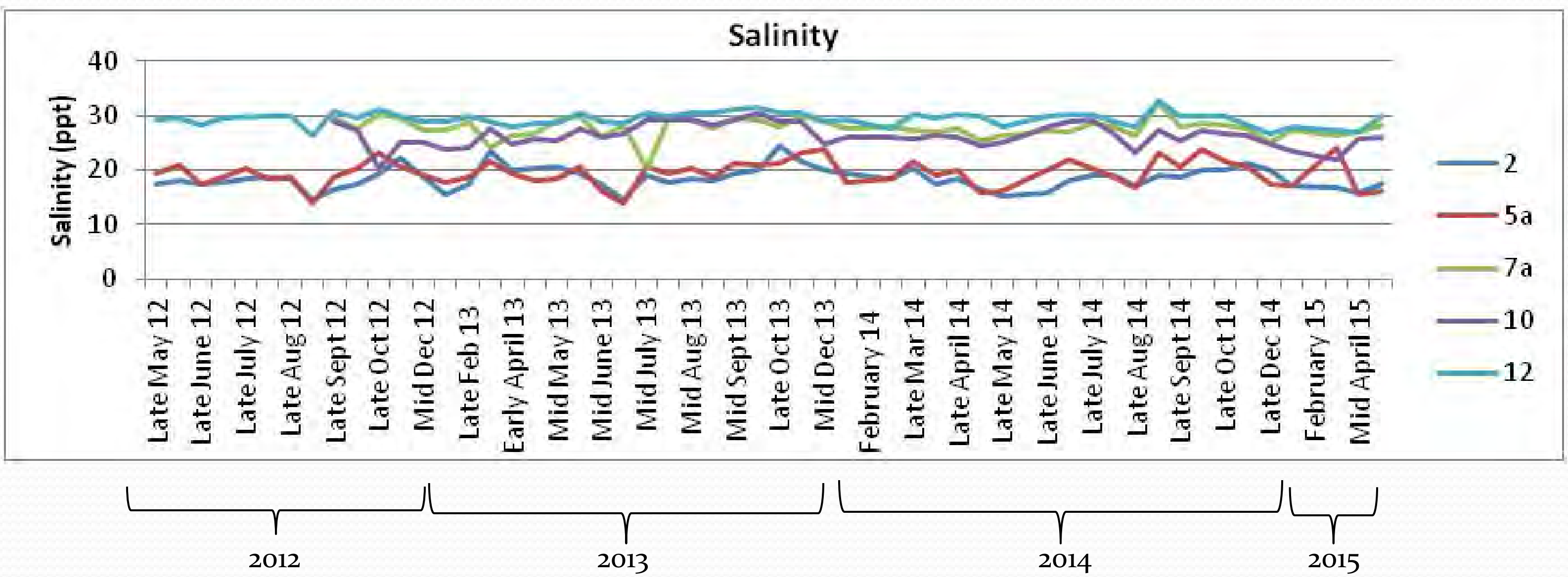
5 sites: BB02, 5a, 7a, 10, 12

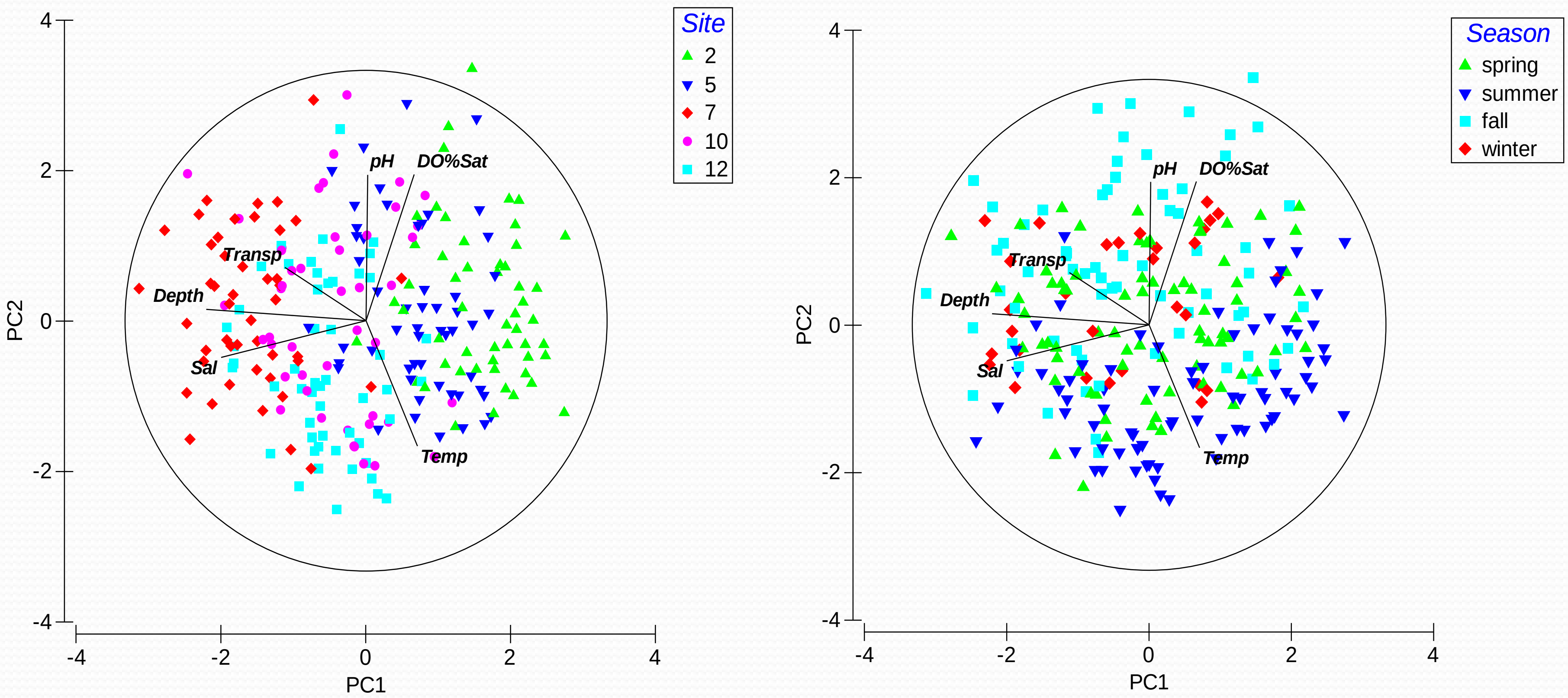
Results

- May 2012 – April 2015
- 54 sampling events
- Four 24 hr intensives at BB05a
- Collected >1000 plankton samples

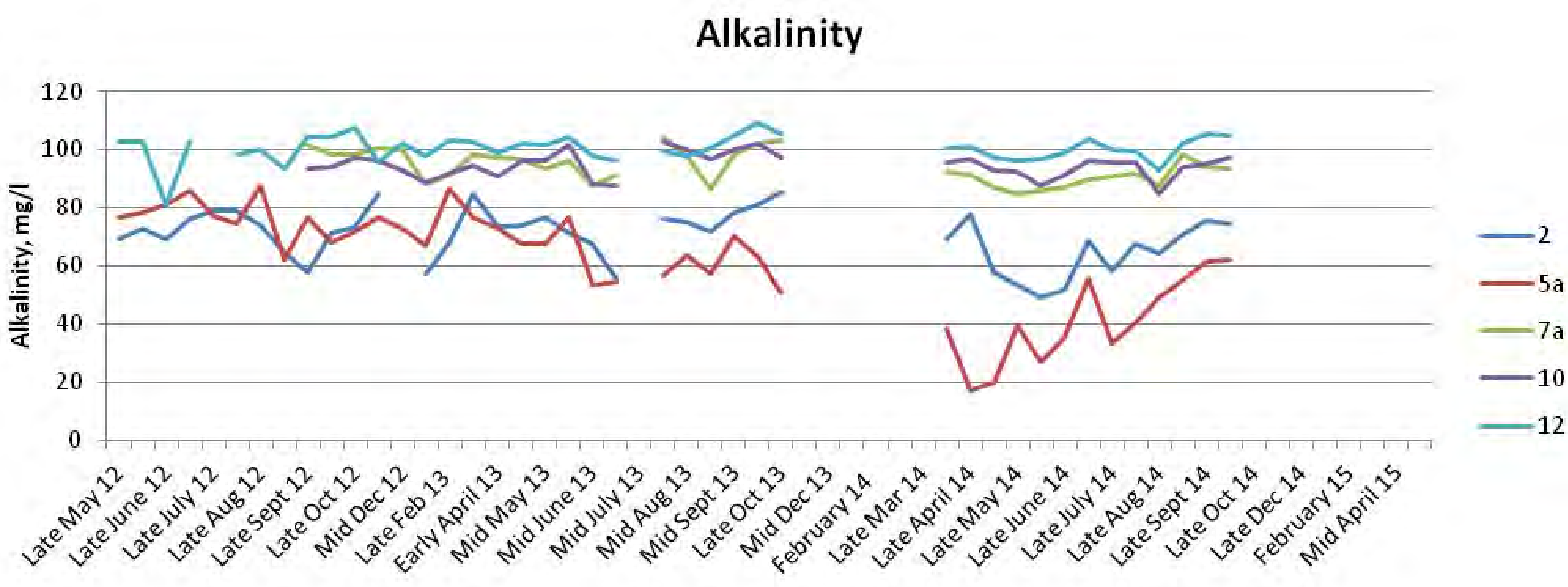
- Water quality
- Zooplankton community dynamics
- Effects of environmental parameters on zooplankton community
- Gelatinous macrozooplankton
- ~~Ichthyoplankton~~

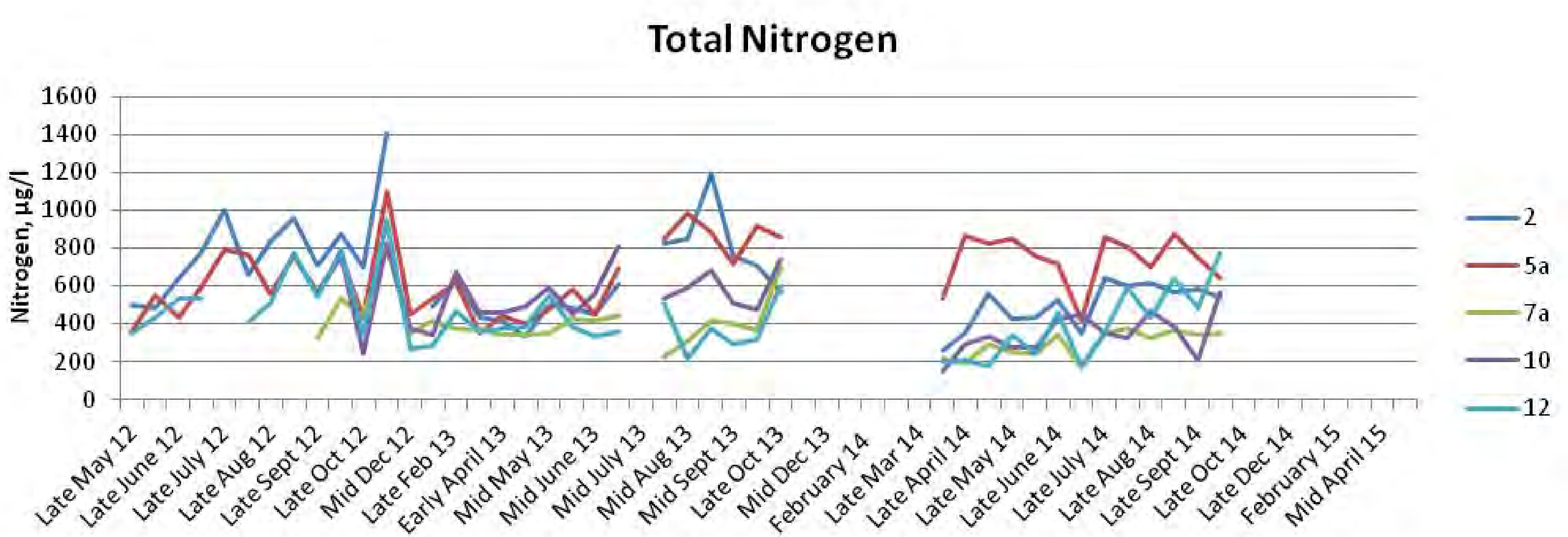

Temperature (°C)
Temperature (°C)
30
25
20
15
10
5
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12
2012
2013
2014
2015

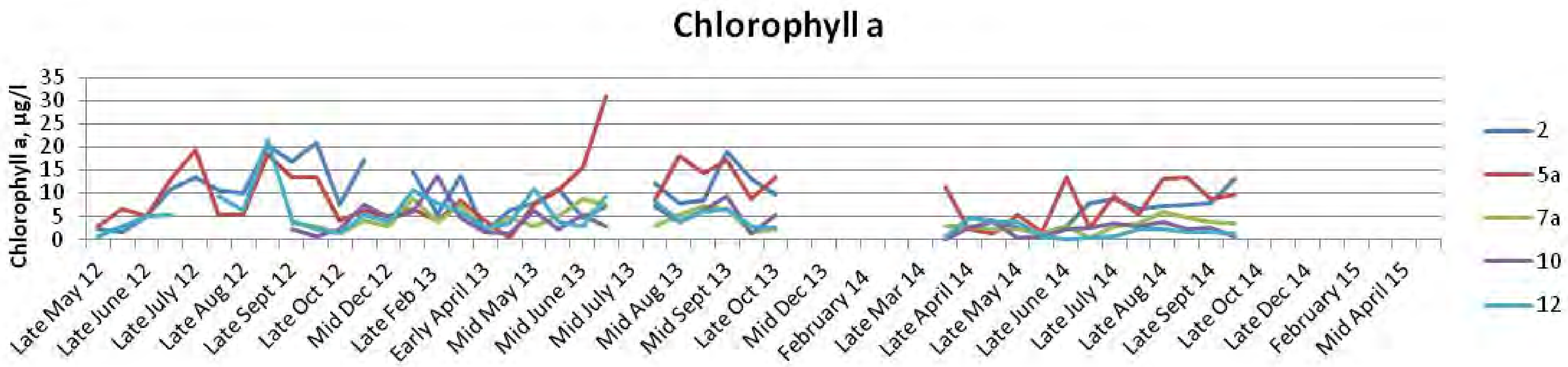

Salinity
Salinity (ppt)
40
30
20
10
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12
2012
2013
2014
2015

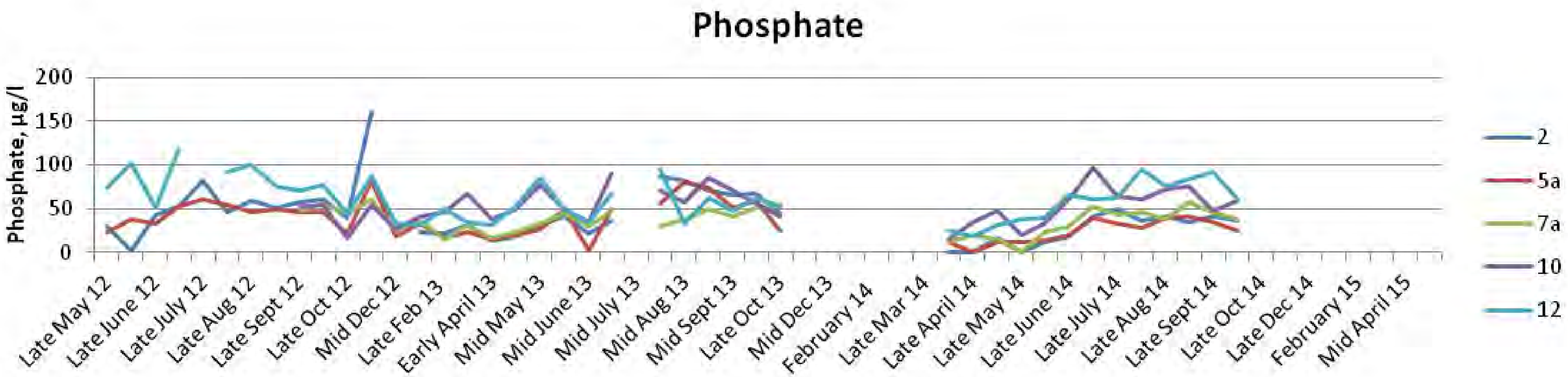


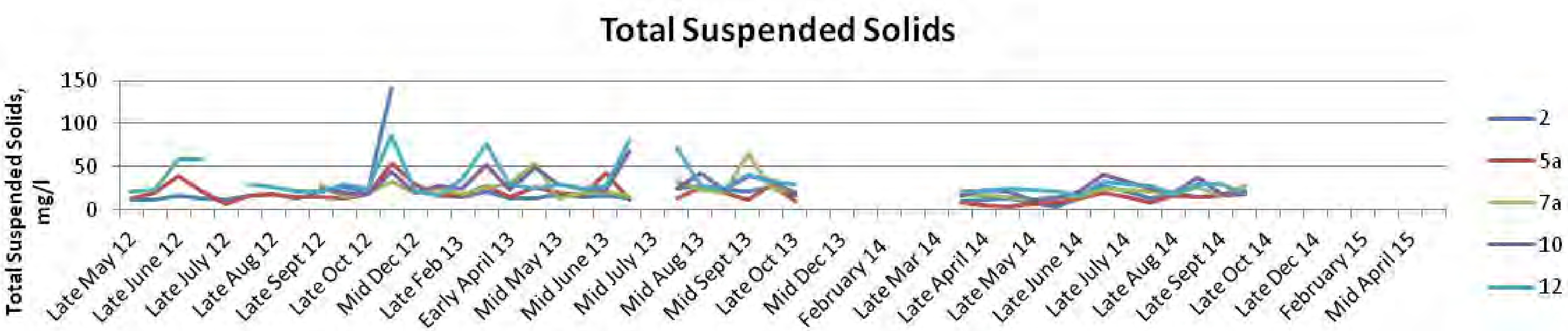
PCA of abiotic water quality data by site and season. Abiotic data were collected for all sampling events. PC 1 = 28.5, PC2 = 22.4

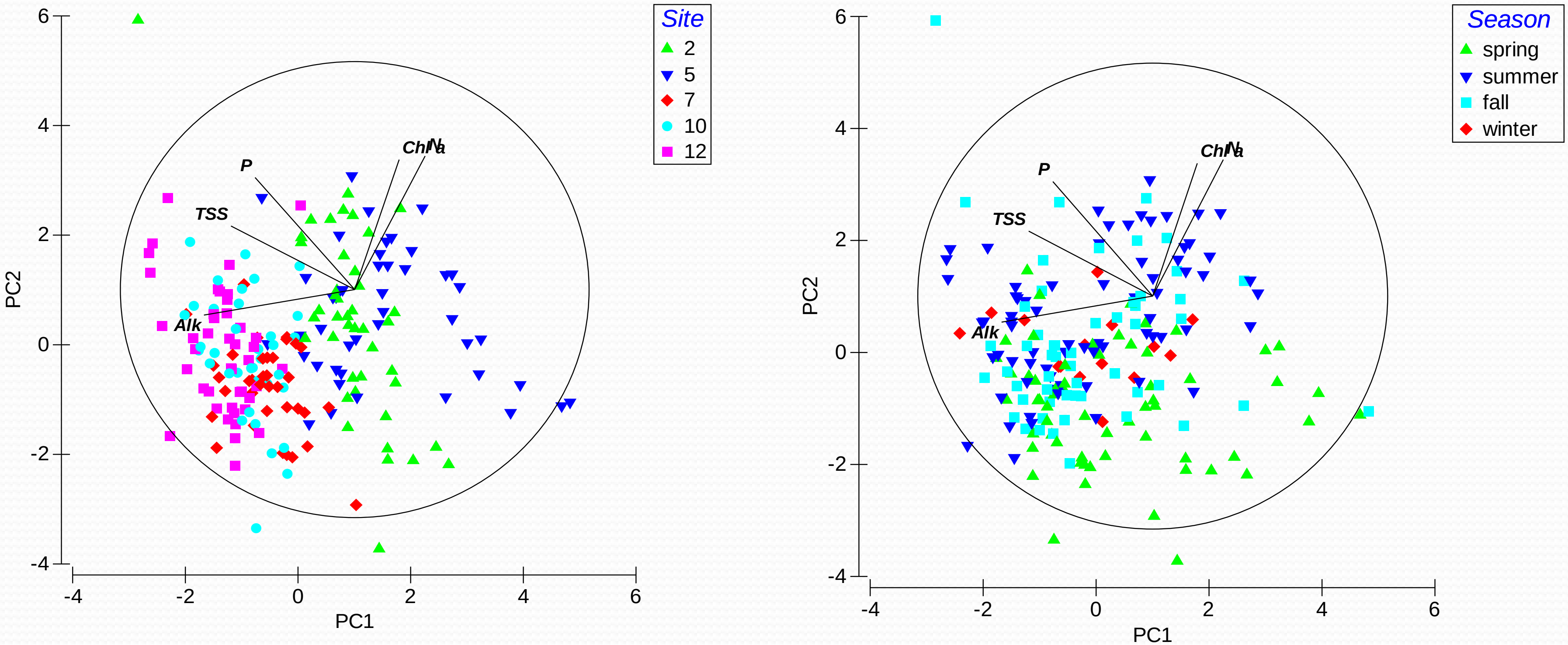

Alkalinity
Alkalinity, mg/l
0
20
40
60
80
100
120
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12


Total Nitrogen
Nitrogen, µg/l
0
200
400
600
800
1000
1200
1400
1600
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12

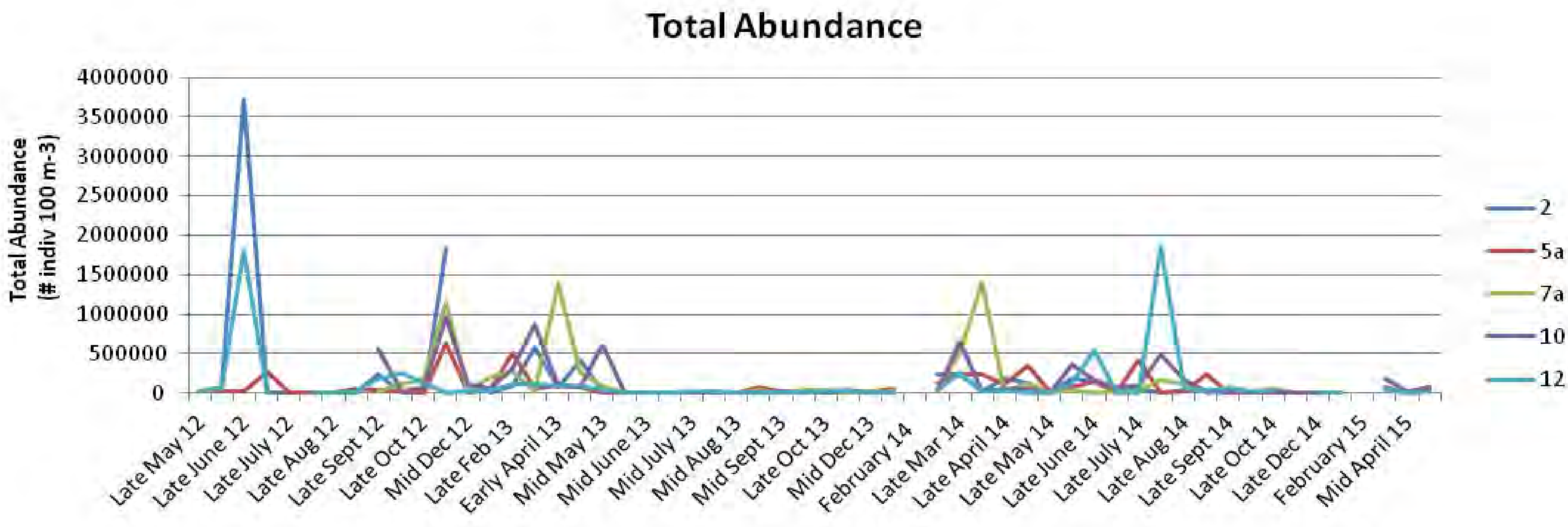

Chlorophyll a
Chlorophyll a, µg/l
35
30
25
20
15
10
5
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12


Phosphate
Phosphate, µg/l
200
150
100
50
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12

