Brown Tide Research Initiative

Sea Grant New York

Report #6 October 2001

2001 BROWN TIDE

The Peconic Bays, site of the first brown tide bloom on Long Island in 1985, has remained free from brown tide for the fifth consecutive year in 2000. Thus far in 2001, the Peconic Bays remain free of brown tide bloom.

In Great South Bay between late March and early April 2001, *A. anophagefferens* cell counts reached less than 3,000 cells/ml. Brown tide cell counts began to increase in late May and by the middle of June reached over 900,000 cells/ml under the Robert Moses Causeway Bridge (see table 1). At the end of June, Shinnecock, Quantuck, Moriches and West Neck Bays remained free from brown tide.

Early results of sampling by the New Jersey Department of Environmental Protection from April 16 through June 4, 2001 showed that brown tide blooms occurred sporadically in Little Egg Harbor. April concentrations from northern Barnegat Bay through Little Egg Harbor were below 5,000 cells/ml. At the end of May, however, Little Egg Harbor and Beach Haven Terrace experienced a brown tide bloom with cell counts ranging from 400,000 – 1,000,000 cells/ml.

Great South Bay

Aureococcus anophagefferens **cell counts**

Station Number/ Approximate Location	3/27/01	4/09/01	4/23/01	5/08/01	5/24/01	6/05/01	6/19/01
150 1.5 mi. South of Green Harbor	272	671				46,003	15,251
160 Nicoll Bay	259	268					
170 1.4 mi. South of Nicoll Point	251	204				101,254	332,111
180 2.3 mi. off Bayberry Pt./West Channel	2,297	591				180,740	290,596
190 Penataquit Creek	637	259				47,426	195,709
200 Coast Guard Station/Fire Island Inlet	0	—			4,409		165,345
210 Oak Island Channel	0	—			10,732		472,771
240 Carll's River	0				19,224		38,126
250 Neguntatogue Creek	0				2,759		1,277
280 Robert Moses Causeway Bridge	240					166,483	912,861

Table 1:
Great South Bay, Long Island *Aureococcus anophagefferens* cell counts (cells/ml) for select sampling stations.

Data courtesy of
Dr. Robert Nuzzi,
Suffolk County Department of Health Services

Brown Tide Research Initiative
Report #6

Writer: Patrick Dooley

Editors: Barbara Branca
Cornelia Schlenk

Designers: Barbara Branca
Sharon O'Donovan
Loriann Cody

BTRI Steering Committee:

Cornelia Schlenk, Chair, NYSG

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Susan Banahan, NOAA Coastal Ocean Program

Vacant, Representative, Town level

Kenneth Koetzner, NYS Dept. of Environmental Conservation, representing New York State

Dr. Robert Nuzzi, Suffolk County Dept. of Health Services, representing Suffolk County

Roger Tollefsen, NY Seafood Council, representing SSER and PEP Citizens Advisory Committees

William Wise, Marine Sciences Research Center, SUNY Stony Brook, representing the South Shore Estuary Reserve (SSER) Council

Sea Grant
New York

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Associate Director: Dale Baker
Assistant Director: Cornelia Schlenk
Communicator: Barbara Branca
Project Assistant & BTRI Outreach Specialist: Patrick Dooley
visit www.nyseagrant.org for a complete staff listing.

2001 BTRI Informational Symposium and Investigator Workshop

The fourth BTRI Informational Symposium, hosted by New York Sea Grant, was held on March 10, 2001 at Long Island University Southampton College in Southampton, New York. During the public symposium, seven BTRI and other brown tide talks were presented to an audience of more than 50 concerned citizens, researchers, agency personnel and reporters.

Dr. Robert Nuzzi, from Suffolk County Department of Health Services summarized Suffolk County's significant efforts in *Aureococcus anophagefferens* monitoring and sample collection. Dr. Gregory Boyer from SUNY College of Environmental Science and Forestry in Syracuse presented a comprehensive overview of the current brown tide bloom dynamics hypotheses and research findings. The three current BTRI research teams next summarized progress to date on their projects (see pages 3 – 6). Additionally, Dr. Christopher Gobler, from Long Island University Southampton College summarized his unique New York Sea Grant funded project looking at both the impacts of nutrients and grazing mortality during a brown tide in Great South Bay.

