Filling in the Gaps: Barnegat Bay Research Update (2012-2015)

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New Jersey Department of Environmental Protection

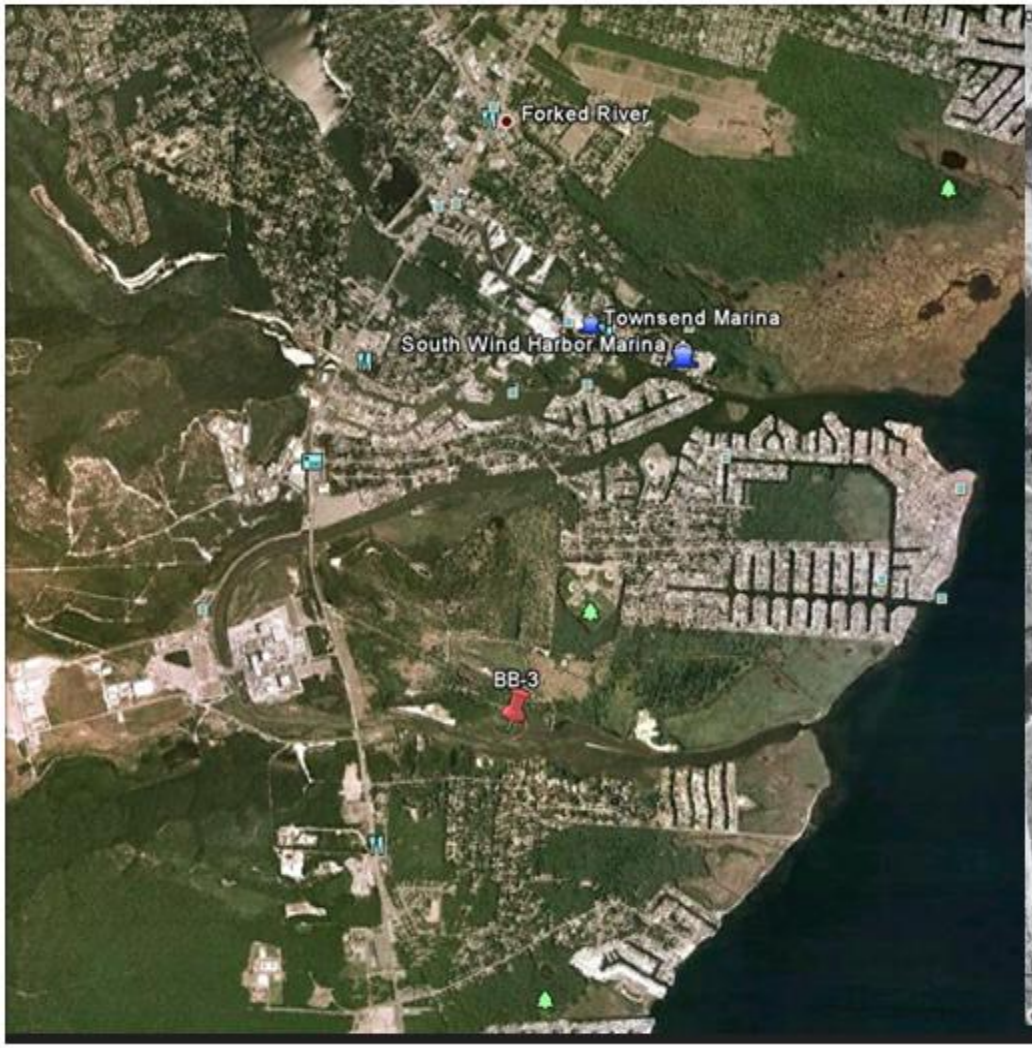
September 8, 2015

2015 Clean Water Council Public Hearing
NJDEP Building, Public Hearing Room
401 East State St.
Trenton NJ 08625

Human Impacts on Estuary

1. Eutrophication (Harmful Algal Blooms, Low DO, Ecosystem effects)
2. Power Plant Operation (Impingement, Entrainment, Thermal Discharges)
3. Habitat Loss and Alteration (Estuary and Watershed)
4. Storm water/Pathogens
5. Hardened Shorelines/Reduced Biodiversity
6. Reduced Freshwater Input (Altered Salinity/Species Susceptibility)
7. Invasive Species (Phragmites Reeds, Chinese Mitten Crabs)
8. Dredging/Boating/Jet Skis
9. Marina Operations (Oil, solvents, anti-fouling paint)
10. Climate Change/Sea-Level Rise
11. Chemical Contaminants
12. Trash/Floatables

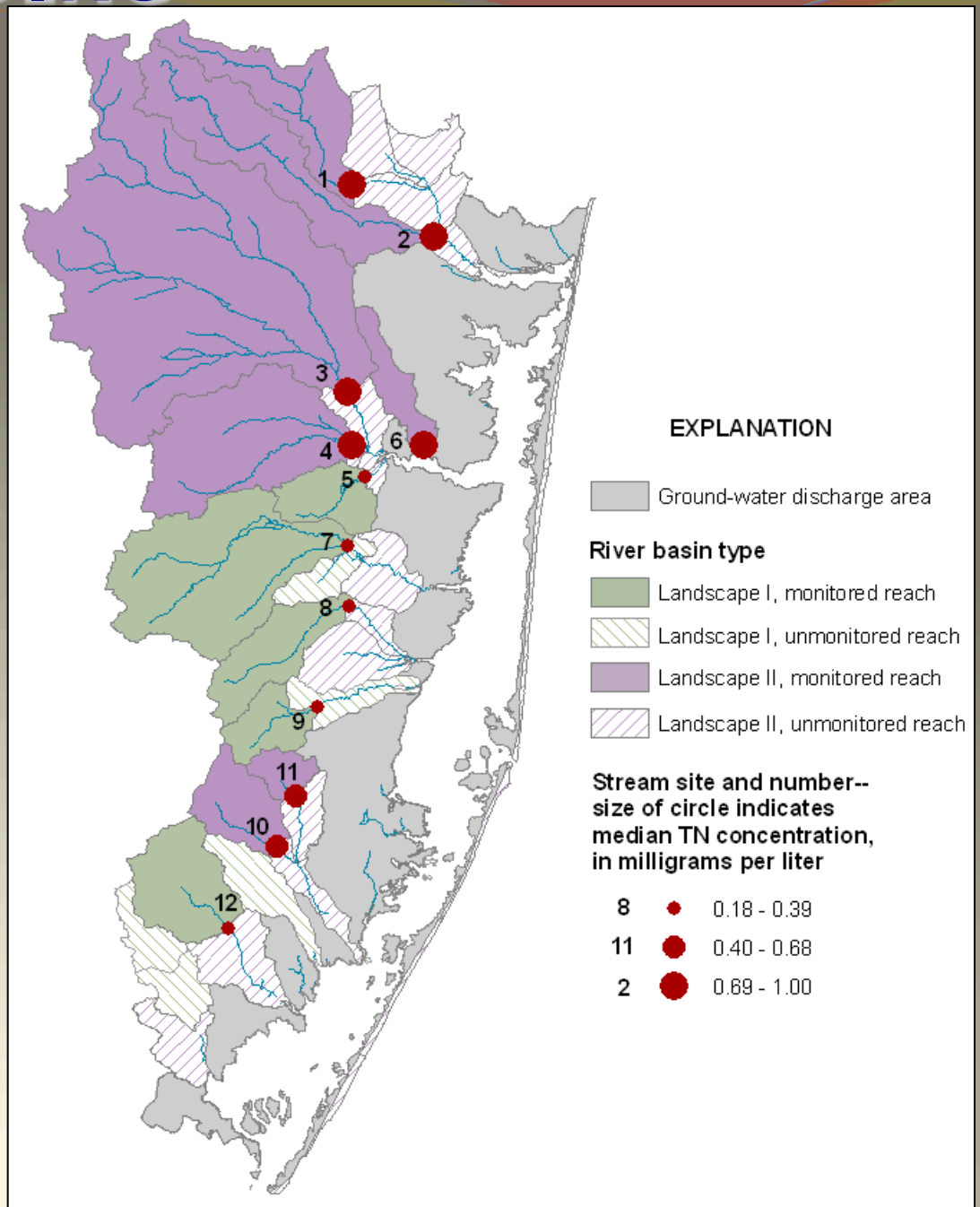
Change in Barnegat Bay Land Use at Forked River and Oyster Creek (1931 and 2011)



NITROGEN LOADING

Total Nitrogen Concentrations in Streams

Median concentrations of total nitrogen (TN) at 12 stream sites in the Barnegat Bay-Little Egg Harbor watershed, 1987-2008