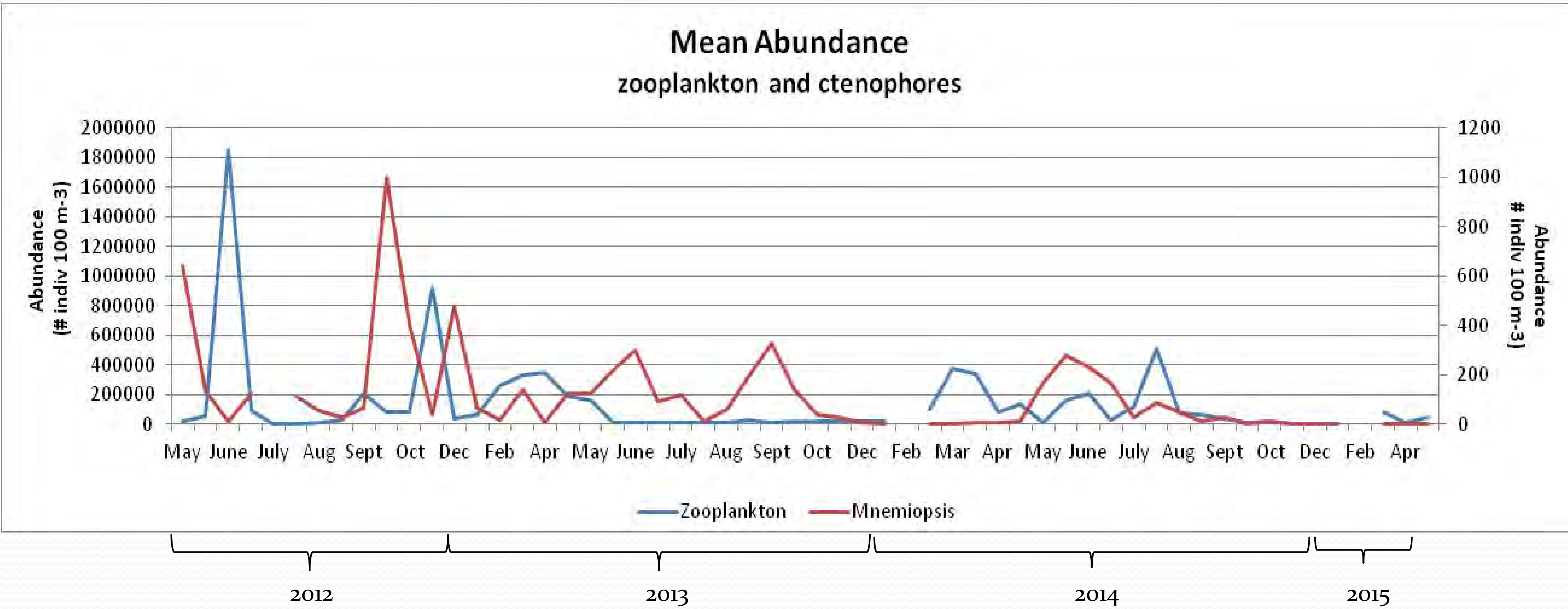

Total Suspended Solids
Total Suspended Solids, mg/l
150
100
50
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12

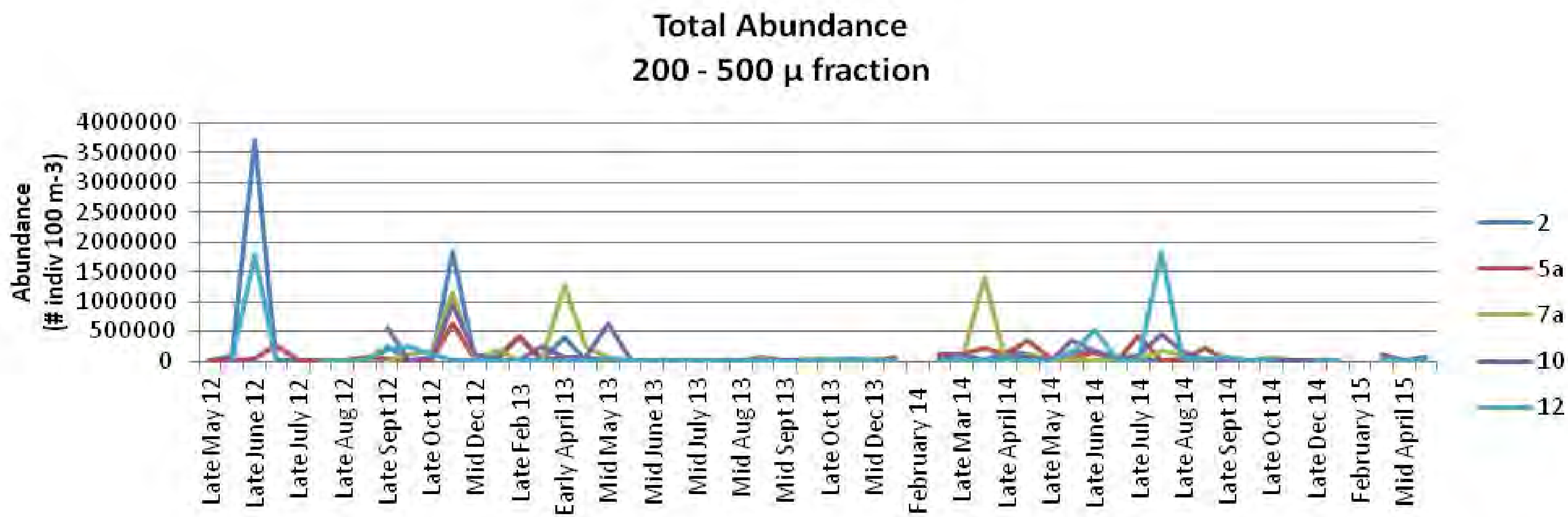


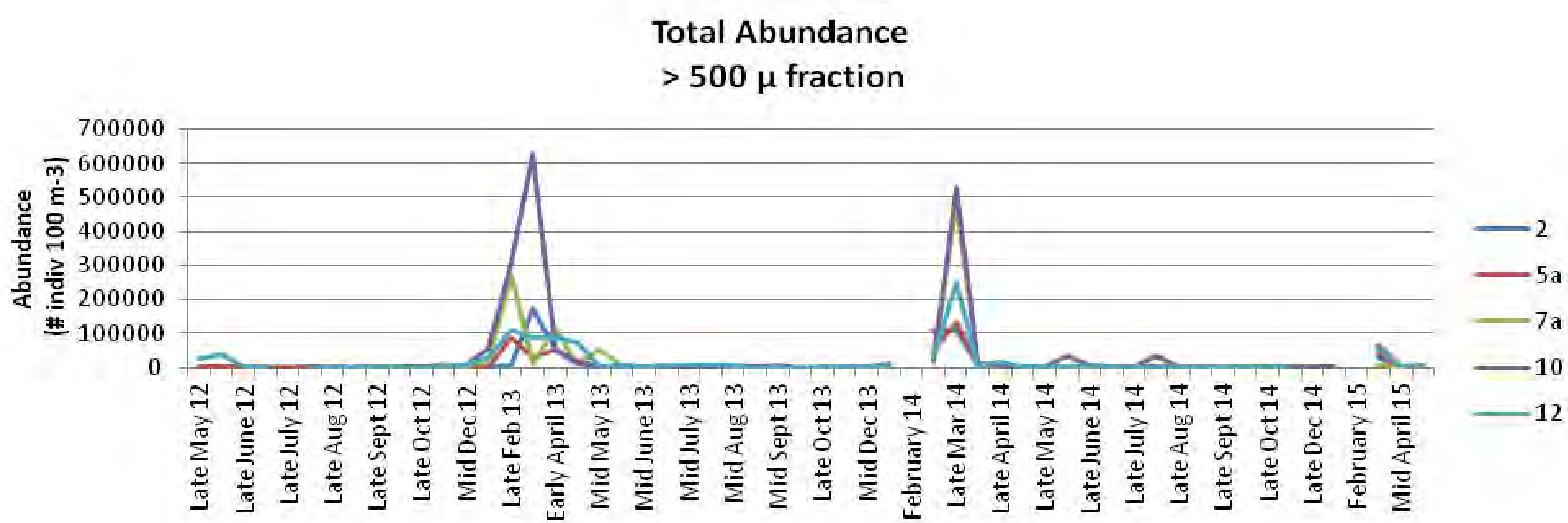
PCA of nutrient water quality data by a) site, b) season, and c) sampling year. Nutrient data were collected for Alk = alkalinity, Chl a = chlorophyll a, N = total nitrogen, P = total phosphorus, TSS = total suspended solids. PC 1 = 41.0%, PC2 = 35.5%.

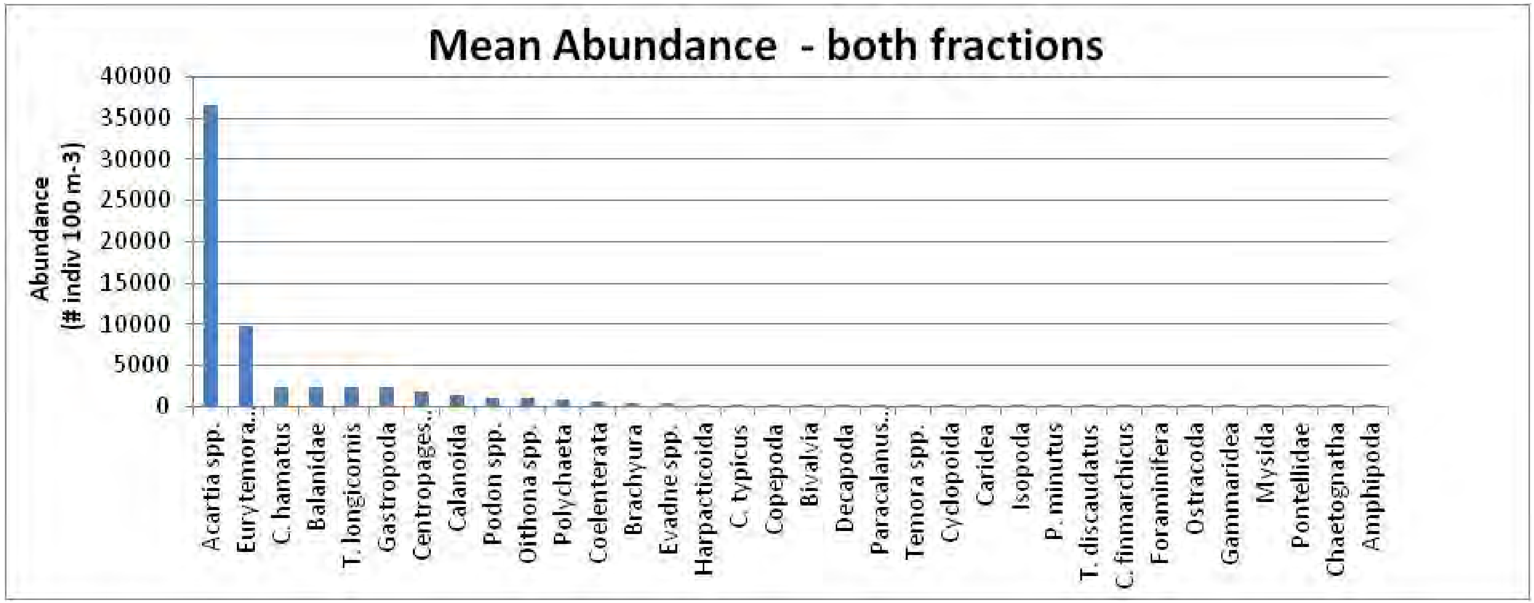


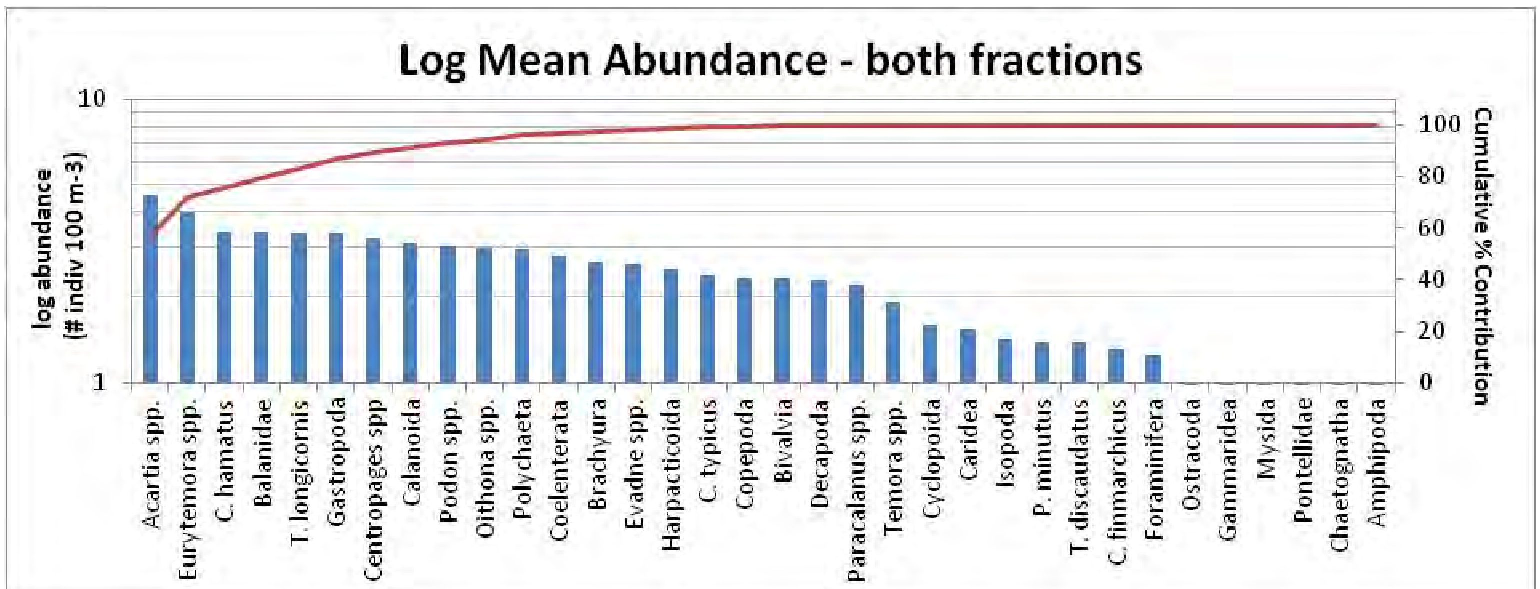
Total Abundance
Total Abundance (# indiv 100 m-3)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12

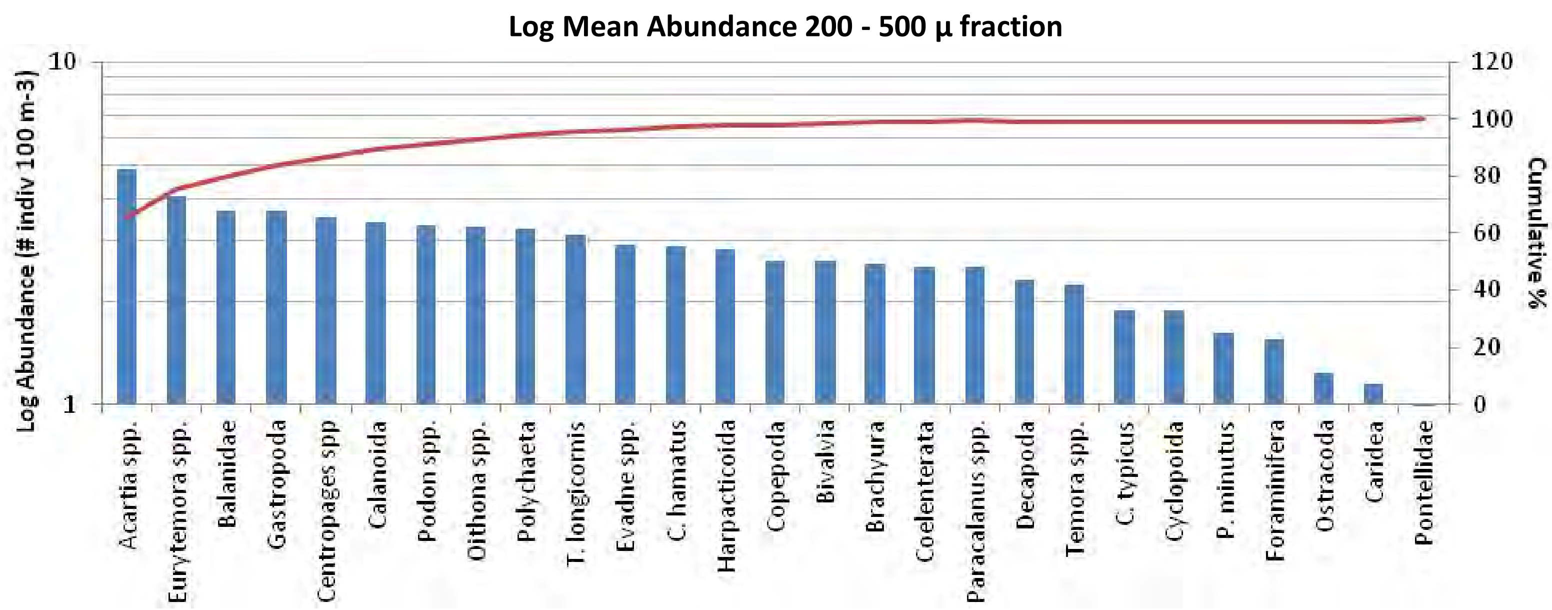

Mean Abundance
zooplankton and ctenophores
Abundance
(# indiv 100 m-3)
2000000
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
1200
1000
800
600
400
200
0
Abundance
indiv 100 m-3)
May June July Aug Sept Oct Dec Feb Apr May June July Aug Sept Oct Dec Feb Mar Apr May June July Aug Sept Oct Dec Feb Apr
Zooplankton
Mnemiopsis
2012
2013
2014
2015


Total Abundance
200 - 500 µ fraction
Abundance
(# indiv 100 m-3)
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12

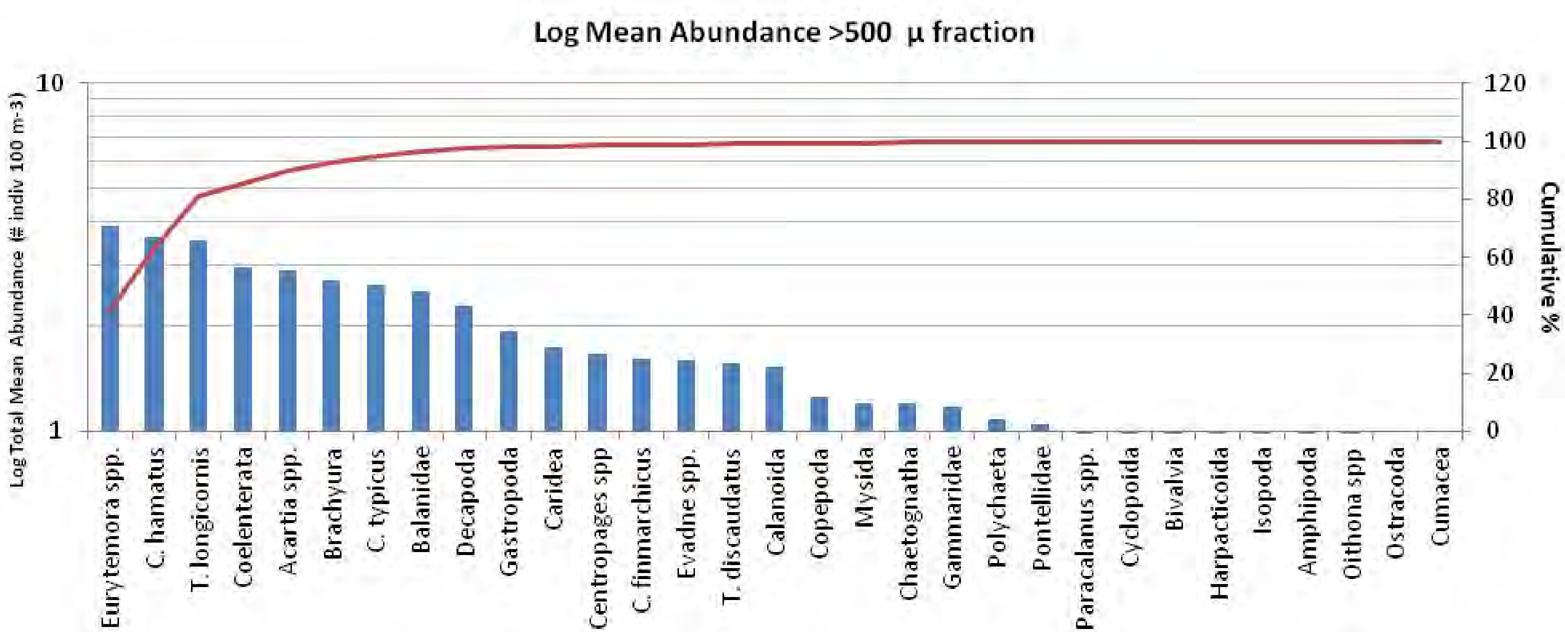

Total Abundance
> 500 µ fraction
Abundance
(# indiv 100 m-3)
700000
600000
500000
400000
300000
200000
100000
0
Late May 12
Late June 12
Late July 12
Late Aug 12
Late Sept 12
Late Oct 12
Mid Dec 12
Late Feb 13
Early April 13
Mid May 13
Mid June 13
Mid July 13
Mid Aug 13
Mid Sept 13
Late Oct 13
Mid Dec 13
February 14
Late Mar 14
Late April 14
Late May 14
Late June 14
Late July 14
Late Aug 14
Late Sept 14
Late Oct 14
Late Dec 14
February 15
Mid April 15
2
5a
7a
10
12


Mean Abundance - both fractions
Abundance (# indiv 100 m-3)
40000
35000
30000
25000
20000
15000
10000
5000
0
Acartia spp.
Eurytemora...
C. hamatus
Balanidae
T. longicornis
Gastropoda
Centropages...
Calanoida
Podon spp.
Oithona spp.
Polychaeta
Coelenterata
Brachyura
Evadne spp.
Harpacticoida
C. typicus
Copepoda
Bivalvia
Decapoda
Paracalanus...
Temora spp.
Cyclopoida
Caridea
Isopoda
P. minutus
T. discaudatus
C. finmarchicus
Foraminifera
Ostracoda
Gammaridea
Mysida
Pontellidae
Chaetognatha
Amphipoda


Log Mean Abundance - both fractions
log abundance (# indiv 100 m-3)
10
1
Cumulative % Contribution
100
80
60
40
20
0
Acartia spp.
Eurytemora spp.
C. hamatus
Balanidae
T. longicornis
Gastropoda
Centropages spp
Calanoida
Podon spp.
Oithona spp.
Polychaeta
Coelenterata
Brachyura
Evadne spp.
Harpacticoida
C. typicus
Copepoda
Bivalvia
Decapoda
Paracalanus spp.
Temora spp.
Cyclopoida
Caridea
Isopoda
P. minutus
T. discaudatus
C. finmarchicus
Foraminifera
Ostracoda
Gammaridea
Mysida
Pontellidae
Chaetognatha
Amphipoda



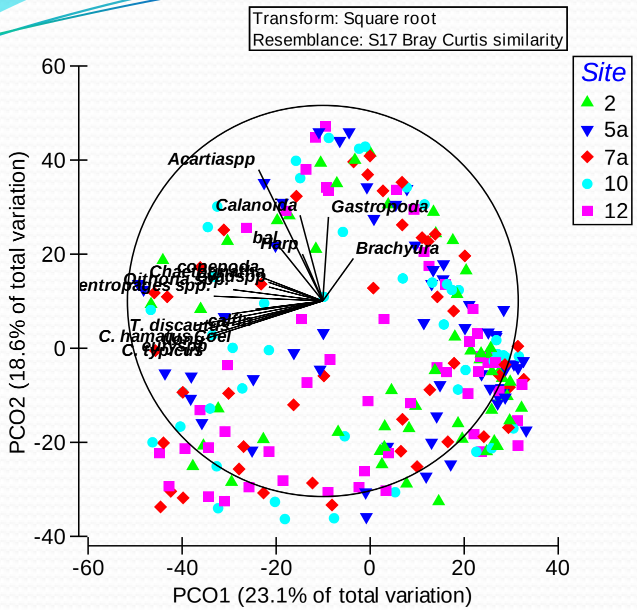
Log Mean Abundance 200 - 500 µ fraction
Log Abundance (# indiv 100 m-3)
Cumulative %
10
1
120
100
80
60
40
20
0
Acartia spp.
Eurytemora spp.
Balanidae
Gastropoda
Centropages spp
Calanoida
Podon spp.
Oithona spp.
Polychaeta
T. longicornis
Evadne spp.
C. hamatus
Harpacticoida
Copepoda
Bivalvia
Brachyura
Coelenterata
Paracalanus spp.
Decapoda
Temora spp.
C. typicus
Cyclopoida
P. minutus
Foraminifera
Ostracoda
Caridea
Pontellidae