Prior to the Informational Symposium, BTRI and other brown tide researchers, program managers and agency personnel convened for an investigator workshop to discuss their results with each other as a peer audience, to brainstorm new ideas and research directions and coordinate the 2001 field sampling season. The investigator workshop has become an integral component of the BTRI effort facilitating coordinated field and laboratory work and as a means for researchers to prepare for the Public Informational Symposium.

BTRI Report Number 6 builds on the preceding 5 BTRI Reports and follows a format similar to the previous issues for easy project tracking. Boldfaced terms are defined under ***Key Terms*** adding to those defined in the earlier reports.

Gregory Boyer and Patrick Dooley (right) discuss new information presented during the Symposium.

Photos by Barbara Branca

A few of the 2001 BTRI Informational Symposium presenters (l-r): Christopher Gobler, Ed Their, Robert Nuzzi, Darcy Lonsdale and Todd Kana. See page 7 for investigator affiliations.

Sieracki: The Effects of Microbial Food Web Dynamics on the Initiation of Brown Tide Blooms

Photo by Barbara Branca

Charlie O'Kelly (right) a member of Sieracki's research team chats with; discusses their results with a Symposium attendee.

This team of investigators is testing a hypothesis examing the "**picoalgae niche.**" Between April and May, there is a succession from larger to smaller algal cells in Long Island bays. Typically, ***Synechococcus*** dominates the smaller picoalgae size class. If, however, *Synechococcus* is selectively removed or its density is reduced, the picoalgae niche opens for some other similar sized algae, such as *Aureococcus anophagefferens*. Reporting on data from West Neck Bay and Quantuck Bay collected in 2000, this team once again documented the seemingly inverse relationship between *Synechococcus* and *Aureococcus.* In fact an *A. anophagefferens* bloom did not develop in West Neck Bay in 2000. *Synechococcus* dominated the picoalgae population reaching its highest density in June (116,000 cells/ml determined by **flow cytometry**).

This team also examined another planktonic population that co-occurred with the picoalgae. *Large* cell sized planktonic grazers called **heterotrophic dinoflagellates** that could graze on *A. anophagefferens* sized organisms, also showed high population numbers in June. The high populations of *Synechococcus* and feeding by the large celled heterotrophic dinoflagellates could explain the absence of brown tide in West Neck Bay in 2000.

Quantuck Bay, on the other hand, developed a brown tide by the end of June in 2000. In early June, the *small* cell sized heterotrophic dinoflagellate population not capable of grazing on brown tide was on the rise, but declined as the *A. anophagefferens* population grew possibly suggesting an inhibition of these small celled heterotrophic grazers by *A. anophagefferens.* By the end of June, *A. anophagefferens* cell density reached 2 million cells/ml and the bacteria population uncharacteristically exceeded 16,000,000 cells/ml (see BTRI Report #4 November 1999 for more information on the bacteria associated with brown tide). The population of small heterotrophic **microflagellate** grazers, capable of grazing on the bacteria associated with brown tide, also peaked with *A. anophagefferens* and the bacteria populations. Throughout this time period, the *Synechococcus* population remained low never exceeding 38,000 cells/ml. Laboratory experiments are currently underway to examine *A. anophagefferens's* growth and grazing rates in these bays.

Kana, MacIntyre, Cornwell & Lomas: Benthic-Pelagic Coupling and Long Island Brown Tide

The first part of this project was to establish suitable sampling sites that would allow investigations of **benthic-pelagic coupling** at several periods surrounding a brown tide event. A transect with three sampling sites was established from the mouth of the Peconic River extending to Flanders Bay to measure along the gradient from a riverine system humic to an open bay location. This transect also represents a gradient in bottom sediment composition from fine mud to sand allowing for an assessment of benthic processes. Three sampling sites were also established in Quantuck Bay due to its highest frequencies of brown tide blooms.