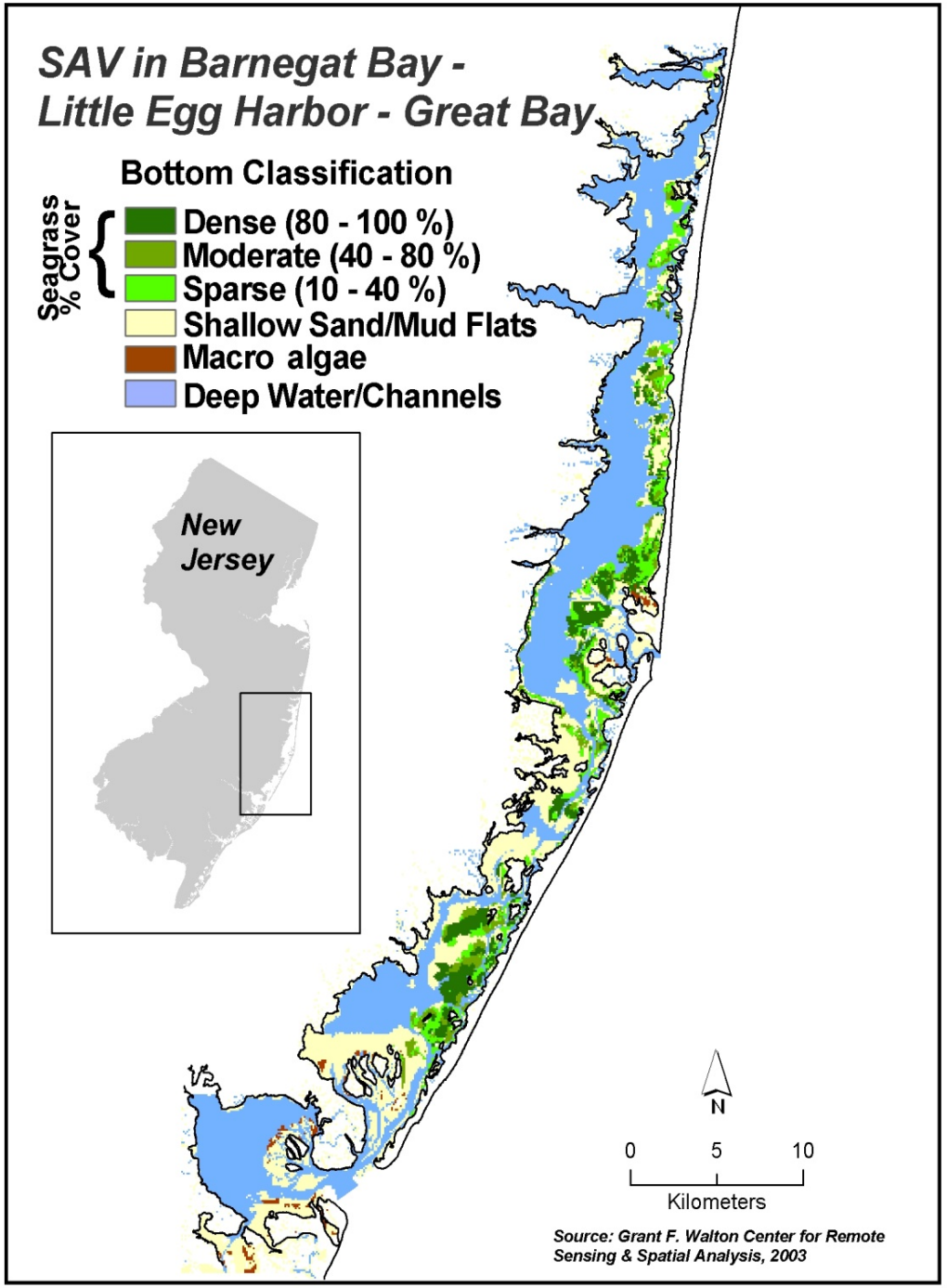
USGS

Eelgrass Decline

>60% in Little Egg Harbor (1975-2000)

>30% in Entire Estuary

(Data Source: Paul Bologna)



Reported landings for hard clams in Ocean County

Chart by G. Calvo based on NMFS data

Governor's 2010 Barnegat Bay Comprehensive Plan of Action

1. Close Oyster Creek Nuclear Power Plant
2. Fund Storm Water 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. Produce More Comprehensive Research
10. Reduce Water Craft Impacts

PROCESS: The NJDEP Division of Science, Research and Environmental Health in consultation with NJDEP program elements (e.g., Standards, Fisheries, Land Use) developed a Comprehensive Research Plan for Barnegat Bay to fill in data gaps and support departmental management objectives including:

- Develop estuarine nutrient water quality criteria (for BBay and rest of state)
- Support water quality modeling (See Action Plan 7)
- Evaluate food safety (harmful algal bloom - toxins)
- Natural resource assessment and management (sustainable fisheries)
- Assess potential ecological and water quality impacts from Oyster Creek Nuclear Generating Station closure in 2019
- Predict algal bloom and jelly fish population explosions
- Reduce boater impacts on environmentally sensitive areas (ESAs)
- Develop and ecological model to support ecosystems-based management of BBay

BARNEGAT BAY COMPREHENSIVE RESEARCH – OBJECTIVES *

	Research Project (in order of priority)	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 Populations 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			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**

RESEARCH SUPPORT
FIVE ENVIRONMENTAL MANAGEMENT AREAS

I.Water Quality (USGS)

II. Biological Endpoints Supporting the Development of Estuarine Nutrient Criteria

III. Characterizing Environmentally Sensitive Areas (ESAs)

IV. Natural Resource Management (Sustainable Fisheries)

V. Ecosystems-Based Management

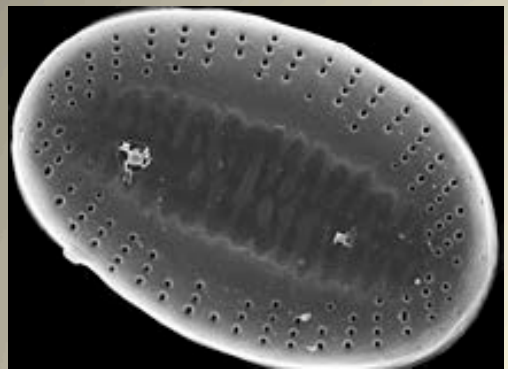
A. BIOLOGICAL ENDPOINTS SUPPORTING THE DEVELOPMENT OF ESTUARINE NUTRIENT CRITERIA (Nitrogen and Phosphorus)

Diatoms as Environmental Indicators in Barnegat Bay, Marina Potapova, Academy of Natural Sciences of Drexel University

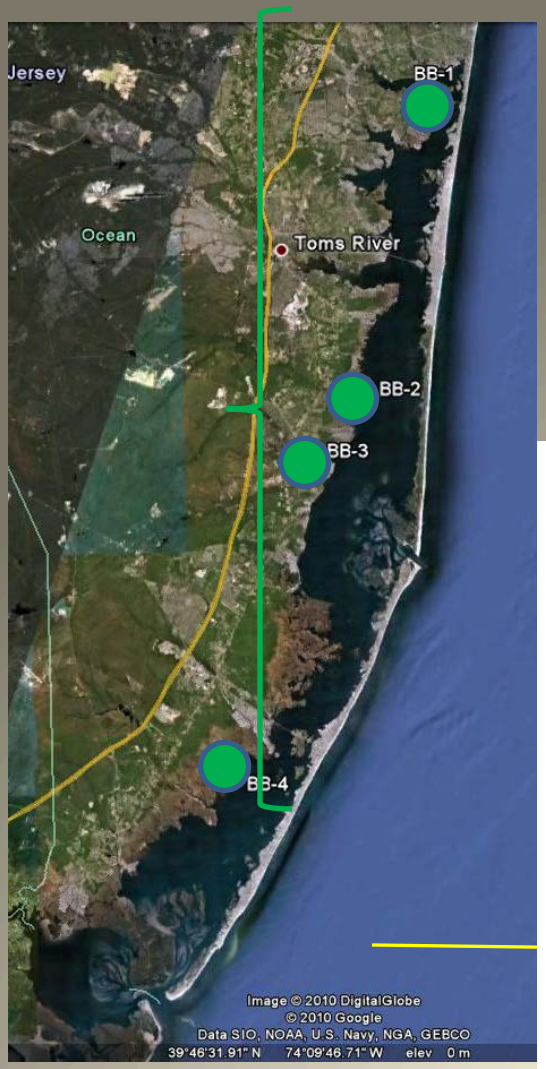
Microscopic algal plankton are the green grass of an estuary (2 types: phytoplankton in water column and periphyton on bottom)

Predictive diatom (silica cell walls) periphyton inference models were constructed from 100 bottom samples for salinity, total dissolved phosphorus, and chlorophyll A 1). in the water column and 2.) for nitrogen in the sediments.

"Reference" diatom assemblages that inhabited Barnegat Bay marshes prior to 1800 are now characterized using salt marsh cores and this information can be used as an important biological endpoint (reference condition) supporting the development of estuarine nutrient criteria.

