Proceedings of

The Emergency Conference on "Brown Tide" and Other Unusual Algal Blooms

Sponsored by:

- New York State Interagency Committee on Aquatic Resources Development
- Living Marine Resources Institute of the Marine Sciences Research Center, State University of New York at Stony Brook
- Port Authority of New York and New Jersey

October 23 and 24, 1986

Hauppauge, New York

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INTRODUCTION

INTRODUCTION

On October 23 and 24, 1986, the Emergency Conference on Brown Tide and Other Unusual Algal Blooms was held in Hauppauge, Long Island, New York.

Impetus for the conference came from the appearance in 1985 and 1986 of brown tide algal blooms in Peconic Bay and other bays of Long Island, New York, and in Narragansett Bay, Rhode Island, as well as an intensification of a similar bloom in Barnegat Bay, New Jersey. These blooms had serious ecological and economic effects in two of the states: in Rhode Island, the bloom was blamed for a severe mussel die-off; while in New York, the effect of two years of bloom incidence in Peconic Bay effectively destroyed the bay scallop population, a commercially valuable resource. Additionally, eel grass, a crucial element in seashore ecosystems, was severely affected by the blooms.

The specific purpose of the conference was to bring together scientists, mostly from the affected states, with expertise in a variety of relevant areas, and representatives of involved government agencies, to discuss the possible causes and effects of the brown tide and other blooms, and to formulate a coordinated research/monitoring plan needed to understand and respond more effectively to such phenomena in the future.

The first day of the conference was attended only by members of the research community, and was devoted to the exploration and evaluation of the scientific issues involved. Governmental agency representatives joined the meeting on the second day, for discussions on how best to develop, coordinate and implement scientific programs and projects addressing these algal blooms. The conference agenda is attached in the appendix along with a list of the conference invitees and participants.

The conference was sponsored by the New York State Interagency Committee on Aquatic Resources Development in association with the Living Marine Resources Institute of the Marine Sciences Research Center, State University of New York at Stony Brook, and the Port Authority of New York and New Jersey. The Interagency Committee, chaired by Secretary of State Gail S. Shaffer, is comprised of the New York State Department of State, the N.Y.S. Urban Development Corporation, the N.Y.S. Department of Environmental Conservation, the N.Y.S. Department of Commerce, the N.Y.S. Department of Agriculture and Markets, and the N.Y.S. Sea Grant Institute.

ACKNOWLEDGEMENTS

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October 23, 1986

ABSTRACTS
OF
BACKGROUND INFORMATION PRESENTATIONS

CHARACTERIZATION OF *AUREOCOCCUS ANOREXEFFERENS* GEN. ET SP. NOV. (CHRYSOPHYCEAE); THE DOMINANT PICOPLANKTER DURING THE SUMMER 1985 BLOOM IN NARRAGANSETT BAY, RHODE ISLAND

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A bloom of a golden alga, 2 um in diameter, at populations of one billion per liter was associated with a general anorexia in filter feeding animals and a marked mortality in the blue mussel *Mytilus edulis*. This picoplankter lacked a flagellum or any other morphological feature useful in discriminating it from other similar sized forms with either phase contrast or epifluorescence microscopy. Natural populations of picoplankton obtained from the height of the bloom until its decline, when examined in thin section with transmission electron microscopy, implicated a cell with a single chloroplast, nucleus, and mitochondrion and an unusual exocellular polysaccharide layer. The ultrastructure of this alga is consistent with that of the Chrysophyceae, and a new genus and species, *Aureococcus anorexefferens* is presented. Cells of *A. anorexefferens* with virus particles occurred throughout the bloom, while both achlorplastidic and chlorplasidic phagotrophic protists capable of grazing this alga, only became frequent when the bloom waned and minute diatoms also become common. Populations of the usually dominant photosynthetic picoplankters, the cyanobacteria, were depressed during the bloom. Attempts to grow this previously undescribed picoplanktonic alga as an obligate phototroph failed, and only yielded cultures of previously described microalgae. Causes for the dominance of this species in the summer of 1985, as well as conditions required for its culture, are unknown.

CULTURE ANALYSIS

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During the summer of 1986 attempts were made to isolate the Long Island "brown tide" alga into culture. A successful culture was made from material collected from Great South Bay on June 6th. We compared light and electron microscope sections of field samples from the bloom with those from cultured material. The bloom organism could be discerned from other similar sized (2-3 um) species (cyanobacteria, small diatoms, etc.) using fluorescent stains and epifluorescent miscroscopy. These observations indicated that through the summer the bulk of the phytoplankton biomass in Great South Bay and other coastal embayments on Long Island was a chrysophyte, similar to the bloom species in Narragansett Bay during the summer of 1985, *Aureococcus anorexefferens*. Electron microscope studies on the cells in culture have indicated that the isolate is also similar to *A. anorexefferens*.

The isolate exhibits fast growth rates, as high as three divisions per day at 20 degrees Centigrade. Growth is more rapid in enriched filtered seawater collected from bloom areas as compared with enriched artificial seawater. This suggests that there are either growth factors present in the natural seawater in which blooms formed or that some inhibitory substance is in the artificial seawater.

Isolating this small phytoplankton species into culture is an important step in allowing us to understand factors which promote recurrent blooms of this organism over wide and non-contiguous coastal areas. In addition, an understanding of the life cycle of this species will be critical in suggesting control measures. Research on these factors is now being planned.

OCCURRENCE AND DISTRIBUTION OF THE 1985 BROWN TIDE IN NARRAGANSETT BAY

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The "brown tide" development was evident in early May 1985 at the permanent station sampled weekly in lower Narragansett Bay near Fox Island.

Beginning on July 25, 1985, coverage of this bloom event in lower Narragansett Bay was extended baywide to weekly analyses at 7 stations extending from the Providence River to the Jamestown Bridge. This study was initiated at the request of the Rhode Island Department of Environmental Management. This study has continued to evaluate potentially anomalous plankton dynamics during the 1985 winter and 1986. The following observations are being made at three depths at each of the seven stations: temperature, salinity, NO_3, NH_4, PO_4, SiO_2, chlorophyll, ATP-carbon, phytoplankton species composition and abundance, and nitrate reductase activity. Water column light transmission is also measured, and a sample pooled from the 3 sampling depths is used to determine carbon-14-based primary productivity at 5 light levels. A zooplankton net tow is made to determine zooplankton and benthic larvae species composition and abundance, dry weight, carbon and nitrogen; ctenophores are also collected to determine their abundance in 4 different size classes.

The principal findings to date are:

1. Major "brown tide" bloom abundance occurred in Greenwich Bay and extended into lower West Passage. Abundances in upper Narragansett Bay (north of Patience/Prudence Islands) were lower. Up to 1.2 billion cells per liter were found.

2. A significant bloom of red tide dinoflagellates co-occurred with the "brown tide" north of Patience/Prudence Islands.

3. Maximum abundance occurred in nutrient-poorer waters; hence, the "brown tide" bloom does not suggest a response to eutrophication.

4. The causative species grew at division rates of about 1 doubling per day.

5. The normal summer diatom flora and the flagellate <u>Olisthodiscus luteus</u> were insignificant.

6. The "brown tide" began to collapse in September prior to Hurricane Gloria. <u>In situ</u> events, therefore, rather than washout, appeared to be responsible for its decline and disappearance.

