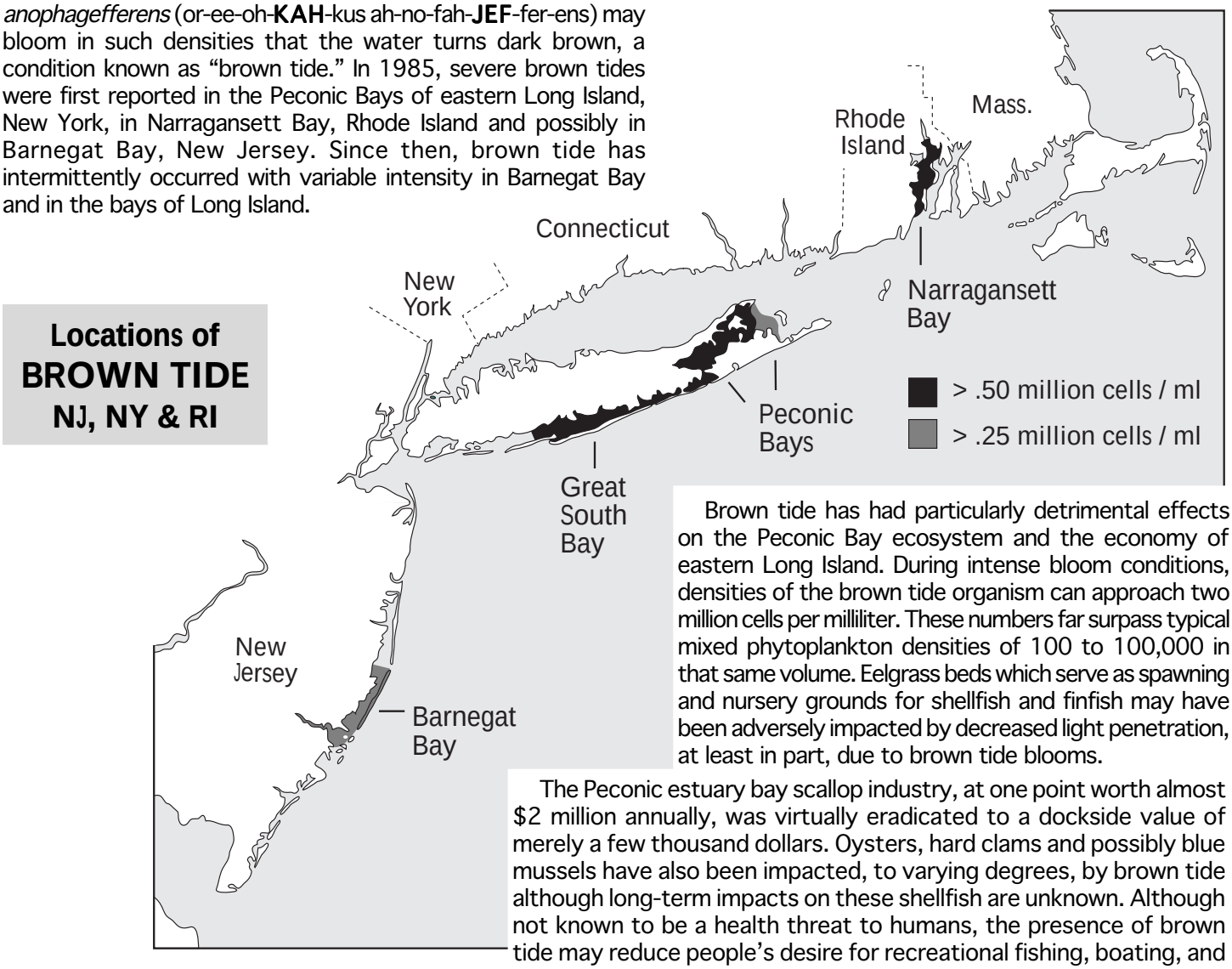
Sea Grant
New York

Brown Tide Research Initiative

Report #1 March 1998

BROWN TIDE — AN OVERVIEW

Brown tides are part of growing world-wide incidences of harmful algal blooms (HAB) which are caused by a proliferation of single-celled marine plants called phytoplankton. One species of phytoplankton, the microscopic alga *Aureococcus anophagefferens* (or-ee-oh-**KAH**-kus ah-no-fah-**JEF**-fer-ens) may bloom in such densities that the water turns dark brown, a condition known as "brown tide." In 1985, severe brown tides were first reported in the Peconic Bays of eastern Long Island, New York, in Narragansett Bay, Rhode Island and possibly in Barnegat Bay, New Jersey. Since then, brown tide has intermittently occurred with variable intensity in Barnegat Bay and in the bays of Long Island.