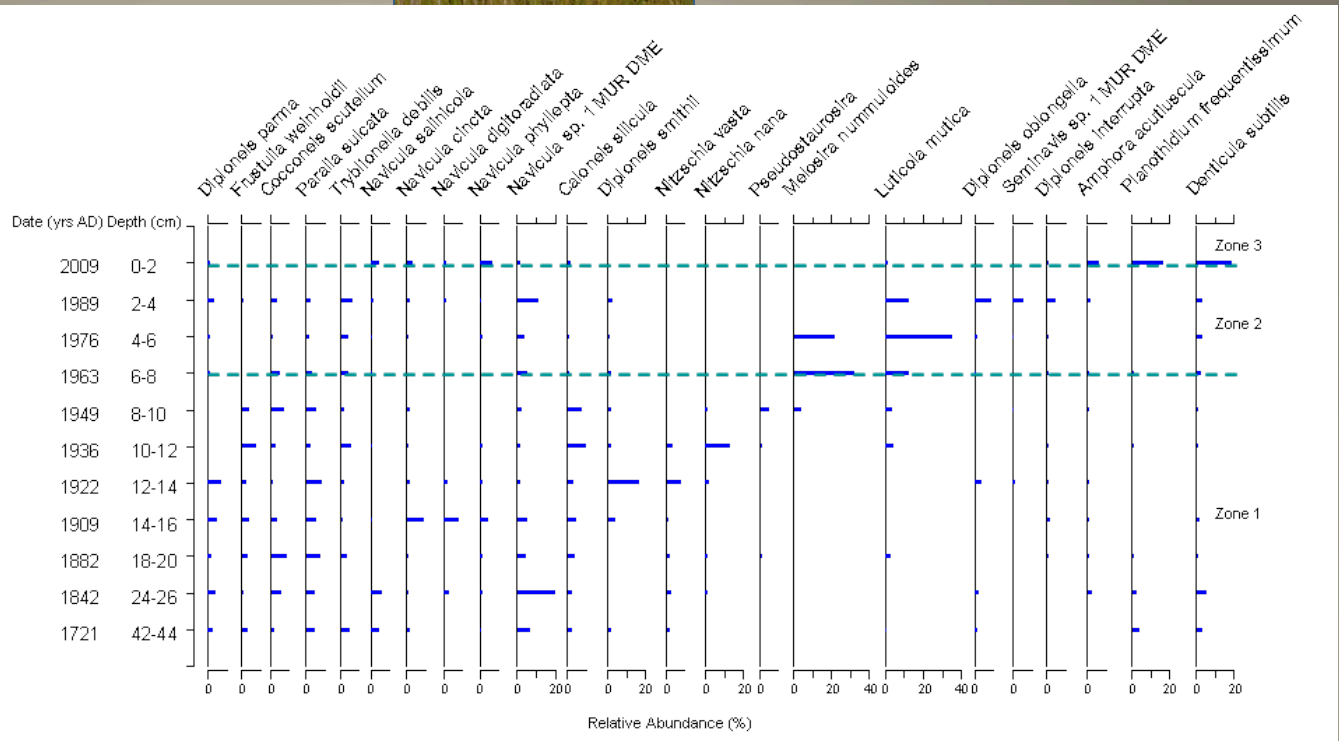


Reconstructing environmental conditions in the Bay using marsh sediment cores



Four cores collected in 2009 another in 2013

Core dating - Cs 137/Pb210 chemistry, pollen and diatom analyses



A. BIOLOGICAL ENDPOINTS SUPPORTING THE DEVELOPMENT OF ESTUARINE NUTRIENT CRITERIA (Nitrogen and Phosphorus)

Baseline Characterization of Phytoplankton and Harmful Algal Blooms, Ling Ren and Don Charles, Academy of Natural Sciences of Drexel University

• Typical phytoplankton species compositions were noted and successions including bloom patterns directly linked to nutrient loading.

•Several major Harmful Algal Blooms or HABs (e.g., Red Tides and Brown Tides) were documented but not at severe bloom-toxic levels.

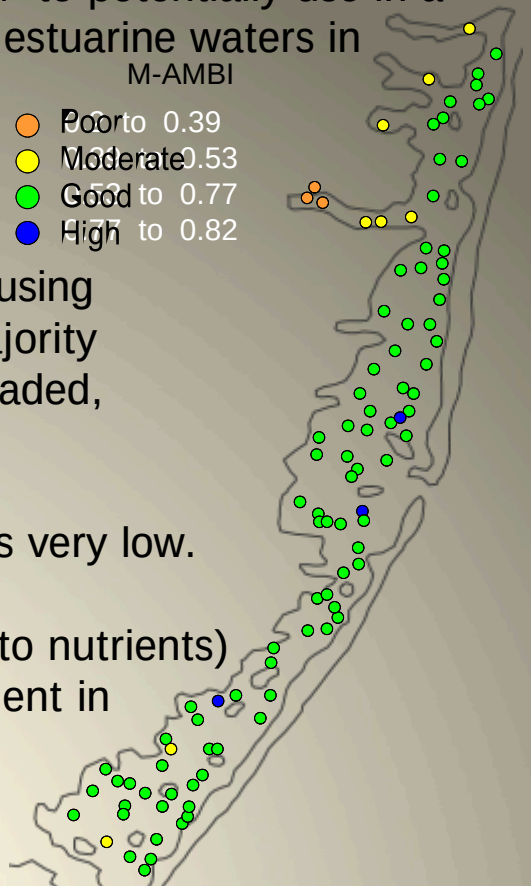
•Developed a phytoplankton index of biotic integrity (P-IBI) for Barnegat Bay (potential nutrient criteria)

• 56% of the sampling events (202 samples collected between 2011 and 2014) were classified as Poor and Mixed-Poor conditions, indicating that the present-day water quality is often undesirable (from a nutrient perspective), HOWEVER, only three years of data is not enough to define conditions and additional monitoring is recommended.

A. BIOLOGICAL ENDPOINTS SUPPORTING THE DEVELOPMENT OF ESTUARINE NUTRIENT CRITERIA (Nitrogen and Phosphorus)

Benthic Invertebrate Community Monitoring and Indicator Development, Gary Tagon, Judith P. Grassle, Charlotte M. Fuller, and Rosemarie F. Petrecca, Rutgers

AQUATIC LIFE CRITERIA: We have successfully developed a set of benthic invertebrate (in-bottom worms, clams and crabs) biological indices (4) for NJDEP to potentially use in a routine monitoring program to assess the biological integrity of estuarine waters in Barnegat Bay and possibly all NJ coastal waters (Clean Water Act: fishable - swimmable).

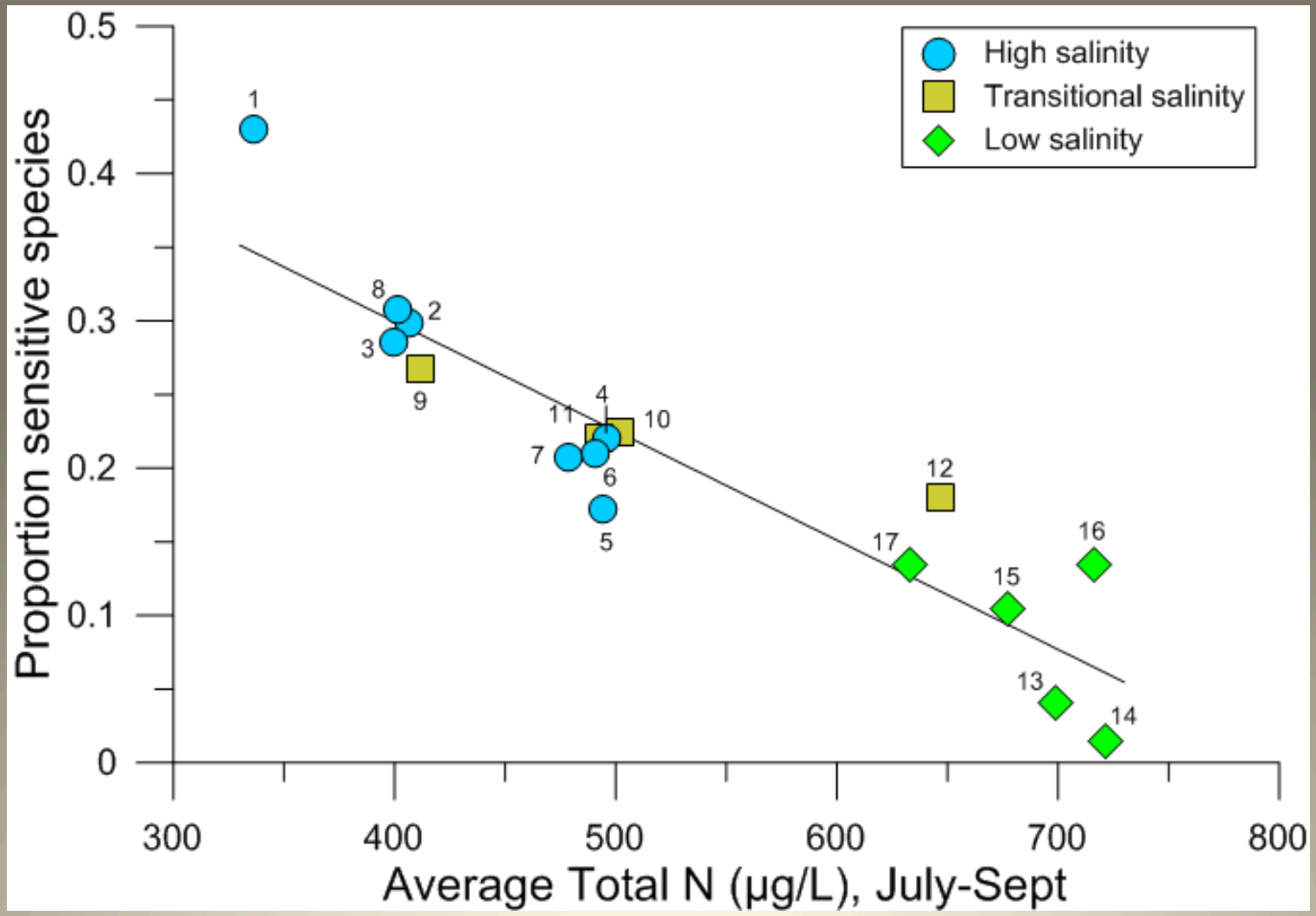


Results: All four indices of habitat quality developed for NJDEP using benthic invertebrate data have characterized the substantial majority of the 100 sites sampled throughout Barnegat Bay as “not degraded, good, or of high quality.”

