6TH ANNUAL
CAPE COASTAL CONFERENCE
DECEMBER 4-5, 2018



Water Quality Improvement from Quahog Fishery Restoration and Oyster Aquaculture in the Waquoit Bay System

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Mashpee, MA

Outline

- *Water Quality Problems* – DEP 303(d) list
- *Nitrogen removal required* – MEP/TMDL Reports
- *N reduction options* – Sources, more flushing?, shellfish?
- *Production Methods* – Fisheries Restoration and Farming
- *Shellfish Nitrogen Content* – Sampling/analysis
- *Risk reduction* – Predator exclusion and crab trapping
- *Site Selection* – Habitat, Approved Harvest Areas
- *Potential* – Standing crop survey, historical data
- *Monitoring* – Water quality , shellfish standing crop, and HAB
- *Results* – Total Nitrogen Reduction / Water Quality Improvement

5 - Impaired - TMDL required

Water Body Segments - Lakes, Ponds and Estuaries

Category

- 2 - Attaining some uses; other uses not assessed
- 3 - No uses assessed
- 4A - Impaired - TMDL is completed
- 4C - Impairment not caused by a pollutant
- 5 - Impaired - TMDL required

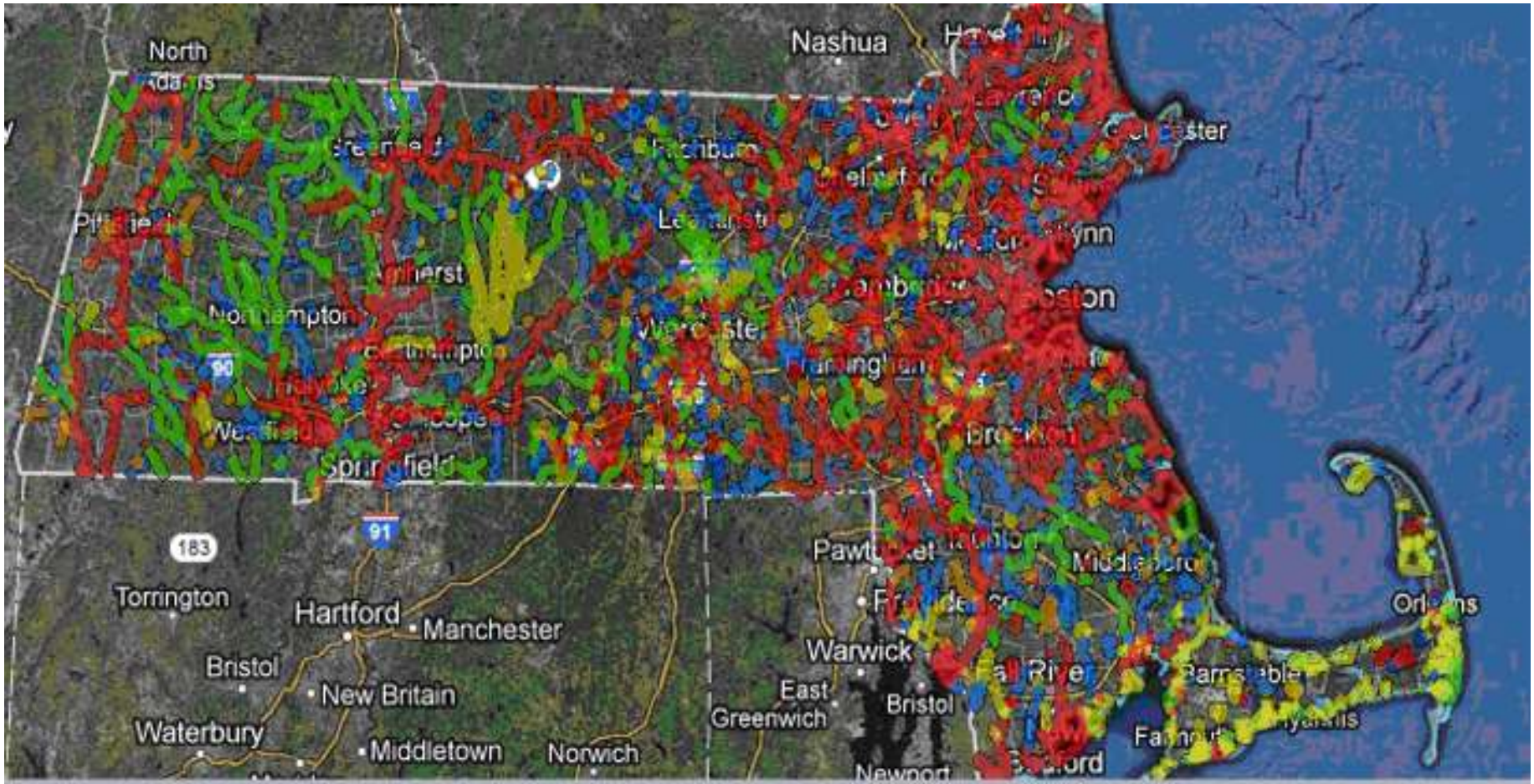
Dam

Political Boundaries

- MA State Boundary
- MA Municipal Boundary

NRCS Basins

- HUC 12 Basin Boundary



2012 Integrated List of Waters (305(b)/303(d)) Interactive Map

Nitrogen Loading Impacts

High N

Anoxia from algae blooms – Fish kills
Habitat degradation – muck (dead algae)
Loss of species abundance and diversity

Algae blooms – Loss of eelgrass / scallops
Habitat degradation – muck (dead algae)
Lower species abundance and diversity

More algae – more shellfish production

Low N

Healthy estuary, high species diversity

CWMP Shellfish Option Background

- EPA/DEP allow shellfish in Comprehensive Wastewater Management Plans for water quality restoration

  Conference: Sustainable Cape Cod – New Tools and Practices for Clean Water and Community Benefit October 22-23, 2012 Sponsored by USEPA, Cape Cod Commission and the Water Alliance.

  EPA and Massachusetts DEP allow removal of nitrogen by shellfish to be included in CWMPs with a "Plan B" for backup.

  Cost benefits and risks of interest. Adaptive Management required.