Brown tide has had particularly detrimental effects on the Peconic Bay ecosystem and the economy of eastern Long Island. During intense bloom conditions, densities of the brown tide organism can approach two million cells per milliliter. These numbers far surpass typical mixed phytoplankton densities of 100 to 100,000 in that same volume. Eelgrass beds which serve as spawning and nursery grounds for shellfish and finfish may have been adversely impacted by decreased light penetration, at least in part, due to brown tide blooms.

The Peconic estuary bay scallop industry, at one point worth almost $2 million annually, was virtually eradicated to a dockside value of merely a few thousand dollars. Oysters, hard clams and possibly blue mussels have also been impacted, to varying degrees, by brown tide although long-term impacts on these shellfish are unknown. Although not known to be a health threat to humans, the presence of brown tide may reduce people's desire for recreational fishing, boating, and swimming in affected waters.

Advances have been made regarding the identification and characterization of *Aureococcus anophagefferens*. However, the factors that cause bloom conditions and those that allow blooms to persist need further investigation. For this reason the Brown Tide Research Initiative was developed (see page 8). The research underway, supported by the BTRI effort, is described in this Report #1.

Brown Tide Research Initiative
Report #1

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Research Project Briefs: Culturing

What genetic strains of brown tide algae can be cultured?

Andersen: Multiple Culture Isolates (Xenic and Axenic), Biodiversity and Ultrastructure of *Aureococcus anophagefferens.*

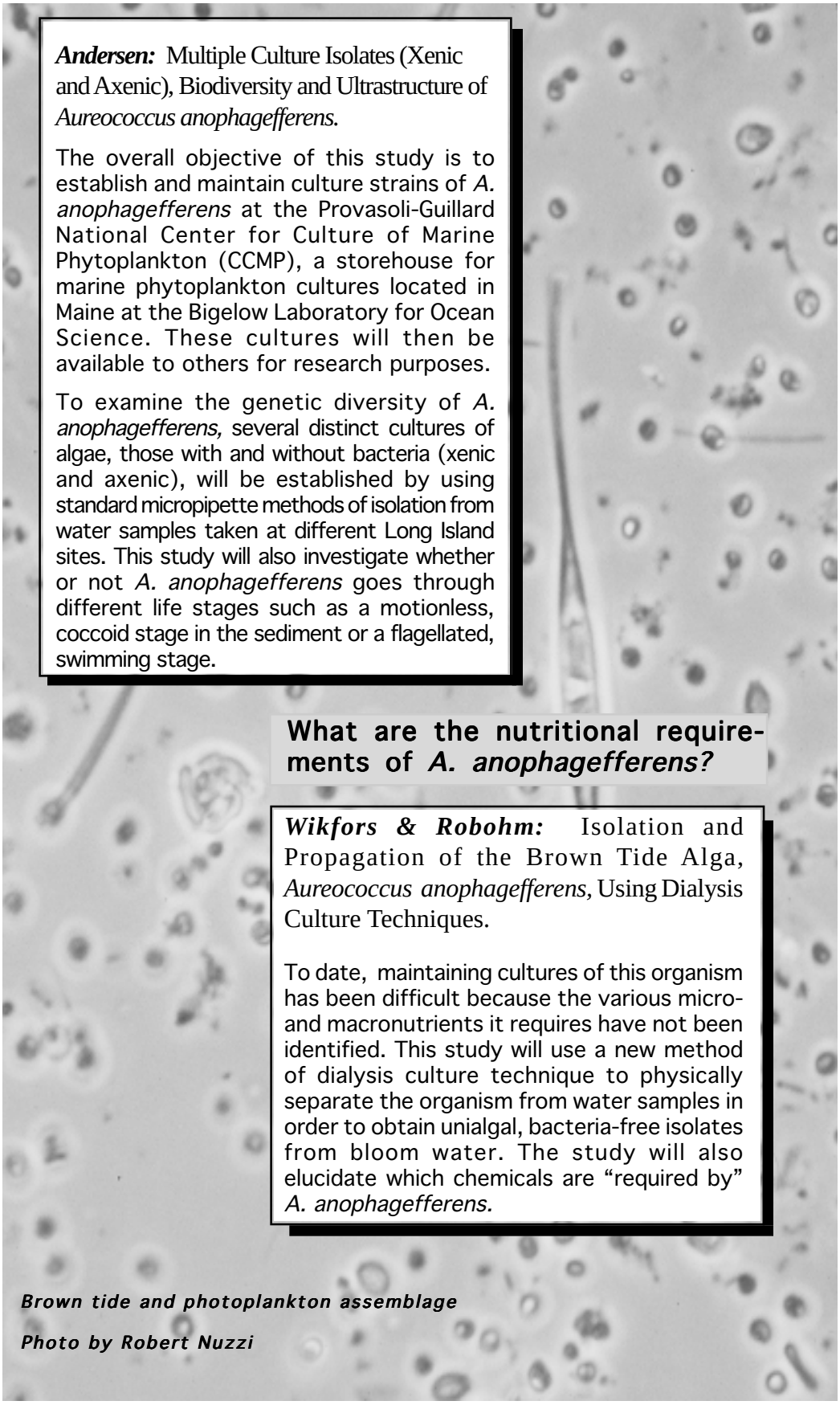
The overall objective of this study is to establish and maintain culture strains of *A. anophagefferens* at the Provasoli-Guillard National Center for Culture of Marine Phytoplankton (CCMP), a storehouse for marine phytoplankton cultures located in Maine at the Bigelow Laboratory for Ocean Science. These cultures will then be available to others for research purposes.

