



ABSTRACTS • Estuaries: Bridges from Watersheds to Coastal Seas

ESTUARINE RESEARCH FEDERATION
13TH BIENNIAL INTERNATIONAL CONFERENCE

November 12-16, 1995 • Marriott Bayfront Hotel • Corpus Christi, Texas

Estuaries: Bridges from Watersheds to Coastal Seas

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30.2 1 O C S

Abal, E.G., Dennison, W.C., Department of Botany, The University of Queensland, Australia. **SEAGRASS DEPTH RANGE AND WATER QUALITY IN AUSTRALIAN COASTAL WATERS.**

The widespread distribution, ecological importance and sensitivity of seagrasses to water quality parameters have led to the use of seagrass habitat requirements to characterise water quality. The habitat requirement approach used in Chesapeake Bay established the minimal water quality levels necessary for seagrass survival. In Australian coastal waters, we have attempted to correlate seagrass depth range, in addition to seagrass survival, with water quality. A year-long water quality monitoring program in Southern Moreton Bay, Queensland, Australia was coupled with a series of seagrass depth transects. Seagrass depth range had high correlations ($r^2 > 0.8$) with light attenuation coefficient, total suspended solids, chlorophyll *a*, total Kjeldahl nitrogen, but had low correlations ($r^2 < 0.8$) with dissolved inorganic nutrients. Comparing seagrass habitat requirements in Chesapeake Bay with Australian coastal waters, light attenuation coefficient ($0.9\text{-}1.5\text{ m}^{-1}$) and total suspended solids ($10\text{-}15\text{ mg l}^{-1}$) were similar, but chlorophyll *a* and dissolved inorganic nutrients were different due to lower residual levels of dissolved nutrients in Australian coastal waters. By monitoring changes in seagrass depth range over six months to three years, ongoing water quality trends in Moreton Bay were detected. Seagrass depth penetration, thus appears to be a sensitive indicator of some water quality parameters, and hence has application for water quality management.

12.4 1 O C

Adams, J.S., Conrad Blucher Institute for Surveying and Science, Texas A&M University - Corpus Christi, TX, and Patel, B., City of Corpus Christi Wastewater Division, Corpus Christi, TX. **OSO BAY DISSOLVED OXYGEN MONITORING PROJECT.**

This project was implemented to monitor dissolved oxygen (DO) levels in Oso Bay, Nueces County, Texas. At issue is the quality of water (DO levels) in the Blind Oso segment of Oso Bay in response to inflows of effluent from the Oso Wastewater Treatment Plant. A minimum of 5 mg l^{-1} DO in discharged effluent water is required to comply with operating permits issued by The Texas Natural Resource Conservation Commission. Owned by the City of Corpus Christi, the treatment plant discharges up to 14 million gallons per day into the Blind Oso. Three data collection platforms were established at locations within the bay near the outfall point. Hourly averages of DO concentration and % saturation, conductivity/salinity, and water temperature were collected for 25 months, via radio telemetry.

2.4 6 O C S

Aiosa, J.D., Blum, L.K., Laboratory of Microbial Ecology, Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia. **SUSCEPTIBILITY OF SALT MARSH SEDIMENT DOC TO MICROBIAL METABOLISM IN FOUR VEGETATION ZONES.**

Microbial metabolism of dissolved organic carbon (DOC) from salt marsh sediments was measured in 4 plant zones (tall-form *Spartina alterniflora* - TS, short-form *Spartina alterniflora* - SS, *Juncus roemerianus* - J, and *Spartina patens* - P). Suction lysimeters placed at 15 cm depth were used to sample sediment pore water between August 1994 and June 1995. Sediment pore water concentrations of DOC, NH_4^+ , PO_4^- , and sulfide were measured. Filter-sterilized pore water ($0.2\text{ }\mu\text{m}$) was inoculated with the microbial community from an adjacent tidal creek and incubated in the dark for 12 to 24 h under aerobic conditions. Metabolism of DOC was measured as the difference between initial and final concentrations of DOC, change in abundance of bacteria, and CO_2 production. DOC concentrations were higher in the SS and P zones (27.4 ± 8.12 and $34.5 \pm 12.87\text{ mg C L}^{-1}$, respectively) than the TS and J zones (17.2 ± 12.8 and $23.5 \pm 3.96\text{ mg C L}^{-1}$, respectively). Bacterial growth rate constants (0.1136 ± 0.011 , 0.1129 ± 0.013 , 0.0960 ± 0.012 , and $0.0917 \pm 0.009\text{ d}^{-1}$, SS, TS, J, and P, respectively) and CO_2 evolution was highest in the SS and TS zones, where flooding is most frequent (43.24 , 28.02 ± 0.80 , 27.89 ± 3.82 , and $23.09 \pm 3.27\text{ ppm C}$ in SS, TS, P, and J, respectively). However, preliminary results of microbial metabolism of DOC from experimentally flooded plots of *J. roemerianus* and *S. patens* show lower growth rate constants in flooded (0.0642 and 0.0671 d^{-1} , J and P, respectively) than nonflooded control (0.0954 and 0.0838 d^{-1} , J and P, respectively) sites. These results indicate a probable plant effect on DOC availability to a microbial community. The effects of flooding on DOC availability remain uncertain.

11.2 3 O C

Alber, M.¹, Alexander, C.², and Hodson, R.¹, ¹University of Georgia, Athens, GA, and ²Skidaway Institute of Oceanography, Savannah, GA. **PARTICLE-MEDIATED CARBON DYNAMICS IN A SOUTHEASTERN ESTUARY.**

Particle dynamics were investigated during a 13-hour anchor station in the Satilla River Estuary in April 1995 as part of the Georgia Rivers LMER project. Although surface waters remained moderately low in suspended sediment throughout the tidal cycle (averaging 76 mg l^{-1}), bottom waters fluctuated between low (121 mg l^{-1}) and extremely high ($16,630\text{ mg l}^{-1}$) sediment loads. Particles were generally high in organic content (mean = 20%), with an average

C:N ratio of 11. Bacterial production (estimated as nmol leucine incorporated $1^{-1}d^{-1}$) was measured hourly in samples from both surface and bottom water. Leucine incorporation averaged 4.3 nmol leu $1^{-1}d^{-1}$ in surface water and 16.2 nmol leu $1^{-1}d^{-1}$ in bottom water. We deployed a horizontal settling tube to partition bottom water into samples containing particles with different settling velocities. Our results indicate that up to 79% of the bacterial production in the bottom water was associated with particles that can settle. Moreover, there was a significant correlation between suspended sediment and bacterial production in samples from the settling tube. These data suggest that particles in bottom water are potentially important mediators of organic carbon flow in estuaries.

1.2 4 O C

Alberte, R.S., Office of Naval Research, Arlington, VA, and Zimmerman, R.C., Biology Dept., UCLA, Los Angeles, CA, and Procaccini, G., Stazione Zoologica, Naples, Italy. **GENETIC DIVERSITY OF EELGRASS POPULATIONS IN THE WESTERN U.S.: INDICATOR OF ECOLOGICAL STABILITY.**

The genetic diversity of 8 geographically disjunct populations of the temperate seagrass, *Zostera marina* L., distributed from San Diego, CA to Alaska was examined using mini-satellite DNA fingerprinting technologies to determine whether populations were clonal, to assess the role of sexual reproduction in population expansion, to examine gene flow between populations, and to ascertain whether historical habitat disturbance has had significant impact on genetic structure. It was found that all 8 populations possessed genetic similarity values less than 0.70 indicating that none of the populations were clonal. Furthermore, estimation of the F' statistic revealed that all population had restricted gene flow between them indicating that they were reproductively isolated from each other even when comparing populations that were only 30km apart in Monterey Bay. All intertidal populations from pristine, undisturbed habitats had much greater genetic diversity than those from disturbed habitats irrespective of their longitudinal distribution. The findings indicate that habitat deterioration due to increased water column turbidity arising from dredging, erosion or eutrophication may result in the loss of less fit genotypes yielding populations with low genetic diversity and perhaps reduced resilience to environmental change

9.2 1 O C

Alberts, J.J., University of Georgia Marine Institute, Sapelo Island, GA, and Miano, T.M., Università Degli Studi - Bari, Istituto di Chimica Agraria, Bari, Italy. **SYNCHRONOUS AND 3 DIMENSIONAL FLUORESCENCE SPECTRA OF NATURAL RIVERINE ORGANIC MATTER AND THE EFFECT OF PHOTO-OXIDATION ON THESE MIXTURES.**

Naturally occurring organic matter from filtered whole water samples and their molecular size fractions, as determined by ultrafiltration, were collected from rivers of south-

eastern Georgia, USA. Standard excitation and emission spectra of the materials indicate broad peaks, with little definition and characteristic maximum intensities at approximately 350-380 nm and 450-465 nm, respectively. Analyses of the 3-dimensional fluorescence spectra of these materials show a definite bi-modal distribution of fluorophores with higher apparent conjugation occurring in larger size material. Synchronous scan spectra of these same mixtures indicate at least four or five fluorophore groups are present in all samples. Photo-oxidation of both whole waters and the size fractions produce a reduction in fluorescence intensity. However, organic matter of larger apparent molecular size tend to lose fluorescence intensity more rapidly than the chromophores of the smaller size fractions. These trends are consistent over the five rivers studies.

22.1 2 O I

Alexander, C., Ertel, J., Lee, R., Loganathan, R., Smith, B., Windom, H., Skidaway Institute of Oceanography, Savannah, GA. **POLLUTION HISTORY OF THE SAVANNAH RIVER ESTUARY.**

Through the NOAA National Status and Trends Program, 13 cores were collected from the Savannah River Estuary for the production of historical pollutant profiles. These cores, representing intertidal salt marsh, subtidal channel and abandoned boat-slip environments, were dated using Pb-210 geochronologies and analyzed for trace metals, pesticides, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and butyltins. Four contaminant-time patterns were identified. For Ag, Cd, and Zn, profiles show an increase in concentration up to the present time, indicating an increasing loading from non-point-source pollution. Cr and DDT isomers exhibit distributions characterized by maxima that get progressively shallower (and younger) down-estuary, representing redistribution of contaminated material. In one core, Hg exhibits a sharp subsurface maxima, indicating a localized anthropogenic input that has since been controlled. Pb, PCBs and PAHs exhibit subsurface maxima representing peak inputs prior to the institution of environmental regulatory controls. In comparison to densely populated and industrialized regions, the concentrations of most anthropogenic chemicals found in cores from the Savannah Estuary are low. Decreasing concentrations over the past few decades suggest that pollution control regulations have been effective, even while industrial and population growth has occurred. However, levels of inorganic pollutants are approximately twice what they were in the previous century.

13 13 P-2 C

Allen, D.M., Allen, W.B., Kenny, P.D., Ogburn-Matthews, V., Schubauer-Berigan, J., Spruck, C., University of South Carolina, Baruch Marine Laboratory, Georgetown, SC. **INTEGRATION OF MONITORING, RESEARCH, EDUCATION, AND COASTAL ZONE MANAGEMENT AT THE NORTH INLET-WINYAH BAY NATIONAL ESTUARINE RESEARCH RESERVE, SC.**

In 1992, the North Inlet-Winyah Bay National Estuarine Research Reserve (NI-WB NERR) was established as one

of the 22 sites comprising a national network of estuarine reserves. They represent a diverse array of estuarine ecosystem types. Monitoring key environmental variables, generating scientific information useful to coastal zone management, and providing educational products and opportunities for local communities are primary activities at each Reserve. With joint support from NOAA and the University of South Carolina, the NI-WB NERR makes regular measurements of more than 50 meteorological, hydrographic, water chemistry, and biological variables. Some time series have been continuous for more than 15 years. Studies of tidal and diel variability and the role of disturbances on ecosystem structure and function complement the baseline monitoring. Comparisons are being made between the undisturbed North Inlet and stressed Winyah Bay estuaries. Management oriented research in the Winyah Bay area includes the assessment of best management practices for non-point source pollution control in developed watersheds. From the monitoring and research efforts, educational programs have been developed to increase public awareness of problems and potential solutions. Excellent study sites, extant databases, space, and logistic support are available to investigators interested in collaborating on efforts which integrate coastal science, education, and management.

18.1 2 O C

Allen, D.M., Ogburn-Matthews, V., University of South Carolina, Baruch Marine Laboratory, Georgetown, SC. **STRUCTURE AND DYNAMICS OF PENAEID SHRIMP MIGRATIONS INTO INTERTIDAL HABITATS.**

Seine collections over an 11 year period have demonstrated that penaeid shrimps continuously recruit, grow rapidly, and depart from an intertidal salt marsh basin during a well defined period of occupation for each species. Block netting has demonstrated that shrimps of all sizes make tidal excursions onto the flooded marsh. The extent of tidal inundation only partially accounts for large variations in abundance, biomass, and length of penaeids from tide to tide. Replicated lift nets located along an elevational gradient have shown that significant differences in shrimp abundance and size occur among locations on the transect and among replicates at each depth. Variations in distributions among collections made on multiple dates with similar flooding regimes and physical conditions suggest that shrimp zonation and patchiness were influenced by the presence of other tidal migratory animals. Lift net collections during different tidal stages are revealing relationships among the structure and temporal dynamics of the tidal migrations of dominant shrimps and fishes. The data provide evidence for the partitioning of resources between species during their simultaneous occupation of the flooded habitat. Experiments currently underway are testing the hypothesis that changing biotic characteristics of the habitat influence distribution, growth, and survival of shrimps in the nursery area.

2.3 2 O C

Anderson, I.C., Tobias, C.R., and Berry, B.E., School of

Marine Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. **NITROGEN PROCESSING IN SALT MARSH SEDIMENTS: IMPLICATIONS FOR NET MARSH DIN FLUX.**

Net dissolved inorganic nitrogen (DIN) import/export in salt marsh ecosystems appears to vary with developmental age of the marsh. We have developed a mass balance model for an accretional *Spartina alterniflora* marsh located in the Virginia Coast Reserve. Tidal exchange data suggests that this marsh acts as a sink for water column DIN throughout the year. We have examined the role of sediment nitrogen cycling processes within the context of total marsh N flux. Seasonally, over an 18 month period remineralization, nitrification, and denitrification were measured in cores using ¹⁵N isotope pool dilution techniques. Nitrogen fixation was determined using the acetylene reduction method. Results indicate that mineralization was the dominant process generating 64 gN m⁻² y⁻¹. All other sources of N to the marsh including nitrogen fixation, wet atmospheric deposition, and input from tidal water supplied approximately 1 gNm⁻² y⁻¹. Macrophytes plus microalgae together accounted for an uptake rate of 55 gN m⁻² y⁻¹. Nitrification/denitrification and immobilization accounted for an additional loss of 5 gN m⁻² y⁻¹. This mass balance study suggests a tight coupling between DIN production and uptake within this salt marsh community.

33 38 P-1 C

Arnone, R.A., Boyd, J.D., Naval Research Laboratory, Stennis Space Center, MS, and **Linzell, R.,** Richards, J., Neptune Sciences, Inc, Slidell, LA. **RESPONSE OF REMOTELY SENSED TURBIDITY AND SST TO TIDAL FORCING IN ESTUARIES ALONG THE NORTHERN GULF OF MEXICO.**

Several simple tidal models have been coupled with AVHRR turbidity and sea surface temperature imagery for coastal areas in the Northern Gulf of Mexico. Real time remote sensing of estuarine discharge plumes can be defined by the beam attenuation coefficient (c660) and sea surface temperatures for several estuarine systems. These plumes are shown to respond to tidal forcing within the estuary. The spatial variability of the tidal forcing has significant influence on the observed patterns and frontal features observed in the imagery, and physical coastal processes from tides are important in interpreting the remote sensing imagery. A sequence of imagery and coincident tidal model runs has been constructed through the tidal cycle for several estuaries and illustrates variations in turbidity and SST distributions associated with the tidal phases. The software system provides an interactive method of integrating tidal models with real time 1 km Gulf of Mexico data bases currently being developed using AVHRR imagery. The Gulf of Mexico data base is currently available through the internet.

26.1 4 O C S

Ashley, J.T.F., Baker, J.E. Chesapeake Biological Laboratory, The Center for Environmental and Estuarine Studies.

The University of Maryland System, Solomons, MD. **DETERMINING AND MODELING HYDROPHOBIC ORGANIC CONTAMINANT SPECIATION IN MESOCOSMS.**

The bioavailability of hydrophobic organic contaminants (HOCs) in aqueous environments is largely controlled by their interaction with dissolved and particulate organic matter. The binding capacity provides a quantitative means of describing the extent of sequestration of a contaminant. This study was undertaken to evaluate HOC binding capacities within variously sized benthic- planktonic mesocosms during the development of planktonic communities. The ability of each mesocosm to sequester these organic contaminants was followed over time using a gas sparging reactor. Unfiltered water samples, collected from five mesocosms of varying surface area to volume ratios, were spiked with a cocktail containing 16 polychlorinated biphenyls ($\log K_{ow}$'s ranging from 4.55 to 7.65). After a short exposure time, samples were sparged with air. Particulate, dissolved ($2 \mu\text{m}$ non-filter retained) and vapor phase HOC concentrations were evaluated before and after sparging. Dissolved phase HOC concentrations were separated into colloiddally-bound and truly dissolved fractions knowing the vapor phase concentrations and Henry's Law constants. We incorporate the results of this HOC binding capacity study into a time-variable, scale-independent model of contaminant speciation in mesocosms.

21 6 P-3 C

Atila, N., Louisiana State University, Baton Rouge, LA, and Rabalais, N.N., Louisiana Universities Marine Consortium, Chauvin, LA. **BIOREMEDIATION FOR OIL SPILL CLEANUP IN COASTAL MARSHES: EFFECTS ON BENTHIC COMMUNITIES IN LABORATORY MESOCOSMS.**

Coastal wetlands in the Gulf of Mexico can be impacted by oil spills, from the oil or its removal. Bioremediation is a promising yet unproven technique for enhanced oil degradation in marshes. We determined the effects on benthos of two bioremediation treatments (bacterial seeding and fertilizer applications) on oiled and unoiled *Spartina alterniflora* greenhouse mesocosms. There was a mesocosm effect on the macroinfauna diversity over the 12-wk experiment but not abundance. There were no significant differences in abundance or species richness of macroinfauna among treatments or between oiled and unoiled plots. Harpacticoid copepod and copepod nauplius abundances were reduced during the 7-wk acclimation period, but densities of nematodes and oligochaetes were similar to field collections. Copepods and nauplii were reduced over the 12 wks; oligochaete numbers remained stable. There were fewer copepods, nauplii, and oligochaetes in oiled sediments, with the differences in the latter being significant. Nematode densities remained stable in the oiled sediments and declined through time in the unoiled sediments. There were no effects of the bioremediation treatments on the abundances of any of the meiofaunal groups. It appears that application of

bioremediation products in field experiments or actual spills in marshes is a reasonable next step.

16 26 P-1 C

Baker, A., Testrake, D., University of South Florida, Tampa, FL and Jewett-Smith, J., Texas A&M International University, Laredo, TX. **THE PATHOGENIC IMPLICATIONS OF AN ENDOPARASITE, *PLASMODIOPHORA DIPLANTHERAE*, ASSOCIATED WITH THE SEAGRASS *HALODULE WRIGHTII*.**

Plasmodiophora diplantherae infections of *Halodule wrightii* were characterized from 5 sites within Tampa Bay, Florida. The sites varied from 18 to 32 ppt salinity and had sediments with grain sizes that varied in sorting measure from 0.6 to 2.91. Percent cover of infection varied from 0.0085% to 0.56% of short shoots in separate homogeneous *H. wrightii* populations. Infection intensity also varied within populations where up to 3.2% infection cover was observed within randomly located 1 m² quadrats. Infection cover tended to increase as sediments were less sorted. The relationship between infection and sorting suggested that increasing water motion facilitated infection occurrence. At the microscopic level, mature spore masses were found within cortical tissues of the internode, short shoot and basal 0.5 cm of the blade. Spores were also seen in epidermal cells of internodal galls and near the junction of blade and short shoot. This evidence revealed that the parasite was more invasive to its host than previously described. Infected genets showed increased branching (540%), increased nodes (116%), decreased internode length (49%), decreased roots per node (12%) and decreased leaf area per node (63%). Thus the pathogen caused abnormal host development and decreased biomass.

-B-

4.2 4 O I

Baltz, D.M. 1,2, Fleegeer, J.W. 3, Rakocinski, C.1,4, McCall, J.N.3,5, Louisiana State University, 1Coastal Fisheries Institute and 2Department of Oceanography and Coastal Sciences, 3Department of Zoology and Physiology, Baton Rouge, LA, 4Present Address: Gulf Coast Research Laboratory, Ocean Springs, MS, 5Present Address: Department of Biology, University of West Alabama, Livingston, AL. **FOOD, GROWTH, AND MICROHABITAT SELECTION: FACTORS AFFECTING RECRUITMENT POTENTIAL OF JUVENILE SALT MARSH FISHES.**

Larval and post-larval fish distributions in Louisiana salt marshes along the marsh-edge ecotone were studied using a drop sampler to identify nursery microhabitats characteristics for two estuarine-dependent species, red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*). Nurseries were characterized at the microhabitat level by depth, salinity, temperature, dissolved oxygen, turbidity, substrate type, *Spartina* stem density, and distance from the marsh edge. Analysis of specimens also yielded information on daily growth rates and diets, which together with microhabitat data, were used in multiple regression models to evaluate the influence of food, microhabitat selection and species density on recruitment potential as estimated by recent daily growth. A model was selected for each species after preliminary all-possible-regressions procedures of food and microhabitat variables were run separately. For spotted seatrout, two subsets of nine microhabitat (including squared terms to account for non-linearity) and four food variables were combined with density and density² in a fifteen variable general linear model. This model (df = 15 & 88, F value = 3.88, P > F = 0.0001) explained 39.5 percent (R² = 0.395) of the variation in daily growth, but only four variables made significant (P < 0.0018) contributions including DO, DO², substrate, and substrate². A fifth variable, stem density², made a marginally significant (P < 0.051) contribution. For red drum, two subsets of five microhabitat and five food variables were combined with density and density² in a twelve variable general linear model (df = 12 & 84, F value = 3.75, P > F = 0.0002) that explained 40.0 percent (R² = 0.400) of the variation in daily growth. Only four variables, salinity², temperature, DO, and DO² were significant (P < 0.0003). For both species, relatively few microhabitat variables explained about 40% of recent daily growth, but significant contributions by diet and density variables were not detected.

16.1 3 O C

Barba-Macías, E., Sánchez, A.J., Raz-Guzmán, A., Laboratorio de Ecología del Bentos. Instituto de Ciencias del Mar y Limnología. UNAM. Apdo. Postal 70-305. Mexico,

D.F. 04510. **DISTRIBUTION PATTERNS OF CARIDEANS IN LAGUNA MADRE AND LAGUNA DE TERMINOS IN THE SOUTHWESTERN GULF OF MEXICO.**

The distribution patterns of fourteen species of carideans of Laguna Madre (LM) and Laguna de Términos (LT) were compared. *Hippolyte zostericola* was dominant in both systems, whereas *Tozeuma carolinense* and *Palaemonetes pugio* were dominant in LM. Species with an ample distribution associated with the habitat (AAH) were *H. zostericola* in both systems, *T. carolinense* and *P. pugio* in LM and *Periclimenes longicaudatus* and *Palaemonetes vulgaris* in LT. Species with an ample distribution not associated with the habitat (ANAH) were *Palaemonetes intermedius* in both systems, *P. vulgaris* in LM and *P. pugio* in LT. Species with a restricted distribution associated with the habitat (RAH) were *Latreutes fucorum* in both systems and *T. carolinense*, *Periclimenes americanus*, *Latreutes parvulus* and *Thor dobkini* in LT. Species with a restricted distribution not associated with the habitat (RNAR) were *Alpheus heterochelis*, *Alpheus floridanus* and *Ambydexter symmetricus* in LM and *Alpheus* sp in LT. The four distribution patterns were based on the spatial and temporal variation in salinity and the preference of the species for vegetated habitats. Although 44% of the carideans were associated with submerged aquatic vegetation (SAV) in LM and 73% in LT, salinity was the environmental factor that most modified the structure of the caridean community.

22.1 3 O I

Baskaran, M., Asbill, S., Santchi, P.H., Texas A & M University at Galveston, Department of Oceanography, Galveston, TX. **210Pb AND 239,240Pu-BASED CHRONOLOGY OF SEDIMENTS FROM MISSISSIPPI DELTA AND GALVESTON BAY.**

Historical reconstruction of organic and inorganic pollutants requires precise chronology of sediments. Several studies on the historical reconstruction of pollutants in the United States and abroad in marine and freshwater environments have been carried out previously. However, obtaining reliable sediment cores in the estuarine zones for this kind of study is not an easy task. In order to establish the sediment chronology for the past 100 years, using ²¹⁰Pb and ^{239,240}Pu dating techniques, one core from the Mississippi delta and several sediment cores from Galveston Bay were collected. The excess ²¹⁰Pb (²¹⁰Pb_{xs}) profile in the sediment core from the Mississippi delta shows an exponential decrease with depth. There appears to be little sediment mixing in this sediment core. The ^{239,240}Pu and ²¹⁰Pb_{xs}-derived sedimentation rates are the same, i.e., ~0.8 cm/yr. The inventories of ²¹⁰Pb

and $^{239,240}\text{Pu}$ in the Mississippi delta core are about 3 times higher than expected from their direct fallout to the study area. The likely causes for these enhanced inventories are lateral input from the open ocean waters in addition to the inputs from the Mississippi river. In the Galveston Bay system, on the other hand, the $^{210}\text{Pu}_{\text{xs}}$ profiles do not show exponential decrease with depth. It appears that most sedimentary regimes are disturbed. The inventory of $^{210}\text{Pu}_{\text{xs}}$ in the sediment cores from Galveston Bay is comparable to the direct atmospheric fallout, indicating that the riverine inputs are insignificant.

30.2 5 O C

Batiuk, R., U.S. Environmental Protection Agency Chesapeake Bay Program Office, Annapolis, MD. **STATE OF THE SCIENCE SUPPORTING ADOPTION OF SEAGRASS BASED WATER QUALITY STANDARDS.**

Over the past decade, there has been significant progress made both towards understanding the water quality requirements of seagrasses as well as incorporation of seagrass restoration-based requirements directly in estuarine and coastal watershed management decision making. The scientific and management communities have been narrowing the gap between scientific understanding of seagrass requirements and the management tools and programs which can effectively utilize this accumulated knowledge. The state of the science supporting quantification of seagrass water quality requirements has not fully reached the scientific (and policy) thresholds necessary to be reached before seagrass-based light and nutrient water quality standards can be widely established and adopted. Examples drawn from existing estuarine restoration and protection programs (i.e., Chesapeake Bay, Tampa Bay) as well national efforts directed toward nutrient criteria derivation (U.S. EPA Office of Water) illustrate where progress has been made. A course of action for addressing remaining scientific needs and further developing the management programs and tools necessary to result in adoption of water quality standards protective of seagrass communities has resulted from these critical comparisons.

1.1 4 O C

Bell, S.S., University of South Florida, Department of Biology, Tampa, FL 33620-5150. **LANDSCAPE ANALYSES OF SEAGRASS BEDS IN TAMPA BAY, FL: DECIPHERING LINKAGES OF FISH AND SEAGRASS.**

In order to predict the implications of habitat degradation on marine fauna, sufficient information on the relationship between quantitative measures of habitat and fauna must be available. We investigated the relationship between epibenthic and benthic feeding fish and landscape attributes of 24 seagrass beds in Tampa Bay Florida from May 1994-95. No significant relationships between fish and seagrass biomass, shoot density, or canopy or seagrass bed size were detected. However when abundance of fish trophic group and seagrass vegetation were compared among seagrass bed categories created by spatial aggregation (shoal, continuous or isolated) differences were detected. Shoal beds had the

lowest seagrass shoot densities, the greatest canopy height and the highest number of epibenthic feeding fish. Continuous beds had more benthic feeding fish. Isolated beds represented combined attributes of both continuous and shoal beds. Thus by hierarchically combining beds into larger spatial units, landscape analyses provided evidence that processes extending beyond the dimensions of a seagrass patch may influence plant and animal communities.

19.1 6 O I

Benner, R., University of Texas, Marine Science Institute, Port Aransas, TX. **CONCENTRATION AND COMPOSITION OF DOM IN THE MISSISSIPPI RIVER PLUME.**

Seasonal and spatial changes in the concentration and composition of DOM were monitored in water from the Mississippi River and across the salinity gradient to the open Gulf of Mexico. During the spring and summer, elevated concentrations of DOC were observed at intermediate salinities indicating algae were a source of DOC in these seasons. Tangential-flow ultrafiltration (>1 kDa) was used to isolate DOM for detailed chemical characterization. Atomic C/N values of ultrafiltered DOM (UDOM) ranged from 26 in the river to 14 in the open Gulf. Lignin-derived phenol concentrations decreased exponentially across the salinity gradient suggesting that flocculation and/or photo-oxidation were important processes influencing the fate of lignin in the river plume. Concentrations of neutral sugars across the salinity gradient revealed a very different pattern from that of lignin-derived phenols. Concentrations of neutral sugars in UDOM were similar in the river and the open Gulf, but they reached very high concentrations at intermediate salinities where algal blooms were present. The observed changes in chemical composition of UDOM across the salinity gradient are dramatic and indicate that phytoplankton are a major source of dissolved polysaccharides that are rapidly consumed in the plume region.

34 44 P-1 C

Bergstrom, P. W., U.S. Fish & Wildlife Service, Annapolis, MD. **ANOXIA, ALGAL BLOOMS, AND STRATIFICATION IN TWO SHALLOW TIDAL CREEKS OF THE MAGOTHY RIVER, CHESAPEAKE BAY.**

Water quality monitoring done in two shallow tidal creeks (depths 0.8 and 1.7 m at MLW) of the Magothy River, Chesapeake Bay, every one or two weeks since 1992 showed that hypoxia and anoxia in bottom samples occurred at both sites one or more times per summer. The shallowest site, Cattail Creek, which had more algal blooms and more stratification, had more frequent hypoxic and anoxic events. This site had up to 31% of June-September bottom samples below 2.0 mg/l dissolved oxygen and minima of 0-0.5 mg/l. The results show that hypoxia and anoxia can occur in creeks that appear to be too shallow to have these problems, and that bottom dissolved oxygen sampling should be included in water quality monitoring programs in shallow tidal creeks.

30.1 2 O C

Bergstrom, P.W., U.S. Fish & Wildlife Service, Annapolis, MD. **WATER QUALITY IN AREAS OF SUBMERGED AQUATIC VEGETATION (SAV) REGROWTH IN THE MAGOTHY RIVER, CHESAPEAKE BAY.**

Water quality was monitored at 15 shallow water sites in the mainstem of the Magothy River, a small tributary of Chesapeake Bay, to identify possible sites for SAV restoration. Sites were sampled monthly, April through October, 1993-1994, for four of the five water quality habitat requirements for SAV growth in Chesapeake Bay. These include Secchi depth (water clarity), chlorophyll a, dissolved inorganic nitrogen (DIN), and dissolved inorganic phosphorus (DIP). The results suggest that high nitrogen levels may be limiting SAV growth in the Magothy River. DIN seasonal medians did not meet the SAV habitat requirement in both years in upper and lower reaches of the river, where there are few SAV, but met the DIN requirement in mid-river areas where SAV regrowth is occurring. Phosphorus does not seem to be a problem for SAV in the Magothy. The results for Secchi depth and chlorophyll a were less clear-cut, however. The habitat requirements for both parameters were met at all but the most upriver sites in 1993, but these two requirements were met at only a few sites in 1994. There were higher chlorophyll a levels and lower Secchi depths in 1994 compared to 1993, possibly due to higher rainfall in 1994. Possible sites for SAV restoration will be identified, and preliminary results for 1995 will be presented.

37 38 P-2 C

Bernal, D., Universidad Autonoma de Baja California, Ensenada, Baja California, Mexico, and Whitlege, T., University of Texas, Marine Science Institute, Port Aransas, TX. **A STUDY OF NUTRIENT UPTAKE BY THE TEXAS BROWN TIDE USING IN SITU MESOCOSMS.**

A monospecific microalgal bloom referred to as "Texas Brown Tide" has been present in Laguna Madre for nearly five years causing ecological changes in this hypersaline coastal lagoon system. Experiments using small mesocosms (approx. 1300 L.) were conducted in a pond where the presence of brown tide was highly visible and the temperatures ranged from 30-33°C and salinities between 40-47 ppt. Additions of 80, 40, 20 and 10 μM NH_4 to the mesocosm showed the rapid (<24 hrs.) Depletion of cells were monitored every 2 days in the 8 day time series. Initial chlorophyll levels per cell were between 0.2 - 0.025 micrograms, showing a trend to increase with the higher NH_4 concentrations in the different mesocosms. The changing concentrations of NO_2 , NO_3 , SiO_4 and PO_4 were recorded on 6 days of the experiment. The use of these mesocosms demonstrated to be an efficient way to stimulate the natural changes that occur between the sediment and the water column. The changes in nutrient and chlorophyll concentration within three control mesocosms, closely simulated the variations in the pond system. Additional lab and field experiments were conducted to obtain the variation of NH_4 uptake rates between day and night additions. Internal concentrations of NH_4 dur-

ing the night did not decrease as fast as those observed during the day, which led to a much slower depletion of the external supply of NH_4 .

23.2 1 O C

Berounsky, V.M.¹, Pregnall, A.M.², Donovan, T.², and Granger, S.L.¹, ¹Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, ²Biology Department., Vassar College, Poughkeepsie, NY. **WATER-COLUMN NITRIFICATION RATES IN NUTRIENT ENRICHED LAGOON MESOCOSMS WITH DIFFERENT N/P RATIOS.**

In the spring and summer of 1995, nitrification rates were measured in the water column of six lagoon mesocosms located at the University of Rhode Island. Half of the 2.3m X 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 between mesocosms and between treatments. Ammonium and nitrate levels increased by several fold in some of the incubation bottles during the 24 hour incubation. These results suggest that there may be a shift from water-column utilization of nitrogen to eelgrass utilization with continued nutrient enrichment.

2.3 1 O C S

Berry, B.E., Anderson, I.C., Wetzel, R.L., College of William and Mary, School of Marine Science, Virginia Institute of Marine Science, Gloucester Pt. VA. **EXCHANGES OF DIN AND DOC BETWEEN SALT MARSH SEDIMENTS AND OVERLYING TIDAL WATER.**

Salt marshes vary greatly in their abilities to serve as sources or sinks of dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON) and dissolved organic carbon (DOC) to overlying tidal water. In order to better understand the processes and conditions which regulate these exchanges we performed seasonal measurements of DIN and DOC exchanges between salt marsh sediments and tidal water using *in situ* chambers in a Virginia *Spartina alterniflora* marsh. In addition, we measured sediment and water column chlorophyll and DON in the chambers and DIN concentrations in the adjacent creek water over tidal cycles. Results indicate salt marsh sediments exported DOC in the summer and exhibited either no net exchange or slight uptake in the fall and winter. The salt marsh imported DIN from flooding tidal water during all seasons except late winter when no net exchange was measured. The adjacent tidal creek, however, generally exported DIN. We suggest that

direct ground water discharge into the creek provides the source of DIN to the ebbing tidal water. Our results suggest the relative importance of biotic processing and upland fluxes to the source or sink nature of this marsh.

20 1 P-3 C S

Bianchi, T.S., Argyrou, M., Lambert, C., Department of EEO Biology, Tulane University, New Orleans, LA, and Demetropoulos, A., Hadjichristophorou, M., Ministry of Agriculture, Natural Resources and Environment, Department of Fisheries, Nicosia, Cyprus, and Baskaran, M., Texas A&M University, Department of Marine Sciences, Galveston, TX. **PLANT PIGMENTS AS BIOMARKERS OF ORGANIC MATTER SOURCES IN SEDIMENTS AND COASTAL WATERS OF CYPRUS (EASTERN MEDITERRANEAN).**

Plant pigments (chlorophylls and carotenoids) and radionuclides (^{226}Ra and ^{210}Pb) were measured in the coastal waters and sediments off Cyprus (eastern Mediterranean), for the first time, in June and July 1993. Some of the lowest concentrations of chlorophyll *a* (10-95 ng/L) were found in these highly oligotrophic waters. Based on the presence of chlorophyll *b* and zeaxanthin, it appeared that chlorophytes, cyanobacteria, and prochlorophytes were the dominant phytoplankton classes. Despite increased inputs of nutrients along the developing coastline of Cyprus, phytoplankton assemblages were not very different from deeper regions of the eastern Mediterranean. However, there were significantly higher concentrations of pigments in sediments - principally due to seagrasses and macroalgae. In fact, the Red Sea migrant *Caulerpa racemosa* appears to be expanding its areal coverage along the coastline; it remains unclear whether this is related to enhanced nutrient inputs or inherent differences in the life-history characteristics of this migrant versus native species. Low sedimentation rates observed at all stations further suggested that inputs from the water column to the sediments were minimal. The phytoplankton biomass and composition of coastal waters off Cyprus appear to be very similar to that found in deep waters of the eastern Mediterranean.

2.2 3 O I

Bianchi, T.S., Argyrou, M., Tulane University, Department of EEO Biology, New Orleans, LA. **CARBON CYCLING IN TWO SHALLOW-TURBID ESTUARIES IN THE GULF OF MEXICO.**

The Sabine-Neches and Lake Pontchartrain estuaries are shallow-turbid estuarine systems located on the northern gulf coast. The Sabine-Neches estuary (Texas coast) was characterized as having higher concentrations of dissolved organic carbon (DOC) (10-73 mg L⁻¹) and total suspended particulates (TSP) (12-74 mg L⁻¹) than the Lake Pontchartrain estuary (Louisiana coast), 5 to 8 mg L⁻¹ and 10 to 28 mg L⁻¹, respectively. Chlorophyll *a* concentrations for both estuarine systems were low (0.5 - 8.0 gg L⁻¹) in comparison to other shallow estuaries receiving high freshwater inputs. Concentrations of fucoxanthin and zeaxanthin in particulate organic carbon (POC) indicated that diatoms and cyanobacteria

were the dominant classes of phytoplankton in both estuaries. When TSP concentrations were < 10 mg L⁻¹ there were significant increases in the percentage of POC and PON in TSP. Based on lignin-phenol analyses of sediments and high molecular weight DOC (FIMW DOC), there were significant inputs of terrestrially-derived organic matter to these estuaries. These estuarine ecosystems can be characterized as predominantly heterotrophic systems, with low light penetration, high DOC, and high inputs of terrestrial carbon sources. Moreover, terrestrially-derived DOC is likely to be a key controlling variable on the biogeochemical dynamics of these subtropical estuaries.

37 39 P-2 C

Bingham, B., Shannon Point Marine Center, Anacortes, WA, and **Davenport, E.,** University of Maryland Eastern Shore, Department of Natural Sciences, Princess Anne, MD. **THE EFFECTS OF TEMPERATURE ON THE FERTILIZATION OF *STRONGYLOCENTROTUS DROEBACHIENSIS*.**

The green sea urchin, *S. droebachiensis* is a free-spawning benthic invertebrate whose spawning period ranges from January through April, when the waters are 7-8°C. This experiment was performed in an attempt to understand the effects of temperature on sperm longevity and percent fertilization in *S. droebachiensis*. Eggs and sperm from experimental sea urchins were collected into scintillation vials and incubated at 7°C, 10°C, or 13°C. After one hour, 1 ml of the incubated sperm dilutions were injected into egg dilutions held at established experimental temperatures. This procedure was repeated every half hour for four hours. Results indicate a high percent fertilization rate at 7°C and a decrease in fertilization as temperature increased. Sperm tended to have a higher life span in the lower temperature, which decreased with increasing temperature over the four hour experimental period. The implications for sperm survival at various temperatures are discussed relative to my experimental results.

20.1 1 O C

Blanchard, G.F., Guarini, J.-M., CNRS-IFREMER, Centre de Recherche en Ecologie Marine et Aquaculture de L'Houmeau, France. **RHYTHMICITY OF MICROPHYTOBENTHIC PHOTOSYNTHETIC CAPACITY ON INTERTIDAL MUDFLATS**

Benthic primary production on intertidal mudflat is light-limited. Light is available only at low tide because the water is too turbid during high tide due to sediment resuspension. As a result, availability of light is controlled by the combination of circadian and tidal cycles, and it can be predicted. This light flux also induces an increase of temperature at the surface of the sediment, which influences the kinetics of carbon fixation. So, this paper aims at testing the possibility of a relationship between the light availability and the photosynthetic capacity (P_{max} , i.e., the highest rate of carbon assimilation per unit of biomass) of microphytobenthos. P_{max} was measured under different conditions: (1) when low tide

occurred in the morning with increasing light intensity, (ii) when low tide occurred between midmorning and mid-afternoon with the light maximum at midday, and (iii) when low tide occurred in the afternoon with decreasing light levels. Measurements were also performed at different seasons. It turned out that there is a close relationship between P_{max} and the theoretical quantity of light at the sediment surface (predicted by the combination of the circadian and tidal cycles) during the emersion period. Temperature seems to be the main factor explaining P_{max} changes.

32 40 P-3 C

Blankinship, D., Warren, T., Texas Parks and Wildlife Department, Brownsville, TX. **RELATIVE ABUNDANCE AND LIFE HISTORY OF THE COMMON SNOOK (*Centropomus undecimalis*) WITH EMPHASIS ON THE LOWER LAGUNA MADRE OF TEXAS AND RIO GRANDE.**

Review of Texas Parks and Wildlife Department (TPWD) fishery independent data for common snook in Texas, 1975-present, showed consistently low catch rates with occasional years of marked increases in catch rate. Juvenile snook have been observed in the Rio Grande, an important nursery area. Total numbers of snook caught in TPWD gill nets were summarized by bay system and length frequencies were calculated. Recreational catches of snook were summarized from sport-angler surveys. Snook catches from Rio Grande studies were summarized and length frequency of juveniles was calculated. Spawning dates were back-calculated for juveniles using published growth rates from Florida. Relatively large historical commercial catches, the current presence of juveniles in the Rio Grande, and favorable climatic conditions give evidence to the potential for increased numbers of snook. Recent research showing the snook to be a protandrous hermaphrodite creates new possibilities in management strategy. The location of critical nursery habitat at the border between Mexico and the U.S. results in challenging opportunities for habitat management.

11.2 2 O C

Blanton, J., Skidaway Institute of Oceanography, Savannah, GA, and Kineke, G., University of South Carolina, Columbia, SC, and Alexander, C., Simoneau, A., Amft, J., Skidaway Institute of Oceanography, Savannah, GA. **MOBILIZATION AND DEPOSITION OF FLUID MUD IN A COASTAL PLAIN ESTUARY**

Sediment dynamics were examined at an anchor station during spring tide on the Satilla River, GA. The Satilla River drains about 9,000 km² of the Georgia coastal plain and has extensive areas of salt marsh. A station located 16 km from the ocean was occupied for two 13-hr tidal cycles. Simultaneous profiles of suspended sediments, optical backscatterance, current velocity, temperature and salinity were conducted every 0.5 to 1.0 hours. Owen tube measurements were used to estimate particle settling velocity. Tidal currents were ebb dominant: ebb currents (1.0 m s⁻¹ max) lasted 5.5 hrs and flood currents (0.75 m s⁻¹ max) lasted 7

hrs. During slack water, there was a meter-thick layer of mud overlying a sandy bed. Ebb and flood currents advected mud concentrations > 10 g/L into the sampling area. During fast ebb, high concentrations of several hundred mg/l were mixed to the surface; during fast flood, however, the maximum concentrations were constrained to the lower 5 m of the water column. Although bed sediments are sandy several km upstream and downstream of the anchor station, channel deposits are muddy in the adjacent upper and lower reaches. Thus the sediments observed in the water column at the anchor station are derived from non-local sources and are advected and removed at tidal time scales.

