Environmental and Ecological Research in Barnegat Bay (2011 -2014)

Thomas Belton, Gary Buchanan, Joseph Bilinski, Bruce Ruppel, Robert Hazen and Lee Lippincott

New Jersey Department of Environmental Protection
Office of Science

New Jersey Water Monitoring Council and Barnegat Bay Partnership
Joint Technical Meeting on Barnegat Bay

Ocean County College, Toms River, NJ
Arts and Community Center
February 6, 2013
Human Impacts on Estuary

- 1. Eutrophication (Cascading Ecosystem Decline)
- 2. Power Plant Operation Impingement, Entrainment, Thermal Discharges
- 3. Habitat Loss and Alteration (Estuary and Watershed)
- 4. Stormwater/Pathogens
- 5. Hardened Shorelines/Reduced Biodiversity
- 6. Reduced Freshwater Input/Altered Salinity/Susceptibility
- 7. Invasive Species (Sea Nettles, Chinese Mitten Crabs)
- 8. Dredging/Boating/Jet Skis
- 9. Marina Operations
- 10. Climate Change/Sea-Level Rise
- 11. Chemical Contaminants
- 12. Trash/Floatables
Change in Barnegat Bay Land Use at Forked River and Oyster Creek (1931 and 2011)
Governor’s 2010 Barnegat Bay Comprehensive Plan of Action

1. Closing Oyster Creek Nuclear Power Plant
2. Funding Stormwater Mitigation Projects
3. Reducing Nutrient Pollution from Fertilizer
4. Requiring Post-Construction Soil Restoration
5. Acquiring Land in the Watershed
6. Establishing a Special Area Management Plan
7. Adopting More Rigorous Water Quality Standards
8. Educating the Public
9. Producing More Comprehensive Research
10. Reducing Water Craft Impacts
Governor’s Comprehensive Plan of Action for Barnegat Bay

• Plan 9: Produce More Comprehensive Research
  – Support water quality improvement (nutrient criteria)
  – Establish the baseline conditions of the bay
  – Fill in critical data gaps
  – Advance habitat restoration on the bay
  – Elements of the 10 point plan action plan are at http://www.nj.gov/dep/barnegatbay/
Barnegat Bay
Generic Estuarine Ecosystem
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Objectives

- Describe temporal and spatial distribution of phytoplankton
- Identify species composition and succession, and investigate the effects of environmental change on phytoplankton community
- Compare with previous studies to assess long-term change of phytoplankton community
- Provide baseline information on the diversity and distribution of phytoplankton for water-quality assessment, management and restoration efforts
**Samples**

**Grab samples:**
6 buoy sites plus BB01, 04 and 10

**Frequency**

Monthly: Sept-Dec 2011

Biweekly: Jan-Mar 2012

Oct-Dec 2012

Weekly: Apr-Sept 2012

synchronized with NJDEP water quality grab sample collections, by NJDEP Leeds Point, Monmouth and EPA
Preliminary Phytoplankton Results

- Phytoplankton community showed large difference in species composition between Northern, Center and Southern sites.
- Northern sites are more characterized with *Nannochloris atomus*, small phytoflagellates.
- Center area is abundant with a mixture of small centric diatoms (<10 µm) and small flagellates.
- Southern sites are more dominated by undetermined pico-size coccoids and chain-forming diatoms.
- Sometimes, phytoplankton in neighboring sites was very different (BB09 and BB10).
- Dominant species from the same site changed with seasons. Sept-Oct-Jan-Mar.
2. BASELINE CHARACTERIZATION OF ZOOPLANKTON IN BARNEGAT BAY

Jim Nickels¹ Ursula Howson² Tom Noji³ Jennifer Samson³
¹Urban Coast Institute, Monmouth University, ²Department of Biology, Monmouth University, ³Sandy Hook Lab, NOAA

- Characterize zooplankton distribution and abundance
  - Spatially and temporally
- Correlate with abiotics
- Quantify gelatinous macrozooplankton
Plankton sampling
3. Assessment of the Distribution and Abundance of Sea Nettles and Gelatinous Zooplankton in Barnegat Bay

Paul Bologna & Jack Gaynor, Department of Biology and Molecular Biology, Montclair University

2012 Research Objectives:

1. Assess the distribution and Abundance of Gelatinous Zooplankton

1. Assess the distribution of settling larval Sea Nettles (i.e., Polyps)

2. Assess the of larvae and early pelagic stages using DNA analysis

3. Develop a time-step predictive model between early pelagic stages and juveniles and adults
Life History
Study Sites
Methodology

- **Lift Nets** to sample Juvenile and Adult Gelatinous Zooplankton
- **Plankton nets** to sample zooplankton and early stages
- **20L Water samples** filtered through 500µm (early pelagic stages), 100µm, (eggs, larvae), 0.45µm (sperm)
- **Settling Plates**
Distribution of Sea Nettles