7. Following the demise of the "brown tide", an extensive, prolonged bloom of Euglenids occurred throughout Narragansett Bay. This bloom was also extremely anomalous relative to the historical phytoplankton data set. 8. By November 1985 the euglenid bloom terminated

throughout the Bay.

9. The winter-spring diatom bloom began in December. Its species composition, abundance and dynamics were quite normal relative to previous years in contrast to the anomalous summer "brown tide" and euglenid blooms.

10. Ctenophores, which normally disappear in October, persisted throughout the winter in high numbers; notably, north of Patience/ Prudence Islands. Zooplankton populations were more or less normal.

11. A significant die-off of the edible mussel Mytilus edulis occurred during the "brown tide", accompanied by serious impairment of fecundity prior to mortality. Zooplankton grazing was also reduced, as was their fecundity, in experiments.

12. Failure of the scallop population in local coastal salt ponds, where the "brown tide" also bloomed, also occurred. In contrast, the quahog Mercenaria mercenaria appeared quite hardy based on its "condition index".

13. Several other inimical ecosystem effects appeared to have occurred based on anecdotal observations, but these require validation.

14. Two aerial flights revealed that the "brown tide" bloom continued into Rhode Island Sound, contrailed around Block Island Sound, continued to Montauk Point and then extended along the southern Long Island shoreline.

15. A short-lived "brown-tide" development re-occurred in May 1986, but failed to develop and collapsed soon after.

THE DISTRIBUTION AND OCCURRENCE OF BROWN TIDE IN NEW YORK WATERS

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Microscopic analysis of water samples collected from Suffolk County's south shore bays and from the Flanders-Peconic-Gardiners Bay system during 1985-86, and aerial surveillance in both years revealed the occurrence of brown waters from May through September. The causative organism, which appears to be identical to the Chrysophyte Aureococcus anorexefferens described by Sieburth et al., was widely distributed throughout the bays.

Differentiation of the diatom Minutocellus polymorphus, which was found in many of the samples but never assumed dominance, was possible with careful microscopic observation.

A smaller (less than 2 micrometers) organism, likely a cyanobacterium, appeared during the latter stages of the bloom. As differentiation of this organism from A. anorexefferens, using phase microscopy, has proven difficult, it is hoped that future monitoring can include the use of an epifluorescent system.

OCCURRENCE AND DISTRIBUTION OF BROWN TIDE IN NEW JERSEY

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Brownish or yellowish-brown colored water attributable to algal blooms has become conspicuous over the past two summers (1985-1986) in the New Jersey intracoastal system. Blooms apparently began in June in Barnegat Bay, a relatively shallow barrier-island embayment with a lack of tidal flushing and with extensive development around its shoreline; from there the bloom(s) extended southward at least to Great Egg Harbor. The brownish water persisted through September with peak cell concentrations in August exceeding 1,500,000 per milliliter. The species responsible, having coccoid cells approximately 2 um in diameter, under light microscopy could not be distinguished from <u>Aureococcus anorexefferens</u>, as described by Sieburth <u>et al</u>, or <u>Nannochloris atomus</u> Butcher. <u>N. atomus</u> has been dominant in the region, responsible for the recurrence of greenish-colored water in Raritan Bay and adjacent New York Bight apex waters and, in 1985, was detected offshore and subsequently southward along shore to Cape May County. (The Hudson/Raritan estuary and adjacent N.J. northern coastal waters also have long been affected by phytoflagellate red tides, of several species, for which we have monitored; the southern N.J. shore, recently by brilliant green tides of <u>Gyrodinium aureolum</u>, which were the subject of our study in 1986.) There was some evidence of washout or overlap in the vicinity of tidal inlets, where a distinct color contrast was observed between the intracoastal brown water and coastal green bloom water. Depletion of our shellfisheries is apparently not a problem, since our primary resource in the bay system is the hard clam (<u>Mercenaria</u> sp.) which is not as affected as other shellfish; however, shading may have some adverse effect on the eelgrass and local sport fishing.

METEOROLOGICAL STUDIES

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The regional nature of the picoplankton blooms of 1985 and 1986 suggest that regional environmental features such as short-term weather patterns or long-term climatological trends may have directly or indirectly promoted the blooms. Two types of climatological records have been examined to date: long-term records (1827-1985) with low resolution in time (monthly) applicable to Long Island as a whole, and short-term records (1984-1986) with daily resolution applicable to five stations adjacent to the Peconic-Gardiners estuary (Bridgehampton, Brookhaven National Labs, Greenport, Patchogue, and Riverhead). Parameters being examined include air temperatures, precipitation, insolation, summer wind velocities and the Palmer Drought Hydrological Index (calculated by the National Climatic Data Center). The objective of these initial studies is to estimate simple correlations between events and trends in the meteorological record and the appearance and disappearance of the blooms. No attempt is being made to describe the possible mechanisms linking weather and bloom events but the information may indicate appropriate areas for further study.

The study to date indicates that 1984 was the wettest year on record for Long Island and that 1985 was the second driest year. Moderate drought conditions have persisted through August, 1986. There is a consistent (but statistically insignificant) correlation between reductions in bloom cell concentrations and rainfall one to four days preceding. While the 1986 bloom first appeared at different times throughout the Peconic-Gardiners estuary, cell concentrations at all stations monitored by the Suffolk County Department of Health Services were reduced for the first time following a period of rainfall in late June, 1986, however the period of time from precipitation to cell reduction was too long to be accounted for by simple runoff or groundwater effects. It is possible that the frontal system which spawned these rains had other effects on such parameters as flushing in the estuary, a topic which these meteorological studies indicate is of principal concern.

IMPACT OF THE "BROWN TIDE" ON SHELLFISH

I

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Bay scallops, Argopecten irradians, have been the commercial species most severely impacted by the "brown tide" in New York State waters. This is attributable to the scallops' short life cycle and unique feeding biology. Aureococcus caused recruitment failure of the 1985 year class, and 76% reduction in mean muscle weights of adults (1984 cohort) in the Peconic estuary. Post-spawning survivors of the 1985 bloom showed remarkable recovery in tissue weight after the bloom receded in the fall, suggesting that the impact of the bloom is age/size specific. Adult scallops also showed an approximately two month delay in the winter period of mass natural mortality, so that it is estimated that 30% of the population could have potentially survived to a second spawning in 1986. Natural recovery of stocks was precluded however, by reappearance of the bloom in the summer of 1986.

Potential mechanisms explaining the impact of the bloom on shellfish include: poor retention of small (less than 5 um) particles by the animals' feeding apparatus toxicity effects, poor nutritional quality of Aureococcus and/or inefficient feeding at high algal densities. Our laboratory grazing studies using field collected water samples demonstrate that bay scallops retain the alga with low efficiency (ca. 31%) relative to blue mussels (ca. 58% retention efficiency). Low retention efficiency is, however, insufficient to account for the effects observed, given the high algal densities present during the bloom. Other hypotheses are currently being tested using scallops and mussels as test organisms.