15.1 3 O C

Blood, E., Choi, Y.-s., Darbar, P., Jones, W., Jones Ecological Research Center Ichauway, Inc. Newton, GA **AN EVALUATION OF WATERSHED LANDUSE AND NON-POINT SOURCE RUNOFF IN A MULTI-USE ESTUARINE BASIN.**

In the eight coastal counties of South Carolina, the population is expected to increase by 50% in the next 20 years. The major shift in landuse associated with increased population growth will be the conversion of forestland to urban. Non-point source runoff is a significant contribution to the load of sediments, nutrients and oxygen demanding substances entering estuarine systems with the shift to urban landuse. It may contribute 70 to 85% of the total load entering an estuarine system. It is difficult to quantify because of its diffuse nature and the high variability associated with differing landuse, geology, geomorphology, management practices and wetlands occurring within a watershed. The Simulator for Water Resources In Rural Basins Water Quality (SWRRBWQ) model was modified to simulate non-point source runoff from the Charleston Harbor Estuary basin. Nutrients, sediments and water quantity was simulated from GIS information on topography, soils, landuse, landcover, and hydrography and local climate information. The model was modified to accommodate coastal basins and urban development. A representative sub-basin containing the variety of landuses occurring in the larger basin was used for calibration. Non-point source runoff of nitrogen was comparable to the point source discharges within the Goose Creek sub-basin. Non-point source runoff was related to landuse. Increase urban development resulted in increased sediment, nutrient and water being exported from the sub-basin. Sub-surface nutrient transport was greater in forested watersheds.

0 1 O I

Boesch, D. F., University of Maryland Center for Environmental and Estuarine Studies, Cambridge, MD. **SCIENCE, POLICY, AND THE COAST. IMPROVING DECISIONMAKING.**

The findings and recommendations of a recent National Research Council assessment will be reviewed. The assessment was based on three regional symposia (California, Gulf of Maine and Gulf of Mexico) and deliberations of a synthesis committee. Examination of the processes by which sci-

entific information is developed, communicated and considered in policy formulation and implementation identified a number of areas where significant improvements could be achieved. To address these concerns, the committee recommended that agencies and legislatures at state and federal levels: (1) improve the interaction between -scientists and coastal policy makers/implementors at all levels of government; (2) employ integrated and adaptive management approaches in coastal policy making and implementation, and (3) improve the allocation and coordination of resources to achieve effective interaction between coastal scientists and policy makers. Parallel recommendations related to these three goals are also directed to scientists and academic institutions, industry, nongovernmental organizations, and news media.

12.4 4 O C

Boicourt, W.C., Boynton, W., University of Maryland Center for Environmental and Estuarine Studies, Cambridge, MD. **CHESAPEAKE BAY OBSERVING SYSTEM.**

A coastal observing and forecasting system is evolving in the Chesapeake Bay region. At present, the system consists of a series of sensors that are telemetered to a central location, from which processed information is delivered to any interested party in real time via the Internet. This undertaking is motivated primarily by the need to detect long-term ecosystem change, where an improved understanding of the estuary on shorter scales is expected to enhance both the detection and manageability of this change. Secondary, but nonetheless crucial goals involve short-term forecast products that help justify the substantial effort to maintain such a system far into the indefinite future. Education is a third primary goal, from the elementary level, to graduate school and to the general public, who must be informed to support restoration efforts. New technology has emerged to enable measurement of the key variables in the difficult waters of the estuary.

10.1 2 O C S

Bologna, P., University of South Alabama, Marine Environmental Sciences Consortium, Dauphin Island Sea Lab, Dauphin Island, AL 36528. **THE RELATIVE ROLE OF SEAGRASS EPIPHYTES ON BIVALVE RECRUITMENT.**

Many species of bivalves are intimately associated with seagrass as a primary settlement site and/or as adult habitat. However, little is known about the role that epiphytes play in determining the settling and recruitment patterns of these bivalves. I designed an experiment to assess the relative role of epiphytes as food and structure in the northern Gulf of Mexico. Seagrass patches were created using poly-ribbon blades attached to vexar mesh bases. Treatments included blades fouled with a natural community of epiphytes, blades with secondary structure added, and untreated bare blades. Each treatment was allowed to undergo colonization for four weeks; after which, treatments were sampled using a suction dredge with a 500-micron collection bag. Bivalves were

then identified and enumerated. Results show that treatments with 'live epiphytes' show higher densities and diversities of bivalves than treatments with no or artificially created 'epiphytes'. This suggests that seagrass epiphytes play an important role in bivalve recruitment either in increasing passive deposition of larvae and/or decreasing post-settlement mortality.

12.4 2 O C

Boothe, P.N., Taylor, R.J., Presley, B.J., Trace Element Research Laboratory, Department of Oceanography, Texas A&M University, College Station, TX. **TOTAL AND DISSOLVED TRACE ELEMENTS IN THE HOUSTON SHIP CHANNEL (TEXAS).**

The Houston Ship Channel (HSC) is one of the most heavily industrialized waterways in the world and in the 1960's was considered one of the most polluted bodies of water in the U.S. The HSC Toxicity Study was conducted from August 1993 to May 1994 to evaluate the current health of the waterway. As part of the study, ambient water and suspended matter (TSM) samples (total 142) were collected on 6 occasions at up to 35 stations and under various flow conditions. All samples were collected using clean sampling procedures. The concentrations of 13 priority pollutant metals were determined in all samples using clean analysis techniques to achieve the lowest possible method detection limit (MDL, range 0.005-0.2 µg/L) for each metal. A complete suite of field and laboratory quality assurance samples were run with every sample batch to document data quality through each step in the sampling and analysis process. With few exceptions dissolved metal concentrations were low and exhibited a weak relationship with TSM. The total/ dissolved ratios were highly variable. The dissolved trace metal data from the HSCTS, generated using clean sampling and analysis procedures, were without exception significantly lower (2 to >10 fold) than previous studies with few water quality criteria exceedances. Clearly, the use of clean chemistry methodologies by experienced personnel is essential to obtaining accurate trace metals data for natural waters.

1.2 1 O C

Boumans, R.M.J., Short, F.T., Burdick, D.M., University of New Hampshire, Jackson Estuarine Laboratory, Durham, NH 03824. **MODELING EELGRASS ZOSTERA MARINA: FROM PLANT PHYSIOLOGY TO LANDSCAPE DYNAMICS.**

An integrated series of models at various scales of space and time are being developed to describe the dynamics of eelgrass habitat change. The smallest scale model covers the dynamics of leaf physiology and morphology under light and nutrient stress, while the largest scale is a landscape model simulating spatial changes in eelgrass distribution within Great Bay, NH. Intermediate models address the allocation strategy of functional and structural carbohydrates within the plant under different light regimes, inter-species competition, as well as host-pathogen interrelationships between eelgrass and the wasting disease. Each of these models is in

a different phase of development. The emphasis here is on the leaf morphology and wasting disease models, which have been tested against field and mesocosm data. The leaf morphology model addresses questions of survival strategy through phenotype adaptations and the role of the plastochrone interval in determining plant morphology. The wasting disease model shows the competition between leaf growth rates and disease spreading rates as a function of salinities and subtidal elevation. Our modelling demonstrates that dynamics of eelgrass habitat change in Great Bay, NH are in large part determined by the factors controlling plant morphology and wasting disease activity.

2.1 3 O C

Boyer, J.N., Southeast Environmental Research Program, Florida International University, Miami FL and Rizzo, W. M., Southern Science Center, National Biological Service, Lafayette, LA. **BENTHIC AND PELAGIC COMMUNITY PRODUCTION AND RESPIRATION IN THE NEUSE RIVER ESTUARY, NC: A NEARLY BALANCED SYSTEM?**

In conjunction with reported measurements of integrated pelagic primary production and benthic oxygen flux, pelagic respiration was measured at 7 stations along a longitudinal salinity gradient from river to mesohaline estuary during 1987-88. Respiration rates were integrated over depth and time to get daily and annual estimates. Median water column respiration rates in the mesohaline and oligohaline zones (0.075 and 0.080 mg O₂ l⁻¹ hr⁻¹) were significantly higher than in the river (0.068 mg O₂ l⁻¹ hr⁻¹). Pelagic respiration in the mesohaline zone during 1987 was significantly greater than for 1988. Principal component analysis showed that pelagic respiration in the mesohaline zone was positively related to temperature and chlorophyll a while being negatively related to photic depth. Pelagic respiration in the oligohaline zone was positively related to temperature and filterable reactive P. In the riverine zone, pelagic respiration was dependent primarily upon temperature. Daily integrated pelagic respiration rates for the mesohaline, oligohaline, and riverine zones were 3.7, 3.6, and 2.8 mg O₂ m⁻² d⁻¹, respectively. Annual integrated pelagic respiration for the Neuse River estuary was 1.5 and 1.3 kg O₂ m⁻² yr⁻¹ for 1987 and 1988. Previous annual primary productivity estimates were 1.3 and 1.3 kg O₂ m⁻² yr⁻¹ for 1987-88 with an estimated net negative benthic oxygen flux of only 0.017 kg O₂ m⁻² yr⁻¹. Therefore, for 1987-88 the Neuse River estuary was a relatively balanced, although net heterotrophic ecosystem.

21.3 3 O C

Boyer, K.E., Zedler, J.B., Pacific Estuarine Research Laboratory, San Diego State University, San Diego, CA. **ENHANCING CANOPY DEVELOPMENT IN A CONSTRUCTED SALT MARSH: THE EFFECTS OF NITROGEN ADDITIONS.**

We tested methods of improving the height growth of cordgrass (*Spartina foliosa*) in a San Diego Bay constructed marsh, varying timing and duration of urea fertilization. Bi-weekly amendments over 6 months in 1993 increased

aboveground biomass and foliar nitrogen, and all fertilized treatments met our canopy criteria for nesting by the endangered light-footed clapper rail (≥ 100 stems/m² with at least 30 stems taller than 90 cm). However, in August 1994, only those plots fertilized for a second season continued to produce >30 tall stems/m². Apparently, insufficient nitrogen was stored in cordgrass tissue to boost height growth after fertilization ceased; nor was soil nitrogen increased in either year, supporting our hypothesis that nitrogen retention is poor in these coarse constructed marsh soils. We recommend that nitrogen additions be continued over a number of years to produce tall cordgrass that might attract nesting by the endangered rail, until soils are able to develop nitrogen pools adequate to sustain tall cordgrass stands.

11.2 1 O C

Boynton, W.R., Boicourt, W., Houde, E., Kemp, W.M., Roman, M., Harding, L., (Univ. MD-CEES); Brandt, S., Jech, M. (Univ. Buffalo). **DESIGN AND PRELIMINARY RESULTS FROM A NEW LMER PROGRAM IN CHESAPEAKE BAY: TROPHIC INTERACTIONS IN ESTUARINE SYSTEMS (TIES).**

This six year program focuses on mechanisms by which production at higher trophic levels is influenced by inputs from adjacent watershed, ocean and atmosphere, using the full mainstem of Chesapeake Bay as a study site. We hypothesize that the relatively high rates of secondary production characterizing estuarine ecosystems are attributable, in part, to the pulsing nature of materials and energy inputs and the resulting physical structures and biological patchiness, which acts as sites of greatly enhanced activity. The field program has been designed to examine: 1) how fine-scale distributions (as well as regionally integrated values) of physical and biological properties and processes respond to interannual variations in inputs from terrestrial and oceanic margins; and 2) how physical structures and biological patches influence production and trophic structure of the estuarine ecosystem. A suite of numerical models and comparative analyses are proposed to; (1) integrate field observations; (2) contrast differences between processes measured at coarse and fine scale; and (3) investigate factors regulating trophic structure and secondary production at specific sites. To accomplish these goals several new technologies will be utilized (e.g. rapidly towed CTD, fluorescence, acoustic and optic sensors, aerial remote sensing, real-time in-situ moorings) which have emerged that enable reliable estimates of secondary production and insights into the details of interaction between planktonic assemblages and physical structures. Over the past decade, research attention has focused on the question of how changes in the inputs of nutrients to estuaries create regional and interannual variations in primary production, algal biomass, and nutrient recycling. The understanding of these connections in Chesapeake Bay is at a state where we can now focus on the next obvious puzzle: what makes estuaries so efficient in the transfer from primary to secondary production and how is secondary production related to energy and material inputs from the land, air and ocean.

17.2 5 O C

Breitburg, D., Academy of Natural Sciences, Benedict Estuarine Research Center, St. Leonard, MD, and Rose, K., Oak Ridge National Laboratories, Environmental Sciences Division, Oak Ridge, TN, and Cowan, Jr., J., Department of Marine Sciences, University of South Alabama, Mobile, AL. **EFFECTS OF LOW DISSOLVED OXYGEN ON TROPHIC INTERACTIONS IN AN ESTUARINE ZOOPLANKTON - FISH LARVAE - LARVAL PREDATOR FOOD WEB: AN INDIVIDUAL-BASED MODELING APPROACH.**

Low dissolved oxygen is a common feature of bottom waters in stratified aquatic systems with high nutrient loadings. Mesocosm and laboratory experiments, as well as field sampling indicate that low oxygen affects predation rates, vertical distributions, growth and survival in the zooplankton - fish larvae - larval predators food web in Chesapeake Bay. We are currently using a spatially explicit individual-based model to examine how low oxygen in a stratified water column affects predator-prey interactions between fish larvae and two important estuarine predators of larvae - fish and scyphomedusae (the sea nettle *Chrysaora quinquecirrha*). Model results indicate that changes in bottom oxygen that could result from nutrient reduction would greatly alter the relative importance of trophic pathways. For each predator-prey pair, the outcome depended on the relative susceptibility of interacting species to low oxygen. With sea nettle predators, larval survival was highest when bottom oxygen was either high or 0 mg/L - conditions when most interactions occurred at high oxygen concentrations (the bottom layer was avoided when it was anoxic) that maximized escape rates of larval prey. With predatory fish, larval survival was highest at moderately depleted oxygen concentrations that impaired predation but were not strongly avoided by larvae. With more than one predator present, larval survival depended on the relative abundance of fish and sea nettles. At any fixed density, however, the relative capture by these two predators varied with oxygen concentration.

3.3 2 O C

Breitburg, D., Sanders, J., Academy of Natural Sciences, Benedict Estuarine Research Center, St. Leonard, MD. **THE IMPORTANCE OF UNDERSTANDING ECOLOGICAL COMPLEXITY TO PREDICTING EFFECTS OF MULTIPLE STRESSORS ON COASTAL SYSTEMS**

In order to understand the cumulative effects of numerous stressors on coastal ecosystems, the complexity of such systems must be recognized and dealt with. We are currently addressing this complexity through a large, 6-yr multi-investigator program by studying the Patuxent River (a subestuary of the Chesapeake Bay) at multiple levels of organization. Our approach includes 1) a multilevel large-scale experimental study of the effects of stressors (nutrients, inorganic toxics, dissolved oxygen) on ecological processes within the estuary, 2) an examination of the relationships between land-use patterns, geology and the watershed loadings of stressors, 3) modeling of the ecological effects of

stressors from the individual through ecosystem level, including spatially explicit fisheries models, and 4) an economic evaluation of management practices. The research integrates levels of complexity ranging from individual responses to ecosystem processes. This focus is important because there is often a mismatch between the level of complexity at which management actions can be taken, the level at which a response is desired, and the level at which evidence for management options is gathered. First year experiments are testing how varying grazer density affects the response of phytoplankton and microbial communities to nutrient stress.

29.1 1 O C

Bricker, S.B., Clement, C., Pirhalla, D., Frew, S., Harmon, M., National Oceanic and Atmospheric Administration, National Ocean Service, Office of Ocean Resources Conservation and Assessment, 1305 East West Highway, Silver Spring, MD. **NOAA'S ESTUARINE EUTROPHICATION SURVEY: MID-ATLANTIC RESULTS.**

In 1992 NOAA initiated a survey to gather information about indicators of eutrophication for U.S. estuaries in an effort to assess the status and trends of these conditions on a national basis. The survey was sent to 400+ scientists representing 128 estuaries. Information regarding the magnitude, timing (duration and time of year), spatial coverage, and predictability of extreme conditions of indicators such as algal blooms, dissolved oxygen and nutrient concentrations was requested for three salinity zones; Tidal Fresh (0 - 0.5 ppt), Mixing Zone (0.5 - 25 ppt), and Seawater Zone (>25 ppt). The Mid-Atlantic (Buzzards Bay to Chesapeake Bay) was the first region of focus and the information base was completed via site visits and a regional review workshop in late 1994. A preliminary eutrophication index was developed based on area weighted results for 12 indicators. The regional index score for existing conditions was "high," 50-80% of all indicators were reported at problematic levels with only one estuary (of 23) exhibiting a score of very high (>80%). Problematic conditions occurred almost exclusively during the summer months and the mixing zone was the most highly impacted salinity zone. The regional index score for trends (~1975-1994) is "no trend", although one estuary exhibited improvements and four estuaries reported overall degradation of water quality. This is the first in a series of regional assessments that will provide a basis for development of eutrophication management strategies and for constructing cause/effect models of nutrient enrichment.

31.3 3 O C

Brinson, M.M., Christian, R.R., East Carolina University, Biology Department, Greenville, NC. **TRANSITION FROM ORGANIC HIGH MARSH TO MINERAL LOW MARSH.**

In salt marshes undergoing transgression induced by rising sea level, the high marsh must necessarily undergo a transition to low intertidal marsh. We have followed microtopographic changes, ground cover, and plant biomass

on a mainland marsh for 5 years at the Virginia Coast Reserve. Microtopography was more variable and erosion was dramatic from 1990 to 1995 in the transition zone as compared to others. Erosion occurred through the development of depressions lacking high marsh plants. Areas of *Juncus roemerianus* were more resistant to this erosion, and, in fact, the biomass of this species was higher in the transition zone than others. *Ruppia maritima* and *Spartina alterniflora* have become established in barren areas and depressions. We propose that transition from organic high marsh to mineral low marsh involves the formation of a hummock and hollow landscape. This landscape development is necessary to remove accumulated organic-rich sediments and to provide delivery of tidal water through headward migration of tidal creeks.

19.1 4 O I

Bronk, D.A., University of Georgia, Athens, GA, and **Gilbert, P.M.**, University of Maryland, Cambridge, MD, and **Sahlsten, E.**, University of Göteborg, Göteborg, Sweden, and **Banahan, S.**, NOAA, Coastal Oceans Office, Silver Springs, MD. **DIEL AND SEASONAL PATTERNS IN AMMONIUM UPTAKE AND DISSOLVED ORGANIC NITROGEN RELEASE IN CHESAPEAKE BAY.**

We performed time-course experiments in the mesohaline Chesapeake Bay to compare the short-term diel variability (hours) in nitrogen flux rates during May, August, and October. During each experiment, we measured ambient nitrogen concentrations and used ^{15}N techniques to measure rates of NH_4^+ uptake and DON release resulting from NH_4^+ uptake. We found that short-term variability in uptake rates was greatest in August (range was 0.003 to $1.35 \mu\text{mol N l}^{-1} \text{h}^{-1}$); the high variability was likely due to biomass patchiness, which appears to be a common response to wind events at this time of year. Relative to uptake rates, average rates of DON release were remarkably constant from season to season; the seasonal constancy was likely due as much to changes in DON utilization as in the magnitude of DON release itself. The diel patterns observed in DON release rates were also the same over all three seasons with peaks at dawn and dusk suggesting a possible link to cell division. Lastly, rates of DON release were used to calculate "gross" NH_4^+ uptake rates, which were corrected for the loss of ^{15}N -label to the DON pool. The difference between traditionally measured "net" uptake rates, and "gross" uptake rates varied from an average of 15 % in August, to as high as 76 % in October.

1.1 3 O C

Brooks, R.A., Bell S.S., Department of Biology, University of South Florida, Tampa, FL 33620-5150. **SCALING OF PLANT-ANIMAL RELATIONSHIPS IN SEAGRASS BEDS: SEARCHING FOR PATTERNS WITH SMALL CRUSTACEANS.**

We examined the relationships between epiphytal amphipods and a variety of seagrass (*Halodule wrightii*) characteristics in Tampa Bay, FL on three dates from May 1994-June 1995 in 24 seagrass beds. These relationships were examined at the level of 1) an individual sample, 2) an indi-

vidual seagrass bed and 3) beds grouped by landscape features. Typically over 80% of the amphipod assemblage was composed of the tube-building forms, *Jassa falcata* and *Ampithoe longimana*. No relationship between number of individuals and aboveground biomass, shoot density, or canopy height was detected when data were grouped by individual seagrass bed or landscape attributes on any of the sampling dates. However, a significant relationship between number of amphipods and seagrass biomass was detected repeatedly at the level of individual samples (spatial scale < 1m). Number of amphipod species demonstrated no relationship with seagrass regardless of spatial scale employed as often the highest number of species was recorded in samples with wide ranging vegetational attributes. These results reiterate that interpreting the relationship between fauna and seagrass vegetation may depend upon not only the taxa being considered but the spatial scale at which the relationship is investigated.

34.1 2 O C S

Brooks, R.L., **Lehman, R.L.**, Center for Coastal Studies, Texas A & M University-Corpus Christi, Corpus Christi, TX. **NUTRIENT CONTENT AND PLANKTON POPULATIONS BEFORE, DURING, AND AFTER MAINTENANCE DREDGING OF THE GULF INTRACOASTAL WATERWAY IN THE UPPER LAGUNA MADRE.**

The Upper Laguna Madre has been afflicted for the past five years with a brown tide algal bloom consisting of an unnamed Chrysophycean phytoplankton. Possible causes of the bloom are currently under investigation. Maintenance dredging activities by the Corps of Engineers in the Gulf Intracoastal Waterway (GIWW) may contribute to the brown tide bloom. Nutrients released from dredge sediments (ammonium-N and orthophosphate-P) may be beneficial to phytoplankton. This study will reveal effects, if any, on nutrient concentrations and phytoplankton populations during and after maintenance dredging activities. Water samples were collected monthly at five sites in the Upper Laguna Madre and analyzed for ammonia, nitrate/nitrite, and phosphate concentrations. Populations of phytoplankton, especially the brown tide organism, and bacteria are being evaluated. Correlation with meteorological, salinity, and pH conditions is shown.

8.2 4 O C

Brown, C.A., **Kraus, N.C.**, **Conrad Blucher Institute for Surveying and Science**, Texas A&M University-Corpus Christi, Corpus Christi, TX. **HYDRODYNAMIC MODELING OF THE CURRENTS IN THE VICINITY OF THE KENNEDY CAUSEWAY, CORPUS CHRISTI, TEXAS.**

In 1950, the John F. Kennedy Causeway was constructed in Corpus Christi, Texas, on landfill spanning approximately 5 km across the Upper Laguna Madre, a unique hypersaline estuary extending from Corpus Christi to Port Isabel, Texas. Since construction of the causeway, there has been great environmental concern in the local community and the State

of Texas of the perceived degradation of water circulation and water quality in the vicinity of the causeway. The objective of this study is to quantify the impacts of the existing causeway on circulation and to assess the environmental benefits associated with various proposed engineering alternatives for elevating the causeway through hydrodynamic modeling. Model simulations were utilized to maximize the environmental benefits by optimizing the dimensions and placement of proposed openings. The modeling effort consists of a two-tiered approach, involving one- and two-dimensional hydrodynamic models. Utilizing extensive instrumentation in the region, the models were verified with water-level and current data collected in the study area. Model simulations were performed for the existing causeway configuration and five engineering alternatives for summer, winter, and storm conditions. Results showed that it was not necessary to elevate the entire causeway; rather, an opening of approximately 5000 ft along the western side would maximize environmental benefits. In addition, the impact of the withdrawal of 2 million cu m of water per day from the lagoon by a nearby power plant was investigated.

34 45 P-1 C

Brownlee, S., Matos, R., Hartsig, A.M., Lacouture, R., Sellner, K., The Academy of Natural Sciences, Benedict Estuarine Research Center, St. Leonard, MD. **ZOOPLANKTON LINKAGES TO PHYTOPLANKTON IN THE TIDAL-FRESH POTOMAC RIVER DURING SUMMER CYANOBACTERIA BLOOMS.**

Phytoplankton and zooplankton biomass data were analyzed based on samples collected at a tidal-fresh Potomac River station over a period from 1984-1994 as part of the Maryland Chesapeake Bay Water Quality Biomonitoring Program. Mean summer phytoplankton, microzooplankton and mesozooplankton biomass were compared to establish linkages between these groups. From the mid-1980's until the early 1990's, a reduction in phytoplankton biomass (caused by a decrease in summer cyanobacteria blooms) was paralleled by a corresponding decrease in microzooplankton biomass largely due to declining rotifer levels, the group most responsive to phytoplankton in the reach. In 1993 and 1994, cyanobacteria numbers increased and in an apparent response, microzooplankton biomass also increased, reflecting a close coupling between these trophic levels not observed in most tidal-fresh regions of other Bay tributaries.

17 28 P-2 C S

Brumbaugh, R.D., McConaughy, J.R., Department of Oceanography, Old Dominion University, Norfolk, VA. **THE EFFECT OF BENTHIC MACROALGAE ON METAMORPHOSIS OF BLUE CRAB POSTLARVAE.**

In a series of laboratory experiments, the time to metamorphosis (TTM) was recorded for field-collected blue crab (*Callinectes sapidus*) megalopae held in the presence of benthic macroalgae. Three separate treatments, consisting of a small piece of *Ulva lactuca*, *Gracilaria* spp., or no algae, were compared in a factorial design. Megalopae and

test water were collected at three different locations (off-shore, inlet and lagoon), and were randomly assigned to experimental treatments. All megalopae were molt staged at the start of the experiments, and only those in intermolt (off-shore) or early premolt (inlet and lagoon) were included in the statistical analysis. Data were analyzed as a two-factor ANOVA, with location and algal type as fixed effects. Although there was significant interaction ($p < 0.05$) between the main effects, the presence of macroalgae did not appear to alter the time to metamorphosis. However, there was a clear trend for inshore (inlet and lagoon) megalopae to metamorphose sooner than offshore megalopae (TTM inlet 65.43 hrs., lagoon 60.17 hrs., offshore 113.26 hrs.). These data suggest that megalopae that have advanced to premolt (inlet and lagoon) are not receptive to cues from benthic macroalgae.

3 10 P-1 C

Buchsbaum, R., Cooper, A., Massachusetts Audubon Society, Wenham, MA, and Rines, H., Turner, C., Applied Science Associates, Inc. Narragansett, RI. **THE PLUM ISLAND SOUND MINIBAY PROJECT: A MODEL PROGRAM FOR ADDRESSING NONPOINT POLLUTION IN ESTUARIES.**

Plum Island Sound is a 13,000 acre estuary in northeastern Massachusetts well known for its productive clam flats and migratory bird populations. Despite a relatively undeveloped shoreline, the Sound still suffers from stormwater-related pollution of shellfish beds due to high fecal coliform concentrations. In 1992, the Massachusetts Audubon Society was funded by the Massachusetts Bays Program to aid three communities bordering the Sound in addressing this problem through water quality research, land use analysis and public outreach. Our water quality research has focused on calculating the flushing characteristics of different parts of the Sound, quantifying the bacterial concentrations at various sampling stations in both wet and dry weather to identify "hot spots", and determining the bacterial loading rates from different tributaries. From this research, we have been able to identify the major drainage basins contributing bacterial contamination to the Sound and to prioritize subregions for remediation. Land use research has included a shoreline survey for potential sources of pollution and a build out analysis. We have stressed best management practices for horses and cows, controlling pet and feral wildlife wastes, and septic system maintenance as keys for remediating pollution in Plum Island Sound.

13.2 2 O C

Burdick, D.M., Boumans, R.M., Short, F.T., University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Durham, NH, and Dionne, M., Wells National Estuarine Research Reserve, Wells, ME. **RESTORATION OF SALT MARSHES IN NORTHERN NEW ENGLAND.**

Although protected from direct impacts, many salt marshes in the U.S. have continued to deteriorate due to indirect impacts of restricted tidal exchange from undersized

conduits and tidegates under roadways, refuse clogging tidal creeks, and dredge spoil berms. Degradation results in loss of marsh functions and often invasion by plants that are less tolerant of saline soils. Management decisions at two National Estuarine Research Reserves have led to improvement of tidal exchange at two salt marshes, and tidal exchange has been restored at two other marshes in northern New England with the Coastal America Program. Flooding of these systems has increased dramatically following restoration, especially on higher tides, leading to significantly greater water table salinities (greater than 10 ppt increase). Dramatic changes in plant communities include revegetation of die-back and open water areas with *Spartina alterniflora*, *Salicornia europaea*, and *Juncus gerardi*, death of *Lythrum salicaria*, and loss of vigor in *Phragmites australis*. Reestablishment of estuarine fish communities is occurring more quickly at some sites and appears to be influenced by the design of the structure that restored tidal flow. Our results drive a simulation model of salt marsh ecosystem health in the context of tidal restriction and restoration.

16 36 P-1 C

Burdick, D.M., Short, F.T., University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Department of Natural Resources, Durham, NH. **THE EFFECTS OF BOAT DOCKS ON EELGRASS BEDS IN MASSACHUSETTS COASTAL WATERS.**

The effects of docks on eelgrass beds were measured using plant population characteristics (shoot density, canopy height and growth rates), light levels, and an assessment of eelgrass bed quality. Eelgrass populations were impacted under and directly adjacent to docks, as shown by depressed shoot density and canopy structure. Impacts were lower under docks supported by piers than under floating docks, and taller piers resulted in lower impacts. Based on this investigation, we conclude that docks should be greater than three meters in height above the bottom in areas with tidal ranges less than one meter to allow enough light to sustain eelgrass beds. In addition to dock height, dock orientation and width were also important factors affecting eelgrass. Narrow docks with a north-south orientation best supported eelgrass beds. An estuary-wide assessment of dock impacts to eelgrass was performed in Waquoit Bay. In the four sub-basins of the estuary where docks extended into eelgrass beds, docks covered approximately 0.06% of the total area of beds. Although clearly not primarily responsible for the recent decline in eelgrass distribution in Waquoit Bay, docks and associated boat activities may initiate fragmentation and disruption of eelgrass beds, thus contributing to their loss.

16.1 5 O C S

Burke, A., Henderson, C., Texas A&M University, Galveston, TX and **Sheridan, P.**, National Marine Fisheries Service, Galveston, TX. **SPATIAL VARIABILITY OF BENTHOS IN A *HALODULE WRIGHTII* BED IN CHRISTMAS BAY, TEXAS.**

Variation in benthos was examined in October 1994 across four spatial scales (1 km, 100 m, 10 m, 1 m). We used a

nested coring design and ANOVA to determine which scale most clearly defined distribution and abundance of benthos and how taxonomic resolution affected results. Annelids and amphipods composed 89% and 8% of all organisms. With one exception, no significant variation was found at 10 m. For major taxa (Phylum/Class/Order), significant variation was found for Mysidacea at 1 km, for Amphipoda and Isopoda at 100 m, and for Tanaidacea, Pycnogonida, Mollusca, and Annelida at 1 km and 100 m. For 9 dominant "species" (> 1.0% of total; includes Class Oligochaeta), we found: no significant variation for *Mysidopsis bahia*; significance at 100 m for *Gammarus* sp. 2, *Chone* cf. *americans*, and *Heteromastus filiformis*, significance at 1 km and 100 m for *Ampelisca abdita*, *Capitella capitata*, and *Oligochaeta*; and significance at 1 km, 100 m, and 10 m for *Streblospio benedicti*. *Polydora ligni*'s distribution was so skewed it could not be normalized (by transformation) for ANOVA. Benthic sampling designs for seagrasses should be scaled across bed dimensions to obtain accurate estimates of species distributions and densities.

27.1 1 O C

Burkholder, J.M., Glasgow, Jr., H.B., Touchette, B.W., North Carolina State University, Raleigh, NC. **CONTROL OF EELGRASS (*ZOSTERA MARINA* L.) SURVIVAL BY WATER-COLUMN NITRATE ENRICHMENT X AVAILABLE LIGHT.**

In an experimental mesocosm system during the spring-early summer growing season, we examined the effects of simulated coastal eutrophication as water-column nitrate enrichment (low and moderate, as 5 or 15 $\mu\text{M NO}_3\text{-N day}^{-1}$) on eelgrass growth across a gradient of available natural light imposed by neutral density screens (no shading [L-0], versus 25% [L-1], 50% [L-2], or 75% [L-3] reduction of I_0 throughout the day). Controls received no nitrate enrichment (ambient, < 1 $\mu\text{M NO}_3\text{-N}$) or light reduction. Following an initial period (3 wk) of apparent stimulation by low nitrate additions, elevated water-column nitrate acted synergistically with decreasing light to depress *Zostera* growth relative to growth of control plants, even at the lowest levels of nitrate enrichment x shading. The data indicate that in warm-temperate climates, water-column nitrate enrichment can decrease eelgrass survival as a direct effect unrelated to algal-mediated light reduction, and that elevated water-column nitrate can interact directly or indirectly with low available light to promote eelgrass decline in coastal waters under accelerated eutrophication.

14.1 1 O C S

Burns, J., Poirier, P., University of New Orleans, Depts. of Biology, New Orleans, LA., and **Preston, K.** University of New Orleans, Dept. of Geography, New Orleans, LA. **THE RESILIENCE OF SUBMERSED AQUATIC VEGETATION IN THE LAKE PONTCHARTRAIN ESTUARY FOLLOWING NATURAL AND ANTHROPOGENIC DISTURBANCE.**

While conducting long-term ecological studies of submersed aquatic vegetation in the Lake Pontchartrain estuary

(1991-1995), Hurricane Andrew (August '92) and a severe winter storm (March '93) provided a unique opportunity to measure the resilience of an SAV community. The degree, manner, and pace of the recovery of SAV to its initial structure (prior to Hurricane Andrew - 1991) was measured and compared to the historical status of SAV populations in areas where the shoreline has been altered by structures designed to control erosion, such as bulkheads, cement walls and stone revetments. The response of SAV to natural disturbance from storms included shifts in species abundance, composition, and dominance. Total SAV areal cover declined by 74% on the north shore, following Hurricane Andrew, and by 92% on the south shore, following the winter storm. *Ruppia maritima* replaced *Vallisneria spiralis* as the dominant SAV in the estuary and expanded to new areas. Although SAV total areal cover increased to pre-storm levels by 1993, community structure is returning to its initial state at a much slower pace. Submersed aquatic vegetation has not returned to areas where the shoreline has been altered by erosion control structures which increase wave energy and limit the exchange of water between the estuary and its surrounding wetlands. Understanding the resilience of SAV communities and to what extent patterns of recovery differ in response to different types of disturbance may be useful when establishing SAV restoration goals and targets.

25.1 3 O C

Burns, W. A., Mankiewicz, P.J., Bence, A.E., Exxon Production Research Co., Houston TX, Page, D.S., Bowdoin College, Brunswick ME and Parker, K., Data Analysis Group, Cloverdale CA. A LEAST-SQUARES METHOD FOR ALLOCATING SEDIMENT HYDROCARBONS TO MULTIPLE SOURCES.

Allocating sediment hydrocarbons to the sources from which they came is difficult if there are many sources and the hydrocarbons are weathered. A least-square method has been developed to overcome these limitations. It finds the best fit of sediment polycyclic aromatic hydrocarbons (PAH) to a mix of fresh and weathered PAH from possible sources. It determines the amount of PAH present from each source, information not easily available from principal component analysis. The new method is less sensitive to noise or scatter in the data than allocation methods based on one or two key diagnostic ratios. The method was applied to a large set of field data gathered in Prince William Sound, Alaska, following the *Exxon Valdez* oil spill. The sources modeled include spill oil, diesel, diesel soot, crude oil from natural seeps, and pyrogenic compounds from human activities or forest fires.

17 29 P-2 C

Bushek, D., University of South Carolina, Baruch Institute, Georgetown, SC, and Reece, K., Graves, J., College of William and Mary, Virginia Institute of Marine Science, Gloucester Point, VA. INVESTIGATING THE POPULATION STRUCTURE OF PERKINSUS MARINUS.

Since the middle of this century, *Perkinsus marinus* (Apicomplexa) has caused extensive oyster mortality from

Virginia to Texas. Recently, however, it has spread north to Massachusetts. Regional climate warming, development of cold tolerance, and commercial transport of infected oysters have been suggested as mechanisms for its establishment in areas north of Virginia. To better understand the spread of *P. marinus* we are investigating its population genetic structure. Parasites have been collected from Connecticut to Texas to produce *in vitro* cultures which are being cloned for genetic analysis. The complete collection will contain parasites from adjacent oysters, adjacent reefs, adjacent tidal creeks, adjacent bays, adjacent estuaries, and distant estuaries. We created a genomic library from axenic cultures. PCR amplified fragments of the actin, 18S rRNA, ATPase 6 (mitochondrial) and serine protease genes have been cloned and used as library probes. Because these are primarily coding regions unlikely to show intraspecific variability, primers are being designed from the library clones to amplify the non-coding flanking regions of these genes. RFLP analysis or, if necessary, direct sequencing will be used to compare isolates. Results will provide valuable insight into dispersal mechanisms and the spread of *P. marinus*.

34.1 3 O C

Buskey, E.J. Marine Science Institute, The University of Texas at Austin, Port Aransas, TX 78373 WHY CAN'T ZOOPLANKTON GRAZERS CONTROL THE TEXAS BROWN TIDE?

The Laguna Madre of South Texas has experienced a dense, nearly monospecific phytoplankton bloom since January 1990 referred to as the "brown tide". This bloom has disrupted the basic food web by altering the composition and diversity of grazer communities. Zooplankton populations declined following the outbreak of the bloom and planktonic grazers have failed to bring the bloom under control. Field studies show reduced microzooplankton community grazing, and stunted growth and lower egg release rates by the dominant copepod *Acartia tonsa* in brown tide affected areas. Laboratory studies of microzooplankton grazers feeding on brown tide indicate that this alga is nutritionally inadequate to support the growth of many species. The presence of the brown tide also inhibits the growth of some protozoan species even when other nutritionally adequate food species are present. The brown tide appears to be toxic at high concentrations to some protozoans and naupliar stages of copepods. Poor circulation in the Laguna Madre appears to help brown tide concentrations remain above threshold levels at which they show inhibitory or toxic effects on grazers. At least two species of protozoan grazers have been found that grow well on the brown tide and it remains unclear why these species have not exerted greater grazing pressure on the brown tide. The roles of grazers in brown tide bloom dynamics is currently being investigated using a series of *in situ* mesocosms.

20.1 3 O C

Butler, T., Institute of Ecosystem Studies, Millbrook, NY, and Section of Ecology and Systematics, Cornell University, Ithaca, NY, and Swaney, D., Center for the Environin

ment, Cornell University, Ithaca, NY, and Howarth, R., Section of Ecology and Systematics, Cornell University, Ithaca, NY. **EFFECTS OF MIXING ON AQUATIC PRODUCTIVITY AND RESPIRATION IN THE HUDSON ESTUARY.**

Three years of diel measurements of dissolved oxygen, salinity, and temperature profiles at eight stations in the mesohaline Hudson River are used to estimate net ecosystem productivity and community respiration from Upper Haverstraw Bay (river mile 38) to the George Washington Bridge (river mile 10). Salinity, temperature and oxygen profiles, plus chlorophyll concentrations in the water column, suggest that in this reach of the river, phytoplankton are mixed throughout the water column despite slight to moderate salinity "stratification". That is, oxygen is mixed to the bottom across the pycnocline on a time scale of hours, and chlorophyll concentrations in bottom waters are comparable to concentrations in the surface. Because algal biomass spends a significant fraction of the time below the compensation depth, primary production is reduced despite high levels of nutrient concentrations. This productivity-limiting mechanism contrasts with an earlier hypothesis that primary production is limited by rapid flushing of phytoplankton downstream such that the algal residence time is small compared to the development time of algal blooms.

13.2 3 O I S

Buzzelli, C.P., Meyers, M.B., Moore, K.A., College of William and Mary, School of Marine Science, Gloucester Point, VA. **INTEGRATIVE ANALYSIS OF CARBON PRODUCTION IN THE LITTORAL ZONE OF LOWER CHESAPEAKE BAY.**

Littoral zone ecosystems in Chesapeake Bay are situated between the upland and open water and include living resources such as marsh, seagrass, and microalgal habitats. This study uses hypsometric and ecological models to explore carbon production in a littoral zone ecosystem of lower Chesapeake Bay, the Goodwin Islands NERR (GINERR). Inundation, irradiance, and temperature drive the simulation of seasonal primary production in four concentric habitats of the GINERR (nonvegetated and vegetated subtidal and intertidal). Preliminary model runs indicate that *Zostera marina* maximizes biomass in the spring at 150 g C m^{-2} while *Spartina alterniflora* approaches 200 g C m^{-2} in the late summer. Benthic microalgae maintain approximately 2.5 g C m^{-2} both spatially and temporally. Field data are used to initialize and validate output while GIS is used to generate the hypsometric profile and visualize the resulting patterns. The integration of modeling, mapping, and field data provides a potentially powerful method to analyze patterns of production in littoral zone habitats of lower Chesapeake Bay.

2.1 2 O C

Caffrey, J.M., Institute of Marine Science, University of California, Santa Cruz. **THE ROLE OF BENTHIC PROCESSES IN THE NITROGEN BUDGET OF SOUTH SAN FRANCISCO BAY.**

South San Francisco Bay is a well-mixed estuary, where the major source of freshwater and nutrients is from sewage treatment plants. The annual spring phytoplankton bloom represents the major input of organic carbon to the estuary and an important source to the sediments. Sediment NH_4^+ remineralization was enhanced following the spring bloom. Benthic flux measurements (sediment O_2 consumption, NH_4^+ fluxes, and nitrification) made over a 2 year period showed little or no response to the 1992 spring bloom, while rates were enhanced following the 1993 bloom. This difference may be the result of a large bloom in 1993 (average chlorophyll *a* concentrations - 35 mg/l) than in 1992 (chlorophyll *a* - 15 mg/l) Respiration by benthic macrofauna represented about 10% of the sediment O_2 consumption while macrofauna excretion was between 8-30% of the NH_4^+ flux out of the sediments. Sediment nitrogen budgets for the shoals and channel suggest that secondary production of macrofauna represented about 20% of the nitrogen inputs to the sediment at both locations. Denitrification was responsible for the removal of approximately 40% of the nitrogen inputs to South San Francisco Bay.

