ABSTRACTS

FOR THE 1990 NEERS FALL MEETING

25-27 OCTOBER 1990

THE GREENHOUSE INN

NEWPORT, RHODE ISLAND

JOINTLY HOSTED BY

THE GRADUATE SCHOOL OF OCEANOGRAPHY
UNIVERSITY OF RHODE ISLAND
AND
THE ENVIRONMENTAL RESEARCH LABORATORY, NARRAGANSETT
ENVIRONMENTAL PROTECTION AGENCY

Baillie, P. W. & R. S. DeSanto. Marine & Freshwater Research Service, 276 State St., Guilford, CT 06437; DeLeuw, Cather & Co., 290 Roberts St., East Hartford, CT 06116.

EFFECTS OF JOINING A FLOODED QUARRY TO THE CONNECTICUT RIVER ESTUARY

Development of a marina in a flooded brownstone quarry, Portland, CT will require construction of a canal to the Connecticut River through an isthmus separating the two systems. The River was freshwater tidal at Portland (range 0.67 m mean, 0.79 m spring). Water levels in the quarry fluctuated seasonally, but not tidally, with the River. The quarry (mean depth 12.9 m, maximum 30.5 m) was strongly stratified in summer, whereas the River (depth 3.7 m to 4.3 m) was mixed. Phytoplankton communities differed significantly. Secchi, chlorophyll a and total phosphorus levels indicated that the quarry was early mesotrophic. The River was eutrophic. A trophic status model for lakes, based on aerial annual phosphorus loading, mean depth and hydraulic residence time, predicted that the quarry, if Joined to the estuary, would become late mesotrophic but would not decline to the fully eutrophic status of the River.

Boucher, J., Graduate School of Oceanography, Univ. of Rhode Island, Narragansett, RI 02882
SORPTION BEHAVIOR OF PHOSPHORUS IN THE TAUNTON RIVER ESTUARY (MA)

Mineral equilibria and sorption reactions are often invoked as-mechanisms that regulate the concentration of nutrient phosphorus (P) in estuaries, and are sometimes termed collectively as the "phosphate buffer". However, the estuarine chemistry of P is only partly known and from theory alone it is not possible to predict the reactions that occur in a particular estuary. To investigate sorption reactions in the Taunton River estuary, experiments were carried out to simulate *in-situ* conditions and mixing along the salinity gradient, taking into account pH, temperature, solid to solution ratio, mineralogy and biological activity. Experiments with suspended sediments show rapid and reversible exchange of P, persisting on time scales of minutes to days and involving both uptake and release. Flocculation was not shown to be a factor. Adsorption isotherms are described by the Langmuir model, and, for salinities between 2 and 20, have "cross-over" dissolved P concentrations of 3 to 7 µM and "equilibrium" sorbed P of 2 to 9 µmol P per gram of solids. This implies that the concentration at which no net sorption occurs, as well as the amount of P sorbed onto particles, varies along the salinity gradient of the estuary. Under typical conditions in the Taunton, P should desorb from particles as salinity increases, while some P may be adsorbed at low salinities.

Robert M. Burgess[1], George Morrison[2] and Glen Thursby[1]: 1 Science Applications International Corporation c/o U.S. EPA, Environmental Research Laboratory, Narragansett, RI: 2 U.S. EPA, Environmental Research Laboratory, Narragansett, RI
FEASIBILITY OF USING ESTUARINE SPECIES FOR ASSESSING THE SUBLETHAL TOXICITY OF SEDIMENTS

Estuarine sediments accumulate several classes of anthropogenic pollutants. Approaches to assessing the bioavailability of sediment contaminants have relied, to a large extent, on acute amphipod toxicity tests. The next logical step in the evolution of sediment assessment tools is the development of sublethal toxicity tests that use growth and reproductive endpoints. This presentation discusses the feasiblility of using the coot clam Mulinia lateralis and the sea grass Ruppia maritima for assessing the bioavailability of sediment contaminants using growth endpoints. A toxicity test with Mulinia lateralis has been developed for use with complex effluents and receiving waters and Ruppia maritima has been cultured successfully in the laboratory. Preliminary whole sediment studies with the two species indicate that relatively rapid, <10 d, toxicity tests are feasible with-shell and root growth as endpoints. The goal of this research is to develop sediment toxicity tests that incorporate sublethal endpoints as more sensitive indicators of contaminant bioavailability.

Connor, M.S. Harbor Studies Department, Massachusetts Water Resources Authority, Boston, MA 02061.

BOSTON HARBOR REPORT CARD: MAKING MONITORING DATA USEFUL

Marine dischargers spend extensive amounts of money to meet permit-related monitoring requirements. The Massachusetts Water Resources Authority will spend several billion dollars over the next decade to clean up its wastewater discharges to Boston Harbor. To maximize the use of the monitoring data by environmental managers and the general public, we have developed some integrative measures of Boston Harbor environmental quality that address the questions most often asked by the public: Is it safe to swim? Are the fish safe to eat? Are marine resources being protected? Is the harbor acceptable aesthetically? Where possible, we borrow from existing or proposed federal and state standards. When no standards exist, we use comparisons to other estuaries around the country. We rate the harbor in ten categories for 1990 and make predictions as to how these measures will change over the next fifteen years.

Cura, J., Kenzie-Curs & Associates, Inc. Chelmsford, MA 01824.

ABSTRACT: SPECIAL SYMPOSIUM: ESTUARINE EUTROPHICATION
REVIEW OF HISTORICAL PHYTOPLANRTON DATA AND AN ANALYSIS OF MASSACHUSETTS BAY TO EXHIBIT EUTROPHIC CHARACTERISTICS DUE TO THE MWRA OUTFALL

--This presentation will review the historically observed distribution and species composition of phytoplankton in Massachusetts Bay. It will also: compare these characteristics of the Massachusetts Bay phytoplankton with phytoplankton from various eutrophic coastal systems; present the physical and chemical characteristics which appear to cause eutrophication in these other systems; and,assess the potential for eutrophication in Massachusetts Bay due to the MWRA outfall based on a comparison between Massachusetts Bay and systems considered eutrophic.

