# APPENDIX E

# Brown Tide
# Research Projects

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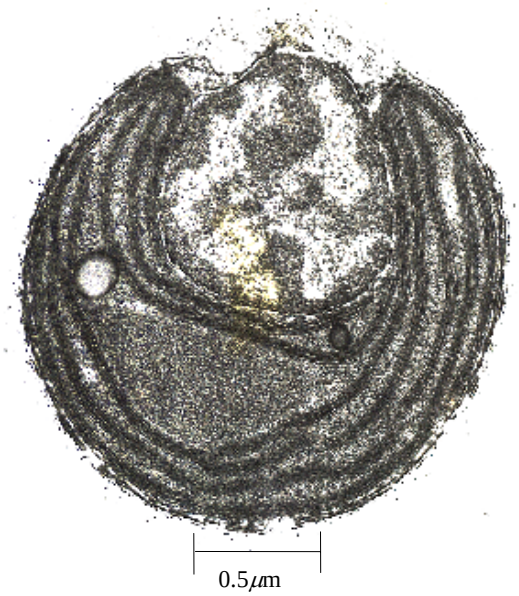
# BROWN TIDE RESEARCH SUMMARY




Transmission electron micrograph of the Brown Tide organism. (x47,000)

***AUREOCOCCUS ANOPHAGEFFERENS***

*("golden sphere")* *("causing cessation of feeding")*

*This package includes a summary of ongoing Brown Tide Research Initiative projects and the Brown Tide Monitoring Network, as well as a list of historic research projects funded by Suffolk County and Sea Grant.*

*The Brown Tide Research Initiative is a multi-year effort to investigate the onset, persistence, cessation and impacts of the Brown Tide. The Initiative was formalized at the October 1995 Brown Tide Summit and is overseen by a Committee with representatives from Sea Grant (Committee chair), the Peconic Estuary Program (PEP), Suffolk County, the National Oceanic and Atmospheric Administration (NOAA), the Stony Brook University Marine Sciences Research Center, and others.*

*Ongoing Brown Tide research is being funded with a portion of a $3.0 million commitment from NOAA (over six years), $100,000 in Brookhaven National Lab (BNL) services, and $100,000 of Suffolk County funds to be used as match for the BNL project. Suffolk County has authorized an additional $450,000 (over three years) in Brown Tide research capital funds. Historic Brown Tide research has been funded primarily by Suffolk County and Sea Grant.*

*Prepared by:*

Suffolk County Dept. of Health Services — Office of Ecology
Peconic Estuary Program, Program Office
County Center
Riverhead, N.Y. 11901
(516) 852-2077

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# BROWN TIDE RESEARCH INITIATIVE
# PROJECTS LIST
## Funded Proposals
(Funded with NOAA Monies)

**B1 Robert Andersen, Provasoli-Guillard National Center for Culture of Marine Phytoplankton, Bigelow Laboratory for Ocean Sciences.** ***Multiple Culture Isolates (Xenic and Axenic) Biodiversity and Ultrastructure of Aureococcoccus anophagefferens***.

The objectives of this program are to establish multiple uni-algal, including axenic (bacteria-free) cultures of *A. anophagefferens* from various areas for use in laboratory studies. The availability of these cultures will allow studies of the organism's physiology to be undertaken in an effort to determine the physical and chemical requirements for its growth. The project also includes examination of strain diversity, genetic studies, and cellular ultrastructure.

**B2 Gregory L. Boyer (Chemistry Department, College of Environmental Science and Forestry, SUNY, Syracuse) and Julie LaRoche (Oceanographic and Atmospheric Sciences Division, Department of Applied Science, Brookhaven National Laboratory).** ***Ferrodoxin and Flavodoxin as Metabolic Markers for Iron Stress in Aureococcus anophagefferens*.**

There is speculation that blooms of the Brown Tide organism, *Aureococcus anophagefferens*, may be triggered by iron. This proposal will develop a metabolic marker for iron stress that can be used to elucidate if iron is limiting to *Aureococcus*.

**B3 David Caron (Biology Dept., Woods Hole Oceanographic Institution) and Darcy Lonsdale, (Marine Sciences Research Center, SUNY, Stony Brook**). ***Microzooplankton-Mesozooplankton Coupling and Its Role in the Initiation of Blooms of Aureococcus anophagefferens (Brown Tides)*.**

A study of the effects of zooplankton-zooplankton and zooplankton-phytoplankton predator-prey relationships on the initiation of Brown Tides.