31.1 5 O I

Cahoon, D., National Biological Service, Lafayette, LA, and Day, Jr., J., Louisiana State University, Coastal Ecology Institute, Baton Rouge, LA, and Reed, D., Louisiana Universities Marine Consortium, Chauvin, LA. **ELEVATION DEFICITS: A NEW APPROACH FOR EVALUATING THE POTENTIAL FOR COASTAL MARSH SUBMERGENCE.**

Evaluations of the relationship between vertical accretion and surface elevation change based on simultaneous measurements from soil marker horizons and sedimentation-erosion table benchmarks revealed that, for some marshes, processes other than surface deposition-erosion were as important in controlling elevation change (e.g., compression, water storage (shrink- swell), organic production-decomposition). The influence of subsurface processes was often episodic and apparently related to natural forces such as major storms (e.g., hurricanes), seasonal flooding, and plant growth-decomposition cycles. Marshes with organic or weakened substrates were more susceptible to the influence of these subsurface processes. The implications for managing marshes during a period of rising sea level are that (1) accretion data do not necessarily reflect the entire response of the marsh

substrate to sea-level rise and coastal submergence (2) we should be calculating elevation deficits and not accretion deficits (3) elevation and accretion techniques need to be used simultaneously in order to identify potentially critical processes (4) a multidisciplinary approach is needed to interpret marsh elevation-sea level relationships and (5) current terminology needs to be revised and standardized to facilitate communication of ideas.

33 39 P-1 C

Caixing, Y., National Laboratory of Estuary and Coastal Research, East China Normal University, Shanghai 200062, P.R.China. **APPLICATION OF REMOTE-SENSING TECHNIQUES IN THE COASTAL ENGINEERING DECISION-MAKINGS.**

The coastal stability and the engineering environment are the first problems an engineering construction department confronted with when making a decision about a coastal engineering project, while the remote-sensing technique is a speedy, economic and effective means in studying such problems. The author had never successfully applied satellite remote-sensing techniques and air images in the harbour setting, the estuarine channel regulation study and the feasibility study of coastal electric power plants, such research involves the coastal dynamic changes, the regime of estuarine currents, the coastal area with a high concentration of suspended sediments, the spatial extent under the effect of sea-ice and its drifting speed etc.

31.1 3 O C

Callaway, J.C., Pacific Estuarine Research Laboratory, San Diego State University, San Diego, CA, and DeLaune, R.D., Patrick, Jr., W.H. Wetland Biogeochemistry Institute, Louisiana State University, Baton Rouge, LA. **SEDIMENT ACCRETION IN COASTAL WETLANDS: A SIMULATION MODEL OF PROCESSES.**

We developed a Fortran computer model which simulates wetland accretion rates, sediment characteristics, and sediment surface elevation. The model uses a cohort approach, allowing annual cohorts of mineral and organic sediment to accumulate on the sediment surface, while earlier cohorts are buried and subjected to below-ground processes, including organic matter production, decomposition, and compaction. Using the model, we successfully simulated accretion rates for sediment cores from a high-marsh site at Stiffkey marsh, UK, and from a mid-marsh site at Biloxi Bay, Mississippi. The use of both accretion rates and sediment characteristics for calibration made this model more realistic than other wetland sediment accretion models. Sensitivity analysis indicated that pore space, mineral matter deposition, ini-

tial elevation, sea-level rise, and below-ground production were the most important factors affecting model-generated accretion rates. The model was useful for predicting changes in wetland relative elevation due to increased sea-level rise. By changing site-specific parameters, it could be used to predict effects of sea-level rise at other coastal wetlands.

13 14 P-2 C

Callaway, J.C., Zedler, J.B., Pacific Estuarine Research Laboratory, San Diego State University, San Diego, CA. **INTERTIDAL WETLAND MESOCOSMS SUGGEST RESTORATION ADVICE.**

Tidal wetland mesocosms at Tijuana Estuary NERR failed to elucidate effects of hydrologic treatments (excluded, impounded, and fully tidal systems; each +freshwater inputs) on pickleweed (*Salicornia virginica*). Although soil salinity increased where tidal flushing was excluded (salinities were -20 to 50% higher in the excluded mesocosms), *Salicornia* cover and algal chlorophyll did not differ among treatments. Effects were seen only in *Salicornia* branch elongation rates (~30% decrease where tides were excluded). We failed to show differences between impounded and fully tidal conditions because the mesocosms had coarse sediments, and impounded water easily drained via subsurface flow. However, the problems with the mesocosms led to this advice for future wetland restoration projects: 1) marshes constructed from uplands or other coarse substrates are unlikely to provide the desired hydrology; 2) conditions for establishing pickleweed may differ from those that allow plant growth and survival; 3) an existing natural marsh may not be the best guideline for the establishment of vegetation; 4) alternative methods of assessing plant growth (hand-held radiometry and remote sensing) are useful and efficient tools for assessing restoration projects.

5.2 4 O C S

Cannon, T.A., Wu, K.W., Blum, L.K., Laboratory of Microbial Ecology, Department of Environmental Sciences, University of Virginia, Charlottesville, VA. **RELATIVE IMPORTANCE OF BACTERIA AND PHYTOPLANKTON TO HIGHER TROPHIC LEVELS IN AUTOTROPHIC AND HETEROTROPHIC ESTUARIES.**

The relative importance of phytoplankton and bacteria to consumers was compared in tidal creeks of a net autotrophic and a net heterotrophic estuary. Grazing of bacterial cells was compared to grazing of phytoplankton cells using a dilution technique. Standing stock and production of both bacteria and phytoplankton were also measured. Bacterial abundance, biovolume, and productivity were all significantly greater in autotrophic water, but bacterial standing stock turnover times were slower than in heterotrophic water. Grazing constants for consumption of bacteria were consistently higher in the heterotrophic (mean = 0.034 h⁻¹) than in the autotrophic (mean = 0.014 h⁻¹) creeks. The phytoplankton standing stocks were consistently greater in the autotrophic system than in the heterotrophic estuary (25.6 ± 1.6 and 12.0 ± 0.3 mm chl-a L⁻¹, respectively for June 1995). Phytoplank-

ton production was at least twice as high for the autotrophic water. In contrast to measures of grazing on bacteria, consumption of phytoplankton appears to balance production in the autotrophic estuary, while no measurable grazing of phytoplankton was observed in the heterotrophic estuary. These results suggest that bacteria in autotrophic waters function primarily in nutrient cycling, but that when phytoplankton standing stock and production are low, bacteria may function as important secondary producers if allochthonous sources of carbon are available.

9.2 3 O C

Capobianco, M., Ruol, P., Abrami, G., Tecnomare, S.p.A., Venezia, Italy, Universitario di Padova, Padova, Italy, Istituto Universitario di Architettura, Venezia, Italy. **LARGE-SCALE, LONG-TERM IMPACTS ON THE EVOLUTION OF THE PO DELTA PLAIN DEFINITION OF SCENARIOS.**

The Po is economically the most important river in Northern Italy. It is of major importance for the supply of water to large, socioeconomically important areas. The external delta is a zone enclosed by a series of low, sandy barrier islands, with lagoons, marshes, fish basins and narrow ridges in the north and with tidal flats and marshes in the east and south east. Present wetlands are almost entirely isolated and hydrologically controlled. On going management activities aim to control water quality, recover the hydraulic network and restore marshes area. However, it could be more economical to return sub-sea-level lands, now devoted to cereal cultivation, to their original lagoonal state, in favour of fishing. Climate Change and Management Options may have a great influence on the discharge regime of the river Po, on the wave climate, on the sediment supply and distribution, on the local subsidence and the relative sea level of the Northern Adriatic Sea. In perspective of the many uncertainties where changes in climatological variables are concerned, scenarios have to be considered prior to the definition of balances (of water, of sediment, etc.) on the deltaic area. Scenarios also need to be considered in respect of possible changes in land use which might alter the local patterns of evolution. A methodology has been defined in order to identify representative scenarios having in mind both the need for the definition of long term trends and possible changes in extremes.

36.1 2 O C

Caraco, N., Cole, J.J., Institute of Ecosystem Studies, Millbrook NY 12545. **ZEBRA MUSSEL INVASION IN A TURBID, RIVER ESTUARY: PHYTOPLANKTON RESPONSE TO INCREASED GRAZING**

Phytoplankton in nutrient rich, well mixed systems, like the Hudson, may be particularly susceptible to the impact of benthic grazers. Mixing increases contact between phytoplankton and benthic grazers. High nutrient concentrations decrease potential for compensatory growth by phytoplankton. Here we use the ongoing zebra mussel invasion in the Hudson River as an ecosystem-level experiment to test these

ideas. An eight-year data set, that covers pre- and post-invasion periods, is coupled with a simulation model of phytoplankton dynamics that tests system sensitivity to benthic grazing. Following the establishment of the zebra mussel there was an 85% reduction in summertime phytoplankton biomass. Changes in light, nutrient regime, planktonic grazers, or hydrology could not have been responsible for this decline. The mechanistic model demonstrates that zebra mussel grazing in the river was sufficient to cause a severe decline in phytoplankton. Our model also sheds light on which features of the Hudson make it particularly sensitive to the effects of benthic grazers. In addition to the previously stressed importance of a mixed water column and high nutrient conditions, our model identifies grazer effects on suspended inorganic load as a major determinant of phytoplankton sensitivity.

24.1 5 O C

Carlson, P., Florida Marine Research Institute, St. Petersburg, FL., and Yarbrow, L., Zieman, J., Heck, K., Dunton, K., Moncreiff, C., Frankovich, T. **PHYSIOLOGICAL RESPONSES OF THALASSIA TESTUDINUM TO IN SITU SHADING AT FOUR SITES IN THE GULF OF MEXICO.**

As part of a larger study examining responses of turtlegrass (*Thalassia testudinum*) to in-situ light reduction, we measured concentrations of dissolved sugars, starch, protein, and ADH activity in *Thalassia* rhizomes, as well as sediment porewater sulfide concentrations, at sites in Corpus Christi Bay (TX), St. Joseph's Bay (FL), and Florida Bay (FL). When data from all sites were pooled, all physiological parameters exhibited significant differences among light treatments in fall 1993 (less than six months after shade treatments began). Sugar, starch, and total carbohydrate concentrations were highest in outside control treatments, lower in control enclosures, and lowest in coarse and fine mesh shade treatments. Surprisingly, ADH activities followed a similar pattern among treatments, suggesting ADH synthesis or activity might be inhibited by extreme light attenuation. After fine mesh shade screens were removed in fall 1993, rhizome sugar, starch, and total carbohydrate concentrations rebounded to levels comparable to control treatments. These results indicate that *Thalassia* rhizome reserves are depleted by severe light attenuation, but *Thalassia*, by virtue of its reserves, has the capacity to survive prolonged periods of light attenuation.

22 12 P-3 C

Carr, R.S., Biedenbach, J., National Biological Service, Texas Gulf Coast Field Station, Corpus Christi, TX, and Hooten, R., May, L., Teas, T., Center for Coastal Studies, Texas A&M University- Corpus Christi, Corpus Christi, TX. **SEDIMENT QUALITY ASSESSMENT STUDIES IN LAVACA BAY, TEXAS - AN ESTUARINE SUPERFUND SITE.**

A sediment quality assessment survey was conducted in the Lavaca Bay system which has been designated a Superfund site because of elevated concentrations of mer-

cury and other contaminants (e.g., PAHs) in the sediments. Twenty-four stations were sampled in the initial survey. Sediment pore water was extracted pneumatically and the toxicity of the pore water determined using the sea urchin fertilization and embryological development assays. Subsamples of the sediments were analyzed for metals, PAHs, and pesticides. Nineteen of the 24 sites were toxic in either the sea urchin fertilization or embryological development assays. Based on these results, several of the most toxic sites were resampled and a preliminary toxicity identification evaluation (TIE) was performed with the pore water using the sea urchin fertilization test. Preliminary results indicated that the toxic components were removed by adsorption on a C-18 column but were not affected by EDTA additions and, therefore, the primary toxicants are hydrophobic in nature.

30.2 4 O C

Carter, V., Rybicki, N.B., U.S. Geological Survey, Reston, VA. **REQUIREMENTS FOR SURVIVAL OF SUBMERSED AQUATIC MACROPHYTES IN A FRESH-WATER TIDAL RIVER.**

A decade of research on macrophyte-light relationships in the freshwater tidal Potomac River and oligohaline transition zone of the Potomac Estuary has demonstrated that light is the primary factor affecting distribution and abundance of submersed macrophytes. A large number of secondary and tertiary variables affect the availability of light and thus partially control the increase or decrease in plant cover. Secondary variables include available sunshine, total suspended sediment, and chlorophyll a concentration. Tertiary variables (those affecting secondary variables) include wind speed, river discharge, and water column nitrogen and phosphorus concentrations. Plant cover decreases when mean seasonal Secchi depths are < 0.65 m or the attenuation coefficient (K) exceeds 2.1 m⁻¹. These low Secchi depths or high Ks are associated with mean seasonal chlorophyll a and suspended sediment concentrations of >15 µg l⁻¹ or >19 mg l⁻¹, respectively. Addition of underwater light results in survival of plants even when critical light penetration, chlorophyll a, and suspended sediment values are exceeded. Increase or decrease in populations is regulated not only by light conditions, but by reproductive success during the previous year and loss of overwintering propagules by predation, burial, freezing, and erosion. Most of these factors are beyond human control, and thus management must concentrate on water-column nutrient and total suspended sediment concentrations.

25 21 P-3 C

Carvalho, R., Santschi, P., Texas A&M University, Department of Oceanography, Galveston, TX. And Benfield, M., Woods Hole Oceanographic Institution, Department of Biology, Woods Hole, MA. **BIOAVAILABILITY OF COLLOIDAL FORMS OF TRACE METALS TO PENAEID SHRIMP.**

While many studies have been carried out on the bioavailability and toxicity of trace metals in ionic form, not much is known about the bioavailability of colloidal

complexed forms. Experiments were designed to compare bioavailability and depuration of selected colloiddally complexed and free ionic radioactive metals at ambient estuarine concentrations to penaeid shrimp. Penaeid shrimp are an ecologically and commercially important, broadly distributed decapod species; their close linkage to heavy metal sinks (detritus, benthos, and sediments) makes them an excellent choice as a bioindicator. Three main mechanisms of uptake and depuration were ascertained by the dissection and subsequent gamma counting of the parts of shrimp, i.e., uptake by 1) gills / exoskeleton (carapace), 2) digestive system (hepatopancreas), and 3) muscle/tissue (abdomen) during early life stages. Preliminary results have shown that metal accumulation is highest in the hepatopancreas (specific activity per gram) followed by the carapace and abdomen. Our hypothesis which is being tested is that A type (strongly hydrolyzing) metal ions are associated with hydrophyllic colloids, which decreases their bioavailability to organisms, and B type metal ions (and organometallics) are associated with lipophyllic colloids, which increases bioavailability. From these initial tests, it is clear that longer-term studies are necessary to evaluate the kinetics of uptake and depuration of specific parts. Mortalities due to canabilism, poor water quality, or stress have been eliminated by recent changes in experimental protocol. Longer-term experiments are currently being assessed.

16.1 1 O C S

Castellanos, D., Rozas, L., University of Southwestern Louisiana, Department of Biology, Lafayette, LA and NOAA/National Marine Fisheries Service, Galveston Laboratory, Galveston, TX. **COMPARISON OF HABITAT UTILIZATION BY NEKTON SPECIES IN THE ATCHAFALAYA DELTA.**

We sampled fishes and macrocrustaceans of intertidal habitats on three natural islands of the Atchafalaya Delta as part of a study completed in summer 1995. Four different habitats (as defined by dominant vegetation and location) were sampled in July 1994 with a one square meter throw trap: *Potamogeton nodosus*, *Najas guadalupensis*, *Scirpus americanus* located behind delta islands, and streamside *S. americanus*. We collected a total of 20 species of fishes and 5 species of decapod crustaceans in 48 samples (12 in each habitat). Rainwater killifish *Lucania parva* and sheepshead minnow *Cyprinodon variegatus* accounted for >75% of the total number of fish associated with each habitat except streamside *S. americanus*. Blue crab *Callinectes sapidus* and freshwater grass shrimp *Palaemonetes paludosus* accounted for >83% of the total number of crustaceans in every habitat. Overall, animals were significantly more abundant in the submersed aquatic vegetation, *P. nodosus* and *N. guadalupensis*, than in the two habitats dominated by emergent vegetation (*S. americanus*). Our results seem to suggest numerical dominance by a few species which show a preference of inland over streamside habitat.

21 7 P-3 C

Chambers, R., Fairfield University, Fairfield, CT.

POREWATER NUTRIENT CHEMISTRY IN PHRAGMITES AND SPARTINA WETLANDS.

Monotypic stands of the common reed *Phragmites australis*, which decrease wetland plant diversity, are expanding in natural, disturbed and restored wetlands throughout the U.S. Limits of *Phragmites* expansion in brackish tidal marshes in the U.S. are in part determined by edaphic conditions of salinity and hydroperiod/depth of flooding. The purpose of this study was to determine whether the nutrient chemistry of wetland soils corresponds with 1) edaphic conditions and 2) observed patterns of *Phragmites* invasion in a *Spartina alterniflora* marsh. Using in situ tension lysimeters, I collected and analyzed porewater along 5 transects in wetlands of the lower Housatonic River, CT; each transect graded from lower elevation stands of *Spartina* to higher elevation stands of *Phragmites*. Among transects, salinities ranged from near 5 to above 20 ppt; sediment sulfide concentrations were higher at lower marsh elevations. Dissolved ammonium and phosphate concentrations were variable both by depth (10, 20 and 30 cm) and by dominant vegetation type. Although the expansion of *Phragmites* stands does not appear limited by porewater nutrient concentrations, sediment sulfide and persistent flooding could influence nutrient uptake and plant growth.

8 22 P-1 C

Chen, J., National Laboratory of Estuary and Coastal Research, and Institute of Estuarine & Coastal Research, East China Normal University, Sliai-iglai 200062, P.R.China) **NATURAL ADJUSTMENT AND ARTIFICIAL REGULATION IN THE CHANGJIANG ESTUARY.**

Estuarine development is mainly governed by the processes of natural adjustment. Understanding the law of estuary's self-regulation is an important way toward the artificial regulation in estuaries. This paper analyzes 1) the basic characteristics of the Changjiang Estuary as an integrated natural system, 2) the processes of natural adjustment and the estuarine development under the time- scale of 2000 years, 3) the natural adjustment under the time-scale of 50 years and the recent changes of estuarine channels. The successful examples of artificial regulation since this century in the Changjiang Estuary are illustrated and, on this basis, the fundamental principles associated with the artificial regulation in the Changjiang Estuary are summarized which has provided a theoretic basis for the present deep-water estuarine channel planning and its future regulation.

31 39 P-3 C

Chen, X., Lohrenz, S.E., Wiesenburg, D.A., University of Southern Mississippi, Center for Marine Sciences, Stennis Space Center, MS. **COMPARISON OF THE DISTRIBUTIONS OF PHOTOSYNTHETIC PARAMETERS AND PRIMARY PRODUCTION IN RELATION TO HYDROGRAPHIC CONDITIONS IN LOUISIANA-TEXAS COASTAL WATERS DURING SUMMER 1993 AND 1994**

Knowledge of the distribution of primary production in

the northern Gulf of Mexico is essential to understanding the region as a large ecosystem. It is required for studies of carbon transport, food web dynamics, and the development of hypoxia in the region. The accuracy of primary production estimates depends on a better understanding of the variability of photosynthetic parameters and the environmental factors that affect them. In the northern Gulf of Mexico, hydrographic conditions in summer 1993 and 1994 differed because of fluctuations in river discharge. This provided an opportunity to evaluate relationships between the hydrography and distribution of photosynthetic parameters and primary production. On two cruises of the Louisiana-Texas Shelf Circulation and Transport Processes Study (LATEX A) in the northern Gulf of Mexico during summer (July-August) of 1993 and 1994, efforts were made to characterize the distribution of parameters of photosynthesis-Irradiance (P-I) saturation curve and of integrated primary production derived from a model using P-I parameters. The study area during summer 1993, compared with that of 1994, was characterized by higher river discharge from the Mississippi and Atchafalaya rivers, higher solar Irradiance, higher surface temperature, and a thinner surface mixed layer. Despite the differences in hydrographic conditions, the mean values of P-I parameters for the two summers were not significantly different. However, the higher river discharge in summer 1993 apparently resulted in higher variations among the P-I parameters. In both summers, the highest integrated primary production occurred in the region of mid-salinity ($S=20-25$), close to the Mississippi River plume. The integrated primary production in summer 1994 was higher due to deeper vertical mixing and higher chlorophyll *a* concentration in the mixed layer in most of the study area. While the mean values of photosynthetic parameters were apparently not affected by differences in hydrography, the horizontal distribution of integrated primary production was strongly modified by differences resulting from variations in freshwater input and large scale meteorological forcing.

20.1 2 O C

Childers, D.L., Florida International University, Miami, FL; and **Koepfler, E., Dame, R.**, Coastal Carolina University, Conway, SC, and **Kjerfve, B.**, University of South Carolina, Columbia, SC. **USING MULTIPLE SPATIAL INDICES TO RELATE STRUCTURE AND FUNCTION IN ESTUARINE ECOSYSTEMS.**

Several recent studies have attempted to use fractal dimensions of salt marsh and estuarine shorelines to classify the spatial characteristics of these systems. Most have shown very similar fractal dimensions among different salt marsh systems, and have thus concluded that they "look alike". We used a number of one and two-dimensional spatial indices to quantify the structure of 8 Atlantic coast estuarine systems of widely varying size and geographic location. One-dimensional indices included fractal dimension and several from Horton's Law of stream numbers. Two-dimensional indices included measures of habitat diversity, dominance, and contagion, and fractal dimension. We used remotely-sensed imagery to calculate these spatial indices for marshes at Sapelo

Island, GA, North Inlet, SC, and two smaller Chesapeake Bay marshes. These multivariate "fingerprints" indicate that, in fact, all salt marsh systems do not "look alike". We are currently relating these measures of ecosystem structure to data that represent integrated ecosystem function—fisheries harvests, habitat utilization, nutrient and organic matter flux. Early results suggest that much of the inter-system variability seen in these functional variables may be explained by the structural uniqueness of salt marsh estuaries.

9 1 P-2 C

Chipouras, E., Miyamoto, M.M., Department of Zoology, University of Florida, Gainesville, FL. **A SIMULATION MODEL FOR GENERATING THE EXPECTED EFFECTS OF VARYING SALINITY ON ESTUARINE FIN FISHES.**

There are biophysical reasons to expect that estuarine habitats, by virtue of their intermediate salinity, should provide an energetic advantage to fishes that is not available to fishes living in either marine or freshwater habitats. The magnitude of this advantage should depend on the spatial and temporal characteristics of the salinity distribution encountered. A model was developed to generate a series of sigmoidal distributions that varied systematically with respect to mean salinity and amplitude. For each distribution, the model produced a second distribution using an algorithm that relates the expected instantaneous energetic expense to the salinity gradient which exists across the organism's body surface. A total expected expense was computed for each distribution by integrating the instantaneous expense over a 12 hr interval. The totals for all of the distributions considered were then plotted as a function of mean salinity and amplitude. The results of this simulation describe the sort of conditions where the direct benefits of living in intermediate-salinity habitats are maximal, and they suggest yet another factor motivating fishes to exploit estuaries. This approach provides a mechanism for examining the effects changes in field salinity distributions, brought about by climatic or anthropogenic factors, are likely to have.

37 40 P-2 C

Chiscano, C.L., Kaldy, J.E., Dunton, K.H., University of Texas at Austin, Marine Science Institute, Port Aransas, TX. **AGE STRUCTURE AND SHOOT DEMOGRAPHY OF SHALLOW AND DEEP *THALASSIA TESTUDINUM* POPULATIONS IN CORPUS CHRISTI BAY, TEXAS.**

Age structure and shoot demography of the Turtle grass (*Thalassia testudinum*) was studied in Corpus Christi Bay (East Flats, EF, 0.6m depth) and in neighboring Redfish Bay (RFB, 1.7m) in the Nueces Estuary, Texas. Measurements of underwater irradiance, shoot density, short shoot internode production, and flowering frequency were collected in July 1995. This data was used in calculations of shoot mortality, recruitment rates, shoot age structure, and net annual new shoot production. The density of the plants at RFB was significantly lower than at EF, and was probably related to underwater light levels, which were 30% lower at RFB com-

pared to EF. The short shoot age structure was based on Plastochrone Intervals (PI) estimated using standard leaf marking techniques. The average annual PI was 12.12 d leaf⁻¹. The oldest shoot found at EF was 11.8 years old and at RFB the oldest shoot was 9.4 years old. EF and RFB plants first flowered between 1 and 2 years of age (10-24 PI). Successive flowering events occurred at regular intervals of 1.5 years in EF and sporadically in RFB. The average annual percentage of shoots that flowered was 3.09% in EF and 1.36% in RFB. The average number of rhizome internodes was 10, and 8 to 10 for EF and RFB, respectively. RFB had a higher mortality rate (0.403 ± 0.063 ln units yr⁻¹) than EF at 0.27 ± 0.043 ln units yr⁻¹. For both sites the average age at death was from 1.5-3.5 years (20-40 PI). The gross recruitment rate was 0.16 ln units yr⁻¹ for EF and for RFB it was 0.30 ln units yr⁻¹. The net annual new shoot production for both EF and RFB was -0.11 ln units yr⁻¹. This work represents the first measurements of seagrass demography in Texas and will be compared with future data from these same sites as well as locations in Laguna Madre, Texas.

31.2 1 O C

Chmura, G.L., Helmer, L.L., McGill University, Dept. of Geography, Montreal, QC H3A 2K6 Canada. SALT MARSH STABILITY AT DIPPER HARBOUR, BAY OF FUNDY.

Sediments of the Dipper Harbour marsh, Bay of Fundy, provide a high-resolution record of changes in vegetation and sediment accumulation rates. Using pollen analysis we have dated sediments at 22 cm-depth which were deposited when the first European settlers came to the region in 1786. Further analyses of concentrations of charcoal, lead, and zinc, as well as the radionuclides lead-210 and cesium-137, show that over the last 200 years sediment accumulation rates varied from 0.6 to 2.1 mm/yr, averaging 1.2 mm/yr for the last 70 years. Readings from the tide gauge at Saint John, New Brunswick show an increase in mean sea level of 2.5 mm/yr averaged over this same period. It has been suggested that approximately one half of this apparent increase in mean sea level can be attributed to increased tidal range in the Fundy basin. If so, then long-term marsh accretion is in equilibrium with sea level rise, despite climatic fluctuations and changes in the local disturbance regime. Over this same period, however, there have been major shifts in vegetation zones, presumably in response to both anthropogenic disturbance and changes in precipitation and temperature.

37 41 P-2 C

Christian, T. University of the District of Columbia, Washington, DC. SURVIVAL OF JUVENILE BLUE CRABS AS A FUNCTION OF VEGETATION AND DEPTH IN THE YORK RIVER, VA.

Juvenile blue crabs (*Callinectes sapidus*), 25 - 50 mm, were captured by scraping and held in aerated tanks. The crabs were tethered by gluing monofilament line to the carapace and attaching to stakes with floating markers in the York River, VA. The stakes were placed in shallow (20-40 cm depth

at mean low tide) and deep (80 - 100 cm) sites with and without seagrass vegetation. There were four replicates with six crabs each. Survival was noted after 24 hours. Crabs placed in shallow sites had higher survival than in deep sites and in vegetated sites higher than unvegetated. The shallow vegetated sites provided greatest protection from predators, which are primarily other blue crabs and fish such as spot and croaker.

13.1 4 O C

Cieslik, L.J., Partnership for the Sounds, Columbia, NC, and Rulifson, R.A., East Carolina University, Greenville, NC. PARTNERSHIP FOR THE SOUNDS: ADDRESSING THE NEED FOR ENVIRONMENTAL EDUCATION, RECREATION AND CONSERVATION IN EASTERN NORTH CAROLINA.

North Carolina's Albemarle/Pamlico estuarine system is the second largest in the United States and the largest lagoonal estuarine complex on the East Coast. The Albemarle/Pamlico peninsula, a large landmass comprised of extensive wetlands and agricultural lands, juts into the lagoonal complex to separate Albemarle Sound (north) from Pamlico Sound (south). The peninsula watershed at near sea level precludes many of the land development options desired by local residents. The Partnership for the Sounds (PFS) was formed in 1993 from grassroots initiatives to build a prosperous and sustainable economy in this area through ecotourism and environmental education programs. Partners in this initiative are federal and state agencies, county governments, and industry. Four environmental education centers will reflect the cultural and natural history of the region and encourage exploration of the region's extensive wetland areas. Supporting environmental education programs and information will educate the public on the interdependence of all the natural communities in the watershed. The PFS initiative to address regional needs for sustainable community-driven economic and environmental well being is a model approach for other areas of the country that are striving to create and equilibrium between nature and economic prosperity.

16 27 P-1 C

Clark, R., University of South Alabama, Mobile, AL, and Stout, J., Marine Environmental Sciences Consortium/University of South Alabama, Dauphin Island, AL. REPRODUCTIVE ECOLOGY OF VALLISNERIA AMERICANA IN AN ESTUARINE ENVIRONMENT.

Male and female populations of wild celery, *Vallisneria spiralis*, were monitored in Mobile Bay, AL to determine reproductive phenology and potential. Although studies in riverine and lake systems have indicated low reproductive output, estuarine beds averaged 77 female flowers and 85 male flowers per square meter. Fruits contained an average of 167 seeds and 5cm-deep sediment cores contained a mean seed reservoir of 23 seeds per 9.6 cm² (23,958 m⁻²). Seeds were found in sediment cores throughout the year but in the late spring as many as 80% appeared damaged by grazing.

Mature fruits are buoyant for several days if separated from the pedicel and should be transported to areas outside of the parent beds to colonize suitable bare substrates or expand existing beds. However, the high reproductive potential of *Vallisneria* does not appear to be realized in this estuarine setting. Seedlings are rarely observed and bare areas once covered by the species have not been recolonized from surviving beds. Salinities in the upper Bay range from 0 to 11 ppt and are suspected to have an effect on seed germination and seedling survival except in the freshest portions of the Bay.

37 42 P-2 C

Clarke, N., Choo, D., Bailey, R., Chillrud, S.N., Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY. TRACE METAL TRENDS AND FINE-GRAINED SEDIMENT FLUXES IN THE UPPER HUDSON RIVER, NEW YORK.

Temporal trends of Cd, Cu, Cr, Pb, and Zn were derived from dated (Cs-137 and Be-7) fine-grained sediment cores collected from the upper Hudson River and its major tributaries (Battenkill, Hoosic, and Mohawk). Maximum metal concentrations in the most upstream core (~188 miles north of Manhattan) were a factor of 10-340 times above estimated natural levels (EF_{max}). EF_{max} of Cd, Cu, Pb, and Cr ranged from a factor of 1.1-7.7 in the tributary cores. Zn was found at high levels during the 1960s in the Battenkill river (EF_{max} 16). There was a general decrease towards the present in most metal concentrations in all tributaries except the Hoosic. A conservative mixing model was used to constrain the net amount of fine-grained sediment entering the river from tributaries, bank erosion and resuspension of previously deposited sediments between the most upstream core collected in the highly contaminated area of the upper Hudson (in PCBs, Cd, Cr, and Pb) and the tidal freshwater Hudson, 40 miles downstream (near Albany). Sediments from the tributaries enter the Hudson between these two points. Cr measurements resulted in a dilution factor of ~16-18. Significant influxes of Pb from the Albany metropolitan area are suggested by the model.

13.1 2 O C

Clements, L.A.J., Dept. Biology and Marine Science, Jacksonville University, Jacksonville FL. INCORPORATING ENVIRONMENTAL SCIENCE INTO INTRODUCTORY BIOLOGY LABORATORIES AT THE COLLEGE LEVEL.

The theme of environmental influence in biological systems at all levels of organization was added to the Introductory Biology course at Jacksonville University using the campus as our field station. The goals of this project were to increase the relevance of skills and concepts presented in the introductory biology to both majors and non-majors enrolled in the course, to make laboratories significantly more investigative and to increase the computer literacy of our students with regard to the process of science. Students in BLY 120 investigated the campus through a series of field trips looking at the forested upland, freshwater stream, plant

distribution, plankton assemblages of the St. John's Estuary and soil microbiology. These field studies provided the platform for questions investigated in benchtop experiments. Computer assisted data analysis was required, as was participation in e-mail discussions of the data. Assessment data indicated a high degree of satisfaction with the course content and enthusiasm for the laboratories. Content-based assessment showed that students in the pilot section retained significantly more information than those in non-revised sections. Plans are to expand the revision to multiple sections with ongoing assessment and publication of the laboratory manual.

22 13 P-3 I

Coakley, J.P., Fox, M.E., Bourbonniere, R.A., National Water Research Institute, Burlington, Ontario, Canada and Smith, D.S., Geology Department, McMaster University, Hamilton, Ontario, Canada. INVESTIGATION OF VERTICAL TRENDS IN COPROSTANOL IN HAMILTON HARBOUR SEDIMENTS, LAKE ONTARIO, CANADA.

Coprostanol (5 β -cholestan-3 β -ol) has been used extensively as a natural tracer of sewage-contaminated sediments, and was used here in studying historical trends in the input of contaminants from a sewage treatment plant (STP). A 1-m long diver-collected core from near the outfall of the Burlington Skyway STP was analyzed for coprostanol and related steroid compounds. The core was also dated using Pb-210. Concentration profiles of both coprostanol and its ketone, coprostanone (5 β -cholestan-3-one) fell sharply below a depth of 10 cm (dated at ca. 1985) by approximately 2 orders of magnitude to levels that remained fairly uniform to the end of the core. Because it is known that the STP began operations in 1962, this more recent date for the transition from what appears to be background levels (non-STP source) to levels associated with the STP operation raises the question of additional controls on the concentration profile, such as in-situ degradation or changes in effluent discharge related to population growth or STP modifications. Examination of the ratio between the coprostanol and ketone concentrations revealed a smooth increasing trend in the top 25 cm indicating unchanged sources, followed by a sharp trend change below this level. The transition was dated at ca. 1965. This result suggests that initiation of STP operations is best reflected in the ratio trend. The ca. 1985 rise in raw concentrations could be due either to slow diagenesis of the compounds in the sediments or the dramatic population increase of Burlington over the past decade.

36.1 1 O C

Coen, L.D., Wenner, E.L., Knott, D.M. Stender, B., Marine Resources Research Institute, SCDNR, Charleston, SC. INTERTIDAL OYSTER REEFS AS CRITICAL ESTUARINE ENVIRONMENTS: EVALUATING HABITAT USE, DEVELOPMENT AND FUNCTION.

In South Carolina, over 95% of the oysters grow intertidally (tidal ranges > 2 m), versus subtidally, making them very different from reefs studied elsewhere. By forming exin

tensive "biogenic" reefs, *Crassostrea* serves as a "key-stone species", generating three-dimensional habitat, both as living organisms and dead shell. Whether these intertidal habitats are functionally equivalent to other structured habitats, such as seagrasses is an important question. Two sites are under study: a "pristine" oyster flat and a "degraded" area adjacent to a marina. Three replicate experimental reefs (each 23 m²) were constructed at each site and we have developed and initiated sampling for transient and resident faunas, including a novel flume net system for quantifying transient species. We are also following the development of the resident reef community, collecting continuous environmental data, and comparing contaminant levels, oyster diseases (Dermo and MSX) and other life history parameters (e.g., growth, condition indices, reproduction) on the experimental reefs, as well as nearby natural reefs. To date we have collected over 24 economically and ecologically important fish and decapod transient species (dominant genera, *Penaeus*, *Palaemonetes*, *Anchoa*); densities often exceed 1,000 individuals/reef. By initiating and following the long-term reef development, we will be able to explore potential changes in reef habitat status and function during reef succession.

2.4 7 O C

Cole, J.J., Caraco, N.F., Raymond, P., Institute of Ecosystem Studies, Cary Arboretum AB, Millbrook NY 12545
CARBON DIOXIDE DYNAMICS IN THE HUDSON RIVER ESTUARY.

We made direct and indirect measurements of the partial pressure of CO₂ (P_{CO₂}) in the tidal-freshwater portion of the Hudson River Estuary. At all spatial and temporal scales the Hudson is supersaturated in CO₂ with respect to the atmosphere. P_{CO₂} in the surface water averaged 1125 ± 403 (SD) μatm while the atmosphere averaged 416 ± 68 μatm. Weekly samples at a single, mid-river station showed a pronounced and reproducible seasonal cycle with highest values (~2000 μatm) in late summer and lowest values (~500 μatm) in late winter. Samples taken along the length of the 240-km section of river showed a general decline from north (~2000 μatm) to south (750 μatm). This decline was most pronounced in summer and very slight in spring. Diel and vertical variation were relatively small in comparison to the standing stock of CO₂. Over six diel cycles, all taken during the algal growing season, the mean range was 300 ± 114 μatm. CO₂ tended to increase slightly with depth but the gradient was small, about 0.5 μmol m⁻¹, or an increase of 190 μatm from top to bottom. Combining our measurements with recent experimental studies of gas exchange in the Hudson we estimate that the Hudson releases about 20 mmol CO₂ m⁻² d⁻¹ from the river to the atmosphere. This flux (~90 g C m⁻²y⁻¹) is much smaller than present estimates of the amount of allochthonously supplied C that is respired in the river.

20 2 P-3 I

Coniariis, C., Loder, III, T.C., Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham,

NH. CAPE COD BAY: A SEASONAL CIRCULATION-DRIVEN NUTRIENT TRAP.

Nutrient distributions were measured during five hydrographic cruises from Aug. 1993 to Dec. 1994. We found that nutrients are concentrated on a seasonal basis in relatively shallow (20-50 m) bottom waters until the system resets itself with the fall overturn in early November. Maximum concentrations (silicate ca. 30 5M, phosphate ca. 1.8 5M and nitrate ca. 13 5M) occur during the late summer and early fall. Phosphate and silicate concentrations are much higher relative to nearby coastal regions whereas nitrate concentrations are proportionally lower when compared to phosphate and silicate. The mechanism of concentration involves the geostrophic circulation of the Gulf of Maine coastal current which varies in intensity seasonally due to variable freshwater runoff. During summer months, this current is generally weaker resulting in a longer residence time for waters in Cape Cod Bay. We hypothesize that organic matter, mainly produced by the early spring diatom bloom within Cape Cod Bay, settles to the shallow bottom and is subsequently remineralized during the warm summer months. The released nutrients are then trapped due to vertical stratification and increased residence time. The relatively low nitrate concentrations compared to silicate and phosphate suggest that selective remineralization and/or denitrification are occurring in these waters.

31.3 6 O I

Conner, W.H., Baruch Forest Science Institute, Georgetown, SC, McLeod, K.W., McCarron, J.K., Savannah River Ecology Laboratory, Aiken, SC. **RESPONSE OF FORESTED WETLAND SPECIES TO INCREASED FLOODING AND SALINITY.**

As sea level rises in coastal and riverine systems of the United States in coming years, areas which were once beyond normal flood levels will be inundated. Although flooding is a natural occurrence in forested wetlands, increased inundation and salinity intrusion will have substantial impacts on these forests, leading to changes in forest structure. Ongoing tree growth studies in Louisiana, an area rapidly subsiding, show that bottomland hardwood forests are being replaced by cypress as flooding increases, and cypress forests are dying as saltwater moves inland. A research program in South Carolina has been focusing on the response of woody species to increased inundation and salinity. Ten species, with a range of flood tolerance, have been chronically (simulating sea level rise) and acutely (simulating hurricane storm surge) exposed to increased inundation and salinity in a complete factorial experiment. Photosynthesis, stomatal conductance, xylem pressure potential, and height were measured monthly during the growing season. Root, shoot, and leaf biomass were determined at the end of the study. Although there is some variation in the degree of impact, all of the tested species would be seriously impacted by increased salinity and inundation from either hurricane storm surge or sea level rise.

3.2 4 O C

Connor, M.S., Massachusetts Water Resources Authority, Boston, MA. **ENVIRONMENTAL SCIENCE AS AN IMPEDIMENT TO RATIONAL ENVIRONMENTAL POLICY.**

The biggest problem in environmental policy is deciding what the big problems are. Resources to solve environmental problems are rarely sufficient, so it is important that these limited resources be appropriately concentrated on the highest priority issues. Progress in a scientific field often starts with observations and then classification into groups with similar behaviors. As a field matures, detailed conceptual models can be developed that explain system functions and cause-effect relationships. Coastal environmental management is a very young field, still in the observation and classification stage. Most successful approaches have been in classification — quick comparative assessments to evaluate problems around the country (NOAA Status and Trends) or historic trends (Chesapeake Bay Program). However, these kinds of efforts favored by the policy community rarely retain the interest or support of the scientific community. The alternative policy approach emphasizes the development of detailed protective standards and fate and transport models or measurements to compare against those standards. Development of standards has proven to be resource-intensive, resulting in detailed solutions for some problems with only spotty overall coverage. While estuarine scientists advocate for more detailed, basic research, I believe the practical problem-solving roots of estuarine science yields the richer payoff for environmental managers. It is in the interest of both managers and scientists that a unified strategy be pursued in the future.

15 20 P-2 C

Conrads, P., U. S. Geological Survey, Columbia, SC, and **Wachowski, J.**, South Carolina Department of Health and Environmental Control, Columbia, SC. **SIMULATION OF FLOW, SALINITY TRANSPORT, AND DISSOLVED OXYGEN OF THE ASHLEY RIVER NEAR CHARLESTON, SOUTH CAROLINA**

Nutrient and dissolved oxygen concentrations in the Ashley River were simulated using the Branch Lagrangian Transport Model (BLTM). The Ashley River is a estuarine tidal slough that is a tributary to Charleston Harbor, located near the middle of the South Carolina coast. The mean and spring tidal ranges near the confluence with the harbor are 1.8 m and 2.0 m, respectively. The model domain of the Ashley River system includes two open-water boundaries. Gauging stations with continuous monitors of water level, salinity, temperature, and dissolved oxygen are located at the two boundaries and at one interior location. Hydrodynamic data for the BLTM model were simulated using the one-dimensional unsteady flow model, BRANCH. The flow model was calibrated and verified using water level, flow, and salinity data. The dispersion rates in the BLTM were determined by calibrating the model for salinity transport in the estuarine system. The model was then calibrated and

verified for temperature, algae, organic nitrogen, ammonia, nitrate, dissolved phosphorus, ultimate carbonaceous biochemical oxygen demand and dissolved oxygen. Calibration and verification were achieved when the mean predicted constituent concentration for the period of observed data fell within the range of the observed data.