Dadswell, M.J. and G.J.Parsons. Dept of Biology, Acadia University, Wolfville, Nova Scotia BOJ 1JO

HYDRODYNAMICS AND SWIMMING OF SEA SCALLOPS.

Sea scallops are great swimmers. They may even do it for fun and fitness for all we know. If you do not believe this come and see the video. It needs music but otherwise is quite eye-opening.

Dadswell, M.J. and G.J.Parsons. Dept of Biology, Acadia University, Wolfville, Nova Scotia BOJ 1JO

LARGE SCALE EXPERIMENTS ON THE AQUACULTURE OF SEA SCALLOPS

Sea scallops perform well in suspended culture. Growth is often twice the growth rate on the bottom and survival to market size (30 meats/lb) is high (70-90%). Adapting Japanese methods we have grown-out 3 year classes and have a fourth (30,000 ind.) and fifth (60,000 ind.) in progress. For those of you with a green thumb, if you know the secrets of growing spinach you can grow sea scallops (that is if you are not prone to sea sickness).

D'Avanzo, C., School of Natural Science, Hampshire College, Amherst, MA and J. Kremer, Department of Biological Sciences, University of Southern California, Los Angeles, CA. OXYGEN DYNAMICS IN AN EUTROPHIC EMBAYMENT

Dramatic diurnal 0_2 swings occur during summer months in the bottom waters of Waquoit Bay, a shallow eutrophic embayment on Cape Cod, MA, in sites characterized by high benthic seaweed biomass and vertical salinity stratification. At dawn bottom waters above the algal canopy are typically hypoxic (<2ppm) and by late afternoon these oxygen values often reach supersaturation. Within the upper third of the algal canopy, the oxygen concentration exhibits similar dawn-dusk excursions; below this depth the interstitial algal water is hypoxic, even at midday. The extent of the diurnal 0_2 swing in bottom waters of two sites in Waquoit Bay is positively related to total ambient light reaching the algae. Anoxic events occur in the bay after a series of cloudy and calm days when cumulative respiration exceeds seaweed photosynthesis. We calculated apparent daytime production and nighttime community respiration from dawn-dusk 0_2 profiles in three sites along a eutrophication gradient. These metabolic rates are typically 2-3x higher in the two sites that receive groundwater enriched by septage nitrogen in contrast to the unenriched location.

L. Deegan, H. Geyer (Marine Biological Laboratory, Woods Hole, Ma 02543). J. Finn, and S. Ayvazian, (University of Massachusetts, Amherst, Ma. 01003). RESPONSE OF AN EELGRASS ECOSYSTEM TO MACROALGAL REMOVAL: FISH NURSERY HABITAT

Within the last twenty years eelgrass ecosystems have diminished in area and abundance and in many cases have been replaced by macroalgal communities. We believe that macroalgal beds are not as suitable as a nursery area for fish and shellfish as eelgrass beds because they do not provide adequate protection from predation, adequate food supplies or a proper physico-chemical environment. This past summer we tested these concepts by creating four plots: a macroalgal removal, an addition, a disturbance control, and a control. The total number and biomass of fish captured over the summer was higher in the removal plot. The number of species of fin and shellfish was also highest in the removal plot, and some species (such as winter flounder were found only in the removal plot. expected predation on winter flounder was apparently decreased in the removal plot, but to our surprise predation on blue crabs was not.

Dzierzesld, M.J., Department of Earth Sciences and Institute for the Study of Earth Oceans and Space, University of New Hampshire, Durham, NH 03824.
VEGETATIVE CHANGES IN A HYDROLOGICALLY ALTERED SALT MARSH ECOSYSTEM.

Little River Marsh in North Hampton, New Hampshire, is a tidal salt marsh that has been altered hydrologically. As a result, this marsh is experiencing reduced tidal, inundation which has caused a shift from salt marsh plant species to freshwater plant species. *Lythrum salicaria,* a freshwater species, has replaced *Spartina patens,* a dominant salt marsh species, resulting in a 70% reduction in area originally dominated by *Spartina patens*. Factors which appear to slow the progression of *Lythrum salicaria* from invading the remaining 30% of this salt marsh include both nitrogen availability and porewater salinity. Initial experimental results from Little River Marsh, in areas where stands of *Lythrum salicaria* were enriched with nitrogen, showed an increase in plant canopy

height and biomass and a decrease in plant density. These results were observed in 1 m^2 plots, fertilized with 12 g of urea (46% N) every two weeks during the summer. The effect of porewater salinity on the distribution of *Lythrum salicaria a* was determined by both field and laboratory studies. *Lythrum salicaria* was not found in areas where porewater salinities exceeded 6 ppt while *Lythrum salicaria* grown in microcosms did not survive when porewater salinities exceeded 9 ppt.

Farris, C. N., Marine Ecosystems Research Laboratory, Graduate School' of Oceanography, Univ. of Rhode Island, Narragansett, RI 02882. BENTHIC NUTRIENT FLUX RATES ACROSS A SALINITY GRADIENT IN A MESOCOSM.

As a part of a stratified estuary salinity gradient experiment at MERL, benthic fluxes were measured throughout the season for a variety of nutrient species; including SiO_4, NH_4, PO_4 and 0_2. Preliminary results show clear differences in sediment-water nutrient exchanges rates at different salinities. Further studies and analysis are needed to better evaluate the significance of the variabilty of these nutrient fluxes. This variabilty could be especially important in the development of limiting concentrations of different nutrients as one moves down an estuary.

Gardner, G.B., Environmental Science Program, University of Massachusetts at Boston, Harbor Campus, Boston, MA 02125
PHYSICAL OCEANOGRAPHIC OBSERVATIONS OBTAINED FROM THE MASSACHUSETTS BAYS PROGRAM

A program of hydrographic surveys has been initiated as part of a multi-institutional study of the physical oceanography of Massachusetts and Cape Cod Bays. A total of 75 stations are being occupied quarterly, beginning in April, 1990. Data from the spring and summer cruises are presented. Evidence is shown of the effect on the hydrographic state of the water column of large amplitude internal waves generated by flow over Stellwagen Bank. Data presented include light transmission and in-situ fluoresence (related to chlorophyll-a concentration). The transmission and fluoresence signals show similar patterns, with maxima generally associated with the pycnocline. The hydrographic and associated observations provide a framework for interpreting biological oceanographic data.