Total nutrient (TN and TP) and TOC concentrations in sediments very low.

NUTRIENT CRITERIA: (how much of aquatic life impacts is related to nutrients) Using the M-AMBI Index we explored nutrient criteria development in order to overcome the salinity gradient which can mask species responses to nutrients.

Nutrient Criteria: Total Nitrogen explains much of the variation in the proportion of sensitive taxa in a linear model consistent across all three salinity zones,

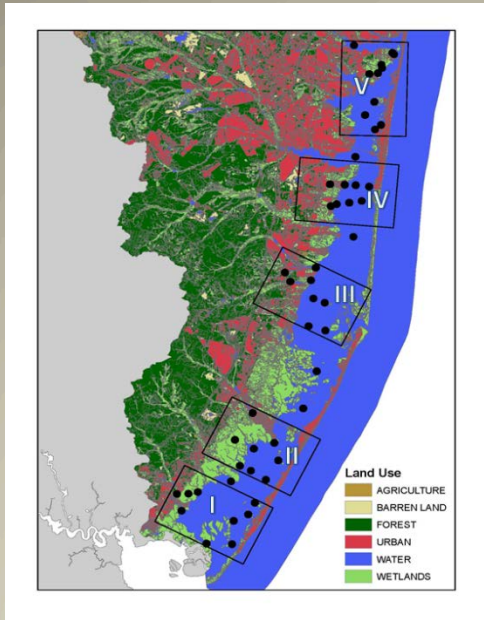


B. NATURAL RESOURCE ASSESSMENT AND MANAGEMENT (SUSTAINABLE FISHERIES)

Assessment of Fishes and Crabs Responses to Human Alteration of Barnegat Bay, Kenneth Able, Tom Grothues and Paul Jivoff; Rutgers and Rider Universities.

Fish trawl and crab trap results to date (2012-2013) show no obvious urbanization gradient (changes in fish distribution and abundances) in Barnegat Bay, which is more urban in the north and less so in the south.

Comparisons with similar sampling gear (otter trawl) from early (late 1970s/ early 1980s) and late (2012/2013) indicate that the fish fauna has changed. The fish faunal response over these decades suggest that some resident and cool-water migrant species are less abundant and have been replaced by warm-water migrants.



Sampling Regime

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

B. NATURAL RESOURCE ASSESSMENT AND MANAGEMENT (SUSTAINABLE FISHERIES)

Hard Clam Survey in Barnegat Bay-Little Egg Harbor Estuary, Kira Dacanay, NJDEP Bureau of Shellfisheries

2011 Little Egg Harbor Bay hard Clam survey estimated 86 million clams, a 32% increase from 2001 but still a 57% decline from 1980s

2012 Barnegat Bay hard clam survey yielded an estimate of 136.7 million clams, which represents an approximately 23% decrease in the standing stock compared with the 177.3 million clams estimated in the 1985/86.

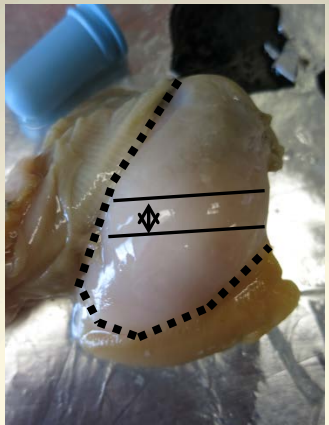
2013 Re-Survey - No significant difference was found in hard clam abundance or mortality in either LEH or BBay when comparing stations sampled before and after Superstorm Sandy.

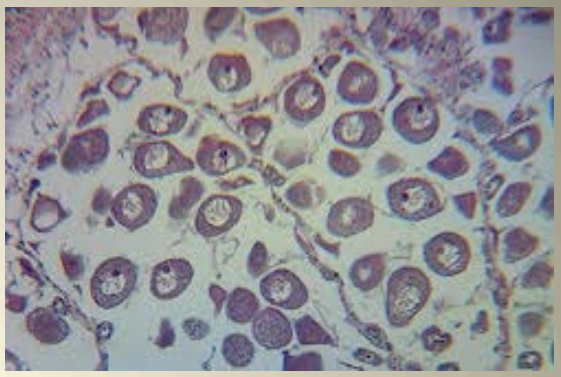
Benthic-Pelagic Coupling: Hard Clams Indicators of Suspended Particulates, Monica Bricelj, John Kraeuter and Gef Flimlin, Rutgers

Hard Clam shell growth in Barnegat Bay-Little Egg Harbor is comparable to other mid-Atlantic coastal ecosystems.

Highest growth rates of juvenile clams occur in relatively undeveloped, protected areas of Barnegat Bay, namely the Sedge Islands Marine Conservation Zone. Reproductive condition was significantly greater at IBSP than Sedge, despite low salinities, and low juvenile growth rates documented at IBSP in 2012-2013.

Reproductive allocation (corrected for size) was significantly lower for necks than larger clams at both study sites. This is an important result as it suggests that the minimum size for legal harvesting may not allow a significant contribution of necks to the population's reproductive output.



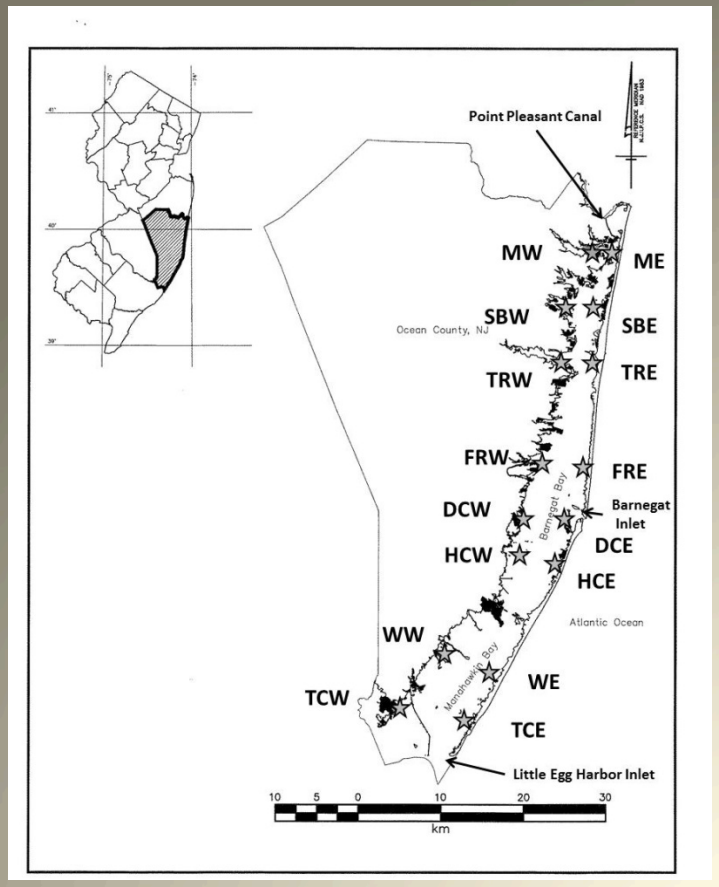


B. NATURAL RESOURCE ASSESSMENT AND MANAGEMENT (SUSTAINABLE FISHERIES) Cont'd

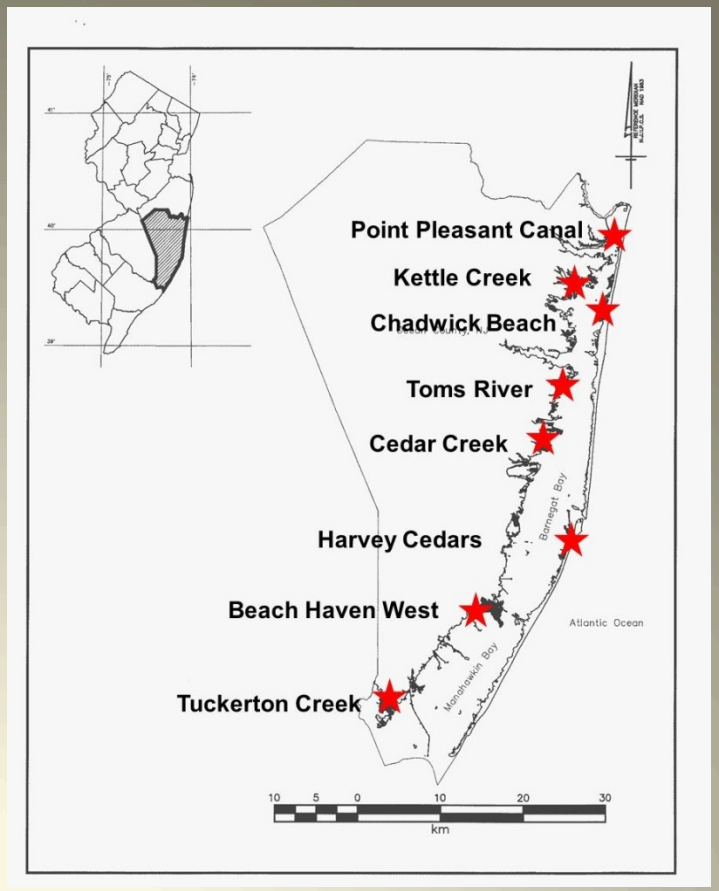
Assessment of the Distribution and Abundance of Stinging Sea Nettles, Paul Bologna and Jack Gaynor, Montclair University

Why do stinging sea nettles seem to be on the increase recently in Barnegat Bay?