**B4 Patricia M. Glibert and Todd M. Kana, Horn Point Environmental Laboratory, University of Maryland.** ***Mechanisms for Nutrient and Energy Acquisition in Low Light: Successful Strategies of Aureococcus anophagefferens*.**

Isolation and culture of additional clones of *A. anophagefferens* and a characterization of their photosynthetic and nitrogen uptake capabilities under varying nutrient and light conditions. Similar characterizations will be made on naturally occurring blooms. The proposal is based on the idea that *A. anophagefferens* outcompetes other phytoplankton by having several mechanisms to acquire energy and nutrients in highly turbid waters.

**B5 Maureen D. Keller and Michael E. Sieracki, Bigelow Laboratory for Ocean Sciences.** ***Physiological Ecology of the Brown Tide Organism, Aureococcus anophagefferens.***

Determination of the photosynthetic and growth characteristics of a variety of isolates of *A. anophagefferens* and other co-dominating nanophytoplankton, in an effort to determine the reason(s) for bloom initiation.

**B6 Theodore J. Smayda, Graduate School of Oceanography, University of Rhode Island.** ***Analysis of Physical Chemical and Biological Conditions Associated with the Narragansett Bay Brown Tide.***

An analysis of the considerable amount of data collected by URI during the Brown Tide bloom, which occurred in Narragansett Bay in 1985.

**B7 Gary H. Wickfors and Richard A. Robohm, Milford Laboratory, NOAA, NMFS**. ***Isolation and Propagation of the Brown Tide Alga, Aureococcus anophagefferens, Using Dialysis Culture Techniques.***

Attempts to provide axenic (bacteria-free) cultures of *A. anophagefferens* using a novel culture technique.

**B8 Sergio Sañudo-Wilhelmy, David Hutchins (MSRC, SUNY, Stony Brook) and John Donat, Old Dominion University.** ***Biogeochemical and Anthropogenic Factors that Control Brown Tide Blooms: The Effects of Metals and Organic Nutrients in Long Island's Embayments.***

Determination of the seasonal and temporal variability of dissolved metals and organic nutrients in an attempt to establish the relative importance of natural processes versus anthropogenic inputs on the development of Brown Tide blooms.

## BTRI 1999-2001

**B9 Sieracki;** ***The Effects of Microbial Food Web Dynamics on the Initiation of Brown Tide Blooms***

Expanding on the work from the Keller and Sieracki BTRI 1996-99 project, this investigator is examining the growth and grazing of *Aureococcus* within the context of the microbial plankton community. The hypothesis is that a picoalgae niche is typically occupied by the algae *Synechococcus* and that *Synechococcus* must be selectively removed or reduced to open the niche to *A. anophagefferens*. This project also addresses the picoplankton community including phototrophic and heterotrophic components, such as bacteria and protozoan grazers.

**B10 Kana, MacIntyre, Cornwell and Lomas; *Benthic-Pelagic Coupling and Long Island Brown Tide***

To gain insight into the regional differences in the occurrence of Brown Tide across the Long Island bays, this group is examining several hypotheses regarding the control of Brown Tide by nutrients and the coupling between water column and bottom (benthic-pelagic coupling). The central focus of the project is on the role of sediment and benthos as mediators of nutrient exchange in the water column. A coupled benthic pelagic coupling model is used as a framework for studying the role of sediments in Brown Tide dynamics. Field sampling includes south shore bays, West Neck Bay and Great Peconic Bay. Physiological experiments utilizing technology developed in Gilbert's 1996-99 project, the turbidostat, will allow for accurate bioenergetic measurements of *A. anophagefferens* growth and photosynthesis under diverse organic nutrient conditions.

**B11 Lonsdale, Caron, and Cerrato; *Causes and Prevention of Long Island Brown Tide***

This project continues efforts utilizing mesocosms to study and understand the factors leading to Brown Tide outbreaks and possible Brown Tide prevention or mitigation. The team is examining several topics including changes in the plankton community structure that takes place as *A. anophagefferens* increases in relative and absolute abundance within a natural plankton assemblage, and the effects that perturbation to the pelagic food web have on the success or failure of Brown Tide. Investigations will continue exploring how suspension feeding bivalves affect planktonic food web structure, and how their activities affect the absolute and relative abundance of *A. anophagefferens*. This investigation will consider the effects of the chemical form of growth limiting nutrients and the rate of nutrient loading as factors affecting Brown Tide initiation and bloom magnitude.