Physiological data obtained in the laboratory can be integrated using the energy budget equation, in order to predict the age-specific effects (e.g. rate of weight loss) experienced by shellfish at field algal concentrations. This information would be useful to hatchery operators and fishery managers, e.g. in assessing the need and benefit of temporarily transferring stocks from impacted to unaffected areas, or in selecting the optimum size of animals for transplant programs.

II

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The major economic impact of Long Island's picoplankton blooms was felt by the area's multimillion dollar shellfisheries. Landings in the hard clam fishery of Great South Bay were depressed temporarily as meat weights of this species dropped as the animals starved during the peak of the 1985 bloom. The longevity and reproductive adaptations of the hard clam prevented the bloom from having any long-term impacts on the fishery. Cultivated oysters being grown to market size in the Peconics-Gardiners estuary did not fare as well with as much as one million dollar losses reported following high mortalities. The bay scallop's unique reproductive strategy - to grow rapidly, to mature very quickly and to spawn only once before dying - is particularly lethal in the face of such widespread environmental perturbations, and in fact Long Island's bay scallop landings have been virtually wiped out along with nearly all of the reproducing population of scallops which could rebuild, albeit slowly, harvestable stocks.

While only adult bay scallops are harvested, it is the bay scallop larvae which are the crucial weak link in the perpetuation of harvestable stocks. Adult and even juvenile scallops can withstand brief periods of starvation without dying, yet the minute larvae must feed effectively during their short planktonic life in order to survive and grow to the point where they can metamorphose into juveniles. In the presence of the 1985 bloom, virtually all bay scallop larvae in the Peconic-Gardiners estuary died prior to settlement and metamorphosis into juveniles. This represents a complete failure of larval recruitment in 1985. Unfortunately, larvae produced by the few surviving two year old adults in 1986 faced a similar bloom and did not survive either. Therefore two consecutive year classes of bay scallops have been lost as a result of the bloom. Without the hatchery-based scallop replenishment programs being conducted by state, county and local town officials, it is likely that the bay scallop fishery would require several years to recover based on the reproduction of the now extremely rare surviving adult scallop.

The same underlying mechanisms proposed as causes of mortalities in adult scallops are being investigated as causes of larval mortalities. There is no theoretical reason why a bivalve larva could not capture such very small phytoplankton cells, however the bloom species might lack specific nutrients essential for larval growth and survival, or possess a structural feature which impedes digestion, or produce a toxic metabolite. It is also possible that bay scallop larvae are not adapted to deal with very high cell concentrations, however short-term absorption efficiency experiments and longer-term growth studies (using M. polymorphus isolated from the 1985 bloom) indicate that the larvae can handle cell concentrations as high as 2 million cells per milliliter. Studies of Aurecoccus annorexefferens as food for larvae are needed.

EFFECT OF BROWN TIDE ON EELGRASS DISTRIBUTION AND ABUNDANCE: POSSIBLE LONG TERM IMPACTS

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Light attentuation by dense algal blooms ("brown tide") during 1985 and 1986 has dramatically reduced the distribution and abundance of eelgrass (Zostera marina) in Great South Bay and the Peconic Bays. The maximum depth that eelgrass can survive is roughly equal to the Secchi disc depth, and bloom conditions have resulted in Secchi depths less than 1 meter. Underwater surveys have confirmed that the maximum depth penetration of eelgrass has been reduced, translating into large areas of bay bottom which cannot support eelgrass growth. These eelgrass declines have profound and long-ranging ecological impacts in the coastal ecosystem. Eelgrass meadows influence sedimentation patterns, nutrient cycling and water flow, and provide crucial habitats for shellfish (e.g., bay scallops) and juvenile fish. Natural recolonization rates of eelgrass are relatively slow and full recovery from a massive decimation could take many years. The possibility of preventing an algal bloom is remote, yet prevention of long-term effects due to loss of eelgrass meadows may be possible. Scallop reseeding efforts can be enhanced if located in eelgrass meadows, and reestablishment of eelgrass can be enhanced with eelgrass transplants. In conclusion, 1) massive decimation of eelgrass meadows have occurred, 2) loss of eelgrass affects subtidal communities (e.g., bay scallops), and 3) adversive effects of the bloom can be mitigated with eelgrass surveys and transplants.

ECONOMIC ISSUES ASSOCIATED WITH BROWN TIDES AND SIMILAR ENVIRONMENTAL PERTURBATIONS

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One of the primary problems associated with the determination of the economic impacts of the "brown tide" is a lack of information. This is a problem both from an ecological and economic perspective. Specifically, before any economic "bottom lines" can be reached, information must be developed on the causes and ecologic consequences of brown tides, and we must also be able to predict how people will react to the change in the quality of the marine environment.

The need for this stems not from mere academic curiosity but from practical policy perspectives. If research shows that it is possible to prevent brown tide or to mitigate its damages, then policy makers must be able to determine whether the benefits of such actions exceed their costs.

From an economist's perspective, an area where preliminary research must be done is in the modelling of behavioral responses to changes in marine environmental quality. For example, in order to ascertain the economic losses from the destruction of bay scallops, one must know more than just the effect on the market for bay scallops. There may be indirect effects as well on other markets. For example, it is necessary to be able to predict what the displaced fishermen will do, as one possibility is that they might fish other fisheries more intensely, causing depletion of those stocks and lowering other fishermen's income. Alternatively, they may leave fishing altogether. Similar types of behavioral models need to be estimated for recreational users of the marine resources. For example, if the Peconic Bay systems waters remain a muddy brown in color, how will tourists respond? Will their activities merely transfer to ocean beaches, so the Peconic Region's loss will be the South Shore's gain, or will there be a net reduction in tourist activities in general? It is important to examine these changes in the context of a system so that it is possible to determine both the direct and indirect effects of the ecological change and so that one can distinguish between transfers of economic benefits and net losses of economic benefits.

In addition to these detailed models of the economic behavior of the users of the marine resources, it is necessary to develop detailed models of the regional economies so that one can predict the ripple effects of changes in expenditures on resource related activities. In the development of these models, it may be possible to build upon existing models such as the Port Authority's input-output model of the New York metropolitan area.

October 24, 1986

REMARKS OF NEW YORK STATE
SECRETARY OF STATE GAIL S. SHAFFER

Good morning, ladies and gentlemen. To our guests from other states I extend a warm welcome to New York and greetings from Governor Mario M. Cuomo. On behalf of the cosponsors of this conference, I offer our appreciation to all of you -- distinguished scientists and Federal, State and local government representatives -- for joining us today.

Let me give you a little background on the genesis of this conference. The primary driving force for us in New York is, of course, the "brown tide". In its most grave manifestation, the algal bloom effectively wiped out the scallop population in the waters of Peconic Bay in 1985 and took its toll of newly transplanted bugs this year. These events have had serious effects on the fishing industry, one already hard hit by new regulations banning the harvesting of striped bass. The news headlines tell it all - "Baymen Face Toughest Winter" and "Long Island Fishing on Disastrous Times". You will also hear today of other posible negative impacts of algal blooms.