There were significant differences in **nutrient loading** and **turbidity** along the transect from the Peconic River mouth to Flanders Bay. Highest values were associated with the River mouth where the Riverhead STP (Sewage Treatment Plant) effluent is located. Brown tide did not bloom along the Flanders Bay transect in the summer of 2000. Quantuck Bay, however, did experience a bloom in late June.

The Kana research team: Jeffrey Cornwell, Hugh MacIntyre, Michael Lomas and Todd Kana.

Photo by Barbara Branca

Nutrient analyses for dissolved organic nitrogen, dissolved organic phosphorous and organic nutrients from the sediment flux experiments are still underway. Preliminary analyses suggests a May-July shift in the dominant location of photosynthesis from the benthos to the water column. For both bays, the **chlorophyll** concentration was 1-4 orders of magnitude higher in the upper 5 millimeters of the sediment than in the water column. Sediment chlorophyll concentrations declined between May and July/ September.

Preliminary data also suggest differences in the bay's underwater light environments. Between May and July, Quantuck Bay showed increases in underwater **light attenuation** (less light penetrated) while Flanders Bay showed no seasonal light attenuation changes.

Work focusing on differences between the bays' underwater light environments continues in the 2001 field season. Use of a new optical light attenuation model will help determine the relative importance of benthic versus water column photosynthesis.

Both Peconic and Flanders Bays served as organic nutrient traps with dissolved organic carbon and nitrogen concentrations doubling between the May and July sampling, while inorganic nitrogen remained low and contributed a maximum of 15% to the total nitrogen pool. During spring rains in May, nitrate was found in higher concentrations than ammonium while the opposite was true in July. Although inorganic nitrogen was only 15% of the available nitrogen, it accounted for greater than 80% of the measured nitrogen uptake by the planktonic community in all seasons. Of the organic nitrogen substrates tested, urea was taken up at the highest rates and accounted for 10-15% of the

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measured nitrogen uptake. It is unlikely that inorganic nitrogen could supply all of the needed nitrogen to support the measured rates of **primary productivity**. It is estimated that as much as 46% of the required nitrogen would have to come from organic sources such as urea and other small organic compounds.

Associated with this seasonal increase in organic nutrients was an increase in **bacterial productivity**. The seasonal increase in bacterial productivity was greater than that for primary productivity leading to a more heterotrophic community in July (see also Sieracki page 3), however, the community was still net autotrophic on both occasions.

Lonsdale, Caron & Cerrato: Causes and Prevention of Long Island Brown Tide

Expanding on and continuing the use of mesocosms, this team's investigation into possible causes of brown tide includes research on planktonic (zooplankton) and benthic bivalve (hard clam, *Mercenaria mercenaria*) grazing on *Aureococcus* and how nutrients influence the timing and magnitude of brown tide blooms.

In mesocosm dilution experiments, zooplankton grazing was measured on the total phytoplankton population, (measured as **total chlorophyll-a**), and also specifically on *Aureococcus*. Zooplankton seemed to graze equally on the total phytoplankton community or just on *Aureococcus*. Although zooplankton consumed brown tide, when *Aureococcus* grew rapidly (growth coefficient = 0.7 – 1.0 per day) in the mesocosms, zooplankton grazing was not sufficient to reduce *Aureococcus* density. By the fifth day of the experiment, brown tide's growth rate had decreased (growth coefficient 0.35 per day) which closely matched the rate of zooplankton grazing (growth coefficient 0.34 per day). At this lower *Aureococcus* growth rate, the zooplankton could effectively controll further *Aureococcus* population growth.

Photo by Rebecca Schaffner

Dave Caron (right) and Dianne Greenfield (left) set up a mesocosm experiment in Southold, NY.

To determine if the presence of hard clams could prevent a brown tide bloom in the mesocosms, total chlorophyll-a, *A. anophagefferens* and zooplankton concentrations, and hard clam (mean shell length 39.7 mm) clearance rates were measured in several mesocosm treatments combining nutrients, pumps and hard clams. The initial *A. anophagefferens* concentration was approximately 13,200 cells/ml across the various treatments during this nine-day experiment. This brown tide concentration was below the hypothesized threshold for feeding inhibition in juvenile hard clams of approximately 35,000 cells/ml.