- Cape Cod Commission "208" Water Quality Restoration Plan includes shellfish
- Mashpee Comprehensive Watershed Nitrogen Management Plan includes shellfish (Mashpee Sewer Commission, May 2015)

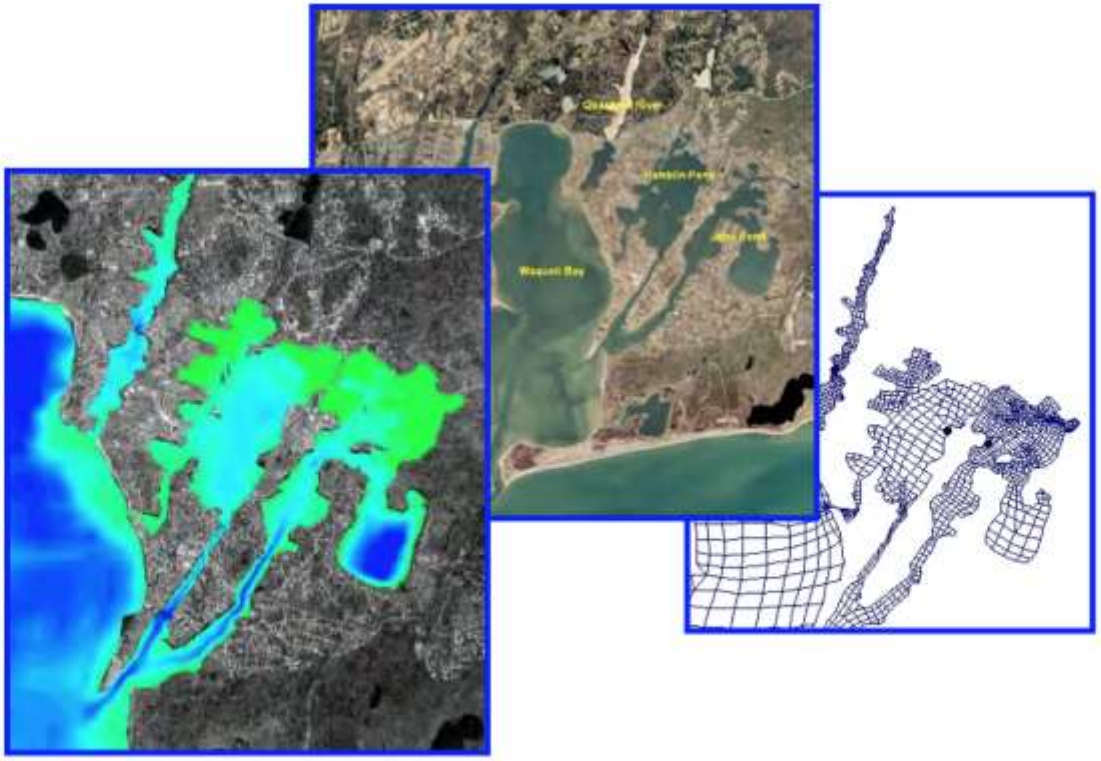
Treatment Systems vs. Shellfish

- Land based
- Storm resistant
- Microbe Growth and Survival Dependent
- Effluent naturally sand filtered (microbes removed)
- Seasonal Load Issue
- Works in all watersheds
- Expensive
- Nitrogen grab samples often monthly
  - Flow Rate monitored

- Estuary based
- Storm resistant
- Shellfish Growth and Survival Dependent
- Septic effluent naturally sand filtered (microbes removed)
- No Seasonal Load Issue
- Some areas not suitable
- Inexpensive – economic +
- Harvests monitored
  - Dealers electronic data
    - Total nitrogen removed calculated from total weight

Massachusetts Estuaries Project

Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Quashnet River, Hamblin Pond, and Jehu Pond, in the Waquoit Bay System of the Towns of Mashpee and Falmouth, MA