Those events were occurring as we at the state level were responding to a recognition by Governor Cuomo of the desirability of increasing New York's role as a fish producer. As a result of our discussions, the New York State Interagency Committee on Aquatic Resources Development has been formed. In addition to myself as chair, the members include Commissioner Henry G. Williams of the Department of Environmental Conservation, Commerce Commissioner Ronald J. Moss of the Department of Commerce, Commissioner Joseph Gerace of the Department of Agriculture and Markets, and Vincent Tese, President of the Urban Development Corporation, as well as Bruce Wilkins, Acting Director of the New York State Sea Grant Institute. The principal goals of the Committee are: to assure the existence of abundant aquatic resources for long-term balanced use and public benefit; to enhance economic development within the aquatic resources industry; and, to eliminate barriers to economic growth in the industry and ensure long term maintenance of the aquatic resources base.

When the brown tide struck again this summer, the Committee decided rapidly that this phenomenon must be addressed. As we started out on the venture, we had in mind a local meeting, one devoted solely to the interests of our state. However, as we cast our nets for scientific and agency expertise to assist us, other brown tide events in Barnegat Bay, New Jersey and in Narragansett Bay, Rhode Island were revealed to us by some of the participants in today's session. Further, speculation arose that New Jersey's "green tide", may be part of a larger problem. Thus, encouraged by scientists and federal and state agency representatives in Massachusetts, Rhode Island, Connecticut and New Jersey, the Committee has no difficulty in expanding the purview of the Conference to encompass both a regional perspective and other unusual algal blooms.

The Committee was also pleased to be able to expand the support for this effort by having our eminent cosponsors join us: the Living Marine Resources Institute of the Marine Sciences Research Center at Stony Brook, and the Port Authority of New York and New Jersey. I thank these two bodies for their contributions to achieving the Conference's goals.

What are the goals of this conference? First, to give the research community a forum for the presentation and discussion of scientific data on algal blooms and for the formulation of a research and monitoring plan. I understand that the distinguished experts worked long and hard yesterday well into the evening. We governmental policy makers and administrators eagerly look forward to hearing the results of your labor this morning. Let me congratulate all of you for your diligence and persistence. I particularly want to recognize the speakers and moderators in both yesterday's and today's sessions. Your willingness to undertake the job of edifying and guiding us is greatly appreciated.

The second goal of the Conference is to review the recommendations of our scientific colleagues, and to discuss how we in government can best develop, coordinate and implement scientific and other programs and projects to deal with the brown tide and other unusual algal blooms. Without unduly influencing the outcome of your deliberations, I hope you will agree that, in an era of scarce resources at all levels of government, we must constantly seek to maximize the return on our investment in research and resource management. Through this Conference, I ask you to consider also how we can attain the widest possible flow of benefits from these investments. By this I suggest perhaps helping to develop a way to continue our dialogue on the algal bloom phenomena so that scientific findings and research and management decisions in this area are widely communicated and, where possible, integrated, more effectively. How this might be done I leave to your discussions.

A recent article in The Wall Street Journal opened with the statement, "Algae don't get much respect". Let me say now that this Conference has the most profound respect for algae and that we intend to leave here today with an agenda for action which reflects that position.

SUMMARY OF BACKGROUND INFORMATION

SUMMARY OF BACKGROUND INFORMATION

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[What follows is a summary of current information on the "brown tide" phenomenon as presented on the opening day of the conference. Not all those individuals investigating aspects of the brown tide made presentations at the conference. An attempt was made to include in this summary the important aspects of work not reported on, although this proved difficult because little of the research on the brown tide has been published in the open literature.]

Introduction

The brown tide phenomenon is caused by a rapid increase in the abundance of one species of phytoplankton. Phytoplankton are minute, single-celled plants that drift passively in marine and fresh waters. Phytoplankton constitute an important element of the inshore marine food web, utilizing carbon dioxide and various salts (nutrients) dissolved in seawater to build up their protoplasm and food reserves and passing this energy along to other trophic levels in the marine food web, particularly the zooplankton and the community of bottom-dwelling, or benthic, organisms. There exists a normal seasonal cycle of phytoplankton abundance in which blooms of various species are triggered by variation in environmental parameters such as photoperiod, sea temperatures, seawater nutrient concentrations, and internal mixing of the water column. In the areas in which it has occurred, particularly on Long Island, the brown tide has clearly represented an aberration in this normal cycle of phytoplankton abundance, involving the dominance of phytoplankton populations by a single species in large bodies of water over extended periods of time, with yet-to-be-determined ecologic and economic consequences.

University research on the brown tide phenomenon has been conducted mainly at the Marine Sciences Research Center (MSRC) of the State University of New York at Stony Brook through its Living Marine Resources Institute, and at the University of Rhode Island's Graduate School of Oceanography (URI). Only modest financial support has been available for brown tide research. Monitoring programs to track the abundance and distribution of the brown tide or other unusual algal blooms have been established on Long Island by the Suffolk County Department of Health Services, and in New Jersey by the State Department of Environmental Protection in cooperation with the U.S. Environmental Protection Agency and the National Marine Fisheries Service. Through the combined efforts of agency and university scientists, the body of information relevant to understanding the causes, impacts, and potential control of the brown tide remains small but is growing. However, hypotheses still greatly outnumber facts, and the significance of these few facts is generally not well understood. Larger and more sustained financial support than has hitherto been available will be required to develop research programs capable of answering the salient questions surrounding the brown tide.

Distribution/Occurrence

The brown tide, or phytoplankton blooms that appeared very similar to the brown tide, has been identified as occurring in the following areas and waterbodies:

Rhode Island	Narragansett Bay
New York	Great South Bay, Moriches Bay, Shinnecock Bay, Peconic Bays system
New Jersey	Barnegat Bay

In Narragansett Bay and the bays on Long Island, brown tide blooms first appeared in May 1985 and persisted throughout the summer, dissipating by early fall. Coastal New Jersey waters have regularly experienced blooms of brownish phytoplankton for the past decade, although the phenomenon appeared to intensify in 1985, especially in the waters of Barnegat Bay. In 1986, the bloom reappeared with the same intensity and geographic range as in 1985 in Long Island and New Jersey waters, but not in Narragansett Bay, which experienced much less severe brown tide conditions in 1986.

In 1986 in Long Island waters and in 1985 in Narragansett Bay, from its first appearance in May the concentration of the bloom built rapidly to a June peak, declined somewhat, rebounded to a second peak, and then gradually declined through September. By October the event was effectively over.

Cell counts at the peak of the brown tide bloom range from 1,000,000 to 4,000,000 cells per milliliter. Cell counts of a normal, mixed phytoplankton assemblage in these waters range from 100 to 10,000 cells per milliliter.

Classification/Identification

The predominant organism responsible for the brown tide is a small (2-3 micron) chrysophyte assigned to a new genus and species, *Aureococcus anorexefferens*, by Dr. John Sieburth at the University of Rhode Island Graduate School of Oceanography. Among the identifying characteristics of *Aureococcus* are included an extracellular polysaccharide layer, cup-shaped chloroplasts, and a frequently-irregular shape. The species apparently has no flagellum. Electron microscopic analysis indicates that this organism is responsible for the brown tide events in Narragansett Bay and Long Island waters. Pigment analysis on cultured material from Long Island confirm that the organism is a chrysophyte, a small class of phytoplankters that only recently has begun to attract attention from marine scientists.

