



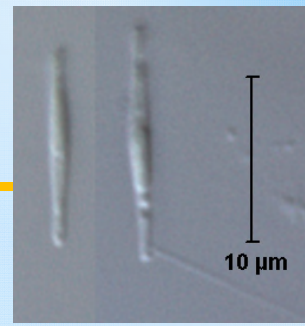
Phytoplankton Reference Communities and Index of Biotic Integrity (P-IBI) for Barnegat Bay-Little Egg Harbor, New Jersey

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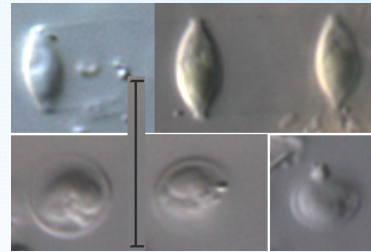
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New Jersey Department of Environmental Protection

INTRODUCTION



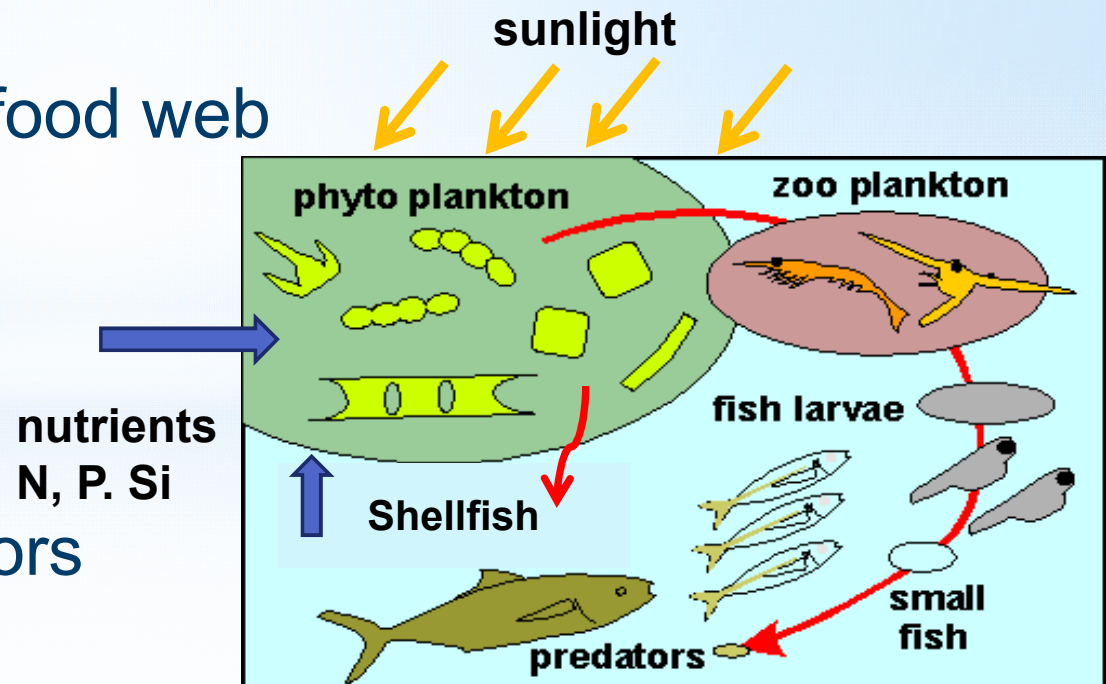
➤ What are phytoplankton?