Geyer, H., L. Deegan, (Marine Biological Laboratory, Woods Hole, Ma 02543), J. Finn, and S. Ayvazian, (University of Massachusetts, Amherst, Ma. 01003).
RESPONSE OF AN EELGRASS ECOSYSTEM TO MACROALGAL REMOVAL: PLANTS AND DISSOLVED OXYGEN

Within the last twenty years eelgrass ecosystems have diminished in area and abundance and in many cases have been replaced by macroalgal communities. This past summer we conducted a large-scale macroalgal removal experiment and measured the response of the eelgrass ecosystem. We created four plots: a removal, a addition, a disturbance control, and a control. The density of macroalgae was reduced to less than 1000 g m^{-2} in the removal plot from an average of 3600 g m^{-2}. One of the most obvious responses was the increase in eelgrass abundance over the course of the summer. The average number of eelgrass tufts increased from 30 to about 55 tufts per transect in the removal plot, while the number of tufts remained at around 30 in the control and addition plots. The number of tufts decreased in the disturbance plot, perhaps indicating that eelgrass disturbed but left in with algae did poorer. Dissolved oxygen profiles indicated a consistently higher DO level in the removal plot, and lower DO in the addition plot. Apparently night time drawdown was not a severe in the removal plot.

Giblin, A.E., C.Hopkinson, J. Tucker, and G.T. Banta. The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA, 02543.
BENTHIC NUTRIENT MINERALIZATION AND *OXYGEN* UPTAKE ALONG A TRANSECT FROM BOSTON HARBON TO MASSACHUSSETTS BAY.

Benthic nutrient flux and oxygen uptake were examined in September 1990 in Boston Harbor and Massachusetts Bay. Six sites were selected to represent a gradient of organic matter and nutrient loading from the city of Boston. Bottom sediments ranged from silty mud to fine sand with cobbles. Water column depths ranged from 12 to 30m.

One purpose of the study was to examine effects of organic matter loading and physical disturbance on benthic respiration and inorganic nutrient release. Using the ratio of Oxygen uptake to nitrogen release as well as the ratio of inorganic N/P release we made the first approximations of the importance of denitrification at these sites. The results of this study will be compared to a similar transect out from the New Bedford sewage outfall in Buzzards Bay.

Goslee, S., M. Berman, A. M. Lott, R. S. Warren and W. A. Niering, Department of Botany, Connecticut College, New London, CT 06320.
ENVIRONMENTAL FACTORS AND VEGETATION CHANGE AT THE WEQUETEOUOCK-PAWCATUCK TIDAL MARSHES, STONINGTON, CONNECTICUT.

Significant areas of this marsh complex have undergone considerable vegetation change over the past 40 years. A valley marsh, converted to *Typha* by 30 years of fresh water impoundment is reverting to salt marsh. In addition, large sections below the impoundment dikes have shifted from *Spartina patens - Juncus gerardi* dominance to a complex of stunted *Spartina alterniflora* and forbs while other sites have remained relatively stable. Soil salinity, redox potential, pH, and water table were followed on microrelief transects established in all three areas. Relationships of these soil parameters and of elevation to species-distribution; vegetation patterns and above-ground. angiosperm production, will be presented.

Haugen, E.M.. W.K. Bellows, and M.D. Keller
Bigelow Laboratory for Ocean Sciences, McKown *Point,* W. Boothbay Harbor. ME 04575
SEASONAL VARIATIONS IN PHYTOPLANKTON POPULATIONS AND PRODUCTIVITY IN MASSACHUSETTS BAY

The phytoplankton of Massachusetts Bay were examined on 6 cruises in 1989 and 1990 on a transect from Boston Harbor west to Stellwagen Bank. Variations in primary productivity and physiological state of the phytoplankton were determined using P vs. I parameters. Size-fractionated cell counts and vertical plankton tows were also collected. Changes in taxonomic groupings for the net and nanoplankton based on light microscopic examination were assessed, as well as epifluorescent observations on small cells. Seasonal trends will be discussed in relation to available nutrient and hydrographic data.

Heufelder, G.[1] and S Macfarlane[2], Barnstable County Health and Environment Dept., Barnst$_4$able, Ma.02630[1] and Town of Orleans Conservation Commission, Orleans, Ma. 02653[2]
CAN WE SAVE THE BAYS? A PRACTICAL APPROACH

Recognizing that nutrient loading problems cannot be solved by individual coastal communities, a Cape Cod Marine Water Quality Task Force was formed in 1988 to identify pollution problems and recommend remedial actions to try to control non-point pollution sources. Legally functioning septic systems that contribute nutrients to the groundwater and estuaries, stormwater runoff, fertilizer and pesticide abuse, and pet wastes are among the most serious threats to shellfishing areas and beaches that form the economic lifeblood of Cape Cod. Local amendments to laws governing septic systems, nutrient loading bylaws, stormwater remediation projects and public education are among the many avenues being pursued to ameliorate the problems. Strong liasons between research and local government are needed to address the problems.

Hoven, Heidi M., Dept. of Plant Biology, and Frederick T. Short, Dept. of Natural Resources and Jackson Estuarine Laboratory, Univ. of New Hampshire, Durham, NH, 03824.
TEMPORAL VERTICAL DISTRIBUTION PATTERNS OF JUVENILE *MYTILUS EDULIS* ON *ZOSTERA MARINA.*

Shoots of *Z. marina* were monitored to assess settlement patterns of juvenile blue mussels *M. edulis* from early June to mid-September, 1989, within an eelgrass bed of Mount Desert Narrows, Maine. Shoots tethered to a weighted pole were cleaned of epibiota and debris, matted for growth, and anchored to the bottom. Undisturbed shoots were collected each time the tethered shoots were sampled and replaced. Mussel settlement may be affected by current velocity changes, canopy height and structural characteristics of eelgrass shoots, the degree of blade fouling by epibiota, and the following trends were evident. Cleaned shoots showed a high recruitment of young mussels (200 - 300 μm). Mussel settlement on tethered shoots graded from 200 pm in size near the distal ends of blades to gradually larger sizes (500 - 900 μm) near the middle and lower portions of blades. Most mussels were located within the top 50 cm of the two longest blades of each vegetative shoot. The highest level of recruitment was found on undisturbed reproductive shoots, with a predominance of large juveniles ($\geq$ 500 μm). Size frequency distribution patterns differed between tethered, and undisturbed reproductive and vegetative shoots reflecting the time and activity of settlement. Reproductive shoots were key components of recruitment in eelgrass, having, juvenile densities three times those of vegetative shoots during peak settlement, thus the timing of reproduction in both species may be linked. By providing an available substratum for growth away from the feeding area of adult mussels, eelgrass beds may be of considerable commercial importance as sites for juvenile mussel settlement.