15.1 4 O C

Conrads, P., U.S. Geological Survey, Columbia, SC, and **Smith, P.**, South Carolina Department of Health and Environmental Control, Columbia, SC. **A COMPARISON OF SIMULATIONS OF SALINITY TRANSPORT OF THE COOPER AND WANDO RIVERS, SOUTH CAROLINA, USING THE BRANCHED LAGRANGIAN TRANSPORT MODEL AND THE WATER QUALITY ANALYSIS SIMULATION PROGRAM**

The Branched Lagrangian Transport Model (BLTM) and the Water Quality Analysis Simulation Program (WASP5) were applied to the Cooper and Wando Rivers, South Carolina, to evaluate which model more accurately simulated the salinity transport in the system. The two one-dimensional models use different approaches to solve the solute transport equation. The Cooper and Wando Rivers are tidally affected systems that are major tributaries to the Charleston Harbor which is located near the middle of the South Carolina coast. The mean and spring tidal ranges of the harbor are 1.7 m and 1.9 m, respectively. The model domain of the two river system includes six open-water boundaries. Gauging stations with continuous monitors of water level and salinity are located at the open-water boundaries and at four interior locations. The models were used to simulate salt transport for a 7-day period, following an 8-day spin-up period. Both models used the same boundary salinity and input hydrodynamic data. The BLTM simulations were generally closer to the mean, range, and standard deviation of the observed data than those of WASP5. On the Wando River, the WASP5 simulations were significantly out of phase with the observed data. The BLTM was chosen over the WASP5 for continued one-dimensional water-quality modeling of the Cooper and Wando Rivers.

0 3 O I

Cook, S., Harbor Branch Oceanographic Institution, Ft. Pierce, FL and **Gilligan, M.**, Savannah State College, Savannah, GA. **THE SSC-HBOI SUMMER UNDERGRADUATE PROGRAM: A BRIDGE TO RESEARCH FOR UNDERREPRESENTED MINORITY STUDENTS.**

The Savannah State College - Harbor Branch Oceanographic Institution 'bridge' program, now in its second year of NSF support, introduces first and second year undergraduates to marine science and the fundamentals of scientific research. The program aims to prepare students for admission to Research Experiences for Undergraduates (REU) programs in the junior and senior year. Activities in the supportive environment of Savannah State College, a historically minority institution, include short courses in research design, sta-

tistics and technical writing as well as a class research project. After 4 weeks, the students move as a group to the professional research environment of HBOI where they carry out research projects in small teams under the supervision of research staff for 5 weeks. Additional components at both sites include interactions with minority mentors, field trips to a variety of marine laboratory settings, oceanographic cruise experience, career guidance and academic program counseling.

25.1 5 O C S

Cooper, D. C., Morse, J.W., Texas A&M University, Department of Oceanography, College Station, TX. SPECIATION AND GEOCHEMISTRY OF TOXIC METALS IN THE SEDIMENTS OF OFFATTS BAYOU, TX - A SEASONALLY HIGHLY EUXINIC BASIN.

Restricted exchange of water between Offatts Bayou (near Galveston, TX) and the adjacent West Bay results in this basin changing between oxic winter and highly sulfidic summer (greater than 500 μM SH_2S) bottom water conditions. It is, therefore, a "natural laboratory" for the investigation of the behavior of toxic metals in an estuarine environment where redox conditions undergo major variations. Field data demonstrate that reactions of toxic metals with sulfides are probably the dominant influence on their potential bioavailability in this type of environment. This is evidenced by large seasonal changes in concentrations of sedimentary sulfide minerals and associated trace metals. Variations in toxic metal concentrations can not be explained by cation exchange models because average solid-phase metal concentrations in surface sediments vary by factors of 4 to 40 whereas reactive-metal:AVS ratios are always less than one. In sediments with large seasonal variations in redox conditions, major cycling of toxic metals between benthic and pelagic systems occurs. Trends in the degree of trace metal pyritization support the theory that kinetic controls on oxidative dissolution of sulfide minerals and release of associated metals are a dominant factor in controlling toxic metal bioavailability in this type of environment.

15.3 6 O C

Corbett, C.W., Porter, D.E., Karinshak, D.A., Belle W. Baruch Institute for Marine Biology and Coastal Research University of South Carolina, Columbia, SC. MODELING SURFACE WATER RUNOFF, SEDIMENT, AND NUTRIENT LOADING IN COASTAL SOUTH CAROLINA: A COMPARISON OF AN UNDEVELOPED AND URBANIZED WATERSHED.

A distributed parameter (grid cell) agricultural nonpoint source runoff model (AGNPS) has been applied to two South Carolina coastal watersheds. The 38 hectare 'control' watershed, selected to represent undeveloped coastal land in South Carolina, is covered with mixed second growth hardwood and pine forest with interspersed cypress wetland, sandy soils, and very low elevational gradients (<1.0%). The test watershed is 15 hectares of residential and commercial areas and also contains a segment of major highway. The model simu-

lates surface water runoff, sediment erosion and transport, and nutrient loading of user defined single storm events. Although intended for agricultural watersheds, the model equations are applicable to a much wider range of land use with adequate empirical calibration data. In this case, model output was calibrated with field data gathered over one full year. The objective was to develop a computer simulation model which could be used to: 1) compare single-storm yield of surface water, sediment and nutrients in an undeveloped and urbanized coastal watershed; 2) investigate seasonal effects on single storm yield in the undeveloped and urbanized watersheds; and 3) simulate the effects of hypothetical land cover changes (e.g., the addition of impervious surface area) on watershed yield. GIS and remote sensing tools were used to develop model input data. Important functions of these tools in this study included watershed delineation and construction of the model grid, DEM construction to define aspect in each cell and thus define flow routing, and land cover classification. Initial results indicate surface water volumes and peak flow rates are roughly doubled in the urbanized watershed which is less than half the area of the undeveloped watershed. On average sediment concentrations are roughly 2.5 times greater in the urbanized watershed, but instantaneous sediment concentrations during peak runoff can be almost 2 orders of magnitude higher in the urbanized watershed. Nutrient concentrations are highly variable. Both watersheds exhibit a seasonal response producing different runoff volumes from the same depth of rainfall depending on time of year. As expected, the addition of impervious surface area has a major effect on watershed yield. Water volumes and peak flow rates increase dramatically and sediment concentrations decrease depending on surface size and location within the watershed. Extreme variability in watershed response at the spatial and temporal scale used in this study makes predictive, mechanistic modeling extremely difficult. Adequate field observation data are essential for model calibration. In spite of these difficulties, the model is useful if applied in a consistent method for relative comparison of watershed yields. In this study, it was clear the urbanized watershed yields greater surface runoff and sediment concentrations. Recommendations for future work to improve watershed modeling of nonpoint source components in coastal SC should include provisions for ground water influence, dry deposition and washoff of pollutants, and spatial variability of rainfall.

11.1 5 O C

Cornwell, J.C., Boicourt, W.C., Harding, L., Horn Point Environmental Laboratory, University of Maryland CEES, Cambridge, MD, and Cooper, S.R., Chesapeake Biological Laboratory, University of Maryland CEES, Solomons, MD. UNDERSTANDING EUTROPHICATION IN THE CHESAPEAKE: INDICATIONS OF ENVIRONMENTAL CHANGE AND CHANGES IN KEY ECOSYSTEM PROCESSES.

Although there is ample evidence for cultural eutrophication in the Chesapeake Bay, the timing and mechanistic causes for this environmental change are not well understood.

The purpose of this paper is to explore the evidence for environmental change at time scales 1) which require paleoecological and geochemical techniques (50 to > 100 years) and 2) in which modern monitoring techniques give quantitative assessments of concentrations and rates of key parameters and processes. Sedimentary evidence includes information on sediment nutrient concentration changes, changes in aquatic vegetation seed abundance, and diatom species composition, while recent direct measurements have shown changing nutrient inputs and concentrations, changing stocks of planktonic and submersed aquatic plants, and changes in fisheries yield. Changes in external nutrient loading and stocks of key aquatic resources have led to a change in key ecosystem processes. Examples include the effect of increased hypoxia/anoxia on sediment N and P recycling pathways and rates, loss of submersed aquatic vegetation from eutrophication-related light stress, and a general shift away from benthic primary production to planktonic primary production. Dissolved oxygen data indicate that a strong relationship between freshwater inflow and volume of anoxia was altered in the 1970-1980 time frame, with current levels of anoxic volume in excess of that predicted by long-term records. We will describe, in a qualitative manner, the changes in biological and biogeochemical processes which may have resulted in major changes to the Chesapeake Bay ecosystem.

7.1 5 O C S

Courtemanche, R.P., Hester, M.W., Mendelssohn, I.A., Louisiana State University, Wetland Biogeochemistry Institute, Baton Rouge, LA. **RESPONSE AND RECOVERY OF THE ISLES DERNIERES BARRIER ISLAND MARSH PLANT COMMUNITIES TO HURRICANE INDUCED DISTURBANCE.**

The Isles Dernieres island chain provides the front line of protection for the Lower Terrebonne Estuary, Louisiana. Landfall of Hurricane Andrew on August 26, 1992 accelerated the erosional processes and altered the plant communities of the islands. To examine the factors affecting the recolonization of vegetation, areas were identified that received considerable overwash during the storm event. Four strata were delineated by the depth of overwash received. A permanent transect and ten groups of three permanent plots were placed within each strata. Sites were visited biannually for two years. Transects were examined for species trends. Each permanent plot was sampled for abiotic factors, such as soil conductivity, all major and minor cations, organic matter, soil pH, and elevation; and biotic factors, such as percent cover by species, herbivory, and soil seed bank. Using multivariate analyses, biotic and abiotic variables were correlated. Soil variables were shown to influence the types of species found on different depths of overwash. These factors relate directly to the plant community zonation found on the Isles Dernieres. Marsh areas which received the greatest sand loadings are now characterized by dune and swale plant species, while low sand loadings are returning to a backbarrier marsh community.

37 43 P-2 I

Cousin, B., Cook, S., Harbor Branch Oceanographic Institution, Ft. Pierce, FL and Gilligan, M., Savannah State College, Savannah, GA. **PROMOTIONAL VIDEO FOR THE SSC-HBOI UNDERGRADUATE PROGRAM.**

In 1994, the Media Center at Harbor Branch Oceanographic Institution produced a short promotional and recruitment video describing the first year of the Savannah State College - Harbor Branch Oceanographic Institution 'bridge' program supported by the National Science Foundation. The video will be shown and audience comments will be welcomed!

20.4 4 O C S

Cowan, J.-L W., University of South Alabama/Marine Environmental Sciences Consortium (MESC), Dauphin Island, AL, and Pennock, J.R., MESC/University of Alabama. **SEDIMENT-WATER NUTRIENT AND OXYGEN FLUXES IN MOBILE BAY, ALABAMA: A STUDY OF SEASONAL AND INTERANNUAL FORCINGS AND FUNCTIONS.**

Sediment oxygen and nutrient fluxes were measured monthly for two years in Mobile Bay. Sediment oxygen consumption rates (0.1 to 1.25 gO₂ M⁻² d⁻¹), ammonium flux (-22 to 181 μmol m⁻² h⁻¹), nitrate + nitrite flux (-16 to 79 μmol m⁻² h⁻¹), phosphate flux (-2 to 20.4 μmol m⁻² h⁻¹), and dissolved silicate flux (-101 to 342 μmol m⁻² h⁻¹) were moderate to high compared to literature values. Sediment nutrient fluxes, on average, supplied 36% and 25% of nitrogen and phosphorous, respectively, required by phytoplankton. Step-wise regression analysis showed dissolved oxygen concentration and temperature to be significant regulators of fluxes by influencing rates of microbial and physicochemical processes. The shallow depth of Mobile Bay allowed for frequent sediment resuspension, rendering the seasonal sediment chlorophyll *a* record nearly constant. Thus, organic matter availability does not appear to regulate seasonality of fluxes, as has been shown in other systems. However, summer-month averaged sediment nutrient release strongly correlated with spring-summer month averaged sediment chlorophyll *a* for this system and for data from Chesapeake Bay, suggesting that the magnitude of nutrient release is ultimately determined by organic matter availability.

17.2 4 O I

Cowan, Jr., J.H., University of South Alabama, Dauphin Island Sea Lab, AL, and Rose, K.A., Environmental Sciences Division, Oak Ridge National Laboratory, TN, and Enright, C., California Department of Water Resources, CA. **FLOW, WATER MANAGEMENT AND RECRUITMENT OF STRIPED BASS IN THE SACRAMENTO-SAN JOAQUIN RIVER SYSTEM, CA.**

Numbers of striped bass *Morone saxatilis* in the estuarine Sacramento-San Joaquin River Delta have declined since the mid-1970's to low levels in recent years. Water management practices and drought, toxins and the introduction of exotic species all have been implicated in the decline, al-

though none are without detractors. We have developed a bioenergetically-driven, individual-based population model of striped bass that includes site specific values for a suite of model inputs configured to represent feeding and growth environments in two spawning and three larval and juvenile nursery locations within the estuary. Baseline environmental inputs and transport of eggs and larvae within the estuary are modified via the history of introduction of exotics, and by flow in simulations using a 2-D hydrodynamic model of Delta-outflow, to realistically represent water management practices, changes in zooplankton community dynamics and climatological trends over the period of striped bass decline. Results suggest that larvae and juveniles in the estuary are food limited, and that probability of recruitment success is highest when flow favors rapid transport of larvae into richer nursery grounds in Suisan Bay. Infrequent wet years since the late 1970's and changes in water management practices, e.g., large diversions of water from the estuary, have contributed to the decline.

31 34 P-3 C

Cox, K.A., Cox & Robinson, Corpus Christi, TX. PREHISTORIC ESTUARINE ECOSYSTEMS: ARCHAEOLOGICAL EVIDENCE FOR THE EFFECTS OF RISING SEA LEVELS.

The examination of estuarine ecofacts found in archaeological deposits indicates that the estuaries of the central Texas coast have witnessed wide fluctuations in productivity throughout most of the Holocene. Otolith studies show that the highly exploitable estuaries of today have only recently reached their present levels of fish population densities. Archaeologically derived implications for rising sea levels, in terms of a humanly exploitable estuarine biomass, are potentially disastrous.

32.2 1 O C

Cox, S.A., Lehman, R.L., Smith, E.H., Tunnell, Jr., J.W., Texas A&M University-Corpus Christi, Corpus Christi, TX, and Merindino, T., Texas Parks and Wildlife Department-Wildlife Division, Rockport, TX. EVALUATION OF AQUATIC MACROFAUNAL POPULATIONS IN A COASTAL MARSH: MAD ISLAND WILDLIFE MANAGEMENT AREA, MATAGORDA COUNTY, TEXAS.

Saltwater intrusion resulting from natural subsidence, channelization, reduction of freshwater inflow, dredging, alteration by construction, and other drainage projects has contributed to the deterioration of coastal wetland systems. The Mad Island Wildlife Management Area (MIWMA), located adjacent to Matagorda Bay, is currently being examined as part of a long range goal to re-establish the freshwater integrity of the Rattlesnake Island marsh community within the MIWMA. This project is Phase I, a baseline study, of a three-phase investigation being conducted by the Texas Parks and Wildlife Department, Wildlife Division. Erosion of the Gulf Intercoastal Waterway and the dredging of Culver Cut Ditch have been determined as sources of saltwater intrusion. Sampling parameters were pre-determined by the

investigating agency and adopted by the principal investigators. Six lakes within the sampling area are being surveyed quarterly (seasonal) to determine species richness, diversity, density and frequency associated with benthic and macronektonic fauna. The first three quarters indicate *Palaeomonetes pugio* (grass shrimp) is the most abundant crustacean (6,813 individuals), *Hesperocorixa* sp. is the most abundant insect (7,824 individuals) and *Gobiosomo bosci* the most abundant fish, (125 individuals). Average salinity for the four quarters ranged from 7 ppt (Cane Lake) to 18 ppt (East Lake). Results suggest that saltwater intrusion due to erosion and Culver Cut Ditch construction has facilitated the settlement of brackish-water tolerant organisms into the system. Seasonal variations of salinities, pH and water levels should be considered in assessing the long term objectives of this project.

22 14 P-3 I

Crecelius, E., Cullinan, V., Lefkovitz, L., Battelle Marine Sciences Laboratory, Sequim, WA, and Peven, C., Battelle Ocean Sciences Laboratory, Duxbury, MA, and Valette-Silver, N.J., NOAA, N/ORCA 2, Silver Spring, MD. HISTORICAL TRENDS IN THE ACCUMULATION OF CHEMICALS IN PUGET SOUND SEDIMENTS.

Core sediments collected in 1982 and 1991 in central Puget Sound showed that as human activity in and around the Puget Sound increased so did the contaminant levels in the sediments. Sedimentation rates in central Puget Sound, determined by 210 Pb dating technique, range from 1 to 2 cm/yr with deposition rates ranging from 480 to 1000 mg/cm²/yr. The cores revealed that input of Ag, As, Cu, Hg, Sb, Zn and hydrocarbons to the sound, in concentrations above background, began in the late 1800's and peaked between 1945 and 1965. Over the last 20 years, this sharp increase was followed by a steady decrease of many contaminants. For example, the mean concentration of Pb has decreased by 30% since the 1960s. Synthetic organic compounds, such as PCBs and DDTs, first appeared in sediments deposited in the 1930s, reached a maximum in the 1960s and was followed by a 2- to 4-fold decrease in surficial sediments. The presence of subsurface maxima and the significant decline of sediment contamination over the last 20 years, is lending support to the hypothesis that the strengthening of environmental regulations since 1970 has influenced the sediment quality of central Puget Sound.

12.2 5 O I

Cross, J.N., Southern California Coastal Water Research Project, Westminster, CA, and Hashimoto, J.Y., US EPA, Region IX, San Francisco, CA, and Weisberg, S., VERSAR, Columbia, MD, and Summers, K., US EPA, ORD, EMAP, Gulf Breeze, FL. THE EXTENSION OF EMAP-ESTUARIES TO ADDRESS REGIONAL, STATE, AND LOCAL ESTUARINE ISSUES - THE SOUTHERN CALIFORNIA BIGHT PILOT PROJECT.

The existing marine monitoring system in Southern California cannot describe the health of the coastal marine envi-

ronment because it focuses on point source discharges, emphasizes meeting standards, and considers each regulated discharge as if it were isolated from all others. As a result, it is difficult to draw conclusions about the status of the marine environment. The Southern California Bight Pilot Project (SCBPP) developed and tested an integrated, coordinated, regional monitoring program that will provide unbiased information about environmental conditions. The SCBPP, which is based on the EMAP sampling design, measured indicators of habitat, pollution exposure, biological response, and human use at 264 sites in reference areas, municipal wastewater discharge areas, and stormwater discharge areas from Point Conception to Mexico in 1994. The results indicate that the coastal area around Los Angeles has been impacted by municipal wastewater discharge and surface runoff. For example, 15% of the sediments in Santa Monica Bay and 30% of the sediments around the sewage outfalls are elevated in organic carbon, while only 4% of the sediments in the rest of the bight are elevated in organic carbon. The SCBPP has strengthened cooperation among the 12 participating federal, state, and local agencies, and it will ultimately improve environmental decision-making in Southern California.

33.1 4 O I

Cruise, J., Rouse, L., Rovansek, R., Louisiana State University, Baton Rouge, LA, and Miller, R., NASA, Stennis Space Center, MS. PROCESSES AND FATE OF SEDIMENTS AND CARBON IN BARATARIA BAY, LA.

An interdisciplinary team of scientists are analyzing processes related to the fate of sediments and carbon in Barataria Bay, LA and its drainage basin. The primary goal of the project is to determine the role of shallow coastal bays and estuaries as sinks for atmospheric carbon dioxide. This paper describes the activities of the hydrology/physical processes work group. A diverse suite of remote sensing instruments are used in conjunction with an intensive field sampling program to characterize the marshes and water bodies and to study the dynamics of the marsh/bay ecosystem. The primary radiometric sensor is the CAMS (Calibrated Airborne Multispectral Scanner), a nine channel scanning radiometer. These data are used to characterize marsh vegetation and to map sediment and chlorophyll concentrations in the water. Landsat TM data are also used to map historical vegetation patterns and study changes in marsh characteristics. Salinity gradients across the bay and marshes are mapped using the Active Electromagnetic Induction Profiler (AEM). Chlorophyll and salinity profiles in the bay and estuary are obtained monthly using a bouy-mounted flow through system. The field sampling program is focused on the movement of water and material within the marshes and main arteries of the drainage system. The relative effects of tidal action, storm surges and wind stresses are analyzed.

21.2 5 O I

Currin, C.A., NMFS/NOAA Beaufort Lab, Beaufort, NC, and Levin, L. A., Scripps Institute of Oceanography, La Jolla,

CA, and Broome, S., NCSU, Raleigh, NC and Thayer, G.W., NMFS/NOAA Beaufort Lab, Beaufort, NC. FACTORS AFFECTING THE ROLE OF BENTHIC MICROALGAE AND INFAUNA IN TRANSPLANTED SPARTINA MARSHES.

Benthic microalgae (BMI) and sediment-dwelling fauna (infauna) play several key roles in *Spartina*-dominated ecosystems. BMI are an important component of marsh primary production, and have direct and indirect effects on nutrient cycling and sediment stabilization. Infauna affect organic matter cycling, alter sediment chemistry through feeding and burrowing activities, and provide food to higher trophic levels. We compare the biomass and productivity of BMI between natural and transplanted marshes, and illustrate the role of light and sediment in controlling BMI production in developing salt marshes. The recovery of infaunal assemblages in transplanted *Spartina alterniflora* marshes is also described, focusing on rates of recovery, colonizer composition and colonization mechanisms. Sediment particle-size, organic matter content and dispersal mechanisms can affect the recovery of marsh infauna in transplanted marshes. Evaluations of the ecosystem recovery of transplanted marshes has often focused on macrophytic vegetation and epifauna. However, benthic microalgae and infauna are important components of the marsh ecosystem, and their role in regaining functional equivalency in transplanted marshes must be considered. Our data suggest that after 3 years, the BMI and infauna communities in a transplanted *Spartina alterniflora* marsh remained different from those in a natural marsh, with important consequences for ecosystem function.

-D-

11 6 P-2 C

Dai, T., Wiegert, R.G., Department of Marine Sciences, University of Georgia, Athens, GA, and Chalmers, A.G., University of Georgia Marine Institute, Sapelo Island, GA. **NUTRIENT OUTPUT FROM A COASTAL RIVER OF GEORGIA: AN ANALYSIS THROUGH MODELING.**

A long-term data set was analyzed to study the ecological impact of a Georgia coastal watershed, Satilla river basin (9100 km²), on the land-sea margin. Satilla river transports about 1667-3500 tons of nitrogen, 114-314 tons of phosphorus and 52000-96000 tons of organic carbon into the estuary annually. The year-to-year variation of nutrient output strongly depends on annual precipitation and the resulting water discharge. The land use pattern of the Satilla watershed was also analyzed using GIS technology, and used as the input to a watershed model (modified GWLF). River flow and nutrient (N, P, and C) output were simulated on a daily basis with the additional input of temperature and precipitation. The predicted river flow agrees well with the existing data, and the anthropogenic disturbances (agriculture and logging) to the watershed show the greatest impact on the nutrient output.

13 15 P-2 C

Dailey, S., Christian, R., East Carolina University, Greenville, NC, and Wetzel, R., William and Mary, VIMS, Gloucester, VA. **INTERACTIONS OF BENTHIC COMMUNITIES AND MATERIAL FLUXES ACROSS THE SEDIMENT-WATER INTERFACE IN NORTH CAROLINA AND VIRGINIA ESTUARIES.**

Sediment-water material fluxes of O₂, NH₄⁺, and CO₂ were measured in core incubations. Through testing of 3 hypotheses, using general linear models with statistical control, I examined relationships of material fluxes and community structure. Fluxes were determined from light and dark core incubations of 1-m and 2-m sediments from: Masonboro Island and Currituck Banks, NC, Goodwin Islands and Hog Island, VA. From the same cores, Chl *a* concentrations (μg cc⁻¹ sediment), bacterial densities (# cc⁻¹ sediment), and faunal densities (# 10 cc⁻¹ sediment) were quantified. Chl *a* concentration contributed to the models that explained O₂ (p = 0.0001) and NH₄⁺ (p = 0.01) fluxes in light incubated sediments, while microfauna contributed significantly to the model of O₂ fluxes (p = 0.0001). Site and depth variables helped explain variances of both O₂ and NH₄⁺ fluxes. Site differences reflect edaphic, water-column, or metabolic characteristics of organism species and sizes indigenous to study locations. Depth may represent long-term differences in the light history of benthic sediments. O₂ and NH₄⁺ fluxes were not well explained by community structure in field experi-

ments. This lack of explained effects of organisms may be from uncontrolled factors in field experiments.

7 17 P-1 I S

Daoust, R.J., Childers, D.L., Department of Biological Sciences and Southeast Environmental Research Program, Florida International University, University Park, Miami, FL. **ESTIMATION OF ABOVEGROUND PRIMARY PRODUCTIVITY IN EVERGLADES MARSHES OF FLORIDA USING NON-DESTRUCTIVE SAMPLING TECHNIQUES.**

We are tracking changes in primary production of the major emergent macrophyte and periphyton components of Everglades marshes as part of ongoing research investigating the potential ecological impacts of increased phosphorus loading. Allometric measures of plant morphology are frequently used as a non-destructive estimation of primary production which can be verified against the more accurate method of determination from harvest samples. We have developed multivariate models relating plant biomass to morphology and periphyton biovolume to several abiotic variables. For macrophytes, these models relate plant-specific biomass, determined from harvests, to measures of morphological characteristics (i.e. number of leaves, leaf length and width, culm height and diameter, inflorescence size). The most important macrophyte species at our sites are *Cladium jamaicense* (sawgrass) and *Eleocharis* spp. (spikerush); early results for these species suggest that aboveground biomass is best predicted by leaf number, length and width in *C. jamaicense* and culm height and diameter in *Eleocharis* spp. The periphyton models relate biovolume to water depth, percentage cover of 1 m² as well as number of emergent plant stems within 1 m²; all of which may be nondestructively measured.

23.1 5 O C S

David, L.T., Kjerfve, B., Marine Science Program, University of South Carolina, Columbia, SC. **OCEANOGRAPHIC PROCESSES IN A LARGE COASTAL LAGOON IN MEXICO.**

Laguna de Terminos, Campeche, is a large (2,500 km squared), shallow (3.5 m), tropical (lat. N 18.3°), micro tidal (diurnal range 0.4 m) coastal lagoon. It is a highly productive coastal ecosystem, probably in large part due to the high average input of river discharge (300m³/s). Terminos is connected to the Gulf of Mexico through two main ocean channels and can be classified as a restricted coastal lagoon. Measurements of salinity, chlorophyll, and suspended solids from 23 stations during the dry season in 1987, indicated that the lagoon consists of two distinct hydrographic units,

each dominated by tidal water exchange through the closest ocean entrance. During the dry season of 1995, further salinity, chlorophyll, and suspended solids measurements were made at 17 stations, in addition to measurements of current velocity and water quality time series during 25-hour periods in the ocean entrances together with several month-long current meter moorings. Surface salinity varied between 13 ppt and 31 ppt in the interior of the lagoon with bottom salinities less than 2 ppt greater. Suspended solids ranged from 16 to 103 ppm near the surface and from 19 to 264 ppm near the bottom. Chlorophyll concentrations ranged between 0.5 and 10.2 mg/m³ near the surface to between 0.8 and 21.2 mg/m³ near the bottom. Chlorophyll concentrations were lowest in the middle of the lagoon. The western ocean channel (Carmen) exhibited a residual lagoonward salt transport but a residual seaward suspended solids transport, whereas the eastern inlet (Real) exhibited a residual seaward salt transport but a residual lagoonward suspended solids transport. The 50% water renewal time for Laguna de Terminos was calculated to be 7 days.

31.2 5 O I

Day, J., Suhayda, J., Kemp, P., Latif, N., Louisiana State University, Coastal Ecology Institute, Baton Rouge, LA, and Reed, D., LUMCON, Chauvin, LA, and Boumans, R., Univ. of New Hampshire, Jackson Estuarine Laboratory, Durham, NH, and Cahoon, D., National Biological Service, Southern Science Center, Lafayette, LA. **RAPID LOSS OF MARSH SURFACE ELEVATION FOLLOWING VEGETATION DEATH IN THE MISSISSIPPI DELTA.**

In the Mississippi delta, wetlands are disappearing at a rapid rate due to relative sea level rise of about 1 cm/yr. Various mechanisms may be responsible for this loss. We measured wetland death and a rapid loss of marsh surface elevation of 8-10 cm in a deteriorating marsh. The deteriorating marsh was flooded about 80% of the time as compared to 20% for a control marsh. This loss was not due to low sediment input because short term sedimentation was high, especially associated with the passage of Hurricane Andrew, and vertical accretion was higher (3.44 cm/yr) than in the control marsh (2.06 cm/yr). Wave energy was not sufficient to cause erosion of the marsh edge. Soil geotechnical properties were very different at deteriorating and control marshes: shear strength was 0.08 vs 0.8 Kg/cm², bulk density was 0.19 vs 0.4 g/cc, fall cone penetration was 103 vs 1 kN/m². We conclude that wetland deterioration was due to lack of soil consolidation because of excessive waterlogging leading to low soil strength and wetland death. After death, there is rapid oxidation of the soil root mass and loss of elevation.

23.2 3 O C

Day, J.W., Louisiana State University, Dept. of Oceanography and Coastal Sciences, Baton Rouge, LA, and **Rismondo, A.,** Scarton, F., Are, D., Biotecnica, Inc., Venice, Italy, Cecconi, G., Consorzio Venezia Nuova, Venice, Italy. **PATTERNS OF SEDIMENT ACCRETION AND SURFACE**

ELEVATION CHANGE IN WETLANDS OF VENICE LAGOON.

Over the past century, Venice Lagoon has experienced a high rate of wetland loss and a strong net export of sediments. From March 1993 until July 1995, the accretionary response of wetlands in the lagoon to changing water levels was studied. Vertical accretion, short term sedimentation, and surface elevation change were measured at several sites with varying sediment availability and wave energy. Short term sedimentation averaged 3-7 g/m²/d with a maximum of 75 during periods of high tides and storms. Accretion ranged from 2-23 mm/y and surface elevation change ranged from 13.8 to -32 mm/y. The sites with highest accretion were near a river mouth and a site with strong wave energy and rapid erosion of the marsh edge with a high resuspended sediment availability. A marsh created with dredged spoil had a high rate of elevation loss due mainly to compaction. The rate of accretion at most sites was sufficient to offset relative sea level rise, but a saline site with low sediment availability had the lowest accretion. The results suggest that reduction of wave energy or increasing sediment availability are needed to offset wetland loss in different areas of the lagoon.

31.3 5 O C

Day, R.H., Biagas, J.M., Doyle, T.W., National Biological Service, Southern Science Center, Lafayette, LA. **A SEA-LEVEL RISE MODEL OF VEGETATION DISTRIBUTION ALONG AN ELEVATION GRADIENT IN A FLORIDA SALT MARSH.**

The ability to predict changes in coastal vegetation caused by sea level rise depends on knowledge of the current vegetation distribution linked to an elevation model. Transects were surveyed with a laser level across the transition zone from *Spartina alterniflora*-*Juncus roemerianus* salt marsh to pine uplands at sites located within St. Marks National Wildlife Refuge on the northwest coast of Florida. To ascertain elevation above sea level, the transects were tied in to existing surveyed benchmarks located by consulting data available from the National Oceanic and Atmospheric Administration - National Geodetic Survey. Elevation ranges were tabulated for dominant and indicator species along the transects. The coastline and hydrography for the USGS 7.5" quads covering St. Marks were digitized and elevations were interpolated between the contours to create a more detailed contour map. Aerial photography and a Florida Fish and Game Commission habitat map were used as information resources to correct the contour map by utilizing correlations between marsh vegetation types and the narrow elevation ranges which they occupy on the landscape. Model simulations were generated to predict a likelihood index of vegetation changes under different scenarios of sea-level rise. This modeling approach offers a technological tool to researchers and wetland managers for effective cumulative impact analysis of wetlands affected by sea-level rise.

8 23 P-I C

De Popovici, G.Ch., General Cordova 759, Depto. 404, Lima 18, PERU. **ANALYSIS OF THE 6405 OCEANOIN the**

GRAPHIC CRUISE FROM PERUVIAN PACIFIC.

Observations from 115 oceanographic stations made in May-June 1964 extending from 04°S (Mancora) to 18° 50'S (Arica) along the meridians 71°W to 85°W are analyzed, and the results are presented as distributions of temperatures, salinity, oxygen, Sigma-T, in the parallel sections to 10, 50, and 100 miles from the Peruvian coast until 1000 m depth. Distribution charts of these oceanographic factors are also present in 0 m, 20 m and 50 m depth. The geopotential anomaly at the surface, 20, 50, 100, and 400 m depth of the Peruvian Pacific with respect to the 1000-decibar surface in dynamic meters is computed and presented in charts. Currents until 1000 m were computed, the data were obtained from 3 stations between 2 parallel sections for obtaining the resultant vector, the direction and speed. The results for 0 m and 50 m are shown in the current charts, where the velocity of the currents is indicated by six classes: 0-20 cm/seg; 20.1-40 cm/seg; 40.1-60 cm/seg; 60.1-80 cm/seg; 80.1-100 cm/seg and greater than 100 cm/seg.

23 19 P-3 C

De Popovici, G.Ch. Avda., General Cordova 759, Depto. 404, Lima 18, PERU. **LIMNOLOGY AND ANTIBIOSIS OF THE MINERO-MEDICINAL LAGOON "SANTA CRUZ DE LAS SALINAS", AT CHILCA, LIMA-PERU.**

The lagoon "Santa Cruz de las Salinas" is one of the 400 minero-medicinal waters registered by the health ministry, located in the latitude 12° 33' s and longitude 76° 43' w, to 1.5 km of the Peruvian Pacific. The area of the lagoon presents tertiary and actual saline deposits. The size is 180 m long by 60 m width with an irregular bathymetric. Chemical analysis of the water determined that this lagoon is a complex solution of organic and inorganic salts with predominance of *clna*, almost three times superior to the sea water. During all the year the lagoon presents a "green aguaje", perenne, and benign. The color is due to the presence of the unic phytoplankton community *Chlorella peruviana* Chacon, chlorophyceae, and to artemia *Salina jensen*, an anostraca crustacean. The behaviour and environment of them during one year is presented by the author. Bacteriological analysis of the water have proved that does not present pathogen bacteria. Assays "in vitro" and "in vivo" using mice and fishes proved that this water has antibiotic action and is innocuo and stimulant of the immunogen system in mice. Around 12,000 persons visit the lagoon each year for alleviating their diseases.

11.1 1 O C

Deegan, L., Garritt, R., Ecosystems Center, Marine Biological Lab, Woods Hole, MA. **CARBON, NITROGEN AND SULFUR ISOTOPES AS TRACERS OF ORGANIC MATTER FLOW IN THE PLUM ISLAND SOUND ESTUARY, MASSACHUSETTS.**

Carbon, nitrogen and sulfur stable isotopes were used to determine the importance of algal production, saltmarsh and terrestrial organic matter sources to the food web of Plum Island Sound. Upstream in the upper bay site, salinity varied

from 0- 16 ppt. with primary and secondary consumers reflecting mixtures of terrestrial, freshmarsh, saltmarsh and algal derived organic matter. Carbon and sulfur isotopic signatures of primary and secondary consumers in the saltmarsh and lower bay sites (19-31 ppt.) suggest *Spartina* and algal organic matter are equally important. Terrestrial organic matter was not detected in consumers from the saltmarsh and lower bay sites. Locally produced organic matter appears to be locally consumed.

7 18 P-1 C S

Delgado, P., Louisiana State University, Baton Rouge, LA, and Jimenez J.A., National Institute of Biodiversity, Heredia, Costa Rica. **MODELING THE STRUCTURE AND DYNAMICS OF AN AVICENNIA BICOLOR MANGROVE FOREST ON THE PACIFIC COAST OF COSTA RICA.**

The use of modeling techniques to describe the structure and dynamics of mangrove ecosystems represents a new approach. A model to simulate the life cycle of *Avicennia bicolor* in the Pacific coast of Costa Rica was developed using the simulation package Stella. The model was based on information compiled during 5.8 yr. in a 0.52 ha plot of *A. bicolor*. This information included density, growth and mortality rates of seedlings, saplings and trees of eight different diameter classes; fruit production was included for the reproductive tree classes. Transition rates from one stage to another, for fruits, seedlings and saplings, were modeled as stochastic variables to simulate natural variability. Simulations were run for a period of 300 years. Results show very stable structural distributions of the different classes through time with higher variability in the lower stages. The model was very sensitive to mortality and transition rates for fruits, seedlings and saplings, attributable to their faster dynamics. Calibration should focus on the dynamics of these stages in *Avicennia's* life cycle. Harvesting, another source of mortality, results in a change in forest dynamics. Modeling can be used as a tool to manage this living resource and prevent degradation.

5 14 P-1 C

Derrick, P., Kennedy, V.S., University of Maryland, Horn Point Environmental Laboratory, Cambridge, MD. **FEEDING PERIODICITY AND PREY SELECTION BY HOGCHOKERS IN CHESAPEAKE BAY.**

In upper Chesapeake Bay, gut fullness in hogchokers *Trinectes maculatus* was 250% higher in June than in October, and was greater by night than by day for both months. Minimal values for gut fullness occurred in the afternoon, increased in the evening, peaked overnight, and declined in the morning. Along the salinity gradient of four tributaries and in the Bay's mainstem, hogchokers exhibited both opportunistic and selective feeding patterns, with diet composition reflecting variation in prey composition and fish size. Polychaetes were major prey taxa as well as the dominant benthic inhabitants of polyhaline regions. Oligochaetes dominated oligohaline benthos, but were rarely eaten. Rather, amphipods were the dominant prey in oligohaline regions,

being replaced by polychaetes as salinity increased. No shells of bivalves or gastropods were found in stomachs, but tellinid siphons were ingested.

3.3 5 O C

Dettmann, E.H., Abdelrhman, M.A., Perez, K.T., Davey, E.W., U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI. HYDRODYNAMIC AND WATER QUALITY MODELING AS A FRAMEWORK FOR QUANTIFYING EFFECTS OF ANTHROPOGENIC STRESSORS IN TWO MASSACHUSETTS ESTUARIES.

Two-dimensional, vertically-averaged, hydrodynamic and water quality simulations were performed for the Acushnet River (New Bedford Harbor) and the Slocum River, on the north shore of Buzzards Bay, Massachusetts, as part of a comparative study of both estuaries. The former system is highly impacted by human activities, whereas the latter is much less disturbed. Hydrodynamic and water quality simulations were used to determine current velocity and salinity distributions as well as flushing characteristics in both estuaries. Variability of these features, caused by differences in tidal forcing, freshwater inflow, and wind forcing, were investigated. For instance, mean freshwater residence time within New Bedford Harbor varied between 1.7 days and 2.6 days for spring and neap tide conditions, respectively, with median freshwater inflows and no wind. Freshwater inflows to both estuaries were estimated by regression of limited stream discharge data for major tributaries with daily discharge data for nearby gaged streams. The Slocum River includes substantial intertidal areas, including a bar just offshore of the estuary inlet, complicating hydrodynamic and water quality simulations for this system. Simulation results provide a physical framework for interpreting water quality and ecological data collected in both estuaries, and estimating the effects of some anthropogenic stressors.

32 46 P-3 C S

Dilworth, S., Turner, B., Serota, T., Jacks, S., USFWS Fishery Resources Office, Corpus Christi, TX and Center for Coastal Studies, Texas A&M University-Corpus Christi, Corpus Christi, TX. THE EFFECTS OF A VARIABLE-CREST WEIR ON FISHES AND COMMERCIALY IMPORTANT CRUSTACEANS IN THE BRAZORIA NATIONAL WILDLIFE REFUGE, TEXAS.

Estuaries play an integral role in the recruitment of certain marine transient fishes and crustaceans. Transient species spawn in the Gulf of Mexico and their eggs and larvae are transported through tidal passes to estuarine nursery areas. Previous research has determined that weirs constructed on tidal creeks that flood critical nursery habitat have negatively affected recruitment of transient marine species. However, resident marine species which spend their entire life cycle in the marsh environment are positively affected by weirs. A study was performed on a variable-crest weir located on the Brazoria National Wildlife Refuge, Texas. The

weir was constructed in 1969 to retain water in the marsh area during winter low tides. Light traps and bag seines were utilized bi-weekly from July 1995 to July 1996 to sample larval and juvenile fishes and crustaceans in a managed weired and unmanaged control area. Relative abundance of marine species was compared between the two areas. Water quality measurements were also taken at both sites for comparison. Information and data from the study will be used to provide future

Dionne, M., Wells National Estuarine Research Reserve, Wells, ME, and Hoffmann, C., Antioch New England Graduate School, Keene, NH. RECOVERY OF A NORTHERN NEW ENGLAND SALT MARSH AFTER PARTIAL RESTORATION OF TIDAL FLOW.

The presence of raised roadways severely restricts tidal flow and freshwater drainage from many marsh-dominated estuaries along the Gulf of Maine coastline. These changes in hydrology can influence salt marsh vegetation by 1) reducing sediment supply/peat accretion, 2) increasing or decreasing soil salinity and saturation, and 3) substrate subsidence. We measured effects of tidal restriction on a marsh in Wells, Maine by monitoring vegetation changes after partial tidal restoration from the loss of a clapper valve under a roadway. Prior to 1988, the site existed as a freshwater wetland, from nearly a century of tidal deprivation. From 1991 to 1994 we documented colonization by *Salicornia*, *Spartina alterniflora*, *Spartina patens* and other salt marsh plants at this site. Plant densities and relative abundances differ from those at an undisturbed reference site. Vegetation differences are related to differences in tidal curves and edaphic factors between the restricted and reference sites. Our study provides an example of the direction and rate of recovery of a Gulf of Maine salt marsh that has been drastically disturbed by absence of tidal flow, and is now experiencing restricted tidal flow. Our results will be useful in selecting sites and designing projects for salt marsh restoration via improvements in tidal flow.

24.2 2 O C

Dixon, L.K., Leverone, J.R., Mote Marine Laboratory, Sarasota, FL. ANNUAL LIGHT REGIME OF LIGHT LIMITED *THALASSIA TESTUDINUM* IN TAMPA BAY, FLORIDA.

SAV losses have occurred at depth (presumably due to light reduction) and empirical relationships have been demonstrated between external nitrogen loads, chlorophyll, and water column attenuation. To guide SAV protection and nutrient load reduction efforts, scalar (4π) PAR sensors were continuously deployed for a year at the deep edges (2.0-2.4 m) of four light-limited *Thalassia* meadows to determine annual irradiance. Attenuation coefficients were used to compute irradiance at depth as a percentage of the extrapolated, immediately subsurface irradiance. Based on midday data (1000-1400 hours), deep edges received between 20.5-23.9% of subsurface irradiance (median attenuation coefficients 0.79-1.12 m^{-1}). Total PAR at depth ranged between 3640-

4930 E yr⁻¹. Blade-integrated epiphytic attenuation was quantified bimonthly and ranged between 32.0-36.2%. The percentage of PAR present in the water column was further reduced by the percent of epiphytic attenuation to estimate the PAR available to the plant, calculated to range between 13.0-14.2% of subsurface irradiance, or 2240-3138 E yr⁻¹. Inclusion of epiphytic attenuation improved the agreement among station light requirements, with comparable percentage requirements determined for stations both with and without high color values. Simultaneous *Thalassia* condition indices indicated that the one station with the lowest PAR value exhibited shading responses, indicating that the measured irradiances bridged an ecological compensation point.