- *Phyto* (plant) + *plankton* (to wander or to drift)
- Microscopic organisms

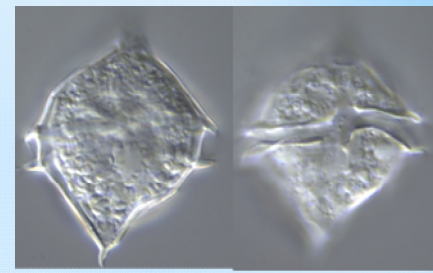


➤ They are important

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



Project Objectives



Three years of investigation on phytoplankton in Barnegat Bay-Little Egg harbor (BB-LEH), 2012-2015

- **To develop season-salinity specific phytoplankton index of biotic integrity (P-IBI)**
- **To assess present-day water quality conditions**
- **To calculate phytoplankton reference communities**

A pilot study, to provide useful information on water quality assessment and management in BB-LEH

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

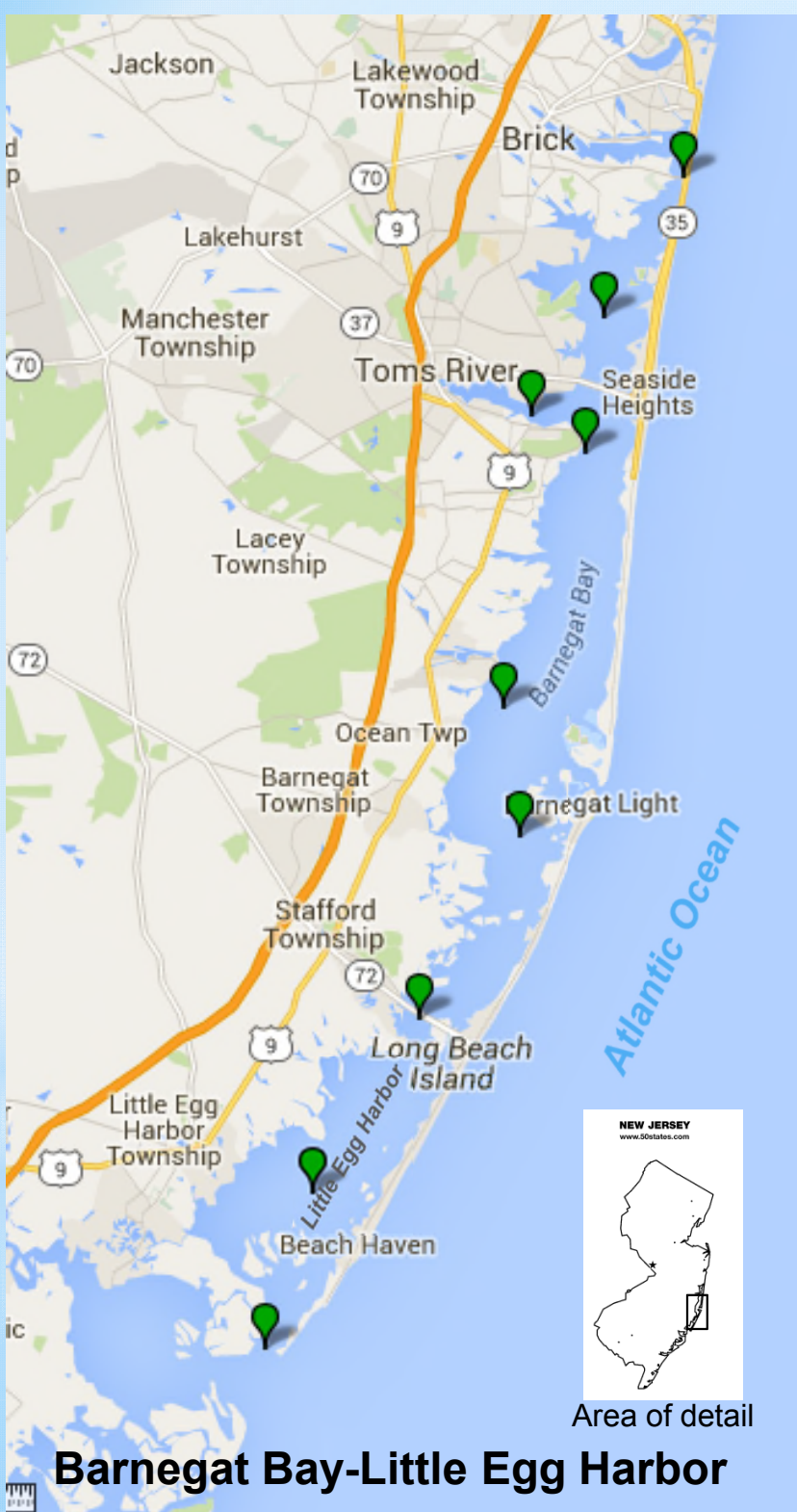
Buchanan et al. 2005, Estuaries 25: 138-159

