New England Estuarine Research Society

MEETING ABSTRACTS

NEW ENGLAND ESTUARINE RESEARCH SOCIETY

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Institute of Ecosystem Studies
Millbrook, New York
AND
Vassar College
Poughkeepsie, New York

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The distribution and growth of shallow water juvenile fishes in an urban estuary: The effects of manmade structures in the lower Hudson River

K.W. Able, J.P. Manderson and A.L. Studholme

A variety of techniques have been used in preliminary and ongoing studies to assess the quality of urban estuarine habitats in the Hudson River. Trapping and caging techniques were used in 1993 and 1994 to determine the relative abundance and growth of juvenile fishes in underpier, pile field and open water habitat types in nearshore areas in the lower Hudson river (40° 44' N, 70° 01' W). Nearly 1,500 mostly juvenile fishes representing 24 species were collected in 1,865 trap days conducted from May through October in the two years. Two seasonal assemblages were apparent. Young-of-the-year (YOY) Atlantic tomcod and winter flounder dominated an early summer assemblage (May-July) while large numbers of YOY striped bass were collected in a late summer assemblage (August -September). The effects of habitat type on fish assemblage structure were significant during both years (2 way ANOSIM, $P<0.01$). Fish abundance and species richness were typically low at underpier stations, where YOY fishes were rare and American eels accounted for nearly 80% of the total catch. In contrast, YOY fishes dominated collections at pile field and open water stations where fish abundance and species richness were high compared with the underpiers.

In 10-day caging experiments conducted with recently settled winter flounder (June-July, 1993 and 1994; 3 experiments yr^{-1} N = 522 ; 14 - 90 mm TL) and tautog (July - August, 1993 and 1994; 3 experiments yr^{-1} N =489 ; 21 - 76 mm TL), instantaneous growth rates in weight (G_w $\%d^{-1}$) were significantly higher (2 way ANOVA, $P<0.05$) in pile field and open water habitat types than in the underpiers where fish lost weight in all of the experiments (winter flounder: (-4.8 - $-0.2\%d^{-1}$): tautog: (-4.3 - -0.5 $\%d^{-1}$)). Growth rates for individual winter flounder and tautog were as high as 8 % d^{-1} and 10 % d^{-1} respectively, in open water and pile field habitats. The results of trapping and caging studies indicate that habitat quality under the platforms of large piers (> 20,000 m) is poor for YOY fishes when compared with nearby pile field and open water habitat types.

Allen, Andrew, and Marshall Pregnall, Vassar College, Poughkeepsie, NY
EFFECTS OF ANOXIA ON METABOLISM OF THE GREEN MACROALGA *(Ulva lactuca)* AND THE BROWN ALGA *(Alaria esculenta)*

Healthy macroalgae are often observed in environments that have undergone anthropogenic-induced eutrophication. Kelp, however, is not associated with such environments. We investigated the effect of one of the major consequences of severe eutrophication, hypoxia/anoxia, on the metabolic survivorship of *Ulva lactuca ,* which is common in eutrophied environments, and *Alaria esculenta* which is not. *U. lactuca* demonstrates prolonged (3 weeks) photosynthetic and respiratory survivorship under such conditions while *A. esculenta* is unable to photosynthesize after three days. Over the three week period, net photosynthesis in *U. lactuca* is reduced in the anoxic treatment. However, during the first 24-48 hours of anoxic treatment, photosynthesis exceeds that of *Ulva* in the aerobic treatment. This pattern is not observed for *A. esculenta,* where photosynthesis in the aerobic treatment exceeds that of the anoxic treatment from the onset of the experimental conditions.

Arnett, Brenda, Marie Pizzorno, Vassar College, Poughkeepsie, NY and George Balazs, National Marine Fisheries Service, Southwest Fisheries Science Center, Honolulu, HI
IDENTIFICATION OF NOVEL VIRAL DNA SEQUENCES ASSOCIATED WITH GREEN TURTLE FIBROPAPILLOMATOSIS (GTFP)

Green Turtle Fibropapillomatosis (GTFP), characterized by multiple benign fibroepithelial tumors on the skin and eyes, has become a growing threat to green turtle *Chelonia mydas* populations worldwide. The cause of GTFP is unknown, but because the disease can be transferred by a cell free extract, a viral etiology is suspected. In this study, representational difference analysis (RDA) was used to identify I)NA sequences unique to tumor tissue. RDA is a polymerase chain reaction technique involving subtractive hybridization between normal and tumor I)NA. DNA samples were isolated from a tumored and a normal kidney of an afflicted *C. mydas* captured off the coast of Hawaii. The unique DNA sequences and their relevance to potential viral causes of GTFP will be presented.

P. H. Balcom, B. L. Welsh, and J. R. Jadamec , Dept. of Marine Sciences and Coastal Environ. Laboratory. Marine Sciences & Technology Center, University of Connecticut, 1084 Shennocossett Road, Groton , CT
METHODS FOR MONITORING NITROGEN SPECIATION IN THE CONNECTICUT RIVER ESTUARY

The Connecticut River was sampled in March and August of 1995 along a nitrogen and salinity gradient (<1 to 33 PSU). The species distribution of total nitrogen is examined along the salinity gradient to determine dominant transformations, and to monitor transport of nitrogen within the estuary. Measured dissolved nitrogen species included nitrates, ammonia and total dissolved nitrogen (TDN) (Automated Ion Analyzer), and calculated species include total inorganic nitrogen (TIN), dissolved organic nitrogen (DON) and total nitrogen (TN). Analytical error associated with measurement of nitrogen species was assessed by repeat sample analyses. The magnitude of differences between initial and repeat analyses were small, but variance in percent differences depended on nitrogen species. Variance in percent differences was highest for ammonia analyses, but the concentration of this species was small compared to TDN. Salinity-substrate plots were generally linear for nitrates, TIN and TDN, indicating no net change in these species and the dependence of concentrations on physical mixing. The responses for ammonia and DON were variable in relation to salinity. In August field replication was increased compared to March in order to make estimates of minimum significant differences for each nitrogen species. In both sampling seasons, the mean percent difference for repeat analyses of each nitrogen species was generally less than the variability among field replicates. There is adequate analytical sensitivity to measure dominant rate process within the estuary.

Berounsky, Veronica[1], Marshall Pregnall [2], Taryn Donovan[2] and Steven Granger[1]
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WATER-COLUMN NITRIFICATION RATES IN NUTRIENT ENRICHED LAGOON MESOCOSMS WITH DIFFERENT N:P RATIOS.

Over the spring and summer of 1995, nitrification rates were measured three times in the water column of six lagoon mesocosms located at the University of Rhode Island. Half of the 2.3m N 1.8m bottom sediments of each shallow (1.1m) mesocosm was planted with eelgrass *(Zostera marina)* from a RI coastal lagoon. Rates were measured using the N-Serve sensitive C-14 bicarbonate incorporation technique. Two mesocosms were controls with no nitrogen or phosphorus enrichment and an approximate N: P ratio of 5:1. two were enriched in both N (as nitrate) and P (as phosphate) in a ratio of 5:1. and two were enriched with the same level of N but a lower level of P. for a 75:1 N:P ratio. Nitrification rates in May (15°C water temperature) showed distinct treatment differences, with rates lowest in the controls, intermediate in the 75:1 mesocosms, and higher in the 5:1 mesocosms. June (20°C) rates were more variable. For all but one mesocosm. rates were highest in August (25°C). For that mesocosm, low nitrification rates coincided with low ammonium concentrations, a phytoplankton bloom, and some eelgrass die-off.