Hruby, T., B. Kolb, T. Smayda. B. Hoves, Camp Dresser & McKee Inc.
MODELING THE IMPACTS OF NUTRIENT ADDITION ON THE EUTROPAICATION POTENTIAL IN NEW BEDFORD HARBOR

The city of New Bedford, MA currently discharges its waste waters into New Bedford Outer Harbor after primary treatment. In the future sewage treatment in the city will be upgraded to secondary treatment *with* the result that much of the organic nitrogen now released in the discharge will be transformed to ammonia at the plant. Al part of the decision process in chasing a location for the new outfall a model was developed to assess the impacts of the increased level of ammonia on the algal productivity and the effects this might have on the concentrations of dissolved oxygen in the water.

The results of the modeling and field studies indicated that algal productivity in the vicinity of the existing primary discharge is not nitrogen limiting and and increase in ammonia here will not increase the productivity and lover dissolved oxygen levels of the Outer Harbor. The modeling indicated that the zone of non-nitrogen limited growth may increase in size, but there should be no decrease in overall eater quality.

Keafer, B. A. and D. M. Anderson, Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.
TOXIC ALGAE IN MASSACHUSETTS BAY: IN SITU GROWTH OR ADVECTION?

The sewage outfall proposed by the MWRA will be located in an area of Massachusetts Bay in close proximity to waters where there are recurring blooms of the toxic dinoflagellate *Alexandrium tamarense*. A major concern is whether the modified nutrient loading will stimulate these blooms and blooms of other noxious algae. Normally, these toxic blooms occur along the coasts of Maine, New Hampshire, and Massachusetts. More recently, toxicity has been detected further offshore on Georges Bank. We will review a conceptual model formulated to explain the development and alongshore transport of *A. tamarense* blooms in the nearshore waters of the Gulf of Maine. A series of cruises in spring, 1990 suggest: 1. the bloom developed and was entrained in a less saline, coastally-trapped buoyant plume in southern Maine waters; 2. the bloom in Mass. Bay was not caused by localized in situ growth but rather the advection of the plume into Mass. Bay from the north; 3. the duration of this low salinity pulse through Mass. Bay was on the order of days to weeks. Clearly, an evaluation of the future impact of the outfall on harmful algal blooms must account for the advection of established populations from the north. Sampling must also be conducted at frequent intervals in early summer after the spring bloom has ended.

Kremer, James N. Marine Biology Research Section, Department of Biology,. University of Southern California, University Park, Los Angeles, CA 90089-0371.
Self-Documenting Simulation Models in the Waquoit Bay LMER Project.

Ecosystem studies involve two distinct kinds of data: 1) reductionistic measurements of component processes or functional relationships, and 2) descriptive measurements of emergent responses at the system level. Mechanistic simulation can provide a rigorous quantitative evaluation of internal consistency of these data predicated upon a conceptual model. The need to establish the adequacy of the conceptual model demands extensive testing and modification. In a group research project this requires that all investigators work closely together. In our Waquoit Bay study, various models are planned for the submodels of the system: terrestrial interception of nutrients, input by septic tanks and transport by groundwater, transformations by the benthic processes in the estuary, and physical advection within and out of the basin. To facilitate participation by our PIs in the modeling, interfaces to the computer models are being developed with substantial attention to their ease of use. Models are self-documenting, allow changes in the structure as well as of specific coefficients. The programs are graphically appealing and fun to use. We believe that this new approach will also eventually assure that the results of our research will be more accessible to other scientists, environmental managers, and the public at large.

Kremer, James N. Marine Biology Research Section, Department of Biology, University of Southern California, University Park, Los Angeles, CA 90089-0371.
Total System Metabolism (TSM) as an Indicator of Coastal Eutrophication.

Diel changes in dissolved oxygen in aquatic systems are the net result of numerous physical and biological processes. In theory, measurements of free water oxygen concentration can be used to estimate the overall levels of primary production respiration of the community, and should be ideal indicators of the extent of eutrophication in coastal waters. These estimates, however, depend upon assumptions used to correct for the effect of physical fluxes. Diffusion across the water surface is the most obvious effect, and numerous methods have been used, some based on direct measurements of the diffusion coefficient and some on indirect estimates and theoretical assumptions. The traditional TSM method assumes that oxygen changes are for the same water mass, and this has imposed practical restrictions on the systems where the method may be used; the complex circulation of many estuaries makes use of the traditional method tenuous. With adequate measurements, however, corrections for advection and diffusion may be possible. In this case, the TSM method could serve as a powerful technique to assess the effects of eutrophication in a wider variety of coastal systems.

Loder, T. C. and S. Becker, EOS, University of New Hampshire, Durham, NH 03824.
STUDIES TOWARDS A BUDGET FOR NUTRIENTS AND SUSPENDED MATTER FOR MASSACHUSETTS BAYS.

The distribution of nutrients (nitrate, nitrite, ammonium, phosphate, and silicate) as well as suspended particulate matter are being studied in conjunction with hydrographic parameters for Massachusetts Bays for a one year period. Data will be presented from cruises in April and July, 1990 covering the entire Massachusetts Bays area. In late April, the highest concentrations of nitrate +nitrite and silicate are found in the surface waters in the northern part of Massachusetts Bay just south of Cape Ann. The highest phosphate values are found in Broad Sound off Boston Harbor as were the highest ammonium values. These data suggest that phosphate and ammonium are supplied to the Massachusetts Bays area mainly from Boston Harbor outfalls while nitrate+nitrite and silicate are brought in from around Cape Ann. Preliminary estimates of the relative importance of these sources during these seasons will be presented. There is a secondary maximum for all nutrients found in the southeast corner of Cape Cod Bay.