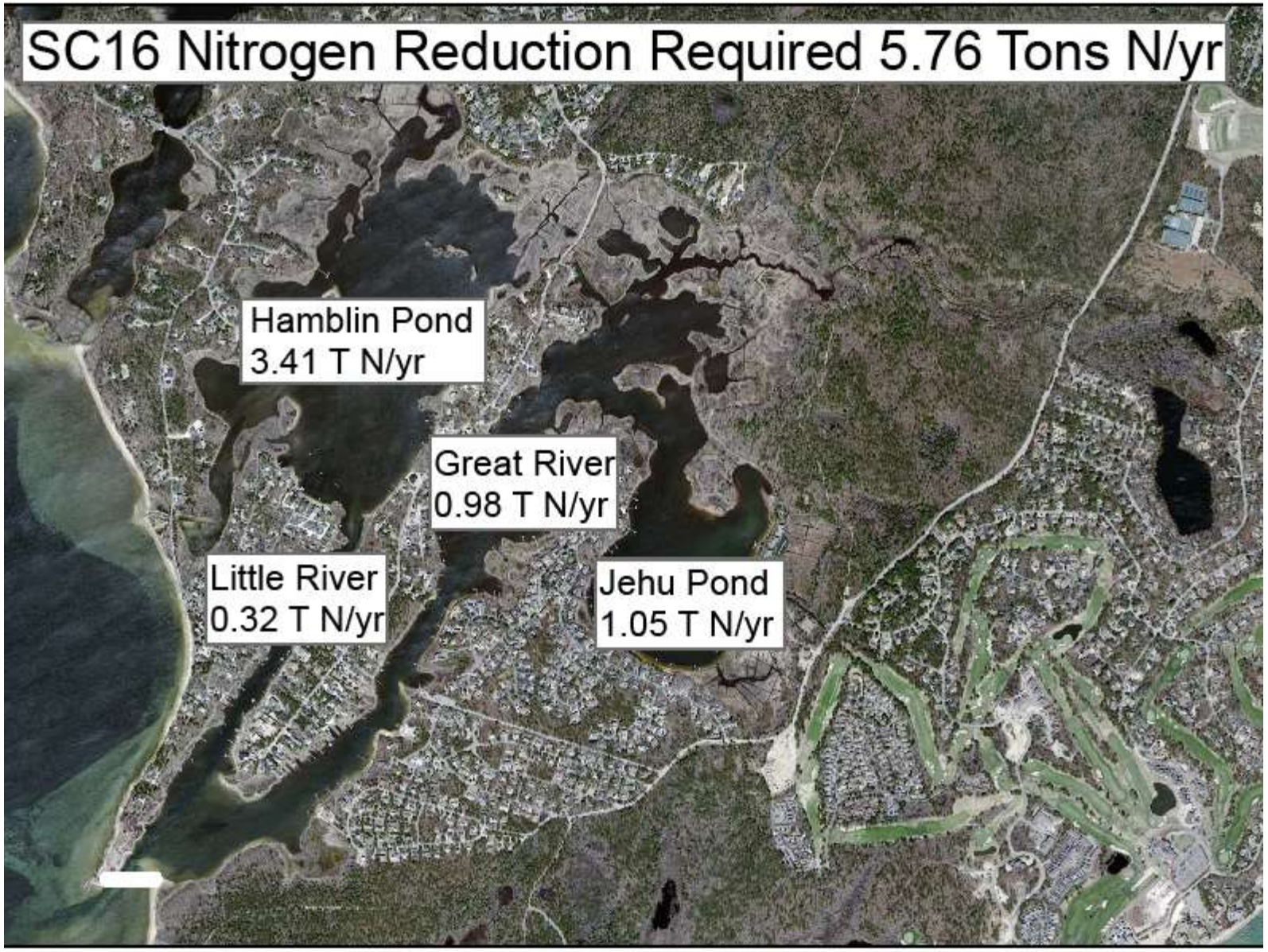


Nitrogen Reduction Required: MEP Report

Great River, Little River, Hamblin Pond and Jehu Pond (SC16)

Sub-embayment	Present* Watershed (kg N/day)	Threshold* Watershed (kg N/day)	Reduction Required (kg N/day)	Reduction Required (kg N/year)
Hamblin Pond	12.395	3.049	9.346	3,411
Little River	1.096	0.211	0.885	323
Jehu Pond	3.912	1.025	2.887	1,054
Great River	3.671	0.997	2.674	976
Total			**15.792**	**5,764**

* Howes B., S. Kelley, E. Eichner, R. Samimy, J. S. Ramsey, D. Schlezinger, P. Detjens (2011). Massachusetts Estuaries Project Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Waquoit Bay and Eel Pond Embayment System, Towns of Falmouth and Mashpee, MA, Massachusetts Department of Environmental Protection. Boston, MA. Table ES-2, page ES 13.


SC16 Nitrogen Reduction Required 5.76 Tons N/yr
Hamblin Pond
3.41 T N/yr
Great River
0.98 T N/yr
Little River
0.32 T N/yr
Jehu Pond
1.05 T N/yr

Shellfish/Water Quality Restoration

- Fisheries – Restoration of Shellfish Populations
  - Water Quality Improvement – Shellfish filter algae for food
  - Economic Development - Commercial Shellfishing
  - Food for family fishing – Locally produced displaces N import
  - Less limited potential than farming - more / better areas
- Commercial Shellfish Aquaculture (Farming)
  - Water Quality Improvement – Shellfish filter algae for food
  - Economic Development – Economic multiplier and jobs
  - Limited Potential - Limited to areas not naturally productive
    - User conflicts

Mashpee Shellfish N Content

Oysters and Quahogs 0.5% N/live wt

Barnstable County Cooperative Extension 2012

Shellfish Sample Data - Barnstable County - Mashpee

all shellfish collected were marked with bands prior to freezing

shellfish were held frozen until lab can process

ID#	Sampling	Date	Vol(ml)	shell Length (mm)	Whole Weight (g)	Shell Dry (g)	Tissue Dry (g)	Condition Index	Soft tissue N Meat %N	grams N	Shell N Shell %N	grams N	Total gN/animal	%N whole wet weight	%N whole average	%N whole yr average	%N whole average
					Wet Weight												
89	Spring	6/22/12	50	63.99	78.52	47.07	2.71	8.62	8.61	0.23	0.18	0.09	0.32	0.407			
90	Spring	6/22/12	25	50.7	38.56	23.18	1.38	8.99	9.28	0.13	0.13	0.03	0.16	0.414			
91	Spring	6/22/12	40	60.07	66.67	39.59	1.14	4.22	8.41	0.10	0.23	0.09	0.19	0.279			
92	Spring	6/22/12	30	55.38	47.95	29.68	1.76	9.65	7.97	0.14	0.21	0.06	0.20	0.422	0.380		
93	Spring	6/22/12	40	62.95	72.16	45.21	2.20	8.18	9.07	0.20	0.29	0.13	0.33	0.460			
94	Spring	6/22/12	35	58.51	57.29	33.89	1.72	7.34	8.46	0.15	0.17	0.06	0.20	0.352			
95	Spring	6/22/12	35	57.56	63.17	41.1	1.79	8.10	8.67	0.16	0.16	0.06	0.22	0.347			
96	Spring	6/22/12	25	50.45	42.32	26.96	1.28	8.32	9.00	0.11	0.20	0.05	0.17	0.400	0.390		
149	Fall	10/11/12	35	58.53	55.1	34.16	3.52	16.83	8.12	0.29	0.25	0.09	0.37	0.674			
150	Fall	10/11/12	30	54.72	47.13	29.05	3.22	17.80	8.38	0.27	0.26	0.08	0.35	0.734			
151	Fall	10/11/12	40	60.05	60.66	37.88	3.64	15.97	6.78	0.25	0.20	0.07	0.32	0.530			
152	Fall	10/11/12	40	62.27	69.09	42.33	5.11	19.10	7.05	0.36	0.16	0.07	0.43	0.622	0.640	0.470	
157	Fall	10/11/12	20	50.29	38.28	24.24	2.64	18.84	8.17	0.22	0.15	0.04	0.25	0.656			
158	Fall	10/11/12	30	59.27	52.46	32.2	2.89	14.29	7.27	0.21	0.14	0.04	0.25	0.485			0.507quahogs
159	Fall	10/11/12	25	51.74	37.26	23.21	2.33	16.59	8.04	0.19	0.17	0.04	0.23	0.611			
160	Fall	10/11/12	30	54.29	42.44	27.43	2.60	17.33	8.20	0.21	0.24	0.07	0.28	0.660	0.603	0.544	
165	Fall	10/11/12	35	91.28	55.8	30.13	3.92	15.28	7.23	0.28	0.17	0.05	0.33	0.599			
166	Fall	10/11/12	25	80.86	38.07	18.85	2.73	14.19	6.60	0.18	0.30	0.06	0.24	0.622			
167	Fall	10/11/12	40	90.18	59.89	31.83	3.80	13.54	6.88	0.26	0.16	0.05	0.31	0.520			
168	Fall	10/11/12	35	80.42	51.14	24.66	4.00	15.11	6.20	0.25	0.18	0.04	0.29	0.570	0.578		
173	Fall	10/11/12	60	83.53	93.7	55.62	5.86	15.40	5.99	0.35	0.21	0.12	0.47	0.499			
174	Fall	10/11/12	50	90.1	88.45	58.09	3.89	12.83	7.35	0.29	0.13	0.08	0.36	0.411			0.510oysters
175	Fall	10/11/12	60	92.12	97.46	57.05	5.45	13.50	5.99	0.33	0.16	0.09	0.42	0.431			
176	Fall	10/11/12	50	84.92	72.96	43.53	4.15	14.11	6.35	0.26	0.11	0.05	0.31	0.425	0.442		