Blair, Elizabeth A., **Dennis Mildner, and Chuck Nieder, Hudson River National Estuarine Research Reserve (NYSDEC), Bard College Field Station, Annandale, NY.**

RESEARCH OPPORTUNITIES AT THE HUDSON RIVER NERR

Research activities at the Hudson River National Estuarine Research Reserve (NERR) enhance resource protection by building a comprehensive body of scientific information for each of its four tidal wetland sites on the Hudson estuary managed for long-term research. Baseline data (water quality, vegetation communities, sediments) are used to monitor changes in the estuarine environment and to provide better management of these and other Hudson River tidal wetlands. Laboratories, collections and data, and accommodations are available. Fellowship opportunities include Polgar and Sea Grant / Hudson River NERR.

Bokuniewicz, Henry, Marine Sciences Research Center, State University of New York, Stony Brook, NY
BUILDING THE TURBIDITY STRUCTURE OF THE HUDSON RIVER ESTUARY.

To examine the large scale structure of the suspended sediment concentrations, axial sections were sampled throughout the geochemical estuary 11 times between May 1994 and September 1995. The limit of sea salt varied over a 70 kilometer section during the period. An intense mid-estuary turbidity maximum was usually found superimposed on weak regional gradients. This appears to be caused by bathymetrically controlled, tidally modulated salinity intrusions. During periods of low freshwater discharge, a second turbidity maximum was seen in saline water above Haverstraw Bay where variations in river cross-section may favor frontogenosis.

Relating Fish Habitat Quality to Population Level Effects

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Enactment of environmental legislation in the late 1960s to early 1970s led to a new dimension for fisheries science, that of evaluating pollution as a potentially significant source of mortality for fish populations. Until that time, the rate of natural mortality was addressed indirectly and was considered a catchall for all sources of mortality other than fishing. Since that time, fishery scientists have been asked routinely by resource managers to pin blame for observed declines in abundance of fish populations on precise causes. Overfishing is no longer accepted as a sole cause for declines without adequate justification why other sources of mortality, especially those related to pollution and other forms of habitat degradation, are not also involved. Evidence that sources of pollution may be wholly or partially responsible for declines in population abundance is elusive due to analytical and technological limitations in the power to separate non-fishing mortality into identifiable and measurable components. Methods exist (and are reviewed) to evaluate the population-level consequences of pollution versus overfishing, and allow managers a means to assess the tradeoffs between the two impact sources. The methods used, however, are limited by available data, particularly estimates of survival rates for early life stages. Increasing the abundance of a population by reducing fishing-related mortality may be a preferred short-term strategy for counteracting pollution impacts while habitats are being restored; such a strategy is being used successfully for striped bass along the Atlantic coast. Unless pollution and other forms of habitat degradation are reversed, however, reducing fishing pressure may only postpone the eventual demise of the fish population.

Bosley, Keith L and Sam C. Wainright, Institute of Marine and Coastal Sciences, New Brunswick, NJ

STABLE ISOTOPE TURNOVER RATE IN JUVENILE STRIPED BASS *(Morone saxatilis)* AND JUVENILE TAUTOG *(Tautog onitis)*

Studies are currently underway to assess estuarine habitat utilization by several species of juvenile fish. Stable isotope ratios of carbon and nitrogen are being used to delineate habitat utilization and establish trophic linkages. This technique requires that fish which utilize one habitat acquire a different stable isotope composition, through feeding on different prey, than fish which utilize an alternate habitat. In our studies, this assumption is being tested by confining fish in cages within different habitats. Given habitat-specific isotopic compositions of fish, an important consideration is the length of time that fish are caged relative to the time required for the fish to acquire a new isotopic composition. A change in isotopic composition is achieved when new tissue growth is large enough to significantly dilute old tissue synthesized in a previous habitat. A second mechanism is the turnover of existing tissue, which occurs even in *a* non-growing fish. Two experiments were carried out to determine the carbon and nitrogen turnover rates of striped bass *(Morone saxatilis)* and tautog *(Tautog onitis)*. The results should aid in the interpretation of previous and future stable isotope studies of habitat utilization by these and other species.

Boumans, Roelof, Frederick Short and David Burdick, University of New Hampshire, Jackson Estuarine Laboratory. 85 Adams Point Rd Durham, NI I 03824.
MODELLING THE INTERACTION OF WASTING DISEASE AND EELGRASS TO INVESTIGATE FACTORS INFLUENCING LFLGRASS LOSS IN GREAT BAY, NH.

We explore the dynamics between eelgrass *(Zostera marina)* and the pathogenic organism known to cause wasting disease, *(Labyrinthula zosterae).* At the population level, an "unstable balance" between host and pathogen can result in rapid changes of eelgrass bed distribution.
The unstable population dynamics result from the most dense beds being the most susceptible to the disease, because disease transmission requires leaf-to-leaf contact. Observations include bathymetry data and eelgrass distributions in Great Bay New Hampshire from 1986 to 1992. We simulated seasonal allocation of carbohydrates within the plant under various growing conditions and the potential effect of wasting disease on carbohydrate allocation to reproductive tissues for making seeds or rhizomes for winter storage. Our findings for other estuaries suggest that poor growing conditions for eelgrass (low light) cause a reduced revegetation potential after a disease outbreak, as less reproductive materials are produced and dispersed, or not enough carbohydrates are stored in the rhizomes to survive the winter.

Acoustic and Bioenergetics Modeling Approaches to Evaluating fish Habitat Quality in Chesapeake Bay

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Habitat quality should be defined from the perspective of the fish; how well will it survive under the prevailing habitat conditions? The quality of the habitat, thus, should *be* considered in terms of both the physical (e.g. temperature, dissolved oxygen concentration) and biological (e.g. prey fish abundance and size structure) characteristics of the environment as well as the physiological and behavioral constraints of the fish. We have recently developed a new approach that combines the strengths of underwater acoustics (detailed maps of prey densities and sizes), bioenergetics (simulations of fish growth rates), and spatial modeling (which accounts for spatial heterogeneity in the habitat) to evaluate fish habitat quality in terms of the growth rate potential afforded by the habitat.

We use examples from striped bass, bluefish, and weakfish in the Chesapeake Bay to illustrate how habitat quality changes across space and among sizes and species of fish, and how deterioration of some components of the habitat (e.g. prey abundance) can be compensated for by improvements in other components of the habitat (e.g. dissolved oxygen). We believe this approach is useful for managing fisheries, assessing the linkages between water quality and fish production, evaluating potential species introductions, measuring ecological efficiency of a species and assessing the potential effects of environmental perturbations.

Buchsbaum, Robert, Massachusetts Audubon Society, Wenham, MA, Linda Deegan and Robert Garritt, The Ecosystem Center, Woods Hole, MA

CHANGES IN THE ESTUARINE FISH COMMUNITY OF PLUM ISLAND SOUND, MASSACHUSETTS OVER A TWENTY FIVE YEAR INTERVAL

We have compared the present fish community in Plum Island Sound, a shallow estuary in northern Massachusetts, with the fish community present in 1967 as determined by the Massachusetts Division of Marine Fisheries (DMF). We revisited the exact same stations as those sampled in the DMF study over a 16 month period and used very similar methods (beach seine and otter trawl). The two most abundant species we collected, Atlantic silversides *(Menidia menidia)* and mummichog *(Fundulus heteroclitus),* accounted for greater than 90 percent of the individuals and biomass in our samples. Although silversides and mummichogs were also the two numerical dominants in the DMF study, they presently make up a much larger percentage of the catch than in the past, thus diversity has declined. Species that have declined relative to the earlier study include winter flounder, yellowtail flounder, rainbow smelt, and long-horned sculpin. Fish that have increased in numbers include Atlantic herring, shad, and striped bass. The possible causes of these differences fit into three categories: regional trends that are not specific to Plum Island Sound, changes within the Sound itself, and methodological discrepancies.