Aureococcus from Rhode Island waters was consistently infected with viruses, whose role, if any, in the growth dynamics of the organism are unknown. At no time have Long Island isolates of *Aureococcus* been observed to have associated viruses.

Aureococcus is a member of the smallest fraction of the phytoplankton, the picoplankton. Discrimination between it and other phytoplankters of similar size and shape, such as small diatoms and cyanobacteria, can be difficult with standard microscopic techniques such as phase microscopy. Improved techniques are required for the easy and efficient identification of the brown tide organism. Development and perfection of an immuno-epifluorescent staining and examination technique offers great promise in this area. Definitive identification and ultrastructural analysis of phytoplankters the size of Aureococcus requires the use of the electron microscope.

Field Studies

Carbon-14 incubations in Great South Bay and the Peconic Bays during peak summer bloom conditions in 1986 indicated turnover times of from 3 to 8 hours, but chlorophyll concentrations that were not greatly elevated (15-26 ug/ml). Moreover, except for the tremendous initial spurt of growth in early June, phytoplankton biomass levels in bloom-infected waters of Long Island were relatively constant until the decline began in late July. This suggests a high level of grazing by zooplankters.

Field studies of the onset and progression of the brown tide in Narragansett Bay and eastern Long Island waters indicate some similarities and some differences. In Narragansett Bay in 1985, the Aureococcus bloom was synchronous with, and somewhat superimposed on the normal summer succession of phytoplankton in the bay. Blooms of euglenids and dinoflagellates occurred at the same time as the Aureococcus bloom, although there was evident spatial separation. During brown tide events on Long Island, Aureococcus was the dominant species (both in numbers and in volume) to be found in the phytoplankton, although the similar-sized diatom, Minutocellus polymorphus, was occasionally present, particularly late in the summer of 1985, but generally constituting less than 10% of the total number.

No conclusive evidence exists that would link initiation and/or progression of the brown tide to anthropogenic eutrophication of impacted waters. Field work in 1985 in Narragansett Bay by the University of Rhode Island found the abundance of the brown tide organism to be negatively correlated with nutrients and other measures of eutrophication. Nutrient data for New York waters have not been worked up as of this workshop. This may suggest that some unidentified micronutrient, vitamin, trace metal, etc., may play a major role in the onset and maintenance of the brown tide. Recent work at the Marine Sciences Research Center, SUNY at Stony Brook indicates that organic phosphorous may be capable of stimulating growth of Aureococcus. Additional work on the growth requirements of this species is reported on in the Lab Culture Studies section below.

There is speculation that one trigger for the brown tide phenomenon may lie in a disruption in the grazing pressure exerted on the smaller-sized phytoplankton by small flagellates, small ciliates, tintinnids, and other micro-zooplankton. Field work in Narragansett Bay in 1985 indicates a relative absence of zooplankton predators at the time the Aureococcus bloom began.

Lab Culture Studies

Controlled experimentation using cultured stocks of Aureococcus are necessary to identify the environmental conditions required for this species' accelerated growth. It has proven a difficult organism to culture. The species was successfully established in laboratory culture by scientists at MSRC in June 1986, using both Instant Ocean and natural seawater from Great South Bay, each enriched with f/2 nutrients. Under both high and low light levels, initial rates of division as high as 3x/day were recorded, subsequently slowing to a rate at which the cultures sustained themselves. Normally an excellent media for culturing phytoplankton, the enriched Instant Ocean consistently supported less rapid growth than did the Great South Bay water, again suggesting that an unidentified micro-constituent present in the natural seawater is required for exceptional growth of Aureococcus.

The cultures are now maintained in volumes of 100 milliliters and will be scaled up to 2 liters. The cultures are unialgal but not axenic. Ridding the system of associated bacteria will permit a clearer evaluation of the physiological growth response of the brown tide organism to a variety of environmental conditions, including nutrients, salinity, temperature, light intensity, etc. These experiments are underway.

Climatological Effects

The broad geographic extent of the brown tide phenomenon has suggested to many that meteorologic forcing is important in stimulating the bloom, although research thus far has been limited to Long Island.

Preliminary examination at MSRC of Long Island rainfall data reveals that 1984 was one of the wettest years on record, while 1985 and 1986 were unusually dry compared with average rainfall in the 1949-1984 period. These anomalies do not appear to correlate well with bloom density, except that in 1986 the initial decline of the bloom at all stations monitored in the Peconic Bays began 1-2 weeks after a significant rainfall event. This time lag is substantially longer than the 2-3 days after which runoff from a rainstorm would be expected to influence conditons in inshore areas.

Trends in precipitation are probably indicative of large scale meteorological events which could be related to the bloom. While examination of possible rainfall/runoff impacts continues, other mechanisms by which meteorologic events could contribute to the brown tide are being examined. One such mechanism is the increased flushing and mixing of inshore bays brought on by changes in the hydrodynamic exchange between the ocean and bays as a result of the passage of meteorologic systems through the region. These systems have been demonstrated to force water up onto the shelf, raising tidal elevations along the shore for as long as a week. This results in a long-period exchange being superimposed on the normal astronomically-driven tidal exchange between the ocean and inshore bays. A preliminary examination of tidal elevation data at Sayville on Great South Bay indicates that mean residual sea level for the period January to May (astronomical tide removed) for the past 3 years is 40-60% below the corresponding level in 1981. These observations will be coupled with hydrodynamic models of the Great South Bay and the Peconic Bay system to assess the extent to which altered circulatory regimes at critical times in these waterbodies may have played a role in the onset, progression, and decline of the brown tide.

Impact of Shellfish

High densities of the brown tide organism had an apparent and sometimes catastrophic impact on shellfish populations in affected waters. The specific name of the brown tide organism, "anorexefferens", connotes the primary impact--weight loss or starvation.

Anecdotal information from Narragansett Bay and Great South Bay indicates that hard clam populations did not suffer detectable, long-term damage, although the average weight and quality of clam meats were temporarily reduced during brown tide events. There is some indication that clams in Great South Bay delayed spawning until after the peak of the brown tide, at which time substantial numbers of hard clam larvae were observed in the water column.

The crop of market oysters held by a company on private leased bottom in the Peconic Bay system suffered high mortalities by the brown tide bloom of 1985.

The shellfish most clearly and drastically impacted by the brown tide has been the bay scallop, the object of an intense, seasonal fishery in the waters of the Peconic Bay system. The bay scallop has a short life span of 18-22 months; adults generally spawn only once in their lifetime, in late spring and early summer. Work at MSRC found that the development of the bloom in 1985 resulted in lower adductor muscle weights (by 75% relative to the previous year) in adult bay scallops. Once the bloom had dissipated, however, adult scallops experienced rapid increase in weight during the fall. Long Island bay scallops generally experience mass natural mortality during mid-winter of their second year. Adult survivors of the 1985 bloom showed a delay in the period of natural mortality, allowing a higher-than-usual percentage of the adult population to spawn again in 1986. Mortality rates of adult scallops coincident with the bloom have not been determined.

While the direct impacts of the bloom on adult bay scallops were perhaps temporary, such was not the case with bay scallop larvae. The occurrence of the brown tide in Peconic Bay waters caused total mortality of larval bay scallops in 1985 and 1986. This may reflect a greater ability of adults to sustain starvation for a longer period than larvae. The brown tide event of 1985 in Narragansett Bay produced massive mortality (in some areas greater than 95%) of mussels, Mytilus edulis, as well as a variety of sublethal effects.