A. anophagefferens did show a positive net growth in the two treatments without clams. However, in mesocosms with hard clams, *Aureococcus* density did not increase above the initial concentration of 13,200 cells/ml. By the ninth day of the experiment, *Aureococcus* concentrations averaged less than 9,000 cells/ml in hard clam treatments. Hard clam feeding appeared, therefore, to remove any positive net *A. anophagefferens* growth (see photos on page 6). When these clams were transferred to tanks with a

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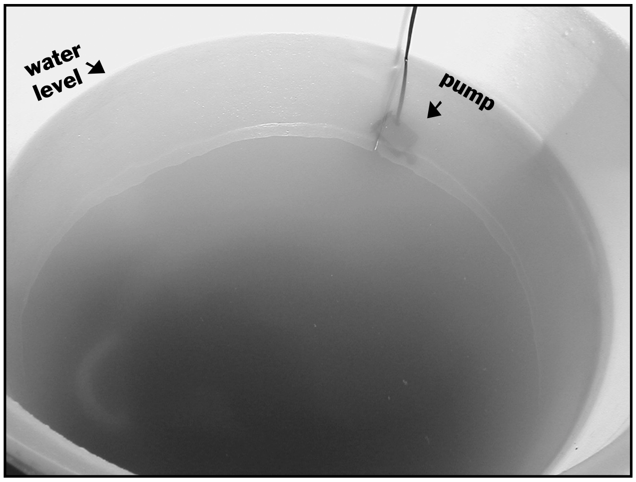
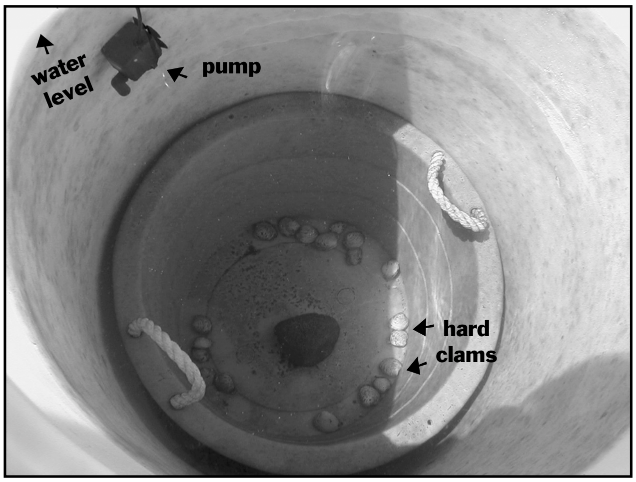


Mesocosm experiment showing a brown tide bloom in a test chamber.



Mesocosm treatment demonstrating the effect of hard clams on water clarity. Brown tide did not develop in mesocosms with hard clams.

Photos by Rebecca Schaffner

higher *Aureococcus* density, their suspension feeding ceased almost immediately demonstrating a form of brown tide "toxicity."

In collaboration with BTRI researchers Drs. Christopher Gobler and Sergio Sañudo-Wilhelmy (see BTRI Reports 1-5) and Dr. Gordon Taylor from the Marine Sciences Research Center Stony Brook University, a nine-day mesocosm experiment was conducted to determine the influence of natural nutrient enrichment (i.e., such as groundwater) on brown tide development. Nutrients were evaluated in five treatments combining inorganic nutrients, pumps, West Neck Bay or Flanders Bay groundwater and a control with an initial average *A. anophagefferens* concentration of approximately 7500 cells/ml. Although results from this experiment are still being evaluated, preliminary findings suggest no striking differences in brown tide development over time among these treatments.