Buchsbaum, Robert, Massachusetts Audubon Society, Wenham, MA

HAZARDS OF SENDING UNTRANSLATABLE ABSTRACTS VIA EMAIL

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Burdick, David, Roelof Boumans and Frederick Short University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Durham, NH and Michele Dionne, Wells National Estuarine Research Reserve, Wells, ME

A COMPARISON OF TIDAL RESTORATION EFFECTIVENESS AT TWO SALT MARSHES

Habitat change was examined following restoration of tidal hydrology at two salt marshes in northern New England. Before restoration, both systems allowed fresh water drainage through a single culvert, and each had a flap gate that prevented salt water from entering the marsh. Tidal exchange was re-established in Drakes Island Marsh, Maine after the flap gate broke off (1988). At Stuart Farm Marsh in New Hampshire, tidal exchange was re-established in 1993 with the installation of a 2 meter arched pipe culvert. Flooding of these systems has increased dramatically, especially on higher tides, leading to a greater than 10 ppt increase in water table salinities. Fresh water plant communities were quickly killed by the salt water. By 1995, we found revegetation of die-back and open water areas with *Spartina alterniflora, Spartina patens, Salicornia europaea,* and *Juncus gerardi,* and death of the invasive species *Lythrum salicaria.* Qualitative differences in the responses of marsh habitats to increased tidal flooding, as well as the rates of recovery, reflect contrasting hydrologies.

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FROM THE BASE OF THE FOOD CHAIN TO FISH PRODUCTION IN THE HUDSON: WHAT DO STABLE ISOTOPES SUGGEST ABOUT ORGANIC FLOWS?

Organic inputs to the Hudson River include allochthonous material from the watershed, production by submerged macrophytes (SAV) and phytoplankton production. Stable isotoped analysis (15N and 13C) were used to trace organic flow from these inputs to primary and secondary consumers. Results suggest spatial variation in the importance of different food sources with allochthonous inputs being more important further up river. Overall, however, isotope data suggest that phytoplankton are by far the most important food source fueling production at higher trophic levels, including larval fish. This result is surprising as allochthonous inputs are nearly 10-fold greater than phytoplankton production. Is it true that allochthonous material is not substantially passsed up the food chain or could a decoupling of C and N flows explain the isotope results.

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SHORT-TERM AND LONG-TERM IMPACTS OF LOW-HEAD, HYDROELECTRIC, TIDAL POWER GENERATION ON ESTUARINE AND ANADROMOUS FISHES.

In 1984 a low head, tube turbine of 20mw generation capacity became operational on the Annapolis River estuary (tide range 7m). Pre-operational studies were conducted on the biological population characteristics of the annual American shad spawning run during 1981-82 and post operational studies during 1989-90 and 1995. During 1985-87 turbine passage effects on adult shad, juvenile alosids and other anadromous and estuarine species were examined. Since the installation of the turbine the annual shad spawning run has decreased in size from approximately 150,000 adults in 1981-82 to approximately 60,000 adults in 1995 (no commercial fishing in this river) but more specifically the mean length, maximum length and mean weight of both males and females have declined 11%, 14% and approximately 30% respectively during the 14 yr. period. The mean age and maximum age of the annual run and the percentage of repeat spawners have also declined significantly. At the same time the parameters for growth rate (K) and total mortality (Z) of the population have both increased. All observed population characteristics indicate the turbine is cropping down the older, larger fish. Near field impacts on an array of species from Atlantic sturgeon to Atlantic herring indicate turbine mortality is caused by mechanical impact, shear, pressure effects and cavitation and varies depending on the size and species of fish.

Davis, Ryan and Frederick T. Short. Department of Natural Resources, Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH.

SURVIVAL RATES AND FUNCTIONAL CHARACTERISTICS OF TRANSPLANTED EELGRASS *(Zostera marina, L.).*

Over the last several decades, a variety of transplantation techniques have been used in an attempt to reestablish seagrass populations. Reported survival rates from these efforts have averaqed 30-40%. We recently transplanted 7.075 acres of eelgrass in the Great Bay Estuary, New Hampshire, using a revised transplantation technique to ensure greater survival and expansion of transplanted eelgrass. The planting technique consists of overlapping the rhizomes of two plants in opposite directions and securing them into the sediment with a bamboo staple. Protective caging was constructed around transplanted areas to minimize bioturbation by green crabs *(Carcinus maenas)* and horseshoe crabs (*Limulus polyphemus).* Survival rates varied dramatically between intertidal (7%) and subtidal (77%) transplants. Annual monitoring of the transplant sites shows that they are currently providing 50% to over 100% of selected functional characteristics (e.g., shoot density, leaf area index, aboveground biomass, and presence of fish and infaunal communities) of nearby naturally occurring eelgrass beds.

Deegan, Linda and Melissa Weaver, The Ecosystems Center, The Marine Biological Laboratory, Woods Hole, Ma.

FROM A FISHES PERSPECTIVE: THE EFFECTS OF EUTROPHICATION IN EELGRASS ECOSYSTEMS

The alteration and loss of submerged rooted aquatic vegetated (SRV) ecosystems provides one example of the link between anthropogenic stress and fisheries habitat. Along the Atlantic coast, eelgrass meadows are a dominant SRV ecosystem and an important fish habitat. Increased development in the watershed and nutrient loading causes declines in the quality of eelgrass habitat and eventually complete loss of large areas. Eutrophication alters the physical structure of eelgrass meadows by decreasing shoot density and blade stature, decreasing the size and the depth of beds, and by stimulating the excessive growth of macroalgae. Macroalgae and phytoplankton eventually outcompete and smother the eelgrass. In this paper we describe some of the ways that alteration of eelgrass habitats affects fish populations.

The replacement of eelgrass by macroalgae in a eutrophic estuary results in a highly modified fish community. The high diversity and abundance of fish in eelgrass ecosystems is due to high survivorship because the physical structure of vascular plant provides protection from predation and high food availability. Caging studies indicated lowered growth and survival in eutrophied estuaries compared to more pristine areas. Experimental studies indicated predation on fishes was increased and food availability was lowered under eutrophied conditions. In studies of Waquoit Bay and Buttermilk Bay on Cape Cod, assessments of the relative degradation of eelgrass habitats were based on year-round measurements of chemical and physical characteristics (e.g., algal blooms, macroalgae, hypoxia, high nutrients, dredged channels). By the end of the summer, when the cumulative effects of low oxygen, higher mortality due to predation and disrupted food webs have been felt by the fish community, there were fewer species, fewer individuals and lower biomass in areas of poor water quality compared to more pristine areas. The number of fish species that use estuaries as a nursery area or spawning location was much lower in areas of poor water quality. Fish associated with the benthic zone were more strongly affected than fish associated with the pelagic zone. For example, winter flounder, a benthic species that spawns in the estuary, was one of the first species lost from eelgrass habitats under eutrophic conditions.

Long before the plants have disappeared, the decline in habitat quality affects fish. In future assessments of the ability of estuaries to sustain fisheries we need to consider the both the quality and quantity of critical habitats.

Feng, Huan, J. Kirk Cochran and David J. Hirschberg, State University of New York, Stony Brook, NY

TRANSPORT AND DISTRIBUTION OF SEDIMENT-ASSOCIATED CONTAMINANTS IN THE HUDSON RIVER ESTUARY.