The few adult scallops that spawned in 1985 and survived to spawn again in 1986 have now died; no recruits are available to replace them. The prospect of complete extinction of a population of so valuable a shellfish has led to the initiation of attempts by State and local governments in New York to reseed areas of bay bottom with juvenile bay scallops in an attempt to rehabilitate the natural population. It is hoped that seeded individuals will grow to maturity, spawn, and recolonize the Peconic Bay system with bay scallops. Numeric simulations of the hydrodynamic regime of the system have been used to identify areas in which to locate these "spawner sanctuaries". These initial transplant programs will be completed by November 1986.

Several mechanisms have been suggested to explain the direct and deleterious physiological impact of the brown tide or brown tide organism on larval, juvenile, and adult shellfish. These include:

- poor retention of small particles by the filter-feeding apparatus of shellfish;
- inefficient feeding (e.g. depressed pumping rates; low absorption efficiency) at high algal concentrations;

- the nutritive quality of Aureococcus is insufficient to sustain shellfish growth;
- the organism and/or associated microflora produce a toxin that inhibits shellfish feeding; and
- the organism possesses structural features which impair its digestion by bivalves.

One or more of the above mechanisms may be operating simultaneously. Work to date has demonstrated that adult bay scallops are poor retainers of Aureococcus when compared to blue mussels, which are relatively effective retainers of small particles. However, work at the E.P.A. Environmental Research Lab in Narragansett, Rhode Island, indicates that feeding rates of mussels were greatly depressed upon exposure to high cell concentrations of Aureococcus. Absorption efficiencies of bay scallop larvae were reduced by 20-30% when larvae are fed Minutocellus polymorphus, a diatom that is similar in size to Aureococcus, as compared with Isochrysis, an alga frequently used to sustain laboratory cultures of larval shellfish. These reduced absorption efficiencies have resulted in poor growth of larval bay scallops fed Minutocellus, even at concentrations very much less than those present in the field during peaks of the brown tide. Preliminary experiments using field-collected samples indicate that Aureococcus is also inefficiently absorbed by adult scallops. Absorption efficiency determinations must be carried out with cultured Aureococcus to confirm results obtained with field samples.

Impact on Eelgrass

Eelgrass (Zostera marina) is a rooted, submerged aquatic plant that plays an important role in inshore marine ecosystems. Eelgrass displays a high level of productivity, is an important pathway for the movement of nutrients between sediments and the water column, serves as habitat for various life history stages of important finfish and shellfish (particularly the bay scallop), plays a role in sediment depositional patterns in inshore waters, and forms the base of the detrital food web in many areas.

Eelgrass abundance and health is controlled by light availability in the deeper areas of bays in which it is found. The brown tide reduces the depth penetration of light in affected waterbodies, cutting off much of the light required by eelgrass for photosynthesis. Secchi disk depths of less than 0.5 meters were common in Long Island waters during the brown tide events of 1985 and 1986. Work has begun to assess the effect of brown tide-induced shading on the abundance, distribution, and health of eelgrass beds on Long Island. Observations along depth transects in Great South Bay and the Peconic Bays system in 1985 and 1986 confirmed that reduced light penetration was correlated with substantial die-off of eelgrass. Depth penetration by eelgrass in some areas of Great South Bay in 1985 were reduced from 7 to 2 feet; reductions from 12 to 6 feet were observed in parts of the Peconic Bays system. More recent field data reveal that shading by the brown tide has reduced the density of eelgrass shoots at a station near Shelter Island in the Peconic Bays system from about 1800 shoots per square meter in 1984 to little over 200 shoots per square meter in 1986. The period in which the brown tide has been most prevalent coincides with the peak of the eelgrass growing season.

Because it plays an important and multi-faceted role in inshore coastal ecosystem, the long-term reduction of eelgrass populations as a result of continued occurrence of the brown tide must be viewed with great concern. Should this occur, natural recolonization or regrowth of eelgrass beds by rhizomes would proceed slowly -- a few meters annually. Many areas of the Northeast that once sustained substantial eelgrass beds are now devoid of eelgrass, the species never having returned after its disappearance during the famous "wasting disease" incident of the 1930s. Experimental plantings of eelgrass in attempts to reestablish eelgrass populations have been carried out with some success. Whether this approach would be feasible on a much broader scale remains uncertain.

Eelgrass beds serve as principal setting areas for bay scallop larvae. Long-term reduction in the abundance and distribution of eelgrass would vitiate efforts to reestablish bay scallop population through transplant programs of the type described above.

Economic Effects

The economies of areas impacted by the brown tide rely heavily on the inshore marine resources threatened by these incidents. Commercial and recreational fishing, swimming, shoreside recreation, tourism, and supporting service industries such as lodging, retail foods, and restaurants are major components of the economic systems of these regions that have been impacted by the brown tide.

Little is known about the direct and indirect economic consequences of the brown tide. Such determinations require first a clearer documentation and understanding of the ecologic effects of these incidents than is now available. Additionally, knowledge of the workings of the local and regional resource-based economies in areas affected by the brown tide is not adequate to predict how those economies will respond to alterations in the resources caused by the brown tide. These responses may not be straightforward; the loss of income and economic activity from a decimated scallop fishery may be somewhat offset by increased harvests of other shellfish species. This is occurring in the Peconic Bays system of Long Island, where baymen are increasing the amount of fishing effort directed at conch. The assessment becomes more complex as the effects of this increased fishing effort on conch stocks are considered.

The need to compile information on the workings of the local and regional marine resource-based economies and to incorporate this information into predictive models of economic behavior is further detailed in the section of these Proceedings dealing with research/monitoring needs.

DRAFT RESEARCH/MONITORING PLAN

DRAFT RESEARCH/MONITORING PLAN

Donald F. Squires
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[This research/monitoring plan was developed by the invited participants on the opening day of the Conference. Following a full discussion of the status of knowledge of the recent "brown tide" blooms in Rhode Island and New York and the "green tide" bloom in New Jersey, working groups of the invited participants were convened. These working groups determined research and monitoring requirements in:

1. Field and laboratory studies of phytoplankton;

2. Effects on aquatic organisms; and

3. Economic effects.

The plan was presented to those attending the second day of the Conference.]

Introduction

The research/monitoring plan is based upon the presumption that there will be another bloom of picoplankton ("brown tide" or anorexia-causing blooms) in the northeastern coastal region which will incur severe economic dislocations among marine industries. It is not now possible to state with authority the causation of such blooms, or their initiating or controlling factors. Indeed, a major uncertainty facing the workshop participants was whether the picoplankton blooms of the past several years are the result of some human activity disturbing the coastal ecosystem or, alternatively, if the blooms are a consequence of some larger scale climate change, or some combination of these factors.

It is clear that the brown tide blooms are occurring on a regional scale. To effectively deal with the monitoring and research required to understand the causes of these blooms necessitates unparalled coordination among governments at federal, state and local levels. The academic community must become broadly involved under circumstances requiring close communication between laboratories and research participants. There will also be a continuing need to identify for agencies, legislatures and the public the nature and scale of the impacts of these brown tide blooms on ecosystems and of the economic impact of their occurrence. From these stems the first recommendation of the conference.