James T. Maughan Metcalf and Eddy, P.O. Box 4043, Woburn, Massachusetts 01880-4043,USA
Peter H. Doering & Candace A. Oviatt, Graduate School of Oceanography University of Rhode Island, Kingston, Rhode Island 02881, USA

Incorporation of Freshly Produced ^{14}C Labeled Phytoplankton by Marine Macrobenthos in Relation to Feeding Mode

Common macrobenthic species from marine mesocosms were examined to relate food sources to feeding mode. ^{14}C was added to large mesocosms so that fresh phytoplankton could be distinguished from sediment carbon. The amount of ^{14}C in their tissue was determined and thus the relative incorporation of fresh phytoplankton and older sediment carbon determined. The feeding mode of the species, as reported in the literature, was significantly correlated with the species' food source. All species showed a strong preference for freshly produced phytoplankton. The relative consumption of fresh phytoplankton, was higher the closer to the sediment-water interface the species fed. This indicated that species feeding near the sediment surface were better able to use the more desirable food source. The ability of these species to use available food may contribute to their generally greater success in a food-rich environment.

Michelson, A.R. C.E. Woodcock and C.S. Yentsch. Center for Remote Sensing, Boston University, Boston, MA 02215.
ANALYSIS OF THE SPATIAL AND TEMPORAL VARIABILITY OF PRIMARY PRODUCTION IN THE BOSTON HARBOR, MASSACHUSETTS AND CAPE COD BAYS

Satellite coverage such as the Coastal Zone Color Scanner (CZCS) imagery provides synoptic spatial information of bulk optical properties which may be semi-quantitatively related to phytoplankton pigment biomass and primary production. In this study, we have used archived CZCS images to establish the annual cycle of phytoplankton and primary production in Boston Harbor and Massachusetts and Cape Cod Bays. Model predicted primary productivity values using "satellite chlorophyll" concentrations, extraterrestrial light intensity and in *situ* photosynthesis vs. light intensity (P vs. I) relationships have been mapped for these regions. Generally, the model predicted primary productivity values agree with literature values and other modeling efforts for similar ecosystems showing maximum rates in the spring and summer and minimum rates in the winter. We have examined an annual mean chlorophyll image and a seasonality index image calculated from the CZCS imagery and the bathymetry data available to explain the observed pat-terns of primary productivity and chlorophyll biomass.

Nowicki, B.L., Marine Ecosystem Research Laboratory, Graduate School of Oceanography, University of Rhode Island, Narragansett, R.I. 02882.
ECOSYSTEM-LEVEL RESPONSES TO NUTRIENT ADDITIONS AND THE FATE OF NUTRIENT INPUTS TO ESTUARIES: AN OVERVIEW OF NUTRIENT ADDITION EXPERIMENTS AT MERL

Large-scale estuarine mesocosms are powerful research tools which make it possible to address questions on coastal eutrophication which are intractable in natural systems. These are the only systems for which all nutrient input and export terms are known, and can be carefully controlled, and where external loadings can be compared with internal cycling on time scales from hours to years. Using nutrient additions to mesocosms, external nutrient loadings have been directly linked to changes in estuarine community structure and function. Additions of sewage effluent have shown that the deleterious effects of adding nutrients alone are compounded by the carbon present in sewerage. While these systems are effective nutrient transformers they are inefficient nutrient traps. Regardless of the level of nutrient loading, 80-90% of total N and P inputs were exported. This lack of nutrient storage suggests that estuaries may respond rapidly to reductions in external nutrient load, and may be important in supplying nutrients to production on the continental shelves.

Peckol, P., B. DeMeo-Anderson, M. Maldonado, J. Weiner & J. Yates, Dept. Biological Sciences, Smith College, Northampton, MA 01063
EFFECTS OF NUTRIENT LOADING ON MACROALGAL PRODUCTIVITY AND GROWTH: ALGALBUSTERS ON THE LOOSE

This study investigated the response of the opportunistic macroalgae, Cladophora vagabunda and Gracilaria tikvahiae, to disparate nutrient loading rates into Waquoit Bay, Cape Cod. We compared algae collected along a gradient of nutrient loading associated with groundwater input from nearby septic systems. Site-specific growth rates were highest at the site bordered by the highest housing density (=highest nutrient input), particularly in shallow water (0.5 m). Photosynthetic rates were greatly affected by the position of the alga within the algal mat; however, both species showed net production under a mat where irradiances were <.01 I_o. Gracilaria showed higher productivity and growth rates than Cladophora, particularly under high PAR photon-flux densities. We found a dramatic temperature effect on dark respiration; July (25^0C) rates were 3-4 times as high as values in June (20^0C). Net production remained relatively stable during this period. A rough calculation indicates a 12% and 40% nighttime consumption of net daytime 02 production during June and July, respectively. Thus, a few overcast days of P_{net0} are sufficient for the respiration demand of the algae to result in anoxic conditions in the Bay, producing observable fish kills. Macroalgal oxygen exchange likely controls the water column 0_2 environment in Waquoit Bay.

Monitoring Water Quality in Boston Harbor/Massachusetts Bay by Remotely Sensed Ocean Color

David A. Phinney and Charles S. Yentsch

Ocean color sensors can provide a means of monitoring water quality in the Boston Harbor/Massachusetts Bay region. Remote assessment of water quality can be made at spatial scales <1 km and temporal scales on the order of days to weeks. The question we are trying to address is whether traditional algorithms relating ocean color to water column constituents affecting water quality are suitable in the harbor/bay system.

Preliminary measurements of phytoplankton chlorophyll and bio-optical properties of the water column at 10 stations within Boston Harbor/ Massachusetts Bay in August, 1989, show that ocean color throughout the majority of the bay area is primarily affected by phytoplankton pigments. Traditional algorithms used in high chlorophyll regions should be satisfactory for monitoring this region. Limitations of this method in the shallow and inner-harbor areas are presented.