Shellfish Plan for Nitrogen Removal

Great River, Little River, Hamblin Pond and Jehu Pond (SC 16)

Area	N Removal * Required (MEP) (mt N/year)	Removal by shellfish (mt N/yr)	Shellfish Harvest (mt N/yr)	Number of shellfish (million)**	Species
Hamblin Pond	3.41	3.41	682	11.37	Quahogs
Little River	0.32	0.32	64	1.07	Quahogs
Jehu Pond	1.05	1.05	210	3.50	Quahogs
Great River	0.98	0.98	196	3.27	Quahogs
Total	**5.76**	**5.76**	**1,152**	**19.21**	

* Nitrogen removal required calculated from: Howes et al. 2011.

** Littleneck quahogs at 60 grams live weight average

Issues and Management

1.) Predation: crabs (invasive green crabs) etc.

ACTION: Grow seed in upwellers, trays, and nets

2.) Harmful Algal Blooms : Alexandrium, Cochlodinium, and Pseudo-nitzschia.

ACTION: Monitor and suspend harvest if present.

3.) Ocean Acidification

ACTION: Monitor pH levels.

SCALE 1 inch : 2339 feet

GROWING AREA CODE: SC16
AREA NAME: LITTLE & GREAT RIVERS COMPLEX
AREA TOWN(S): FALMOUTH/MASHPEE

for legal boundary definition or regulatory interpretation.

AmeriCorps Member Sampling Shellfish Population Density


SC16 Quahog Seeding Areas
Jan 12, 2014
10
5
11
9
15
4
16
13
6
3
8
2
1

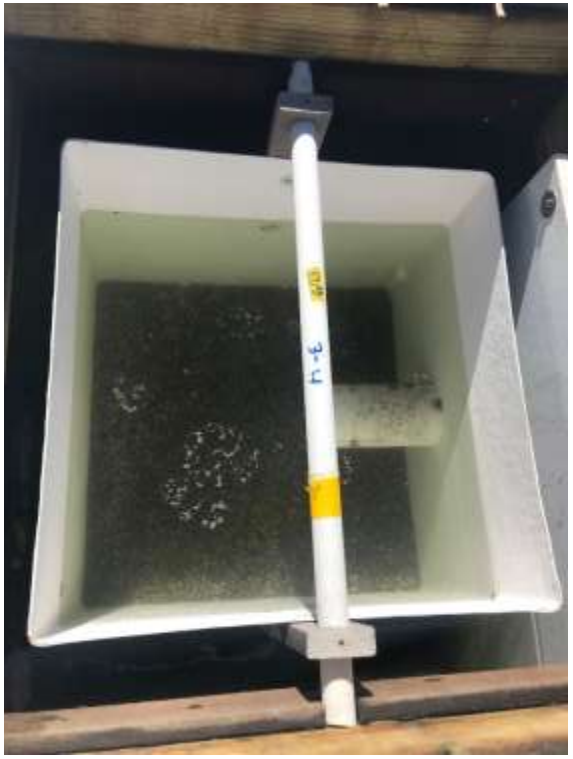
Quahog Seed From the Aquacultural Research Corporation Hatchery (~ 2 mm)

Quahog Seed in Town Upweller
at Little River

Mashpee's FLoating UPweller SYstem (FLUPSY) at Little River

Central trough with ½ hp de-icer pump under dock

Hatches that open for each of the 8 silos in the float.



2’ x 2’ x 2’ fiberglass silo coated with Netmider antifouling paint.

5 FLUPSY Floats at the Little River Town Dock
Housing 40 silos

Quahog seed trays: Larger sorted 15 mm – 25 mm seed are placed in bottom trays in Little and Great River

Field Planting Quahog Seed Under Nets

AmeriCorps Transplanting Quahog Seed From Nets

Quahog seed from nets #/sq. ft.

AmeriCorps Planting Quahog Seed from Nets and Trays

Predator Reduction Methods : Crab Trapping

Quahogs Seeded in Waquoit Bay (SC16) / Hamblin Pond, Little and Great River

Year	Total Seeded in SC16
2014	2,976,700
2015	2,385,782
2016	4,550,000
2017 (Planted in Fall after summer monitoring data)	8,122,669

9.9 million

Shellfish Aquaculture Farms in the area

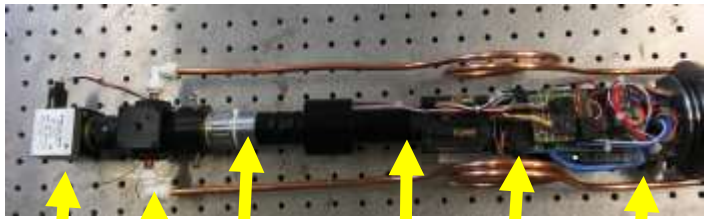
Molly Q Aquaculture Farm in Hamblin Pond

500,000 Oyster seed total on site in 2017

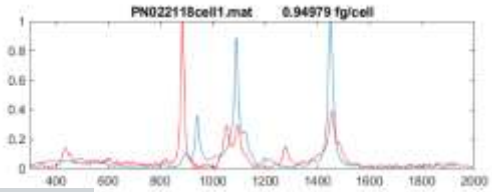
Monitoring/quantification

- Town monitors shellfish harvesting.
- Commercial shellfish harvests recorded electronically when sold to shellfish dealers and automatically reported to DMF.
- Continued water quality monitoring required by DEP/EPA – Town of Mashpee /Mashpee Wampanoag Tribe/University of Massachusetts Dartmouth School of Marine Sciences and Technology. Discrete sampling and deployed YSI 6660 and EXO 2 sondes. WBNERR System-wide Monitoring Program.