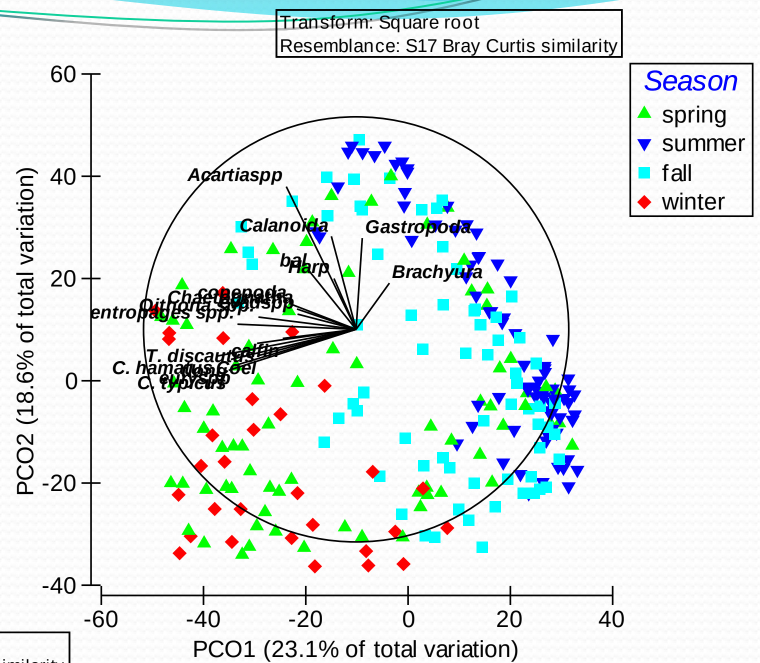


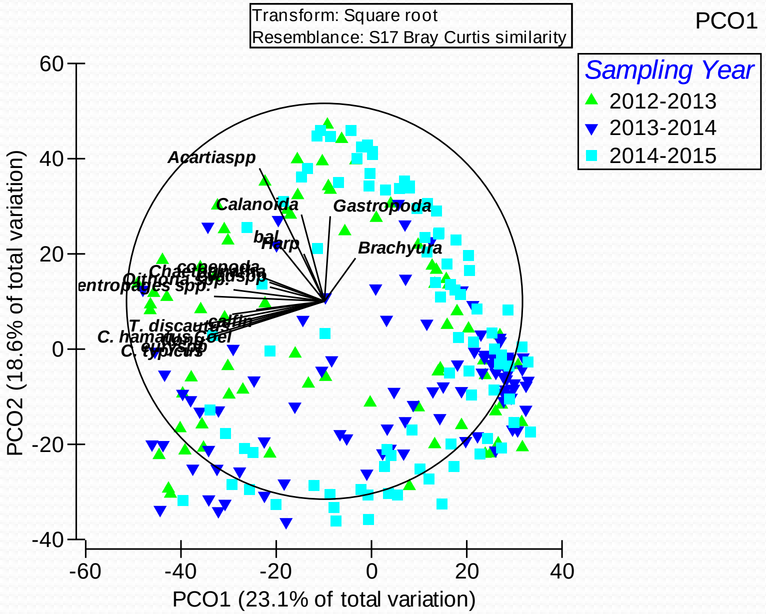
Log Mean Abundance >500 µ fraction
Log Total Mean Abundance (# indiv 100 m-3)
Cumulative %
10
1
120
100
80
60
40
20
0
Eurytemora spp.
C. hamatus
T. longicornis
Coelenterata
Acartia spp.
Brachyura
C. typicus
Balanidae
Decapoda
Gastropoda
Caridea
Centropages spp
C. finmarchicus
Evadne spp.
T. discaudatus
Calanoida
Copepoda
Mysida
Chaetognatha
Gammaridae
Polychaeta
Pontellidae
Paracalanus spp.
Cyclopoida
Bivalvia
Harpacticoida
Isopoda
Amphipoda
Oithona spp
Ostracoda
Cumacea

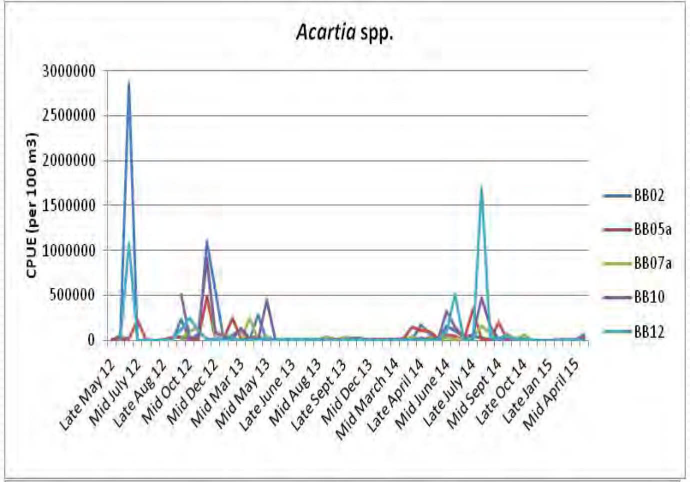
Similarity Analyses

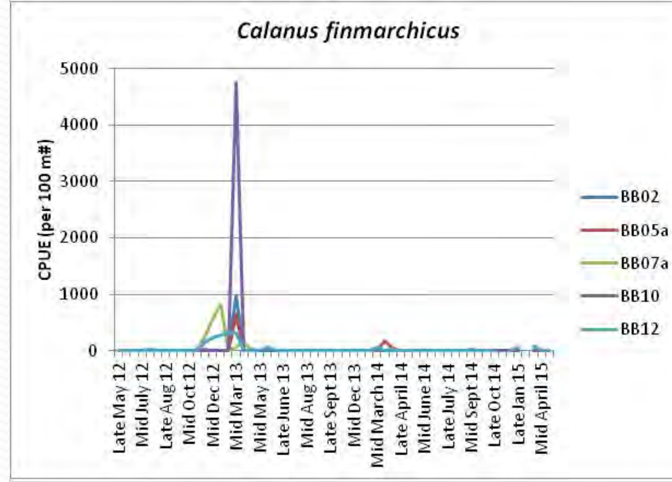
- Compares zooplankton community for each sampling event
  - Communities different between sites, seasons, years
    - Site: BB02/BB12, BB05a/BB12, and BB05a/BB07a
    - Season:
      - Summer/winter – strong difference
      - Spring/summer, summer/fall, spring/fall – weak
    - Year: 2012-2013, 2013-2014, 2014-2015 – strong difference
  - 200-500 fraction – more stable (more similar) between sites, seasons, years (holoplankton)
  - >500 fraction – less stable (more pulse spawning – meroplankton)
- What species are driving these differences?

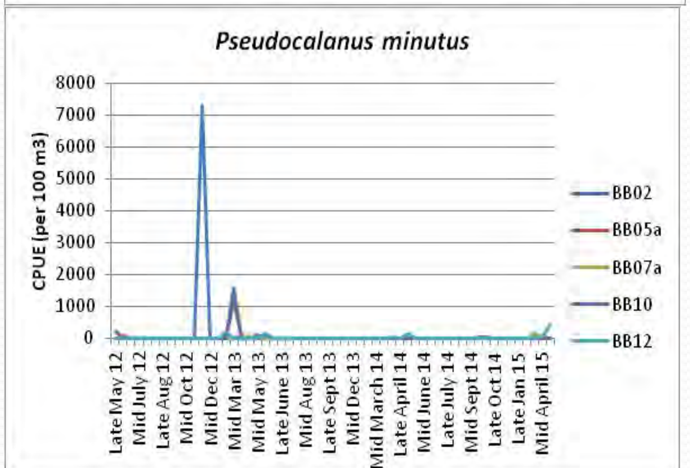

Transform: Square root
Resemblance: S17 Bray Curtis similarity
Site
2
5a
7a
10
12
PCO1 (23.1% of total variation)
PCO2 (18.6% of total variation)
Acartiaspp
Calanoida
Gastropoda
Brachyura
Harp
copepoda
entropages spp.
T. discaudatus
C. hamatus
C. typicus

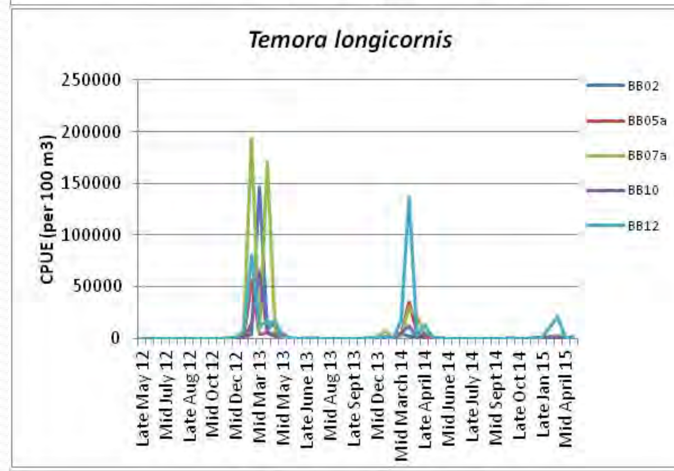

Transform: Square root
Resemblance: S17 Bray Curtis similarity
Season
spring
summer
fall
winter
PCO1 (23.1% of total variation)
PCO2 (18.6% of total variation)
Acartiaspp
Calanoida
Gastropoda
Brachyura
Harp
copepoda
entropages spp.
T. discaudatus
C. hamatus
C. typicus

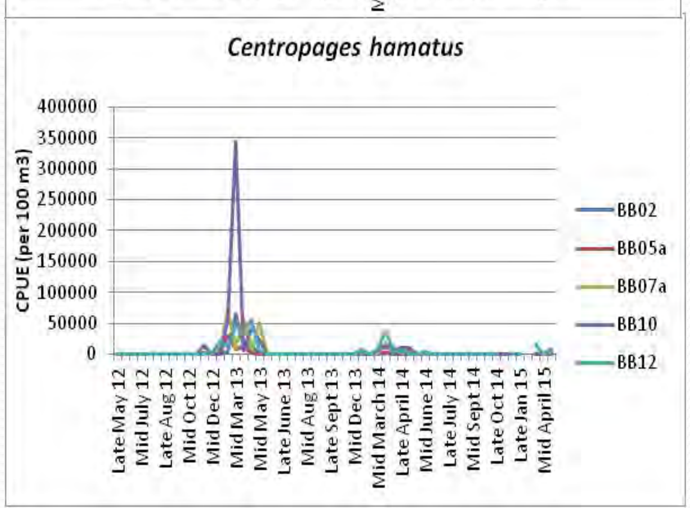

Transform: Square root
Resemblance: S17 Bray Curtis similarity
Sampling Year
2012-2013
2013-2014
2014-2015
PCO1 (23.1% of total variation)
PCO2 (18.6% of total variation)
Acartiaspp
Calanoida
Gastropoda
Brachyura
Harp
copepoda
entropages spp.
T. discaudatus
C. hamatus
C. typicus

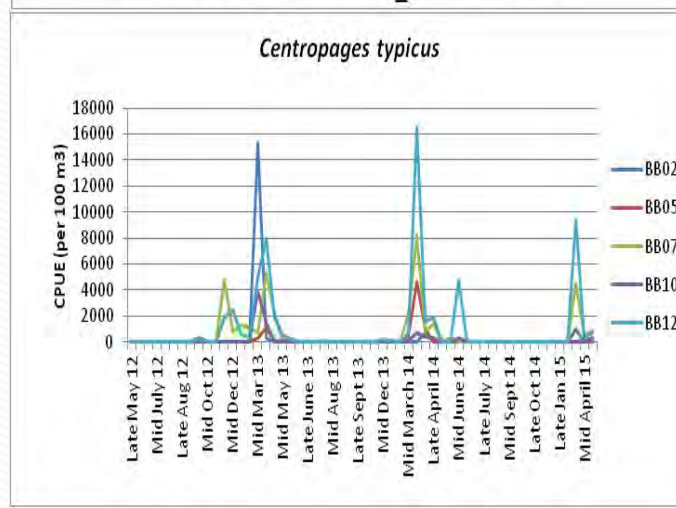

Acartia spp.
CPUE (per 100 m3)
BB02
BB05a
BB07a
BB10
BB12

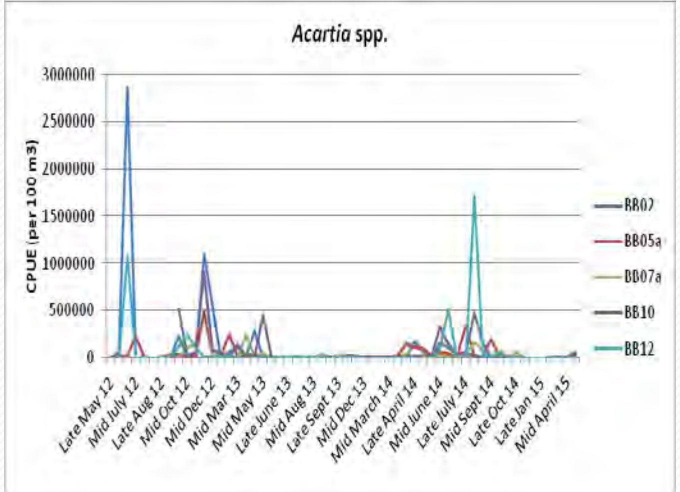

Calanus finmarchicus
CPUE (per 100 m#)
BB02
BB05a
BB07a
BB10
BB12

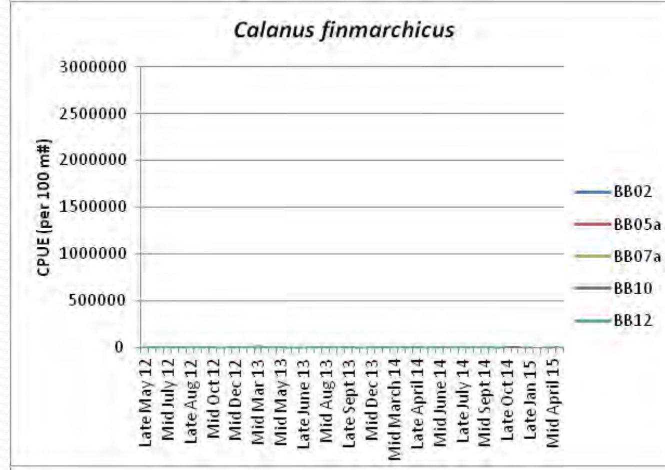

Pseudocalanus minutus
CPUE (per 100 m3)
BB02
BB05a
BB07a
BB10
BB12

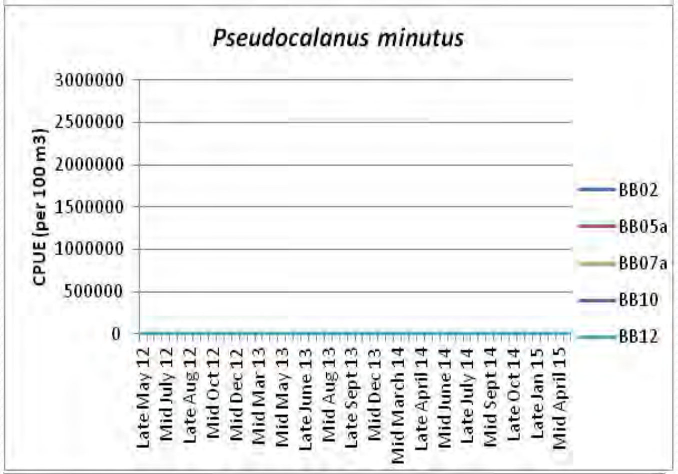

Temora longicornis
CPUE (per 100 m3)
BB02
BB05a
BB07a
BB10
BB12

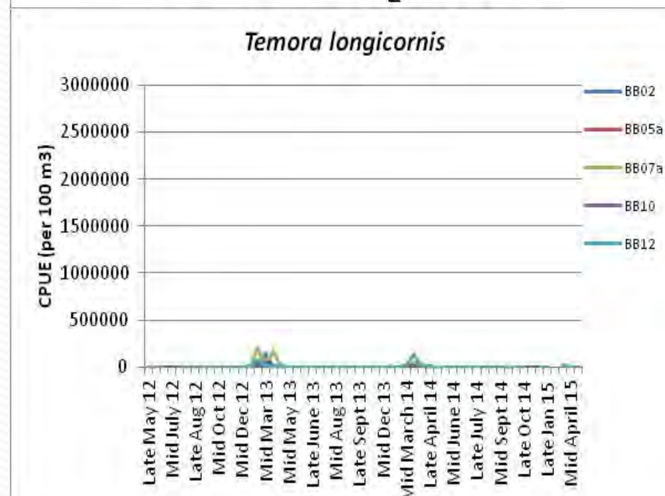

Centropages hamatus
CPUE (per 100 m3)
BB02
BB05a
BB07a
BB10
BB12

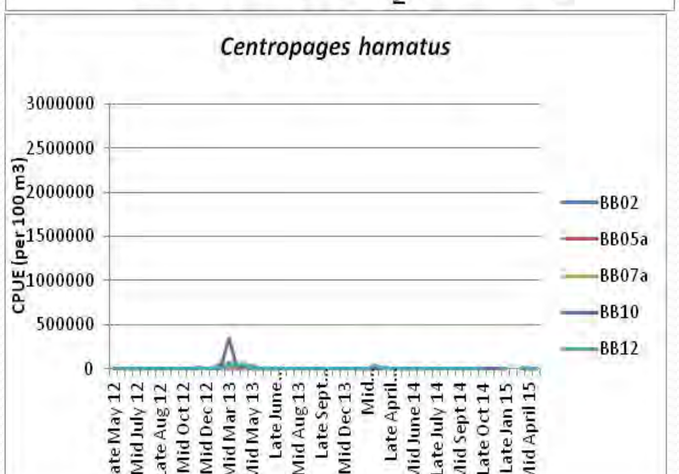

Centropages typicus
CPUE (per 100 m3)
BB02
BB05a
BB07a
BB10
BB12

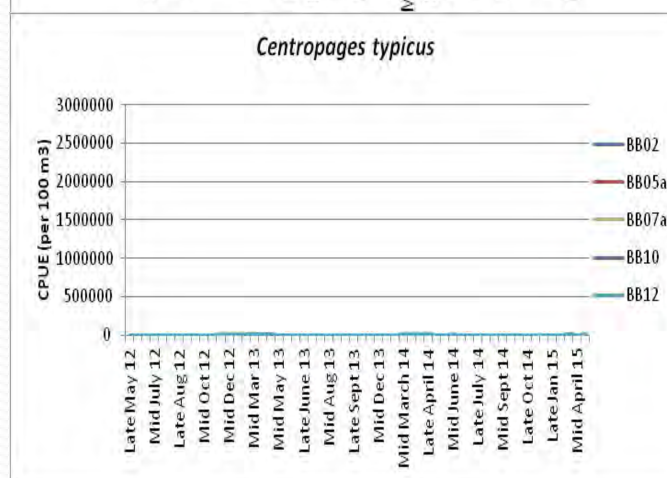

Acartia spp.
CPUE (per 100 m3)
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Mid July 12
Late Aug 12
Mid Oct 12
Mid Dec 12
Mid Mar 13
Mid May 13
Late June 13
Mid Aug 13
Late Sept 13
Mid Dec 13
Mid March 14
Late April 14
Mid June 14
Late July 14
Mid Sept 14
Late Oct 14
Late Jan 15
Mid April 15
BB02
BB05a
BB07a
BB10
BB12


Calanus finmarchicus
CPUE (per 100 m#)
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Mid July 12
Late Aug 12
Mid Oct 12
Mid Dec 12
Mid Mar 13
Mid May 13
Late June 13
Mid Aug 13
Late Sept 13
Mid Dec 13
Mid March 14
Late April 14
Mid June 14
Late July 14
Mid Sept 14
Late Oct 14
Late Jan 15
Mid April 15
BB02
BB05a
BB07a
BB10
BB12


Pseudocalanus minutus
CPUE (per 100 m3)
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Mid July 12
Late Aug 12
Mid Oct 12
Mid Dec 12
Mid Mar 13
Mid May 13
Late June 13
Mid Aug 13
Late Sept 13
Mid Dec 13
Mid March 14
Late April 14
Mid June 14
Late July 14
Mid Sept 14
Late Oct 14
Late Jan 15
Mid April 15
BB02
BB05a
BB07a
BB10
BB12


Temora longicornis
CPUE (per 100 m3)
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Mid July 12
Late Aug 12
Mid Oct 12
Mid Dec 12
Mid Mar 13
Mid May 13
Late June 13
Mid Aug 13
Late Sept 13
Mid Dec 13
Mid March 14
Late April 14
Mid June 14
Late July 14
Mid Sept 14
Late Oct 14
Late Jan 15
Mid April 15
BB02
BB05a
BB07a
BB10
BB12


Centropages hamatus
CPUE (per 100 m3)
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Mid July 12
Late Aug 12
Mid Oct 12
Mid Dec 12
Mid Mar 13
Mid May 13
Late June...
Mid Aug 13
Late Sept...
Mid Dec 13
Mid...
Late April...
Mid June 14
Late July 14
Mid Sept 14
Late Oct 14
Late Jan 15
Mid April 15
BB02
BB05a
BB07a
BB10
BB12


Centropages typicus
CPUE (per 100 m3)
3000000
2500000
2000000
1500000
1000000
500000
0
Late May 12
Mid July 12
Late Aug 12
Mid Oct 12
Mid Dec 12
Mid Mar 13
Mid May 13
Late June 13
Mid Aug 13
Late Sept 13
Mid Dec 13
Mid March 14
Late April 14
Mid June 14
Late July 14
Mid Sept 14
Late Oct 14
Late Jan 15
Mid April 15
BB02
BB05a
BB07a
BB10
BB12

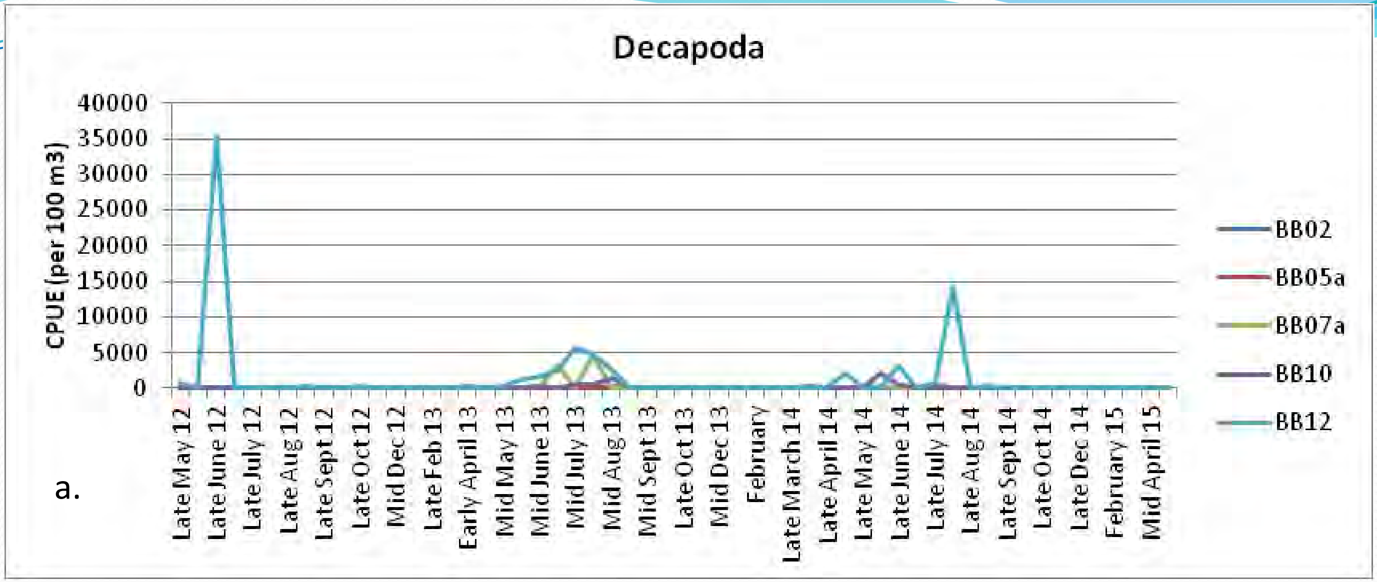
Copepod abundance patterns

- Location
  - *Acartia* dominant at 2, 5a, 10
  - *Eurytemora* dominant at 12
  - 7a – *Acartia*, *Eurytemora*, plus *Centropages* spp., *T. longicornis*, and *Oithona* spp.