To examine the genetic diversity of *A. anophagefferens,* several distinct cultures of algae, those with and without bacteria (xenic and axenic), will be established by using standard micropipette methods of isolation from water samples taken at different Long Island sites. This study will also investigate whether or not *A. anophagefferens* goes through different life stages such as a motionless, coccoid stage in the sediment or a flagellated, swimming stage.

What are the nutritional requirements of *A. anophagefferens?*

Wikfors & Robohm: Isolation and Propagation of the Brown Tide Alga, *Aureococcus anophagefferens,* Using Dialysis Culture Techniques.

To date, maintaining cultures of this organism has been difficult because the various micro- and macronutrients it requires have not been identified. This study will use a new method of dialysis culture technique to physically separate the organism from water samples in order to obtain unialgal, bacteria-free isolates from bloom water. The study will also elucidate which chemicals are "required by" *A. anophagefferens.*



Brown tide and photoplankton assemblage

Photo by Robert Nuzzi

Research Project Briefs: Ecology

What possible physiological mechanisms initiate algal blooms and allow them to persist?

Keller & Sieracki: Physiological Ecology of the Brown Tide Organism, *Aureococcus anophagefferens.*

This project uses cultured algae to examine the physiological factors that initiate an algal bloom. The investigators will try to determine whether *A. anophagefferens* out-competes other species in light-limited environments. Its photosynthetic ability may give it an advantage in turbid (cloudy) waters such as Long Island embayments. Which algae are predominantly grazed upon, including brown tide and other co-occurring species, will be investigated. If the co-occurring species are selected by grazers as their primary food source while brown tide organisms are avoided, then brown tide populations may be able to increase to bloom densities.

To culture *A. anophagefferens* and other co-occurring algae, a variety of enrichment, dilution and single-cell isolation techniques will be used. To identify, mark and count the algae populations in field samples, flow cytometry and antibody methods will be employed. In this manner, the mechanisms which initiate a brown tide and its bloom cycle will be investigated.

How does brown tide meet its nutritional needs in low light conditions?

Glibert & Kana: Mechanisms for Nutrient and Energy Acquisition in Low Light: Successful Strategies of *Aureococcus anophagefferens.*

It is believed that *A. anophagefferens* out-competes other phytoplankton by having mechanisms to acquire energy and nutrients in highly turbid waters as are found in the Peconics. This competitive success is believed contingent on the ability to supplement photosynthesis with heterotrophic uptake of organic compounds and to utilize two different pathways for assimilating organic nitrogen under limited-light conditions.

This study will explore the photosynthetic, respiratory, and nitrogen uptake capabilities of laboratory clones of *A. anophagefferens* under a range of light and nutrient conditions. The results from these cultured clones will be compared to several other naturally co-occurring species or species that are representative of turbid bays. Size fractionation, serial dilution and a variety of media types will be used to culture the algae. The use of tracer techniques will also be employed to investigate its rates of photosynthetic, respiratory, and nitrogen uptake.