24.2 4 O C

Dixon, L.K., Nissankal, A., Mote Marine Laboratory, Sarasota, FL., and Tomasko, D.A., Southwest Florida Water Management District, SWIM Department, Venice, FL. **ANNUAL LIGHT REGIME OF LIGHT LIMITED SEAGRASSES (THALASSIA TESTUDINUM and HALODULE WRIGHTII) IN SARASOTA BAY, FLORIDA**

To develop management strategies aimed at improving water clarity in Sarasota Bay, attenuation coefficients were determined biweekly from vertical profiles with both cosine-corrected (2π) and scalar (4π) PAR sensors for one year. Measurement sites included seven locations at the deep edges of both *Thalassia* and *Halodule* beds in areas under a wide range of both nutrient loading and water color influences. Attenuation coefficients ($0.75-1.63 \text{ m}^{-1}$), station water depths (0.5-1.6m), and extrapolated, immediately subsurface irradiance data were used to compute PAR at depth as a percentage of subsurface irradiance (28-50%). Blade-integrated epiphytic attenuation was quantified monthly by station, and ranged between 40-56 %. The percentage of PAR present in the water column was further reduced by the percent attenuation attributable to epiphytes to calculate the PAR available to the plant, estimated at 12-24 % of subsurface irradiance, with most stations near 22 %. One station, under a much higher current regime, received substantially lower PAR levels than the remainder. Inclusion of the effects of epiphytic attenuation improved the agreement between the light requirements of various stations. No species-specific differences in annual light totals were observed, although the *Halodule* blades were able to tolerate several months of very low PAR (< 10%) caused by heavy epiphytic growth.

9.1 2 O C

Dodson, J.A., Regional Water Director, City of Corpus Christi, Corpus Christi, TX, and Nicolau, B.A., City of Corpus Christi, Corpus Christi, TX. **BUILDING CONSENSUS FOR THE MANAGEMENT OF FRESHWATER RESOURCES IN SOUTH TEXAS: EFFECTIVE SOLUTIONS TO MEET COMPETING DEMANDS.**

The City of Corpus Christi owns and operates the Choke Canyon/Lake Corpus Christi Reservoir System, providing water for approximately 370,000 residents in seven coun-

ties. In addition, regional bays and estuaries are highly dependent on this valuable resource to ensure a healthy ecosystem. Under the water rights permit for Choke Canyon Reservoir the City is required to provide 151,000 acre-feet per year of freshwater inflow to the Nueces Estuary. Under the Interim Operating order implemented in March of 1992 the City began making releases from the reservoir system to meet these needs. This plan, while providing needed inputs to the estuary, also effectively diminished freshwater availability for municipal and industrial use by 30,000 acre-feet per year. The order also called for the creation of the Nueces Estuary Advisory Council to study the effects of this operating plan. Comprised of local government officials, scientists, and citizens this council evaluated the effects of this operating plan and possible alternatives that would successfully meet all competing demands. Effective resource management requires consensus building by all parties involved and in April of 1995 implementation of a new plan began which provides for the estuarine system while increasing the available water supply for human uses.

9 2 P-2 C

Doering, P.H., South Florida Water Management District, West Palm Beach, FL. **FRESHWATER INFLOW AND THE TEMPORAL VARIATION OF WATER QUALITY IN THE ST. LUCIE ESTUARY, SOUTH FLORIDA.**

Since the 1960s, the St. Lucie Estuary has changed from a seagrass to a phytoplankton-based system which now experiences blooms exceeding $80 \mu\text{g Chl } a / \text{L}$. Anthropogenic alteration of watershed hydrology and an unnatural connection to Lake Okeechobee have changed the magnitude and timing of freshwater inflow to the system. Five years of monthly monitoring data were analyzed to examine the influence of freshwater discharge and constituent concentrations on salinity, nutrient concentrations and other water quality parameters in three segments of the estuary. During the period Nov. 1989 - Oct. 1994, there were long-term increases in basin rainfall and freshwater discharge to the estuary. Concomitantly, salinity and chlorophyll *a* decreased throughout the system. Freshwater discharge, freshwater constituent concentrations, or both, explained between 0 and 40% of the monthly variation in estuarine water quality parameters. An index of tidal and wind mixing, (salinity, corrected for variation caused by freshwater discharge) explained an additional 6-35% of the variation in all parameters. On a seasonal basis (wet, dry), freshwater discharge explained up to 80% of the variation in some parameters while discharge-corrected salinity explained virtually none. Alterations in freshwater discharge through management practices most likely may be discerned on seasonal, rather than, monthly time scales.

34.1 5 O C

Dortch, O., Robichaux, R.J., Rabalais, N.N., Louisiana Universities Marine Consortium, Chauvin, LA, and Soniat, T.M., Dept. Biological Sciences, Nicholls State University, Thibodaux, LA, and Fryxell, G.A., Dept. Oceanography,

Texas A&M University, College Station, TX, and Turner, R.E., Parsons, M.L., Dept. Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA. **ABUNDANCE OF PSEUDO-NITZSCHIA IN THE NORTHERN GULF OF MEXICO.**

Pseudo-nitzschia spp. were extremely abundant (up to 108 cells l⁻¹) from 1990 to 1994 on the Louisiana and Texas continental shelves and moderately abundant (up to 10⁵ cells l⁻¹) over oyster beds in the Terrebonne Bay estuary in Louisiana in 1993 and 1994. On the shelf there was a strong seasonal cycle with maxima in spring and fall, related to river flow, water column stability, and nutrient availability. In the environmentally more variable estuary there was no apparent seasonal cycle. Although there have been no outbreaks of Amnesic Shellfish Poisoning in this area, toxic, sometimes toxic, and not-toxic species have been observed in the northern Gulf. Historical data suggest that *Pseudo-nitzschia* spp. abundance has increased with increased eutrophication in the coastal zone.

7 19 P-1 C

Doyle, T.W., Day, R.H., Wells, C.J., National Biological Service, Southern Science Center, Lafayette, LA. **FIELD OBSERVATIONS OF LEAF AND NODAL PRODUCTION IN MANGROVE SPECIES ACROSS SOUTH FLORIDA.**

Mangroves predominate in the intertidal zones of the world's tropical coastlines. Studies show that mangal growth may be controlled by a number of dynamic factors: light, inundation, salinity, nutrient availability, predation, among others. A field study was initiated to determine the process and rate of forest regeneration and growth of mangal species, *Avicennia genninans*, *Laguncularia racemosa* and *Rhizophora mangle* in coastal sites across south Florida. Seedlings and stem sprouts were measured for diameter, height, and node development from freshwater and saltwater locations. Quarterly observations of leaf production and nodal remeasurement have yielded predictable seasonal growth patterns. Significant differences have also been observed between measurement periods that suggest that mangroves are sensitive to environmental changes. Field measurements with this technique offer the ability to measure growth rate potential on a tree by tree basis that in turn can be used to estimate site quality and tree age of mangroves. It should also be useful for dating recent disturbances that significantly alter growth pattern, such as fertilization, herbivory, logging, hurricane, lightning, and hard freezes.

7 20 P-1 C S

Doyle, T.W., Wells, C.J., Walters, R.J., National Biological Service, Southern Science Center, Lafayette, LA. **EFFECTS OF SHADING ON PLANT FORM AND FUNCTION OF NEOTROPICAL MANGROVE SPECIES.**

Mangrove species of coastal Florida are subject to various disturbance phenomena including hard freezes, lightning, and hurricanes. Hurricanes, in particular, cause major structural alterations in mangrove communities ranging from com-

plete blowdowns to varying degrees of leaf defoliation. An experimental study is underway to investigate the growth habits of mangrove species, *Avicennia genninans*, *Laguncularia racemosa*, and *Rhizophora mangle*, under shaded and open-grown conditions. Four treatments of shade from 10%, 30%, 60%, and 100% full sunlight were implemented to mimic a range of canopy disturbances. Plant survival, height, diameter, leaf production, leaf size, leaf thickness, and chlorophyll fluorescence have been measured over two years. Results showed that there were little differences between shade treatments in overall seedling height and survival. However, differences in leaf production rates, stem diameter and volume, leaf size and thickness, and chlorophyll fluorescence were found between species and across shade treatments. In general, leaf production, leaf size and thickness, and stem size increase with increasing light availability. Rank order of species tolerance to shade indicates that red > black > white. Growth response curves to light have been constructed and are being used in a forest simulation model for neotropical mangroves. This study suggests that mangrove seedlings can persist in the short-term under a wide range of shaded conditions and that species response may be adapted to varying degrees of canopy closure and disturbance.

17.1 4 O I S

Drescher, K., Holt, G.J., University of Texas, Marine Science Institute, Port Aransas, TX. **THE NUTRITIONAL CONDITION OF LARVAL RED DRUM (*SCIAENOPS OCELLATUS*) COLLECTED FROM A TIDAL PASS IN PORT ARANSAS, TEXAS.**

To investigate the effect starvation might play in recruitment and year-class strength, larval red drum were collected throughout the fall spawning season in a tidal pass in Port Aransas, Texas. RNA content, DNA content and RNA:DNA ratios were determined for individual laboratory-reared red drum to establish calibration for nutritional condition. DNA content, RNA content, and RNA:DNA ratios of well fed larvae increased with both age and size. Results indicated large interindividual variation within a natural population of red drum larvae. Laboratory studies established the decrease in RNA:DNA ratio with increased number of days starved. A critical RNA:DNA ratio was established relative to length for red drum. The validity of the RNA:DNA ratio to describe the nutritional situation of a well fed or starving larvae was proven and it is postulated that the presented critical RNA:DNA values make it possible to evaluate the nutritional condition of a larvae caught in the field by taking only the length at time of capture and determining RNA and DNA content.

5.1 4 O C S

Duffy, J.T., Epifanio, C.E., University of Delaware, College of Marine Studies, Lewes, DE. **PREDATION BY GELATINOUS MACROZOOPLANKTON ON LARVAE OF THE RED DRUM (*Sciaenops ocellatus*).**

Experiments were conducted in field enclosures to ex-

amine the effects of predation by various species of macrozooplankton on four age classes of red drum larvae, 1 and 2 days post-hatching (DPH), 4 and 5 DPH, 7 and 8 DPH, and 11 and 12 DPH. Predation potentials of five different species of macrozooplankton, *Chrysaora quinquecirrha*, *Aurelia aurita*, *Stomolophus meleagris*, *Beroë ovata*, and *Mnemiopsis mccradyi* were tested at each larval age. Enclosures were stocked at a density of 0.05 larvae l⁻¹ (100 enclosure⁻¹) and larvae were allowed to equilibrate for 2 h prior to the addition of a predator. A single predator was then added to each enclosure and the duration of the experiment was 6 h. There were four replicates of each treatment and controls were run in the absence of predators to estimate natural mortality. At the conclusion of the experiment the predators were measured for displacement volume, and the remaining contents of the enclosures was preserved in 4% formaldehyde. Preliminary results indicate that while rates of mortality were high across predator type for all age classes examined, rates dropped with increasing larval age. These results suggest that predation by gelatinous predators may result in substantial mortality among red drum larvae.

24.1 4 O C

Durako, M.J., Florida Marine Research Institute, St. Petersburg, FL, and Fourqurean, J.W., Florida International University, Miami FL. **CHANGES IN PHOTOSYNTHESIS VERSUS IRRADIANCE CHARACTERISTICS OF *THALASSIA TESTUDINUM* IN RESPONSE TO SHORT-TERM LIGHT REDUCTION.**

The effects of short-term light reduction on the photosynthetic capacity of *Thalassia testudinum* were assessed by comparing the photosynthesis versus irradiance (P/I) characteristics of leaf segments from short-shoots growing in mesocosms and *in situ*. Experimental treatments included ambient light and approximately 10% and 20% reduction from ambient. In the mesocosm experiments, samples were harvested 3 days before shade screens were installed (pre-treatment), and then after 3, 6, and 12 days of light reduction. A final set of samples were harvested after 110 days to evaluate longer-term effects. Samples from Sunset Cove in the Florida Keys were harvested the day the screens were installed, and then after 3, 6, 12, and 25 days of light reduction. In the mesocosm experiments, there was a significant decrease in a, P_{max}, respiration, and chlorophyll *a* with decreasing light, after 12 days of reduced light. The trends in the P/I characteristics were similar whether calculated on a dry weight or chlorophyll *a* basis. After 110 days, there were less treatment-related patterns in the P/I characteristics, but respiration rates continued to exhibit stepwise reductions with light. Unlike the mesocosm experiments, there were no treatment-related trends evident in any of the measured characteristics from Sunset Cove *Thalassia*, although there was an overall increasing trend in respiration rates over the 25-day experimental period. These two light reduction experiments illustrate some pros and cons of mesocosm versus *in situ* manipulations. The mesocosm experiments showed significant short-term responses to the treatments, but the results also suggested a general deterioration of the plant materials

3.1 I O C

Efron, S.J., Proctor, B., Binder, C., Lin, J., Institute of Technology, Melbourne, FL. **EFFECTS OF SALT MARSH RECONNECTION ON THE NUTRIENT, SEDIMENT, AND INFAUNA AT THE ADJACENT LAGOON.**

Most of the saltmarshes along the Indian River Lagoon, central-east Florida, were impounded to control mosquito populations in the 1950s. Since the 1980s, large numbers of culverts have been installed to reconnect the marshes to the lagoon. This study examined the potential short-term (1 month) impacts the marsh reconnection may have on the nutrient concentrations and benthic faunal communities at the adjacent lagoon. Dissolved nutrients (ammonia, NO₃, and

15.2 I O C

Dustan, P., Taylor, M., Conner, S., Grice Marine Biological Laboratory, Department of Biology, University of Charleston, Charleston, SC. **OXYGEN VARIABILITY IN THE ESTUARINE CREEKS OF THE CHARLESTON HARBOR WATERSHED**

The oxygen variability of two estuarine creeks was monitored continuously at 5 minute intervals during a three year period. One watershed was a well-developed urbanized community with .3 to .5 acre housing lots, shopping centers, heavily trafficked roads, and its storm drainage routed into the creek. The second site was a less well-developed, nearly pristine forested watershed in the early stages of becoming an upscale low density housing community with 2 acre lots, golf course, and a storm water catchment system. In-situ instrument recording of oxygen levels showed that a short term oxygen depletion event (STODE) occurs after heavy rainfall. Oxygen levels fall soon after rainfall and then slowly return to "normal" seasonal levels after 4 to 5 days of dry weather. In-vitro incubations of water samples from dry and wet periods revealed that the decrease in oxygen is closely linked to increased water column respiration. The magnitude of the STODE effect is greater and more short lived in the urbanized estuarine creek as runoff enters the creek quickly due to enhanced sheet flow and storm sewer drainage. At the less developed site the range and amplitude of the STODE a rainfall is considerable lower apparently due to the capacity of the ecosystem to absorb and slowly release runoff to the bordering creek. The general working hypothesis is that land use alters the coupling between coastal watersheds and estuaries through changes in the loadings of dissolved and particulate materials. The differences in water column respiration rates appear to be the result of increased loadings due to anthropogenic changes in land use which diverges from the generally conservative character of natural systems.

-E-

3.1 1 O C

Efron, S.J., Proctor, B., Binder, C., Lin, J., Institute of Technology, Melbourne, FL. **EFFECTS OF SALTMARSH RECONNECTION ON THE NUTRIENT, SEDIMENT, AND INFAUNA AT THE ADJACENT LAGOON.**

Most of the saltmarshes along the Indian River Lagoon, central-east Florida, were impounded to control mosquito populations in the 1950s. Since the 1980s, large numbers of culverts have been installed to reconnect the marshes to the lagoon. This study examined the potential short-term (1 month) impacts the marsh reconnection may have on the nutrient concentrations and benthic faunal communities at the adjacent lagoon. Dissolved nutrients (ammonia, NO_3 , and PO_4) in the water column, sediment characteristics (% organics, ratio of mud, sand, and gravel), and infaunal communities (density and community structure) were measured before and after the opening of two culverts in an impoundment. Duplicate samples were collected from two locations in the lagoon (inner and outer, about 1 and 13 m away from the impoundment, respectively) at each of the two impact sites (each with a new culvert) and at a control site (no culvert). There was no evidence of large nutrient discharge after the reconnection. However, there were significant increases in % organics and % mud at both impact sites. Infaunal density among the sites was not significantly different. However, there was a significant difference in density and distinct difference in community structure between infauna at inner and outer locations. Infaunal density at the outer locations was one order of magnitude higher than that at the inner locations. The infaunal community at the outer locations is highly dominated by amphipods (*Ampelisca verrilli*), whereas the inner locations have a high proportion of polychaete species. The study suggests that the short-term impact of marsh reconnection on the adjacent lagoon is minimal.

1.1 2 O C

Eggleston, D., Elis, W., Posey, M., North Carolina State University, Raleigh, NC and University of North Carolina-Wilmington, Wilmington, NC. **LANDSCAPE ECOLOGY AND ESTUARINE HABITAT MOSAICS: LINKING HABITAT FRAGMENTATION AND HETEROGENEITY TO SPECIES ABUNDANCE AND DIVERSITY.**

We field tested an "intermediate fragmentation" conceptual model in shallow seagrass and oyster habitats in North Carolina. The model predicts that species abundance or diversity per unit area is highest at intermediate patch sizes, and in the most diverse habitats. We tested these hypotheses with 0.25 m^2 settlement trays filled with either air-dried oyster shell, artificial seagrass, or a combination of the two (mixed), placed in different patch sizes ($0.25 \text{ m}^2 - 4 \text{ m}^2$) on

27.1 4 O C S

Ehrenfeld, E.A., Howarth, R.W., Marino, R.M., Section of Ecology and Systematics, Cornell University, Ithaca, NY. **NITROGEN FIXATION IN SEAGRASS BEDS: TEMPERATE/TROPICAL OR ENRICHED/PRISTINE?**

Higher rates of nitrogen fixation have been reported in tropical seagrass beds than in temperate beds. However, in comparison to the tropical systems which have been studied, many of these temperate seagrass beds have elevated levels of nitrogen in the water column due to human impact. Can the differences in nitrogen fixation rates between temperate and tropical seagrass beds be explained by differences in level of water column enrichment? Our measurements of nitrogen fixation by the acetylene reduction assay in temperate seagrass mesocosms suggest that the rate of nitrogen fixation is inversely correlated with water nitrogen concentration. Narragansett Bay seagrass grown under four different nitrogen loadings was assayed over the summer for acetylene reduction rates associated with the leaf and epiphyte community. Blades from tanks in which water nitrogen levels had been stripped to below ambient levels produced the highest rates of reduction and were similar to rates in tropical systems. This suggests nitrogen fixation rates can be comparable in temperate and tropical seagrass systems in the absence of human-elevated nitrogen.

19.1 3 O I

Eldridge, P.M., Cifuentes, L.A., Texas A&M University, Department of Oceanography, College Station TX 77845, Texas Parks and Wildlife Department, Aquatic Studies Branch, Austin TX 78704. **EFFECT OF DOC CHARACTER ON BIOLOGICAL ESTUARINE PROCESSES INTERPRETED FROM CARBON ISOTOPE RATIOS, MICROCOSMS, AND MODELING.**

Natural and anthropogenic nutrient loadings are known to affect the gross characteristics of rivers and estuaries. Increased loading and longer residence times of nutrients due to fresh water diversions can result in biomass accumulation, sedimentation and oxygen depletion. We examine the effects of reactivity and loading of dissolved organic carbon (DOC) in concert with inorganic nutrients on biological estuarine processes. Primary production and metabolic processes over the length of the Nueces River TX are estimated with a microbial food web model in which we maintained a mass-balance of ^{12}C and ^{13}C in DIC, dissolved organic carbon (DOC), particulate organic carbon (POC), bacteria (BOC) and grazer (GOC) biomass. River flow, mixing, and light were the dynamic parameters in this model whereas concentrations of nutrients, DIC, DOC, POC, BOC and GOC, and their corresponding isotopic signatures provided the

boundary conditions at the riverine and coastal end-members of the estuary. The model was validated by reconciling results with carbon isotope analyses from Nueces Estuary. The model demonstrates how estuarine hydrodynamics set up salinity, nutrient and temperature gradients along which biological processes are distributed. We use the model to describe relationships between reactivity of DOC pools, nutrient dynamics, and estuarine trophic dynamics.

12.1 2 O I

Engle, V.D., National Biological Service, Gulf Breeze, FL, and **Summers, J.K.**, Macauley, J.M., U.S. Environmental Protection Agency, Gulf Breeze, FL. **THE USE OF BENTHIC COMMUNITY MEASURES AS INDICATORS OF ESTUARINE CONDITION.**

Estuarine benthic invertebrates are the major trophic link between primary producers and higher trophic levels, including fish, birds, and other wildlife. Benthos provide an important food source, affect water quality and productivity, and can alter contaminant distributions in sediments. As an important link in Gulf of Mexico food webs, the condition of benthic communities is an important indicator of the biological and ecological condition of estuarine resources. A series of benthic indices, based on structural community parameters, were constructed from benthic community information collected during the 1991 through 1993 EMAP sampling efforts in the Louisianian Province. The final benthic index incorporates variables relating to species diversity (adjusted for salinity) and to the abundance of indicator species. This index showed 29% \pm 6% of the estuarine bottom habitat in the province to be characterized by benthic communities similar to those observed in environments stressed by contaminants, hypoxia, and sediment toxicity. Validation testing showed that the benthic index properly categorized impacted and non-impacted environments with a 96% and 94% success rate, respectively. The benthic index successfully discriminated between stressed and unstressed benthic communities and proved to be a better ecological condition indicator than any one of its components.

17.1 2 O I

Epifanio, C.E., Garvine, R.W., College of Marine Studies, Hugh R. Sharp Campus, University of Delaware, Lewes, DE. **TRANSPORT AND RECRUITMENT OF SURFACE-DWELLING LARVAE: A MODEL WITH ADVECTION AND MORTALITY.**

Inshore flow in the Middle Atlantic Bight is dominated by buoyancy-driven currents (bdc) that flow southward immediately adjacent to the coast. The bdc are strongest in spring and become weaker during late summer when predominant winds drive a northward current just offshore of the bdc. These winds also generate offshore Ekman flow with coincident upwelling. More intense across-shelf transport is driven by southward wind events that occur frequently in autumn. These drive onshore Ekman flow with consequent increases in subtidal sea level along the coast. In this paper we describe a mathematical model that simulates the transport and settlement of surface-dwelling larvae in this envi-

ronment. Model currents are driven by wind over the continental shelf and by river discharge into the estuary. Diffusive processes and biological mortality are included. We first assessed the model's general properties by using simple analytic forms for the variations in wind and river discharge. Then we used records of observed wind and discharge to compare model results with records of blue crab settlement during a four-year period in Delaware Bay. The model simulated actual settlement events in 1989 and 1990. Critical mortality was approximately 0.20 d⁻¹.

37 44 P-2 C

Escorcía, S.P., Fourqurean, J.W., Department of Biological Sciences and Southeast Environmental Research Program, Florida International University, Miami, FL, and **Zieman, J.C.**, University of Virginia, VA. **INTRA-ANNUAL VARIATION OF C, N, AND P IN *THALASSIA TESTUDINUM*.**

Samples of *Thalassia testudinum* have been collected at different times of the year since June, 1992 along a transect across Conch Reef off the east coast of Key Largo in the Florida Keys. From results of total C, N, and P analysis, a variation in the C:N and C:P ratio on a seasonal basis can be seen. C:N and C:P ratios show a seasonal trend increasing over the summer months of June and August (ratios as high as 30:1 and 545:1, respectively) and decreasing through the winter and spring (ratios as low as 12:1 and 139:1, respectively). Although there is a variation in the amount of C present during the year (less than 10% within each site), the greater influence in the ratios is the variation of N (between 30% and 54%) and P (between 55% and 125%) during the year at each site. The trend is seen continuously over the three year time frame during which samples were analyzed. C:N:P ratios also vary spatially across the region, in response to ecosystem-scale patterns in nutrient availability. The large intra-annual variation at each site can confound interpretation of spatial pattern if not taken into account.

18 36 P-2 I S

Espinoza, J., Cárdenas, W., Gaivor, N., Rivera-Monroy, V., Twilley, R.R., Department of Biology, University of Southwestern Louisiana, LA. **THE INFLUENCE OF HYDROGRAPHY, PREDATION, AND REPRODUCTIVE ACTIVITY ON THE ABUNDANCE OF COMERCIAL PENAEID SPECIES IN THE GUAYAS RIVER ESTUARY, ECUADOR.**

The abundance of five Penaeid species was surveyed for 11 months during 1989 to 1990 in two sub-estuaries of the Guayas River Estuary, Estero Grande and Churute, with low and high freshwater inflow, respectively. The most abundant species were *Penaeus vannamei* and *P. californiensis* while *P. stylirostris* and *P. occidentalis* were less abundant. *P. brevisrostris* was seldom present. Monthly size frequency and abundance of *P. vannamei* (white shrimp) post-larvae suggest a seasonal, possible bimodal, recruitment pattern, and by inference bimodal spawning activity. *P. californiensis* (brown shrimp) recruitment pattern revealed no seasonal variation. This species was abundant in broad ranges of sa-

linity and temperature compare to the other species, which may reflect its high adaptability to the estuarine environment. High mortality of *P. vannamei* by predation possibly occurs in contrast to *P. californiensis*, which showed a successful survival and growth in the estuary. Juveniles of both species seems to prefer higher salinities than their post-larval stages. The highest peak of *P. vannamei* post-larvae in February of 1990, was coincident with high levels of salinity prior to high river discharge.

33.2 2 O I

Estep, L., Lillycrop, J., Parson, L., Waterways Experiment Station Coastal Engineering Research Center Vicksburg, MS. ENVIRONMENTAL REMOTE SENSING OF LAGUNA MADRE, TEXAS.

Laguna Madre represents a unique ecosystem — since it is one of the few large, hypersaline lagoonal environments in the world. An hyperspectral scanner (HSS) acquired spatial and spectral data over germane regions of the Laguna. The collected data was corrected for atmosphere and water surface noise. Water depth information was the initial environmental data product generated. The depth information was produced using data, collected by conventional survey, to calibrate the HSS imagery. The water depth information, in turn, was used to normalize variations in ocean color for each band over the scene due to changing depth. The normalized bands were then used to classify the bottom using field collected library spectra to compare pixel spectra against. The resulting product consisted of mosaick, color coded imagery of bottom type as well as GIS vector files. The bottom type data provided by the study enables a baseline assessment of the areal distribution of Laguna sea grass meadows. The depth data generated by the study will be used as input to a circulation model developed specifically for Laguna Madre.

26.1 1 O C

Evans, D.W., Engel, D.W. NOAA/National Marine Fisheries Service, Beaufort Laboratory, Beaufort, NC. REGIONAL CONTAMINANT MONITORING AND PRELIMINARY RISK ASSESSMENT IN THE GULF OF MEXICO.

Data from regional monitoring programs in The Gulf of Mexico are used in the problem formulation phase of a gulfwide ecological risk assessment. Sediment and tissue concentrations of chemical contaminants are spatially displayed to identify areas of potentially elevated risk. Not surprisingly, these areas are typically near urban centers in estuarine waters of low salinity or restricted circulation. Large areas exist with sparse sample coverage, limiting our ability to infer the extent of potential problems. Persistent chemicals such as metals, chlorinated organics, and PAHs are the dominant monitored contaminants. Accepted criteria of concentrations in both sediments and tissues associated with detrimental ecological effects are lacking for many of these contaminants, however. In addition, many of these monitored chemicals are no longer produced or used; their presence in environmental samples is a result of past usage. It is

therefore difficult to employ existing monitoring data to assess and manage current point and non-point inputs. Input monitoring programs such NPDES target a different suite of contaminants, most of which are not persistent.

-F-

12.4 6 O C

Fabrizio, M.C., Ferreri, C.P., Hansen, M.J., National Biological Service, Great Lakes Science Center, Ann Arbor, MI. CAN PREY FISH COMMUNITIES SERVE AS INDICATORS OF ECOSYSTEM HEALTH IN LAKE MICHIGAN?

We evaluated several measures of fish community structure for assessing the health of nearshore and offshore waters of Lake Michigan by examining a collection of historical data. Since 1973, prey fish numbers and biomass were monitored annually by bottom trawling at 8 ports evenly distributed around the lake. Four species — alewife, bloater chub, rainbow smelt, and deepwater sculpin — dominated the catches (at least 87% and 95% of the biomass in nearshore and offshore waters). In nearshore areas, all indicators of assemblage complexity, productivity, or importance of exotic species showed significant trends through time when evaluated on a whole-lake basis. In offshore areas, only total biomass and a similarity coefficient showed no significant change. Indicators based on total biomass and exotic species biomass of nearshore and offshore fish communities appeared to be sensitive to changes in environmental stressors. Whereas significant increases in fish species diversity and richness likely indicated an amelioration of environmental conditions, the decrease in exotic species biomass (from 70-90% to 5-15%) was a desired effect of fisheries management actions. The patterns we observed in condition indicators are those expected if environmental stressors had, indeed, effected changes in fish community structure or function.

16 28 P-1 C

Fano, A., Gaiani, V., Gatti, L.G., Dep Biologia, sec. Biologia Evolutiva, University of Ferrara, Via Borsari 46, 44100 FERRARA, Italy. DIEL VARIATION IN MACROINVERTEBRATE PHYTAL COMMUNITY STRUCTURE

In seagrass and macroalgal system, the motile epifauna are recognized as key links in the transfer of energy to higher consumers (Howard 1984; Leber 1985). High abundances of epifauna, generally related to vegetal biomass available (Summerson and Peterson 1984; Lewis 1987; Schneider and Mann 1991) and their relative accessibility to epibenthic predators enhance their trophic role. Aim of this study is to examine diel pattern of abundance and structure of macrobenthic community associated to drift macroalgae and seagrass beds in three coastal lagoons. Sampling areas were three European lagoons: the Sacca di Goro (Po river Delta, Adriatic sea, Italy), the Etang du Prevost (Rhône river Delta, Mediterranean Sea, France), the Lagune de Certes (Atlantic Ocean, southwestern France). The stations chosen for sam-

pling were st.4 and 7 in Goro, st.11 in Prevost and st. CI in Certes). The vegetal beds found in the four station were *Gracilaria verrucosa* and *Ulva*.

8.2 1 O C

Fennessy, M.J., Dyer, K.R., Christie, M.C., Institute of Marine Studies, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK. THE CONTROL OF FLOC SIZE AND DENSITY SPECTRA IN ESTUARIES BY TURBULENCE.

Size and settling velocity of individual flocs within discrete samples, obtained using the In Situ Settling Velocity instrument (INSSEV), allow effective density to be calculated. Spectra of floc mass are produced in bands for size, settling velocity and density which show consistent variation with turbulent energy in the water column. Turbulent energy is quantified from current meter profiles and high frequency time series at the same height above bed (0.5 m) as the INSSEV samples. INSSEV and current meter data have been obtained from four European estuaries in both wave and current dominated locations. The INSSEV floc samples cover a range of SPM concentration and salinities. Results indicate that energy variation, over time scales of tens of minutes, is a highly significant control on flocculation processes with floc effective density showing a greater range in magnitude than either size or settling velocity. It is suggested that estuarine sediment transport modelling should feature the strong causal relationship between turbulent energy and both floc size and floc density in any attempt to simulate settling flux.

13.3 6 O I

Findlay, S., Nieder, W.C., Institute of Ecosystem Studies, Millbrook, NY and HRNERR, Annandale, NY. TIDAL WETLANDS AS MODULATORS OF NUTRIENT EXPORT FROM TERRESTRIAL ECOSYSTEMS.

Tidal wetlands fringing the Hudson River estuary have the capability to modify amounts and composition of materials in transport from terrestrial systems to the mainstem Hudson. Wetlands varying in vegetative cover have markedly different effects on nutrient ratios in water entering and leaving these marshes. Comparisons of N:P molar ratios in tributaries to marshes, water in the mainstem Hudson and water ebbing from the marshes shows large differences in ebb tide ratios that are not related to tributary loads. For example, water exiting Tivoli North Bay (a cattail marsh) has N:P of 45, enriched relative to flood water from the mainstem (N:P ~ 30). This enrichment occurs despite tributary inputs to the marsh depleted in N (N:P < 10). In contrast, Tivoli South Bay exports water greatly depleted in nitrate (N:P <

10) despite receiving tributary loads dramatically enriched in nitrate (N:P >150). In this case, active denitrification in South Bay sediments (porewater nitrate is completely depleted by mid-July), is responsible for alterations in nutrient delivery to the mainstem. These wetlands occur at critical points in the landscape and have the biotic potential to modify point and non-point exports from terrestrial drainages.

20.3 6 O C

Foerster, J., U.S. Naval Academy, Oceanography (9d), Annapolis, MD. **COASTAL ZONE/OPEN OCEAN INTERACTIONS: COLUMBIA RIVER STUDY**

Annually, the Columbia River passes through its estuary, emptying 7300m³/sec of water into the Northeast North Pacific Ocean. A major question is how does this river influence the coastal ocean of Oregon and Washington and interact with the open ocean? The hypothesis is that the Columbia River plume shifts seasonally affecting a wide area of the coastal zone. Results, using satellite remote sensing and oceanographic measurements, show the Columbia River plume moves when the Spring current patterns in the Northeastern North Pacific Ocean change. This is an adjustment relative to the changing wind patterns and geostrophic current flow. During the Spring, the river plume shifts from flowing north along the coast (March) to offshore (April). In May, the river plume flows south along the coast and out over the shelf. This shift conservatively influences the coastal ocean productivity of 8750 km². The data demonstrates a shifting river plume, knowledge of which is important to understanding coastal zone interactions and managing coastal resources.

1.1 5 O C

Fonseca, M.S., Meyer, D.L., NMFS/NOAA, Beaufort Laboratory, Beaufort, NC and Bell, S.S., University of South Florida, Tampa, FL. **FAUNAL ATTRIBUTES OF SEAGRASS LANDSCAPES WITH VARYING SPATIAL HETEROGENEITY: UNMET EXPECTATIONS.**

Throwtraps (1 m²) were used to capture resident fish and shrimp in seagrass beds near Beaufort, NC. Sampling occurred in June and September, 1991-1992. Eighteen sites, representing a range of bed spatial heterogeneity (50 x 50m, 1m resolution of coverage) were surveyed. Coverage ranged from 13 to 100%, with lower coverage sites comprised of isolated patches and/or anastomosing patterns. Coverage was inversely proportional to wave exposure and current speed. Examination of total abundance, number of taxa and composition among sites as a function of waves, currents, seagrass cover, sediment composition, plant density and biomass revealed few, if any patterns. This lack of pattern held whether data were grouped as fish or shrimp, by species within groups or sampling season. Absence of a response by these fauna to extreme differences in habitat heterogeneity does not follow what would be expected under various hypotheses such as intermediate disturbance. The mechanism(s) responsible for this apparent absence of pattern remain unclear, but these data point out the absence of a minimum critical habitat size, meaning that even small patches of seagrass have significant resource value.

21.4 2 O C

Foote, A.L., U.S. National Biological Service, 700 Cajundome Blvd. Lafayette, LA 70506. **THE EFFECTS OF STRUCTURAL MARSH MANAGEMENT ON HYDROLOGIC PATTERNS IN MICROTIDAL COASTAL WETLANDS OF LOUISIANA**

As part of a three-year field experiment we measured the surface hydrology of managed and unmanaged coastal wetlands. The three overwhelming factors that influence the surface water levels included: lunar tides, hydrologic linkage (connectivity), and meteorology. Continuous water level data was recorded electronically at four managed and four adjacent unmanaged areas during 1993-1995. The effects of structural marsh management on seasonal hydrology are apparent from the record. Structural marsh management is capable of muting tidal signals and affecting wetland processes depending on the configuration of water control structures. The schedule of hydrologic manipulation that is permitted in coastal Louisiana wetlands is a series of compromises. Rapid changes in water level have killed vegetation, raised serious questions about ingress and egress of estuarine organisms and altered sediment attributes. Gradual filling and later dewatering are strategies that may favor wetland biota more than the current regimes.

31.2 2 O I

Ford, M.A., Grace, J.B., Louisiana State University, Baton Rouge, LA and National Biological Service-Southern Science Center, Lafayette, LA. **HERBIVORY IMPACTS ON SOIL ELEVATION AND SOIL ACCRETION IN A BRACKISH MARSH OF COASTAL LOUISIANA.**

In rapidly subsiding wetlands, such as those in the Mississippi delta region, the persistence of marshes is dependent upon sufficient soil accretion to outpace rate of subsidence. This study was conducted in order to assess the impact of mammalian herbivores, especially nutria and wild boar, on soil accretion processes. The use of exclosures in conjunction with feldspar and benchmark techniques allowed us to measure the effects of herbivore exclusion on surface accretion, marsh elevation changes, vegetation, and litter production. Herbivory has been found to have substantial effects on standing biomass as well as species composition. Herbivores have also been found to increase decomposition of material on the soil surface because of the destructive nature of the feeding habits. Changes in soil surface elevation over time indicate that while herbivory appears to have a significant effect on sedimentation, it does not seem to be the dominant variable affecting soil elevation changes in this system.

33 40 P-1 C

Fortner, A., Meaburn, M. National Marine Fisheries Service, Southeast Fisheries Center, Charleston, SC. **A DEMONSTRATION OF GIS APPLIED TO SHELLFISH MANAGEMENT.**

State public health agencies routinely monitor fecal coliform levels in molluscan shellfish growing waters to regu-

late the fishery. Heavy reliance is placed on manual cartography. This process is cumbersome and unresponsive to water quality changes in a dynamic estuarine environment. A Geographic Information System (GIS) is a viable alternative to the current mapping process. Objectives of this project are to demonstrate the applicability of GIS to shellfish resource management and estuarine ecosystem health research. A study area in the southwest quarter of the James Island USGS quadrangle, Charleston County, SC was selected for this purpose. The demonstration has two sections. (1) a slide presentation explaining GIS and its application to shellfish management and research; and (2) a user interactive GIS simulation. Users can access maps of oyster resources and potential sources of pollution. The concept of combining data layers to study interrelationships between environmental attributes (e.g., land use and water quality) is also introduced. Data reports are provided to illustrate the link between GIS maps and their associated databases. This demonstration was produced for a broad audience consisting of natural resource managers, the molluscan shellfish industry, and the scientific community. A multimedia PC is used to display this poster.

12.1 4 O I

Fournie, J., Summers, K., U.S. Environmental Protection Agency, Gulf Ecology Division, Gulf Breeze, FL, and Weisberg, S., Versar, Inc., Columbia, MD. **GROSS PATHOLOGICAL ABNORMALITIES IN FISHES AS INDICATORS OF ESTUARINE CONDITION.**

Gross external pathological abnormalities are frequently used indicators of anthropogenic influence in estuarine and marine waters, but little baseline information is available to identify what constitutes normal prevalences. To establish this baseline, trawl samples were collected from 120 randomly located estuarine sites in the Virginian (mid-Atlantic) biogeographic province in 1990, and from 220 randomly located sites in the Louisianian biogeographic province (Gulf Coast) in 1991 and 1992. Sediment contaminant concentrations were measured at each site. A total of 28,287 fish, comprising 87 species, were examined for gross pathological abnormalities and background prevalences were estimated to be 0.5% in the mid-Atlantic and 0.7% in Gulf Coast estuaries. Fifteen different types of gross pathologies were noted. Skin lesions were the most prevalent abnormalities in both provinces, followed by ocular abnormalities (e.g., exophthalmia, keratitis) in the Virginian Province and branchial chamber abnormalities in the Louisianian Province. The prevalence of gross pathologies was about three times higher for demersal fish than for pelagic fish and was about eight times more prevalent at sites with high sediment contaminant concentrations. Among the major estuarine systems, pathologies were most prevalent in Galveston Bay and lowest in Long Island Sound and Mississippi Sound.

2.2 4 O I

Fourqurean, J.W., Jones, R.D., Southeast Environmental Research Program, Florida International University, Miami,

FL. BIOGEOCHEMISTRY OF THE SUBTROPICAL BAYS AND ESTUARIES OF SOUTHWEST FLORIDA.

Florida Bay, and the mangrove-lined estuaries and bays of the southwest coast of Florida, are unique systems in the US. They are underlain by carbonate bedrock and sedimentary deposits, and are dominated by communities of mangroves and seagrasses. We have monitored concentrations of biogeochemically reactive elements, as well as assays of the size and activity of the planktonic community, in these systems since 1989 on a monthly basis. These systems typically have low concentrations of SRP (usually $< 0.05 \mu\text{M}$), high DIN (often $> 100 \mu\text{M}$), and high DOC (often $> 1000 \mu\text{M}$). The chief form of DIN in these systems is ammonium. Light attenuation, especially in the mangrove-dominated embayments, is chiefly caused by DOM. Major perturbations have occurred over the period of record, including Hurricane Andrew, poorly understood dieoff of seagrasses, and increased turbidity. Despite these perturbations, phytoplankton biomass is generally quite low (usually $< 3 \text{ mg/L}$). Contrary to temperate estuaries, the biomass of primary producers is limited by P availability over most of the region. The anomalous, phosphorus-limited nature of these systems results from very high N:P in the inputs to the system from the Everglades watershed.

12.1 5 O I

Frithsen, J.B., Weisberg, S.B, Versar, Inc., Columbia, NM, and Oviatt, C.A., Keller, A.A., Graduate School of Oceanography, University of Rhode Island, Narragansett, RI. **AN INDEX OF EUTROPHICATION FOR POLYHALINE WATERS.**

Eutrophication in marine waters is typically defined by its symptoms. An alternate definition was recently developed based upon annual carbon inputs; however, quantifying eutrophication in this way requires data that exist for few estuaries. We present a summer index of eutrophication for polyhaline waters that relates water quality and sediment metrics to carbon input. The index was developed using data from the Delaware-Maryland Coastal Bays and uses eight metrics commonly associated with eutrophication: nitrate+nitrite, total dissolved nitrogen, total particulate nitrogen, phosphate, total particulate carbon, chlorophyll, percent oxygen saturation, and sediment organic carbon. Data from the nutrient addition experiments conducted in the enclosed experimental mesocosms of the Marine Ecosystems Research Laboratory (MERL) were used for the initial validation of the index. The index reproduced the nutrient gradient of the MERL experiments, which ranged from 1 to 32 times the average aerially weighted nutrient input to Narragansett Bay. Additional validation of the index was completed using data from other East-coast estuarine systems to better understand how robust this index is and its limitations.

28.1 I O C S

Fugate, D., Virginia Institute of Marine Science, College of William and Mary, Gloucester Pt., VA. **ENQUIRY INTO**

THE FRACTAL NATURE OF TIDAL CHANNEL NETWORKS.