Evaluate the Spatial and Temporal Distribution



Yr 1 Bay Wide Sampling Stations



Yr 2 Lagoon Sampling Stations

B. NATURAL RESOURCE ASSESSMENT AND MANAGEMENT (SUSTAINABLE FISHERIES) Cont'd

Assessment of the Distribution and Abundance of Stinging Sea Nettles, Paul Bologna and Jack Gaynor, Montclair University

Why do stinging sea nettles seem to be on the increase recently in Barnegat Bay?

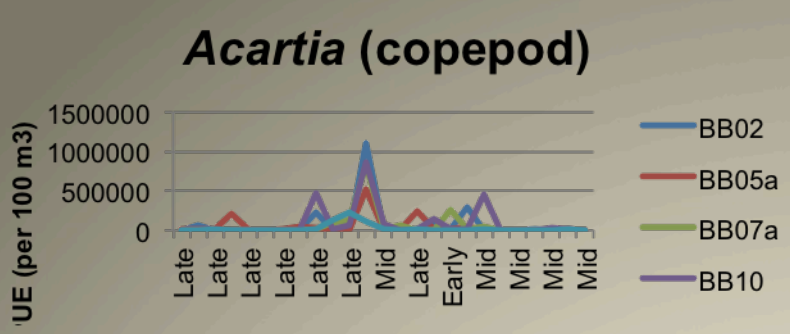
- Polyps need hard surfaces for polyp development (Recent increase in plastic and vinyl bulkheads vs. treated woods)
- Sea nettles can live in degraded environments (low DO, high nutrients = lagoons)
- There is evidence that sea nettle blooms are being driven by BOTH top-down processes (predation, competition) and bottom-up (eutrophication effects like anoxia) drivers in Barnegat Bay.
-
- Sea Nettles assuming Top Planktonic Predator Status
- Actively consume numerous taxa including commercially important fish, crab, and bivalve species
- Sea Nettles appear to be expanding their range south into Little Egg Harbor; and boating lagoons are important areas for polyp settling and attachment, especially due to the prevalence of hard structures in these areas (e.g. bulkheads, plastics, docks, etc.).

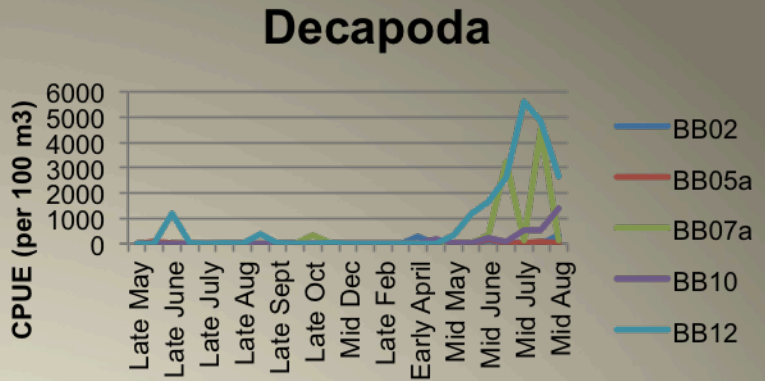
B. NATURAL RESOURCE ASSESSMENT AND MANAGEMENT (SUSTAINABLE FISHERIES) Cont'd

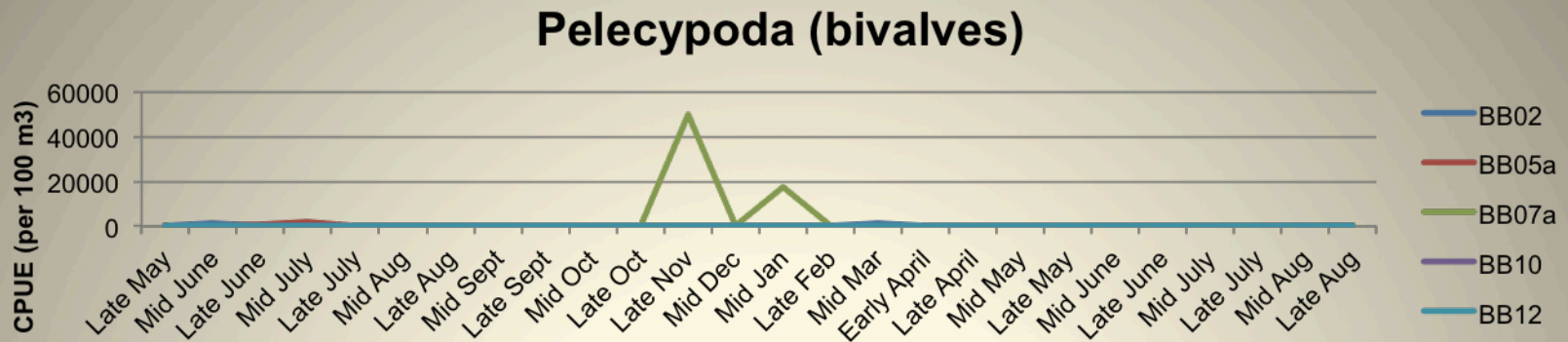
Baseline Characterization of Zooplankton in Barnegat Bay, Jim Nickels and Ursula Howson Monmouth University

•Zooplankton such as copepods (shrimp-like crustaceans) are important components of the zooplankton during spring and fall blooms throughout the bay.

•Groups such as decapods (crabs) and bivalves (hard clams) exhibit discrete spawning pulses during certain times of the year, and are almost absent from the plankton otherwise.







C. ECOSYSTEMS-BASED MODELING AND MANAGEMENT SCENARIOS

Multi-Trophic Level Modeling of Barnegat Bay, Olaf Jensen, Heidi Fuchs and Jim Vasslides, Rutgers

Developed an Ecosystem-Based model of food web biomass based on literature values and BBay site specific (Plan 9) data.

EBMs used by NOAA to set coastal fish landing quotas.

Can us EBM model for ecosystem hypothesis testing:

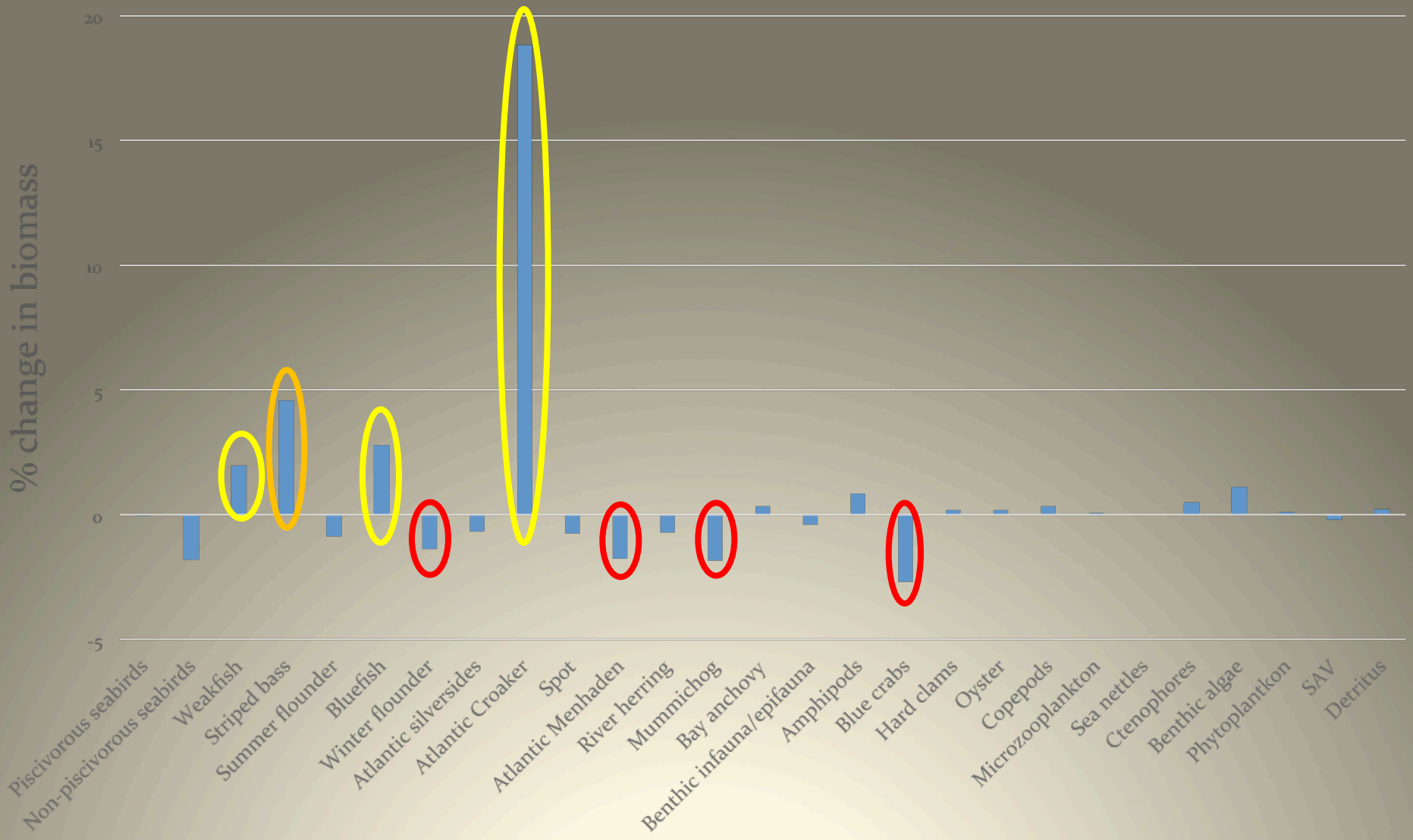
Preliminary modeling of stressor release scenarios upon fisheries in Bbay such as:

•Closure of Oyster Creek Nuclear Generating Station (i.e., release of cooling water intake impingement and entrainment effects on zooplankton)

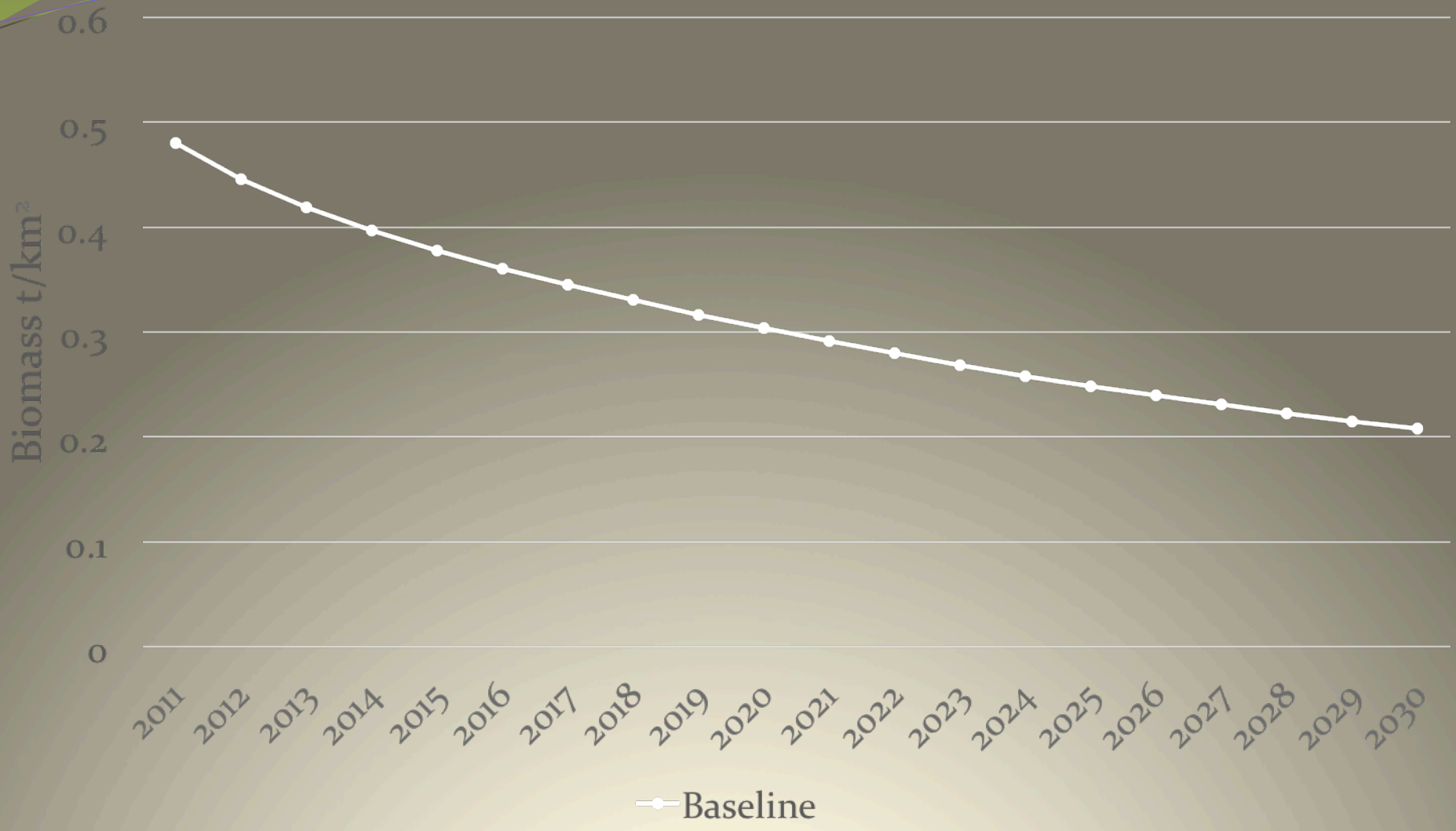
•Upstream nutrient reductions 20 % and 40 % on phytoplankton and cascading food web effects

•Potential implementation of species-specific fishery management plans (e.g., hard clam and blue crab)