Key Terms from *Algae* to *Zooplankton*

algae Primitive, often aquatic, plants that may carry on photosynthesis, but lack the flowers, roots, stems, and leaves of higher plants.

algal bloom High concentrations or densities of algae.

anthropogenic (source of nutrients) Derived from human activities (i.e., fertilizer, animal waste, sewage, automobile exhaust, urban runoff).

axenic culture The growth of a single species of organism in the absence of living cells of another species.

culture A growth of microscopic cells in a controlled artificial environment.

DIN Dissolved Inorganic Nitrogen (e.g., nitrate, nitrite, and sometimes ammonium).

Don Dissolved Organic Nitrogen (e.g., urea).

ecosystem Organisms of a natural community together with the environment.

ferredoxin An iron-containing protein important for growing cells.

flavodoxin A non-iron containing protein important for growing cells.

graze To feed by browsing on, cropping, or eating.

growth Increase in cell number and/or size of an organism.

HAB Harmful Algal Bloom.

herbivory The consumption of plant material.

heterotrophic An organism that obtains nourishment from the ingestion and breakdown of organic matter rather than from photosynthesis.

inorganic Composed of chemical compounds that do not contain carbon as the principal element; matter other than plant or animal.

macronutrient Nutrients required in relatively large concentrations such as nitrates, nitrites and phosphates.

mesocosm Experimental apparatus or enclosure in which environmental factors can be manipulated.

mesozooplankton Medium sized zooplankton (size range: 20-200 microns).

micronutrient Nutrients required in relatively small concentrations such as trace organics, metals and chelators.

microzooplankton Small zooplankton (size range: 2-20 microns).

nitrogen A biologically important nutrient essential to plant growth.

nutrient A substance required for growth (e.g., nitrogen, phosphorus, vitamins, trace metals).

organic Compounds containing carbon and also containing hydrogen with or without oxygen, nitrogen, or other elements.

photosynthesis Process whereby plants convert water, carbon dioxide, and sunlight into sugars for energy.

physiological Characteristic of an organism's health or normal function.

phytoplankton Microscopic algae, usually suspended in the water column. *A. anophagefferens* is an example of a picoplankton (< 2 microns).

plankton Organisms, both plants and animals, that live freely in the water column and may be transported by tides and currents.

strain A group or organisms of the same species of presumed common ancestry with clear-cut physiological but usually not morphological distinctions (i.e., a stock, line, or ecotype).

trace metal A metal found in minute but measurable quantities.

zooplankton Microscopic animals that are suspended in the water column.

Research Project Briefs: Ecology

Dr. Darcy Lonsdale discusses brown tide at a National Sea Grant media briefing.

Lab technician Michael Doall holds a flask containing brown tide algal cells.

Photos by Barbara Branca

What interactions in the pelagic food web can initiate brown tide?

Caron & Lonsdale: Microzooplankton-Mesozooplankton Coupling and Its Role in the Initiation of Blooms of *Aureococcus anophagefferens* (Brown Tides).

The focus of this study is on the growth and grazing relationships involving *A. anophagefferens* and other small plankton during the earliest stages of the onset of bloom conditions. The investigators hypothesize that one of the factors in the initiation of brown tide is the inability of certain grazing microzooplankton (small animal plankton) to control the abundance of brown tide by feeding on it. If the brown tide organism is not eaten by these grazers, then the algae population increases and can possibly lead to a bloom.

To investigate this question, the researchers will conduct field mesocosm experiments using containers in which environmental conditions will be manipulated. They will examine the effects of experimental changes in the pelagic food web (i.e., within the water column) and microbial herbivory on the growth and abundance of *A. anophagefferens.*

TIMELINE OF BROWN TIDE ACTIVITY AND BLOOM MANAGEMENT

1985	1986	1987	1988	1990	1991
Simultaneous development of brown tide in: • Peconic Bays, NY • Great South Bay, NY • Narragansett Bay, RI • Barnegat Bay, NJ++	• Great South Bay • Peconic Bays	• West Neck Bay • Peconic Bays*	• West Neck Bay • Peconic Bays* • South Shore Bays*	• West Neck Bay • Peconic Bays	• West Neck Bay • South Shore Bays* • Peconic Bays
	• Monitoring Peconic Bays brown tide by SCDHS • MSRC's Living Marine Resources Institute, Port Authority of New York and New Jersey, and NYSUDC hold emergency brown tide and unusual algal bloom conference	• Initiation of the Brown Tide Task Force and Brown Tide Comprehensive Assessment and Management Program (BTCAMP) by SCDHS	• MSRC hosts symposium on Novel Phytoplankton Blooms		

KEY TO LOCATIONS

Peconic Bays: includes sampling stations from the Peconic River to Lake Montauk.