Poucher, Sherry, and Don C. Miller
Science Applications Int'l Corp. and U.S. EPA, Narragansett, RI
Effects of Reduced Oxygen on American Lobster Larvae.

A series of discrete tests, covering the first three planktonic molting stages of the lobster, Homarus americanus, indicates similar patterns of sensitivity to low dissolved oxygen. Flow through exposure treatments ranged from 0.7 to 4.5 mg dissolved oxygen (D.O.)/L. Complete mortalities resulted within 2 hrs in the most hypoxic treatment of each test, while effects at higher D.O. levels were associated with intermolt development. LC50s ranged from 2.5-3.2 mg/L for 96 hr exposures. Weight and time-to-molt were affected. Non-molting fourth stage larvae exposed for 96 hrs were more tolerant (LC50- 0.8 mg/L). A continuous 15 day exposure beginning with first stage larvae resulted in-pronounced impacts on growth and rate of ecdysis. Experimental design questions include the influence of flow rate, acclimation and fluctuating exposures. Exposure of egg-bearing females to determine D.O. requiremants at hatch involves another order of complexity.

Recchia, M., K. Murphy, M. Peck and P. E. Fell, Department of Zoology, Connecticut College, New London, CT 06320.
SNAIL POPULATIONS ON A RESTORED TIDAL MARSH IN EASTERN CONNECTICUT

Snail populations were studied on an impounded marsh in Stonington, CT that changed from a *Typha* - dominated system to one with typical tidal marsh vegetation following the re-establishment of tidal flooding. The distribution and abundance of snails on the high marsh were determined by counting snails within 50 cm square quadrats situated 5 m apart along transects extending across the marsh from the water's edge to the upland. Sections of marsh above and below the impoundment dike were compared in order to assess the extent to which tidal marsh snails have recolonized the restored region. *Melampus bidentatus* was widely distributed throughout the marsh system; however, density and size range varied with microhabitat. The mean density of *Melampus* was 83/0.25m^2 (n=82) above the impoundment and 112/0.25m2 (n=128) below the.impoundment, but the mean biomass of this snail was the same in both regions of the marsh. The modal size of *Melampus* above the impoundment was 2 mm larger than that below the impoundment. *Succinea wilsoni* was common near the upland border in both parts of the system.

Ryder, C. R., L.A. Deegan and J. T. Finn. Department of Forestry and Wildlife, University of Massachusetts, Amherst, MA 01003 and Marine Biological Laboratory, Ecosystems Center, Woods Hole, MA 02543.
DEVELOPING AN INDEX OF BIOTIC INTEGRITY (IBI) FOR A SOUTHERN NEW ENGLAND ESTUARY: POSSIBILITIES AND PROBLEMS.

Fish populations of Buttermilk Bay, a southern New England estuary were sampled over a two year period. Samples were taken monthly at 14 stations using two sampling gears, haul seine and otter trawl.

Patterns of species occurrence and abundance are discussed. Analyses show seasonal cycles in number of species and individuals, and biomass of fishes. Fish species trophic composition and life history class are identified.

It is suggested that this community data can be used in an assessment of estuarine environmental conditions, by using an Index of Biotic Integrity (IBI). The IBI, originally developed as a stream biological monitoring system, needs to be adapted for use in an estuarine environment. Changes made to the IBI consist of using meristics based on life history rather than taxonomic classes and selection of sampling; dates to deal with the seasonality of the fish community. Other difficulties expected in the IBI application to estuarine environments including sampling effort required are outlined.

Spencer, L. T., Natural Science Department, Plymouth State College, Plymouth, NH 03264

MARINE RESEARCH IN THE PEOPLE'S REPUBLIC OF CHINA, OR HOW I GREW TO LIKE RICE AND FISH HEADS.

Chinese fleets cruised the Pacific and Indian Oceans in the 15th century, but added very little to our understanding of the oceans. It wasn't until the late . 1930's when detailed studies in the ocean sciences were begun. Since then Chinese researches have extended for beyond the coastlines of China and have the potential to add considerable detail to our knowledge of regional oceanography. This oral presentation will detail briefly the history of Chinese oceanography, the structure of modern oceanography in China and indicate some areas of Chinese expertise.

Stoddard, A., K. Farley and J. Cure, Mensie-Cura Associates, Chelmsford, MA 01824. BOX MODEL ANALYSIS OF THE EFFECTS OF THE MWRA OUTFALL ON CARBON, OXYGEN AND NITROGEN IN MASSACHUSETTS BAY

MWRA is upgrading the Deer Island POTW with the proposed effluent flow (1200 MOD) discharged into Massachusetts Bay at a depth of 30 m. The purpose of our model was to provide a preliminary assessment of the impact of the MWRA discharge on eutrophication and oxygen depletion during summer by considering: phytoplankton carbon, sewage carbon, oxygen, nitrate and ammonia within a 3 layer system over an extended source region of the outfall. The impact of MWRA loading was estimated from mixtures of primary and secondary effluent. Steady state results for the baseline condition (no discharge) are in agreement with July-August 1987 field measurements of oxygen, nitrogen, phytoplankton biomass and productivity. For all discharge scenarios, the potential impact of the MWRA discharge appears to be minimal in both the upper and lower water column. Significant increases inorganic accumulation and reductions- in-oxygen in surface sediments near the MWRA outfall were, however, calculated for the various scenarios. More detailed calculations are necessary before we can determine, with any confidence, wastewater loading conditions that will result in anoxic sediments.

A Numerical Model of Eutrophication and Nutrient Enrichment in Peconic Bay

A. Stoddard[1], J.R. Pagenkopf[2] and M.R. Morton[3]

[1]Principal Environmental Engineer, Creative Enterprises of No. Va., Inc., 112 Orchard Circle, Hamilton, VA 22068

[2]Director and [3]Sr. Engineer, Tetra Tech, Inc., 10306 Eaton Place, Fairfax, VA 22030

The Peconic system an interconnected series of shallow coastal embayments is at the eastern end of Long Island, New York, is characterized by a vertically well mixed water column with circulation driven by sea surface pressure gradients, tidal exchange and wind forcing. From 1985-87 an anomalous algal bloom resulted in widespread ecological devastation of the scallop fishery and eelgrass beds. The causative agent of the bloom has been identified as a new species, *Aureococcus anophagefferens*, commonly called the Brown Tide (BT).