Samplings of suspended solids and sediments for natural radionuclides and trace metals have been carried out along the lower -90 km of the Hudson River, including the turbidity maximum zone off Manhattan. The results show that particulate Ag, Cd, Pb and Cu concentrations are correlated well with particulate Fe concentration, implying that the fine suspended particles play an important role in transporting the particle-reactive contaminants. In the surface sediments (0-3 cm), trace metal/Fe ratios generally exceed the background values of the Hudson River sediments. Ag, Cu and Pb show an increasing trend down river with maximum values in New York Harbor sediments. In contrast, Cd and PCB's show a decreasing trend toward the New York Harbor. The results suggest that Ag, Cu and Pb are dominated by downstream sources such as sewage or urban runoff, or the history of their inputs is such that they have been progressively transported downstream. Cd and PCB's, on the other hand, have distributions that are dominated by upriver sources. Significant spatial variations of natural radionuclide activities (^{234}Th and ^{7}Be) and trace metal concentrations in the sediments were found in the turbidity maximum zone. The difference is especially significant between the midchannel and flanks.

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THE EFFECTS OF SUBMERSED AQUATIC MACROPHYTES ON SEDIMENT POREWATER CHEMISTRY.

Submersed aquatic vegetation (SAV) plays a key role in coastal and estuarine ecosystems. SAV provides food and refuge for aquatic life, serves as a nutrient filter, and prevents sediment erosion. The purpose of this study was to determine if submersed macrophytes play an active role in altering their sediment chemistry. Root zone oxidation and plant nutrient uptake appear to provide macrophyte species with mechanisms for removing soluble phosphorus (P) from the sediment porewater. A laboratory experiment was conducted which evaluated the effects of two submerse macrophytes, *Vallisneria americana* and *Potamogeton pectinatus*, on levels of porewater P. The two species were grown separately at different densities of vegetation in tubs of homogenous sediment. Equilibrators, or peepers, were used to collect water samples from these vegetated tubs as well as control tubs of bare sediment. Results show that levels of porewater P were significantly reduced ($p<0.001$) when macrophytes were present. At a depth of 3 cm, the average porewater concentrations for all treatments were 0.5 mg/L, 1.25 mg/L, and 2.4 mg/L for *Vallisneria*, *Potamogeton*, and the control, respectively. The results from this experiment suggest that sediment nutrient availability can be coupled with shifts in macrophyte community composition.

Helting, L. J., Research Scientist, Albany, NY, Norbert Jaworski, Research Scientist, Narragansett, RI, and Patrick Phillips, US Geological Survey, Troy NY.

LONG TERM CHANGES IN WATER QUALITY OF TRIBUTARIES TO THE HUDSON ESTUARY

Data on long term changes in water quality (>100 years) has been collected for tributaries to the Hudson Estuary. Sources of the data include university thesis, the NYS Departments of Health and Environmental Conservation, and the US Geological Survey. Data for major tributaries to the Hudson River and the Hudson River mainstem indicate that chloride concentrations have generally increased ten-fold, and nitrate concentrations have increased nearly five-fold in the last century. In contrast, total residue have either not changed or decreased in the last century.

Jennifer M. Hogan, Northeastern University, Boston, MA
LONG-TERM EFFECTIVENESS OF SALT MARSH RESTORATION AND CREATION IN MASSACHUSETTS.

A series of Massachusetts salt marsh restoration and creation projects initiated between 1980 and 1989 were previously evaluated for plant community development and mitigation "success". Six of these sites will be re-assessed during the summer of 1996 for additional plant community development. A subset of the sites will be evaluated further and compared to natural marshes for a suite of wildlife habitat and functional parameters. The goal of this study is to evaluate whether short-term monitoring of plant coverage is an adequate indicator of longer-term development of a natural plant community, faunal habitat and ecosystem functions in created and restored salt marshes.

Hoven, H.M. and F.T. Short, Department of Natural Resources and Jackson Estuarine Laboratory, University of New Hampshire, Durham New Hampshire, 03824. EELGRASS *ZOSTERA MARINA,* L. AS AN INDICATOR OF HEAVY METALS IN ESTUARINE WATERS AND SEDIMENTS.

Natural beds of eelgrass growing adjacent to the Portsmouth Naval Shipyard were sampled for the presence of heavy metals in leaf and root/rhizome tissues. Elevated Pb, Hg, and Cr concentrations were found in eelgrass leaf tissue at six of fifteen stations. High concentrations of Pb, Hg, and Cr were found in the root/rhizome tissue at five stations. Concentrations were considered elevated when they exceeded three standard deviations above reference location levels. We found a significant correlation between root/rhizome and sediment metal concentrations (r^2 for Pb = 0.64, Cr = 0.67, Cu = 0.66); we also found a correlation between sediment and leaf tissue concentrations of Hg (r^2 = 0.96). Significant reduction in rhizome length correlated with increased concentrations of Pb in the sediment (r^2 = 0.91), suggesting inhibition of eelgrass growth. A gradient of decreasing metal concentrations was found with increasing distance from the depositional areas around the Shipyard. Our data shows that eelgrass tissue reflects concentrations of contamination in the environment, functioning as a bioaccumulator of metal contaminants from both sediment and water column and may be used as a sentinel indicator.

Kinney, Eleanor H., Graduate School of Oceanography, University of Rhode Island. Narragansett, RI and
Charles T. Roman, National Biological Service, University of Rhode Island, Narragansett, RI
PRIMARY PRODUCTION OF MACROALGAE, *RUPPIA MARITIMA,* AND PHYTOPLANKTON IN BASS HARBOR MARSH, MAINE

Growing coastal populations threaten estuarine water quality, and shallow coastal systems worldwide are exhibiting increased algal growth in response to nutrient enrichment. This study evaluates production patterns of three primary producers (macroalgae, *Ruppia tnaritima,* and phytoplankton) as they respond to low levels of nutrient enrichment in Bass Harbor Marsh, Maine. Seasonal biomass curves show an inverse relationship between macroalgal density ($gdwm^{-2}$) and chlorophyll a concentration, which peaks following a mid-summer decline in macroalgal biomass. *Ruppia s* seasonal biomass trend mirrors that of the macroalgae, with low levels in the spring and fall separated by an early-summer maximum. While *Ruppia's* seasonal pattern seems unaffected by macroalgal production, it is possible that total *Ruppia* production is greatly depressed through competition with the algae. Total system biomass in the lower basin of Bass Harbor Marsh is dominated by the opportunistic green macroalgae, which exhibit a peak biomass of 150 $gdwm^{-2}$ in contrast to *Ruppia's* peak biomass of 33 $gdwm^{-2}$. These results indicate that Bass Harbor Marsh may already be exhibiting patterns typical of a shallow eutrophied system, despite relatively low levels of nutrient enrichment.

Korff, Wyatt, Vassar College, Poughkeepsie, NY, Long, John H., Vassar College, Poughkeepsie, NY, and Suter, Robert, Vassar College, Poughkeepsie, NY.
TO JUMP A FISH: CALCULATING THRUST POWER OF AROWANA *(Osteoglossum bicirrhosum)*

Central to our understanding of how animals move is knowing how much mechanical power is required at different speeds and in different media. In water the situation is a complex mechanical interaction with the surrounding fluid, complicated by an inability to directly measure force without disrupting the motion. To date, the only estimates of the mechanical power (W) required to swim have come from hydrodynamic theory. Thus, our goal was to test, experimentally, theoretical estimates of thrust power in an undulating swimmer. Because a method has not yet been found to directly measure thrust power of a swimming fish while it is in the water, we took advantage of the jumping behavior of the South American arowana, *Osteoglossum bicirrhosum,* to measure thrust power from the potential energy of the jump itself by using high-speed video (1000 images per second). The thrust power values calculated in this manner were compared to those from Lighthill's large-amplitude, slender body hydrodynamic theory, the most commonly used method to estimate thrust power. Our results show that EBT underestimates actual thrust power by a factor of four. Higher power requirements mean that fish, and other undulatory swimmers like dolphins and worms, may be less efficient swimmers than previously thought.