South Shore Bays: includes Great South Bay, Moriches Bay, and Shinnecock Bay.

Research Project Briefs: Bloom Triggers

What roles do metals and organic compounds play in brown tide?

Sañudo-Wilhelmy, Hutchins & Donat: Biogeochemical and Anthropogenic Factors that Control Brown Tide Blooms: The Effects of Metals and Organic Nutrients in Long Island Embayments.

This study will establish the relative importance of natural versus anthropogenic processes for brown tide blooms in Long Island's embayments.

Previous laboratory studies have suggested that *A. anophagefferens* has a high iron requirement for growth. However, iron's exact role in the bloom cycle needs further investigation. It is also unclear what role other nutrients including dissolved organic nitrogen compounds, dissolved inorganic nutrients (such as nitrate and ammonia) and other trace metals play in brown tides.

These compounds and their various forms vary seasonally in Long Island embayments. To gain insight into the roles of these compounds and their sources as bloom initiators, water samples will be "ultrafiltered" to separate out each component by chemical species, then analyzed for nutrient and metal content. Mesocosms will be used to determine the role of these metals and organic nutrients on the growth of *A. anophagefferens.*

Dr. Sergio Sañudo-Wilhelmy (above) and Sea Grant Scholar Christopher Gobler (below) in the trace metals clean lab.

MANAGEMENT ACTIONS IN THE NORTHEAST

ACTIVITY

1992	1993	1994	1995	1996	1997	1998
• West Neck Bay • South Shore Bays	• Great South Bay*	• Great South Bay	• West Neck Bay • South Shore Bays • Peconic Bays • Barnegat Bay		• West Neck Bay* • South Shore Bays • Barnegat Bay	

KEY TO AGENCIES

MSRC - Marine Sciences Research Center at SUNY Stony Brook
NYSDEC - New York State Department of Environmental Conservation
NYSG - New York Sea Grant
SCDHS - Suffolk County Department of Health Services
NYSUDC - New York State Urban (now Empire) Development Corporation

ACTIONS

1995	1996	1997	1998
• New York Sea Grant and NOAA'S Coastal Ocean Program host the Brown Tide Summit	• Brown Tide Research Initiative (BTRI) started	• New York Sea Grant hosts the first BTRI Informational Symposium	• New York Sea Grant hosts the second BTRI Informational Symposium

(*) Low densities and/or limited bloom locations.
(++) Not confirmed to be *Aureococcus anophagefferens*

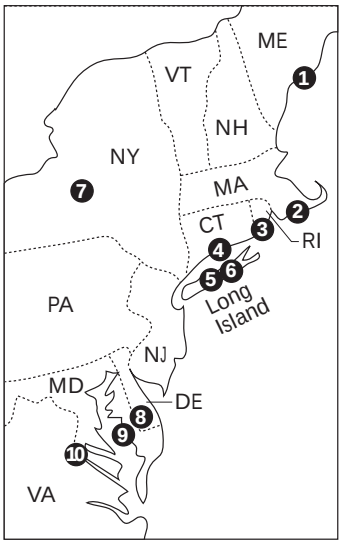
Research Project Briefs: Bloom Triggers

Sea Grant Scholar Darlene Szmyr counts brown tide cells.