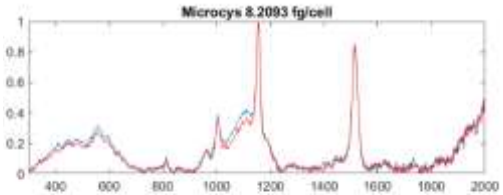
Harmful Algal Bloom Monitoring:
Raman Spectroscopy
HABStats- New Sensor for Detection and Quantification of HAB Cells and Toxins using Raman Spectroscopy

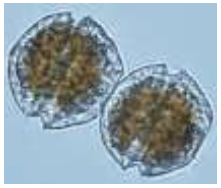


Quantification of domoic acid in *Pseudo-nitzschia*



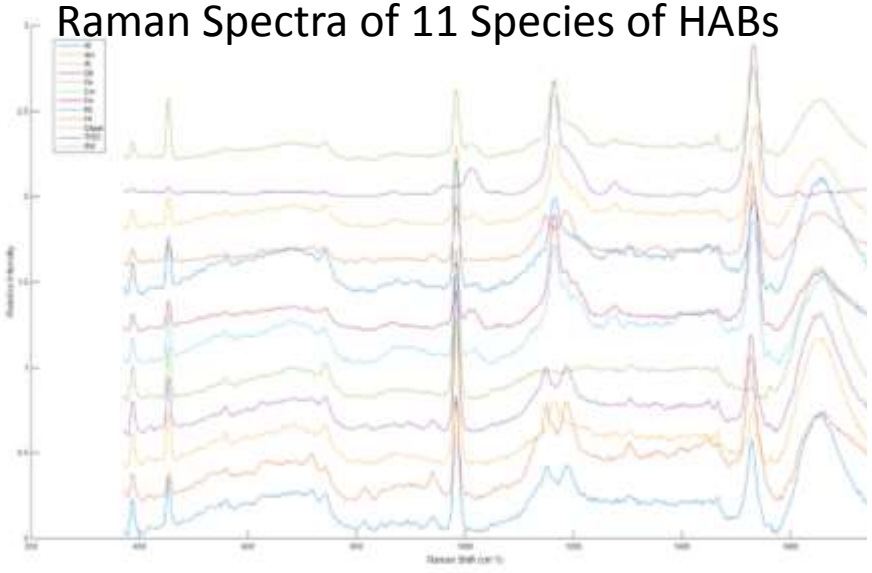
microcystin in *Microcystis aeruginosa*



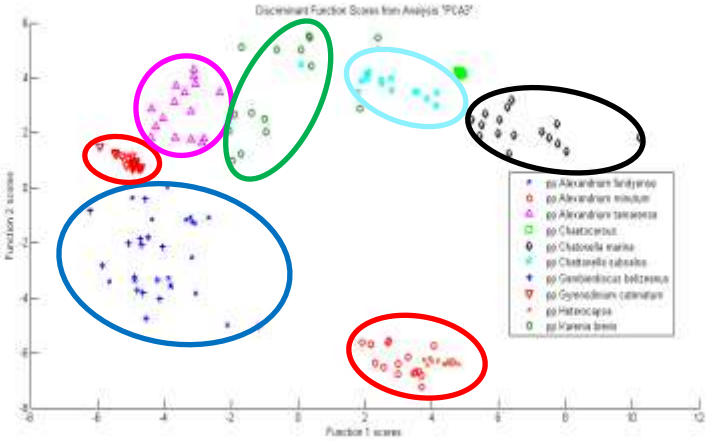


Karenia brevis, Alexandrium fundyense, Gymnodinium catenatum

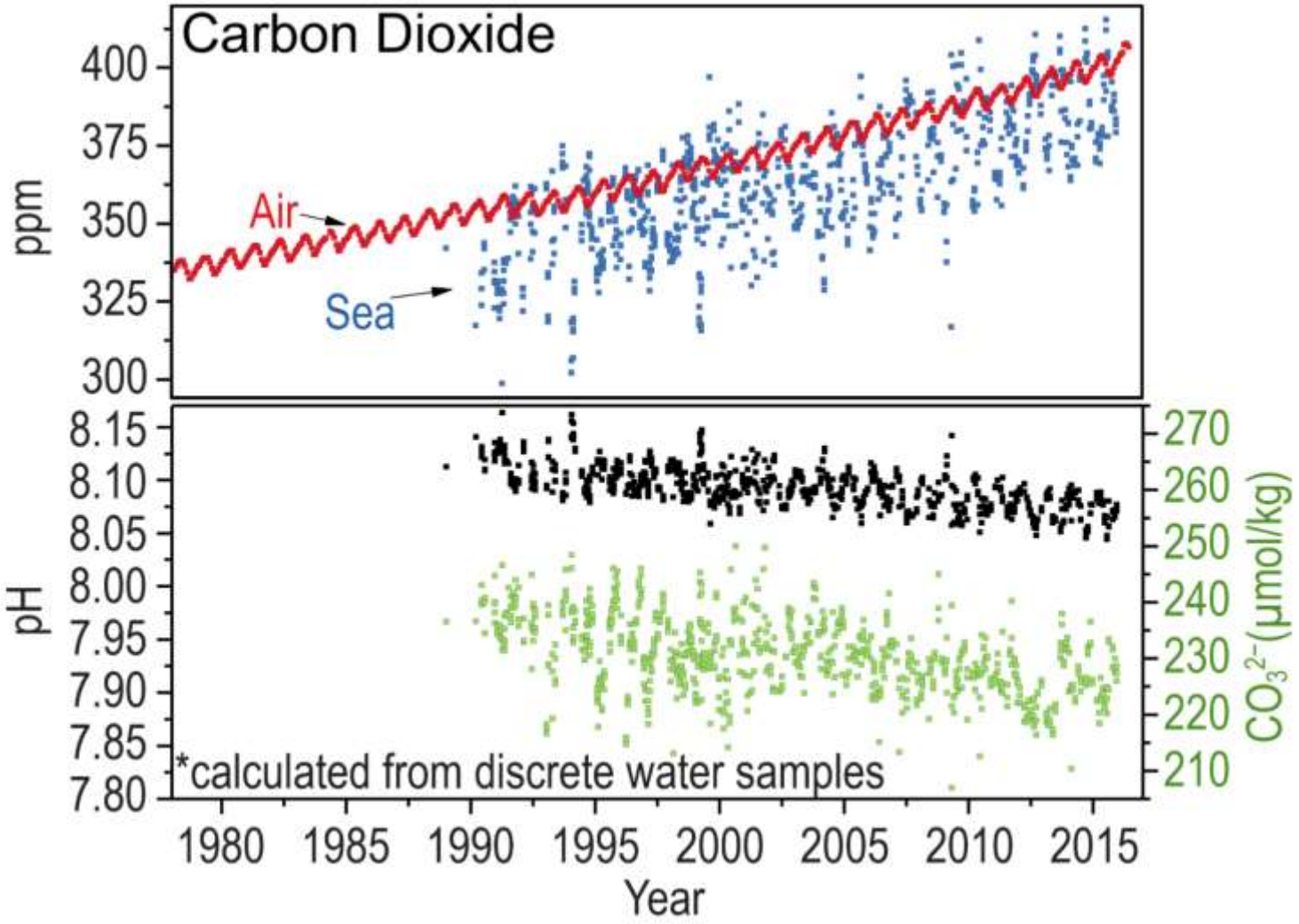
Raman Spectra of 11 Species of HABs



Near 100% Classification of HABs

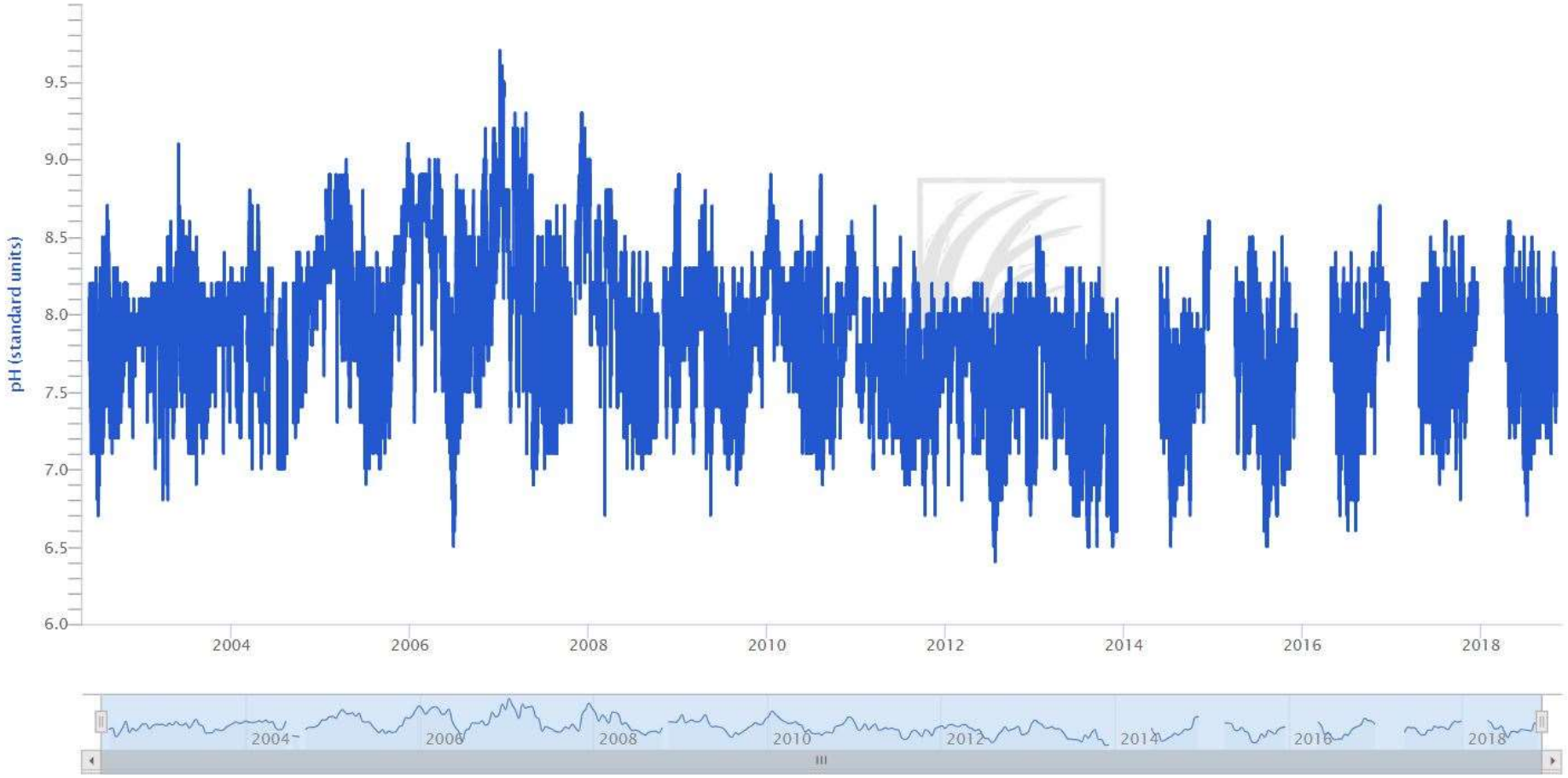


Ocean Acidification



Trends in surface (< 50 m) ocean carbonate chemistry calculated from observations obtained at the Hawai'i Ocean Time-series (HOT) Program in the North Pacific over 1988–2015. The upper panel shows the linked increase in atmospheric (red points) and seawater (blue points) CO_2 concentrations. The bottom panel shows a decline in seawater pH (black points, primary y-axis) and carbonate ion concentration (green points, secondary y-axis). Ocean chemistry data were obtained from the Hawai'i Ocean Time-series Data Organization & Graphical System (HOT-DOGS, http://hahana.soest.hawaii.edu/hot/hot-dogs/index.html). (Figure source: NOAA).