Linden, Ruth, The University of Connecticut at Stamford, Ct.

OBSERVATIONS ON THE REPRODUCTIVE BIOLOGY AND POPULATION ECOLOGY OF EELGRASS (Zostera marina L.) IN NIANTIC BAY, LONG ISLAND SOUND

Population estimates calculated from biomass samples collected from an eelgrass bed in Niantic Bay and results from germination experiment with Niantic Bay eelgrass seeds will be presented. Eelgrass reproduce vegetatively throughout the year and simultaneously becomes sexually reproductive during the Spring and Summer. The fruits and seeds produced between pollination (May—July) and dehiscence of the ovule (June (late) — mid August) are of different colors and are at different levels of maturity. Sterilization of seeds prior to storage and then use in experiments, seed color, and seed maturity appear to have an effect on seed germination rates.

Litvin, S.Y., Wainright, S.C., Able, K., Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, and Phelan, E., NMFS Howard Laboratory, Highlands, NJ, and Periera, J., Goldberg, R., NMFS, Milford, CT.

HABITAT UTILIZATION BY JUVENILE WINTER FLOUNDER AND TAUTOG AS INDICATED BY STABLE ISOTOPE RATIOS.

The measurement of stable isotopes in the tissues of marine consumers can provide a time-integrated characterization of assimilated diet. Taken together carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) provide a two-dimensional view of the trophic position of juvenile fish within an environment. If fish in one habitat have a different diet from fish in another habitat stable isotope ratios may offer an alternative to gut content analysis for discerning such differences. In a NOAA/COP funded study juvenile winter flounder and tautog were confined to cages for ten days in four different habitats in each of three Northeastern estuaries. The juvenile fish and environmental samples consisting of sediment, macroalgae, and *Zostera* were analyzed for $\delta^{13}C$ and $\delta^{15}N$ values. Ten 10 days within a cage was long enough to impart an isotopic signal upon the fish. Fish seem to be deriving their organic matter from a benthic source; their isotope values, on average, were two trophic levels removed from sediment values (based on previously published trophic enrichment data). *Zostera* and macroalgae appear to be relatively unimportant in the juvenile fish food chain. Caged fish, vegetation, and sediment isotope values were estuary specific, therefore the ability to use stable isotopes to determine habitat utilization by juvenile fish may vary between estuaries. Overall the $\delta^{15}N$ values of all three types of samples from the Tuckerton, NJ estuary were lower than those from the Milford, CT or Sandy Hook, NJ systems, perhaps due to higher anthropogenic input in the latter two estuaries.

Mazurkiewicz, Michael, University of Southern Maine, Portland, Maine

THE DISTRIBUTION OF A SCALE AT DIFFERENT SCALES

A scale insect, Haliaspis spartinae, has been discovered living abundantly on Spartina alterniflora along the shores of a small estuary in Maine. This is a new northern distributional record for this monophytophagous sap-feeding insect which is also known from just eleven other widely scattered localities along the Atlantic, Pacific and Gulf coasts. Is this disjunct distribution a reality or has the insect been overlooked? Some fascinating smaller scale distributional patterns have also been uncovered, hence the title of this presentation.

McEnroe, Maryann, Lilah Brand and Hazel Mutia, Purchase College, Purchase, NY 10577-1499.
Utilization of Alternative Modes of Respiration by *Fundulus heteroclitus* and *Fundulus majalis* Exposed to Environmental Hypoxia.

Cyprinodonts such as the mummichogs, *Fundulus heteroclitus,* and striped killifish, *Fundulus majalis,* arc abundant in stressed environments, Both species occur sympatrically in bays and harbors of western Long Island Sound, which may become hypoxic during the summer months. Among fishes there is a wide array of physiological, morphological, and behavioral adaptations to hypoxia, including aquatic surface respiration (ASR) and bimodal respiration. These alternative modes of respiration are best documented for tropical freshwater fishes from hypoxia-prone habitats but have also been shown to be used by temperate fishes (Gee, 1978; Kramer, 1987; Graham, 1994). We found that both species of *F. heteroclitus* and *F. majalis* altered their respiratory behavior when exposed to hypoxia. Ventilation rate, measured by opercular movements, increased directly as dissolved oxygen levels fell. The fish adopted aquatic surface respiration increasingly after oxygen concentrations fell below 4 mgO_2/l. In addition, below 4 mgO_2/1 both species were observed to break the water surface with increasing frequency, apparently to gulp air. Air bubbles held in the mouth may be used to oxygenate water flowing past it, thereby enhancing oxygen uptake in these primarily water-breathing fish.

McEnroe, Maryann and Don Kroslowitz, Purchase College, Purchase, N Y 10577-1499.
Behavior of Juvenile Winter Flounder, *Pseudopleuronectes americanus,* to Acute Hypoxia.

Winter flounder are bottom dwelling fish which are important residents of Long Island Sound. The shallow bays and wetlands serve as nurseries where the juveniles may grow rapidly. During summer these waters commonly become depleted of oxygen, hypoxic. There have been occasional newspaper reports of flounder "gasping at the surface". Our results suggest that such atypical behavior is probably a response to severe oxygen-deficiency in nearshore waters. We measured respiratory and behavioral responses of juvenile winter flounder to different levels of hypoxia. The measurements included: a) opercular ventilation rate; b) frequency of aquatic surface respiration: c) frequency of air gulping; d) swimming activity, in horizontal and vertical planes; e) percent time spent at the surface. Fish were maintained in aquaria with conditions typical of the Sound in summertime. Oxygen concentration of the water was gradually lowered by bubbling inert N_2 into the tank, from normoxic levels to I mg 0_2/1. Flounder ventilation rates increased steadily as DO declined, but when DO fell below 2 mg 0_2/1 ventilation rate fell quickly. In moderate hypoxia, about 4 mg O_2/1, flounder were restive and characteristically raises their heads off the bottom. As hypoxia progressed, flounder frequently swam up to the surface and exhibited air gulping behavior, this increased with oxygen depletion. Below 3 mg 0_2/1 there was a marked increase in swimming

McGuinness, Lora R., Wainright, Sam C., Institute of Marine and Coastal Sciences
Rutgers University, New Brunswick, NJ 08903-0231
THE RESUSPENSION OF PAH CONTAMINATED SEDIMENTS AND ITS EFFECT ON PAH CONCENTRATIONS IN THE PARTICULATE, COLLOIDAL AND DISSOLVED PHASES

Polycyclic Aromatic Hydrocarbon (PAH) concentrations increase with increasing organic carbon content and decreasing sediment grain size in marine sediments. The resuspension of contaminated sediments introduces particulate, colloidal and dissolved organic material and associated PAHs into the water column where they can be transported, redeposited or degraded. Colloidal material may remain in suspension for long periods of time and enhance desorption/adsorption of PAHs. A laboratory experiment examined the changes in PAH concentrations in the overlying water column due to resuspension. Sediments were collected at a tidal creek off of the Arthur Kill, New Jersey, resuspended in filtered water and allowed to settle. The flasks were sampled and analyzed for changes in PAH concentrations in the particulate, colloidal and dissolved phases over a period of 18 hours after resuspension had ceased. Organic carbon was also measured for each phase and compared to PAH concentrations. Good correlation between organic carbon and the total PAH concentrations was found. The particulate phase (>1.0 μm) accounted for 80 % of the total PAHs measured . A detailed analysis of the distribution of PAHs among the three phases will be presented. The correlations of three compounds, phenanthrene, pyrene and benzo(a)pyrene, to organic carbon are being examined to determine the effect of the increasing compound complexity on PAH distribution.