- Seasonal
  - *Eurytemora* (42%) > *Acartia* (35%) in spring
  - *Acartia* dominates during summer (95%) and fall (88%)
  - Winter: *Acartia* 21%, other taxa 73% (*Eurytemora*, *C. hamatus*, *T. longicornis*, *C. finmarchicus*)
  - Overall abundance: summer > spring, winter > fall
    - Likely due to influence of Sandy plus harsh winters of 2013-2014, 2014-2015

- *Acartia* – summer and fall (estuarine euryhaline/eurythermal species)
- *C. finmarchicus, C. hamatus, T. longicornis*, etc.- winter, spring

- **Temperate bloom paradigm not obvious in Barnegat Bay during this study**



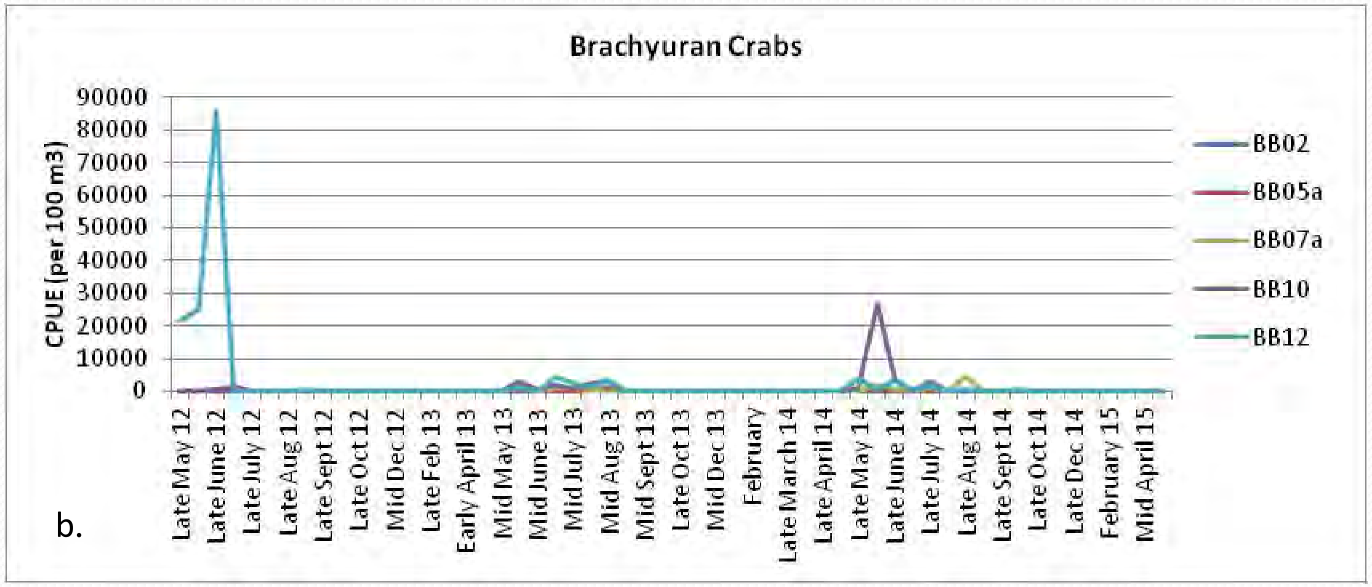
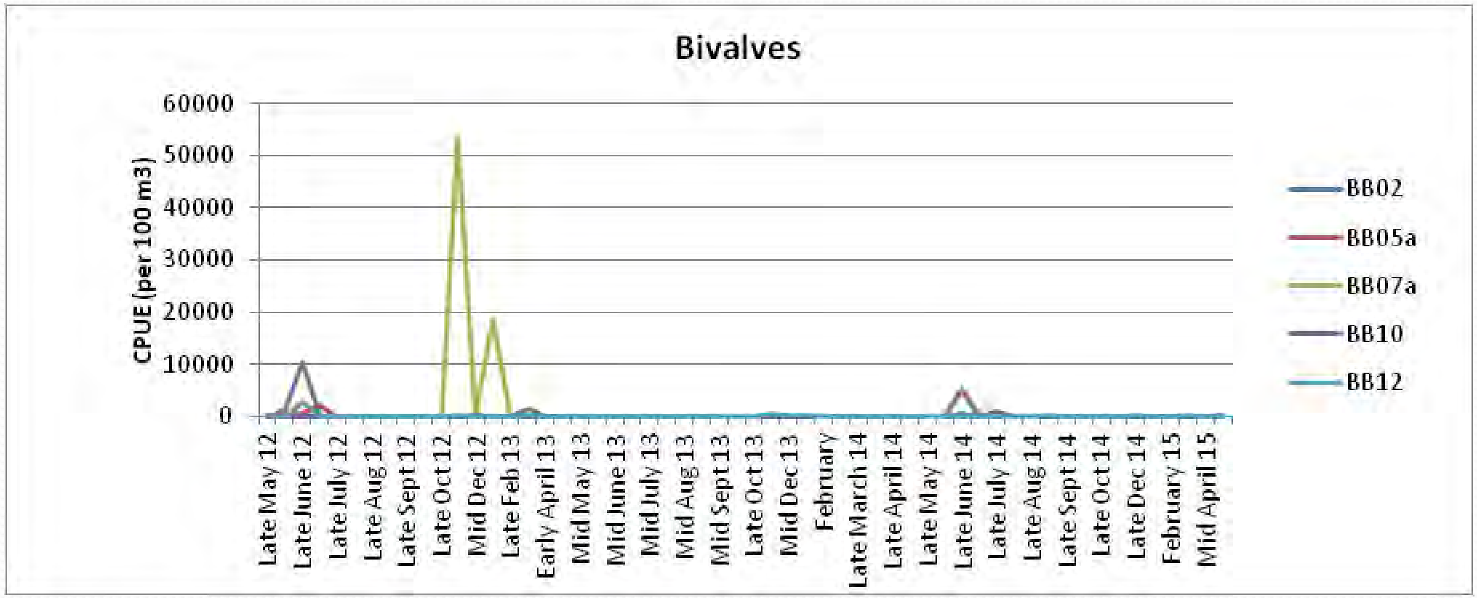
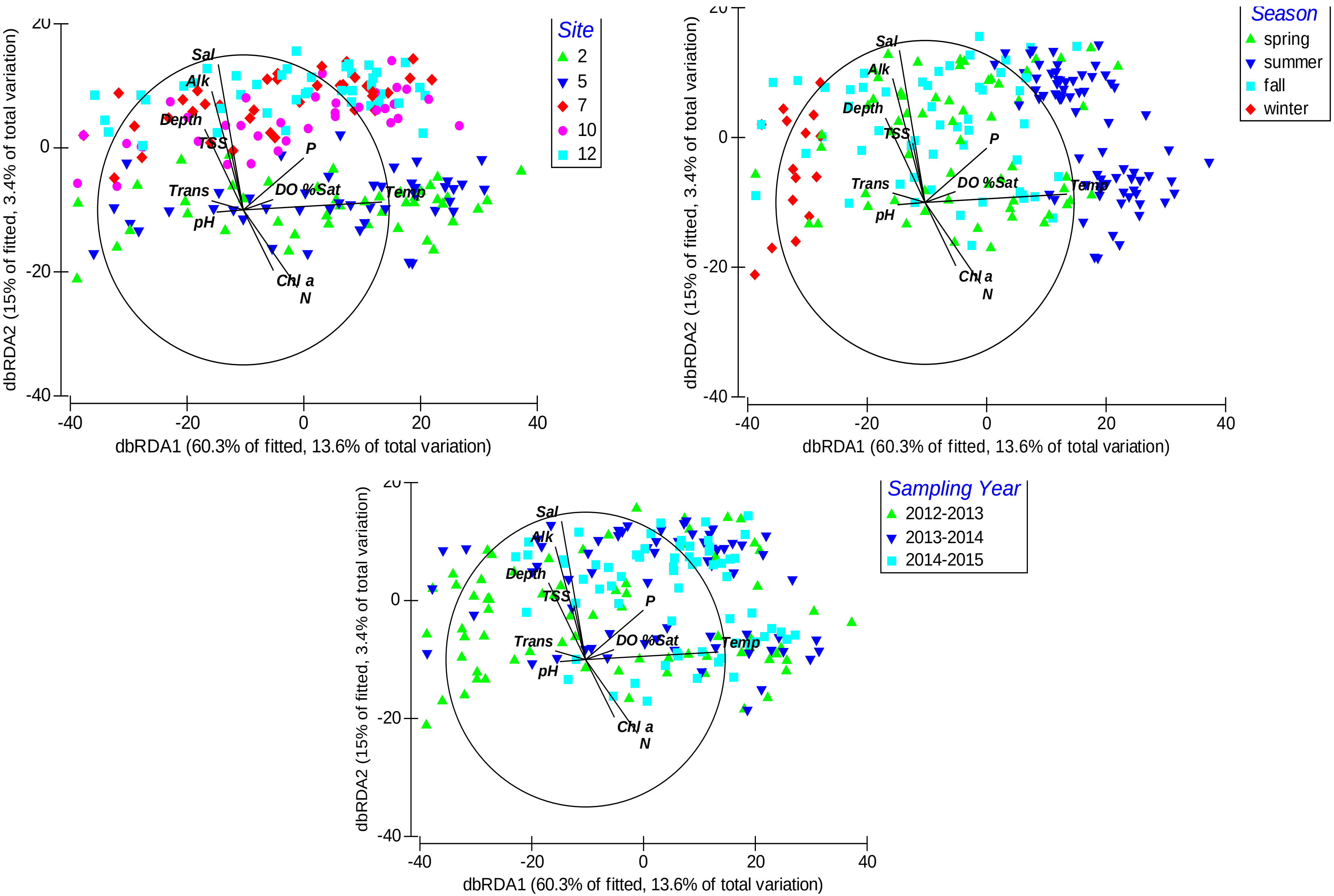


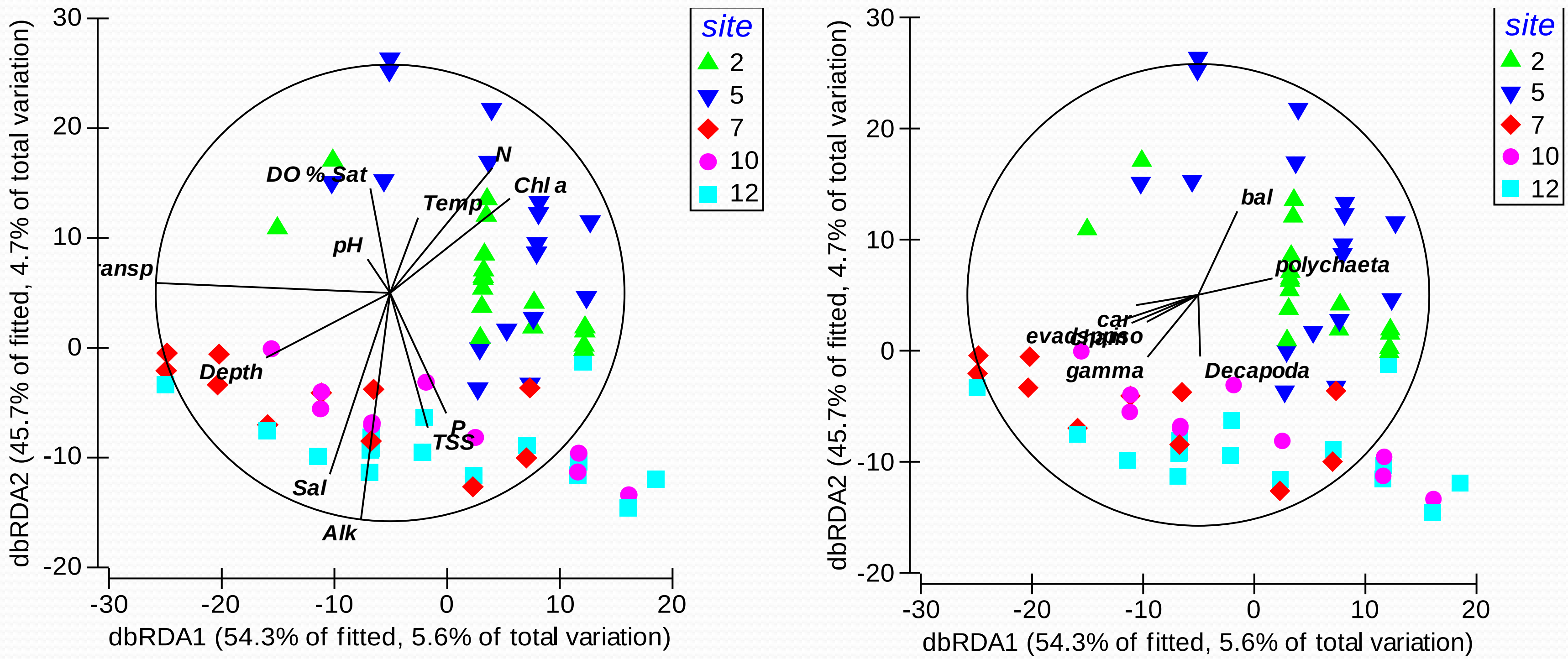
Figure 7. Abundance of arthropod larvae collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – April 2015. a. Decapoda b. Brachyura (crabs). Sites BB7a and BB10 were added in late September 2012.



Abundance of bivalve veliger larvae collected at Sites BB2, BB5a, BB7a, BB10, and BB12 in May 2012 – April 2015. Sites BB7a and BB10 were added in late September 2012.



Distance-based redundancy analysis (dbRDA) plots of the zooplankton community data Bray-Curtis resemblance matrix for combined environmental variables (nutrient + abiotic) and combined fractions. a) by site, b) by season, c) by sampling year.



Distance-based redundancy analysis (dbRDA) plots of the zooplankton community data Bray-Curtis resemblance matrix for summer, combined fractions. a) by site, with all environmental variables, b) by site, with zooplankton taxa. Correlation = 0.25.

Characteristics of the Barnegat Bay Zooplankton Community

- Pronounced spatial, seasonal, and interannual variability
- Temperature – most important abiotic variable
- Nitrogen – most important nutrient (phosphate, alkalinity)
- Community dominated by estuarine species in summer/fall, coastal species in winter/spring
  - *Acartia* most important taxon, seasonally variable
- Northern (Sites 2, 5a) and southern (7a, 10, 12) communities
  - Northern – N, Chl a, estuarine copepods, barnacles, polychaetes
  - Southern – Alk, P, coastal copepods, decapods, gammarids, cladocerans

- Barnegat Bay: very vulnerable system
- Environmental/climatic effects may cause dramatic changes in community structure

… in conjunction w/an anthropogenic issue

= potential catastrophic impact

Recommendations

- Analysis of linkage between phytoplankton and zooplankton communities (density-dependent factors), environmental parameters
- More comprehensive monitoring of nutrient load in bay
- Long-term monitoring of phytoplankton and zooplankton communities (including gelatinous macrozooplankton) – esp. target species

Our thanks to the following:

- NJDEP Office of Science
- NOAA - Dr. Tom Noji and Dr. Jennifer Samson
- Chloe Baskin, Erik Bugenhagen, Peter Chace, Dominic Chiarello, Ryan Corbett,Tara Engelken, Kristina Guarino, Bryan Hewins, Kristen Jezycki, Rebecca Leitt, Charlotte Maiden, Katherine Markowitz, Grace McIlvain, Megan O'Donnell, Mackenzie Roche, Kim Rogan, Mike Ruth, Chandler Schaeffer, Katie Smedley.

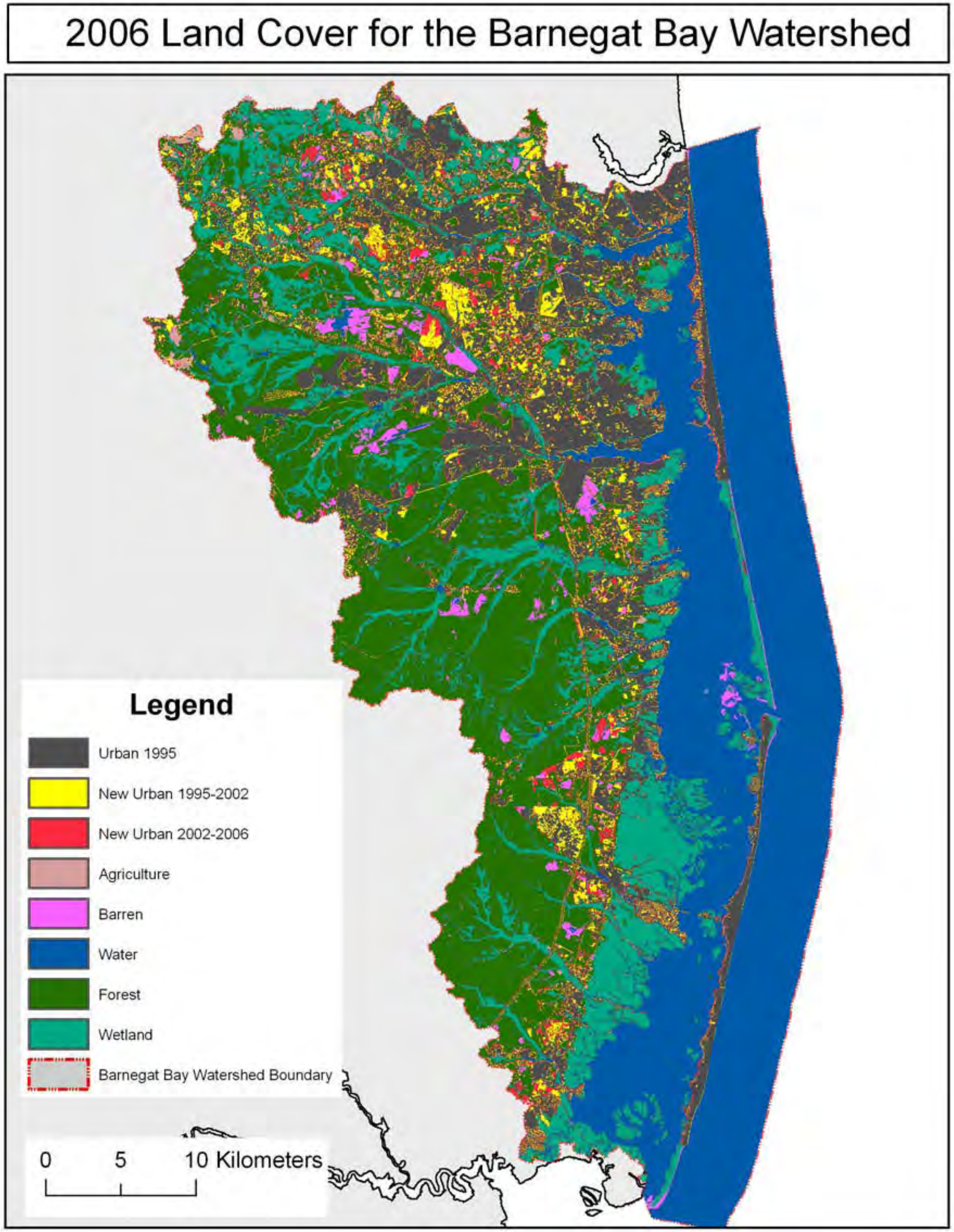
Assessment of Fishes and Crabs Responses to Human Alteration of Barnegat Bay

Thomas M. Grothues, Kenneth W. Able, Jessica Valenti

Rutgers University Marine Field Station

Paul Jivoff

Rider University



Rationale

Focus on fishes because

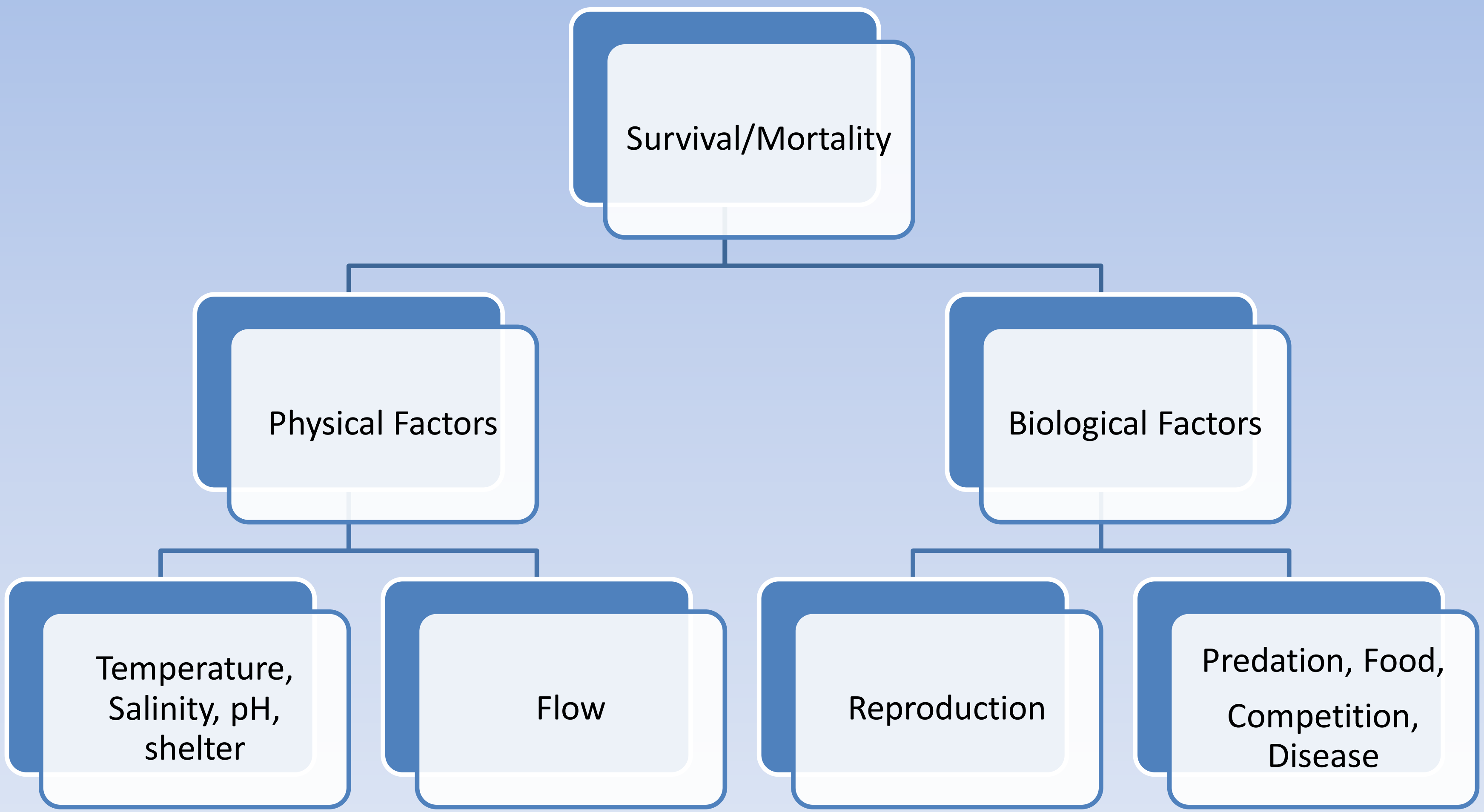
- Make up a large component of the animal life in BB
- Central to ecosystem function (predators and prey)
- Harvested in recreational and commercial fisheries

Long Term Goal

- Characterize the fish population
  - What is Where and When its There
- Determine how fish in Barnegat Bay respond to changes made by humans

1) Identify patterns of juvenile and adult fish distribution and abundance across habitats (seagrass, creek, open bay)
2) Define what changes humans make and where
3) Determine if changes in fish populations correspond with those changes to the Bay
4) Determine what change is natural

The Abundance and Distribution of Fishes



Human Impacts

- Flow
- Eutrophication
- Shoreline Engineering
- Benthic Engineering
- Removal
- Heating

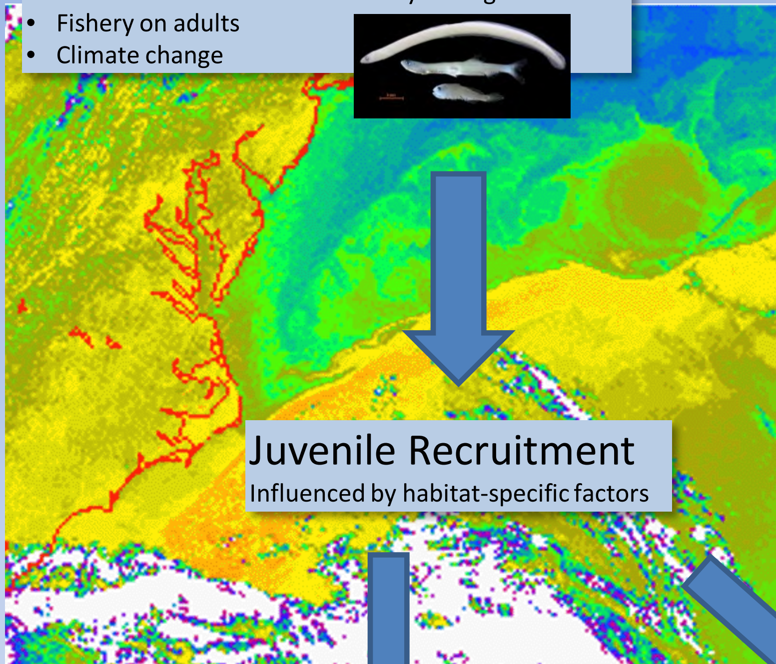
Natural Impacts

- Storms
- Flow
- Delivery
- Heating
- Stochastic Effects

Larval Supply

Indirect contact with human activity through:

- Fishery on adults
- Climate change



Juvenile Recruitment

Influenced by habitat-specific factors

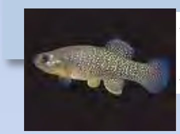
Nested Design

Assessed by trawl & PCA

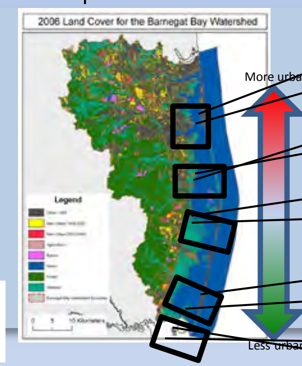
Marsh Residents

Direct contact with human activity through:

- Shoreline changes
- Outflow
- Dredging
- Altered Circulation



Annual & seasonal recruitment variation assessed by trawl and trap collection & PCA



Urban creeks*
Natural creeks

Urban creeks
Natural creeks

Urban creeks
Natural creeks

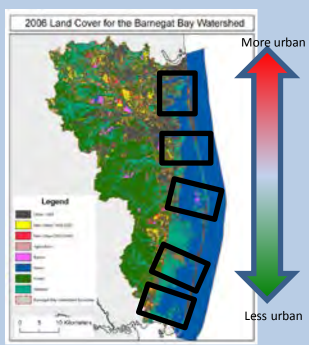
Urban creeks
Natural creeks

Urban creeks
Natural creeks

SAV Residents

Indirect contact with human activity through:

- Altered Circulation
- Climate change
- Eutrophication/SAV loss
- Sediment Alteration
- Predator/Prey Change

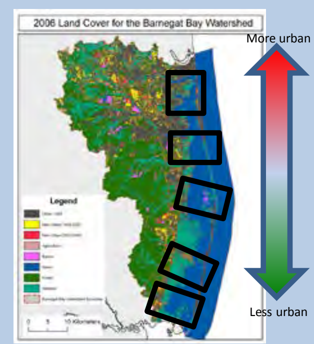


Annual & seasonal recruitment variation assessed by trawl and trap collection & PCA

Open Bay Residents

Indirect contact with human activity through:

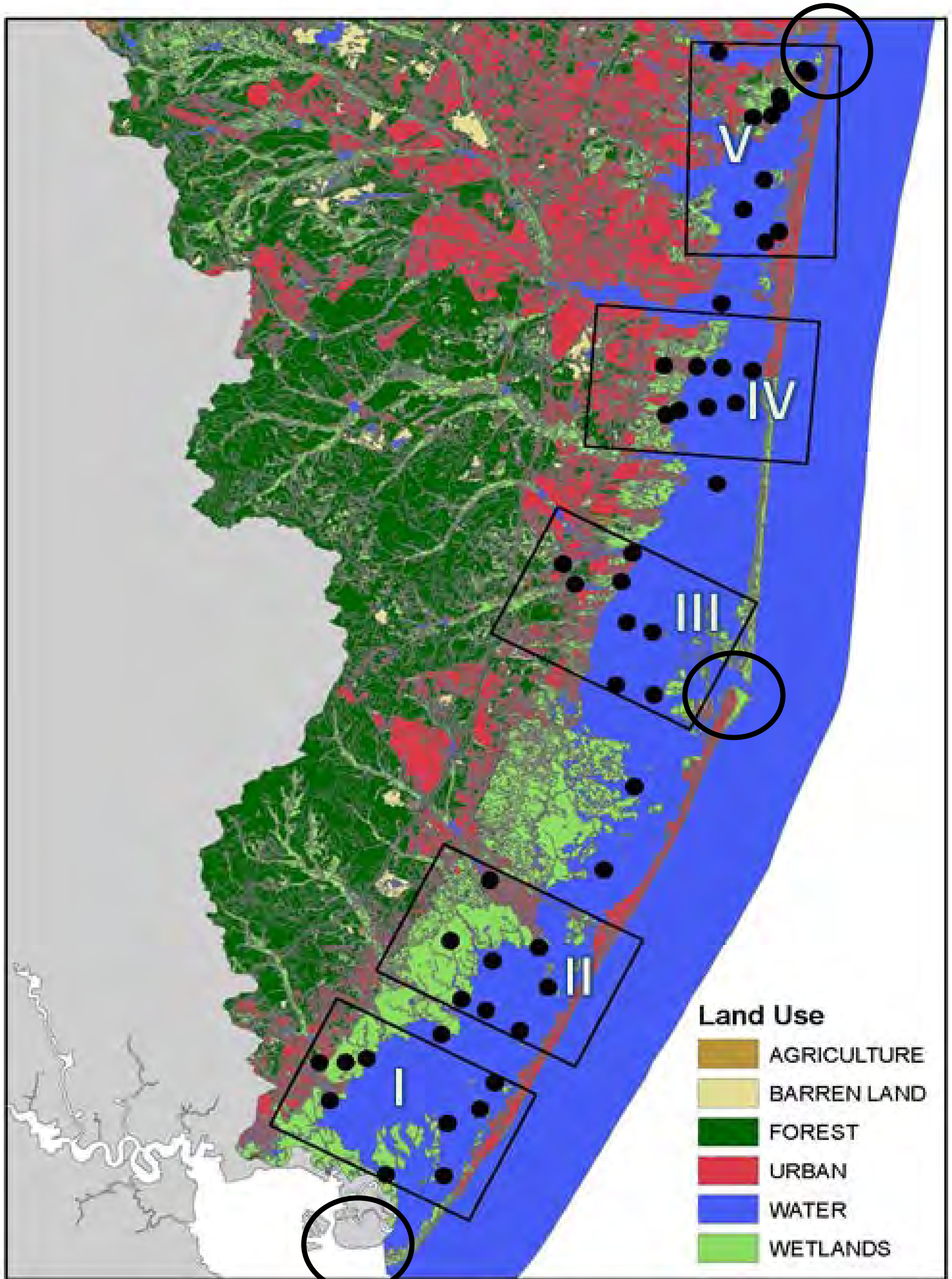
- Altered Circulation
- Climate change
- Eutrophication
- Predator/Prey Change



Annual & seasonal recruitment variation assessed by trawl and trap collection & PCA

How do we sample for that?

- Collect larval fish
- Collect juvenile fish
- Collect information about human populations
- Do it again twice more



Sampling Regime

- Larval supply to Little Egg Inlet, Barnegat Inlet, and Pt. Pleasant Canal
- Habitat specific sampling along urbanization gradient by otter trawl (clusters)
- Larval ingress time series Little Egg Inlet (weekly since 1989)




92 Species - 4110 Individuals

Callinectes	sapidus	1017
Anchoa	mitchilli	634
Syngnathus	fuscus	288
Pseudopleuronectes	americanus	181
Bairdiella	chrysoura	165
Menidia	menidia	156
Paralichthys	dentatus	148
Leiostomus	xanthurus	139
Gobiosoma	bosc	124
Apeltes	quadracus	106
Opsanus	tau	102
Brevoortia	tyrannus	83
Sphoeroides	maculatus	81
Micropogonias	undulatus	69
Libinia	emarginata	68
Centropristis	striata	60
Anchoa	hepsetus	47
Anguilla	rostrata	43
Tautoga	onitis	41
Pomatomus	saltatrix	40
Libinia	dubia	30
Hippocampus	erectus	29
Fundulus	heteroclitus	27
Urophycis	regia	26
Chasmodes	bosquianus	25
Lagodon	rhomboides	25
Trinectes	maculatus	24
Cynoscion	regalis	23
Gobiosoma	ginsburgi	20
Cancer	irroratus	18
Clupeiformes	sp.	18
Chilomycterus	schoepfi	17
Tautogolabrus	adspersus	17
Hypsoblennius	hentz	13
Menticirrhus	saxatilis	12
Etropus	microstomus	11
Ovalipes	ocellatus	11
Peprilus	triacanthus	10
Morone	sp.	9
Morone	americana	8
Mustelus	canis	8
Gobiesox	strumosus	7
Gobiosoma	sp.	7
Microgobius	thalassinus	7
Limulus	polyphemus	6
Menidia	sp.	6
Pollachius	virens	6
Selene	setapinnis	6
Clupea	harengus	5
Menidia	beryllina	5
Prionotus	carolinus	5
Scophthalmus	aquosus	5
Selene	vomer	5
Lepomis	gibbosus	4
Lucania	parva	4
Mugil	curema	4
Stenotomus	chrysops	4
Caranx	hippos	3
Dasyatis	say	3
Libinia	sp.	3
Pogonias	cromis	3
Alosa	pseudoharengus	2
Carcinus	maenas	2
Chaetodon	ocellatus	2
Cyprinodon	variegatus	2
Lutjanus	griseus	2
Sciaenidae	sp.	2
Symphurus	plagiusa	2
Unidentified	fish	2
Archosargus	probatocephalus	1
Astroscopus	guttatus	1
Callinectes	similis	1
Caranx	crysos	1
Clupeidae	sp.	1
Conger	oceanicus	1
Dactylopterus	volitans	1
Eucinostomus	argenteus	1
Fundulus	luciae	1
Fundulus	majalis	1
Fundulus	sp.	1
Gadus	morhua	1
Gasterosteus	aculeatus	1
Ictalurus	punctatus	1
Morone	saxatilis	1
Mugil	cephalus	1
Mycteroperca	microlepis	1
Peprilus	sp.	1
Perca	flavescens	1
Portunus	gibbesii	1
Raja	erinacea	1
Strongylura	marina	1
Synodus	foetens	1

92 Species - 4110 Individuals

Callinectes	sapidus	1017	Clupea	harengus	5
Anchoa	mitchilli	634	Menidia	beryllina	5
Syngnathus	fuscus	288	Prionotus	carolinus	5
Pseudopleuronectes	americanus	181	Scophthalmus	aquosus	5
Bairdiella	chrysoura	165	Selene	vomer	5
Menidia	menidia	156	Lepomis	gibbosus	4
Paralichthys	dentatus	148	Lucania	parva	4
Leiostomus	xanthurus	139	Mugil	curema	4
Gobiosoma	bosc	124	Stenotomus	chrysops	4
Apeltes	quadracus	106	Caranx	hippos	3
Opsanus	tau	102	Dasyatis	say	3
Brevoortia	tyrannus	83	Libinia	sp.	3
Sphoeroides	maculatus	81	Pogonias	cromis	3
Micropogonias	undulatus	69	Alosa	pseudoharengus	2
Libinia	emarginata	68	Carcinus	maenas	2
Centropristis	striata	60	Chaetodon	ocellatus	2
Anchoa	hepsetus	47	Cyprinodon	variegatus	2
Anguilla	rostrata	43	Lutjanus	griseus	2
Tautoga	onitis	41	Sciaenidae	sp.	2
Pomatomus	saltatrix	40	Symphurus	plagiusa	2
Libinia	dubia	30	Unidentified	fish	2
Hippocampus	erectus	29	Archosargus	probatocephalus	1
Fundulus	heteroclitus	27	Astroscopus	guttatus	1
Urophycis	regia	26	Callinectes	similis	1
Chasmodes	bosquianus	25	Caranx	crysos	1
Lagodon	rhomboides	25	Clupeidae	sp.	1
Trinectes	maculatus	24	Conger	oceanicus	1
Cynoscion	regalis	23	Dactylopterus	volitans	1
Gobiosoma	ginsburgi	20	Eucinostomus	argenteus	1
Cancer	irroratus	18	Fundulus	luciae	1
Clupeiformes	sp.	18	Fundulus	majalis	1
Chilomycterus	schoepfi	17	Fundulus	sp.	1
Tautogolabrus	adspersus	17	Gadus	morhua	1
Hypsoblennius	hentz	13	Gasterosteus	aculeatus	1
Menticirrhus	saxatilis	12	Ictalurus	punctatus	1
Etropus	microstomus	11	Morone	saxatilis	1
Ovalipes	ocellatus	11	Mugil	cephalus	1
Peprilus	triacanthus	10	Mycteroperca	microlepis	1
Morone	sp.	9	Peprilus	sp.	1
Morone	americana	8	Perca	flavescens	1
Mustelus	canis	8	Portunus	gibbesii	1
Gobiesox	strumosus	7	Raja	erinacea	1
Gobiosoma	sp.	7	Strongylura	marina	1
Microgobius	thalassinus	7	Synodus	foetens	1
Limulus	polyphemus	6			
Menidia	sp.	6			
Pollachius	virens	6			
Selene	setapinnis	6			

10 Crab species

92 Species - 4110 Individuals

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Libinia	emarginata	68	Carcinus	maenas	2
Centropristis	striata	60	Chaetodon	ocellatus	2
Anchoa	hepsetus	47	Cyprinodon	variegatus	2
Anguilla	rostrata	43	Lutjanus	griseus	2
Tautoga	onitis	41	Sciaenidae	sp.	2
Pomatomus	saltatrix	40	Symphurus	plagiusa	2
Libinia	dubia	30	Unidentified	fish	2
Hippocampus	erectus	29	Archosargus	probatocephalus	1
Fundulus	heteroclitus	27	Astroscopus	guttatus	1
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Chasmodes	bosquianus	25	Caranx	crysos	1
Lagodon	rhomboides	25	Clupeidae	sp.	1
Trinectes	maculatus	24	Conger	oceanicus	1
Cynoscion	regalis	23	Dactylopterus	volitans	1
Gobiosoma	ginsburgi	20	Eucinostomus	argenteus	1
Cancer	irroratus	18	Fundulus	luciae	1
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Peprilus	triacanthus	10	Mycteroperca	microlepis	1
Morone	sp.	9	Peprilus	sp.	1
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Mustelus	canis	8	Portunus	gibbesii	1
Gobiesox	strumosus	7	Raja	erinacea	1
Gobiosoma	sp.	7	Strongylura	marina	1
Microgobius	thalassinus	7	Synodus	foetens	1
Limulus	polyphemus	6			
Menidia	sp.	6			
Pollachius	virens	6			
Selene	setapinnis	6			

Rare species

92 Species - 4110 Individuals

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Morone	americana	8
Mustelus	canis	8
Gobiesox	strumosus	7
Gobiosoma	sp.	7
Microgobius	thalassinus	7
Limulus	polyphemus	6
Menidia	sp.	6
Pollachius	virens	6
Selene	setapinnis	6
Clupea	harengus	5
Menidia	beryllina	5
Prionotus	carolinus	5
Scophthalmus	aquosus	5
Selene	vomer	5
Lepomis	gibbosus	4
Lucania	parva	4
Mugil	curema	4
Stenotomus	chrysops	4
Caranx	hippos	3
Dasyatis	say	3
Libinia	sp.	3
Pogonias	cromis	3
Alosa	pseudoharengus	2
Carcinus	maenas	2
Chaetodon	ocellatus	2
Cyprinodon	variegatus	2
Lutjanus	griseus	2
Sciaenidae	sp.	2
Symphurus	plagiusa	2
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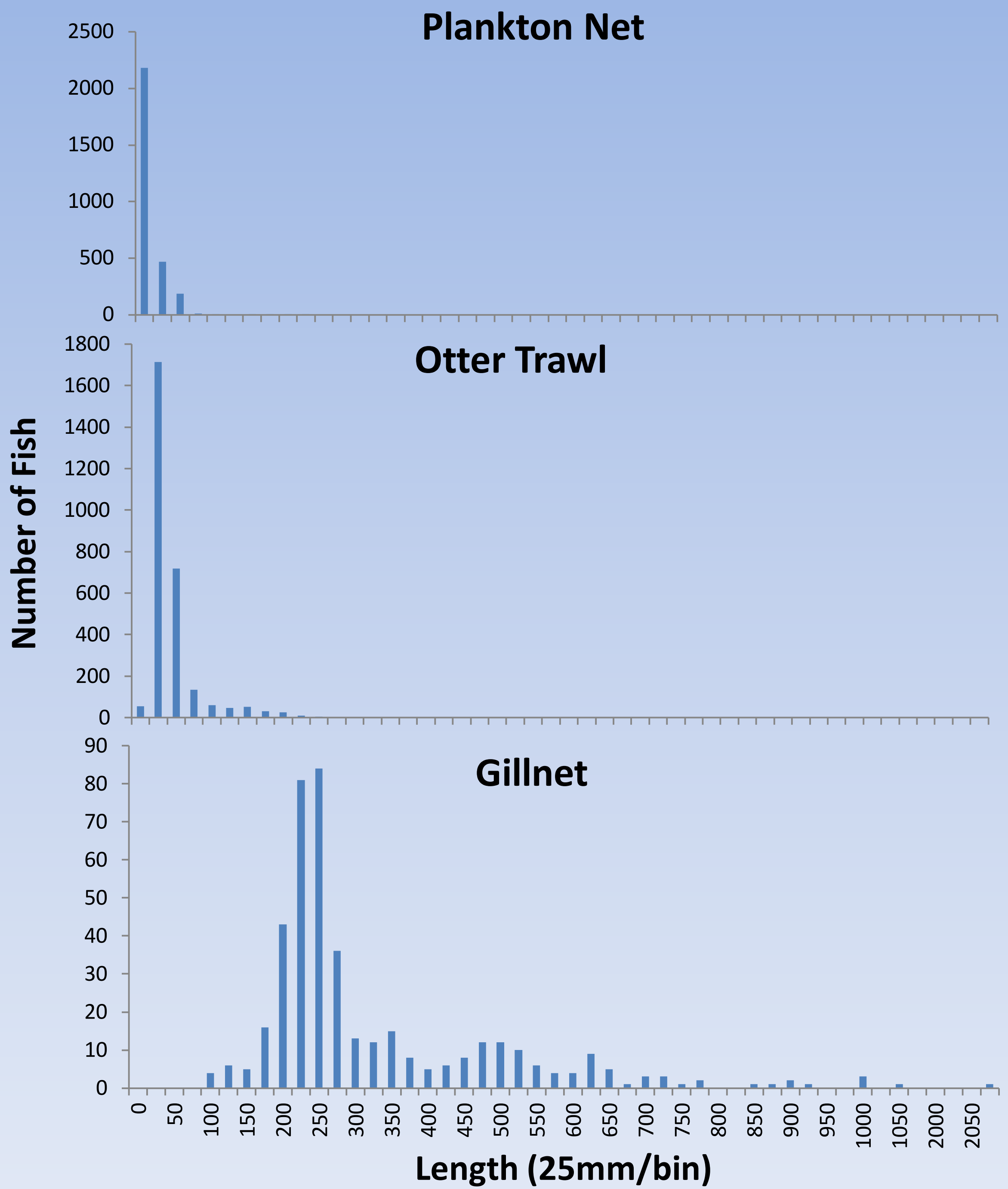
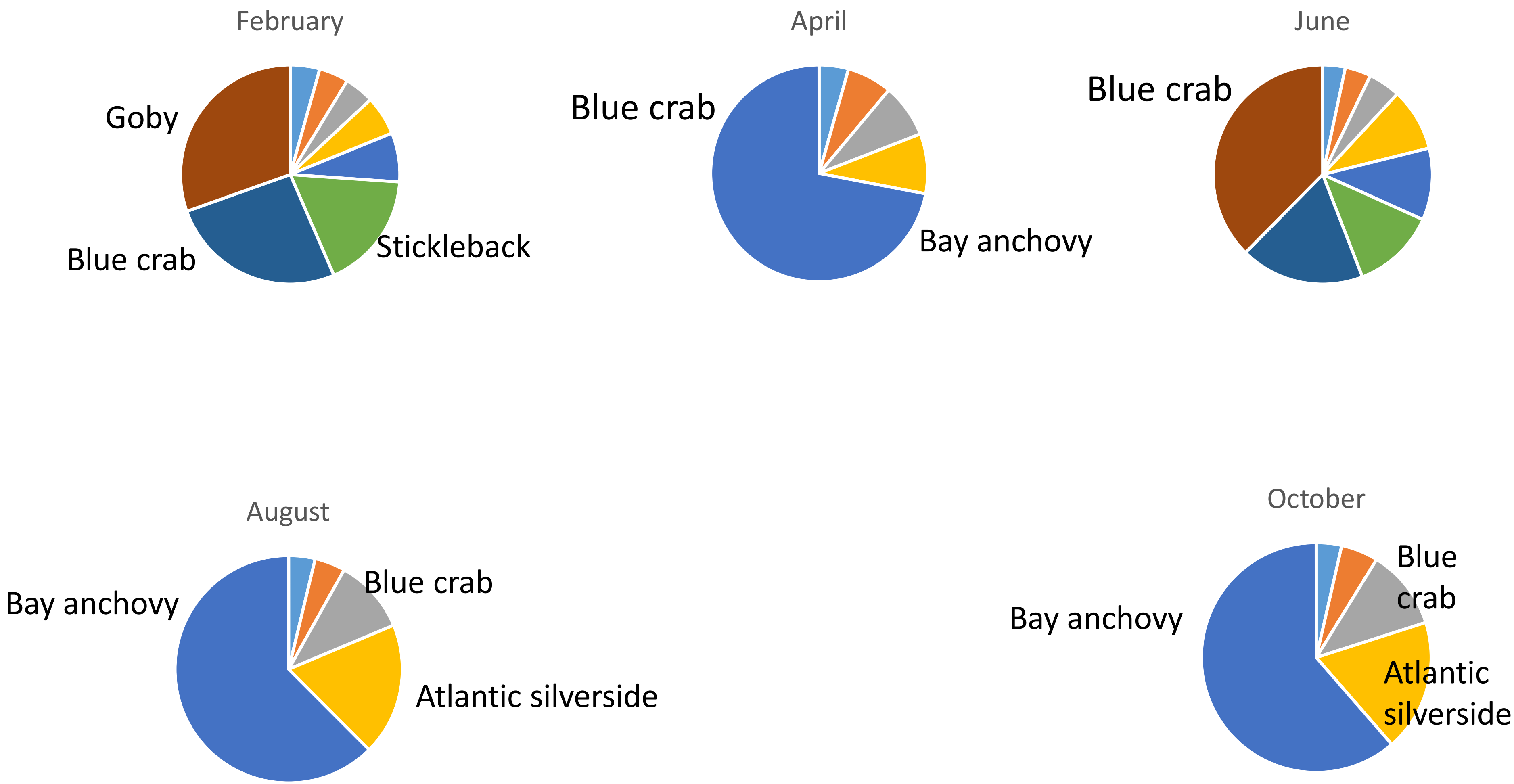
Astroscopus	guttatus	1
Callinectes	similis	1
Caranx	crysos	1
Clupeidae	sp.	1
Conger	oceanicus	1
Dactylopterus	volitans	1
Eucinostomus	argenteus	1
Fundulus	luciae	1
Fundulus	majalis	1
Fundulus	sp.	1
Gadus	morhua	1
Gasterosteus	aculeatus	1
Ictalurus	punctatus	1
Morone	saxatilis	1
Mugil	cephalus	1
Mycteroperca	microlepis	1
Peprilus	sp.	1
Perca	flavescens	1
Portunus	gibbesii	1
Raja	erinacea	1
Strongylura	marina	1
Synodus	foetens	1

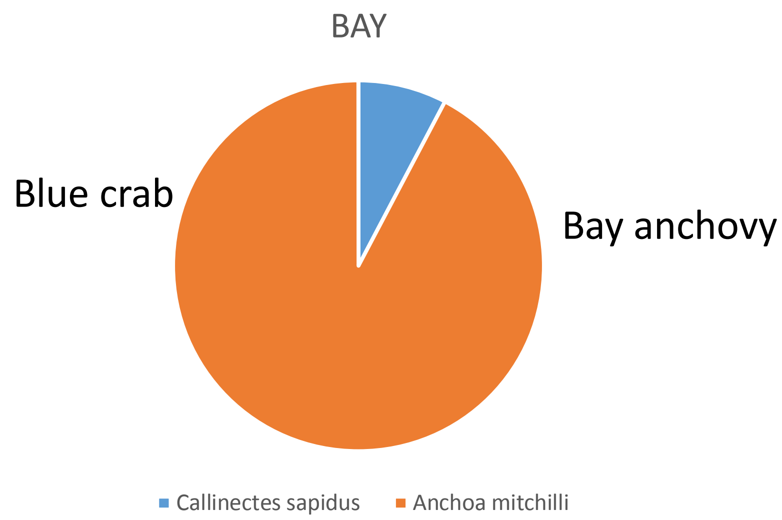
Southern species

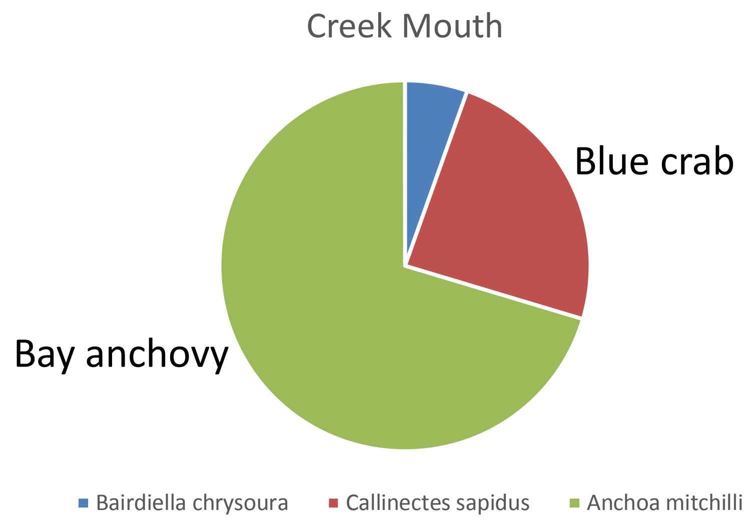

Plankton Net
Otter Trawl
Gillnet
Number of Fish
Length (25mm/bin)
2500
2000
1500
1000
500
0
1800
1600
1400
1200
1000
800
600
400
200
0
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
2000
2050