Childs River pH levels from 2002 to present



Source: WBNERR SWAMP data

Estuarine systems in the Waquoit Bay have pH fluctuations from 6.5 – 9+

2017 Results

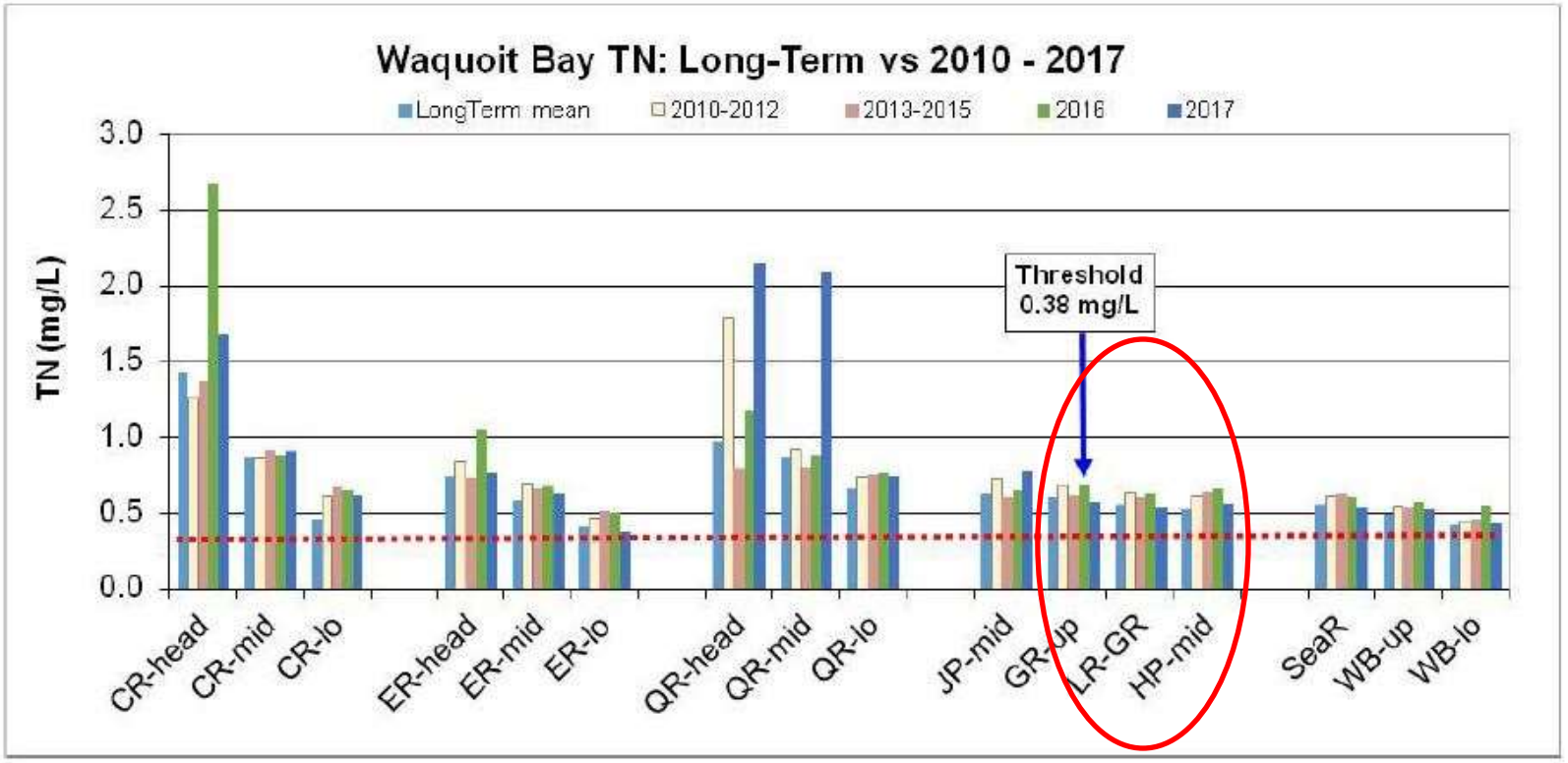
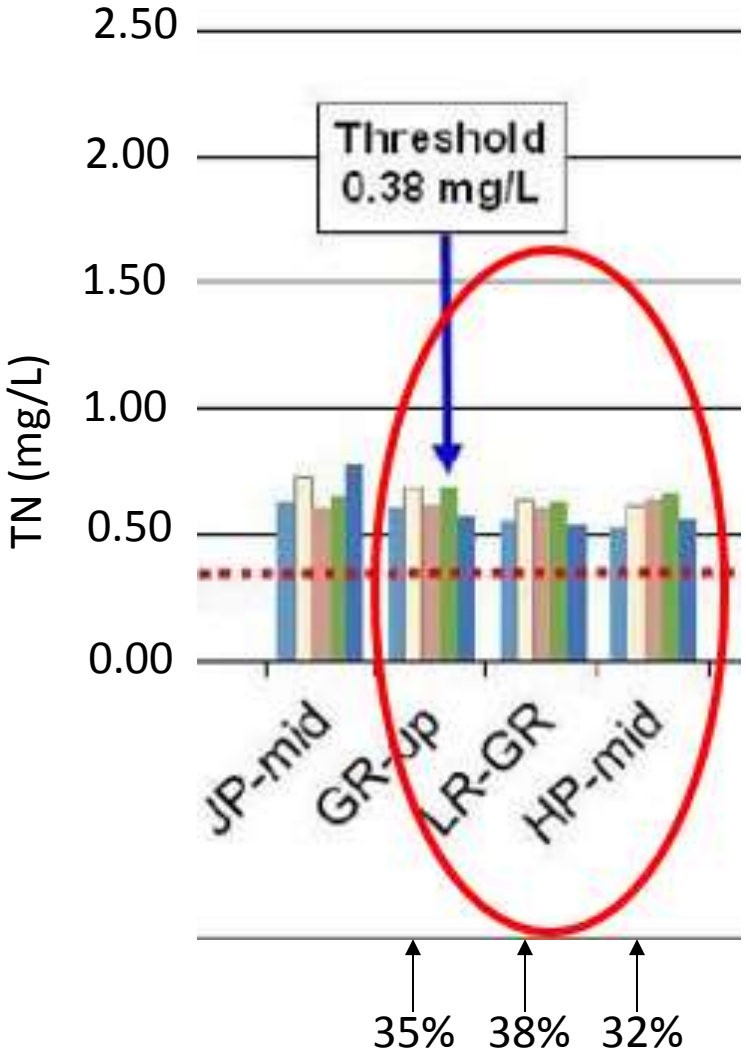


Figure 7. Distribution of Total Nitrogen within the Waquoit Bay Estuarine System, long-term and during the summers of 2010 through 2017. Nitrogen enters through groundwater inflows all along the shoreline, with additional "point" loads from the upper regions of the watershed via Moonakis River, Childs River, and Red Brook. These nitrogen loads plus recycling within the estuary mix with the low nitrogen waters of Nantucket Sound entering through the tidal inlets to create the observed gradient. CR - Childs River, ER - Eel River, QR - Quashnet River, JP - Jehu Pond, GR - Great River, LR-GR - Little River-Great River confluence, HP - Hamblin Pond, SeaR - Seapit River, WB - Waquoit Bay main basin; head - uppermost reach, mid - middle reach, lo - lower basin near mouth or inlet. The red line shows the offshore TN concentration (0.28 mg/L) and "Threshold" is the TMDL target for restoration.