Key findings of the analyses demonstrate: (1) significance of tidal exchange and circulation on water quality; (2) importance of macrophytes and sediment oxygen consumption as components of the diurnal oxygen balance; (3) significance of sediment nutrient flux to total nutrient balance; and (4) importance of zooplanlcton grazing as a recycle mechanism for nutrients.

Sung, W. and M. S. Connor, Harbor Studies Department, MWRA, Charlestown Navy Yard, 100 First Ave. Boston, MA 02129

RESEARCH, MONITORING AND MANAGEMENT CONCERNS IN MASSACHUSETTS BAYS

The Massachusetts Bay and Cape Cod Bay (collectively known as Mass Bays) have been added recently to the EPA's National Estuary Program (NEP). The proposed sewage outfall being planned and constructed by the Massachusetts Water Resources Authority (MWRA) will be the largest point source discharge into the bay. Current plans are to operate the outfall by 1995 with primary treatment with phased upgrade to 100% secondary treatment by 1999. The MWRA is in the process of designing and implementing an outfall monitoring program. The various research and monitoring programs should be planned so that management decisions can be made on the following potential issues: the timing for the combined sewer overflow projects within the inner harbor, toxic accumulation in the sediments and benthos, eutrophication, concerns and the potential need for nutrient removal and/cr nutrient manipulation of the effluent.

Thornton-Whitehouse, S., Graduate School of Oceanography, University of Rhode Island, Narragansett, R.I.02882

PREDATION AND DISTURBANCE OF BENTHIC MACROFAUNA BY CRANGON SEPTEMSPINOSA

Predation and disturbance are two of the factors that determine benthic community structure. Other factors are food supply, competition and recruitment. In Narragansett Bay the sand shrimp Crangon septemspinosa is a dominant epibenthic predator. Crangon also disturbs the sediment as it burrows and searches for food.

An experiment was conducted to separate the effects of predation and disturbance by Crangon on benthic macrofauna. The amount of benthic biomass consumed by Crangon was quantified. The experiment consisted of three treatments; one contained normal Gramm which preyed on and disturbed the benthos, one included Crangon which were unable to feed, and one without Crangon served as a control. Three benthic macrofauna species were used as prey: Ampelisca sp., Streblospio benedicti and Nucula sp.

The results of the experiment indicate that disturbance by Crangon does not cause mortality of benthic macrofauna. Crangon does consume large amounts of benthic biomass; up,to 22 mg dry wt/Crangon/day. When all three species were available, Crangon ingested 42 Arnpelisca, 7 Streblospio and 1'Nucula on average per day. Considering these consumption rates, predation by Crangon can account for 70-100 % of the decline in benthic biomass observed during the summer in Narragansett Bay.

Todd, K.[1], R.N. Buchsbaum, D. Porter[2]2 and F. Short3 Massachusetts Audubon Society, 58 Hesperps Ave., Gloucester, MA 01930; Department of Botany, Univ. of Georgia, Athens, GA 30602; Jackson Estuarine Lab., Univ. of NH, Durham, NH.03824

EFFECT OF EELGRASS EXTRACTS, AND PHENOLIC COMPOUNDS ON THE GROWTH OF LABYRINTHULA ZOSTERAE.

The recent outbreak of the eelgrass wasting disease in parts of New England is caused by the slime net protoctist Labyrinthula zosterae. We have been examining the role that secondary metabolites from eelgrass, Zostera marina L., play in the disease cycle. L. zosterae was cultured in vitro in the presence of varying concentration of eelgrass water extracts and pure phenolic compounds. The ranges Of concentrations of phenolics we tested were equivalent to the ranges we have found in eelgrass in the field. Extracts inhibited the growth of L. zosterae cells by 50-75% at concentrations equivalent to those found in eelgrass from some eutrophic estuaries. Inhibition greater than 90% occurred at extract concentrations representing the high end of the eelgrass phenolic scale. Both chlorogenic and ferulic acids, two phenolics found in eelgrass, inhibited the growth and cell migration of L. zosterae by greater than 90% even at the lower concentrations. The results suggest that variations in phenolic levels in eelgrass may influence the extent to which the plant suffers from wasting disease.

Townsend, D.W., L.M. Cammen, J.P. Christensen, S.G. Ackleson, M.D. Keller, E.M. Haugen, S. Corwin, W.K. Bellows and J.F. Brown. Bigelow Laboratory for Ocean Sciences, W. Boothbay Harbor, ME 04575

SURVEY RESULTS ON THE BIOLOGICAL OCEANOGRAPHY OF MASSACHUSETTS BAY

The oceanographic conditions in Massachusetts Bay were surveyed on 6 cruises: October in 1989, and February, March, April, June and August of 1990. We sampled a grid of 18 stations selected to describe the hydrographic and nutrient fields of the northern half of Massachusetts Bay, and focused on a central transect of 5 of those stations for intensive optical and biological measurements. These included measures of: pigments, POC, PON, phytoplankton cell counts, P vs. I, DO, SPM, and particulate and dissolved light absorption. We are still digesting the results as of this writing, but several, seasonal trends in vertical and areal--distributions of production, as well as nutrient dynamics, will be discussed in relation to the local hydrography.

Voyer, R.A., USEPA, South Ferry Rd., Narragansett, RI 02882

EFFECT OF SALINITY ON CHRONIC TOXICITY OF CD TO MYSIDOPSIS BAHIA

Response surface techniques were used to evaluate influence of constant and fluctuating salinities on chronic effects of Cd to M. bahia. Estimated 28-day LC50s ranged from 4.8 to 6.3 μg Cd /liter-over tie salinity range of 10 to 32 o/oo. Dry weights and fecundity of exposed and unexposed females were comparable when Cd was <5 μg/liter and salinity was >20 o/oo. At higher Cd concentrations, female size, and reproduction decreased regardless of salinity. The latter response was less at low than at high salinities, even in the absence of Cd. This effect of low salinity on reproduction was not moderated by cyclic exposure to higher levels of this variable. Changes in reproduction observed were consistent with the distribution of M. bahia in estuaries relative to salinity. The approximated no-effect concentration is 4-5 μg Cd /liter.