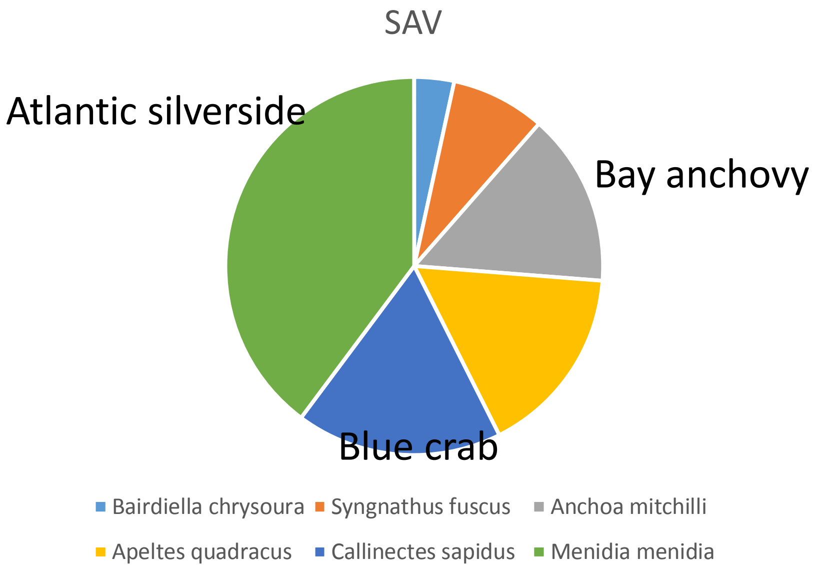
Seasonal Change

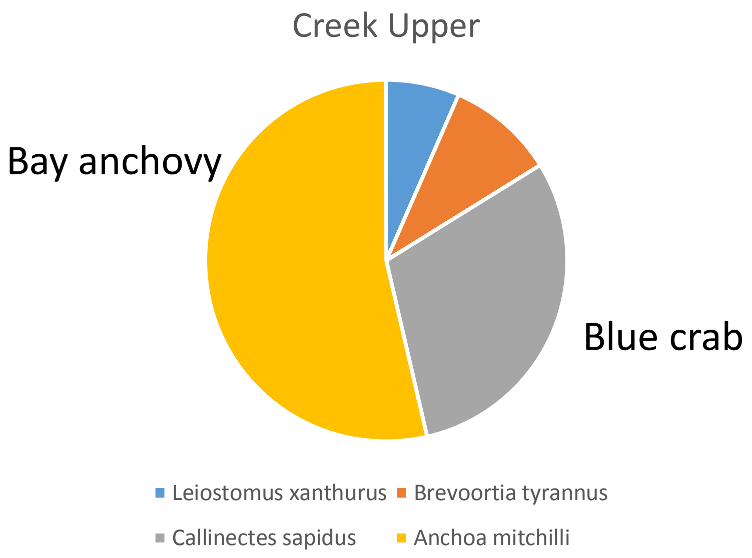


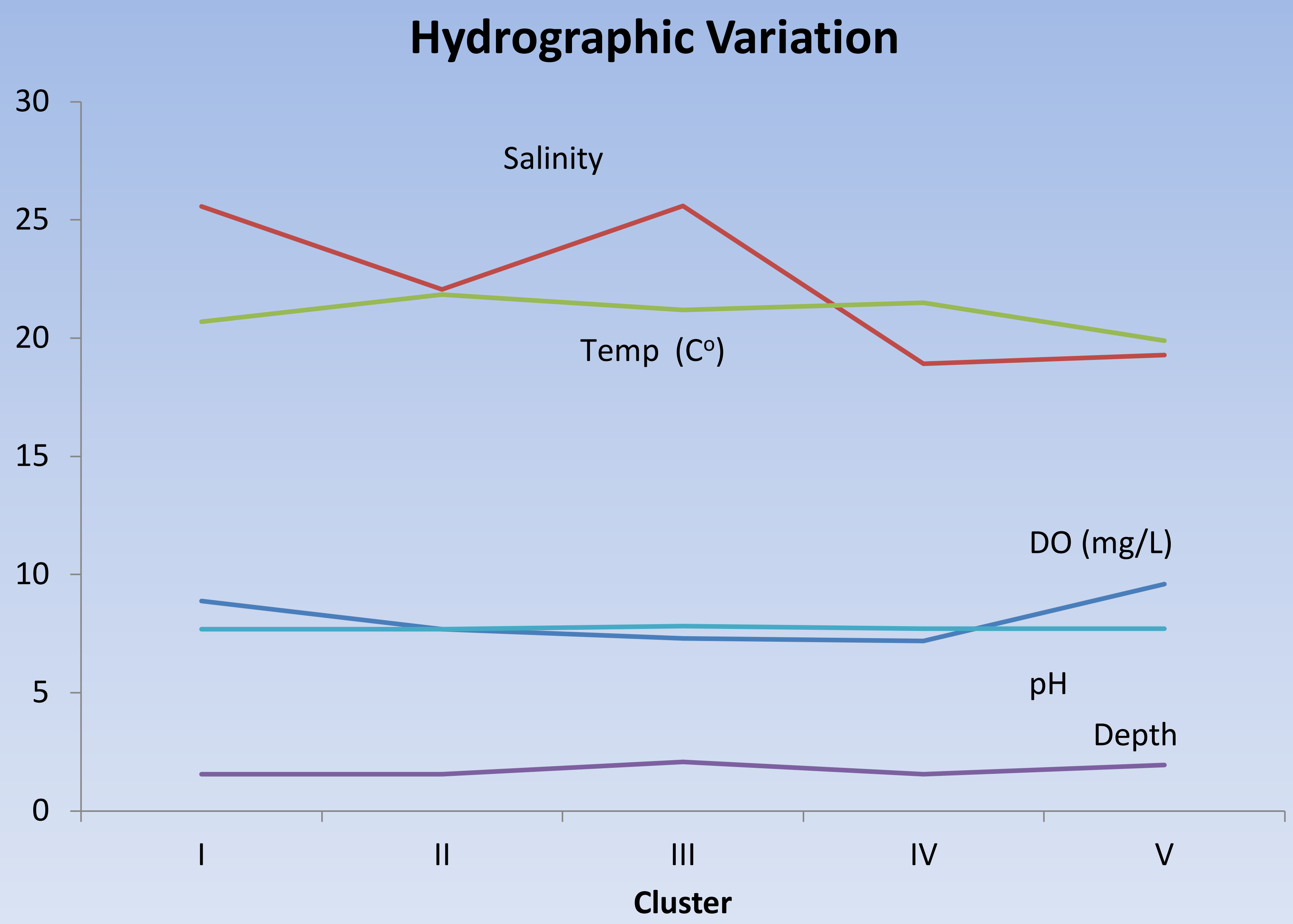
Habitat Segregation



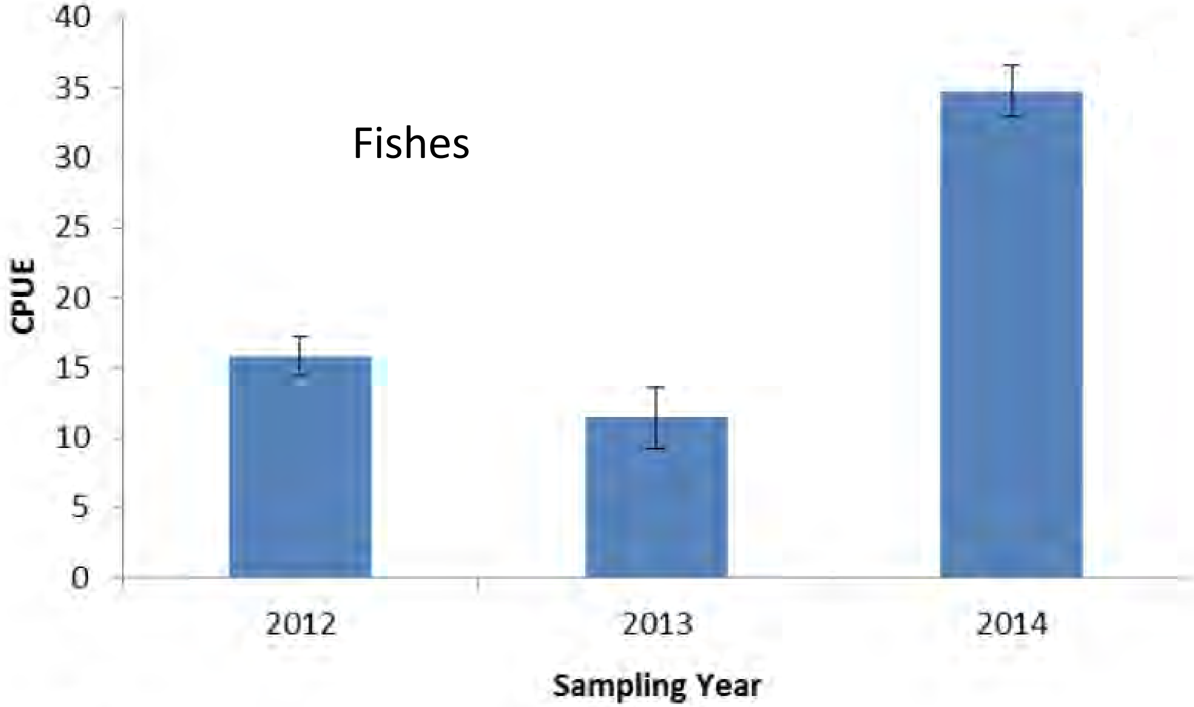


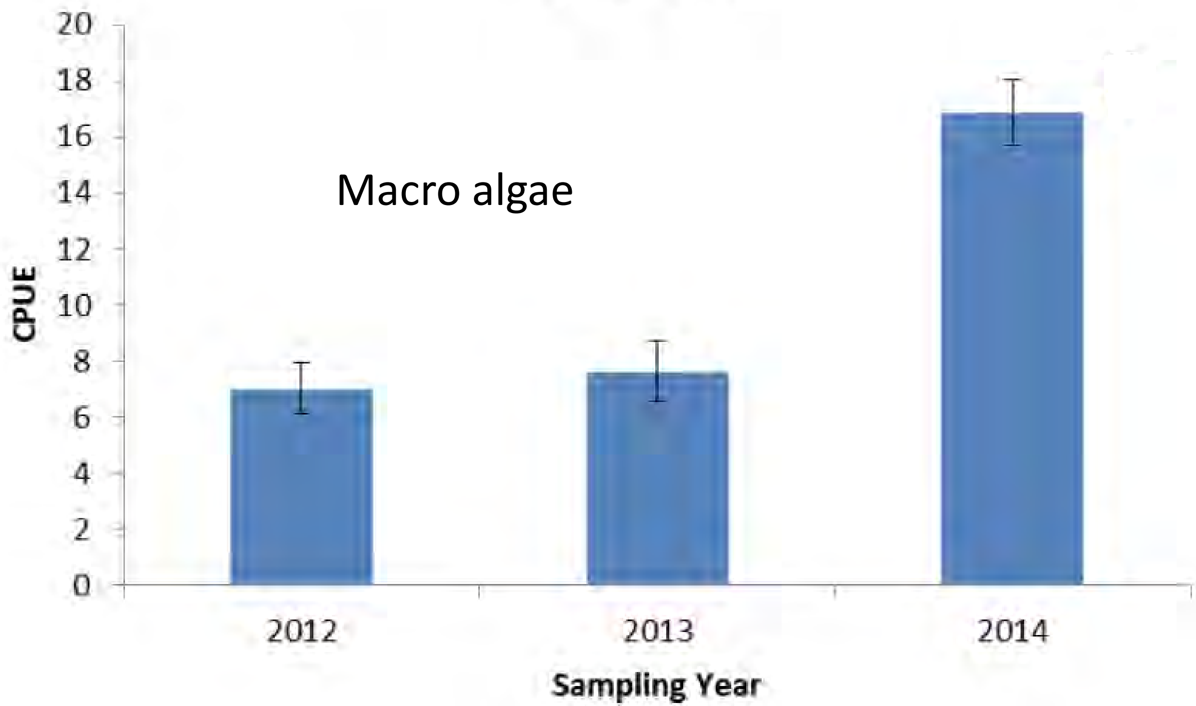




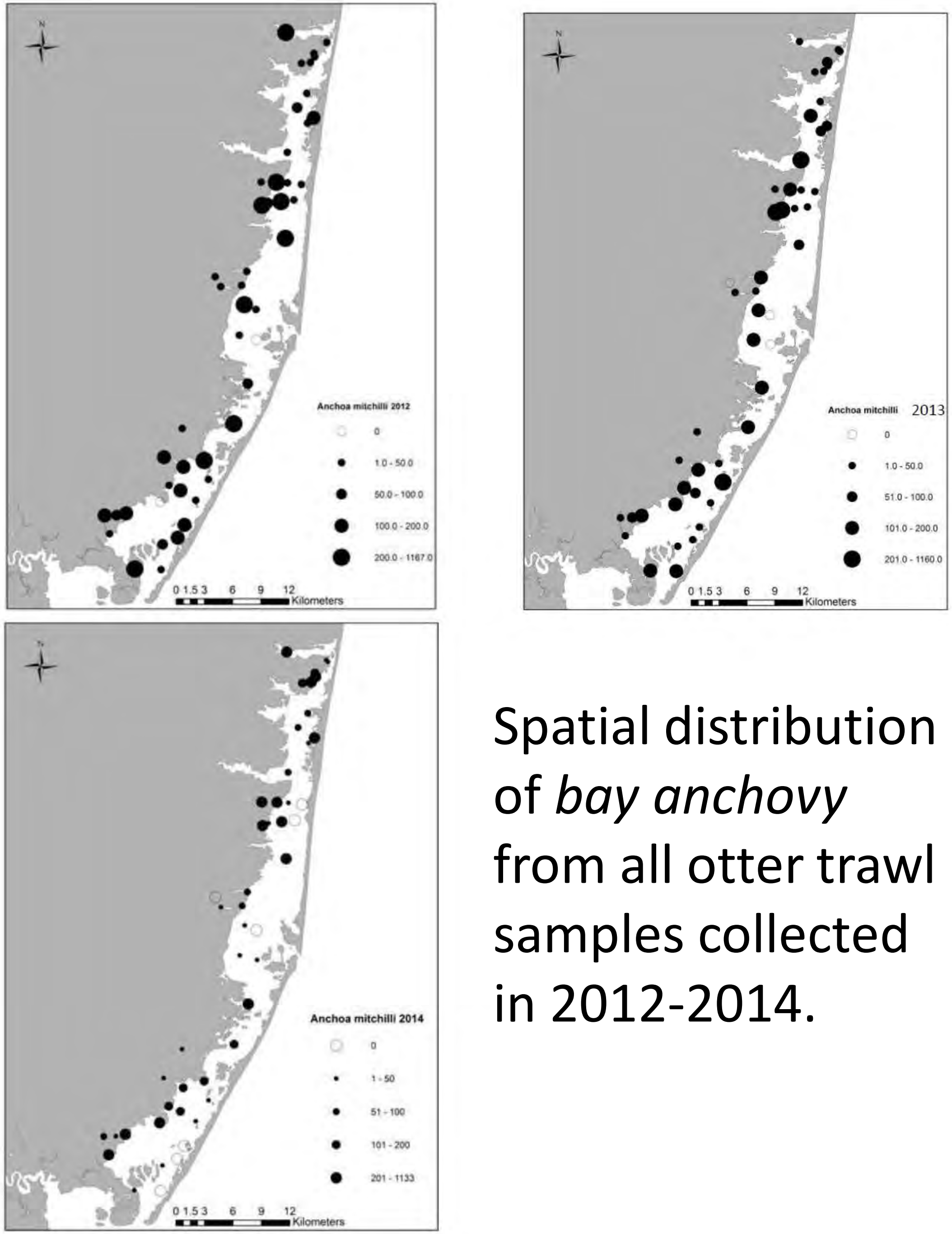


Hydrographic Variation
30
25
20
15
10
5
0
Salinity
Temp (Cº)
DO (mg/L)
pH
Depth
I
II
III
IV
V
Cluster

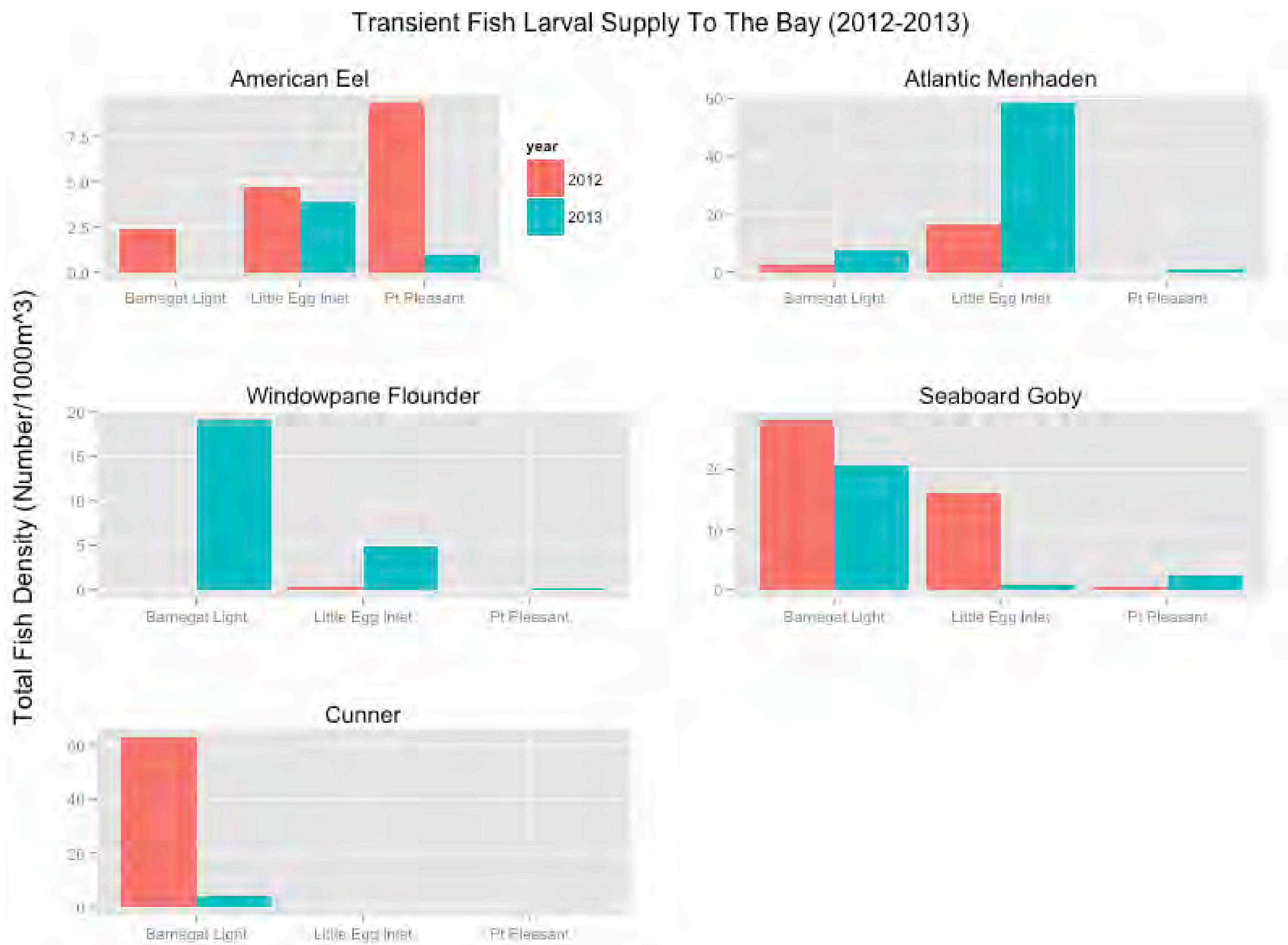




Catch per unit effort (CPUE) (± standard error) by otter trawl across habitats, clusters and adjacent sampling sites, and sampling dates between April and October of 2012-2014.



Spatial distribution of *bay anchovy* from all otter trawl samples collected in 2012-2014.


Transient Fish Larval Supply To The Bay (2012-2013)
Total Fish Density (Number/1000m^3)
American Eel
Atlantic Menhaden
Windowpane Flounder
Seaboard Goby
Cunner
year
2012
2013
Barnegat Light
Little Egg Inlet
Pt Pleasant

Resident Fish Larval Supply To The Bay (2012-2013)
Bay Anchovy
Naked Goby
Atlantic Silverside
Northern Pipefish
Winter Flounder
Total Fish Density (Number/1000m^3)
Barnegat Light
Little Egg Inlet
Pt Pleasant
year
2012
2013


JM EAGLE
SCH40 DWV
WARNING
AVISO

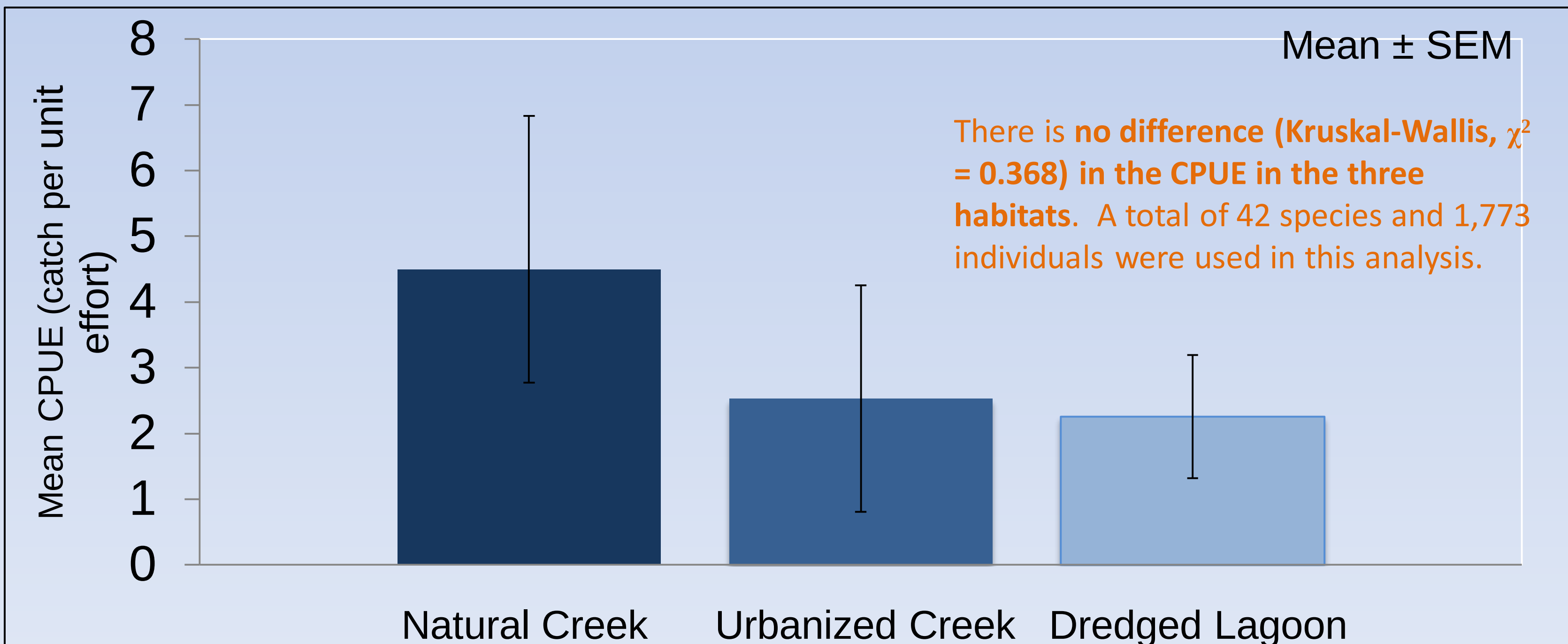
Natural Creek (n=2)

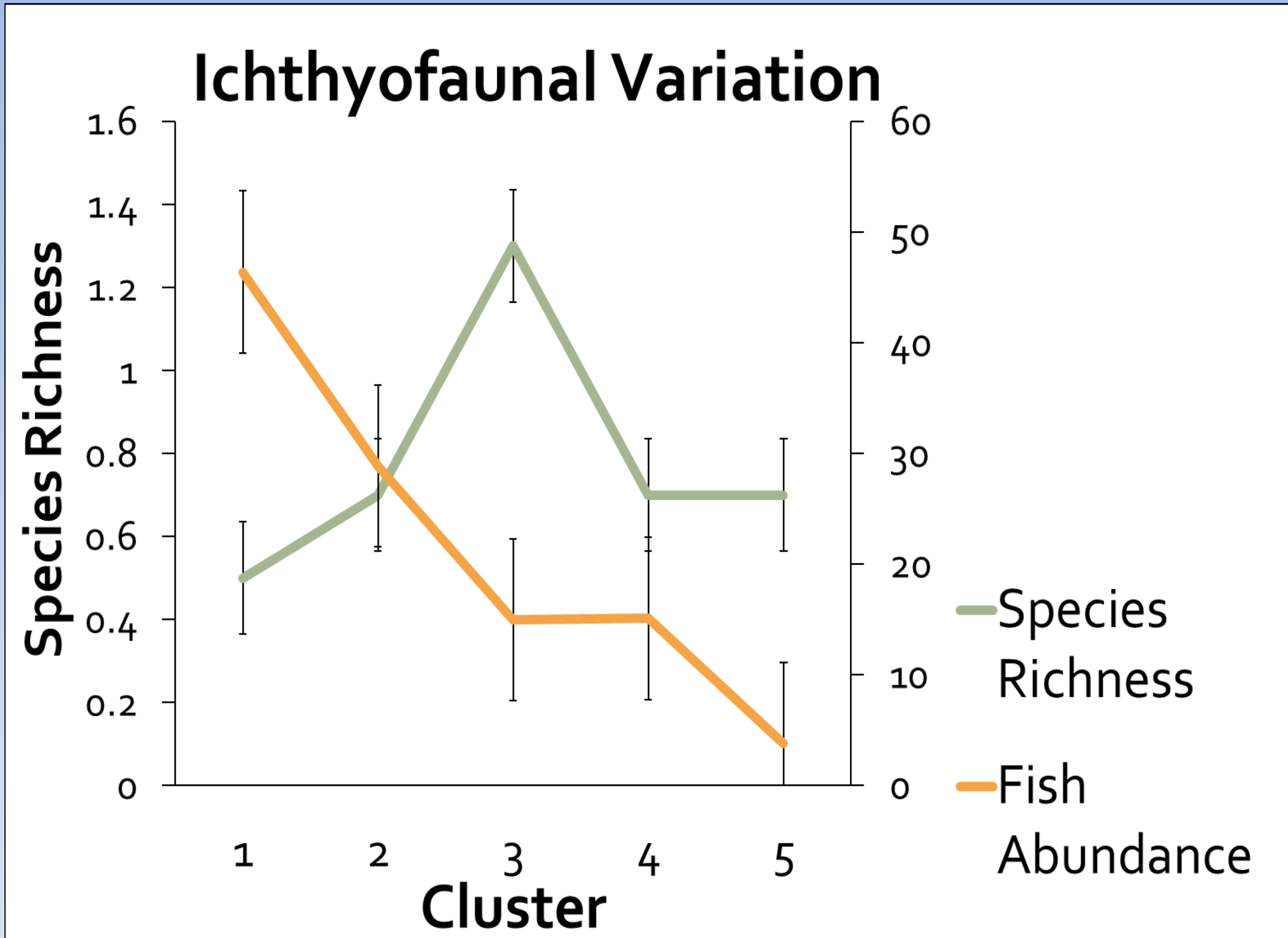
Dredged Lagoon (n=2)