Whether a tidal creek erodes, accretes, or migrates depends on the biota, flow regime, and suspended sediment load, which are all related to and dependent upon the spatial pattern of the network through which the water flows. The topology of self similar patterns such as that exhibited by drainage networks may be quantified by their fractal dimension, a measure which does not suffer from scale dependencies as do traditional sinuosity measures. The degree of meandering in transgressing salt marsh drainage networks is empirically estimated as a fractal dimension using the functional box-counting technique. Variations of this technique are compared with each other, as well as with theoretically derived estimates of the fractal dimension. The degree of meandering amongst different aged creeks is explored and placed in the context of network evolution. The fractal dimension for salt marsh networks is compared with published estimates for non-tidal riverine drainage network patterns, and the differences between them discussed in terms of their evolution according to laws of minimum energy expenditure of the system.

18 37 P-2 C S

Gaibor, N., Coello, S., Rosero, J., Mosquera, G., Altamirano, M., Aquino, K., Instituto Nacional de Pesca, Guayaquil, Ecuador. Department of Marine Affairs, University of Rhode Island, Kingston, RI, Programa de Manejo de Recursos Costeros, Guayaquil, Ecuador. Comuna de Valdivia, Valdivia, Ecuador. THE ARTISANAL SHRIMP POSTLARVAE FISHERY IN ECUADOR.

Many coastal resources have been depleted in developing countries due to the necessity of food by local consumers. Ecuador has not been the exception and many natural resources have been destroyed during the last years. The mangrove ecosystem is an example of this destruction due mainly by the shrimp aquaculture industry. As part of this industry, the artisanal shrimp post-larvae fishery has been developed to supply shrimp ponds. Fishermen called *larveros* supply 70% of the annual demand of larvae for shrimp ponds. Although the artisanal shrimp postlarvae fishery has been developed along the surf zone of beaches, this activity started in earlier years in the inner of the estuaries. The total catch is composed of the four commercial Penaeid species; *Penaeus vannamei*, *P. stylirostri*, *P. occidentalis*, and *P. californiensis*. Nearly 54% of *larveros* use the scissor net, while the use of others (riso, vaca, and stationary net) represents 46% together of the total nets used for this fishery. The shrimp postlarvae and bycatch are concentrated into a small pocket of the push net where they are subject to undue mortality due to cannibalism. Another important cause of mortality occurs by waves hitting against the push nets.

18.1 1 O C S

Gaibor, N., Garcia, R., Luzuriaga de Cruz, M., Massay, S., Ortega, D., Villamar, F., Mora de Banos, E., Basantes, A., Vicuna, H., Institute Nacional de Pesca, Guayaquil, Ecuador. Department of Marine Affairs, University of Rhode Island, RI, and Coello, R., Programa de Manejo de Recursos Costeros., Guayaquil, Ecuador. EVALUATION OF THE ARTISANAL SHRIMP POST-LARVAE FISHERY AND ITS BY-CATCH ALONG THE ECUADORIAN COAST-LINE.

The spawning season of Penaeid shrimp occurs from December to April, and coincides with the main period of postlarval abundance along the Ecuadorian coastline, especially in the Gulf of Guayaquil. Samples were collected between June 1991 and June 1992, in the intertidal zone of eight locations, to study the composition, abundance and distribution of shrimp-postlarvae and its by-catch in the coastal zone of Ecuador. The capture of organisms was done with the "scissors's net," that was used by 54% of fishermen. Penaeids registered greater abundance in March and

April of 1992, probably due to the high intensity occurrence of the El Niño phenomenon. Fish larvae and post-larvae showed greater abundance in July 1991, and in March-April, 1992. Of 115,779 samples, *Penaeus vannamei* registered the highest percentage (57%), followed by *P. occidentalis* (35%), *P. stylirostri* (7%), and *P. californiensis* (1%). The highest percentage of the total organisms collected corresponded to the group named "other crustacean" (i.e., Myscideaes, Callinectes, Emeritas, and Megalopas), which represented 62.77%, followed by penaeids of commercial importance (*Penaeus vannamei* and *P. stylirostri*), with 18.47%; and other penaeids (*P. occidentalis*, and *P. californiensis*), with 10.51%.

4.2 2 O I

Gallagher, J., Mutz, L., Halpern, B., Halophyte Biology Laboratory, College of Marine Studies, University of Delaware, Lewes, DE. IS THERE MERIT IN BEING A YOUNG WETLAND? - A FISHEYE VIEW.

Comparisons were made on several aspects of fish populations among a young created wetland, an old natural wetland, and two ponds in a natural *Spartina alterniflora* wetland. Pit traps collected more juvenile fish on the ebbing tide as the water left the marsh surface after high tide in a young created wetland than in an old natural marsh. Seining and trapping in the tidal pool/creek complex of the created marsh captured more fish than in the creek in the natural marsh. Mark and recapture studies gave population estimates similar to those obtained by seining or trapping in the created wetlands. Ponds in the natural marsh influenced by only the spring tides yielded less fish upon trapping than did the created pool/creek which has daily tidal changes. *Fundulus heteroclitus* was the primary fish collected from the natural marsh creek and in the pit traps in that marsh. Both that species and *Cyprinodon variegatus* were abundant in the ponds and in the pool/creek in the created wetland. Early in the summer the larger fish were in the natural marsh, but late in the summer those in the created wetland were larger than those in the natural marsh or the two ponds. Other comparisons included gut fullness index, gonadosomatic index, and condition index.

3.3 3 O C

Garber, J.H., Dettmann, E., Nelson, W., Pesch, C., Voyer, R., Walker, H., United States Environmental Protection Agency, Atlantic Ecology Division, Narragansett, RI. A COMPARATIVE APPROACH FOR QUANTIFYING THE CUMULATIVE EFFECTS OF ANTHROPOGENIC ACTIVITIES ON NORTHEASTERN ATLANTIC COASTAL ECOSYSTEMS.

Ecological "health," "integrity," "productivity," and "sustainability," are terms difficult to define with generally acceptable scientific precision. However, the concepts these words convey lie at the center of recent efforts to protect coastal resources. They appear with increasing frequency in the language of environmental statutes. In this talk we present an overview and the preliminary findings of a multi-disciplinary effort aimed at quantifying, understanding, and predicting the cumulative effects of anthropogenic activities on "health and integrity" — which we define in terms of measurable characteristics and ecological structure — of coastal water bodies. Our approach involves a combination of probability-based field sampling, laboratory microcosm studies, mathematical modeling, and historical reconstructions of a polluted target estuary and a physically similar and presumably cleaner reference system. Initial work focused on sub-basins of Buzzards Bay, MA: the Achushnet River Estuary (target) and the Slocums River (reference). Results to date support the concept of a "healthy" system as exhibiting relatively higher benthic species richness, lower water column productivity, and an absence of environmental contaminants. However, the comparative approach is complicated by the apparent effects of water circulation and sediment type on organism distributions. Definition of acceptable "reference" conditions remains particularly elusive.

22.1 5 O I S

Garcia-Romero, B., Wade, T., Alcalá-Herrera, J., Geochemical and Environmental Research Group, Texas A&M University, College Station, TX., and Presley, B., Trace Element Research Laboratory, Texas A&M University, College Station, TX, and Baskaran, M., Department of Oceanography Texas A&M University Galveston TX, and Alexander, C., Skidaway Institute of Oceanography, Box 13687, Savannah, GA. **HISTORICAL CONTAMINATION TRENDS RECORDED IN ESTUARINE AND COASTAL SEDIMENT CORES.**

Concentrations of total DDTs, PCBs, and PAHs were determined in dated sediment cores collected from an estuarine site on the Saint Johns River, Florida (SJ) and a coastal site in the Mississippi Delta, Louisiana (MD). The sedimentation rates estimated for these cores based on excess ^{210}Pb were similar (1.0 and 0.81 cm yr^{-1} for SJ and MD, respectively). Contaminant concentrations in both cores increased above background in the mid 1940's. Total DDTs (sum of DDT and its metabolites) concentrations ranged from below detection to 30 and 2.5 ppb for SJ and MD cores, respectively. Total DDTs indicate no decreases in environmental concentrations in recent years. PCBs ranged from 40 to 400 ppb and from below detection to 30 ppb for SJ and MD cores, respectively. PCB concentrations for the MD core decreased from the mid 1980's to the 1990's while the core from SJ showed a continuous increase during this period. Total PAH concentrations ranged from 1500 to 6000 ppb in the SJ core and from 200 to 800 in the MD core. Total PAH concentrations indicate fluctuating inputs over short time scales in both cores and did not show clear temporal trends. Contaminant concentrations were from five to more than ten times higher

in SJ compared to MD. This may be the result of closer proximity to input sources for the Saint Johns River core. Vertical distributions reflect the complexity of the processes involved in contaminant transport and deposition for each environment. However, the similar general contaminant history observed at both locations indicates that contamination was and continues to be a geographically wide spread problem.

35 47 P-3 C

Garono, R.J., Backus, E.H., Miller, J.A., Sigman, M.J., Oregon State University Tillamook Bay National Estuary Project, Corvallis, OR. **THE USE OF GIS IN THE LAND OF CHEESE, TREES, AND OCEAN BREEZE, TILLAMOOK BAY NATIONAL ESTUARY PROJECT, GARIBALDI, OR.**

In 1992, Tillamook Bay, OR was accepted into the EPA-sponsored National Estuary Program (TBNEP), a community-based effort aimed at developing a comprehensive conservation and management plan (CCMP) to address environmental problems in the estuary. NEPs are designed to promote and coordinate research and management efforts focused on the priority problems identified for selected estuaries. Priority problems for the watershed include: 1) pathogen contamination affecting shellfish resources and water-contact uses; 2) sedimentation; and 3) critical habitat degradation. The development of management strategies on a watershed scale requires standardization of existing data. TBNEP chose ArcInfo/ArcView geographic information system (GIS) as the tool for data management and analysis as well as public education. The use of GIS facilitates the compilation of information produced through TBNEP-sponsored research and other agencies. The development of compact discs (CD) with GIS data files and multimedia educational programs can be used by researchers, land managers, educators, and the public. Additionally, two satellite computer stations with ArcView capabilities and the TBNEP data set will be placed within the Tillamook school district and at a community location.

21.4 1 O C

Garono, R.L., Gienger, E. Oregon State University, Tillamook Bay National Estuary Project, Garibaldi, OR and Neah-Kah-Nie High School, Rockaway Beach, OR. **USING ADULT INSECTS COLLECTED BY LIGHT TRAP TO EVALUATE SALMON HABITAT IN THE MIAMI RIVER, TILLAMOOK BAY, OREGON.**

Salmon habitat degradation was identified as a priority problem for Tillamook Bay National Estuary Project (NEP). Since the 1980's various government agencies have completed more than 30 salmon enhancement projects in the Tillamook Bay watershed. Salmon enhancement projects typically consist of the placement of boulders, logs or other structures to increase stream heterogeneity. In this study, paired light traps were used at three sites along the Miami River to collect adult insects in order to evaluate insect response to salmon habitat restoration efforts. Traps were op-

erated. from dusk to dawn, at two week intervals at a three year old, one year old, and an unmanipulated site. A total of 7,777 insects have been identified to order from a May 1995 collection. Insect abundances ranged from an average of 434.0 individuals at the three year old site to 1916.0 at the one year old site. The highest average number of orders (4.5) was collected at the unmanipulated site, and 4.0 and 2.0 orders were collected at the one year old and the three year old site, respectively. Diptera and Lepidoptera were collected at all sites. Wholly aquatic orders (Trichoptera, Ephemeroptera) were only collected at the one year old and unmanipulated sites.

5.1 2 O C

Gaston, G.R., Cleveland, C.M., Brown, S.S., Biology Department, University of Mississippi, Oxford, MS, and Rakocinski, C, Gulf Coast Research Laboratory, Ocean Springs, MS. **DO MACROBENTHOS FEED DIRECTLY ON PHYTOPLANKTON IN NORTHERN GULF OF MEXICO ESTUARIES?**

We used trophic structure to examine the fate of detritus in Gulf of Mexico estuaries sampled at 201 sites from Florida to Texas. Detritivores represented over 80% of the macrobenthic organisms and over 90% of the biomass. We analyzed gut contents of dominant suspension feeders, and classified them as detritivores, since they primarily fed on resuspended detritus or recently settled material. The paucity of benthos that consumed plankton directly led us to hypothesize that macrobenthos in Gulf of Mexico estuaries had less effect on plankton communities than was documented in U.S. East Coast and European estuaries, where benthic communities consumed much of the phytoplankton produced. We provided as evidence the gut-contents analyses, the absence of deep-burrowing benthos (especially clams), the relatively small size of benthos, and the harsh physical (hypoxia) and biological (predation) conditions in Gulf of Mexico estuaries.

20.3 4 O C

Gearing, J.N., University of Massachusetts Dartmouth, North Dartmouth, MA. **HIGHLY BRANCHED ISOPRENOID HYDROCARBONS IN ST. LAWRENCE SEDIMENTS: COMPARISON OF RIVERINE, ESTUARINE AND COASTAL AREAS.**

Over twenty different highly-branched, isoprenoid hydrocarbons (C₂₀, C₂₅ and C₃₀ alkanes and alkenes) have been reported from a wide variety of aquatic sediments since their first description in the Gulf of Mexico. Many of these biogenic compounds have physico-chemical properties similar to those of common contaminant hydrocarbons, allowing the isoprenoids to be used in pollutant indices as a mechanism to compensate for some natural variability. Eighty-two surface sediment samples from the St. Lawrence System were analyzed for aliphatic and aromatic hydrocarbons. Concentrations of the C₂₀ and C₂₅ compounds varied between non-detectable and 89 ng/g, with the upper estuary containing the lowest levels. The suite of compounds also varied, with

one pattern characterizing the freshwater areas and another pattern found in the coastal sediments. Aliphatic and aromatic contaminants were normalized to the major isoprenoid (C₂₅:3) and these ratios were compared with values of established indices such as pristane/n-C₁₇, pristane/phytane, benzo(a)pyrene/perylene and phenanthrene/methylphenanthrenes. These new indices complement existing ratios, providing additional information on the relative importance of pollutant inputs and primary productivity.

29.2 5 O C S

Gerken, M.A., Great Lakes Center, Buffalo State College, 1300 Elmwood Ave. Buffalo, NY. **HYPOXIA: TO WHAT DEGREE DOES IT AFFECT STRIPED BASS GROWTH AND CONSUMPTION?**

Low dissolved oxygen can be a limiting factor in many aquatic ecosystems. In particular, fish distributions, growth, consumption, and metabolic rates can be significantly affected by the amount of dissolved oxygen available. In systems with a long history of cultural eutrophication, such as the Chesapeake Bay, low dissolved oxygen can limit striped bass (*Morone saxatilis*) production during the summer when stratification occurs. In a laboratory setting, striped bass consumption and growth were measured over a two-week time period at three oxygen levels and four temperatures. Both consumption and growth decreased significantly as dissolved oxygen levels decreased. Some interactions between temperature and oxygen concentrations were present. Laboratory results were used to develop equations to modify existing bioenergetics models of striped bass in the Chesapeake Bay. The bioenergetics models were then used to examine trade-offs between temperature, prey availability, and oxygen levels across the Chesapeake Bay.

20.2 3 O I

Geyer, W.R., Anderson, D.M., Fozlcg, D.A, Keafer, B.A., Woods Hole Oceanographic Inst., Woods Hole, MA, and Signell, R.P., Butman, D., US Geological Survey, Woods Hole, MA, and Franks, P.J.S., Scripps Institute of Oceanography, La Jolla, CA, and Loder, T.C. III, University of New Hampshire, Durham, NH. **TRANSPORT OF FRESH WATER AND TOXIC DINOFLAGELLATES BY A RIVER PLUME IN THE WESTERN GULF OF MAINE: THE IMPORTANCE OF WIND FORCING.**

Observations in the western Gulf of Maine during 1993 and 1994 show large differences in the transport of the freshwater plume from the Kennebec-Androscoqqin estuary, even though the river discharge was comparable in these two years. During 1993, the plume turned to the right and flowed as a coastal current toward the south, with most of the fresh water trapped along the coast. In 1994 the plume spread offshore with much less southward transport, resulting in higher salinities in the coastal water to the south. The difference in plume dynamics between the two years appears to result from differences in wind forcing. In 1993, several periods of strong northerly winds around the time of peak river discharge

caused coastal downwelling, which trapped the plume along the coast and accelerated it in the southward direction. In 1994, the winds were generally upwelling favorable during peak discharge, which spread the plume in the seaward direction and arrested the southward tendency of the regional circulation. The different advective regimes in the two years resulted in large differences in the distributions of Alexandrium, a toxic dinoflagellate that is associated with the Kennebec-Androscoogiri plume. In 1993, high concentrations of toxic algae were advected southward, resulting in closure of shellfish beds in southern Maine, New Hampshire and Massachusetts. In 1994, the dinoflagellates were advected seaward, and there was little toxicity at the coastal monitoring stations.

29.2 3 O C

Gilmour, C., Bell, J., Academy of Natural Sciences, Benedict Estuarine Research Lab., St. Leonard, MD and Capone, D., Aldridge, G., Univ. of Maryland, Chesapeake Biological Lab., Solomons, MD. **BACTERIOPANKTON DYNAMICS IN THE PATUXENT RIVER: RESPONSE TO NITROGEN ABATEMENT.**

Bacterioplankton abundance, production, and the uptake and regeneration of organic and inorganic nutrients have been measured in the eutrophied Patuxent River, a sub-estuary of the Chesapeake Bay, since 1990. The Patuxent appears to be a net heterotrophic ecosystem, due to light limitation, substantial sources of DOC and DON, and the potential for bacterioplankton to outcompete phytoplankton at times for nutrients. Secondary and primary production were only weakly coupled temporally throughout the river, suggesting other, external sources of bacterial substrates. Experiments examining the size distribution of DIN and DIP uptake, as ^{15}N and ^{32}P , suggest that bacterioplankton compete with phytoplankton for inorganic nutrients. Bacterioplankton accounted for up to a quarter of ammonium uptake at the meso- and oligohaline stations in summer. Bacterioplankton growth was not limited by inorganic N at any station in summer, but DON increasingly stimulated growth relative to DOC as salinity increased. These results have important implications for the effect of ongoing N reductions on water quality. Bacterial growth, especially upriver, appears to be fueled by allochthonous sources, and limited by organic C rather than N. In the mesohaline estuary, recycling of nutrients through bacterioplankton may temper the effects of reduced N loading on phytoplankton growth.

34.2 5 O C

Glasgow, Jr., H.B., Burkholder, J.M., Lewitus, A.J., North Carolina State University, Raleigh, NC and Belle Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Georgetown, SC. **RESPONSE OF AN ICHTHYOTOXIC DINOFLAGELLATE TO DIVERSE ALGAL PREY.**

The estuarine dinoflagellate, *Pfiestefia piscicida* (gen. et sp. nov.; Steidinger *et al*) becomes toxic in the presence of live fish. Flagellated and amoeboid stages of this microbial predator are also known to consume an array of bacteria,

algae, and other microfauna, accomplished by engulfing the prey or by using a peduncle to suction the prey contents. In short-term assays (4-6 days), we examined the response of zoospores taken from nontoxic cultures (without fish, in *f/2* medium) when given algal prey in single-species trials as diatoms (*Thalassiosira*), coccoid green or blue-green algae (*Nannochloris* and *Synechococcus*, respectively), flagellated greens (*Dunaliella tertiolecta*) chrysophyte flagellates (*Pseudoisochrysis*), or cryptomonads (*Cryptomonas*). The growth response and prevalence of flagellated versus amoeboid stages of *P. piscicida* varied with algal prey type. Zoospore abundance was significantly higher with cryptomonad prey than with other algal taxa, whereas amoebae transformed from zoospores were most common in cultures with coccoid blue-green algae. The data indicate a mechanism whereby *P. piscicida* can thrive among phytoplankton in the absence of fish prey affect feeding and growth efficiency.

33.1 5 O C

Godshall, F.A., Bowen, R.D., Science Applications International Corporation, Narragansett, RI, and Walker, H.A., EPA, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division. Narragansett, RI. **RUNOFF VARIABILITY IN TEXAS AND LOUISIANA GULF COAST REGION INTERPRETED FROM A SATELLITE-BASED GENERAL VEGETATION INDEX.**

The Texas and Louisiana Gulf Coast region contains numerous small rivers, lacustrine areas, and coastal lagoons into which local land regions drain. Seasonal and interannual variability in runoff from local land areas has important influences on the estuarine ecology in this region. Typically such variability is characterized utilizing data on river flow, at specific gauging stations. Variability of land runoff, regulated through precipitation and evaporation, also affects vegetation distribution and phenology which can be interpreted from a satellite-based Normalized Difference Vegetation Index (NDVI). NDVI is a synoptic measure that incorporates many factors of land area hydrology. Seasonal and interannual variability in NDVI in this region provides additional information on spatial and temporal variability in hydrology, not captured in the river flow data. This pilot study investigated spatial and temporal relationships among precipitation, ground-cover vegetation characteristics, NDVI, and river flow in this region. We conclude that variance in NDVI provides an integrative measure of runoff potential in this region, and may have utility in other coastal areas.

21.2 4 O C S

Goldberg, A., Minello, T., National Marine Fisheries Service, Galveston, TX and Texas A&M University, Department of Wildlife and Fisheries Sciences, College Station, TX. **DEVELOPMENT OF BELOW-GROUND ORGANIC MATTER AND MACROFAUNAL POPULATIONS AT THREE CREATED SALT MARSHES IN GALVESTON BAY, TEXAS.**

High rates of wetland loss in the northern Gulf of Mexico

have stimulated efforts to create marshes on dredged material. These marshes, however, may not function similarly to their natural counterparts in supporting benthic infaunal populations used as food by estuarine animals. *Spartina alterniflora* grows rapidly after being planted on dredged material, but infaunal abundances do not appear to be correlated with above-ground plant biomass. To examine the relationships between infaunal abundances and sediment parameters, we compared two created marshes (ages 9 and 5 years) with a newly created marsh at the same location. Core samples were taken to measure infaunal densities, live root and detritus biomass, and sediment organic content and grain size, at different elevations in each of the marshes. The dominant organism in the samples was the polychaete *Streblospio benedicti*. Infaunal densities in the youngest marsh were comparable to those in the other marshes within the first year. In general, low elevation was correlated with high infaunal abundances. Preliminary analyses of sediment parameters suggest that live root biomass and sediment grain size are important in explaining infaunal abundance.

14.1 6 O C

Goodman, J.L., Moore, K.A., Orth, R.J., Virginia Institute of Marine Science, Gloucester Point, VA. **CHANGING SUBMERSED AQUATIC VEGETATION (SAV) DEPTH DISTRIBUTIONS IN THE CHESAPEAKE BAY: 1990-1994.**

Distribution of SAV in the Chesapeake Bay is mapped annually from aerial photographs. This data base provides details of distribution patterns and relative abundance of submersed macrophytes, but it does not address certain important factors such as species composition as it is related to water depth. For this reason, twenty permanent transects were sampled in 1990 and 1994 in seven regions of the Chesapeake Bay to determine short term changes in macrophyte abundance relative to depth and distance from the shoreline. Seven species of SAV were sampled in these transects. Baywide, *Zostera marina* declined in distribution from 1990 to 1994 in shallower (0-30 cm below MLW) regions sampled and increased in abundance in deeper areas (90-170 cm below MLW). *Ruppia maritima* abundances remained relatively constant from 1990 to 1994 throughout its depth limit (0-120 cm below MLW). The low salinity species *Vallisneria americana* and *Zannichellia palustris* increased in density in deeper areas sampled (90-130 cm below MLW). *Potamogeton perfoliatus* increased in abundance from 1990 to 1994 in all sampling regions and at all depths of occurrence (45-70 cm below MLW). *Hydrilla verticillata* was present only in the Potomac River and relative abundance and depth distribution remained constant. Overall, SAV from 1990 to 1994 extended in distribution relative to the shoreline. Transects measured in 1994 increased up to 200% of the length of the transects in 1990 as a whole.

36 49 P-3 C

Gottlieb, S.J., Schweighofer, M., University of Maryland, College Park, MD. **OYSTERS AND THE CHESAPEAKE BAY ECOSYSTEM: A CASE FOR EXOTIC SPECIES**

INTRODUCTION TO IMPROVE ENVIRONMENTAL QUALITY?

Restoration of the Chesapeake Bay ecosystem has been a top priority for residents and governments of the Bay watershed for the past decade. One obstacle in the efforts to "save the Bay" has been continuing nutrient enrichment from agricultural and sewer runoff. The attainability of a mandated 40% nutrient reduction goal has yet to be seen. Many scientists have begun to suspect that disappearance of certain organisms may have had an adverse effect on the resilience of the ecosystem. The Eastern oyster (*Crassostrea virginica*), once abundant in Chesapeake Bay, is reported to be a vital part of the food web, processing excess phytoplankton and depositing materials on the bottom. Overharvesting and disease have decimated the native oyster population, and some have suggested that the introduction of an exotic species, the Japanese oyster (*Crassostrea gigas*), may be the only hope for reestablishing a robust oyster community in the Bay. We have reviewed the literature related to the role of the oyster in estuarine ecosystems and found that bivalve molluscs are an essential part of healthy estuaries around the world. We compared the literature regarding physiology of *C. virginica* and *C. gigas* in terms of adaptation to temperature and salinity environments and resistance to disease. While *C. virginica* is ideally adapted to conditions in Chesapeake Bay, it does not exhibit the ability to stave off flie endemic diseases. *C. gigas* appears to be suited to conditions in the middle and lower Bay, and is much less susceptible to the same diseases. We conclude that continued research into the potential role of *C. gigas* in Chesapeake Bay is a necessary element in the effort to restore the ecosystem to historic quality, especially if disease-resistance in *C. virginica* does not emerge from scientific efforts.

33.2 3 O C

Gould, Jr., R.W., Planning Systems, Inc., Slidell, LA, and Arnone, R.A., Naval Research Laboratory, Stennis Space Center, MS. **REMOTE SENSING ESTIMATES OF INHERENT OPTICAL PROPERTIES IN A COASTAL ENVIRONMENT.**

An experiment was conducted in August, 1994, to characterize the temporal and spatial variability of the optical environment in the coastal area off Fort Walton Beach, Florida, and to relate the variability of the *in situ* measurements to synoptic, airborne remote sensing measurements through modeling. During the experiment, a variety of platforms and instruments were utilized to collect data, including ship, aircraft, and moored sensors. Measurements of physical properties (temperature, salinity, waves, currents) and optical properties (absorption, scattering, reflectance, water-leaving radiance, particle size spectra, beam spread function) were collected over the short space and time scales required to characterize the near-shore environment. The remote sensing reflectance data collected by aircraft using the CASI (Compact Airborne Spectral Imager) sensor at SeaWiFS wavelengths were used in a published optical model to estimate absorption and backscattering of the water col-

umn, after removing the bottom component of reflectance. The modeled values are compared to ship and mooring data to assess the validity of the algorithm in coastal waters. By applying the model to each pixel in a subsene of the aircraft imagery, spatial estimates of the optical parameters were produced.

31.3 4 O C

Grace, J.B., Pugesek, B.H., National Biological Service, Lafayette, LA. **PREDICTING THE EFFECTS OF RISING SEA LEVEL ON COASTAL PLANT DIVERSITY.**

Previous attempts to predict the effects of environmental change on plant diversity have dealt with only one or two variables at a time. However, evidence clearly indicates that plant diversity is controlled by a complex interplay of abiotic and biotic forces. The purpose of the research presented here has been to develop statistically valid, multivariate models for predicting the impact of changes in flooding and salinity on diversity in a coastal marsh landscape. In order to accomplish this, structural equation modeling has been employed as a method of statistically evaluating alternative models about dependence relationships. Using this method, we show that plant diversity is controlled in this system by a combination of biotic and abiotic variables. This method is used to present quantitative predictions of the impacts of rising sea level and salinity on plant diversity.

36.1 3 O C

Grant, J., Pilditch, C.A., Department of Oceanography, Dalhousie University, Halifax, Nova Scotia B3H 4J1 and MacDonald, B.A., Marine Research Group, Department of Biology, University of New Brunswick, Saint John, New Brunswick E2L 4L5. **MODELS OF CARRYING CAPACITY AND THEIR USE IN BIVALVE AQUACULTURE.**

A simulation model has been developed for prediction of growth and carrying capacity in bivalve aquaculture. Although initially applied to suspended culture of blue mussels (*Mytilus edulis*) in coastal Nova Scotia, recent efforts have been aimed at expanding its application to other species and other sites. These changes require increased flexibility in the model in terms of physiological parameterization of the bivalves, as well as in the environmental components such as primary production. Application of the model to sea scallops (*Placopecten magellanicus*) highlighted the bioenergetic differences between scallops and mussels and subsequent changes to the simulation of scope for growth. Specifically, the scope for activity as it relates to feeding is reduced in scallops compared to mussels, and the distinction between active and routine metabolism is less clear cut than in mussels. In addition, functional feeding relationships must be adapted to species differences in selection efficiency and turbidity tolerance. Because the tidal and wind-driven exchange of water are so important in seston renewal and ultimately carrying capacity, a PC-based numerical circulation model has been coupled to the culture simulation modelling order to input exchange coefficients. Examples of these model adaptations are provided for scallop aquaculture in Nova

Scotia as well as in Sungo Bay, China, site of intense scallop culture (*Chlamys farreri*). The latter provides the uncommon example of an aquaculture ecosystem which is near or beyond the carrying capacity for scallop production.

18.1 3 O C

Greay, P.A., Department of Biological Sciences, Henson School of Science and Technology, Salisbury State University, Salisbury, MD, and Minello, T., National Marine Fisheries Service, Galveston Laboratory, Galveston, TX. **THE INFLUENCE OF TURBIDITY IN FORAGING AND GROWTH OF BROWN SHRIMP (*PENAEUS AZTECUS*).**

Young brown shrimp *Penaeus aztecus* use turbid estuarine environments as nursery grounds. Shrimp mortality in these systems is mainly influenced by fish predation. Brown shrimp normally burrow in the substrate during the day and cannot forage when they are burrowed. In turbid water, however, burrowing rates are decreased. Thus, foraging by brown shrimp may be risk-sensitive, and increased foraging under low-risk turbid conditions may result in increased growth rates. We conducted a laboratory experiment to measure growth of brown shrimp under turbid and clear conditions. Two different substrates (sand versus hard bottom) were incorporated into the crossed experimental design to determine whether burrowing interacted with the effect of turbidity. Food was provided ad lib, and growth of individual shrimp was measured using 20 replicate chambers for each treatment combination. Experimental growth rates were significantly higher under turbid conditions. Substrate type did not influence growth nor interact with the effect of turbidity. The results suggest that foraging by brown shrimp is risk-sensitive, and turbid conditions promote growth in brown shrimp. However, the role of burrowing is unclear. Further experiments in which daily ration is measured in conjunction with growth will determine whether turbidity and substrate directly affect feeding and growth efficiency.

30.2 2 O C

Greening, H., Eckenrod, R., Tampa Bay National Estuary Program, St. Petersburg, FL, and Morrison, G., Southwest Florida Water Management District, Tampa, FL, and Janicki, A., Coastal Environmental, Inc., St. Petersburg, FL, and Martin, J., ASci Corp., Athens, GA. **USING SEAGRASS WATER QUALITY REQUIREMENTS TO DETERMINE WATERSHED MANAGEMENT TARGETS FOR TAMPA BAY, FLORIDA**

Local, state and federal participants in the Tampa Bay National Estuary Program (TBNEP) have agreed to adopt nitrogen loading goals for Tampa Bay based on the water quality requirements of *Thalassia testudinum*. Participants have adopted the restoration of seagrass to the areal extent observed in 1950 (approximately 14,000 additional acres bay-wide) as a long-term target. Two independent modeling approaches (empirical regression analyses and the mechanistic WASP model) have been used to estimate nitrogen loading rates and chlorophyll concentrations that will allow 20-

25% of subsurface irradiance to reach target depths (1-2m) in major bay segments. Using data from the period 1985-1991, both models indicate that target light requirements can be maintained by "holding the line" on existing nitrogen loading in much of the bay, a goal which will be increasingly difficult to maintain with an estimated 30% increase in population over the next 20 years. Additional modeling, using data from the period 1985-1994, is currently being performed. Through an intergovernmental agreement addressing the issue of nitrogen load allocation, TBNEP is seeking to incorporate seagrass-based water quality requirements and associated nitrogen loading goals into federal and state regulatory programs for point and non-point source pollution control and Local Government Comprehensive Plans.

27.1 2 O C S

Gregory, L.L., University of Alabama/Marine Environmental Sciences Consortium (MESC), Dauphin Island, AL, and Pennock, J.R., MESC/University of Alabama. **EFFECTS OF NUTRIENT ENRICHMENT AND GRAZER PRESENCE ON THE EPIPHYTES OF THE SEAGRASS *THALASSIA TESTUDINUM*.**

Two, one-month long *in situ* mesocosm experiments were conducted in St. Joseph Bay, Florida to determine if hermit crab grazers at ambient densities could control epiphyte composition, biomass and cover on *Thalassia testudinum* grass blades at varying levels of nutrient enrichment. Mesocosm chambers (plexiglass cylinders 50 cm high by 20 cm in diameter) were deployed in quadruplicate in a 2 by 3 experimental design for grazers and nutrient concentration. Nutrient delivery was obtained by using a time released fertilizer that maintained nutrient levels in the control, moderate and high nutrient treatments at $\sim 1 \mu\text{M N}:\sim 0.5 \mu\text{M P}$, $\sim 100 \mu\text{M N}:\sim 10 \mu\text{M P}$, and $\sim 1000 \mu\text{M N}:\sim 75 \mu\text{M P}$, respectively. At both levels of nutrient enrichment, epiphyte speciation showed an increase in green algae, decreases in brown and fleshy red algae species, and a loss of encrusting red algal forms. Epiphyte biomass showed significant increases only in the highest nutrient treatment, and then only in the absence of grazers. These results suggest that nutrient enrichment greatly affects speciation of epiphytes on *Thalassia testudinum* blades, and that hermit crab grazers are capable of regulating epiphyte biomass even under levels of high nutrient enrichment over short time periods.

36.1 7 O I

Guevara, E., Lester, J., Environmentat Institute of Houston, University of Houston - Clear Lake, and Baker, B., Houston Lighting and Power Company, Houston, TX. **THE EFFECT OF BIOFILTRATION BY *CRASSOSTREA VIRIGINICA*, *SPARTINA ALTERNIFLORA* AND *RUPPIA MARITIMA*, ON THE WATER QUALITY OF AQUACULTURE EFFLUENTS.**

This year-long cooperative project identifies constraints to adopt biofiltration fields as an alternative to clean effluents from ponds stocked with red fish *Sciaenops ocellatus* and brown shrimp (*Penaeus azteus*), fed with commercially

available sinking pellets at Cedar Bayou Marine Lab, Baytown, TX. The water quality of pond effluents flowing throughout a biofiltration field with *Spartina alterniflora*, *Ruppia maritima* and the American oyster (*Crassostrea virginica*) was monitored using Standard Methods techniques, and Hach equipment. Changes in the levels of Total and reactive phosphorus, Total Nitrogen, Un-ionized ammonia, Nitrates and Nitrites, Chlorophyll a, and Total suspended solids throughout the biofiltration field indicate that the adoption of this approach can contribute to a long-term goal in sustainable aquaculture: the prevention of pollution of coastal waters by commercial aquaculture operations. Drastic fluctuations in salinity due to unexpected rainfall are the major constraint for using oysters in biofiltration fields, supporting the use of recirculation of biofiltered water to counteract low salinities.

19.1 5 O C

Guo, L., Santschi, P.H. Dept. of Oceanography, Texas A&M University, Galveston, TX 77553-1675. **A CRITICAL EVALUATION OF THE CROSS-FLOW ULTRAFILTRATION TECHNIQUE FOR SAMPLING OF COLLOIDAL ORGANIC CARBON IN SEAWATER.**

Cross-flow ultrafiltration is one of the most efficient techniques to isolate colloidal organic matter, COM, for biochemical, elemental and isotopic characterization, and for phase partitioning studies of trace elements. Colloidal organic matter is one of the least studied phases due to the lack of a reliable method for size separation. Retention characteristics, integrity and performance of cross-flow ultrafilters (Amicon S10N 1, 1kDa) were examined. In addition, the effects of concentration factors, sample storage and cartridge cleaning on dissolved organic carbon (DOC) mass balance and size fractionation were investigated using natural seawater and macromolecule solutions containing compounds of different molecular weights. Concentrations of DOC in the permeate and the percentage of colloidal organic carbon (COC) retained change with concentration factor during the ultrafiltration process. Thus, the entire permeate should be collected for DOC measurements. This allows for the calculation of the percentage of COC and the evaluation of DOC mass balance during ultrafiltration. Reproducible results for size fractionation can be achieved ($\pm 2\%$), and that losses or contamination problems during ultrafiltration were negligible. However, this required rigorous cleaning and strict sampling protocols during ultrafiltration experiments. Ultrafiltration of DOC in seawater can be well characterized by a permeation model with a constant permeation coefficient of < 1 .

-H-

11.1 3 O C S

Hagy, J.D., Boynton, W.R., Kemp, W.M. UM-CEES Chesapeake Biological Laboratory and UM-CEES Horn Point Environmental Laboratory. **SEASONAL AND REGIONAL PATTERNS IN COMMUNITY METABOLISM AND NUTRIENT PROCESSING IN A LAND-MARGIN ECOSYSTEM: AN ANALYSIS WITH BOX MODELS.**

Net ecosystem metabolism (NEM=P-R) is an important measure of how estuaries process organic and inorganic materials entering from watersheds and at their seaward margin. Using a simple box modeling approach, monthly estimates of net production rates were made for different estuarine regions for dissolved oxygen, DIN, Si, PO₄, TOC, and plankton chlorophyll. Rates for each of these variables were inter-related via stoichiometric relationships. Inputs to the box models consisted of monthly mean freshwater input rates and volume-weighted regional distributions of salinity and the non-conservative materials listed above. The mean concentrations were generated from the spatially-resolved 10-year Chesapeake Bay Water Quality Monitoring Program data set. The oligohaline region of Chesapeake Bay was found to be net heterotrophic on an annual basis, while the polyhaline region was found to be net autotrophic, with a bay wide mean rate similar to that calculated by other method, (~100 gC m⁻² d⁻¹). Although the Patuxent estuarine ecosystem had similar seasonal and regional patterns in NEM, it tended to be more heterotrophic. This box modeling approach also allowed calculations for rates of denitrification, phytoplankton sinking, and the relative contribution of diatoms to total algal production.

14.1 3 O C

Hall, M.O., Durako, M.J., Florida Department of Environmental Protection, Florida Marine Research Institute, St. Petersburg, FL 33701. **ASSESSING CHANGES IN FLORIDA BAY SEAGRASS COMMUNITIES: A DAMAGING DECADE?**

The Florida Bay ecosystem has undergone significant degradation during the past decade and seagrass communities have suffered particularly heavy damage. In 1987, large areas of seagrass began to die in Florida Bay. This die-off continues, and may now influence an area as large as 100,000 acres. Seagrasses are also being adversely affected by widespread, persistent microalgal blooms, and resuspended sediments. The purpose of this study was to assess changes in seagrass distribution, abundance and species composition that have occurred in Florida Bay over the past ten years. Quantitative collections for seagrasses and macroalgae were made during the winter and summer of 1994 at over 100 stations sampled ten years earlier by Zieman, Fourqurean and Iverson.

Our data suggest that seagrass communities in eastern Florida Bay have changed little over the last decade. However, shoot densities and above-ground biomass of seagrasses in western Florida Bay have generally declined since 1984, probably due to die-off and increased water column turbidity. In addition, results from reconstructive shoot-aging techniques indicate that seagrasses in western Florida Bay will continue to decline unless conditions improve.

30.1 4 O C

Hanisak, M.D., Harbor Branch Oceanographic Institution, Fort Pierce, FL, and Zimba, P.V., University of Florida, Gainesville, FL. **PHOTOSYNTHETICALLY ACTIVE RADIATION /SUBMERGED AQUATIC VEGETATION STUDY IN THE INDIAN RIVER LAGOON.**

A macrophyte-based ecosystem is a high priority for managing Florida's Indian River Lagoon. While there is evidence that seagrass within this diverse lagoon has declined because of decreased water quality, there is no clear understanding of how changes in water quality parameters might be responsible. This site-specific study addressed the problem of seagrass loss by determining the relationships of photosynthetically active radiation (PAR), water quality parameters, and the abundance and productivity of seagrasses and their epiphytes at six sites representing a range of water quality conditions. During the year, continuous PAR measurements were integrated and recorded every 15 minutes and the amount of light attenuation in the water column calculated. Water quality parameters relevant to light attenuation and growth of seagrass and algae (i.e., total nitrogen, total phosphorus, total and inorganic suspended solids, chlorophyll, turbidity, and color) were measured weekly. Seagrass abundance, epiphyte loads on seagrass blades, and the rates of seagrass and epiphyte productivity were quantified quarterly. Analyses of the first year of data are ongoing. Ultimately, these data will be used to help establish water quality standards or targets for the purpose of protecting seagrass habitat in the Lagoon.

7.1 6 O C

Hardegree, B., Hicks, D.W., Tunnell, Jr., J.W., Center for Coastal Studies, Texas A&M University-Corpus Christi, Corpus Christi, TX. **HIGH SALT MARSH PLANT SUCCESSION FOLLOWING IN SITU BURNING OF SPILLED OIL ON THE SOUTH TEXAS COAST.**

On 7 January 1992, a rupture in a underground oil transfer pipeline resulted in the spillage of approximately 2,950 barrels (469 m³) of crude oil into a high marsh community near Chiltipin Creek, San Patricio County, Texas. Authorization for burning the oil, as a cleanup method, was given

by the Texas General Land Office (the designated state On Scene Coordinator). The purpose of this study is to monitor changes in the associated floral community over time. Ultimately 6.5 hectares (ha) of oil and vegetation out of the 15.5 ha surrounded by sorbent booms were burned, causing them to become barren. These bare patches produced by the bum were rapidly colonized by grasses, mainly *Distichlis spicata*. Secondary succession by perennial climax species is slow resulting in significantly lower species diversity and biomass in the oiled and burned area even after 3 years. The 3 year quarterly comparison of the burned area with an adjacent unoiled/unburned area yields an estimate of approximately 7 years before succession will produce a climax vegetation community. Future spill responders will benefit from this study by having a base upon which to choose the most appropriate cleanup technique.

26.1 6 O C S

Harman, J.A., Baker, J.E., University of Maryland, The Center for Environmental and Estuarine Studies, Solomons, MD, McCoflell, L.L., USDA-ARS, Beltsville, NM. **A TWO YEAR SURVEY OF CURRENT-USE AGRICULTURAL PESTICIDES IN AIR, SURFACE WATER, AND RAIN.**

The Chesapeake Bay estuarine drainage area is approximately 22,000 square miles, of which 33 percent is agricultural. This drainage area receives the highest pesticide application (over 4.8 million pounds) in the nation. After application, agrichemicals enter surface water not only by direct runoff, but also by atmospheric deposition. The Patuxent River is a subestuary of the Chesapeake Bay whose watershed is predominately agricultural, wetlands, and forests. Concentrations pesticides in air, surface water, and rain were measured daily near the mouth of the Patuxent River in May of 1994 and April - June of 1995. Additional upstream sampling sites were also monitored in 1995. Contaminants in the samples were extracted and analyzed using GC-MS. In 1994, cyanazine, metolachlor, alachlor, diazinon, atrazine, and simazine were consistently detected in surface water with levels ranging from 5-40 ng/L respectively. Air concentrations in 1994 were rarely above our limit of detection, however rain concentrations were notable. The temporal and spacial information gathered in this investigation will contribute to a better understanding of pesticide loadings to the Chesapeake Bay.