OCNGS closure scenario



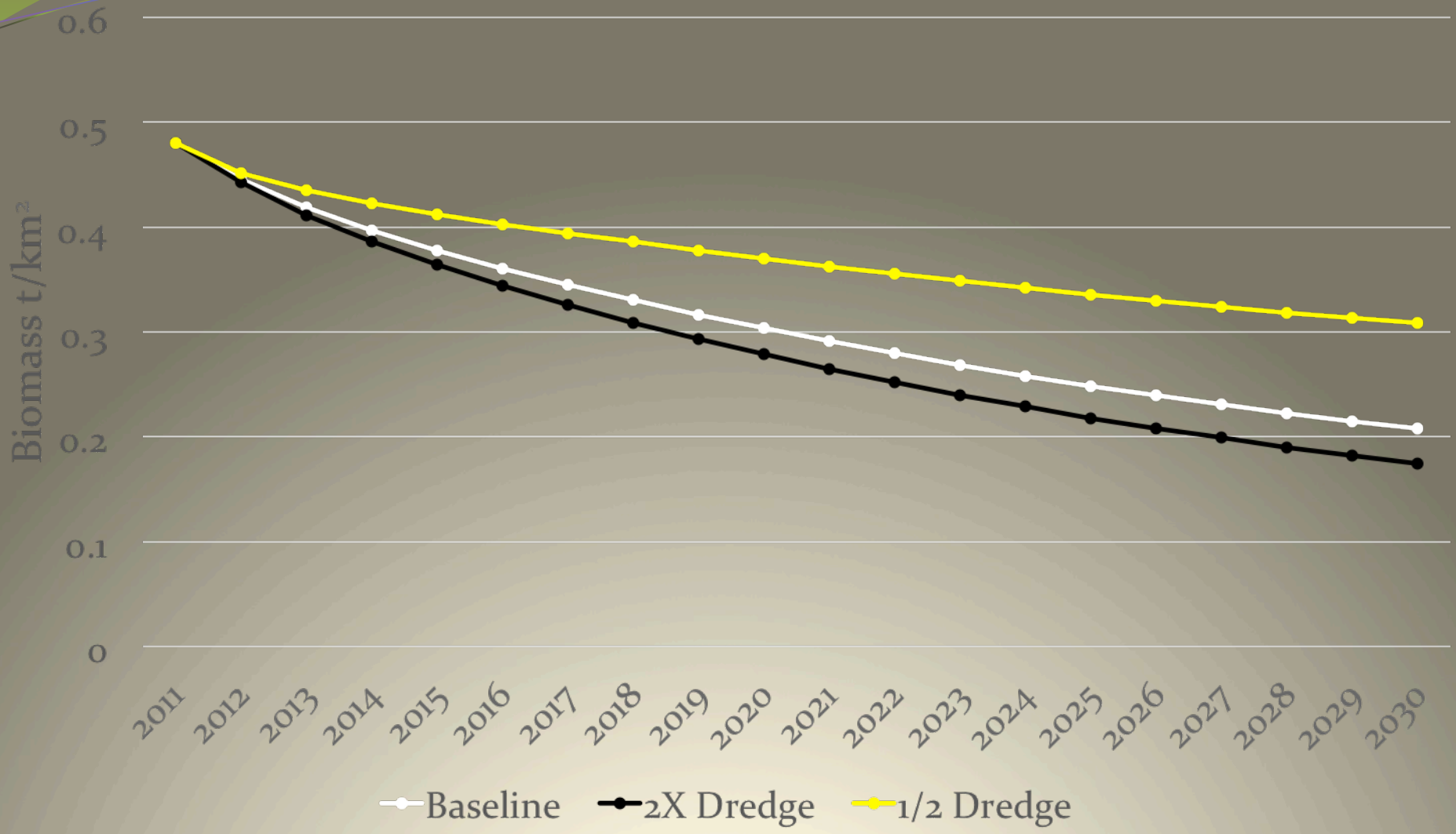
Blue crab harvest control



Baseline Dredge– 44 MT

Baseline Pot – 210 MT

Blue crab harvest control



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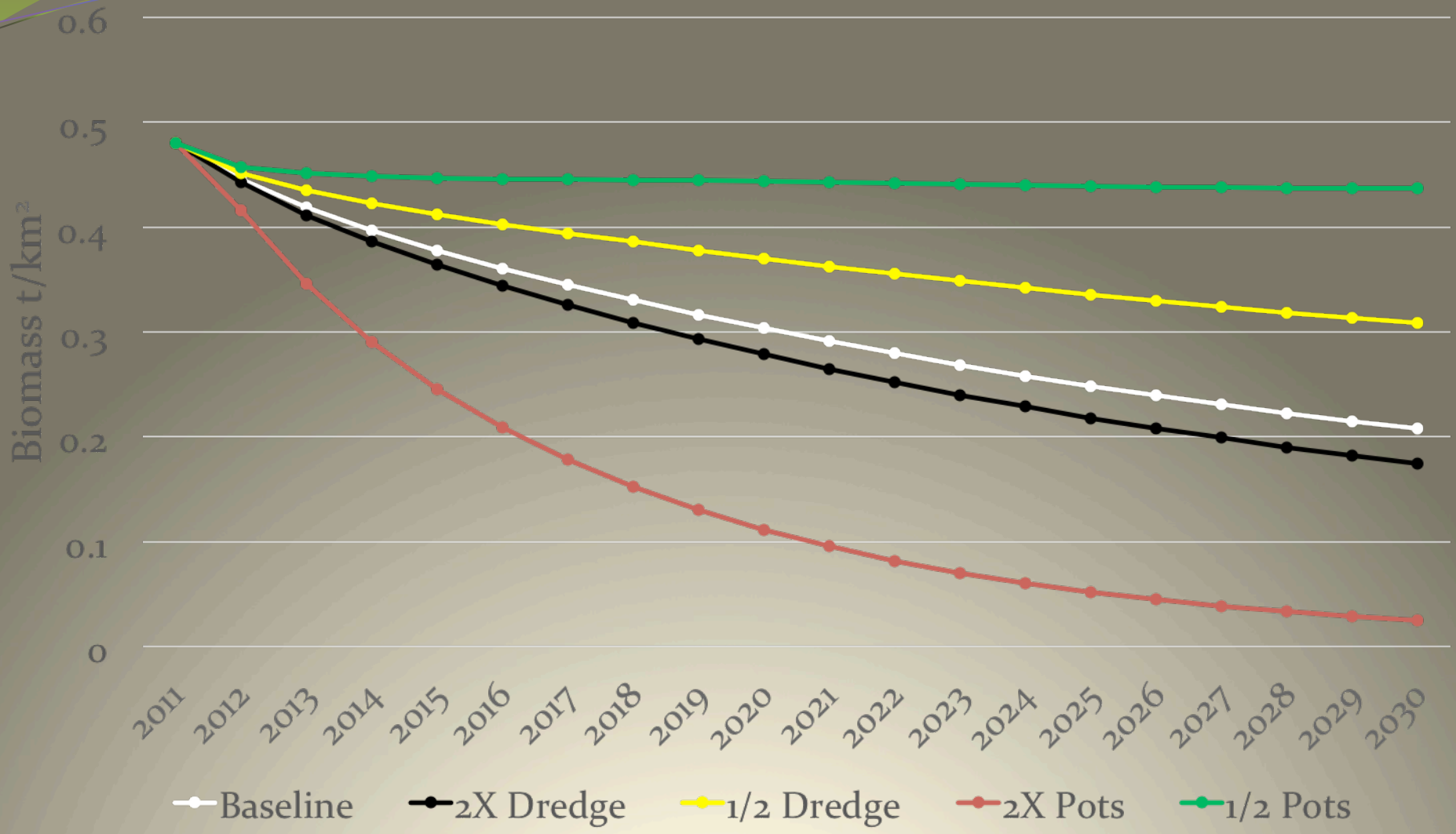


Baseline Dredge– 44 MT

Baseline Pot – 210 MT

D. CHARACTERIZING ENVIRONMENTALLY SENSITIVE AREAS (ESAs)

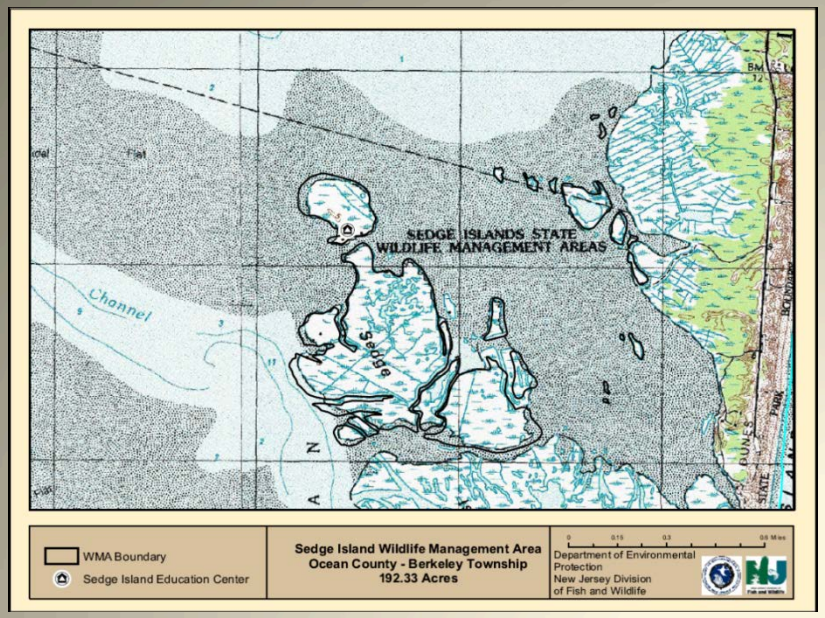
Ecological Evaluation of Sedge Island Marine Conservation Area (SIMCZ), Paul Jivoff, Rider University

SIMCZ established in 2001 to conserve acreage at bottom of Island Beach State Park where commercial fishing is prohibited as well as access by personal water craft to enhance the undisturbed experience of a state natural area.

RESULTS:
SIMCZ had greater abundance of male blue crabs, a sex ratio that is more skewed towards males, and a greater proportion of egg-bearing (spawning) females than mid Barnegat Bay and western-bay locations outside the SIMCZ.

Throw trap sampling for fish and crabs indicated that two economically important fish species (winter and summer flounder) were more abundant inside than outside the SIMCZ.

Data from this study were presented to the Tidelands Council in 2014 as justification for NJDEP obtaining management rights to SIMCZ showing its importance for maintaining the sustainability of ecosystems and populations of economically important species in BBay.



Objectives:

-Are habitats inside SIMCZ equivalent to those outside?

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

D. CHARACTERIZING ENVIRONMENTALLY SENSITIVE AREAS (ESAs)

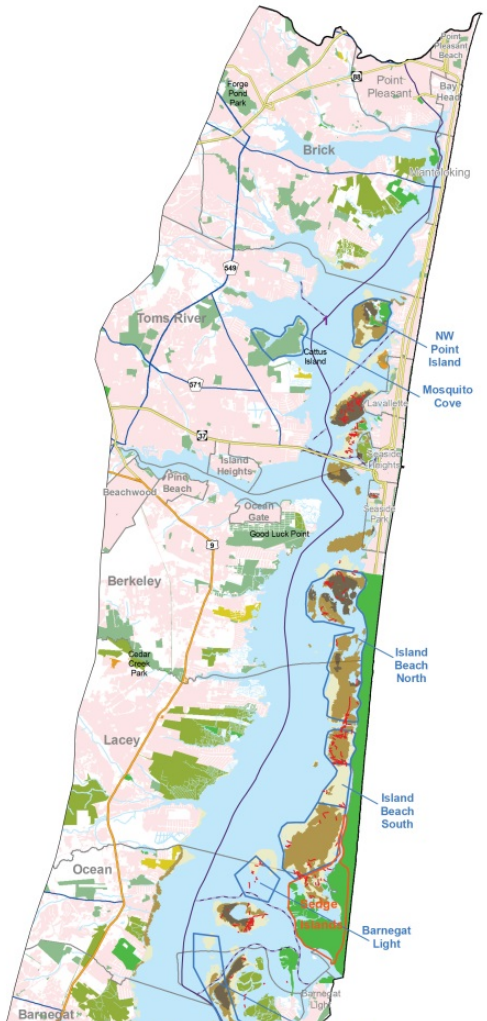
Evaluation of Environmentally Sensitive Areas (ESAs) to Water Craft Impacts, Richard G. Lathrop Jr. and Edwin Green, Rutgers University

Barnegat Bay is a playground for recreational activities, such as boating. Motorboat propellers crossing through SAV beds can cut SAV leaves, scar SAV beds, and harm marine life. Also, turbulence caused by propeller wash can erode shorelines and disturb nesting shorebirds.