# SUFFOLK COUNTY
# Funded Brown Tide Research

| Ref. # | Year | Funding | Name/Description |
|---|---|---|---|
| S1 | 1986 | $78,998 | **Part I. ($36,058)**<br>Effects of high algal concentrations (field samples) on feeding performance of bay scallop and mussel. Feeding Performance of scallops using "normal" phytoplankton species. (Bricelj) |
| S2 | | | **Part II. (42,940)**<br>Effects of light limitation on eelgrass growth. (Dennison) |
| S3 | 1987 | $43,563 | (Cosper, Carpenter)<br>Laboratory growth studies of bloom organism (macro-micronutrients, physical/chemical parameters)<br>Positive identification using EM. |
| S4 | | $9,300 | Supplemental funds for technical assistance on above project. |
| S5 | | $16,663 | (Dennison)<br>Photographic overflight of Peconic System to map eelgrass. Groundtruthing of aerial overflight imagery. Preparation of eelgrass habitat inventory map. |
| S6 | | $9,998 | (Siddall, SUNY, Stony Brook)<br>Bay Scallop Landing of 1985-1986 and the Effects of Brown Algal Blooms. |
| S7 | | – | (Siddall, SUNY, Stony Brook)<br>Climatology of Long Island Related to the Brown Tide Phytoplankton Blooms of 1985 and 1986. |
| S8 | 1988 | $46,800 | (Cosper)<br>$^{14}C$ productivity studies. |
| S9 | | $24,999 | (Anderson)<br>Development of immunofluorescent identification procedure and training of SCDHS personnel. |
| S10 | | $6,680 | (Levandowsky)<br>Attempts to obtain an axenic culture of *Aureococcus anophagefferens.* |
| S11 | 1989 | $13,885 | (Levandowsky, Haskins Laboratory, NYC)<br>The use of satellite based remote sensing for monitoring the Brown Tide phenomenon. |
| S12 | 1994–95 | $33,848 | (Beltrami, SUNY Stony Brook)<br>Inferring Brown Tide Dynamics in Peconic Bay from Models and Data. |
| S13 | | $18,606 | (Lonsdale, SUNY, Stony Brook)<br>A Field Study of Microzooplankton Biomass and Grazing Rate. |
| S14 | | $5,803 | (Mahoney, NMFS, Sandy Hook)<br>Purification of *Aureococcus anophagefferens* Culture. |
| S15<br>N7 | 1994–95 | $32,168 | ($10,000 SCDHS, $22,168 Sea Grant — Wilson and Beltrami, SUNY, Stony Brook) |
| S16 | | $31,000 | (Boyer, SUNY — Env. Science & Forestry, Syracuse)<br>Iron and Nitrogen Nutrition in the Brown Tide Algae *Aureococcus anophagefferens* |
| S17 | 1996–97 | $100,000 | Brown Tide Monitoring Network (Brookhaven National Lab)<br>This project will use $100,000 in Suffolk County funds with significant match by BNL (minimum $100,000 match in first year). Suffolk County funding will be used to deploy real-time in-situ fluorometers, construct and maintain a Brown Tide home page on the |