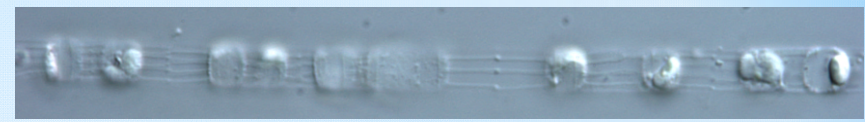
Lacouture et al 2006, Estuaries and Coasts 29: 598-616

Gibson et al. 2000,

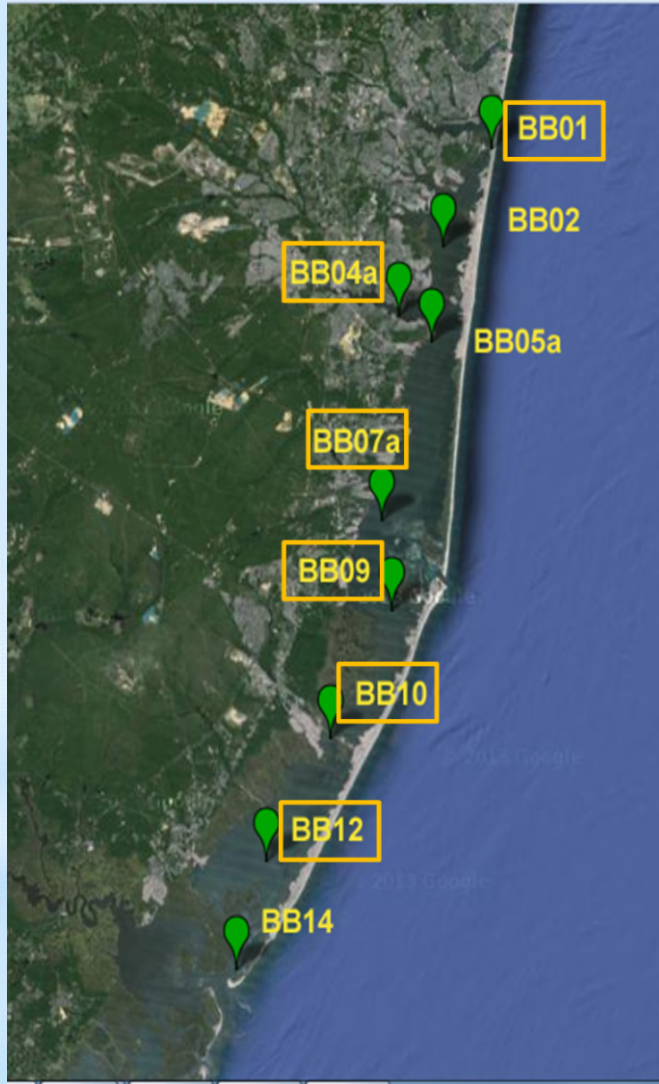
STUDY AREA

- Long: 70 km
- Narrow: 2 to 6 km in width
- Shallow: 1 to 6 m, avg. 1.5 m
- Poorly flushed: 13 d (~0 to 30 d)
- Highly developed watershed
- Classified as highly eutrophic system (Kennish et al. 2007):
 - High primary production and Chla
 - Episodic 'brown tide' and other HABs
 - Loss of submerged aquatic vegetation and shellfish