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KEY TERMS

A compiled list of Key Terms can be found on the New York Sea Grant web page at www.nyseagrant.org

bacterial productivity
The amount of bacteria that grows during a given time period.

benthic-pelagic coupling
Benthic-pelagic coupling describes the interaction that links the benthos or bottom with the water column or the pelagic ecosystems. In particular, it refers to how the dynamics in one ecosystem influences the dynamics of the other. In other words, how benthic systems affect pelagic systems, and how pelagic systems influence benthic systems.

chlorophyll
The photosynthetic pigment responsible for converting light energy to chemical energy used for plant growth.

dinoflagellates
Dinoflagellates are unicellular protists, which exhibit a great diversity of lifestyles including photosynthetic (autotrophic), heterotrophic and parasitic. Many harmful algae blooms are caused by dinoflagellates.

flow cytometry
Flow Cytometry is a process in which cell or particle measurements are made while the cells or particles pass, preferably in single file, through the measuring apparatus in a fluid stream.

heterotrophic
Organisms that obtain nourishment from the ingestion and breakdown of organic matter.

light attenuation
The decrease in light intensity as a result of absorption of energy and of scattering due to particles in the water.

microflagellate
Small **protists** that can be photosynthetic or heterotrophic.

nutrient loading
Discharge of nutrients from the watershed into a receiving body such as a lake, stream, wetland or estuary.

picoalgae
Very small, single-celled planktonic algae in a size range 0.2 – 2.0 µm.

primary productivity
The total amount of new organic matter produced by photosynthesis.

protist
A group of simple organisms not distinguished as animals or plants, though having some characteristics common to both.

Synechococcus
A species of cyanobacteria that contain chlorophyll-*a* and are coccoid in shape.

total chlorophyll-a
Represents the measure of chlorophyll from all phytoplankton in a given sample.

turbidity
The lack of clarity of a liquid as measured by the amount of suspended material (i.e., particulates such as sediments, phytoplankton, colloids, etc.) in a volume of water. Turbidity reduces the depth of light penetration in a water column.

Current Investigators

Bigelow Laboratory for Ocean Sciences, ME
- Dr. Charles O'Kelly
- Dr. Michael Sieracki
- Mr. Ed Thier

Horn Point Environmental Laboratories, University of MD
- Dr. Todd M. Kana
- Dr. Hugh L. MacIntyre
- Dr. Jeffrey C. Cornwell

Long Island University, Southampton College, NY
- Dr. Christopher Gobler

Marine Sciences Research Center, Stony Brook University NY
- Dr. Darcy L. Lonsdale
- Dr. Robert M. Cerrato

University of Southern California
- Dr. David A. Caron

Bermuda Biological Station for Research, Bermuda
- Dr. Michael W. Lomas

This glossary was compiled with input from an assortment of sources:

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Webster's New Collegiate Dictionary (1981), Henry B. Woolf, Editor-in-Chief

Various BTRI investigators and Steering Committee Members

INSIDE

If you have any questions about brown tide, would like a copy of *Report #1*-6, or would like to be added to our mailing list, please contact Patrick Dooley at New York Sea Grant (pdooley@notes.cc.sunysb.edu or 631-632-9123). You may also read these reports by visiting our website: << http://www.nyseagrant.org>>. This publication may be made available in an alternative format and is printed on recycled paper.

The Brown Tide Research Initiative (BTRI) is funded by the National Oceanic and Atmospheric Administration's Coastal Ocean Program and administered by New York Sea Grant. The first (1996-1999) three-year $1.5 million BTRI program was developed to increase knowledge concerning brown tide by identifying the factors and understanding the processes that stimulate and sustain brown tide blooms. Continued funding for BTRI (1999-2001), as a $1.5 million three-year effort, comes once again from NOAA's COP. The COP, National Sea Grant Office, National Science Foundation, Environmental Protection Agency, Office of Naval Research, and National Aeronautics and Space Administration are jointly sponsoring research on Harmful Algal Blooms (HAB) ecology and oceanography in the interagency research program, Ecology and Oceanography of Harmful Algal Blooms (ECOHAB).

There were eight projects in the first three-year effort, then three new projects in the second three-year effort. All BTRI projects were selected from national calls for proposals. The research projects chosen for BTRI funding were selected following peer review and evaluation by a technical review panel. To involve concerned parties and aid in decision-making, New York Sea Grant formed the BTRI Steering Committee of representatives from state, local and government agencies and citizen's groups.

This Report Series will aid in the dissemination of general brown tide information. The results and conclusions of the projects will help determine the directions of potential management and future research.

Sea Grant New York

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121 Discovery Hall
Stony Brook University
Stony Brook, NY 11794-5001

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