Density (Individuals/m³)

Sampling Event (May-September)
qPCR of Ephyra
Collection I (May 31, 2012)
4. Assessment of Fish and Crab Response to Human Alteration in Barnegat Bay

Kenneth W. Able, Thomas M. Grothues, Rutgers University Marine Field Station
and
Paul Jivoff, Rider University

**Long Term Goal:**
Determine how fish and crabs respond to human alterations in Barnegat Bay

**YEAR ONE**
Compare the temporal (annual, seasonal) and spatial variation along the gradient of human alterations
Determine seasonal variation in species composition and abundance for larval fishes
Determine juvenile and adult fish and crab distribution and abundance across habitats (SAV, non-SAV and in sub-estuary/tidal creek tributary, open bay)
Preliminary Results

- Fishes and crabs well represented across multiple habitats with otter trawls
- Pronounced seasonal variation in abundance
- Extensive sampling along gradient of human development indicates reduced fish abundance in upper bay during June
- Larval fish supply at multiple inlets (Little Egg Inlet, Barnegat Inlet, Pt. Pleasant Canal) and OCNGS still being evaluated
- Adult fish distribution still in process
5. Benthic Invertebrate Community Monitoring and Indicator Development

Gary Taghon, Judith Grassle, Charlotte Fuller, Rosemarie Petrecca
Institute of Marine and Coastal Sciences
100 sampling sites - random stratified selected - to reflect north–south salinity gradient and east-west bottom type gradient (sand-east/silt-west)

Total sediment nitrogen in 2012* (Sediment nitrogen concentrations were not measured in previous sampling programs.)

*Phosphorus and total organic carbon also analyzed
Summary: Benthic invertebrates (pending)
Community different in 2012 than last comparable sampling effort in 2001
Species diversity greater in 2012
Numerical dominants shift from crustaceans to polychaete worms

To do: multivariate analysis of community structure
6. Barnegat Bay Diatom Water Quality Calibration

Marina Potapova, Jerry Mead, Roger Thomas, David Velinsky
Academy of Natural Sciences of Drexel University

Mihaela Enache, Thomas Belton
New Jersey Department of Environmental Protection

Study design

- Select sampling sites along gradients of land use and habitat types (GIS)
- Collect surface sediment and water chemistry samples
- Investigate taxonomy of diatom species
- Develop a regional calibration set to relate nutrient levels and other human impacts to diatom communities
Diatoms: algae with silica skeletons

• The most abundant and diverse algae in aquatic habitats
• Sensitive indicators of environmental conditions
• Widely used for water-quality assessments
• Mineralized (silica) cell wall (frustule) - preserves in sediments
Sampling
Paleolimnology
Northern Barnegat Bay Diatom Stratigraphy *

7. Benthic-Pelagic Coupling: Hard Clams as Indicators of Suspended Particulates in Barnegat Bay – Little Egg Harbor

Monica Bricelj\textsuperscript{1}, John Kraeuter,\textsuperscript{2} Gef Flimlin\textsuperscript{3}

\textsuperscript{1}Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ
\textsuperscript{2}Haskin Shellfish Research Laboratory, Rutgers University, Port Norris, NJ
\textsuperscript{3}Cooperative Extension of Ocean County, Toms River, NJ

GOALS

- Determine the seasonal and spatial variation in seston quality/quantity in BB-LEH using suspension-feeding juvenile hard clams, Mercenaria mercenaria, as a biosensor
- Determine the relationship between clam growth, temperature, salinity & seston characteristics at 4 sites
FIELD STUDY SITES

- Barnegat Bay
- Little Egg Harbor
- Toms River
- Is. Beach State Park
- Sedge Is. MCZ
- Harvey Cedars
- Tuckerton Cove

Legend:
- Water Quality Monitoring Sites
  - Discontinued or Suspended
  - Macroinvertebrates Only
  - Tributary
  - Tributary / Macroinvertebrates
  - In Bay
  - Monmouth BB Realtime Station
  - Continuous Water Quality Delta
  - BB new gaging stations
  - Barnegat Bay Estuary Boundary
  - Historical Deurnal Station
  - USGS existing stations
  - Gage Height
  - Stream Flow
Mesh bag containing juvenile clams 23 cm (9”) off-bottom

Initial size of juvenile clams = 9 to 13 mm shell length, SL

Survival, growth in SL & soft tissue DW, & condition (DW/SL^3):
3 to 4 cages per site
30 to 50 clams/cage/sampling date
8. Ecological Evaluation of Sedge Island Marine Conservation Area in Barnegat Bay

Paul Jivoff, Rider University
Department of Biology

Rationale
- NJ’s First Marine Conservation Zone.... for preserving diversity of essential habitats
- Little work to assess habitats present or evaluate effectiveness for organisms