<u>Recommendation</u>: Regular meetings of involved research and monitoring personnel should be held. The Sea Grant programs of the participating states might provide the required coordinating and sponsoring group for these meetings.

In the limited time available to participants in the workshop, it was not possible to develop a strategic research plan setting forth activities, priorities and costs. Rather, the conference identified understandings that could be achieved within three time frames: immediate -- 6 months to one year; mid-term -- three to five years; and longer term -- five to ten years. It was assumed in making these projections that appropriate support and coordination would be available. Without financial support, most research activities will be sporadic and uncoordinated, responding to available financial resources. It is therefore critical that those agencies potentially contributing to the required research program continue to participate in coordination conferences so that there is an even development of necessary knowledge. From the near-term research results should arise those understandings that will permit the development of conceptual models of the picoplankton bloom phenomenon at subsequent meetings. Such models will further assist and refine the research agenda.

<u>Understandings Achievable in the Immediate Future</u>
(6 mo. to 1 year)

1. A summary of existing data on the brown tide or anorexic blooms and a catalog of research and monitoring personnel and resources.

2. A retrospective analysis of climatic data on possible forcing factors of the blooms.

3. Development of an understanding of the mechanisms of brown tide bloom impacts on both shell and fin fisheries including:

    a) identification of target species based on commercial value, indicator value, or ecological role;

    b) identification of stress indices at species/community/ecosystem levels specifically related to brown tide bloom events; and

    c) an assessment of the effects on fin fish and zooplankton other than the high value target species.

4. An increase in the number of isolations of anorexic bloom causing species and greater characterization of those cultures as to the biological similarity or diversity.

5. New identification techniques developed providing quick and replicable identification of bloom organisms.

    a) Fluorescent dyes techniques may provide a tool to distinguish among photosynthetic picoplankton.

    b) Fluorescent antibody techniques may be used for the same purpose.

    c) Inter-laboratory exchanges initiated to assure comparability in the use of these techniques.

6. New means of detecting picoplankton blooms and monitoring their development on a regional basis will be developed.

    a) Use of remote sensing techniques from aircraft or satellites will be investigated.

b) Specifications and techniques for making measurements of environmental conditions both before, during and after blooms should be noted: temperature, salinity, light, nutrients, etc., will be determined.

1) Rate measurements of nutrient uptake, primary productivity, and grazing on the bloom must be determined. The frequency of these measurements must be greater because of the short-lived character of the picoplankton blooms.

2) Examination of sediments for cysts of bloom species must be undertaken.

3) Measurements of meteorological conditions (wind, rain, insolation) as indices of embayment flushing rate, a possible initiating factor in blooms, will be required.

7. Monitoring programs will be redefined to include appropriate environmental data, a determination of rate processes, and a monitoring of impacted fisheries, benthic communities, mortality rates, physiological indices, etc.

<u>Understandings Achievable in the Mid-Term (3 to 5 years)</u>

1. Understanding of factors causal to the bloom and related to its continuance:

a) laboratory studies designed to understand factors which lead to the explosive growth in brown tide isolates -- unique nutrient, chemical and physical requirements of the bloom;

b) measurements of absolute maximal growth rates in laboratory cultures;

c) inter-specific comparisons between similar bloom species (i.e. comparison of <u>Nannochloris</u> and <u>Minutocellus</u> with <u>Aureococcus</u>) as related to growth dynamics;

d) release of ectocrine compounds or those others which may inhibit competitors or grazers on bloom organisms;

e) release from grazing pressure due to the absence or reduction of normally present herbivores;

f) life cycle studies on cyst and other stages which may relate to the persistence of the species;

g) experimental manipulation of field populations to understand factors which stimulate or repress the bloom (this work could be done in the field or, alternatively, in the MERL tanks at the University of Rhode Island); and

h) cycling rate of major nutrients (C, N, P) from the brown tide to herbivores, then their excretion.

2. Understanding factors controlling the bloom.

   a) laboratory studies on predation by microzooplankton, including rates and potential herbivore organisms;

   b) occurrence and significance of viruses as possible controlling mechanisms of bloom; and c) observations in the field of factors which may limit and cause the decline of blooms.

3. Understanding the trophodynamic effects of the bloom:

   a) cycling of the major nutrients -- nitrogen, phosphorus and carbon as affected by bloom organisms;

   b) fate of carbon-fixed in photosynthesis; and

   c) effects of alteration of the food web on carbon flow as a result of the brown tide blooms -- where does the fixed carbon go?

4. Understandings of the phytoplankton/herbivore interactions (the coupling between water column and benthos):

   a) determination of the grazing pressure of different herbivores on bloom algae;

   b) determination of the relative contribution of planktonic versus benthic grazers; and

   c) the feeding biology of herbivores, including shell fish, to develop indices of food value of phytoplankton species. (Stress the importance of experimental/laboratory approaches focusing on interspecies differences.)

<u>Mitigation</u>

Possible steps which may be taken to mitigate the effects of blooms in the midterm include:

1. control measures such as abatement of any stimulatory factor such as unique nutrients or eco-factors which may have been introduced anthropogenically;

2. careful examination and evaluation of possible biological control mechanisms such as viruses or predators;

3. delineation of seed or cyst regions which could be used as sites for the implementation of control measures;

4. notation of prime bloom areas and times which should be avoided in transplant or other culture processes;

5. determination of the recolonization potential of different animal and plant species in different areas; and

6. determination of the criteria for optimum restocking efforts, including

site selection and timing of stocking programs.

Understandings Achievable in the Long-Term (5-10 years)

1. The ecological implications of recurrent brown tide events, such as shifts in major fisheries, food web interactions, consequences of long-term shifts from macro to picoplankton, disappearance of eel grass, etc.

2. The geographical, spatial and temporal scale of brown tide bloom phenomena.

3. A predictive model of the system, allowing for the prediction of bloom events and the effects of their occurrence.

Mitigation

Mitigation strategies which might be adopted in the long term include development of preventive and management strategies, including aquaculture, new fishing management systems, and utilization of new species not affected by the blooms.

CLOSING REMARKS

CLOSING REMARKS

Dennis Suszkowski
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[These remarks followed a general discussion by the participants about the proposed Research/Monitoring Plan and after invited agency representatives described their past efforts and potential future activities and funding regarding brown tide type algal blooms.]

I'm going to try to be as brief as possible; I think it's been a long day. I'm not going to go beyond what's been discussed today, only make a couple of personal observations. I think it's been a tremendously successful meeting.

I am contrasting my own thoughts on the brown tide with some of the work that we had done with the green tide in New Jersey; there are a couple of interesting similarities and a couple of interesting differences. The brown tide strategy highlighted by Don Squires is remarkably similar to what we laid out for the green tide, except, I guess, that New Jersey took a little longer to get to this point. There are some quality researchers here. That gives me a good feeling that should this program proceed, and I really think that it will, there are a lot of very qualified people that would be involved, hopefully over the next months or years. I'd like to talk in terms of the legacy that's to be left from this meeting. I really see three products coming out. The first of them was accomplished yesterday -- an assessment of the state of the knowledge of brown tide. The second element that has already been accomplished is the development of a draft plan of attack which Don Squires went through earlier today. However, I think my task here today is to be the catalyst for a third task, and that is to address "Where do we go from here?" or, better yet, "How do we get this plan moving?". Let's accept for the time being that we can all come to a basic agreement that the plan is one in which we all can concur. I suspect that as we move ahead, the plan will be greatly revised and updated accordingly.