Mugue, Nikolai, and Judith S. Weis, Dept. Biological Sci., Rutgers Univ., Newark, NJ.

MUMMICHOG (*Fundulus heteroclitus*) IN NEW JERSEY, NEW YORK, AND CONNECTICUT ESTUARIES: EVIDENCE FOR FORMATION OF A THIRD, intermediate, RACE BETWEEN *F.h.heteroclitus* AND *F.h.macrolepidotus*.

Populations of two mummichog subspecies, *Fundulus heteroclitus heteroclitus* and *F. h. macrolepidotus* from NJ, NY, and CT estuaries and the Hudson River were assessed for morphological and genetic variation. Sharp concordant clines in allozyme (Mdh-A) and mtDNA (RFLP of PCR-amplified D-loop) showed the present subspecies boundary. Mummichogs with intermediate allozyme and morphological phenotypes inhabit area between heteroclitus and macrolepidotus - low parts of the Hudson and the Hackensack rivers and NY/NJ Harbor estuaries. According to genotype distribution data, intermedius race is a product of previous hybridization between heteroclitus and macrolepidotus and now is partially reproductively isolated from both parent species. Current wide spread of intermediate race onto the North shore of Long Island is evident, when morphology and genetics of Long Island populations, studied in 1972 by J. Mitton, was compared with the data of present-day populations from the same locations.

Nieder, William C., Hudson River National Estuarine Research Reserve, New York State Department of Environmental Conservation, Annandale, NY

IDENTIFICATION OF NONPOINT SOURCES OF POLLUTION IN A MULTIPLE LAND USE WATERSHED: SAW KILL, DUTCHESS COUNTY, NY.

It is important to identify the sources of nonpoint pollution that are responsible for the observed water quality of coastal waters in order to effectively implement best management practices or BMPs. This study combines remote sensing with precipitation responses of surface waters in the Saw Kill watershed to identify nonpoint pollution sources. The three dominant land uses within this 26.6 sq. mi. watershed include: forested (51.1%), agriculture (25.8%), and urban/residential (16.5%). Surface waters discharging from five sub-catchments within the Saw Kill watershed were sampled through six precipitation events from April through December 1993. These five sub-catchments represented the following land uses: forested, row crop agriculture, orchard, residential, and solid landfill. Surface waters at these sub-catchments were sampled before and for three to five days after a precipitation event. Nitrate, phosphate, sulphate, chlorides, seston, dissolved oxygen, temperature, conductivity, pH, discharge, and alkalinity were measured at each site. Comparisons of the five land uses with nutrient concentrations indicate that residential land use practices are strongly correlated with the observed concentrations of nitrate and phosphate. Water quality responses of the residential sub-catchment to precipitation indicate the primary sources of nitrate and phosphate to be septic systems and landscape practices respectively.

Raposa, Kenneth, Graduate School of Oceanography, University of Rhode Island. Narragansett, RI 02882

A STRUCTURAL ANALYSIS OF FISH AND DECAPOD CRUSTACEAN COMMUNITIES ASSOCIATED WITH SALT MARSH AND BEACH SHORELINES AND EELGRASS *(Zostera marina)* BEDS

Epibenthie macrofauna (fishes and decapods) were sampled from May through October, 1995 along salt marsh and intertidal beach shorelines on the north shore of Fire Island, New York. The role of shoreline type in influencing communities in subtidal habitats was also examined using concurrent sampling from eelgrass beds adjacent to each salt marsh and beach station. On a smaller scale, factors affecting faunal distribution patters in eelgrass beds were investigated, including the effects of *Zostera marina* and macroalgae biomass, and the distance of grass beds from shore.

Total abundance and biomass of fauna were similar between marsh and beach habitats, although several species exhibited clear preferences for one habitat over the other. These preferences were not necessarily translated to similar patterns in adjacent grass beds, For some species, grass bed characteristics appear to override the effects of shoreline habitat type. However, the proximity of eelgrass beds to salt marsh shorelines also has an effect, as some species known to utilize the marsh surface are more abundant in eelgrass close to the shore as compared to beds farther out.

Ron Rozsa, Connecticut Department of Environmental Protection - Office of Long Island Sound Programs, 79 Elm Street, Hartford, CT 06106

Zostera marina: Historic and present day distribution in Long Island Sound

Historic data and research were used to reconstruct the pre-1931 distribution of *Zostera* in the Sound. Post 1931 recovery patterns were determined primarily from annual wildlife conference reports. Present day distribution is based upon a recent mapping project completed by Dr. Charles Yarisch and his research team which documents a long term decline in *Zostera* abundance. Extant populations are found only in eastern LIS, a region with excellent water quality. It is speculated that the post 1931 recovery in central and western LIS was poor as a result of water quality degradation.

Salt Marshes: Biophysical characteristics of drained salt marshes and post restoration biotic changes.

The use of tide gates in Connecticut causes radical alterations of the biophysical characteristics of salt marshes and leads to habitat degradation, reduced biological diversity and sometimes nonpoint source pollution. Scientific investigations and restoration planning studies document these changes and provides a basis for designing salt marsh restoration projects. Post restoration monitoring demonstrates ecosystem recovery. One of the most useful and practical monitoring techniques is the use of permanent photostations.

Scheirer, Kevin, David Burdick, Roelof Boumans, University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Durham, NH and Michele Dionne, Wells National Estuarine Research Reserve, Wells, ME

FISH USE OF FOUR NEW ENGLAND SALT **MARSHES** FOLLOWING TIDAL **RESTORATION**

Fish use of salt marsh habitat was examined in four restored salt marshes that had been tidally-restricted in northern New England. Tidal exchange was increased in Sandy Point and Awcomin marshes by cutting tidal creeks to the interior, and by reconfiguring culverts in Drakes Island and Stuart Farm marshes. Fyke nets were used to fish restored and reference sections of each marsh as they were flooded by spring tides. Fish use, an indicator of habitat value, was measured as the number of fish per square meter of marsh area fished. Comparisons of restored vs. reference levels of fish use appeared to vary with the type of restoration, with greater fish use found in marshes upstream of improved culverts. Compared to a similar study done in Awcomin marsh immediately following restoration in 1993, an increase in fish use of the restored area was noted. Although restoration clearly improves fish access to marsh areas, it remains difficult to quantify the increase in habitat value from tidal restoration. Current fishing methods and possible ways to improve upon the reliability of measures to assess habitat value will be discussed.

Schmidt, Robert E., Simon's Rock College, Great Barrington, MA
and Karin E. Limburg, Institute of Ecosystem Studies, Millbrook, **NY**
ASSESSING FISH HABITAT AT THE RIVER'S MARGINS: MARSHES AND TRIBUTARIES

Marshes, embayments, and tributary streams provide significant habitat for many estuarine and tidal riverine fish species. We illustrate some of the functions of these habitats through a synthesis of studies in the tidal Hudson River. We assess: the ecological services provided by these habitats; species richness; functional diversity of the fish fauna; and usage of these habitats relative to the mainstem estuary. Services of marshes include: conversion of marsh production into fish biomass; spawning sites for anadromous species; nursery areas for some species, and feeding stopovers for migrating, young-of-year anadromous fishes. Tributaries serve as important sources of early life stages of both anadromous and potamodromous species, as well as sites of exotic introductions. Finally, the state of information needed for management and restoration is evaluated.