Datasets for P-IBI development



Map of Sites

➤ **Phytoplankton Dataset**

- Aug 2011-Aug 2013
- 205 samples; Biweekly/Monthly
- species composition, cell density, biovolume and carbon biomass for the major taxonomic groups

➤ **Water Quality Dataset**

- NJDEP water quality monitoring
>25 key parameters;

For more information:

<http://www.state.nj.us/dep/barnegatbay/bbmapviewer.htm>

➤ **Data collections were synchronized**

Season and Salinity Classification

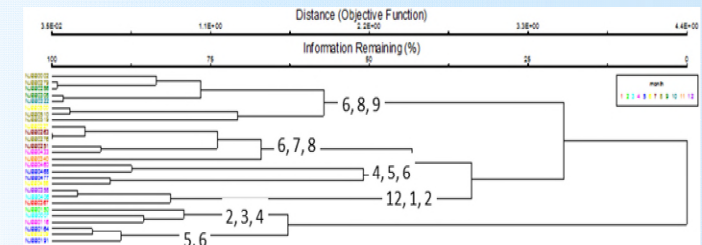
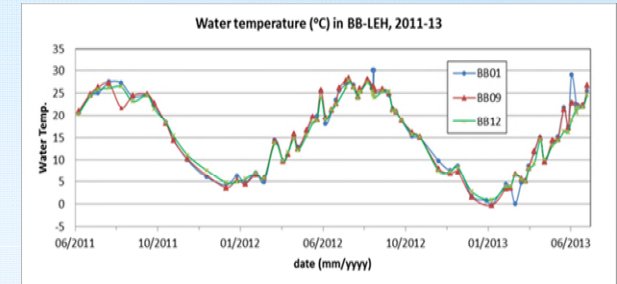
➤ Seasons