Objectives
- Use blue crab as a model organism for evaluating relative effectiveness of SIMCZ
- Increase understanding of factors influencing blue crab fecundity
Abundance of fish and select decapods: seagrass, macroalgae, and unvegetated areas
   a. Field data: SIMCZ vs outside using 1m² cylinder (throw-trap) sampler monthly May-September

Population structure of adult blue crabs: abundance, size, sex ratio
   a. Field data: SIMCZ vs central bay vs western shore using traps monthly May-August

Female blue crab reproductive success
   a. Field data: brood size, egg viability, spatial variation, duration of season
   b. Field experiment: brood size, timing & number, egg viability location, female size, food level
Habitat-based Sampling

4 replicate sites of each habitat in each location

2 cylinder samples from 1 site
Summary

(1) Species diversity
   habitats inside SIMCZ are similar to those outside the SIMCZ

(2) Juvenile blue crab abundance
   habitats inside SIMCZ contain fewer juvenile crabs

(3) Adult blue crab population structure
   more abundant
   relatively more males
   greater proportion of females are close to spawning
9. Wetland Studies of Ecological Function and Adaptation: Denitrification Year 1

T. Quirk and D.J. Velinsky; Academy of Natural Sciences of Drexel University and A. Smyth and M. Piehler, University of North Carolina

OBJECTIVES

➢ Evaluate permanent nitrogen (N) removal services provided by Barnegat Bay coastal wetlands

➢ Bay-wide seasonal denitrification rates in salt marshes

➢ Mosquito control pond effect on denitrification

➢ Combine data with existing N burial rates (Velinsky et al. 2010) to begin to obtain an overall estimate of N removal services provided by Barnegat Bay wetlands
**NITROGEN CYCLE**

- **Organic N**
- **NH$_4^+$**
- **NO$_3^-$**
- **N$_2$ (g)**

**Tidal Exchange**

- **Plant uptake**
  - Algae and *Spartina*

**Fluxes**

- NH$_4^+$ flux
- NO$_3^-$ flux
- N$_2$ (g) flux

**Processes**

- Net Ammonification
- Net Nitrification
- Denitrification
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
A. EcoSim-Ecopath and NPZ Models

Mass balance models based on the flow of energy among different species/taxa (production – consumption).

A snapshot of the ecosystem state, interactions, and exploitation

B. Fuzzy Cognitive Maps

Help us understand the relationships between organisms and their biotic and abiotic environment

This includes humans (and their abstract concepts), making these social-ecological system models
EcoPath Model Inputs

For each species/taxa stanza we need:

- Biomass: \( \text{t/km}^2 \)
- Production/Biomass (PB): \( \text{yr}^{-1} \)
- Consumption / Biomass (Q/B): \( \text{yr}^{-1} \)
- Other mortality (EE): proportion
- Diet information: proportions
- Catches: \( \text{t/km}^2/\text{yr} \)

*EcoPath can estimate one parameter given the rest*
The NPZ Model

- **N** (Nitrogen) interacts with **Z** (Zooplankton) through predation.
- **P** (Phosphorus) undergoes uptake and death processes.
- **Z** is grazed upon by higher trophic levels.

Arrows indicate the directions of these interactions.
Creating the Barnegat Bay FCM

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<th>Stakeholder group</th>
<th>Maps (N)</th>
<th>Occupation/organization/social group</th>
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<tr>
<td>Scientists</td>
<td>19</td>
<td>Academic scientists, federal and state agency research scientists</td>
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<td>Managers</td>
<td>11</td>
<td>Federal, state, county, and local resource managers</td>
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<td>Environmental NGOs</td>
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<td>Regional, statewide, and local environmental non-profits</td>
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<td>Local people</td>
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<td>Baymen, commercial fisherman, local fisherman, longtime residents</td>
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“What do you think are the major components and relationships that are important to understanding how the Barnegat Bay ecosystem works?”
# BARNEGAT BAY COMPREHENSIVE RESEARCH - OBJECTIVES

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Additional Information

New Jersey Governor’s Comprehensive Plan of Action for Barnegat Bay, NJ (Sub-Plan 9):
Fill in the Gaps on Research
http://www.state.nj.us/dep/barnegatbay/plan-research.htm

NJDEP Barnegat Bay Comprehensive Research Workshop: Kickoff Meeting Presentations - September 2011
http://www.state.nj.us/dep/dsr/barnegat/research.htm

NJDEP Selected Bibliography of Ecological and Land Use Studies of Barnegat Bay
http://www.nj.gov/dep/dsr/barnegat/index.htm

NJDEP Nutrient Related Research
http://www.state.nj.us/dep/dsr/nutrient/
QUESTIONS?