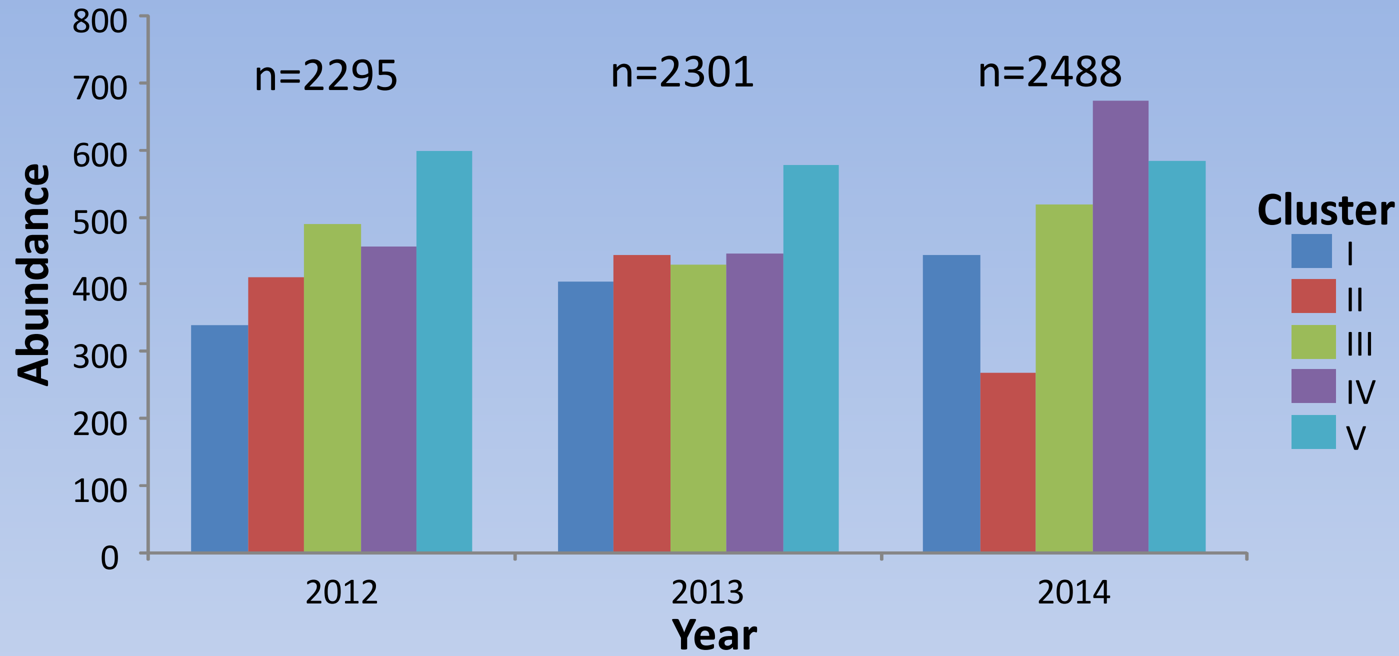
Urbanized Creek (n=2)

Least Most

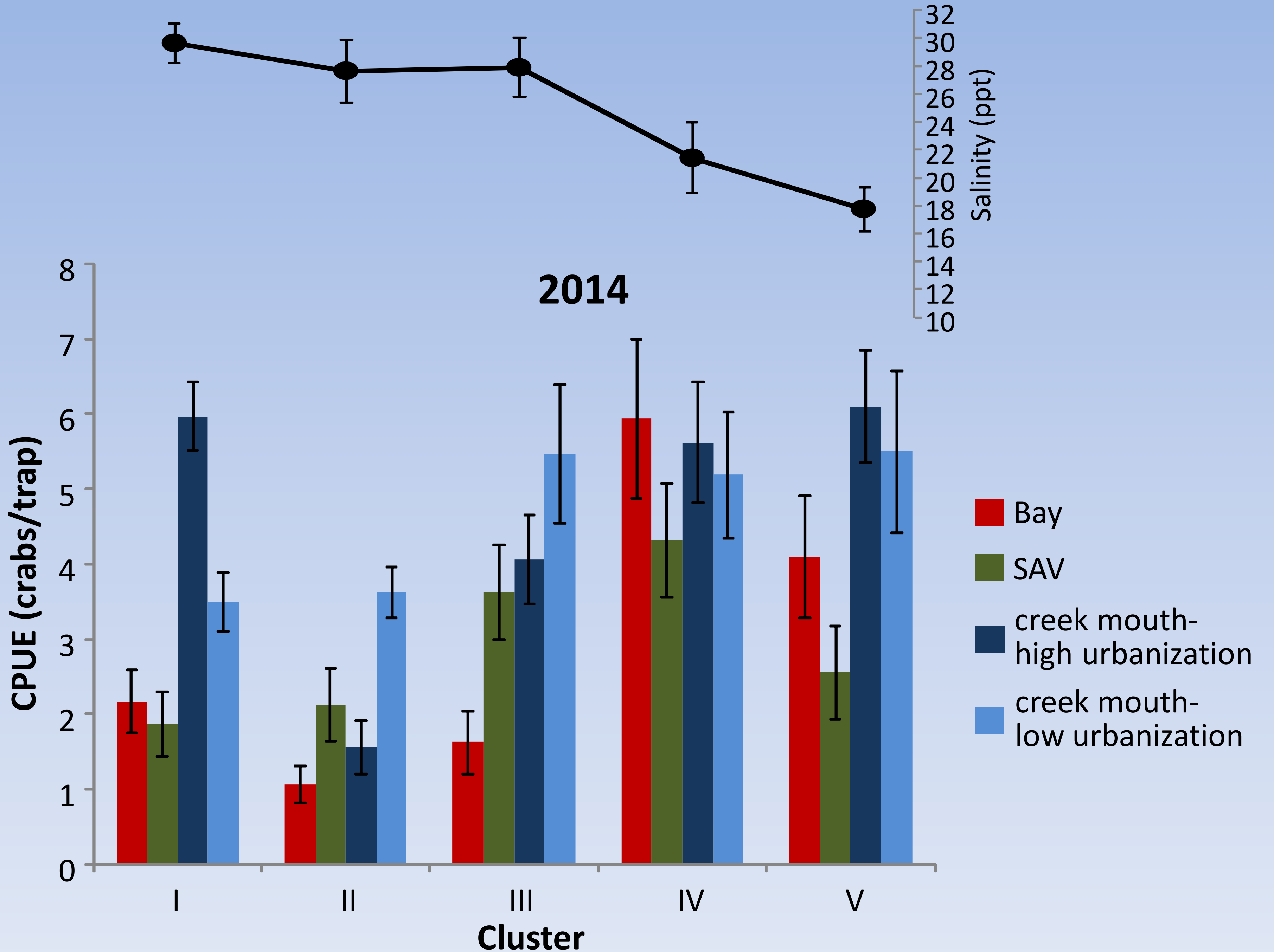
Categories of Human Alteration




Ichthyofaunal Variation
Species Richness
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
60
50
40
30
20
10
0
1
2
3
4
5
Cluster
Species Richness
Fish Abundance


n=2295
n=2301
n=2488
Abundance
800
700
600
500
400
300
200
100
0
2012
2013
2014
Year
Cluster
I
II
III
IV
V


Abundance
800
700
600
500
400
300
200
100
0
2012
2013
2014
Year
Habitat
Bay
SAV
creek mouth-
high urbanization
creek mouth-
low urbanization


2014
CPUE (crabs/trap)
0
1
2
3
4
5
6
7
8
Salinity (ppt)
10
12
14
16
18
20
22
24
26
28
30
32
I
II
III
IV
V
Cluster
Bay
SAV
creek mouth-
high urbanization
creek mouth-
low urbanization

Conclusions

- Environmental variability (seasonal, annual) occurs with salinities, temperatures, and habitats
- Larval fish supply varies annually and seasonally across sources
- Response to urbanization gradients bay-wide is weak and related to inlet flushing
- Within urbanization clusters, fish populations in altered vs. natural creeks are similar, with weak exceptions
- Blue crab distributions reflect proximity to inlet and a higher vulnerability to catch in urban habitats
- This analysis reflects conditions in habitats but does not reflect the loss of habitat across the urbanization gradient

Acknowledgments

- RUMFS Technicians
- USGS – Hydrodynamic model (Neal Ganju and Zafer Defne)
- NSF-REU (RIOS) Interns
- NJDEP – Office of Science

Ecosystem modeling to guide management of Barnegat Bay

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Rutgers University

Olaf Jensen, Michael McCann, and Jennifer Pincin
Department of Marine and Coastal Science,
Rutgers University

Ecosystem Modeling

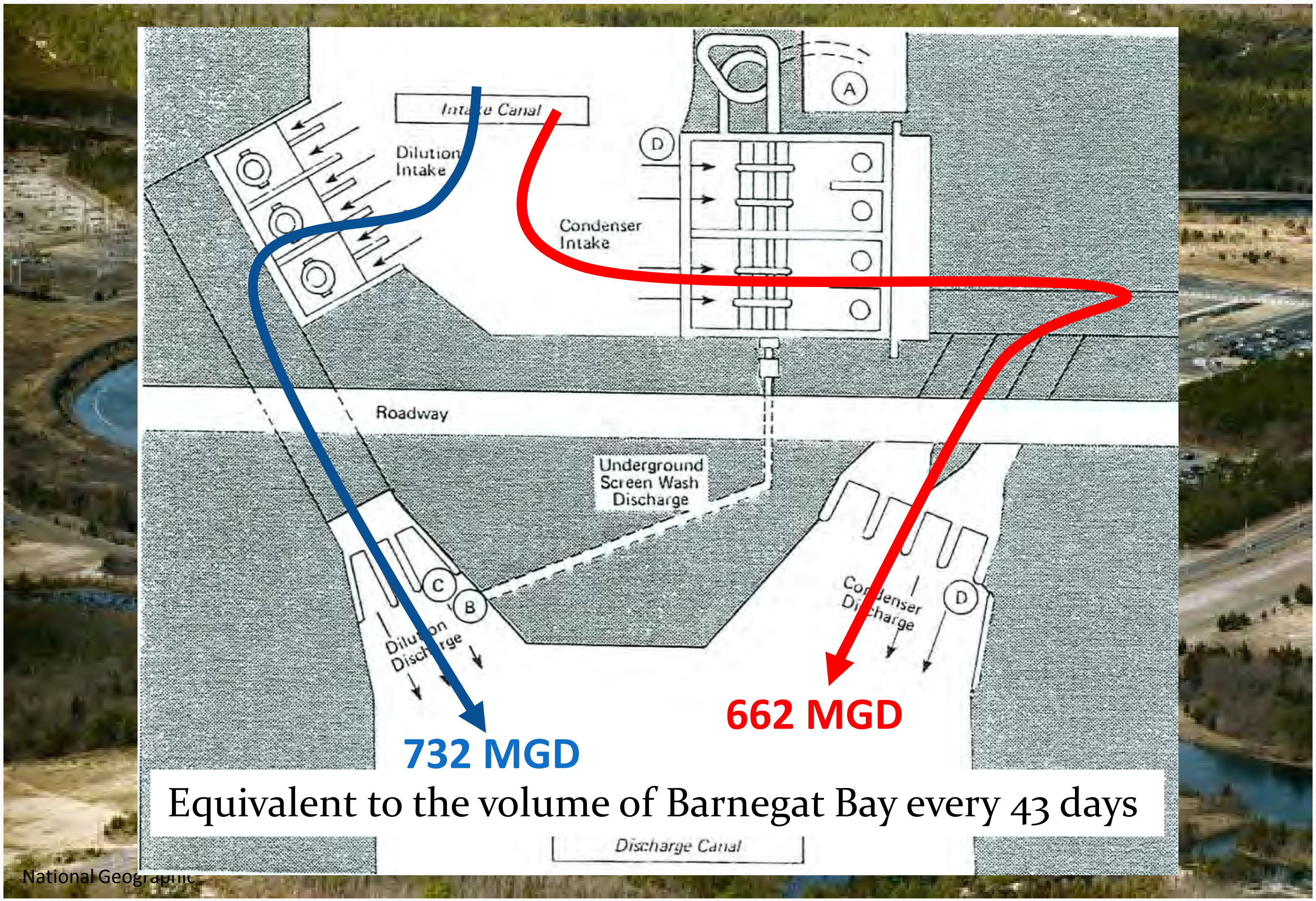
- "All models are wrong. Some models are useful"
  - George Box (statistician)
- Many details are left out. But important ones for the process of interest must be included.
- Can be qualitative or quantitative
- Ecosystem models can be useful for asking questions about secondary or indirect effects.
- Often used to ask "What if…" questions. Management scenarios.

Scenarios

Blue crab

Hard clam

OCNGS


Intake Canal
Dilution Intake
Condenser Intake
Roadway
Underground Screen Wash Discharge
Dilution Discharge
Condenser Discharge
Discharge Canal
A
B
C
D
732 MGD
662 MGD
Equivalent to the volume of Barnegat Bay every 43 days
National Geographic

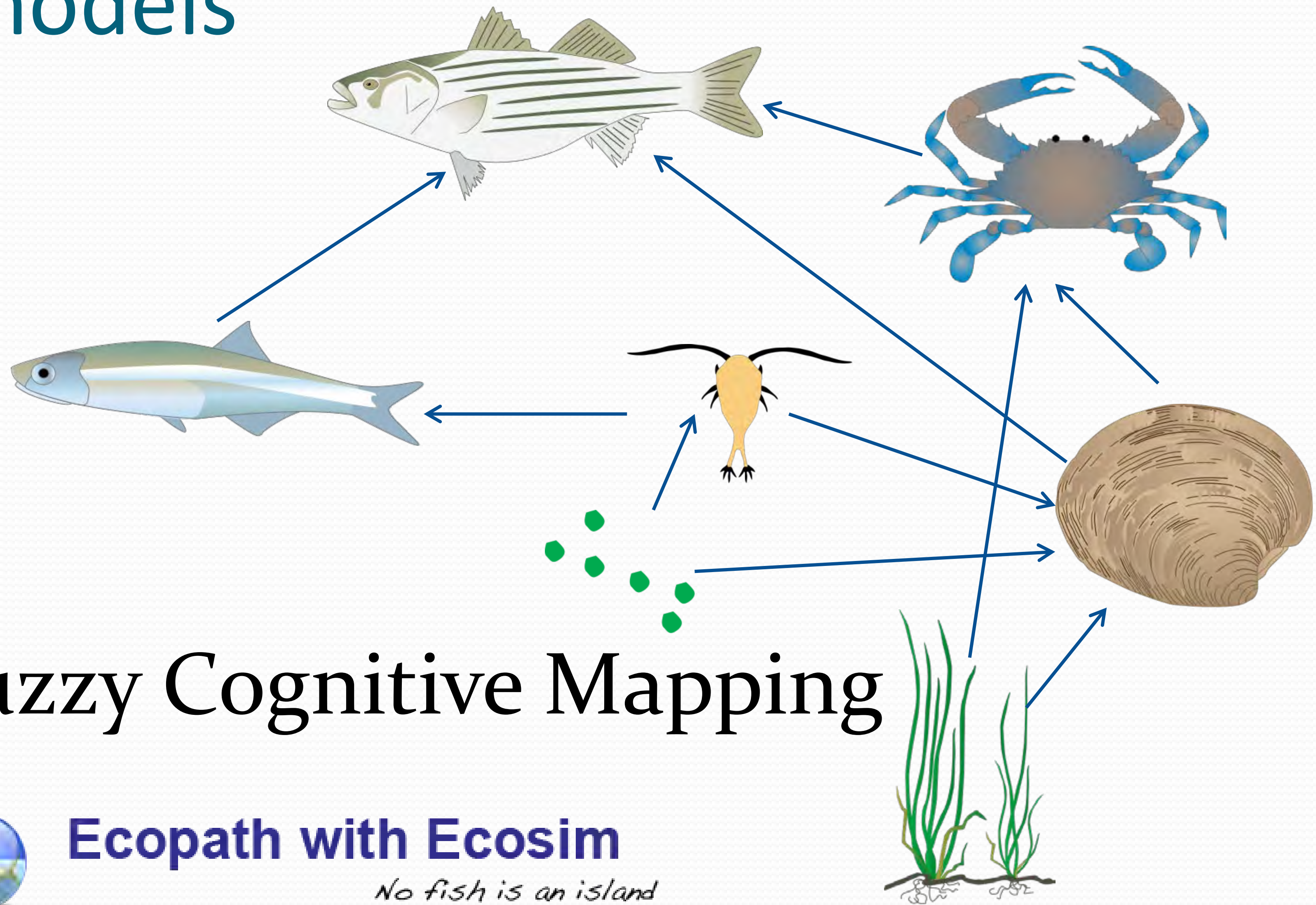
The questions

Are there important differences in stakeholder perceptions of how the BB ecosystem works?

What are the likely effects of different management strategies for blue crab and hard clam?

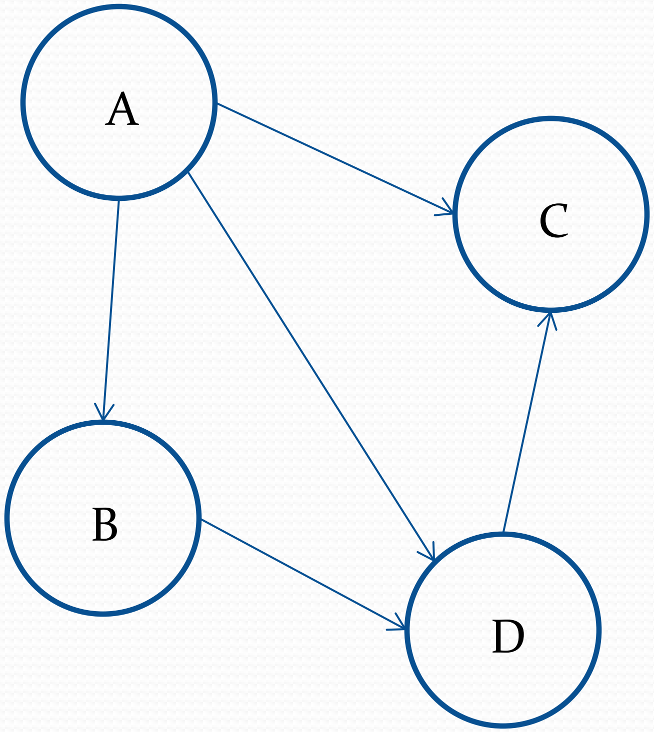
What changes in the biotic community might we anticipate following a 96% reduction in intake at the OCNGS?

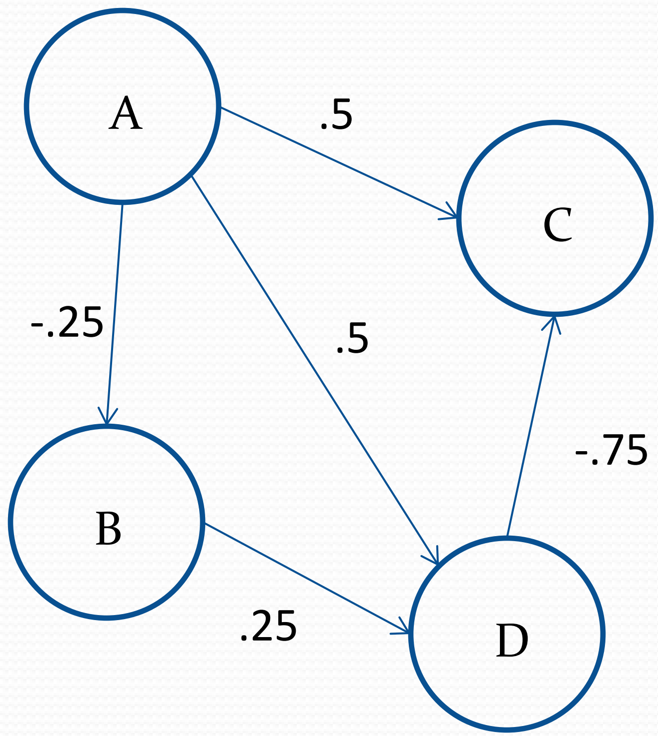
The models



1. Fuzzy Cognitive Mapping
2. Ecopath with Ecosim

No fish is an island


A
C
B
D


A
B
C
D
.5
-.25
.5
-.75
.25

Creating the Barnegat Bay FCM

Stakeholder group	Maps (N)	Occupation/organization/social group
Scientists	19	Academic scientists, federal and state agency research scientists
Managers	11	Federal, state, county, and local resource managers
Environmental NGOs	6	Regional, statewide, and local environmental non-profits
Local residents	6	Baymen, commercial fisherman, local fisherman, longtime residents

"What do you think are the major components and relationships that are important to understanding how the Barnegat Bay ecosystem works?"

What did we learn?

Scientist, Managers, and Local Residents had about the same number of concepts in their maps

Stakeholder group	Scientists	Managers	E-NGOs	Local residents
Maps (N)	19	11	6	6
Number of variables	24.5 (6.7)	25.5 (6.5)	39.3 (21.8)	24.2 (4.8)

What did we learn?

Managers and Scientists see slightly more relationships between the variables than the others.

Stakeholder group	Scientists	Managers	E-NGOs	Local residents
Maps (N)	19	11	6	6
Density	0.08 (0.03)	0.09 (0.03)	0.06 (0.03)	0.06 (0.02)

What did we learn?