Spring: March-May

Summer: June-September

Fall: October-November

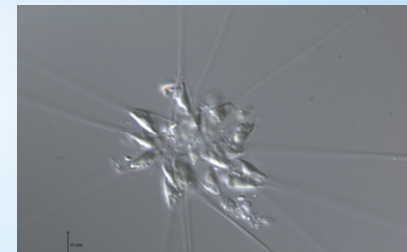
Winter: December-February



➤ Salinity Zones: Venice system 1958

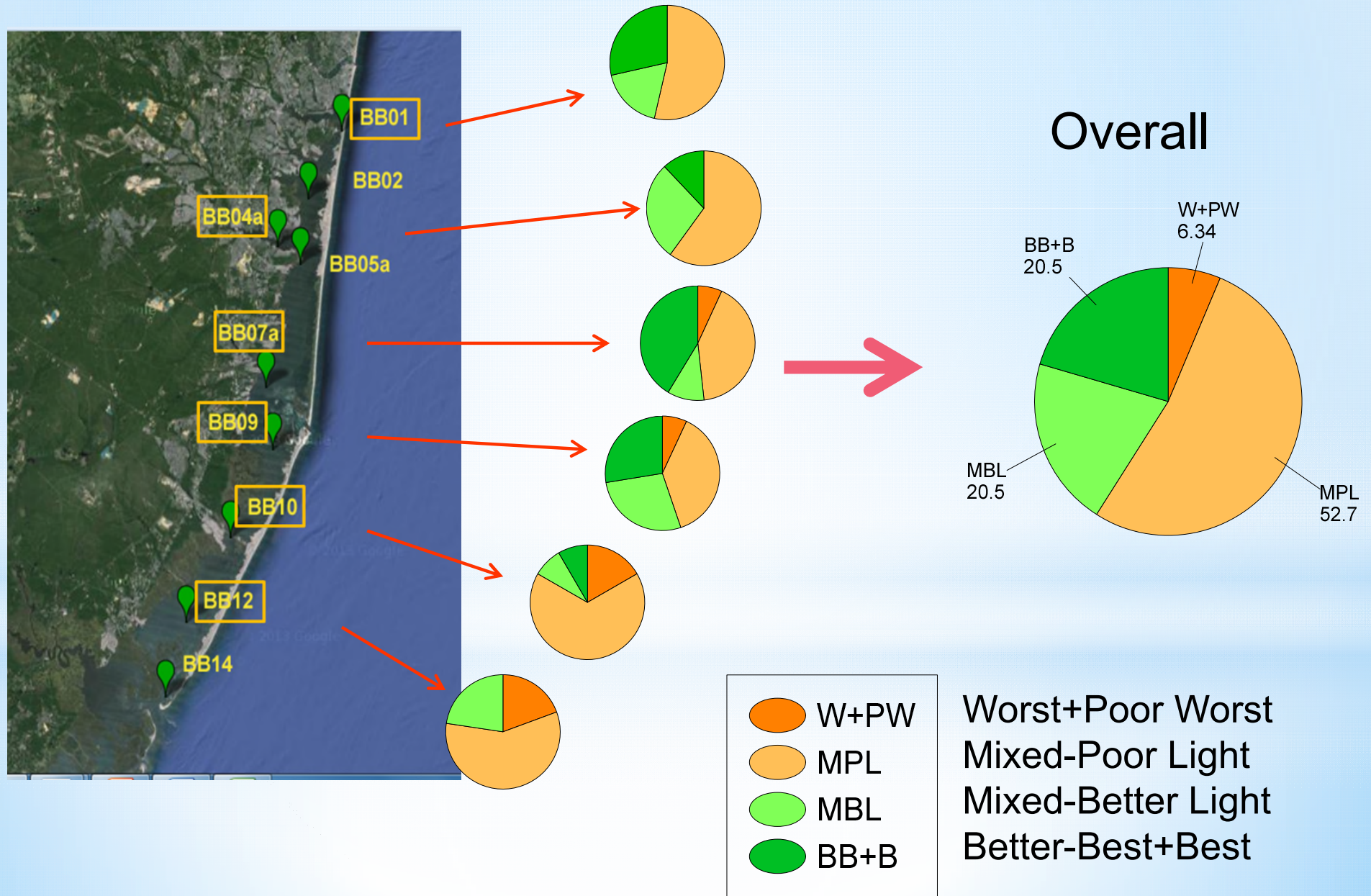
Mesohaline (5-18 ppt): 18%, Near Toms River

Polyhaline (> 18 ppt): 82% of total samples



Habitat Classification

Based on Light, DIN and ortho-P



P-IBI Metrics Selection

W+PW

MPL

MBL

BB+B

Worst+Poor Worst → **Impaired (or degraded)**

Mixed-Poor Light

Mixed-Better Light

Better-Best+Best → **Least-Impaired (or Reference)**

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

9 Phytoplankton metrics:

Chla

Chla : 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 4 season-salinity zones

Spring MH and PH

Summer MH and PH

MH: (mesohaline, 5-18 ppt)

PH: (polyhaline, >=18 ppt)

RESULTS

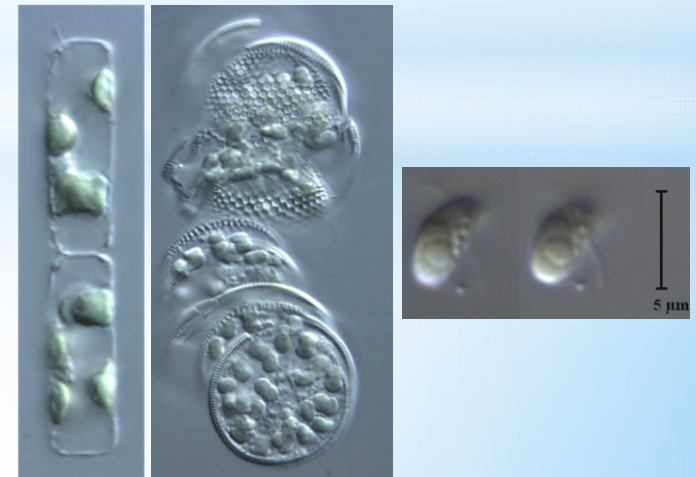


Discrimination efficiencies and classification efficiencies of the P-IBI scores in impaired conditions, least-impaired conditions, and overall