34 46 P-I C

Hartsig, A.M., Lacouture, R.V., Sellner, K.G., The Academy of Natural Sciences, Benedict Estuarine Research Center, St. Leonard, MD. **CONTROLLING FACTORS FOR NUISANCE ALGAL BLOOMS IN THE POTOMAC RIVER ESTUARY.**

Summer cyanophyte blooms typify the tidal-fresh portion of the Potomac River estuary. Since August, 1984, the Chesapeake Bay Water Quality Monitoring Program has documented steadily decreasing N and P loads to this river segment. Cyanophyte densities and densities of the nuisance alga, *Microcystis aeruginosa*, were relatively high from 1984-

1988, decreased between 1989-1992 and subsequently increased in 1993 and 1994. Coincident with the recent increases were two abnormally high spring freshets. The interactions of nutrient loading accompanying spring runoff, spring-summer flow, summer residence time and episodic wind and rain events have been examined as potential controlling factors for the recurring bloom in this eutrophic tributary of the Chesapeake Bay.

5.1 5 O C

Harvey, E.A., Epifanio, C.E., University of Delaware, College of Marine Studies, Lewes, DE. **EFFECTS OF VARYING IRRADIANCE AND VARYING PREY ABUNDANCE ON PREY SELECTION OF LARVAL MUD CRABS (*PANOPEUS HERBSTII*).**

Feeding experiments were conducted in the laboratory to examine the selection capabilities of *Panopeus herbstii* larvae when presented with a choice of prey items, newly hatched brine shrimp nauplii (*Artemia sp.*) and rotifers (*Brachionus plicatilis*). Selection potentials were tested at four irradiance levels : no light, 10, 100, and 500* 10¹² quanta/cm². Experiments were performed in 100 ml fingerbowls and 3 prey treatments were tested at each light level - 100, 1,000, and 5,000 prey items/liter. Once the bowls were stocked with the appropriate concentrations of prey, 10 depurated larvae were added and allowed to forage for 3h. There were three replicates of each treatment, and controls were run without larvae to account for potential losses of prey and the reproductive rate of the rotifers. Experiments were run with larvae 2 days post-hatching (DPH), 5 DPH, 8 DPH, and 12 DPH to correspond to the four zoeal stages of mud crab development. Preliminary results indicate significant preferences toward the larger brine shrimp over the smaller rotifers with increasing larval age. These results suggest that crustacean larvae may regulate their diets when presented with a choice of prey items. Furthermore, their selection capabilities may increase throughout larval development.

1.2 3 O C S

Harwell, M.C., Orth, R.J., Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. **EXPLORING METAPOPULATION DYNAMICS CONCEPTS IN MACROPHYTE ECOLOGY.**

Seagrasses exhibit characteristics applicable to theories of sources and sinks in metapopulation dynamics. Dispersal mechanisms of macrophytes can provide simple modeling terms of "migration" patterns. Seagrass habitats are often locally fragmented due to the coupling of abiotic and biotic factors (TSS, nutrients, PAR, anthropogenic activities, and others), though understanding the ecology involves landscape level changes in distribution. Shoal areas (<2m) of the Chesapeake Bay were stratified into 12 broad zones composed of vegetated and non-vegetated regions. Cores for *Zostera marina* seeds were taken from random locations within each zone; the number of cores a function of the density of vegetation within a zone. Relationships between densities of grass beds and the abundance of seeds found within a bed

appears to provide insight into the application of source and sink theory to macrophyte systems. Restoration efforts aimed at establishing grass beds needs to consider size, density and location in terms of long term bed maintenance.

23.1 6 O C

Hay, R., Texas A&M University - Corpus Christi, Center for Water Supply Studies, Corpus Christi, TX. **GROUND-WATER FLOW TRANSPORTS AMMONIUM FROM WIND TIDAL FLATS TO THE LAGUNA MADRE.**

Ongoing groundwater investigations at the Padre Island National Seashore reveal three subsurface water quality zones exist on the island: a seawater zone adjacent to the Gulf of Mexico, a freshwater zone from the foredunes westward to the wind tidal flats of the Laguna Madre, and a hypersaline zone adjacent to the Laguna Madre. Salinities measured in monitoring wells along the Laguna Madre range as high as 165‰ with corresponding densities of up to 1.1271 g/cm³. Nitrates and phosphates in this groundwater zone have concentrations within general groundwater ranges; however, measured ammonium levels are high (5 to 10 mg/L). Correction of hydraulic head for water density differences yields a net flow of groundwater from this region westward, discharging to the Laguna Madre/Gulf Intracoastal Waterway. This groundwater discharge provides additional influx of ammonium and other nutrients to the Laguna Madre ecosystem.

10.1 5 O C

Heck, Jr., K.L., Valentine, J.F., Sklenar, S.A., Marine Environmental Sciences Consortium (MESC), Dauphin Island Sea Lab/University of South Alabama, Dauphin Island, AL, and Pennock, J.R., Gregory, L., MESC/University of Alabama **TOP/DOWN AND BOTTOM/UP EFFECTS IN SEAGRASS ECOSYSTEMS.**

Eutrophication is commonly believed to lead to seagrass decline through increased light attenuation and algal overgrowth of macrophyte leaves. Alternatively, we hypothesized that losses of top predators from seagrass habitats could produce a trophic cascade that shifts seagrass-dominated systems to plankton-dominated systems. Results from two years of field manipulations of nutrient supply (3x and 12x ambient DIN and SRP) and intermediate predator abundance (3x ambient densities of pinfish) in northern Gulf of Mexico turtlegrass meadows show few significant "bottom/up" effects but several significant "top/down" effects (e.g. macroinvertebrate decreases). Our conclusions to date are that top/down effects are able to regulate the impact of moderate levels of nutrient enrichment; however, because pinfish feed at multiple trophic levels, we have yet to observe any strong evidence of cascading trophic effects.

9.1 5 O C

Heimbuch, D., Seibel, J., Wilson, H., Logan, D., Coastal Environmental, Inc., St. Petersburg, FL, and **Morrison, G.**, Southwest Florida Water Management District, Tampa, FL., **ESTIMATION OF NATURAL AND ANTHROPOGENIC COMPONENTS OF OBSERVED REDUC-**

TIONS IN FRESHWATER INFLOW TO CHARLOTTE HARBOR, FLORIDA

Charlotte Harbor, Florida's second largest estuary, receives about 60% of its freshwater inflow from the Peace River. During a period beginning in the mid-1960's, gauged flows in a portion of the river's main stem were reduced by approximately 30% below long-term means. We analyzed long-term relationships between rainfall and gauged flows within the Peace River watershed to estimate the contributions of natural and anthropogenic factors to observed flow reductions. Rainfall and streamflow data were divided into pre-reduction (1933-1960) and post-reduction (1966-present) time periods. Regression models relating streamflow to cumulative rainfall were developed for both time periods. Measured streamflow, and streamflow generated per unit rainfall, were compared between the two periods. Reductions in streamflow attributable to reduced rainfall were considered "natural," while reductions attributable to reduced streamflow per unit rainfall were considered "anthropogenic." Approximately 85% of the observed reduction in streamflow appears attributable to reduced rainfall, and about 15% appears due to anthropogenic reductions in the volume of streamflow generated per unit rainfall. Anthropogenic activities that may have affected streamflow in the watershed include groundwater pumpage (for a variety of human uses) and alterations in surface hydrology associated with the mining of phosphate ore.

31 35 P-3 C S

Hensel, P.F., Day, Jr., J.W., Pont, D., Day, J.N. Coastal Ecology Institute, Louisiana State University, Baton Rouge, LA and Equipe DESMID, C.N.R.S. U.R.A. 1974, Arles, France. **SHORT-TERM SEDIMENTATION PATTERNS IN THE RHONE RIVER DELTA, FRANCE**

Short-term sedimentation was evaluated from August 1992 to May 1993 in areas influenced by the Rhone River, the Mediterranean, or isolated from both. Sedimentation was measured on paper filters placed on the soil surface for several weeks. Significant seasonal trends occurred in all habitats: high in late summer, low in winter. Higher sedimentation at riverine sites (0.287-3.132 g m⁻² d⁻¹) was related to a combination of southerly winds and river stage, and was sensitive to episodic pulsing events (floods). A lag time is suggested between the occurrence of a flood and sedimentation at riverine sites. Marine and impounded wetlands experienced low sedimentation throughout the period. Percent organic matter showed seasonal trends (lowest in fall) and was highest in impounded areas. Organic matter does not provide enough elevation to compensate for the lack of sedimentation in most impounded sites. Short-term sedimentation patterns agree with on-going longer-term measurements (marker horizons and S.E.T). Sedimentation is one important factor in elevation changes, and this study shows that impounded habitats, the most common natural environments left in the delta, may become vulnerable to sea level rise in the future if management practices continue to isolate these wetlands from riverine sedimentation.

Herzka, S.Z., Dunton, K.H. The University of Texas at Austin Marine Science Institute, Port Aransas, TX. **PHOTOSYNTHETIC PERFORMANCE OF THE SEAGRASS *THALASSIA TESTUDINUM* IN CORPUS CHRISTI BAY AND LOWER LAGUNA MADRE, TX.**

Photosynthesis vs Irradiance (P vs I) curves were constructed on a bimonthly basis to characterize the seasonal photosynthetic performance of two disjunct populations of *T. testudinum* in Texas. The study sites were located at 1.4 m depths on the east side of Corpus Christi Bay (CCB) and Port Isabel, Lower Laguna Madre (LLM). A spherical quantum sensor interfaced to a LI-1000 datalogger was used to make continuous measurements of underwater irradiance during the sampling period. Whole plants were collected using a 15 cm coring device. Leaf segments were cleaned of epiphytes and incubated at *in situ* temperatures using a Rank Brothers Oxygen Electrode System at light levels ranging from 0 to 1100 $\mu\text{mol photons m}^{-2} \text{ s}^{-1}$. Maximum gross photosynthetic rates (P_{max}) and respiration rates on a gram dry weight (g dry wt) basis were correlated with temperature. Winter gross P_{max} ranged from 44.31 ± 5.36 to 58.01 ± 3.33 $\mu\text{mol O}_2 \text{ g dry wt}^{-1} \text{ hr}^{-1}$ for LLM and CCB, respectively. During early spring and summer, P_{max} ranged from 206.16 to 324.57 ± 21.87 $\mu\text{mol O}_2 \text{ g dry wt}^{-1} \text{ hr}^{-1}$, varying according to site and sampling time within that range. Respiration rates were lowest in winter (-5.33 ± 0.73 to -12.01 ± 2.41 $\mu\text{mol O}_2 \text{ g dry wt}^{-1} \text{ hr}^{-1}$ for LLM and CCB, respectively) and highest in summer during peak *in situ* temperatures (-70.42 ± 8.40 to -82.45 ± 7.49 $\mu\text{mol O}_2 \text{ g dry wt}^{-1} \text{ hr}^{-1}$ for LLM and CCB, respectively). Photosynthetic efficiency and saturating irradiance also varied between sites and among sampling dates. Our preliminary data suggest the two isolated populations have different photosynthetic characteristics.

Hesse, D., Brannigan, P., Jones, H., Schell, J., TERRA, Inc., Tallahassee, FL. THE USE OF GREAT LAKES WATER QUALITY INITIATIVE TOXICITY ASSESSMENT METHODS IN AN ECOLOGICAL RISK ASSESSMENT.

Because mink demonstrate a particular sensitivity for the reproductive toxicity of PCBs, they were chosen as an indicator species in an ecological risk assessment done on Manistique Harbor in Michigan. The large experimental database for mink allowed for the development of a no observable adverse effect level, lowest observable adverse effect level, average daily intake, average daily dose, and, eventually, a mink reference dose. Toxicity assessment methods described in the Great Lakes Water Quality Initiative (GLWQI) were used as a basis to calculate a hazard threshold for mink. When assumptions made in the GLWQI were not considered reflective of site-specific conditions, attempts were made to substitute more relevant exposure descriptions. This process led to a simple equation for determining the hazard threshold for mink dependent upon the PCB concen-

tration of fish. PCB concentrations in fish considered to be the primary food source of mink, estimated as a result of various remediation scenarios, were entered into the equation to determine what scenarios, if any, resulted in a hazard threshold of less than one, indicating mink reproductivity would not likely be adversely affected. Additionally, as more information is known about various environmental factors, the equations can be refined even further.

Hesse, I.D.¹, Doyle, T.W.² and Day, Jr, J.W.^{1,3}, ¹Coastal Ecology Institute and ³Department of Oceanography and Coastal Sciences, ²National Biological Service, Baton Rouge, LA 70803 LONG-TERM GROWTH ENHANCEMENT OF BALDCYPRESS (*TAXODIUM DISTICHUM*) FROM MUNICIPAL WASTEWATER APPLICATION.

Ecological impacts of waste treatment and eutrophication on natural systems is a growing applied discipline. Tree-ring data offer long-term growth measurements capable of assessing both acute and chronic effects of environmental change. Tree-ring analysis was used to document the long-term effects of municipal wastewater on the growth rate of baldcypress (*Taxodium distichum* L. Rich.). The study site, a swamp in St. Martin Parish, Louisiana, has received municipal wastewater for the last 40 years. Growth chronologies were developed from crossdated tree core samples taken from treated and control sites that had similar size and age classes. The sampling period from 1920-1992 was chosen to provide >30 years of both pre-treatment and treatment growth. Mean diameter increment (DINC) and mean basal area increment (BAI) chronologies were constructed separately for each stand. These chronologies were summarized by tree and stand into seven nine-year intervals resulting in three pre-treatment intervals and four treatment intervals. Significant differences in growth response between sites showed a consistent pattern of growth enhancement in the treated site coincident with the onset of effluent discharge. These results clearly demonstrate sustained long-term baldcypress growth enhancement throughout 40 years of municipal effluent discharge.

Hester, M.W., Southeastern Louisiana University, Biology Department, Hammond, LA, and Mendelssohn, I.A., McKee, K.L., Louisiana State University, Wetland Biogeochemistry Institute, Baton Rouge, LA. INTRASPECIFIC VARIATION IN SALT TOLERANCE IN *SPARTINA ALTERNIFLORA*: INVESTIGATIONS OF UNDERLYING FACTORS.

Our previous research has documented significant intraspecific variation in salt tolerance in Gulf Coast populations of *Spartina alterniflora*. To investigate factors potentially associated with intraspecific variation in salt tolerance, we subjected a subset of populations ranging from highly salt tolerant to poorly salt tolerant to a sublethal salinity excursion of 30‰ (ppt) and measured plant photosynthesis and growth response, biomass partitioning and numerous

physiological/biochemical responses after one week (early harvest) and after five weeks (late harvest). In the early harvest, highly salt-tolerant populations had significantly greater photosynthetic rates, leaf expansion rates and leaf glycinebetaine concentrations than poorly salt-tolerant populations. By the late harvest, there were no significant differences between populations in aboveground biomass, leaf total cation concentration, glycinebetaine, or proline concentrations, but highly salt-tolerant populations were able to selectively decrease their leaf Na:K ratio relative to the poorly salt-tolerant populations. Poorly salt-tolerant populations also had a significantly greater proportion of dead aboveground biomass than highly salt-tolerant populations. Belowground and root biomass in the highly salt-tolerant populations were significantly less than those of the poorly salt-tolerant populations, resulting in significantly lower root-to-shoot ratios in the highly salt-tolerant populations.

9.1 3 O C

Heyl, M.G., CAMP DRESSER & McKEE INC., Sarasota, FL. POTABLE WATER AND THE COST OF MINIMUM RELEASE STANDARDS.

The effectiveness of controlling downstream salinity with minimum freshwater releases from an in-stream impoundment on the Manatee River (Florida) was evaluated using a hydrodynamic (DYNHYD) model of tidal mixing and ambient inflows, coupled with a water quality model (TOXIWASP) of salinity. Salinity was estimated consecutively at a half hour time step for a period of one or two years for average and dry (80th percentile) background conditions, and over a range of assumed minimum reservoir releases. Monthly reservoir flows were estimated from a 50 year record of simulated inflows and withdrawals using a reservoir routing model external to the water quality models. Various combinations of off-stream, in-stream and underground storage (aquifer storage and retrieval) facilities were sized and evaluated in terms of the reliability of providing minimum releases, and providing additional potable water in a region experiencing a critical water shortage. The alternatives were costed and ranked according to both the cost of water released and the cost of providing additional potable water. The results will be used to establish resource targets through a technical review symposium convened in August 1995 by the Tampa Bay National Estuary Conference.

37 45 P-2 C

Ho, K., U.S. Environmental Protection Agency Research Lab, Narragansett, RI, and Liggans, G., University of Maryland Eastern Shore, Department of Natural Sciences, Princess Anne, MD. EFFECT OF DATA ON TOXICITY OF METAL CONTAMINATED SEDIMENT.

The objective of this study was to determine the ability of ethylenediaminetetraacetic acid (EDTA) to reduce toxicity in metal spiked sediments. Long Island Sound (LIS), a relatively clean marine sediment, was analyzed for AVS and spiked with different metals (Cu, Ni, Cd, mix) at 10 times

the concentration of sediment that would yield LC₅₀ data for mysids *Mysidopsis bahia* and amphipods *Ampelisca abdita* so that EDTA's effectiveness to reduce toxicity could be tested. For the copper (Cu) spiked sediment which was spiked to 95 micrograms/gram (10 times AVS) 20 percent of the sediment (19 micrograms/gram) showed adequate toxicity so that EDTA (5,50 and 75 mg/L) could be tested as a toxicity reducing agent. Toxicity of the 20 percent copper sediment to amphipods was reduced by the addition of 5 mg/L EDTA and even more so by the addition of 50 mg/L; 75 mg/L EDTA showed no additional protection above the 50 mg/L EDTA. Mysid toxicity at 20 percent copper sediment was increased by the addition of 5 and 50 mg/L EDTA; 75 mg/L showed no protection. The results indicate that metal toxicity in sediment may be reduced by the addition of EDTA when using amphipods as an indicator.

11 7 P-2 I

Hobbie, J.E., LMER Coordinating Committee, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA. THE LAND MARGIN ECOSYSTEMS RESEARCH PROGRAM: UNDERSTANDING CHANGES IN COASTAL ENVIRONMENTS

The Land Margin Ecosystems Research program seeks to increase the understanding of 1) the organization and function of land-margin ecosystems; 2) the linkages between these systems and adjacent terrestrial and marine systems, and 3) the impacts of major environmental perturbations in these regions. All sites are funded by the National Science Foundation; current funding is for six years. Six sites in the coastal United States have been supported by NSF. They are widely distributed geographically and represent different types of land-margin environments.

15.2 3 O C

Holland, A.F., Riekerk, G.H.M., Lerberg, S.B., Zimmerman, L.E., Sanger, D., South Carolina Marine Resources Research Institute and University of Charleston, Charleston, SC, and University of South Carolina, Columbia, SC. EFFECTS OF WATERSHED DEVELOPMENT ON ECOLOGICAL CHARACTERISTICS OF TIDAL CREEK ECOSYSTEMS

Twenty four unbranched tidal creeks near Charleston, SC, with watersheds ranging in size from 13 to 436 hectares were sampled in summer 1994 to assess the impacts of watershed development on nursery functions and ecological condition. Twelve of the watersheds had highly developed drainage basins (>75% urbanized), and twelve had relatively undeveloped drainage basins (>75% forests and wetlands). Creeks ranged in length from 300 m to 1,500 m and included low and high salinity environments. Land cover information was developed for each watershed, and sediment contaminants, toxicity, and physical characteristics; the kinds and abundances of macrobenthos; and fish abundance, size, and diversity were measured for each strata. Water quality (DO, salinity, temperature, depth) was also measured every thirty minutes for several tidal cycles near the mouth of each creek.

The headwaters of creeks in developed watersheds had elevated metal levels, higher sediment toxicity, and lower benthic abundances than creeks from undeveloped watersheds. Watershed size was strongly related to sediment distributions. Differences in dissolved oxygen dynamics and fish population characteristics among creeks were small. Data collected by this study are being used to define parameters and ecological characteristics that best represent the "health" or condition of tidal creek systems.

12.1 1 O I

Holland, M.M., Department of Biology, The University of Mississippi, Oxford, MS, and Summers, K., U.S. Environmental Protection Agency, Office of Research and Development, Gulf Breeze, FL. **EMAP ESTUARIES: PAST ACCOMPLISHMENTS AND FUTURE DIRECTIONS.**

The Environmental Monitoring and Assessment Program (EMAP) is a program of ecological monitoring designed to document status and trends in ecological systems in the United States. The U.S. Environmental Protection Agency originally created EMAP in 1988 in response to several major concerns over national environmental protection efforts. Sampling of estuarine resources has been undertaken in several Provinces along the USA coastline. Currently EMAP is moving through a transitional period from "EMAP Phase I" to "EMAP Phase II". The original EMAP design of Phase I was based primarily on an "extensive" monitoring approach for retrospectively measuring the condition of ecological resources through use of ecological condition indicators, probability-based sampling, and regional-scale analysis. The two major long-term goals of EMAP Phase II are to: (1) create an integrated monitoring system consisting of a network of index sites, representative of major ecoregions of the U.S. that are linked across a range of spatial scales through a regional monitoring program of the original EMAP design, and (2) initiate a comprehensive research program for the development of indicators of ecological condition. To reach these two major goals, EPA's strategy in Phase II of EMAP is to build on the existing EMAP scheme, but to integrate it with more intensive sampling.

17.1 3 O I

Holt, J., Holt, S., University of Texas, Marine Science Institute, Port Aransas, TX. **LARVAL RED DRUM (*SCIAENOPS OCELLATUS*) TRANSPORT TO ESTUARINE NURSERY AREAS: STUDY INTRODUCTION AND SPAWNING PATTERN.**

Variation in fish population size is thought to be rooted in the early life-stages, particularly during transport to nursery areas when larvae have limited locomotor capabilities, food availability is critical and predation is high. In south Texas, red drum spawn near the coast, eggs and larvae move into inlets, and late stage larvae recruit to seagrass beds in primary estuaries. Essentially all the young of the year in the Corpus Christi - Aransas Bay system move through the Aransas Pass inlet to reach the estuarine nursery, making it an ideal site to investigate larval fish recruitment dynamics.

We undertook a study to explore how hydrographic events affect larval mortality during transport. Specific objectives were to determine the temporal pattern of spawning, estimate density of pelagic larvae, determine birth-date distribution of demersal postlarvae that successfully recruited to the seagrass beds, and finally to develop a conceptual model of the effects of abiotic events on survival during transport. Daily egg collections provided the baseline data to evaluate recruitment. Spawning occurred from August 23 through November 4, with a daily mean egg density of 2 per cubic meter. Peaks in egg density showed no lunar periodicity.

17.1 5 O I

Holt, S.A., Amos, A.F., Univ. of Texas, Marine Science Institute, Port Aransas, TX. **THE RELATIONSHIP OF TEMPORAL PATTERNS IN DENSITY OF RED DRUM (*SCIAENOPS OCELLATUS*) LARVAE IN A TIDAL INLET AND LOCAL HYDRODYNAMIC PROCESSES.**

Estuarine-Dependent-Marine-Species spawn offshore in marine waters but pass at least part of the juvenile stage inside the estuary. The process of getting from spawning grounds to nursery area involves moving across the shelf to the coast, passing through the tidal inlet, and dispersal within the estuary. We examined the periodic nature of immigration through the inlet through daily ichthyoplankton collection on flood tide in the Aransas Pass, Texas tidal inlet. Changes in density between tidal cycles (ie., on a daily basis) was highly episodic. Although there were often substantial changes in density from one day to the next, daily changes were not entirely random. Rather, there were periodic pulses of high density over two or three consecutive days followed by several days of relatively low density. In most cases, suites of species react similarly, suggesting that physical processes are important determinants of relative density.

19.1 2 O I

Hopkinson, C.S., Buffam, I., Deegan, L., Garritt, H., Giblin, A., Hobbie, J., Tucker, J., Vallino, J., The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543. **ORGANIC MATTER AND INORGANIC NUTRIENT INTERACTIONS IN ESTUARIES**

While much research focuses on the effect of inorganic nutrient loading on estuarine processes, we find organic matter inputs to also play an important role in controlling estuarine trophic productivity and efficiency. On average 1-2% or 1-14 g C m⁻² of terrestrial NPP enters the coastal zone yearly. Organic N inputs exceed inorganic N inputs in most rivers of the world. In watersheds of Plum Island Sound, organic N inputs exceed inorganic inputs about 2: 1. We have been conducting experiments to enable prediction of the degradability of organic matter originating from various land uses. We find a strong relationship between the degree of substrate reduction of the organic matter undergoing decomposition and the rate and efficiency of its incorporation into microbial biomass. Additional experiments have indicated the relative effect variations in inorganic vs. organic inputs have on regulating productivity and trophic efficiency. DOM

transacts in the Plum Island Sound estuary show that organic matter from various sources degrades differentially. The balance between organic matter degradation and inorganic nutrient uptake by primary producers results in distinct regions of autotrophy and heterotrophy along the estuary. The chemical nature of allochthonous organic matter inputs to estuaries and numerous mechanisms that retain organic matter in estuaries tend to cause estuaries to be net heterotrophic.

22.2 3 O I

Hornberger, M.I., Luoma, S.N., van Geen, A., Fuller, C., Anima, R., U.S. Geological Survey, 345 Middlefield Rd., MS 465, Menlo Park, CA. **HISTORICAL TRENDS OF TRACE METALS IN THE SEDIMENTS OF SAN FRANCISCO BAY, CA.**

A historical record of metal inputs to San Francisco Bay was compiled using sediment cores collected throughout the estuary. Anthropogenic inputs into the bay are characterized by downcore concentration changes of Hg, Pb, Ag, Cu and Zn. A large smelting operation appears to explain Pb and Ag trends in the North Bay sediments. High concentrations of Hg buried in the North Bay sediments have declined in recent years, but historic inputs were apparently very large. Declining concentrations of Cu and Zn are not detectable in most cores. Although no apparent downcore trend is detectable in Cr or V, a geographical gradient occurs throughout the estuary: Near the mouth of the estuary, concentrations of Cr and V (80 $\mu\text{g/g}$ and 70 $\mu\text{g/g}$ respectively) characterize marine sediment. Concentrations of Cr and V near the head of the estuary (110 $\mu\text{g/g}$ and 100 $\mu\text{g/g}$ respectively) are indicative of terrigenous sediment. A mixing model showed that Central Bay sediments were a mixture of these two end-members. The model suggests that historically (pre-1950) sediment transport from the North Bay to the Central Bay was small (~22%). In more recent times (post-1950), this contribution increased to ~51%, perhaps as a result of hydrologic changes in the bay.

17.1 1 I C

Hoss, D.E., NOAA/NMFS, Beaufort Laboratory, Beaufort, NC, and Settle, L.R., NOAA/NMFS, Beaufort Laboratory, Beaufort, NC, and Spach, H.L., Centro de Estudos do Mar, UFPR, Brazil. **SPECIES-SPECIFIC BEHAVIOR IN FISH LARVAE AND ITS INFLUENCE ON THE TRANSPORT PROCESS.**

Many species of commercially and recreationally important fishes, that utilize coastal wetlands as late larvae and juveniles, are spawned on the continental shelf. These "estuarine dependent species" make up most of the total finfish catch along the Southeast and Gulf Coasts of the U.S. Understanding how larvae are transported from coastal waters to estuarine nursery areas, and determining the causes of the sometimes dramatic natural fluctuations in recruitment, are questions that need to be answered if sustained wetland productivity is to be achieved. The NOAA South Atlantic Bight Recruitment Experiment (SABRE) addresses these questions. A central hypothesis of this study is that physical processes

cause favorable current regimes which transport larvae, essentially as passive particles, from spawning areas to, and through inlets into the estuary. This may be an over-simplification. We examined the life-history and distribution of several species of clupeids, sciaenids and bothids which are all spawned in the same area during the same season. Our studies show that larvae have different behavioral characteristics and quickly develop activity patterns that have the potential to affect shoreward transport.

15.2 6 O C

Howarth, R.W., Cornell University, Ithaca, NY, and Jaworski, N.A., U.S. Environmental Protection Agency, Narragansett, RI. **NUTRIENT AND MINERAL FLUXES OF THIRTY MID-ATLANTIC AND NORTHEAST COASTAL WATERSHEDS.**

Long-term chemical analysis data from surface water drinking supplies and periodic historical surface water surveys have been analyzed to determine temporal and spatial trends of coastal watersheds of the Mid-Atlantic and Northeast. The analysis of the historical data of 15 watersheds, with some analysis dating to 1885, and the current (1990-1993) analysis of 30 watersheds include both nutrients and minerals. Significant increases over the past 90 years in nitrates, chlorides, sodium, and total solids have been observed for the James, Potomac, Susquehanna, Delaware, Schuylkill, Hudson, Blackstone, and Merrimack watersheds. Similar increases have been observed for the New York City, Boston, and Portland water supply reservoirs. Potential sources of these increases are suggested. A south-to-north increase in TOC flux rates was an unexpected finding. The watersheds in Maine have about three times the TOC flux rates as those in Virginia.

2.1 4 O C

Hughes, J.E., Wainright, S.C., Rutgers University, Institute of Marine and Coastal Sciences, New Brunswick, NJ. **UPTAKE OF O_2 AND CO_2 SUGGESTS ENHANCEMENT OF CHEMOAUTOTROPHY IN RESUSPENDED SEDIMENTS.**

Several studies have demonstrated that resuspension of sediments promotes bacterial growth, and that the increase in cell number and biomass can be rapid (~ h). The bacteria responding to this ultimate sediment disturbance have not been identified, nor has the effect of resuspension on organic matter processing been measured. In laboratory experiments with organic-rich, surficial estuarine sediments, resuspension accelerated mineralization of sedimentary organic matter. Oxygen demand was higher in experimentally resuspended surficial sediments compared to that in undisturbed controls, due to both biotic and chemical oxidations. In addition to elevated heterotrophic O_2 uptake in suspended particles, chemoautotrophy was likely enhanced also, as indicated by a deficit of CO_2 production in resuspended treatments compared to that in undisturbed controls. These results suggest that chemoautotrophic production may enrich resuspended particles as potential food for filter-feeding organisms, and

that hypoxia in near-bottom waters may be exacerbated by sediment resuspension.

8 24 P-1 C

**Huzzey, L., U.S. Coast Guard Academy, New London, CT.
LATERAL VARIABILITY IN STRATIFICATION AND
FLOW ACROSS THE THAMES RIVER, CT.**

The Thames River is a strongly stratified coastal plain estuary which empties into Long Island Sound. Repeated hydrographic transects across this estuary taken at varying times within the tidal cycle, and under different freshwater inflow conditions, show lateral differences in the surface density, a persistent lateral tilt to the pycnocline, and intratidal differences in the strength of the stratification. Associated current meter deployments document lateral differences in flow speed and direction, and a distinct cross-estuary component to the flow, at both tidal and residual time scales. These lateral differences in hydrography and flow can be partially related to the bathymetry and further illustrate the importance of considering the lateral dimension in estuaries when estimating the net transport of suspended and particulate materials.

12 9 P-2 C

Hyland, J., NOAA Carolinian Province Office, Charleston, SC., ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM (EMAP) CAROLINIAN PROVINCE ESTUARIES COMPONENT.

This program is aimed at assessing the ecological conditions of estuaries of the Carolinian Province. The sampling area extends from Cape Henry, Virginia through the Indian River Lagoon system along the east coast of Florida. Estuarine resources of this region are diverse and extensive covering an area of about 12,000 km². The program was initiated as a pilot study in the summer of 1993 and is continuing as a full Demonstration Project with sampling during the summers of 1994 and 1995. Between 80 to 90 stations are sampled each year. At each station, synoptic measurements are made of a variety of chemical/physical, toxicological, and biological variables as indicators of pollutant exposure, natural habitat conditions, and biological responses. A random sampling design is incorporated so that results can be used to make probability based estimates of the extent and magnitude of degraded versus non-degraded estuaries. Studies to develop and test the effectiveness of alternative approaches to assessing ecosystem conditions, including new ecological indicators, supplement the core monitoring activities. The program is being conducted through partnerships between NOAA, EPA, and several State research laboratories and universities. Some preliminary results of the summer 1994 field season will be presented.

26.1 3 O I

Iannuzzi, T.J., Shear, N.M., Harrington, N.W., Curry, C.L., Henning, M.H., ChemRisk®, A Division of McLaren/Hart Environmental Engineering Corporation, 1685 Congress Street, Portland, ME 04102. **AN EVALUATION OF EXPOSURE FACTORS CONTROLLING THE UPTAKE OF XENOBIOTIC CHEMICALS IN AN ESTUARINE FOOD WEB.**

An evaluation of literature on the behavior, physiology, and ecology of estuarine organisms was conducted in order to identify those variables that most strongly influence uptake of xenobiotic chemicals from sediments, water and food sources. The ranges, central tendencies, and probabilistic distributions of several key parameter values for polychaetes (*Nereis sp.*), mummichog (*Fundulus heteroclitus*), blue crab (*Callinectes sapidus*), and striped bass (*Morone saxatilis*) in east coast estuaries were identified. The exposure factors of interest included ingestion rate for various food sources, growth rate, respiration rate, excretion rate, body weight, wet/dry weight ratio, lipid content, chemical assimilation efficiency, and food assimilation efficiency. These exposure factors are critical to the execution of mechanistic food web models which, when properly calibrated and validated, can be used to estimate tissue concentrations of nonionic chemicals in aquatic organisms based on knowledge of the bioenergetics and feeding interactions within a food web, and the sediment and water concentrations of chemicals. Each exposure factor, as possible, was represented by one of four distributional forms: uniform, triangular, beta, or truncated normal. Incorporation of probabilistic analyses into evaluations of bioaccumulation greatly improves our ability to evaluate the range of possible exposure scenarios and environmental risks of chemicals to aquatic organisms, and humans who consume contaminated fish and shellfish.

8.1 1 O C

Ibañez, C., Univ. of Barcelona, Dept. d'Ecologia, Barcelona, Spain, and Pont, D., Centre Nationale de la Recherche Scientifique, Lab. d'Ecologie, Arles, France, and Prat, N., Univ. of Barcelona, Dept. d'Ecologia, Barcelona, Spain. **SALT WEDGE DYNAMICS IN THE EBRE AND RHONE ESTUARIES. A BASIS FOR DEFINING AND CLASSIFYING SALT WEDGE ESTUARIES.**

River discharge is the main factor controlling the dynamics of the Ebre and Rhone estuaries. The topography of the bed also influences the advance and retreat of the salt wedge, whereas tides have little influence because of their low range. Mean annual river discharge is close to the critical discharge which determines the formation and the break up of the salt wedge. This is because river discharge controls the sedimen-

tary dynamics of mouth's sand bar. As a function of the conditions in which the salt wedge is formed, two different types of highly stratified estuaries can be established: 1) Estuaries in which the salt wedge regime is established during low river flow periods, while during high flows the salt wedge is washed away and the estuary becomes a river. These are the typically considered "salt wedge estuaries", corresponding to type 4 of the Hansen-Rattray classification. 2) Estuaries in which the salt wedge is established during periods of high river flow, while during low flows they become partially mixed estuaries. These correspond to types 3b and 2b of the Hansen-Rattray classification. A new definition of salt wedge estuary based on the conclusions of the study is proposed.

31 36 P-3 C

Ibañez, C., Univ. of Barcelona, Dept. d'Ecologia, Barcelona, Spain, and Day, J., Louisiana State University, Dept. of Oceanography and Coastal Sciences, LA, and Pont, D., Centre Nationale de la Recherche Scientifique, Lab. d'Ecologie, Arles, France, and Curcó, A., Univ. of Barcelona, Dept. de Biologia Vegetal, Barcelona, Spain. **PRIMARY PRODUCTION AND RELATIVE SEA LEVEL RISE IN WETLANDS OF THE RHONE DELTA, FRANCE.**

Aboveground primary production, salinity and water levels were studied in seven wetland sites in the Rhone delta from October 1992 to October 1993. The sites were located in three characteristic zones of the delta: a low salinity area close to the river mouth, a marine site near the Mediterranean sea and a managed impounded wetland. Wetland production was affected by salinity, grazing, and water level. A non-grazed fresh water site had the highest production (2840 gm⁻²yr⁻¹) while the lowest production was in an impounded Salicornia-type marsh near the sea with high salinity and ground water levels (179 gm⁻²yr⁻¹). The most productive Salicornia salt marshes were in areas with low salt and water stress near the river mouth (1184 m⁻²yr⁻¹) and with a free connection to the sea (1 261 gm⁻²yr⁻¹). A grazed Salicornia-type salt marsh had a production of 205 gm⁻²yr⁻¹. In a non-grazed brackish reed marsh at the river mouth, production was 659 gm⁻²yr⁻¹, whereas in an unprotected site nearby, grazing was so intense that the vegetation disappeared. Increases in sea level will lead to lowered primary production and losses in wetland vegetation.

23.1 2 O C

Iizumi, H., Hokkaido National Fisheries Research Institute, Kushiro, Hokkaido, JAPAN, and Minagawa, H.M., Hokkaido University, and Udagawa, T., HNFRI. **VARIATION OF STABLE ISOTOPE RATIOS AT A SEMI-CLOSED ESTUARY IN NORTHERN JAPAN.**

Stable isotope ratios of particulate carbon and nitrogen were determined to investigate food web structures in Akkeshi-Ko in northern Japan. Akkeshi-Ko is a small (ca. 64 sq. km) estuary, which is connected to coastal waters through a narrow channel and has a wet land at the mouth of a river flowing into the estuary. As the average water depth is less than 2 m, tidal exchange of water makes the estuary as saline as at the coastal waters. Though the estuary water is physically open, the food web in the estuary seemed to be rather closed system, like a lake. Nitrogen stable isotope ratios of *Crangon* (Decapoda, at the highest trophic level as fish), dominant fish (Pholidae) and *Hippolyte* (Decapoda, probably main prey of fish) were 13~16, 13~14 and 13permil, respectively. Detrital nitrogen had ca. 10permil. High levels in nitrogen isotope ratios suggest that denitrification is active, leaving heavier isotope in the estuary, and that the recycling of organic matter through food web is also active.

8.2 3 O I

Inoue, M., Wiseman, Jr., W., Coastal Studies Institute, Louisiana State University, Baton Rouge, LA. MODELING SHEAR-FLOW DISPERSION, TRANSPORT AND MIXING PROCESSES IN LOUISIANA ESTUARIES

Circulation in Louisiana estuaries is strongly driven by tides and winds. Topographic interaction with wind- and tide-driven flow generates strong shear-flow, impacting dispersion and mixing of water within the estuaries. This is also a dominant mechanism for mixing the estuarine waters with the open gulf water. A two-dimensional, depth-integrated hydrodynamic model, forced by observed wind and tide, is used to study detailed circulation in Louisiana estuaries. Model calibration/verification is done against observations based on a multi-year field program aimed to understand physical processes contributing to land loss. The Lagrangian movements of passive tracers released in the hydrodynamic model are used to identify the dominant flow paths associated with subtidal circulation. They also reveal complex shear-flow patterns. As a result, some initially adjacent particles end up widely scattered within a short time period while others tend to stay in proximity for an extended period. Consequently, shear-flow pattern determines dispersion and mixing of water within the estuaries. These observations point to the importance of resolving small-scale, in both space and time, shear-flow patterns in order to understand dispersion, transport and mixing processes in these estuaries.

21.3 6 O I

Jaap, W., Florida Department of Environmental Protection, St. Petersburg, FL; and **Graham, B.**, Continental Shelf Associates, Inc., Jupiter, FL; and **Mauseth, G.**, Beak Environmental Consultants, Kirkland, WA. **FIRAT GROUNDING ASSESSMENT AND CORAL REATTACHMENT PROJECT.**

The Turkish freighter FIRAT grounded along the nearshore reef of Fort Lauderdale, Florida on 15 November 1994. Following the grounding event, a qualitative assessment was conducted using an integrated video mapping system (IVMS) to delineate the boundaries of the impacted areas, make qualitative observations concerning the spatial distribution and severity of the impacted areas, and provide baseline information for tasks related to damage compensation. Based on grounding assessment data, a field project for reattaching viable hard coral colonies present within the impacted areas was conducted to expedite habitat resource restoration. A major portion of the impacted areas was searched for viable hard coral colonies (including specimens dislodged by the grounding and by natural processes) to be reattached to the impacted substrate. A total of 588 hard coral colonies, representing 12 species, were reattached at 16 sites within the impact area. Of the 588 reattached coral colonies, 127 of them were permanently tagged and mapped for potential monitoring efforts. A site visit was conducted approximately 5 months after the coral reattachment project, to determine the condition of the reattached coral colonies. The results of the site visit indicated approximately 98% of the reattached coral colonies were healthy and firmly attached to the substrate. This project was a cooperative effort between the responsible party and their representatives and the State of Florida and presented a unique approach for applying resource restoration to compensatory measures.

32.1 4 O C

Jacks, S., Serota, T., USFWS Corpus Christi Fishery Resources Office, Corpus Christi, TX. **FISHERIES MANAGEMENT ON TEXAS COASTAL NATIONAL WILDLIFE REFUGES.**

National wildlife refuges (NWR), located on the Texas Gulf Coast traditionally have been managed for waterfowl production and endangered species refugium. Available information regarding aquatic resources found on these public lands is incomplete. The U.S. Fish & Wildlife Service, Corpus Christi Fishery Resources Office (CCFRO) has been active in collection of baseline fishery data and the design and implementation of Fishery Management and Monitoring Plans for the nine coastal NWR's. Recently completed and current studies include: impact of recreational angling

on NWRs, development and implementation of structural enhancements for recreational angling, water control structure design and function, relationships between fresh and brackish water and fishery habitat requirements, and the role that State and Federal fish stocking should have on these highly productive and valuable refuges.