Photo by Gregory Boyer

BTRI Investigators

1. *Bigelow Laboratory for Ocean Sciences, ME*
   Dr. Robert A. Andersen
   Dr. Maureen Keller
   Dr. Michael Sieracki
2. *Woods Hole Oceanographic Institution, MA*
   Dr. David A. Caron
3. *Graduate School of Oceanography , RI University of Rhode Island*
   Dr. Theodore, J. Smayda
4. *Northeast Fisheries Science Center, CT NOAA/NMFS*
   Dr. Richard A. Robohm
   Dr. Gary H. Wikfors
5. *Marine Sciences Research Center, NY SUNY at Stony Brook*
   Dr. Darcy J. Lonsdale
   Dr. Sergio Sañudo-Wilhelmy
6. *Brookhaven National Laboratory, NY*
   Dr. Julie La Roche
7. *SUNY College of Environmental Science and Foresty, NY*
   Dr. Gregory L. Boyer
8. *College of Marine Studies, DE University of Delaware*
   Dr. David A. Hutchins
9. *Horn Point Environmental Laboratories, MD University of Maryland*
   Dr. Patricia M. Glibert
   Dr. Todd M. Kana
10. *Old Dominion University, VA*
    Dr. John Donat



How does iron metabolism relate to blooms of *A. anophagefferens?*

Boyer & La Roche Ferredoxin and Flavodoxin as a Metabolic Marker for Iron Stress in *Aureococcus anophagefferens.*

The trace metal iron may be a limiting factor influencing brown tide blooms. The amount of total iron measured in the environment is much greater than the amount of iron available to a growing cell, making it difficult to determine if iron is limiting. This study will look at changes inside the cell itself to see if *A. anophagefferens* is limited by iron. Two energy producing proteins, ferredoxin, which contains iron, and flavodoxin, which does not contain iron, will be measured using both chromatographic (HPLC) and immunological techniques. Ferredoxin and flavodoxin will also be purified and characterized to serve as standards for the assay. By measuring the ratio of these two proteins under different conditions in culture, a metabolic marker for iron-stress can be developed to determine if iron is limiting to natural populations of *A. anophagefferens.*

Can statistical study of previous brown tides be used to characterize and predict future blooms?

Smayda: Analysis of Physical, Chemical and Biological Conditions Associated with the Narragansett Bay Brown Tide.

This study involves the statistical analysis of the extensive set of physical, chemical and biological data that exists for Narragansett Bay brown tide. The advantage of this project is that all samples have already been collected and processed, thus allowing data analysis and interpretation to be the focus of study.

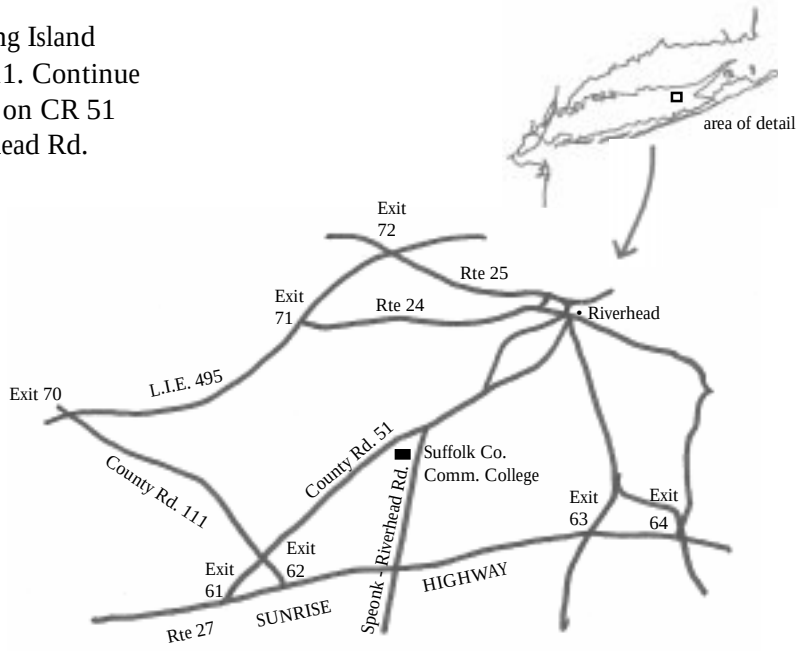
Through this study, investigators will quantify the role of physical, chemical and biological factors which contributed to the initiation, continuation and demise of brown tide prior to, during, and subsequent to the 1985 bloom event in Narragansett Bay using an extensive 1985-1987 data set. The comparative analyses of the Narragansett Bay event with similar brown tide blooms elsewhere will establish common habitat features and bloom properties for potential predictive uses.