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|---|---|---|---|
| | | | World Wide Web reporting resulting data, and determining basic photosynthetic physiology of Brown Tide in the field. BNL is also performing "hind-casting" and autoecological investigations through in-kind match. |
| S-18 | 1998–99 | $49,945 | (Lonsdale & Taylor, SUNY, Stony Brook)<br>Differential Phytoplankton and Microzooplankton Analyses in Long Island Bays. Research to increase knowledge of the plankton ecology of Long Island Bays. The researcher's goal is to describe as completely as possible the temporal and spatial patterns in composition and biomass of phytoplankton and microzooplankton, including protozoa and micrometazoa, at three sites in the Peconic Bays system, and two in south shore bays. Based on experience and the literature, the researchers will categorize where possible the planktonic members by trophic group (*e.g.*, as primary producers, grazers, omnivores, bacteriovores) which is a first step towards characterization and comparison of planktonic food web structure in these bays. |
| S-19 | 1998–99 | $200,00 | (LaRoche *et al*., Brookhaven National Laboratory)<br>Dissolved Organic Nitrogen and Brown Tide Blooms in Long Island's Coastal Waters: Testing the Groundwater Hypothesis.<br>A study to identify the source of DON that is available to *A. anophagefferens* via field and laboratory studies. The laboratory work will involve 1) the identification of the DON components from the Peconic estuary or Great South Bay that can support growth of the alga and 2) characterization of the DON uptake systems and utilization mechanisms that make this alga competitive at utilizing nitrogen 3) the production of immunological probes to major proteins *of A. anophagefferens* involved in the utilization of DON. In the field, BNL will characterize the DON fraction utilized by *A. anophagefferns* during a bloom as well as follow the nitrogen nutrition of this algae using immunological probes. Weekly or biweekly nutrient bioassays and analysis of various dissolved and particulate nitrogen pools will complement the field sampling of Suffolk County Department of Health Services (SCDHS) surface water monitoring program. The result will be analyzed in the context of the groundwater hypothesis, the SCDHS survey and the Brown Tide Research Initiative (BTRI) project. |

# NEW YORK SEA GRANT INSTITUTE*
## Brown Tide Research

| Ref. # | Project |
|---|---|
| N1 | R/F-48: Blooms of Brown Tide Phytoplankters in Long Island Bays: Physiological Characteristics.<br>Dr. Edward Carpenter, MSRC, SUNY at Stony Brook.<br>Started: 8/15/86 Ended: 2/28/87 $9,685 |
| N2 | R/CMB-2: An Investigation of Coupling Between Phytoplankton Productivity and Zooplankton Dynamics in Long Island Coastal Embayments.<br>Drs. Elizabeth Cosper and Darcy Lonsdale, MSRC, SUNY at Stony Brook<br>Started: 1/01/91 Ended: 12/31/92 $147,529 |
| N3 | R/CMB-11: A Study of Viral Activity in the Brown Tide Alga, *Aureococcus anophagefferens.*<br>Dr. Elizabeth Cosper, MSRC, SUNY at Stony Brook<br>Started: 2/01/93 Ended: 3/06/92 $7,936 (Scholar only) |
| N4 | R/CF-5: Environmental Factors Enhancing 'Brown Tide' Blooms: A Field Experimental Approach.<br>Drs. Elizabeth Cosper, Darcy Lonsdale and Edward Carpenter, MSRC, SUNY at Stony Brook<br>Started 2/01/93 Ends: 7/31/95 $150,692 |
| N5 | R/CE-7: Impact of Brown Tide (*Aureococcus anophagefferens)* on Microbial Food Web Processes in a Long Island Bay.<br>Dr. Darcy Lonsdale and Gordon Taylor, MSRC, SUNY at Stony Brook.<br>Started: 2/01/94 Ends: 1/31/96 $117,061 |
| N6 | R/FBM-16: Relative Susceptibility of Bivalves to the Brown Tide Alga *Aureococcus anophagenfferens:* Comparison among species and life history stages.<br>Dr. Monica Bricelj, MSRC, SUNY at Stony Brook<br>Started: 9/1/95 Ends 8/31/97 $164,387 |
| N7<br>(S15) | R/CE-10: Causative Factors in the Initiation of Brown Tide Blooms.<br>Robert Wilson, MSRC, and Ed Beltrami, Mathematics, SUNY at Stony Brook<br>1-year starting 2/01/96 $22K approx. (Plus $10K from Suffolk County)<br><br><u>TO BE FORWARDED TO NATIONAL OFFICE FOR FUNDING IN 1996-97 OMINIBUS PROPOSAL:</u> (intended but not yet approved for funding). |
| N8 | R/CMB-12: Cell Cycle Technique for Measurement of Growth Rates and Environmental Effects of the Brown Tide Alga.<br>Edward Carpenter, MSRC, SUNY at Stony Brook<br>2-year project starting 2/01/96 $35K/year approx. |

* Information provided by Sea Grant

# ECOHAB
# Funded Research

| Ref. # | Project |
|---|---|
| E-1 | (Stabile *et al*., 1998-99)<br>Genetic Variability Among Spatially and Temporally Isolated Blooms of the Brown Tide Microalga, *A. anophagefferns*.<br><br>Final project description is forthcoming. |