I would like to present my recommendations on where we ought to be going. I'd like to open up a discussion and hopefully leave today with an understanding of the steps that would be necessary to implement a plan. The first thing we've got to do is form a coordinating committee. As we saw happening with green tide, we have to have a way of communicating with each other, discussing our ideas, and getting them moving. One thing that has been accomplished in that regard is the volunteering of the New York State Sea Grant Program to assume the leadership role.

I suspect that the first order of business would be formalizing who's going to be the actors; who's going to be talking to one another over the next several months. I don't know whether we need to go into any detail, but I suspect most of the agency people here today will be involved. How the academic institutions are involved will have to be handled. Regarding the green tide, the group that was continually involved represented several government agencies. A peer group was also set up. People such as Dr.

Harold Haskins generously donated their time and assistance along the way. How this brown tide group constitutes itself, either with a peer review group or with a direct tie to the academic community, is not really important so long as all those represented here can be part of an ongoing plan. This draft plan presented by Don Squires, and I'll call it a plan, needs to be finalized. I don't think what we have before us is going to help anyone. It's not going to help the agencies that may provide the funding. It does not fully explain the work that is needed, the costs, and who is responsible for it. Also, I'm not sure whether it's going to help the academic community in providing enough insight into what really needs to be done. I think there were a number of comments raised: "have all the questions been answered, are we really truly addressing the right questions?". I'm not sure of the answers. However, I think it's important that all of the questions that have come out during the last two days be addressed within the plan.

The next thing that I would propose would be putting some "meat on the bones" of that plan and identifying as best as can be defined, what those phrases actually mean in terms of the kinds of work that needs to be done. Then it would have to be decided who the agencies are that have responsibility for these types of activities. I think that things will begin to fall out at that point. For instance, EPA may be a funding source and maybe Sea Grant, maybe National Fisheries Service, the State of New York, whomever.

Then we get to a key point: We have a wish list right now of things to be done. However, it may be a reality that much of this work cannot be accomplished for a variety of reasons. We therefore need to be very clear as to what the priorities are going to be, and establish those up front. The plan should then focus on how they are going to be pursued.

I think that a lot has been accomplished at this Conference. Frankly, I was surprised to see that such a varied group of people managed to put their heads together and come up with something that's both credible and scientifically valid, and will have some usefulness to the government agencies that have to go back and discuss it.

APPENDICES

CONFERENCE AGENDA

EMERGENCY CONFERENCE ON "BROWN TIDE" AND

OTHER UNUSUAL ALGAL BLOOMS

DATES: October 23 and 24, 1986

LOCATION: Holiday Inn of Hauppauge
1740 Express Drive South
Hauppauge, Long Island
New York

SPONSORS:

* New York State Interagency Committee on Aquatic Resources Development
* Living Marine Resources Institute of the Marine Sciences Research Center, State University of New York at Stony Brook, NY
* Port Authority of New York and New Jersey

EMERGENCY CONFERENCE ON "BROWN TIDE"

AND OTHER UNUSUAL ALGAL BLOOMS

AGENDA

OCTOBER 23

1:00 p.m. I Opening Remarks
George R. Stafford, N.Y.S. Department of State and N.Y.S. Interagency Committee on Aquatic Resources Development

1:15 p.m. II Background Information: Presentations
Moderator: Donald F. Squires, University of Connecticut

A. Classification and Identification
John Sieburth, University of Rhode Island

B. Culture Analysis
Edward Carpenter and Elizabeth Cosper, State University of New York, Stony Brook

C. Distribution and Occurrence
1. Rhode Island:
Theodore Smayda, University of Rhode Island
2. New York:
Robert Nuzzi, Suffolk County Department of Health Services
3. New Jersey:
Paul Olsen, New Jersey Department of Environmental Protection

D. Meteorological Factors
Scott Siddall, State University of New York, Stony Brook

E. Effects on Shellfish
Monica Bricelj and Scott Siddall, State University of New York, Stony Brook

F. Effects on Eel Grass
William Dennison, State University of New York, Stony Brook

G. Economic Effects
James Kahn, State University of New York, Binghamton

3:00 p.m. COFFEE BREAK

3:15 p.m. III Research and Monitoring Priorities: Short-Term and Long-Term

Moderator: Donald F. Squires

A. Working Group Discussions

1. Field Studies
   Leader: Elizabeth Cosper and Edward Carpenter

2. Effects on Aquatic Organisms
   Leader: Monica Bricelj

3. Economic Effects
   Leader: James Kahn

5:00 p.m. B. Presentations by Working Groups

6:00 p.m. DINNER

7:30 p.m. C. Discussion (all participants)

8:30 p.m. D. Synthesis of Priorities into a Research/Monitoring Plan

9:15 p.m. ADJOURN

OCTOBER 24

8:30 a.m. I Welcome and Opening Remarks
Gail S. Shaffer, Secretary of State, State of New York, and Chair, N.Y.S. Interagency Committee on Aquatic Resources Development

8:45 a.m. II Background Information
Moderator: Gerhardt Muller, Port Authority of New York and New Jersey

A. Summary of Day 1
William Wise, Living Marine Resources Institute of the Marine Sciences Research Center, State University of New York at Stony Brook

B. Questions

10:00 a.m. COFFEE BREAK

10:15 a.m. III Research and Funding Priorities
Moderator: George R. Stafford, Department of State and N.Y.S. Interagency Committee on Aquatic Resources Development

A. Presentation of Research/Monitoring Plan, Short Term, Long Term
Donald F. Squires

B. Agencies Describe and Discuss Their Priorities and Possible Roles

Potential Agency Respondents

Federal
Environmental Protection Agency
Region I and II
Estuarine Programs Office, NOAA
National Marine Fisheries Service
Milford, CT
Sandy Hook, N.J.
National Sea Grant

New York State

Department of Agriculture and Markets
Department of Commerce
Department of Environmental Conservation
Department of Health
Department of State
Urban Development Corporation
Long Island Regional Planning Board
Nassau County Department of Health Services
New York Sea Grant Institute
Suffolk County Department of Health Services

New Jersey

Department of Environmental Protection
  Division of Coastal Resources
  Division of Water Resources
Sea Grant Program

Rhode Island

Department of Environmental Management
Sea Grant College Program

Connecticut

Department of Environmental Protection
Department of Agriculture
Sea Grant

Interstate

Interstate Sanitation Commission
Port Authority of New York and New Jersey

12:30 p.m.	LUNCH	
1:30 p.m.	IV	Summary and Recommendations Leader: Dennis Suszkowski, Environmental Protection Agency, Region II, New York
3:30 p.m.	V	Concluding Remarks William Wise
3:40 p.m.	ADJOURN	

LIST OF INVITEES AND PARTICIPANTS

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