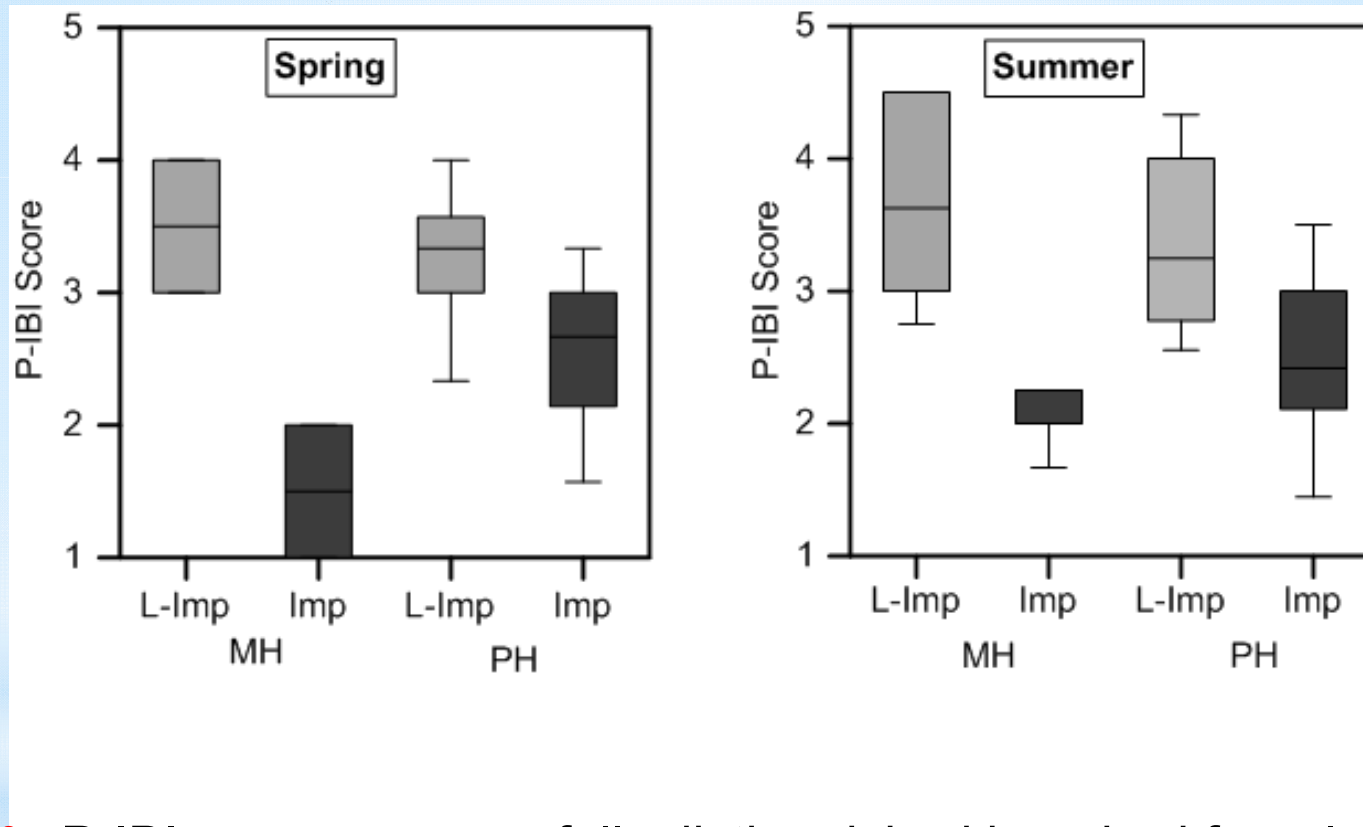
		Sample Size (n)	% DT	DO	Chla	%_dino	%_crypto	TOC	DOC	Chl:C	%_pico	overall P-IBI	classification efficiency
Spring MH	L-imp	4	25%	100%								50%	67%
	imp	2	100%	50%								100%	
Spring PH	L-imp	23	43%	96%	39%	48%	60%					48%	57%
	imp	30	60%	0%	50%	32%	63%					53%	
Summer MH	L-imp	4	25%	25%	50%	50%	50%	67%				50%	81%
	imp	12	83%	25%	83%	27%	50%	100%				92%	
Summer PH	L-imp	12	25%	83%	33%		33%		50%	45%	50%	64%	68%
	imp	38	61%	8%	61%		35%		50%	45%	63%	71%	