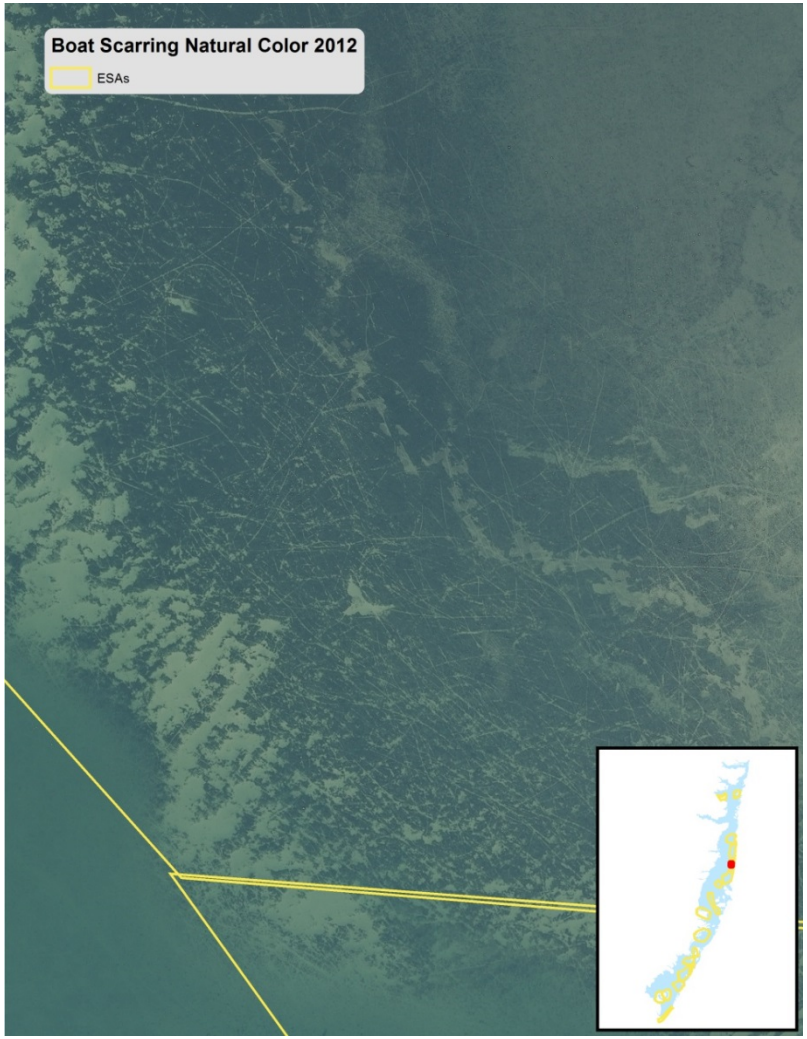
Due to concern over the impacts of watercraft to BB' s shallow water ecosystems and island/marsh nesting habitats, a series of official designated Environmentally Sensitive Areas (16) was delineated using best available data (e.g., SAV beds, shellfish beds, colonial shorebird and raptor nesting and foraging areas, etc.)

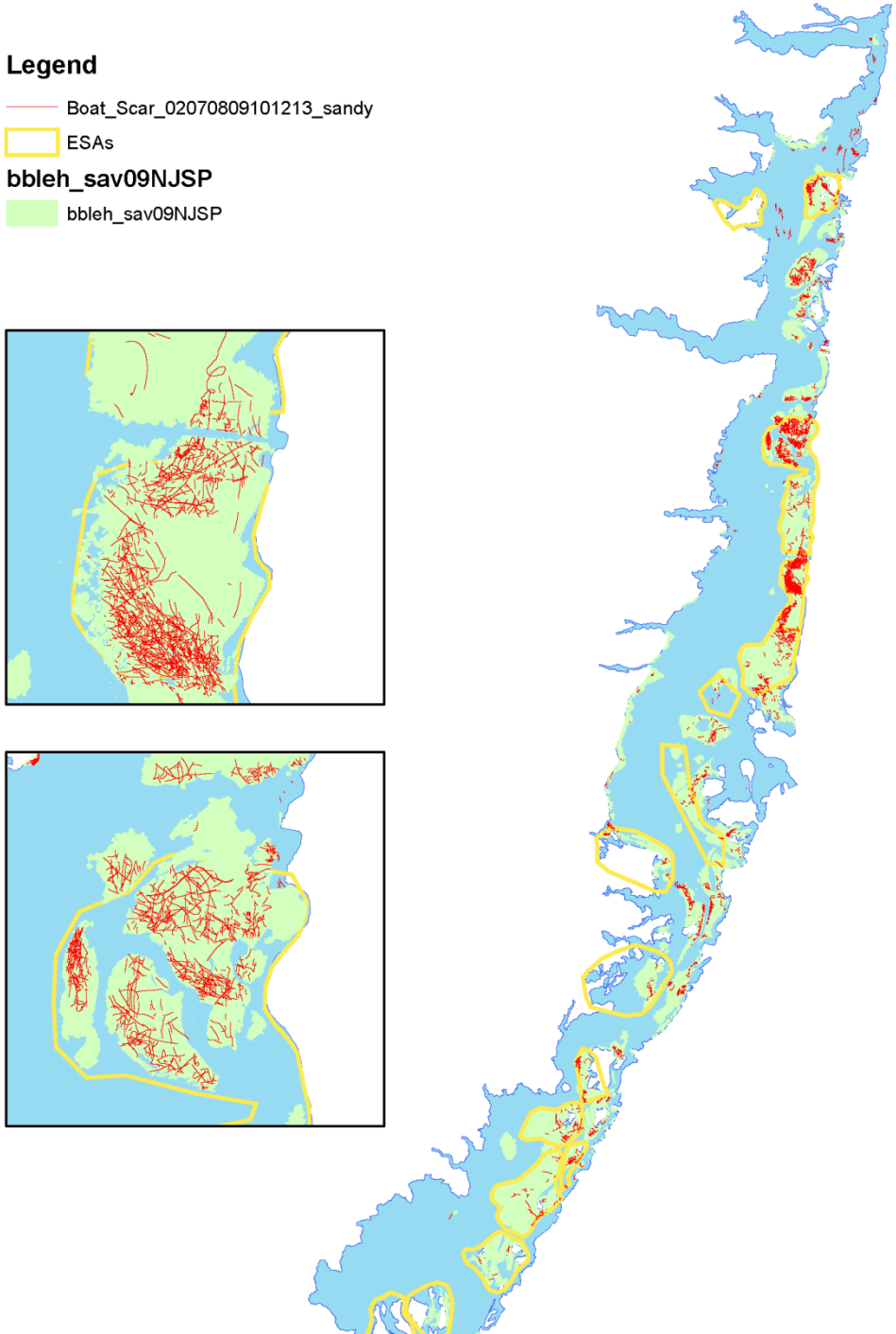
GOAL: Use Plan 9 data and other data sets to add more statistical rigor to these ESA designations.

RESULTS TO DATE:
Two statistically significant indicators exist predicting differences in habitat between 16 ESA's and non-ESA areas including: bird habitat quality and percent of bottom with submerged aquatic vegetation (SAV) or sea grass. These sets of metrics are being further addressed for ESA index development.



Boat scarring in Barnegat Bay





E. WATER QUALITY MODELING SUPPORT

1. Salt Marsh Study - Nutrient Histories in Barnegat Bay from Historical Cores, David Velinsky, Don Charles, Mihaela Enache, Academy of Natural Sciences of Drexel University, Christopher Summerfield, University of Delaware

•Over 28% of Barnegat Bay's salt marshes have been lost to development.
•Salt marshes remove over 80% of the estimated 7 x 10^5 kg/year nitrogen load to Barnegat Bay.

2. Salt Marsh Denitrification Study, David Velinsky, Tracy Quirk, Jeff Cornwell, and Mike Owens; Academy of Natural Sciences of Drexel University, Patrick Center; Louisiana State University, and University of Maryland, Center for Environmental Science

•A significant amount of this sequestered nitrogen is then converted to nitrogen gas and returned to the atmosphere through microbial action.

3. Phosphorus Dynamics in Barnegat Bay Sediments, David Velinsky and Bhanu Paudel**,** The Academy of Natural Sciences of Drexel University

•There are countervailing patterns of nutrient concentrations in Barnegat Bay with highest loading coming into the northern bay from more urban areas although higher concentration of nitrogen are found in the north while higher phosphorus concentrations in the south.

•How might water column geochemical processes and/or bottom sediment geochemical processes play a role in nutrient transport and eutrophic condition?

Results to date:
•Gradient of phosphate in Bay confirmed
•Sediments are large reservoir of P
•Higher sediment P in central and south Bay
•Sediments do not appear to be a source of phosphate to water (but a sink)
•Substantial water-column production of phosphate in central and south Bay in July under anoxic conditions (which does not happen often)

Barnegat Bay Action Plan: Plan 9 – Comprehensive Research

Status and Schedule

Ten multi-year research projects were funded for FY12, FY13 and FY14 @ $3.8M.

Year 1 Complete – 2012 Final Reports are posted on the DEP website.

Year 2 Complete – 2013 Four final reports posted online, rest to follow shortly.

Year 3 In Progress – 2014 Draft final reports received July 1st 2015, under review. Posting online: Fall 2015.

Initial Comprehensive Assessment by September-October 2015 for management briefing (includes a communication plan and an action plan).

DEP/BBP Stakeholder Forum: November 17, 2015 at Ocean County College

Final Comprehensive Assessment after WQ modeling of BBay (Plan 7) and management scenarios are completed (2016).

Ultimate Goal
Develop a Barnegat Bay Management and Action Plan

Sting Sea Nettle (Jellyfish)