WELSH, B.L., D. DRAPEAU AND J. JOHNSON. MARINE SCIENCES DEPARTMENT, UNIVERSITY OF CT. AVERY POINT, GROTON, CT 0 6 3 4 0 . OCCURRENCE AND PERSISTENCE OF HYPOXIA IN STRATIFIED SYSTEMS :A COMPARATIVE APPROACH .

Summertime 0_2 deficits in bottom waters of stratified coastal systems are becoming more severe, extensive, and persistent, presumably from increased phytoplankton production associated with nutrient enrichment. The degree to which such deficits will develop depends on rates of biological oxygen removal relative to physical replacement through vertical and horizontal mixing. Hypoxia (< 3 ppm 0_2) and anoxia (0 ppm) have been reported in Narragansett Bay, Long Island Sound, New York Bight, Chesapeake Bay and its York River subestuary, and the Gulf of Mexico and its subsystem, Mobile Bay. All these systems develop a stratification barrier preventing downward mixing of 0_2 below the photic zone. There are differences, however, in the relative importance of processes producing stratification in these systems which appear to affect the occurrence, duration, intensity and persistence of hypoxic conditions.

YARISH, S.M., Project Oceanology, Avery Point, Groton, CT 06340
HYPOXIA IN THE THAMES RIVER ESTUARY:PRELIMINARY REPORT

The Thames River is a tidally dominated estuary in Southeastern Connecticut. Data collected since 1977 indicated that bottom water at the head of the river was becoming hypoxic, <3 mg/1 dissolved oxygen, during the summer months. In 1989-90 high school teachers enrolled in an NSF Teacher Enhancement Program conducted research to determine the extent of hypoxia in the Thames River. Hypoxia initially occurred in bottom water (11 m) at the head of the river in June. By Septemeber, hypoxia existed below the halocline (2-3 m) in the upper 7 km of the-river. Hypoxia was consistently associated with high concentrations (>30 uM) of NH_4^+. Water above the halocline was well oxygenated, >5 mg/l, and was associated with high concentrations of NO_3^-. Changes in river flow affected the depth of the halocline, but did not change the chemical or physical properties of the water in each layer. Addition studies are presently being conducted to determine the onset/breakdown of hypoxia and possible cause and effects.

Foreman, Kenneth H., J.E. Costa, C. D'Avanzo and J. Kremer. Preliminary measurements of phytoplankton biomass and productivity in subestuaries of Waquoit Bay receiving different nutrient loadings.

Standing stock of chlorophyll a, gross primary production (GPP) and net community production were measured in the water column of 3 subestuaries receiving nutrients from watersheds containing different densities of houses. Differences is housing density result in estimated nitrogen (N) inputs of 8084 kg yr^{t} (11.8 kg yr'ha-^{t}) in the Childs River, 7449 yr^{l} (2.8 $yr^{l}ha^{-1}$) in the Ouashnet/Moonakiss, and 51 yr^{1} (0.9 $yr^{t}ha^{-1}$) in the Sage Lot Pond subestuaries. Despite these large differences in N loading, water column dissolved inorganic N concentrations were similar each of these systems. Nonetheless, a pronounced gradient in Chl a exists within the Bay. The more heavily loaded Childs River subestuary has average Chi a concentrations of - 22 $\mu g\ l^{-1}$ compared to - 7 $\mu g\ l^{-1}$ in the comparable, but less loaded Moonakiss River, 5.6 $\mu g\ l^{-1}$ in the mid-bay and 3 pg at the Vineyard Sound inlet. Preliminary measurements of photosynthesis suggest that GPP in the heavily loaded Childs River system is about double that in the intermediately loaded Moonakiss/Ouashent subsystem, and 3X higher than that in least loaded Sage Lot Pond.

In addition to phytoplankton, huge stocks of unattached benthic macroalgae accumulate within the Waquoit Bay system. During spring and early summer, much of the N released by mineralization and input from the watersheds may be taken up by these macroalgae. In late summer, high benthic algal respiration due to warm temperatures coupled with low daytime photosynthesis during series of cloudy windless days, appears to drive the bottom waters anoxic. Phytoplankton blooms may be triggered by N released from macroalgae when they die off during such anoxic events.

Valiela, I., Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543.
NATURAL AND ANTHROPOGENIC NUTRIENT SOURCES IN COASTAL ECOSYSTEMS LESSONS FROM BUTTERMILK BAY

Mass balance estimates of nitrogen sources are useful to evaluate relative importance of nutrient sources, and external vs internal nutrient supplies. These estimations often require interdisciplinary, multi-investigator studies, and also often are based on rough approximations. Nonetheless, they can guide research, and frame contexts for management policies.

In Buttermilk Bay, for example, we could conclude that septic tanks furnished-the principal freshwater-borne nutrient source to groundwater within the watershed, and that groundwater was the principal transporter of nitrogen and phosphorus to the Bay.

Mass balance nutrient budgets, however, are insufficient to provide evidence of specific nutrient limitation. Measurements of water turnover, regeneration, and enrichment experiments are needed to better understand how nutrient dynamics is coupled to production in coastal waters.

Valiela, I., Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543
OVERVIEW OF WAQUOIT BAY LMER PROGRAM

The Waquoit Bay LMER is a multi-investigator, multi-disciplinary study of the nutrient-related processes that couple coastal watersheds to adjoining coastal waters. In Waquoit Bay we can delineate subwatersheds that receive diffreent rates of nutrient loading. This provides us with a regional-scale experiment in nutrient (principally nitrate) loading.

Work on the terrestrial and hydrological components of the WBLMER will provide us with the nutrient inputs to the sediment/water interface, the second major component of our study, where significant nutrient transformations take place. The third component of WBLMER is study of the response of the aquatic ecosystem to the different degrees of nutrient loading.

We apply models to guide research, and to bring together the multiple data of the three components, and also *will* involve the coastal management community in application of the insights garnered by WBLMER.

"Nothing great was every achieved without enthusiasm."
Ralph Waldo Emerson