Classification efficiencies:

- 48-64% in least-impaired
- 53-100% in impaired
- 57-81% overall



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



- P-IBI scores successfully distinguished impaired from least-impaired samples for most season-salinity zones

MH: Mesohaline, salinity 5-18 ppt
PH: Polyhaline, salinity ≥ 18 ppt

Phytoplankton reference communities and supporting habitat conditions for polyhaline zone

ANOVA significance: ** $p < 0.01$, * $p < 0.05$, ns: not significant; blank: not applicable

Δ: reference community values higher than impaired community values;

▽: reference community values lower than impaired community values

Polyhaline: >18 ppt

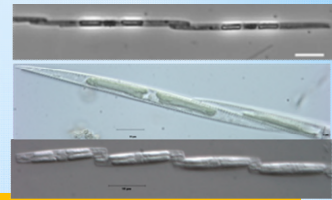
	Spring			Summer			
	B+BB (n=13)			B+BB (n=12)			
	Max/Min	Median	p	Max/Min	Median	p	
Chl a	3.5/0.3	1.26	*∇	11.6/1.3	2.9	**∇	ug/L
Chl:C	0.122/0.002	0.022	* ∇	0.14/0.006	0.041	* ∇	ratio
NM abundance	4.6/0.6	1.3	ns	10.8/0.7	3.6	ns	10 ⁷ cells/L
NM biomass	8.2/0.2	2.2	ns	7.95/0.6	2.4	ns	10 ⁹ um ³ /L
avg NM Cell Size	774/77	164	ns	441/17	77	ns	um ³ /cell
Pico biomass	12.0/7.2	3.3	ns	730.4/9.4	127	*∇	ug/L
TN	0.48/0.22	0.3	ns	0.48/0.24	0.32	**∇	mg/L
TP	0.023/0.008	0.018	* ∇	0.05/0.02	0.04	**∇	mg/L
DO	8.9/5.2	7.9	*Δ	8.65/5.75	7.17	**Δ	mg/L
TSS	25.5/11.0	16.7	*Δ	25.4/9.35	14.75	* ∇	mg/L
DIN	0.06/0.01	0.035		0.04/0.01	0.017		mg/L
PO4	0.0045	<0.0011		0.0075	0.006		mg/L
Secchi depth	2.3/1.7	1.9		1.86/1.09	1.52		m

SUMMARY



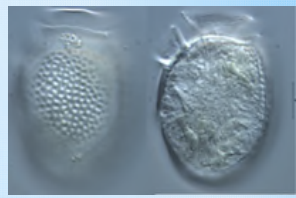
- Near 60% of the samples were in impaired conditions. Only 20% of the samples were identified as least-impaired conditions.
- Phytoplankton reference communities, in comparison to impaired ones, showed lower Chl_a, Chl:C ratio and summer picoplankton biomass, as well as lower TN, TP and TSS, but higher DO.
- P-IBI scores showed good separation between impaired and least-impaired. The developed P-IBI correctly classified 57-81% of the samples in the calibration dataset.
- 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 (Ren 2015). 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 and strengthen the P-IBI.

ACKNOWLEDGEMENTS



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- **Dr. Don Charles and Elena Colon at the Academy of Natural Sciences for their support**