Brown Tide Research Initiative

Announcing: An Informational Symposium for the Public
9:00 AM - 3:00 PM
Saturday, April 25, 1998 at Suffolk County Community College,
Shinnecock Building, Eastern Campus, Riverhead, NY

The very dense and extensive algal blooms known as *brown tide* have intermittently plagued areas of Long Island's coastal waters since 1985. Since that time, research and monitoring activities advancing our understanding of this devastating phenomenon have been underway. In 1996, with $1.5 million from NOAA's Coastal Ocean Program, New York Sea Grant began the Brown Tide Research Initiative (BTRI), a multi-year program designed to coordinate and support a suite of necessary next-step research efforts. The purpose of the second Symposium is to update the public and other interested parties about the progress of the BTRI program in its efforts to understand and help "solve" the brown tide.

Directions from the west: Proceed east on the Long Island Expressway to Exit 70. Exit right onto County Road 111. Continue approximately four miles to County Road 51. Turn left on CR 51 and continue for just over three miles to Speonk-Riverhead Rd. Turn right and the college entrance will be on the right.



Registration: There is a registration fee of $10 ($5 for full-time students) to help defray Symposium expenses. Please phone, fax or email the pre-registration information requested below by April 17. Bring the fee with you to pay on the day of the conference. Do NOT send payment.

Lunch: Lunch will be provided on campus and is part of your registration fee.

Travel and Lodging: If you are in need of additional travel information or motel accomodations, please call our office at (516) 632-6906.

PRE-REGISTRATION FORM: BROWN TIDE SYMPOSIUM APRIL 25, 1998

Pre-registration required. Deadline for pre-registration is **April 17, 1998.**

Send by mail to: **New York Sea Grant**, attn: Patrick Dooley, 121 Discovery Hall, SUNY Stony Brook, Stony Brook, NY 11794-5001
By fax: (516) 632-6917 By E-mail: pdooley@ccmail.sunysb.edu By phone: (516) 632-9123

Name: _____

Affiliation (if any): _____

Street Address: _____

City: _____ State: _____ Zip: _____

Telephone/fax: _____ Email: _____

☐ YES! Register me now for the Symposium. Payment will be $10 (or $5 for full-time students) at the door.

☐ I will not be attending, but I would like to stay on your mailing list for future BTRI reports.

☐ Please remove my name from your mailing list.

☐ Please add the following person to the mailing list. _____

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- Research Project Briefs
- Key Terms
- Brown Tide Timeline
- BTRI Investigators
- Announcement of second BTRI Informational Symposium, April 25, 1998

OTHER LOCAL BROWN TIDE EFFORTS

The Brown Tide Research Initiative follows approximately a decade of research and monitoring funded primarily through New York Sea Grant and Suffolk County. Scientists at SUNY Stony Brook, Brookhaven National Laboratory (BNL), Southampton College (LIU), and others have been at the forefront of work to understand brown tide and its impacts. New York State, local towns, baymen's groups and Cornell's Suffolk County Cooperative Extension Program have also been involved in shellfish reseeding and monitoring efforts.

Besides the BTRI Steering Committee which provides guidance and feedback specifically for the BTRI effort, a broader group, the Brown Tide Steering Committee has also been formed. A coalition of various federal, state, and local representatives, this Committee interacts to develop and continually refine, update, and pursue funding for a research workplan. The Brown Tide Steering Committee will meet immediately following the April BTRI Symposium to discuss the information presented and revise the workplan accordingly.

Further information about these and other Brown Tide-related efforts will be included in other materials produced under the BTRI outreach program.

Sea Grant New York

Brown Tide Research Initiative

The Brown Tide Research Initiative Initiative (BTRI) is funded by the National Oceanic and Atmospheric Administration's Coastal Ocean Program and administered by New York Sea Grant. The 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. The program will help us better understand brown tide and advance strategies for minimizing its impact.

The BTRI is composed of eight peer-reviewed research projects that were selected from a national call for projects. To involve concerned parties and aid in decision-making, New York Sea Grant formed the BTRI Steering Committee of invited state, local and government agency representatives, and citizen's groups (see side bar, page 2). The research projects selected for BTRI funding were submitted by investigators from along the east coast including: Maine, Massachusetts, Rhode Island, Connecticut, New York, Delaware, Maryland and Virginia.

This *Report Series* will aid in the dissemination of general and background information about brown tide and focus on introducing and updating the BTRI projects. The results and conclusions of the projects will help determine the directions of future research and possible mitigation/ control measures for brown tide. The second BTRI Informational Symposium is scheduled for April 1998. Other brown tide outreach efforts will also be underway later this year.

Sea Grant New York

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