Shepherd , W.R. III and J.H. Long, Jr. Vassar College, Poughkeepsie, NY
ANGUU LIFORM SWIMMING: A COMPARATIVE STUDY OF FORWARD AND BACKWARD LOCOMOTION

Anguilliform, or eel-like, swimmers possess the ability to reverse their caudally traveling undulations and swim tail first. Because fish have repeatedly evolved the anguilliform bauplan, we predicted that the details of this swimming behavior would vary with phylogeny. Using high speed video (500 frames/s), we captured sequences of both forward and backward volitional swimming in three divergent taxa: the sea lamprey, *Petromyzon marinus* (Petromyzontiformes), the American eel, *Anguilla rostrata* (Anguilliformes), and the Indo-Pacific engineerfish, *Pholidichthys leucotaenia* (Perciformes). Kinematic variables examined were head and tailtip amplitude, tailbeat frequency, axial curvature, and the length and position of the propulsive half-waves, as well as relative power and efficiency. While all species exhibited lower swimming efficiencies, increased curvature and a restriction of tailtip amplitudes during backward swimming, interspecific and inter-directional variations in the axial undulatory wave were apparent, including changes in the headtip amplitude and the number of propulsive half-waves present. In particular, the engineerfish exhibits unique motions that may relate to its benthic, burrowing ecology.

Smith, Graeme and Judith Weis, Rutgers University, Newark, NJ
PREDATOR-PREY RELATIONSHIPS IN MUMMICHOGS (FUNDULUS HETEROCLITUS) : EFFECTS OF LIVING IN A POLLUTED ENVIRONMENT.

Analysis of *prey* capture ability of mummichogs from a mercury-polluted tidal Creek compared with conspecifics from an uncontaminated environment showed that the latter captured the prey organism *Palaemonetes pugio* at a significantly faster rate and had significantly lower levels of mercury in their brain tissues. Exposure of uncontaminated fish to conditions similar to those of the polluted Creek caused both a reduction in their prey capture rate and an increase in brain mercury to levels similar to those of fish native to the creek. Polluted fish maintained in the laboratory for extended periods failed to show either an increase in prey capture rata or a decrease in their levels of brain mercury. Sire-selective predation on grass shrimp was observed among mummichogs from both sites, but did not appear to vary between sites. Videotape analysis of predatory behavior showed that fish from the polluted creek made significantly fewer attempts to capture prey. Fish from the polluted environment suffered significantly greater mortality in the presence of a predator, the

Steidl, Jill, Marine Science Dept., University of Connecticut, Groton, CT.
Is Retention of Connecticut River Nitrogen within the Eastern Basin of Long Island Sound Indicated by Spatial and Temporal Chla Distributions?

Spatial and temporal distribution of chla during low flow (August) and high flow (March) were examined for evidence that Connecticut River nitrogen was being retained within the eastern basin of Long Island Sound. The range of concentrations was similar, 0.82-10.65 μg/1 and 0.28-9.04 μg/1 respectively, for low and high flow. The size fraction <10μm was 60-95% of total chla in August, and only 15-20% of total chia in March. There was a general increase in chla with time and distance from the river during the March high flow period, and evidence for potential stimulation of phytoplankton standing stock by riverine nitrogen. Chla accumulated in the lower water column, in March, in a water parcel tracked over four days, which indicated retention of riverine nitrogen in particulate form. The opposite trend occurred during the August, low flow period. Chla generally decreased, with no apparent accumulation in the lower water column. Pigment flux from the surface layer was calculated from chla in the water column and that collected in sediment traps deployed on drifters 7m below the surface. They indicated that 70-100% of total pigment biomass was removed from the surface layer daily in August. Flux values for March have not been calculated yet, but indications from standing stock are that they will be equally high. Given the high daily flux during August, the lack of accumulation of chla in the lower water column may be related to higher temperatures, hence higher metabolism of sinking material.

Daniel Steinitz, Vassar College, Samantha Boswell, Juniata College, and Marshall Pregnall, Vassar College
NUTRIENT LOAD ANALYSIS FOR JUNE 1995 OF AMMONIUM, PHOSPHATE AND NITRATE ALONG THE CASPERKILL, DUTCHESS COUNTY, NEW YORK

The Casperkill is a small tributary of the Hudson River which runs through Dutchess County, New York. In this study the nutrient loads of ammonium, phosphate and nitrate in the stream were determined at twenty sites along the length of the stream. At each site dissolved oxygen, temperature, pH, and stream discharge were measured and water samples were taken for nutrient analysis. Maximum nutrient concentrations were observed in the upper 5 km of the stream. A decrease from the maximum ammonium concentration coincided with an increase to the maximum nitrate concentration, suggesting that nitrification by bacteria is possibly occurring in the stream. A decrease in nitrate and total nitrogen were observed at each impoundment along the stream such as Sunset Lake, Swan Lake and Cobalt Lake. Nitrogen to phosphate ratios were examined in an attempt to determine whether plants growing in the stream are nitrogen or phosphate limited. Stream pH varied from 6.13 to 7.75, perhaps due to the effects of the substratum of the stream or acidic rainfall. It is possible that pH affects the dissolved phosphates in the stream. More research must be done to determine the limiting nutrient to the biota in the stream.

Strayer, D., N. Caraco, J. Cole, S. Findlay, and M. Pace, Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545
THE ZEBRA MUSSEL INVASION OF THE FRESHWATER, TIDAL HUDSON RIVER AND ITS ECOLOGICAL EFFECTS.

Zebra mussels first appeared in the Hudson River in May, 1991, and spread rapidly through the freshwater, tidal section of the river. By the end of 1992, the biomass of the zebra mussel population (22 g shell-free DM m^{-2}) exceeded the combined biomass of all other consumers in the river, and its filtration rate (6 m d"') was more than 25 times higher than the filtration rates of all filter-feeders in the pre-invasion river. Densities of phytoplankton and microzooplankton fell quickly to 10-20% of their pre-invasion levels, and have remained low. In contrast, water clarity has increased only modestly, and macrozooplankton populations have been stable. Populations of native unionid clams have been declining, even though only ca. 25% of the unionids have been infested by zebra mussels. Other macroinvertebrates living on soft substrata appear to be unaffected by the zebra mussel invasion. Probably as a consequence of the reduced phytoplankton densities, zebra mussel recruitment and growth have been highly irregular (interannual variation of 10,000X and 4X, respectively). We suggest that the trajectory of the zebra mussel population, and those of any components under its control (e.g., phytoplankton), may be erratic in the future.

Swaney, D,P., R.W. Howarth, T.J. Butler, and N. Jaworski, Section of Ecology and Systematics, Cornell University, Ithaca, NY 14853

NUTRIENT DYNAMICS AND METABOLISM OF THE HUDSON RIVER.

We review some of our ongoing work in estimating nutrient loads to the Hudson, as well as estimating ecosystem metabolism within the river. Allocthonous inputs from nonpoint sources on land represent about 60% of the organic carbon budget of the freshwater Hudson. Before the arrival of the zebra mussel, phytoplankton GPP represented another 28%. We are currently working on extending this analysis to the entire mesohaline reach of the River.