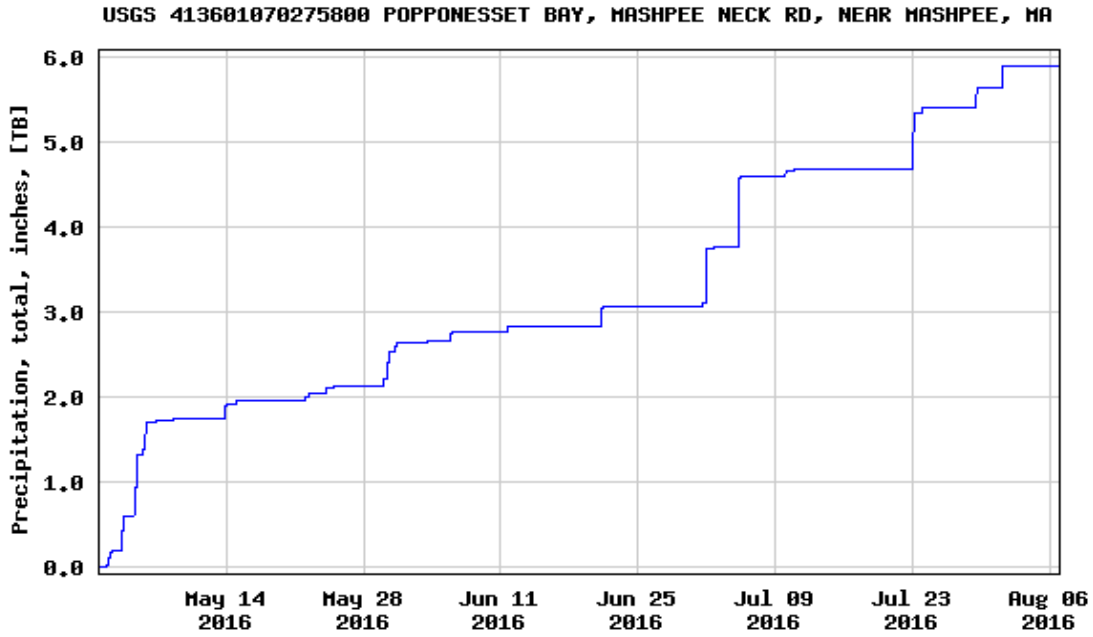
TN Concentration reduction seen in Hamblin Pond, Little and Great River for 2017



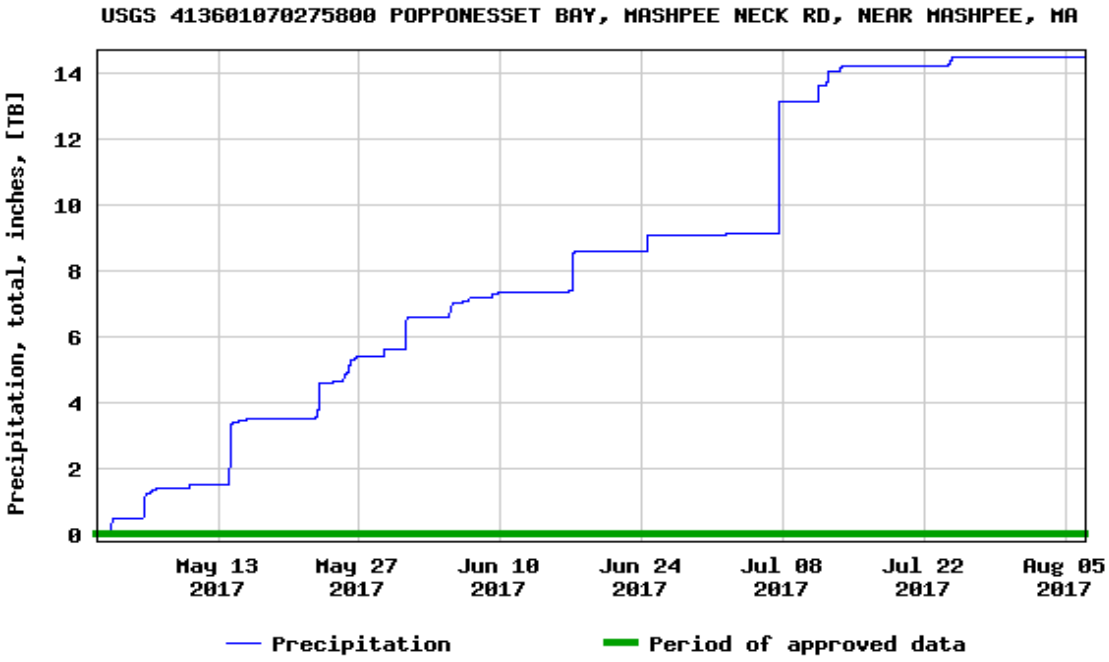
Source: Umass Dartmouth SMAST

32-38 % reduction to target 0.38 mg/ L TN in 2017

Improvement was noted from our seeding efforts despite higher N-load from increased rainfall



6 inches of Rain Reported from May 1 – August 6 2016



14+ inches of Rain Reported from May 1 – August 6 2017

Acknowledgements

- AmeriCorps Cape Cod
- Barnstable County Cooperative Extension
- Mashpee Wampanoag Tribe
- Massachusetts Division of Marine Fisheries
- Town of Mashpee
- University of Massachusetts Dartmouth, SMAST
- Waquoit Bay National Estuarine Research Reserve