Scientists	Managers	E-NGOs	Local people	Community
Nutrients	Development	OCNGS	Seagrass	Development
Development	Human population	Atmospheric deposition	Development	Seagrass
Seagrass	Bay water quality	Bay salinity	Human population	Nutrients
Bay salinity	Impervious surfaces	Bay water temp	Public awareness	Human population
Gelatinous zooplankton	Nutrients	Climate change	Bay ecological condition	
	OCNGS	Development	Boating	
		Freshwater input	Fertilizers	
		Impervious surfaces	Gelatinous zooplankton	

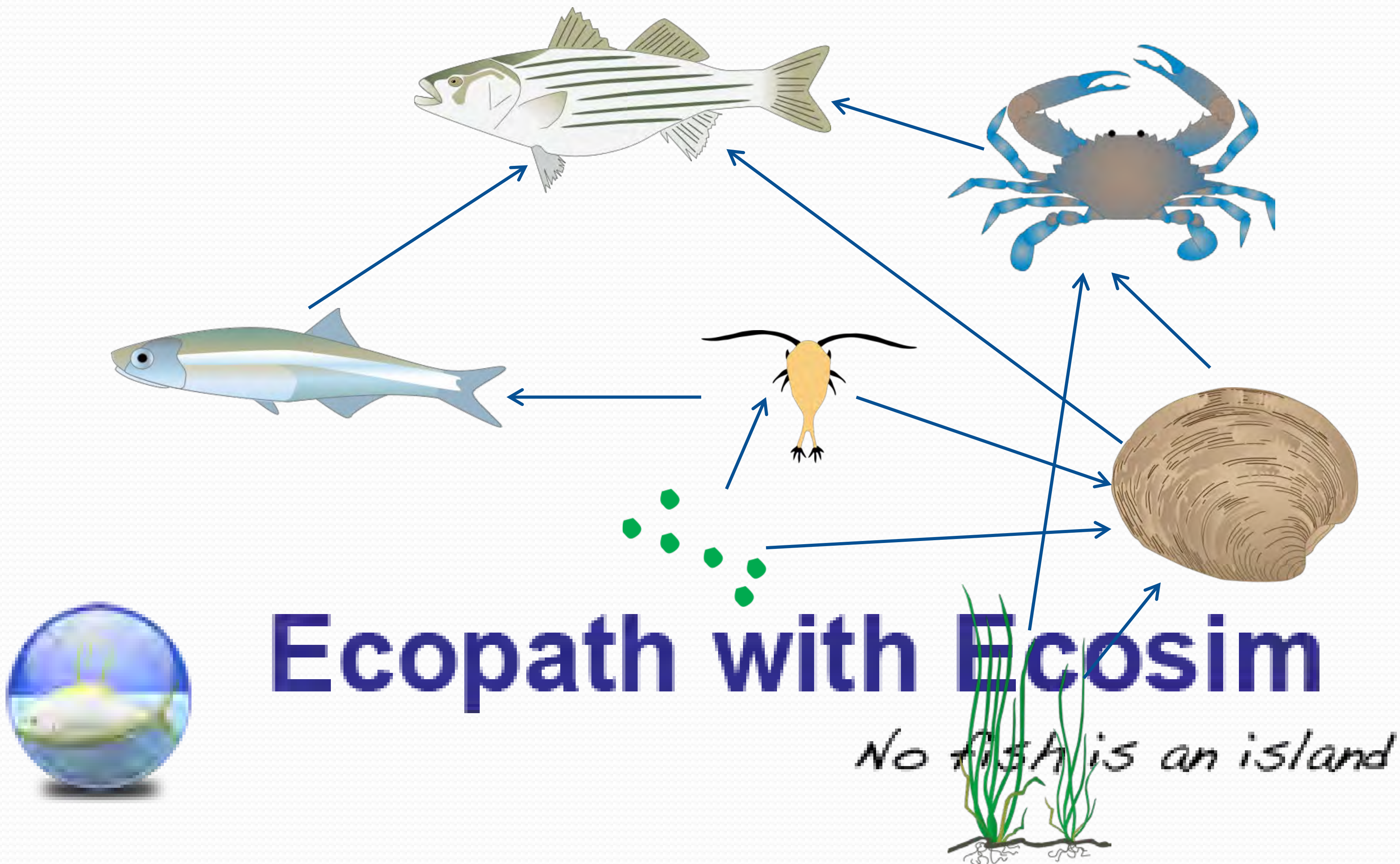
The Take Home Message

There is little difference between the stakeholder groups in the major indices

The stakeholder groups share many of the most mentioned variables, particularly Scientists and Locals

There is a common understanding of the major pressures and drivers, but the biotic responses are less well defined and agreed upon (other than seagrass)

The models

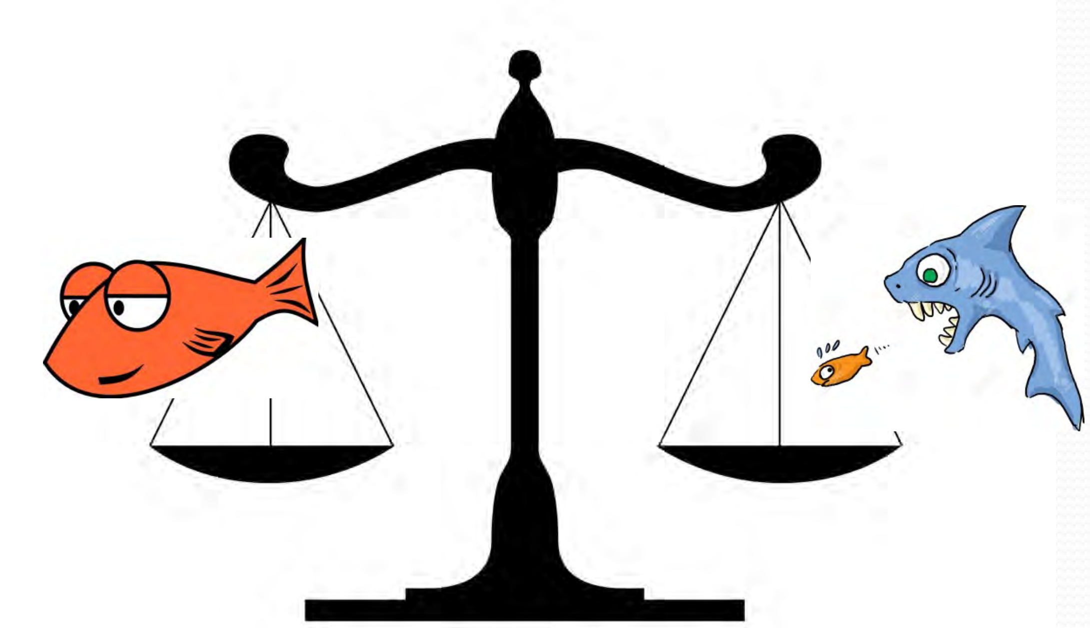


Ecopath with Ecosim

Ecopath inputs

- Biomass
- Production
- Consumption
- Ecotrophic Efficiency
- Diet
- Landings
  - commercial
  - recreational
  - OCNGS

Total production within a group = total removals from that group

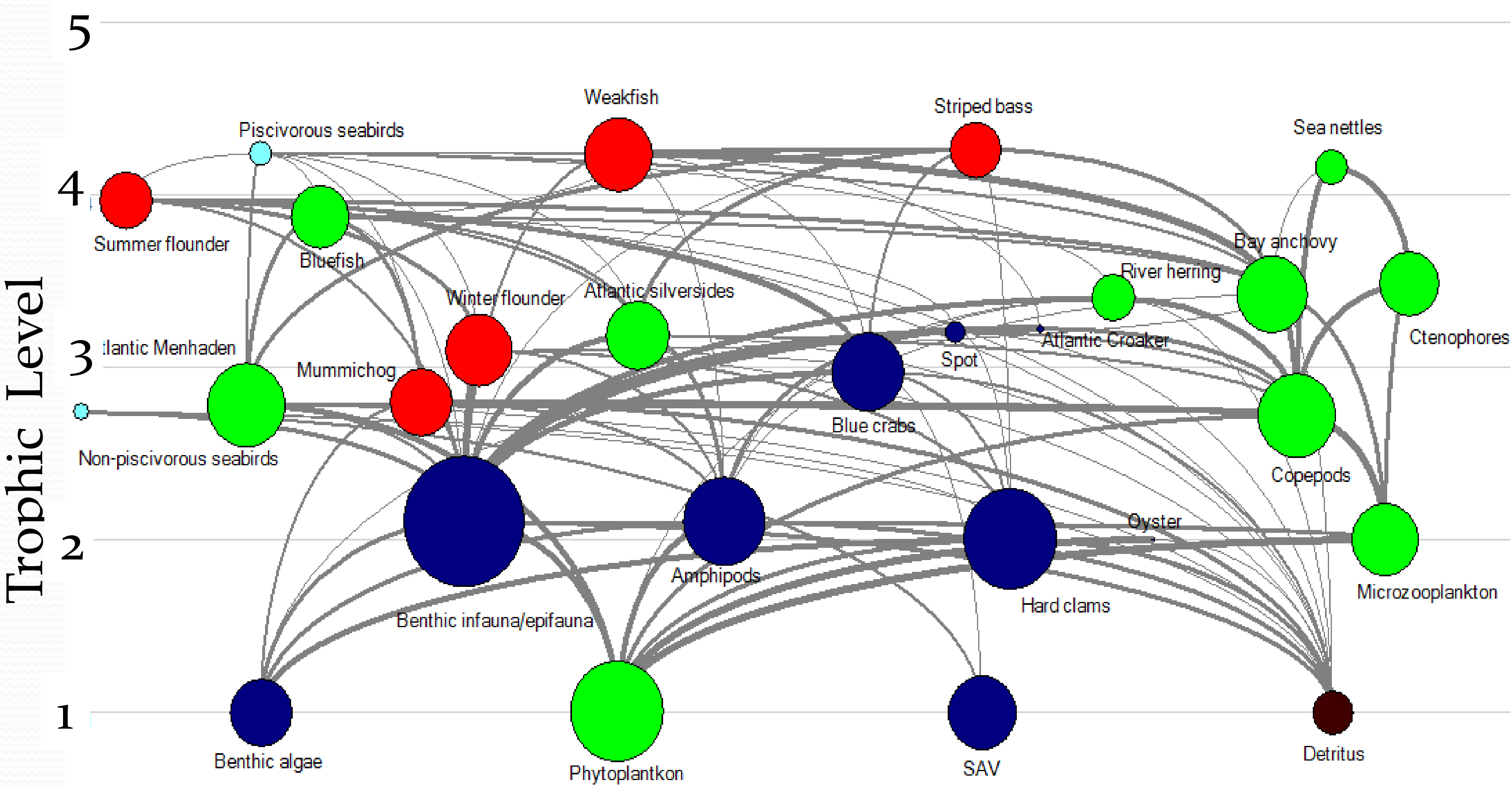


The Ecopath model

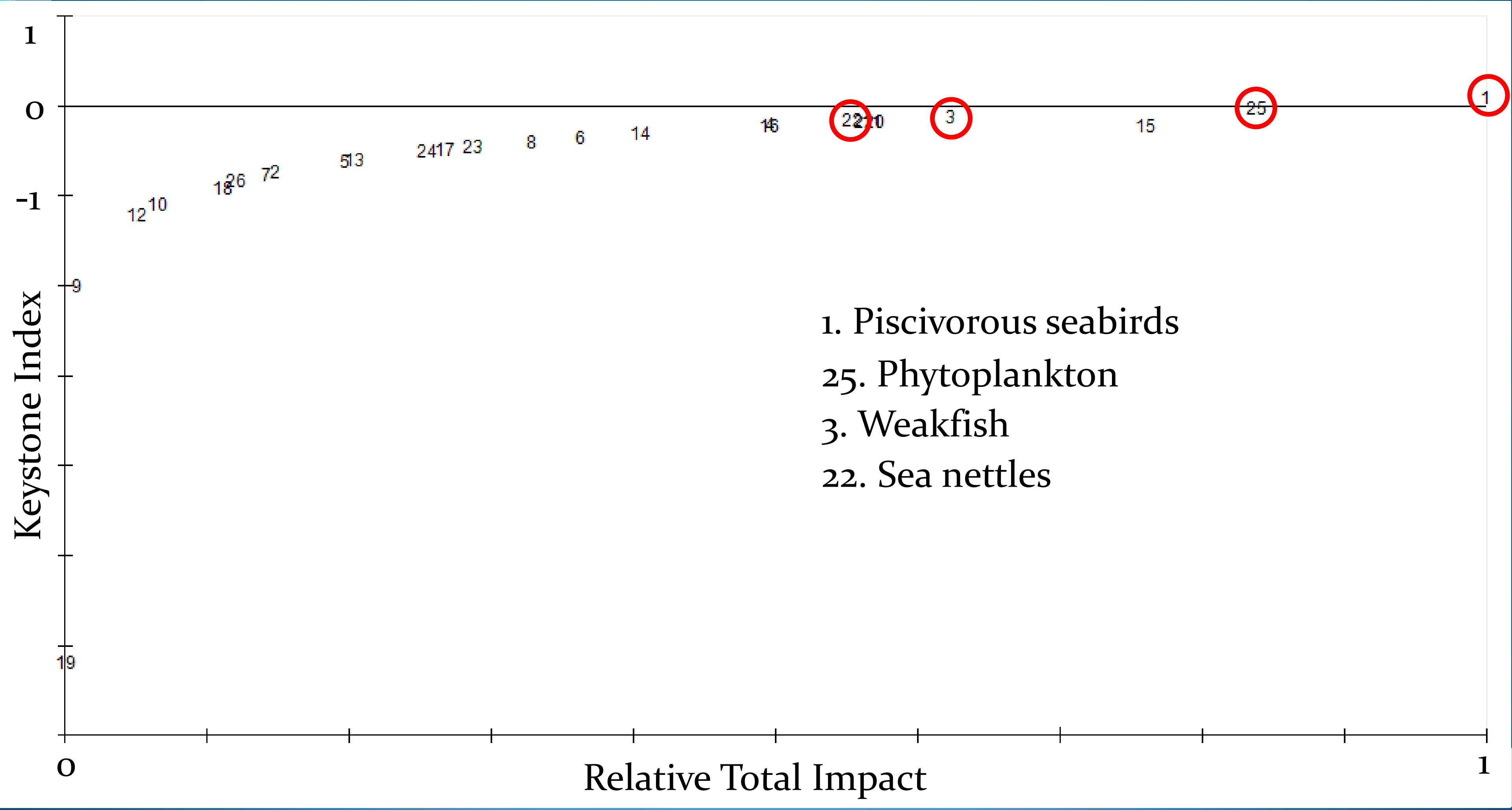
27 Compartments

- Seabirds – Piscivorous, Non-piscivorous
- Lg pelagics – Bluefish, Striped bass
- Demersal fish – Atlantic croaker, Mummichog, Spot, Summer flounder, Winter flounder, Weakfish
- Small pelagics – Atlantic menhaden, Atlantic silverside, Bay anchovy, River herring,
- Benthos – Blue crabs, Hard clams, Oyster, Amphipods, Benthic infauna/epifauna
- Zooplankton – Sea nettles, Ctenophores, Copepods, Microzooplankton
- 1^{o} producers – Phytoplankton, Seagrass, Benthic algae

Ecopath results – Barnegat Bay 1981



Keystoneness

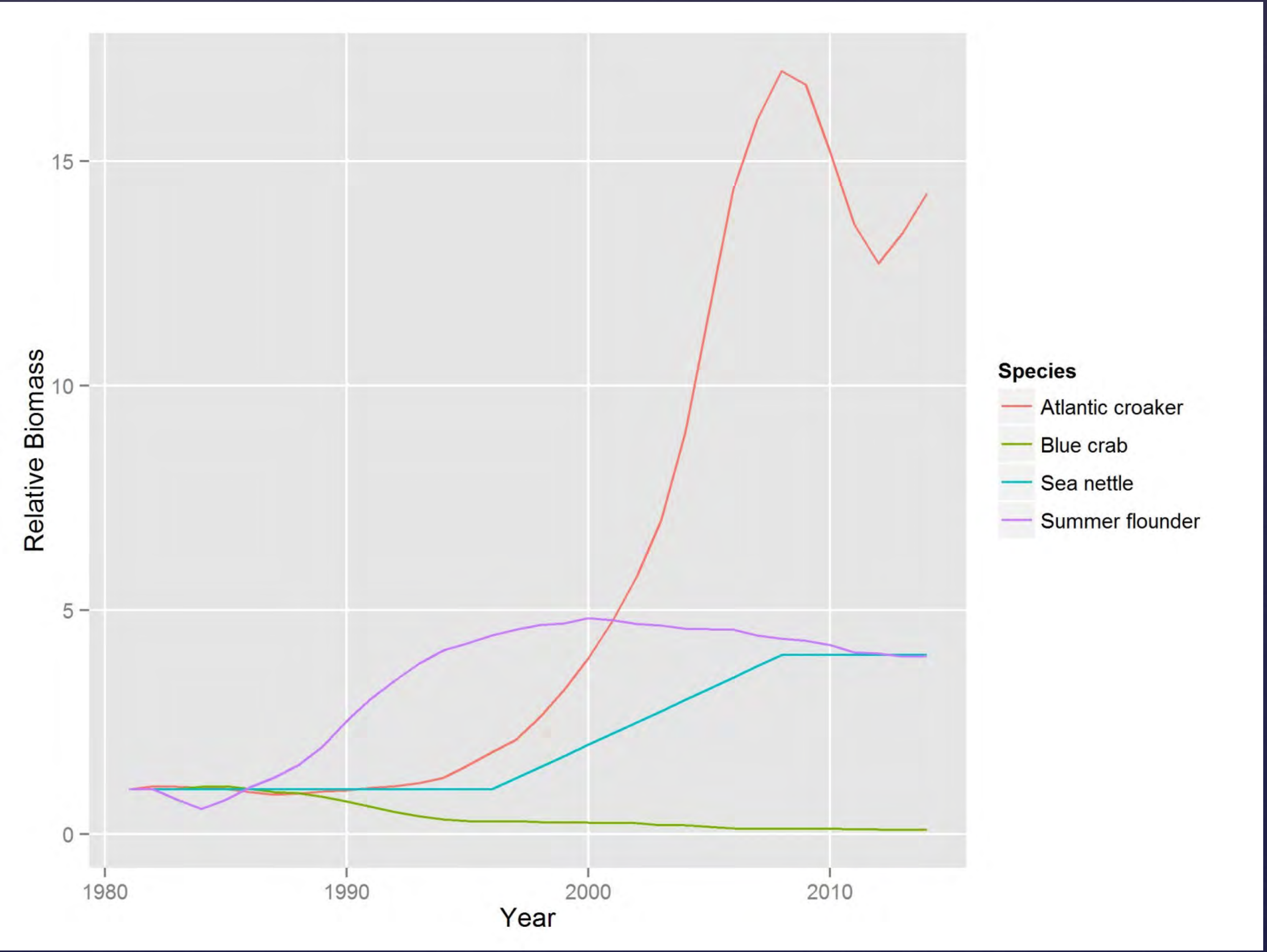


Scenario modeling

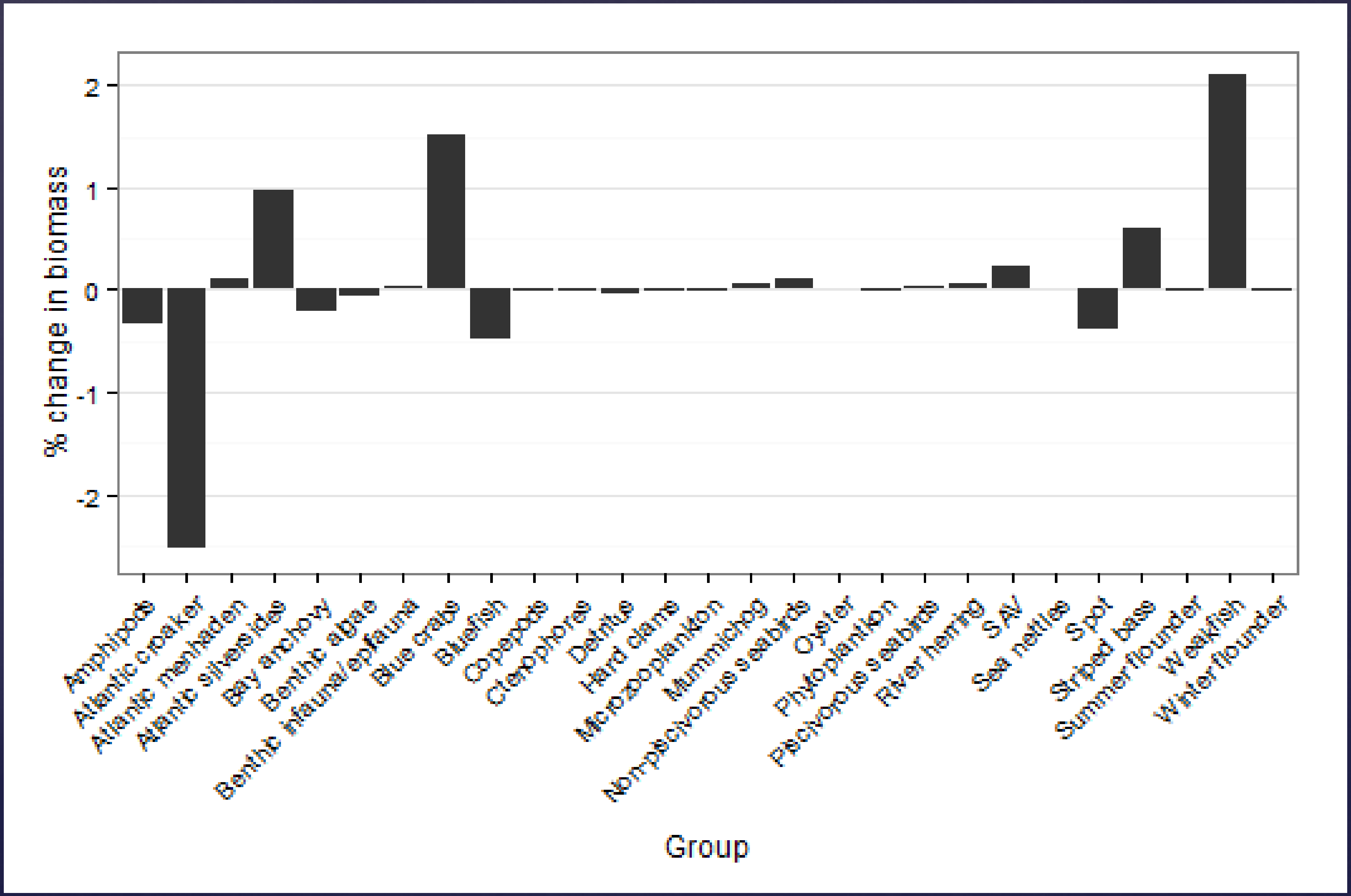
- Run a "baseline" scenario to 2030.
  All forcing (harvest, forcing functions, *etc.*) remains at 2011 levels

- Management Scenarios
  - OCNGS reduced to 4% of 2011 value in 2020.
  - Blue crab harvest 2x and ½ by gear
  - Hard clam limited landings and moratorium

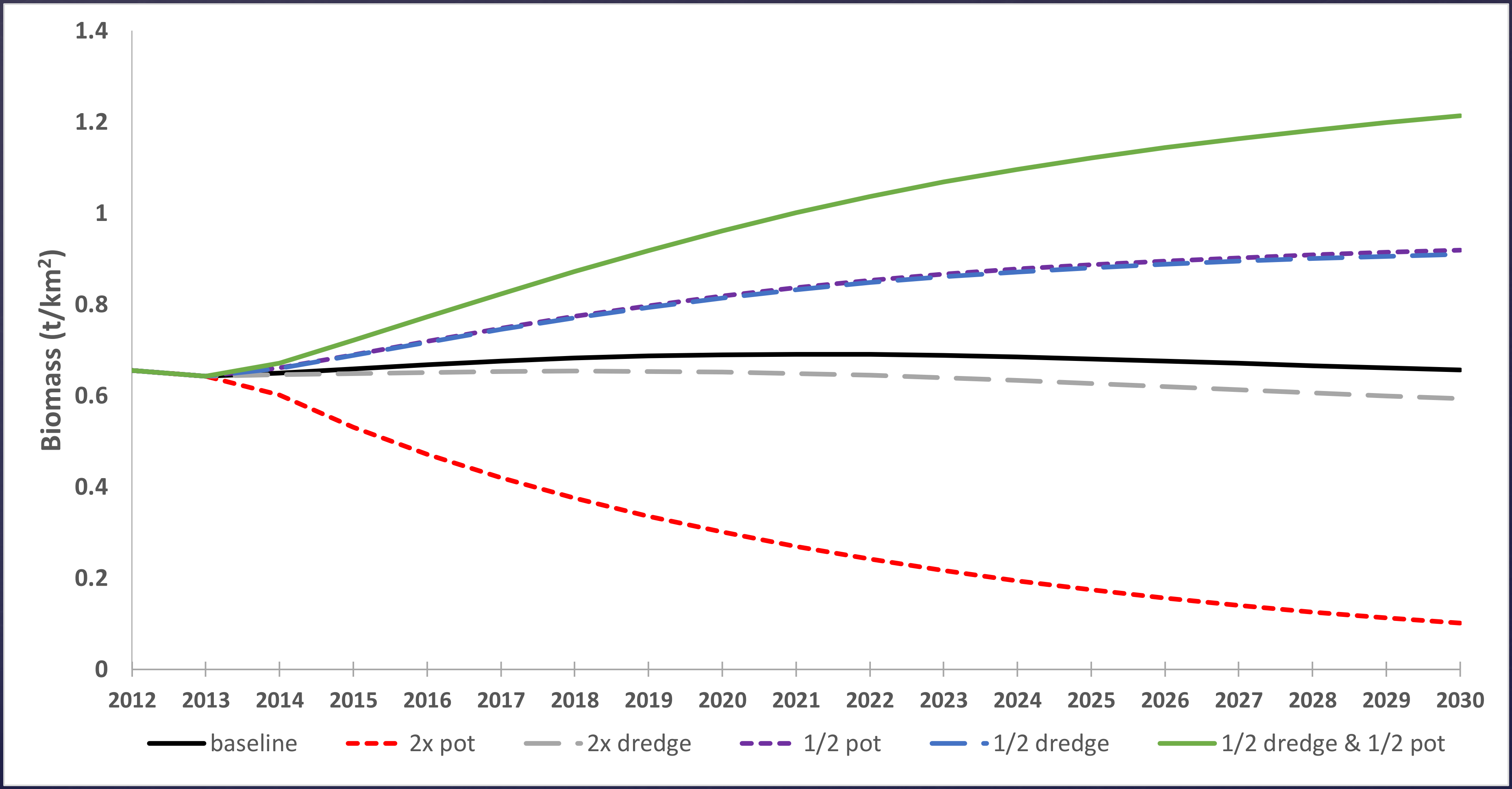
Ecosim 1981-2011 simulation



OCNGS closure scenario



Blue crab harvest control



Baseline Dredge– 44 MT   Baseline Pot – 210 MT

Hard Clam scenarios

NO CHANGE

Scena… 000 lbs limit 2012-2030

Scenario 2 – … m 2012-2022

25,0… it 2023-2030

Acknowledgements

N.J. Department of Environmental Protection

U.S. Environmental Protection Agency

Dr. Howard Townsend

Barnegat Bay research data contributors and Tom Belton


Questions?