Templer, Pamela, Stuart Findlay, and Cathleen Wigand, Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545

SEDIMENT CHEMISTRY ASSOCIATED WITH NATIVE AND NON-NATIVE EMERGENT MACROPHYTES OF THE HUDSON RIVER MARSH ECOSYSTEM

Wetland vegetation can influence nutrient cycling through several processes including direct assimilation into plant tissues and indirect effects on sediment hydrology or oxygenation. In tidal freshwater marshes of the Hudson River, Typha angustifolia represents the baseline condition while coverage by Lythrum salicaria and Phragmites australis have increased greatly over the past twenty years. Prior to any attempts at restoration of historical coverage, we wanted to describe the current relationship between these plants and sediment nutrient pools. Extant pools (n=3) of L. angustifolia, L salicaria and L australis were sampled with porewater equilibrators in spring and summer of 1995 to measure porewater ammonium, nitrate, and phosphate. Porewater pools of phosphate were significantly lower ($p<0.05$) in stands of L. salicaria with concentrations only half those in stands of P. australis and T. angustifolia. Nitrate was undectable in sediments associated with all three plant communities and there was depletion of porewater ammonium. Porewater ammonium at the time of peak plant standing crop was highest in P. australis beds (0.88 +/- 0 .19 mg/L) and lowest in stands of L. salicaria (0.15 +/- 0.02). Marsh management practices intended to shift the relative vegetation coverage towards native species should consider the subtle but ecologically significant effects on nutrient cycling.

von Stackelberg, Katherine and Menzie, Charles, Menzie-Cura & Associates, Inc. 1 Courthouse Lane, Suite 2, Chelmsford, MA, 01824

DEVELOPMENT OF A PROBABILISTIC PCB-BIOACCUMULATION MODEL FOR SIX FISH SPECIES IN THE HUDSON RIVER

In 1984 the U.S. Environmental Protection Agency (USEPA) completed a Feasibility Study on the Hudson River that investigated remedial alternatives and issued a Record of Decision (ROD) later that year. in December 1989 USEPA decided to reassess the No Action decision for Hudson River sediments. This reassessment consists of three phases: interim Characterization and Evaluation (Phase 1); Further Site Characterization and Analysis (Phase 2); and, Feasibility Study (Phase 3). A Phase I report was completed in August, 1991. The team then completed a Final Work Plan for Phase 2 in September 1992. This work plan identified various PCB fate and transport modeling activities to support the Hudson River PCB Reassessment Remedial Investigation and Feasibility Study (RI/FS). This talk provides a description of the development of a probabilistic bioaccumulation models to describe the uptake of PCBs on a congener-specific basis in six fish species.

We have developed a framework for relating body burdens of PCBs in fish to exposure concentrations in Hudson River water and sediments. This framework is used to understand historical and current relationships as well as to predict fish body burdens for future conditions under specific remediation and no action scenarios. The framework incorporates a probabilistic approach to predict distributions in PCB body burdens for selected fish species. These models can predict single population statistics such as the average expected values of PCBs under specific scenarios as well as the distribution of expected concentrations. The probabilistic models have been developed for two reasons: 1) they provide information on the fractions of the fish populations that are at or above particular PCB levels; and 2) they provide a framework for constructing biologically-based food chain relationships that explicitly incorporate variability and uncertainty inherent in the underlying data.

Melissa J. Weaver and Linda A. Deegan, The Ecosystems Center, Marine Biological Laboratory, Woods Hole MA

RECENT CHANGES IN THE FISH COMMUNITIES OF WAQUOIT BAY AND BUTTERMILK BAY

Recent changes in the abundance and quality of the submerged rooted vegetation beds and in the fish community of Waquoit Bay (Vineyard Sound) and Buttermilk Bay (Buzzards Bay) indicate further habitat degradation, probably due to continued nutrient-loading. Loss of eelgrass beds and a decrease in the density of the remaining patches of eelgrass are evident in both bays. The status of the estuarine fish community, as reflected in the Estuarine Biotic Integrity Index, indicates a decline in estuarine dependent fishes, especially in Waquoit Bay. The Estuarine Biotic Integrity Index (EBI) is a measure of estuarine ecosystem condition that is based on the species and trophic composition of the fish community of submerged rooted vegetation beds. Higher trophic levels, which in aquatic systems are often fishes, require a broad diversity of intact ecosystem functions and processes to feed, survive, grow, and reproduce. The EBI consists of eight metrics that include both functional groups and specific species as indicators of estuarine status and is strongly correlated with anthropogenic stress. Thus, the EBI evaluates the integrated functioning of estuaries and their watersheds. Loss of eelgrass habitat and a reduction of habitat quality due to anthropogenic stress lead to a loss of fish community integrity as measured by the EBI.

Improvements in Water Quality of the Delaware River and Resurgence of Fish Populations: Distinguishing In-River Effects from Coast-Wide Factors

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Water quality in the tidal Delaware River has improved dramatically over the last several decades. Areas near Philadelphia that were once anoxic and formed a pollution block to migratory fish passage, now rarely experience dissolved oxygen concentrations less than 3 ppm. To assess whether these improvements in water quality led to increased abundance of juvenile fishes, data from a beach seine survey conducted annually since 1980 were examined. The number of species captured increased throughout the tidal river, but the increase was greatest in the areas downstream of Philadelphia, where water quality has improved the most. Abundance of juvenile striped bass and American shad, two important game species in the river whose migratory patterns make them susceptible to water quality problems, both increased more than 1000-fold during the last decade. Correlations between the temporal abundance patterns of these species in the tidal Delaware River and in other East Coast systems were poor, suggesting that increases in their numbers were related more closely to improving conditions within the Delaware than to factors affecting coastal stocks.

Wigand, Cathy, Stuart E.G. Findlay,[2]Chuck Nieder, Pam Templer, and David Fischer, Institute of . Ecosystem Studies, Box AB, Millbrook, NY 12545; [2]HRNERR, Annandale-on-Hudson, NY 12504
SUBMERSED PLANT EFFECTS ON SEDIMENT BIOGEOCHEMISTRY IN THE TIDAL FRESHWATER HUDSON RIVER ESTUARY.

Aquatic grassbeds are known to provide habitat for fish and waterfowl, and are important in ecosystem nutrient cycling. Although much is known about light requirements of submersed macrophytes, little is known about sediment characteristics that promote submersed macrophytes although such knowledge is critical to any efforts to restore beds of SAV or prevent habitat degradation. We have measured plant biomass and species composition along with redox potential, % organics, porewater nutrients (N and P), solid-phase P and metals in Hudson River grassbeds. *V. americana* beds are dominant in the Hudson and had significantly higher ($p < 0.001$) porewater P in the summer than in spring 1995. Tissue (above- and below-ground) analyses for field-collected and lab-grown *V. americana* suggest N-deficiency or luxuriant P-uptake. In a lab experiment, vegetated treatments had significantly lower ($p < 0.001$) porewater P pools compared with controls. In addition, the calculated turnover rates of porewater P was on the order of days in the vegetated treatments which is similar to P turnover rates estimated from our field data in *Vallisneria* beds. Based on our field measurements and laboratory results, we propose that SAV in the Hudson promotes particulate deposition resulting in higher porewater nutrient levels which mask the effect of root nutrient uptake. These plant effects are significant in sediment P dynamics in the Hudson River.

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Behavior of larval mummichogs *(Fundulus heteroclitus)* from a polluted vs cleaner habitat

Eggs and sperm were collected from mummichogs from a polluted site (Piles Creek-PC, NJ), from which adults show poor prey capture and predator avoidance, and a cleaner site (Tuckerton-TK, NJ), and fertilized eggs raised in the laboratory. Larvae were tested regularly for spontaneous activity, swimming performance, prey capture ability and predator avoidance behavior. Both swimming performance and prey capture improved with larval age. Though spontaneous activity was not correlated with larval age, both TK and PC larvae exhibited the same pattern of activity as they grew. PC larvae were consistently more active but poorer in swimming performance than TK larvae. Younger larvae from PC showed significantly higher prey capture rate and were less vulnerable to predation than TK larvae. However, older TK larvae (1-month old) showed better ability to avoid predation than PC larvae, and by 2wk, they were capturing prey as well as the PC larvae. But both younger and older PC larvae demonstrated more miscues than larvae from T K. Since the larvae were raised in clean water, it is likely that both the polluted environment in PC and inherent factors have something to do with the PC larval behaviors.