12.3 3 O C

Jackson, T., **Wade, T.**, **Sericano, J.**, **Brooks, J.**, **Wong, J.**, **Garcia-Romero, B.**, **McDonald, T.**, Geochemical and Environmental Research Group, Texas A&M University, College Station, TX. **GALVESTON BAY: TEMPORAL CHANGES IN THE TRACE ORGANIC CONTAMINANT CONCENTRATIONS IN NOAA NATIONAL STATUS & TRENDS OYSTERS (1986 - 1994)**

The temporal distributions for six classes of trace organic contaminants (Chlordanes, DDTs, Dieldrin, PAHS, PCBs and Butyltins) in oysters from six Galveston Bay sites from NOAA's NS&T Mussel Watch Program are compared with other NS&T sites from the Gulf of Mexico as well as all NS&T sites of the United States (East coast, West coast, and Gulf of Mexico). Decreases in the median for the Gulf-wide concentration of chlordanes, dieldrin, and butyltins occurred during 1986-1994. The Gulf-wide median concentrations of DDTs, PAHS, and PCBs appear to be strongly influenced by a large-scale climatic factor, such as the El Nino/Southern Oscillation. For Galveston Bay oysters, "high" concentration is defined as the concentration greater than the median plus one standard deviation for all Gulf of Mexico sites. The percentage of "high" concentration samples during 1986-1994 for Galveston Bay oysters are 44% (butyltins), 39% (dieldrin, chlordanes), 36% (PCBs), 28% (PAHS), and 19% (DDTs). For PCBs, 43% of Galveston Bay oyster samples analyzed over the first nine years have concentrations high enough for potential biological effects to be observed in the oysters, chlordanes (22%), butyltins (22%), dieldrin (5%), and PAHS (4%). NAS proposed regulatory limits for oysters were exceeded in only 2% of Galveston Bay samples for DDTs and 1 % for PCBs. All other contaminants were below proposed NAS limits.

33.2 5 O C

Jeffries, T.Z., **Freund, R.A.**, **Kraus, N.C.**, **Conrad Blucher Institute for Surveying and Science**, Texas A&M University-Corpus Christi, Corpus Christi, TX. **EXTENSION OF THE TEXAS COASTAL OCEAN OBSERVATION NETWORK (TCOON) CAPABILITIES.**

The Conrad Blucher Institute for Surveying and Science operates a network of 24 stations in the estuarine waters of Texas extending from Freeport to South Padre Island, at

which real-time monitoring of water level is conducted. Originally sponsored by the Texas General Land Office to provide information for marine boundary delineation, the Network is being extended to include measurement of wind velocity, water velocity, directional wave spectra, water temperature and salinity, air temperature, and barometric pressure through incorporation of the instruments and data from a variety of projects sponsored by state and federal agencies. The data from these stations are typically collected at 6-min intervals and transmitted to the Institute by satellite transmission or line-of-sight radio via relays at towers. In addition to an extensive physical infrastructure, the TCOON also comprises a sophisticated quality-control and management system by which more than 3 gigabytes of data are available on line and supported by a graphical interface. The extended TCOON, together with the Blucher Environmental Database, is a powerful tool available to researchers, government agencies, and private industry for engineering and environmental studies. Typical applications of the data involve studies of estuarine and bay circulation, oil spill fate, movement of larvae, and re-suspension and transport of dredged material. This paper will provide an overview of the extended TCOON, properties of the multi-year time series of the measurements, and examples of uses of the data.

2.4 2 O C

Jensen, H.S., Krogh, G., Rasmussen, K., Sampou, P., Holmer, M., National Environmental Research Institute, Silkeborg, DK. **DECREASE IN PHOSPHORUS RETENTION WITH CHANGE FROM FRESHWATER TO ESTUARINE CONDITIONS.**

After 25 years as an eutrophic freshwater lake, Hjarbæk Fjord, Denmark was restored as an estuary in 1991 by opening a sluice gate to allow the intrusion of 25 ppt, nutrient-poor seawater. Water retention time decreased from 50 to 25 days, however, water quality deteriorated from 1992 through 1994. This was probably caused by the increased release of phosphorus (P) from the sediment. During the freshwater period ~8 ton P yr⁻¹ was retained in the fjord, mainly as iron-bound P in accumulating sediments. From 1992, P was released from this pool as a consequence of increased sulfide production stimulated by a 30-fold increase in bottom water sulfate concentration. This mechanism was inferred from the stoichiometry of sediment-water fluxes and from experimental investigations of the sulfate effect on sediment P release. Due to the high internal P loading, the net retention changed to a net release of 30 t P yr⁻¹ in 1992-93 and 15 t P yr⁻¹ in 1994. Correspondingly, the pool of iron-bound P in the sediment decreased by >60 t from April 1992 to April 1995. The case-study of Hjarbæk Fjord provides strong support to the hypothesis that increased sulfate reduction has a negative impact on P retention efficiency in clastic sediments.

30.3 5 O C S

Jensen, S.L., Robbins, B.D., Bell, S.S., University of South Florida, Department of Biology, Tampa, FL. **TESTING THE VALIDITY OF A MODEL FOR SEAGRASS POPULA-**

TION DECLINE: VOGUE OR VAGUE?

The ability to predict seagrass population decline would be of great benefit to coastal managers. To make predictions on the trajectory of seagrass population dynamics, demographic characteristics of the population must be known. The reconstructive technique has come into vogue, whereby the past growth dynamics of seagrass are elucidated either from the current structure of the population's age distribution (snapshot sample) or from leaf scars left on the seagrass rhizome. Future population dynamics are then predicted using a deterministic model based upon the logistic equation. We attempt to quantify the inherent spatial variability of age distributions of seagrass populations, and validate the deterministic model. Samples of *Thalassia testudinum* were removed from Rabbit Key Basin, Florida Bay, FL, in June 1994. Using sample and data processing techniques described in a previous study, we looked at spatial variability in population age structures across the basin, and at potential demographic bias brought about in sample processing. We found that sample processing underestimated the age of the population, and considerable variability in demographic characteristics within a continuous seagrass meadow exists. The results of the population models diverged, showing a population increase contrary to previous model predictions of decline.

16.2 5 O C

Jewett-Smith, J., Texas A & M International University, Laredo, TX, and Bird, K., UNCW-CMSR, Wilmington, NC. **RAPD ANALYSIS OF THE GENETIC DIVERSITY OF FLORIDA HALOPHILA SPECIES.**

The seagrasses *Halophila engelmannii* (He), *H. decipiens* (Hd), and *H. johnsonii* (Hj) were collected from the Indian River Lagoon, surface cleaned and the DNA extracted. The extraction procedure used a simple grinding buffer (TRIS, NaCl, EDTA and SDS), RNase treatment at 65°C, freezing at -70°C and alcohol precipitation. Using randomly amplified primer DNA in the polymerase chain reaction (RAPD-PCR) the "DNA fingerprints" or fragment banding patterns of these species were compared. The amplification program consisted of the following steps: 1 min. 95°C to melt, 1 min. 35°C to anneal, and 2 min. at 72°C to extend for 40 cycles. With primer P09, He amplified 9 of 13 common fragments, Hd had 10 of 13 common fragments and Hj had 5 of 13 common fragments. With primer P05, Hd had 4 of 12 common fragments, Hj 9 of 12 common fragments. Variation in PCR fragment patterns among ramets of a single population of non-sexually reproducing Hj was also observed for the 10 base pair primers P05, P09 and another primer, the 17 base pair M13. Hj is a plant that to date has not had male flowers identified or collected. The variation seen within the Hj bed points to some source of genetic diversity other than sexual reproduction involving pollination.

12.3 4 O C S

Jiann, K.T., Presley, B.J., Department of Oceanography, Texas A&M University, College Station, TX. **SPATIAL AND TEMPORAL VARIATIONS IN TRACE METAL CON-**

CENTRATIONS IN OYSTERS FROM GALVESTON BAY, TEXAS.

Nearly one thousand American oysters (*Crassostrea virginica*) were collected in different seasons from several locations around Galveston and adjacent Bays in 1992-1993. Oysters were shucked, dried, digested, and analyzed individually for Ag, As, Cd, Cu, Fe, Ni, Pb and Zn in order to investigate spatial and temporal variations. Average metal concentrations, calculated from the individuals analyzed showed significant differences, up to a factor of five, at the different locations around the bays, which suggests that localized control. Spatially, higher trace metal concentrations were found in western Galveston Bay and deep (eastern) East Bay. Summer metal concentrations at a given site were as much as two times higher than those in other seasons. Among the elements determined, Fe and Pb correlated best ($R^2=0.8$) although these may be affected by sediment contained in the oyster tissue. Zinc and Cu, and Cu and Ag showed similar changes among seasons and locations. Salinity may affect metal speciation and lead to variations in Zn, Ag and Cu uptake by oysters. Decreases of metal concentrations in oysters from summer/fall to winter/spring indicate that under natural conditions, oysters depurated trace metals fairly quickly, even without transplanted from contaminated sites to pristine areas. Half-lives in oysters, based on this study, were estimated to be several months for Ag, Cd, Cu and Zn, and infinite for As.

3.1 3 O I S

Jin, C., Pollution Administrative Division of Anhui EPB, Hefei, Anhui, P.R.C. **THE TREATMENT STRATEGY OF POLLUTION IN ANHUI HUAIHE RIVER.**

The Huaihe River is the 7th main river in China, the 2nd in Anhui Province. The river flows across Henan, Anhui, Jiangsu Province, then into the Chinese East Sea (or the Pacific Ocean). It is the most seriously polluted river in the country. The basin suffers heavy economic losses every year because of the pollution, making treatment of the river is a pressing task. The treatment of Anhui Pollution will cost 4 billion RMB (\$ 0.47 billion USD) in 2000. Anhui will strengthen the comprehensive treatment of water pollution by establishing a responsibility system and strictly controlling the discharge of waste water. Including: 1. The engineering treatment will reduce 43% of chemical oxygen demand (COP) in 2000. 2. The non-engineering treatment management will cut down 47% of COP in 2000. The management covers: A list of polluted firms on the river will have to be closed or converted to other lines of production or have to discharge pollutants within an allowed quota were announced, etc.

30.3 1 O C

Johansson, J.O.R., Bay Study Group, City of Tampa, Tampa, FL. **PROGRESS OF WATER QUALITY AND SEAGRASS RECOVERY FOLLOWING NUTRIENT POLLUTION ABATEMENT IN TAMPA BAY, FLORIDA.**

Tampa Bay has been impacted extensively by watershed

development. The long-term chlorophyll-a record (+40 years) confirms serious eutrophication from the late 1960's to the early 1980's, specifically in Hillsborough Bay, one of the four major segments of Tampa Bay. Nutrient loading to Hillsborough Bay was substantially reduced from the mid 1970's to the early 1980's. Better control of nitrogen discharges from point-sources, including a large domestic wastewater plant and several agricultural fertilizer producing plants resulted in a near 70 percent loading reduction of dissolved inorganic nitrogen. Phosphorous loading was also reduced substantially, mainly as a result of water conservation measures at phosphate mines and fertilizer plants. The nitrogen reduction is of special interest, however, because the Tampa Bay phytoplankton population appears to be nitrogen limited during all seasons. By the mid 1980's, Tampa Bay showed signs of lessened eutrophication. These included a bay-wide decrease of phytoplankton biomass and new growth of submerged seagrass in the upper portions of the bay. Today, phytoplankton biomass has stabilized at levels found prior to the late 1960's. Further, seagrass is expanding rapidly in the upper portions of the bay, although, the areal coverage is still much below that found 40 to 50 years ago.

13.3 3 O C

Jones, T.W., Salisbury State University, Salisbury, MD. **TEMPORAL AND SPATIAL VARIABILITY OF ESTUARINE MARSH CREEK WATER QUALITY IN AN AGRICULTURALLY IMPACTED MARSH.**

Typical water quality parameters (carbon, nitrogen, phosphorus, total suspended solids, and chlorophyll *a*) were measured in three marsh creeks draining the Monie Bay component of the Maryland National Estuarine Research Reserve in three time/space frames over a consecutive two-year period. In the first year, bi-weekly samples were taken from two locations in each creek. In the second year during June, August, December, and March, bi-hourly samples were taken from one location in each creek over a tidal cycle, and samples were taken from five equidistant locations along the length of each creek within a two hour period on the day following the tidal cycle study. The data indicates a strong nutrient input from agriculture (fertilizer supplemented with chicken manure) surrounding two of the creeks. The watershed area to creek water volume differences for the creek systems played a significant role in the water nutrient concentrations. spatial variation in nutrient concentrations along the length of the agriculturally impacted creeks correlates closely to the location of chicken manure application.

3.3 1 O C

Jordan, S.J., Maryland Department of Natural Resources, Cooperative Oxford Laboratory, Oxford, MD, and Vaas, P.A., Duke University School of the Environment, Durham, NC, and Linder, C., Maryland Department of Natural Resources, Cooperative Oxford Laboratory, Oxford, MD. **DIAGNOSING THE "HEALTH" OF LARGE ESTUARINE ECOSYSTEMS: INTEGRATIVE APPROACHES BASED ON BIOTIC ASSEMBLAGES AND HABITAT CONDITIONS.**

The goal of restoring balanced, healthy and productive estuarine ecosystems can be expressed by semi-quantitative or categorical models (hypotheses) that establish expectations for the responses of biotic groups such as benthos, fish, aquatic vegetation, zooplankton and phytoplankton. These expectations can be used as reference points for temporal trends or spatial gradients, which in turn may correlate with trends in ecosystem stresses. We have explored indices and "metavariables" that integrate data for several biotic groups and their habitat conditions. The value of these measures for diagnosing ecosystem integrity can be tested by comparing their behavior to the expectations models. Examples from Chesapeake Bay and Atlantic coastal lagoon systems show clear patterns in several aggregate biotic variables, which are correlated with land use patterns, water and sediment quality, or physical habitat conditions. Mechanistic ecosystem models of estuaries eventually may supplant less rigorous approaches, but have not yet shown that they can capture the dynamics of higher trophic level species aggregates over large spatial and temporal scales.

11.2 4 O C

Joye, S.B., Mazzotta, M.L., Hollibaugh, J.T., Center for Environmental Studies, San Francisco State University, Tiburon, CA. **COMMUNITY METABOLISM IN ESTUARINE INTERTIDAL MICROBIAL MATS: THE ROLE OF IRON AND MANGANESE REDUCTION.**

We examined community metabolism and nutrient, iron (Fe) and manganese (Mn) cycling in two intertidal marine microbial mat communities during short (4-5 d) incubations in closed, flow through microcosms. Sediment microcosms were incubated under either light (light-dark cycles) or dark (continuous darkness) conditions to assess the effect(s) of photosynthetic oxygen production and microalgal activity on nutrient, Fe and Mn cycling. The effects of chemical redox reactions between reduced sulfur (S), Fe and Mn cycling were examined by blocking sulfate reduction with 25 mM molybdate. Both microbial mat communities exhibited similar rates of gross photosynthetic oxygen (O_2) production, but different rates of net benthic O_2 flux. In light-incubated microcosms, negligible fluxes of nutrients and trace metals were observed. A substantial sediment to water flux of reduced Fe (Fe^{2+}) and Mn (Mn^{2+}) was observed in microcosms incubated under continuous darkness; highest fluxes were observed in molybdate-amended microcosms. At both sites, biologically-mediated redox reactions accounted for a substantial (>50%) portion of the Fe^{2+} and Mn^{2+} flux. Data from dark versus dark + molybdate-amended microcosms illustrate that chemically-mediated redox reactions between metal oxides and reduced S complicated the interpretation of Fe and Mn fluxes, underscoring the need to separate chemical and biological reactions when attempting to determine the role of biological trace metal reduction in organic carbon oxidation.

21.1 5 O I

Julius, B., NOAA Damage Assessment Center. **USE OF HABITAT EQUIVALENCY ANALYSIS IN SEAGRASS**

DAMAGE ASSESSMENT AND RESTORATION CASES IN THE FLORIDA KEYS.

A major problem facing natural resource trustees responsible for performing damage assessments and restoring injured natural resources is determining the proper scale of restoration project(s). This problem is particularly relevant for the trustees charged with managing the Florida Keys National Marine Sanctuary (FKNMS), where between 5,000 and 10,000 acres of seagrass are estimated to have suffered severe injuries due to propeller scars and vessel groundings. A successful damage assessment and restoration plan needs to address not only the injuries incurred on-site, but also the natural resource services lost during the period in which the injured resource provides less than its baseline level of services. In response to the need for an analytic framework in which to determine the appropriate scale of restoration and compensatory habitat creation projects, NOAA developed the habitat equivalency analysis (HEA) approach. This paper addresses issues specific to the implementation of HEA for seagrass environments, including the use of specific aggregate metrics to capture total habitat services and the projection of recovery horizons for injured areas within the FKNMS.

8.1 5 O C

Justic, D., Rabalais, N.N., Turner, R.E., Wiseman, Jr., W.J., Coastal Ecology Institute, Louisiana State University, Baton Rouge, LA, Louisiana Universities Marine Consortium, Chauvin, LA, Coastal Ecology Institute and Department of Oceanography and Coastal Sciences, Baton Rouge, LA and Coastal Studies Institute, Louisiana State University, Baton Rouge, LA. **SHORT-TERM OXYGEN CYCLING, RANDOM WALK AND HYPOXIA IN THE COASTAL OCEAN**

Continental shelf of the northern Gulf of Mexico is the site of the largest (up to 16,500 km²) and the most severe hypoxic/anoxic zone in the western Atlantic Ocean. Hypoxic bottom waters (< 2 mg O_2 l⁻¹) are found throughout most of the summer on the inner continental shelf, extending up to 60 km offshore. Continuous oxygen, temperature and salinity records were collected at station C6, in the core of the hypoxic zone, from July 1990 onward. The measurements were carried out at 15-min. intervals, using an Endeco 1184 pulsed dissolved oxygen sensor. The instrument was deployed approximately 1 m above the seabed in a 20 m water column. Results of time-series analysis show that there is a surprisingly large variability in bottom oxygen concentration over a time scale ranging from 15 minutes to several days. Efforts to seek statistically significant coherence between dissolved oxygen and various physical and biological parameters, however, have proven futile. Characteristic tidal signals, for example, were not found in the periodograms of oxygen data series from station C6. Results of Monte Carlo simulations suggest that short-term oxygen variability may well be approximated by a simple random walk.

-K-

6.2 2 O C S

Kaldy, J.E., Dunton, K.H. The University of Texas at Austin Marine Science Institute, PO Box 1267, Port Aransas, TX 78373. **PHOTOSYNTHETIC PARAMETERS, CARBOHYDRATE CONTENT AND BIOMASS OF CULTURED *THALASSIA TESTUDINUM* SEEDLINGS FROM SOUTH TEXAS.**

We examined changes in the photosynthetic physiology of *Thalassia testudinum* seedlings in relation to their ontogenetic development. During 1994 flowering and seed set was observed in *Thalassia* beds in the lower Laguna Madre near Port Isabel, TX. Fruits and seeds were collected in August 1994 and maintained in laboratory culture for > 1 year. At regular intervals we measured the photosynthetic parameters and soluble carbohydrate carbon content of the seedlings. Average plant weight following germination increased from 0.095 gdw at c.a. 1 week to 0.185 gdw at 9 months. The average root : seed : shoot ratio changed from 0 : 11 : 1 for a 1 week old plant to 1 : 1.2 : 1.3 for a 9 month old plant. During the culture period, gross P. increased from 5.5 to 82.2 $\mu\text{mols O}_2 \text{gdw}^{-1} \text{hr}^{-1}$, while whole plant respiration increased from -11.4 to -25.4 $\mu\text{mols O}_2 \text{gdw}^{-1} \text{hr}^{-1}$. As the photosynthetic parameters increased, the average carbohydrate carbon content of the seeds decreased from 23.6 to 3.0 mg C seed⁻¹. Our data also provides evidence of a substantial increase in respiratory rates as a result of wounding, documenting the importance of measuring whole plant respiration.

20.2 2 O C

Kapolnai, A., Werner, F.E., Marine Sciences Program, CB #3300, University of North Carolina, Chapel Hill, NC, and Blanton, J.O., Skidaway institute of Oceanography, Savannah, GA. **CIRCULATION, MIXING AND EXCHANGE PROCESSES IN THE VICINITY OF TIDAL INLETS: A NUMERICAL STUDY**

The circulation the vicinity of an idealized tidal inlet connecting a continental shelf and a coastal sound is examined. The circulation is forced by an M_2 tide and a weakly buoyant discharge. The buoyant discharge forms a plume in the coastal ocean and induces a distinct anticyclonic circulation at the plume edge. We focus on the plume's onset and its evolution over 5-10 tidal cycles. Over the time-scales considered, the plume was roughly circular - slightly skewed in the along-coast direction. The model solution yielded high vertical Ekman numbers of $O(5)$ in the vicinity of the inlet mouth, dropping to $O(0.25)$ at the plume's seaward edge. Passive particles released seaward of the inlet mouth describe the exchange between the coastal region and the inlet. A marked asymmetry between ebb and flood flows is observed

in the vicinity of the inlet, with jet-like ebbing currents and weaker potential-flow like flooding currents. Over a tidal cycle, not exchanges between the coastal ocean and the inlet are spatially and temporally dependent, i.e., particle trajectories depend on the release point and the time of the release in the tidal cycle. The near-inlet residual circulation shows significant differences in the absence of stratification.

13 16 P-2 C

Kappmeyer, C., Ott, J., Repenning, R., Florida Department of Environmental Protection/ Southwest Florida Aquatic and Buffer Preserves Office, Bokeelia, FL. **SOUTHWEST FLORIDA AQUATIC AND BUFFER PRESERVES: EXCEPTIONAL RESOURCES AND INNOVATIVE MANAGEMENT.**

Southwest Florida is enriched by relatively large tracts of high quality estuarine seagrass meadows, mangrove forests, salt marshes and hydric pine flatwoods. Eight of these regionally significant estuaries and adjacent wetlands have been set aside by the legislature as state Aquatic and Buffer Preserves. The intent of the Florida Aquatic Preserve Program is to preserve these unique natural resources "in essentially natural conditions so that their aesthetic, biological and scientific values may endure for the enjoyment of future generations." Under the program, the Florida Department of Environmental Protection uses state statutes and administrative codes as guides lines for managing the estuaries and wetlands. These Guidelines are incorporated into management plans for the individual aquatic and buffer preserves. While each of the aquatic and buffer preserves have unique resources, environmental risks, and political challenges, integrated management of the system as a whole is critical for effectively and efficiently achieving the desired result of sustainable resources. Management of the aquatic and buffer preserves focuses on resource management, education and research activities. Resource management includes activities such as removal of exotic vegetation, prescribed burns, directing boating traffic away from shallow seagrass areas, siting marinas away from frequent manatee areas and assisting local governments with proper storm water management programs. Education activities include adult environmental education guided nature walks, and a variety of school and public presentations. Aquatic and buffer preserve staff assist with seagrass productivity, mangrove function and water quality research projects. The wise and sustainable use of these unique resources is invaluable to the health and well being of Florida's citizens, biological communities and economy.

15 21 P-2 C

Kawaguchi, T., Aelion^{1,2}, C.M., McKellar^{1,2}, H. University

of South Carolina, Department of Environmental Health Sciences¹, School of Public Health and Marine Science Program², Columbia, S.C. **EVALUATION OF SIMULTANEOUS DETERMINATION OF TOTAL KJELDAHL NITROGEN (TKN) AND TOTAL PHOSPHATE (TP) BY IN-LINE DIGESTION WITH SHENA LASCA 6880 AUTOMATED CHEMISTRY ANALYZER.**

Automatic segmented flow methods of chemical analyses have become well established over the past two decades. However, time consuming, tedious and often dangerous manual block digestion and transfer steps are still required for TKN and TP analyses using most automated chemistry analyzers. We evaluated the performance of Shena LASCA automated system for TKN and TP analyses of estuarine samples. Continuous digestion is achieved by pumping a digestion mixture in a quartz mixing coil in an electronic heater. Continuous micro-distillation for separation of volatile components from sample streams is done using an electronically heated reactor. Samples are concentrated after cooling into a digestant stream. We were able to analyze TKN and TP at 30 samples/hr with standard deviation less than 0.03. Furthermore, a mini-diode photometer was used to eliminate interferences due to differences in matrices. Automated background correction was achieved by splitting the light beam after passing through the flowcell. The signals were automatically subtracted from the array of the two light beams. This eliminated the matrix interferences and the need for two modules. We concluded that this system is a significant improvement over manual block digestion for TKN and TP analyses of estuarine samples.

15.3 4 O C

Kawaguchi, T.¹, Lewitus, A.J.^{2,3}, Wahl, M.¹, Aelion, C.M.^{1,2}, McKellar, H.^{1,2} University of South Carolina, Department of Environmental Health Sciences¹, Marine Science Program², and Baruch Marine Field Laboratory³, Columbia, SC. **CAN URBANIZATION LIMIT IRON AVAILABILITY TO ESTUARINE ALGAE?**

Although iron is generally abundant in coastal regions, only limited fractions can be assimilated by algae because bioavailable iron species are highly unstable in oxygenated, salt water. Dissolved organic matter (DOM) produced by coastal forests may play an important role in chelating iron and thus enhancing its availability to phytoplankton and macroalgae. In fact, the reduction of organically-bound iron (org.-Fe) caused by deforestation is considered the causative factor in the gradual disappearance of brown algae in the coastal region of the Japan Sea. We tested the hypothesis that urbanization associated deforestation in Murrells Inlet (MI) reduced iron availability to phytoplankton. Bioavailable iron distribution and response to iron addition of phytoplankton population growth and community composition were compared in MI and an undeveloped estuary, North Inlet (NI). DOM and org.-Fe were higher in forested streams of NI. Iron stimulated the growth of phytoplankton in both estuaries, but differences were observed in the timing and magnitude of the iron response. The results indicate that iron potentially can be limiting to phytoplankton growth in both

estuaries. The differences in iron response (growth, nutrient conditions and phytoplankton species composition) between estuaries are discussed.

33.1 2 O C

Kelley, B.J., Porcher, R.D., The Citadel, Charleston, SC. **EFFECTS OF THE REDIVERSION OF THE COOPER RIVER: CHANGING VEGETATION PATTERNS IN FRESHWATER TIDAL MARSH.**

Freshwater flow into the Cooper River near Charleston, SC was reduced in 1985 from an average of 420 m³/sec (15,000 CFS) to an average of approximately 126 m³/sec (4,500 CFS) by rediverting water to the Santee River. Lowered water levels, as much as 15 cm in some locations, have accelerated vegetational succession in the freshwater tidal marshes that border the upper portion of the river. Most of the bordering marsh of the upper Cooper was cleared of swamp forest and diked for rice cultivation during the 18th and 19th centuries. In 1995 all but a few of the old rice fields have breached dikes with daily tidal flow. Each of the fields was photographed at ground level and low levels from the air. Four of the fields have been sampled for species composition, frequency and biomass/species at intervals beginning in 1982. Through the combination of on the ground sampling and analysis of aerial photography (NAPP color IR's and color slides), changes in percent cover and species/community composition have been documented for the period 1979-1995. The ecological and recreational implications of the vegetational changes for the drainage basin are examined.

20.2 5 O C

Kelly, J.R., Battelle Ocean Sciences, Duxbury, MA. **THE COASTAL WATERSHED EXTENDED: NITROGEN FLOW AND THE ECOLOGICAL INTERACTION OF BOSTON HARBOR WITH MASSACHUSETTS BAY.**

This paper summarizes evidence that most of the N load to Boston Harbor is expelled to shallow shelf waters of Massachusetts Bay, where it strongly influences ecological dynamics. N concentrations in the Harbor, compared to those in loading, indicated that removal processes are active in the Harbor. Extensive measurements of sediment denitrification confirmed that rates of N₂ gas loss are high in an absolute sense, but relative to loading denitrification removes a small portion of the Harbor's N load. Western Massachusetts Bay receiving waters were examined for a signature of export from the Harbor. Data consistently show a gradient of decreasing N concentrations from the Harbor. The enrichment of Bay surface waters extends about 10-20 km into the Bay; in cases, nutrient concentrations with salinity show nearly conservative mixing, which implies virtual export. Extensive high-resolution studies of water properties in the Harbor-Bay mixing region suggest that export occur with release of surface water from tidal ebb-flow cycles. High-resolution studies of water properties and chlorophyll (fluorescence) further indicate that mixing of Harbor and Bay waters is accompanied by *in situ* stimulation of chlorophyll.

2.1 5 O C

Kemp, W.M., Petersen, J., Chen, C.C., Goertemiller, T., Cornwell, J., Sanford, L., Malone, T., University of Maryland, Horn Point Environmental Laboratory, Cambridge, MD 21613. **EXTRAPOLATING FROM MESOCOSM TO ESTUARY: SCALE-DEPENDENCE OF PLANKTONIC- BENTHIC ECOSYSTEM PROCESSES.**

A system of replicate experimental estuarine ecosystems was devised to examine the scale-dependence of planktonic and benthic processes. Mesocosms were constructed and operated at 3 volumes (0.1, 1.0, 10 m³) in 2 design series, one with constant depth (1 m) and the other with constant ratio of wall-surface-area to water-volume ($A:V = 3.6 \text{ m}^{-1}$). Experiments were conducted for 6-7 wk periods in 3 seasons, with a pulsed nutrient input administered after 4 wk to examine response times. Nutrients were removed rapidly from mesocosm waters at rates inversely related to water column depth. Increases in algal biomass resulting from nutrient additions were inversely related to mesocosm volume. Within 2-3 wk after study initiation, periphyton growth on walls dominated biomass and metabolism in tall, narrow mesocosms; relative importance of periphyton was directly proportional to $A:V$. Vertical attenuation of light (PAR) was inversely related to radius of mesocosm cylinders, with wall reflectance dominating at $< 0.5 \text{ m}$ radius. Rates of primary production per area were constant among all mesocosms in spring, while rates per volume were constant in summer, suggesting seasonally varying scaling criteria with changing relative availabilities of nutrients and light.

11 8 P-2 C

Kemp, W.M., Smith, E., Whipp, K., Madden, C., University of Maryland, Horn Point Environmental Laboratory, Cambridge, MD. **CONTRIBUTIONS OF SHALLOW-WATER REGIONS TO THE NET ECOSYSTEM METABOLISM OF CHESAPEAKE BAY.**

This study tests the hypothesis that rates of net ecosystem production ($NEM = P-R$) are inversely related to water depth along shore-normal transects in Chesapeake Bay. This idea is potentially important because of the fact that approximately 40% of the Bay area is $< 6 \text{ m}$ depth. Rates of photosynthetic production and respiration (as O_2 and TCO_2) for planktonic and benthic communities were measured at 4-5 stations along a depth transect from 2-20 m in the mesohaline region of the Bay, with sampling cruises at bimonthly intervals. Concentrations (m⁻³) of phytoplanktonic chlorophyll generally decreased with water column depth as did benthic chlorophyll densities (m⁻²). In contrast, water clarity tended to increase with depth, due to higher chlorophyll concentrations and to enhanced bottom resuspension. During most cruises rates of net planktonic community production (m⁻²) were highest at the two shallowest stations, while respiration rates were relatively independent of station depth. Benthic photosynthesis was relatively unimportant ($< 20\%$ of total) at all but the 2 m station. In summary, these results support the idea that integrated rates of NEM in shallow regions of the Bay contribute substantially to the overall C-budget.

22.2 5 O C

Kiesling, R.L., Ecosystem Research and Assessment, Texas Natural Resource Conservation Commission, Austin, TX. **THE IMPORTANCE OF SPECIES-AREA RELATIONSHIPS IN ASSESSING THE IMPACT OF ESTUARINE SEDIMENT CONTAMINATION.**

Surveys of Galveston Bay, Texas, have identified San Jacinto Bay as an area of high sediment toxicity and low benthic invertebrate diversity. To investigate this relationship, we surveyed six stations along two transects in San Jacinto Bay for benthic community structure and elevated concentrations of conventional and priority pollutants in water and sediment. Benthic community characterization consisted of species composition and abundance estimates from five replicate Ekman Dredge grab samples at each site. Total organism abundance in San Jacinto Bay was comparable to other upper tidal environments in the Galveston Bay system ranging from 393 ind./m² to over 740 ind./m². Benthic community species richness ranged from 5 to 13 species with corresponding densities of 606 ind./m² and 743 ind./m². In contrast, previous studies of San Jacinto Bay have estimated a species richness of 2 species for the benthic community. Species-area relationships from this study indicate that these differences can be attributed to inadequate sampling methodology employed by previous studies. Replicate analysis clearly indicates that the appropriate surface area to sample for estimates of species richness is greater than 0.5 m² of bay bottom. Previous studies have sampled areas as small as 0.002 m².

33.1 6 O C

Kiesling, R.L., Farmer, L., Ecosystem Research and Assessment, Texas Natural Resource Conservation Commission, Austin, TX, and Garono, R.J., Tillamook Bay National Estuary Project, Oregon State University, Garibaldi, OR. **DEVELOPMENT OF A NONPOINT SOURCE POLLUTION POTENTIAL INDEX FOR THE SAN ANTONIO-NUECES AND NUECES-RIO GRANDE COASTAL BASINS.**

Land use, soil erosion, and sediment loading have been used to develop indices of NPS pollution potential. We combined existing information on soils and land cover class to produce a guide to the risk posed to natural systems by NPS pollution within two coastal basins in Texas. Index components were based upon the Universal Soil Loss Equation and included estimates of soil erodibility (K), steepness (S), and land use and land management (C). Soil erodibility and slope steepness were derived from certified copies of the U.S. Soil Conservation Service (SCS) State Soil Geographic Data Base (STASGO) GIS data layers. Land-cover classes were derived from the USGS GIRAS data. Values for each variable were assigned to polygons in an ARC/INFO data layer, and discrete polygons were created using the UNION command in ARC. A uniform index equation was applied to all unique polygons using the CALC command. This produced a simple numerical index of relative NPS pollution potential based upon the maximum potential contributions of sediment. Com-

parisons of index values for the San Antonio-Nueces and Nueces-Rio Grande coastal basins with other basins in Texas indicates a relatively moderate level of risk.

17.2 3 O C

Kimmerer, W.J., Romberg Tiburon Center, San Francisco State University, Tiburon, CA; and **Bennett, W.A.**, Bodega Marine Laboratory, Bodega Bay, CA, and **Burau, J.**, U.S. Geological Survey, Sacramento, CA. **INTERACTION OF PHYSICS AND BIOLOGY IN THE LOW-SALINITY ZONE OF THE SAN FRANCISCO BAY-DELTA ESTUARY.**

Many estuarine species can adjust vertical position, and under simple assumptions about current distributions, this movement could result in retention in the estuary. We have re-examined the interaction of vertical position and longitudinal motion and retention using state-of-the-art velocity measurements made with acoustic doppler current profilers (ADCP) in the low-salinity zone (LSZ) of the San Francisco Bay-Sacramento-San Joaquin Delta estuary. We examined the relationship between vertical and longitudinal positions of common planktonic species and the velocity field under various conditions of tide and freshwater outflow. Stations were selected on the basis of nominal salinity values rather than fixed locations: in 1994 we sampled near 0.5, 1.5, and 3 psu at the surface, while in 1995 we sampled continuously from two vessels attempting to maintain position near 2 and 4 psu at the bottom. In 1994, estuarine circulation was rare in the LSZ; most organisms migrated vertically in a combined diel-tidal pattern that minimized losses due to strong ebb currents and took advantage of flood flows to move upstream. Tidal migration was less pronounced at the upstream salinity, at least for some taxa. During much higher flows in 1995, estuarine circulation was strong, and vertical migration may not have been necessary for retention.

8.1 3 O C

Kineke, G.C., University of South Carolina, Columbia, SC, and **Geyer, W.R.**, Woods Hole Oceanographic Institution, Woods Hole, MA. **THE TIME VARIATION OF SUSPENDED SEDIMENT IN THE LOWER HUDSON RIVER ESTUARY.**

A region of high turbidity occurs in the lower Hudson River estuary, approximately 10-20 km upstream, just south of the George Washington Bridge. As part of an ongoing study of sediment dynamics in the lower estuary, a field experiment was conducted in April 1993 to investigate the processes responsible for maintaining the region of high turbidity and to examine the temporal variations in suspended sediment. Variations in sediment resuspension between the flood and ebb parts of the tidal cycle are influenced by tidal straining, or the variation of stratification due to the interaction of the shear and horizontal salinity gradient. During the flood, stratification close to the bed is broken down, allowing resuspension and mixing within the bottom boundary layer to the height of the halocline. During the ebb, there is competition between enhanced stratification (which suppresses

mixing) and increased shear (which tends to break down stratification and allow mixing). High suspended loads observed in the deepest part of the channel imply trapping during the ebb caused by flow convergence in the bottom boundary layer. Sediments reside only temporarily in the thalweg, however, and are transported across the channel to the areas of high accumulation on the west banks due lateral transport within the advancing salt wedge.

33 41 P-1 C

Kirkman, H., CSIRO Division of Fisheries, North Beach, Western Australia, Australia. **MAPPING THE UNDERWATER HABITATS OF THE AUSTRALIAN COAST**

Australia's coastline was first mapped at the beginning of the 19th century. Now the underwater features are being mapped with extensive ground truth, satellite technology and computer mapping and digitising techniques. Landsat TM imagery is processed to enhance underwater features. The enhanced imagery is then taken into the field for strategic ground truth verification of features seen in the imagery. GPS position fixing is used to find a position of interest or to position a site where verification takes place. Once an image has been verified the ground truth points are placed on an outline of the coast and these points placed on the image. Eight categories of habitat are used in the map but these may vary depending on where in Australia the mapping is done. The features are traced onto the image and digitised and the map presented at 1:100,000 on Arc Info. The success of this project relies on the collaboration and cooperation of State Government departments, so far, most of South Australia and Western Australia from Exmouth Gulf to the border of South Australia has been completed, the Victorian government has bought the satellite images and preliminary interpretations have been done. New South Wales has bought the first of about ten images and Tasmania has made a commitment to assist in mapping that state. The aim is to complete all of Australia within three years.

20.1 4 O I S

Kistner, D.A., Pettigrew, N.R., Townsend, D.W., University of Maine, Orono, ME. **THERMOHALINE AND TIDAL CIRCULATION IN THE KENNEBEC RIVER ESTUARY AND RESULTING PATTERNS OF PRODUCTIVITY.**

The role of freshwater inflow and circulation in determining productivity was investigated in the Kennebec Estuary, Maine. Hydrographic and ADCP measurements were made 8-10 times during a semi-diurnal tidal cycle in May and September of 1994. Top to bottom velocity differences exceed 1 m/s and salinity differences reach 20 PSU on the ebb tide in May. Lateral velocity shear exceeds 2 m/s over 400 m distance. Residual velocity differs from top to bottom by up to 60 cm/s, with residual landward flow in the lower layer exceeding 20 cm/s. A double peaked chlorophyll pattern is evident throughout the summer. The peak near the head occurs in a light limited water column and coincides with a turbidity maximum. Gradient Richardson numbers in

that region indicate frequent potential for vertical mixing, explaining the presence of chlorophyll at depth; however, the direction of supply is unclear. A highly stratified region seaward of the turbidity maximum has little potential for vertical mixing causing chlorophyll to settle into the landward flowing lower layer, be brought back to the turbidity maximum, be trapped and senesce. A second peak near the mouth occurs in less turbid water carried in from the GOM on the flood tide.

16.2 2 O C

Kitting, C., Hanson, L., Department of Biological Sciences and Urban Environmental Center, California State University, Hayward, CA. **EELGRASS AND WATER CLARITY > 1M ARE ASSOCIATED WITH SMALL FISHES AND EPIBENTHIC INVERTEBRATES NEAR A MAJOR EELGRASS MEADOW IN SAN FRANCISCO BAY, CALIFORNIA.**

From 1985 until 1993, with supplementary experiments since, seasonal non-destructive 1 m² pushnet samples characterized distributions of common small fishes and their available foods inside and outside a major eelgrass meadow (*Zostera marina*) in central San Francisco Bay. Most of these animals were 5- to 150-mm-long amphipods, shrimp, and juveniles of several fish species. Each was concentrated within the vegetation except for *Crangon* shrimp and anchovy. Epibenthic invertebrates (> 5 mm long) reached mean population densities exceeding ~1000 individuals per m². Fishes reached mean population densities exceeding 2 per m². Eelgrass densities rose dramatically during 1993, but densities of small fishes declined to levels <1 per 5m², despite usual food abundances. Overall, low water clarity was correlated with low animal densities. Fish and epibenthic invertebrate populations among eelgrass usually were very sparse when water clarity was less than 1 m, but often exceeded 1 fish / m² plus well over 100 invertebrates / m² during higher water clarity. Feeding rates of the most common fish, *Syngnathus leptorhynchus* pipefish, were tested over a range of water clarity, and showed that feeding rates at -50 % transmittance (water clarity) were only 1/3 as rapid as those feeding rates tested at higher water clarity.

23.2 5 O C

Kjerfve, B., Oliveira, A., Marine Science Program, University of South Carolina, Departamento de Geoquímica, Universidade Federal Fluminense, and Niteroi, RJ, Brazil, LABMAR, Universidade Federal de Alagoas, Maceio, AL, Brazil. **MODELING OF WATER AND SALT TRANSPORTS IN A HYPERSALINE COASTAL LAGOON IN BRAZIL.**

Lagoa de Araruama (lat 23°S and lon 42°W) is a 210 km squared hypersaline choked coastal lagoon in Brazil with salinity averaging 55 ppt. Extensive long-term field measurements indicate that the hypersalinity is in quasi steady state, maintained by excess evaporation over precipitation and balanced by advection of ocean water into the lagoon and dispersion of salt out of the lagoon. We implemented a

vertically integrated coupled finite difference circulation-dispersion model for the lagoon and solved the equations explicitly during numerous simulations carried out for 40-150 days, using 841 active 500 m grids and a 20 s time step. Water depths varied from 0.5 to 14 m. A single canal connects Lagoa de Araruama to the South Atlantic Ocean and acts to filter the 1.3-0.8 m semidiurnal ocean tidal range to less than 1 cm within the lagoon. However, the canal does not choke longer term tidal constituents. In particular, the Mm partial tide with a 27.5 day period produces an oscillation with an 11.4 cm range in the canal and throughout the lagoon. The Mm water level and current oscillations are important in controlling water and salt exchanges, and give rise to the seaward dispersion of salt, which balances the salt advection into the lagoon as a result of the negative water balance produced by the strong net evaporative water loss. The simulation model was forced by ocean tides, fresh water input from two small rivers, a homogeneous 1.5 mm evaporation rate, and steady homogeneous winds. Water level harmonics from four tide stations and numerous salinity time series were used to calibrate the model by adjusting a friction coefficient and a salinity dispersion coefficient. Outside of the canal, simulated lagoon currents are small, 1-10 cm/s, and largely wind driven. Salinity simulations indicate that the lagoon requires more than three months to achieve a quasi steady-state salinity of 55 ppt in the absence of wind forcing but in less than half that time with winds. Independent data calculations yield a 50% lagoon water renewal time of at least 84 days.

9.1 6 O C

Klein, C.J., Ives, R.C.P., Harris, M.D., NOAA Strategic Environmental Assessments Division, Silver Spring, MD. **CHARACTERIZATION OF LONG TERM RIVERINE DISCHARGE TO 23 ESTUARINES IN THE GULF OF MEXICO.**

Efforts to describe and characterize flow from river systems which discharge into the various estuaries along the Gulf of Mexico have identified long term changes in the flow. A method was developed which reduces long term data sets containing up to 80 years of average daily flow rates into data made up of a moving 25 year average. Daily data were categorized as occurring either during the wet season months or the dry season months for a given river. Those values were then averaged in that season for a particular year and then these yearly values averaged over a moving 25 year period. The data was also normalized over the range of the yearly seasonal values and then plotted as a percentage of that range. This was performed to detect both small dry season values as compared to wet season values and to provide a basis for across estuary comparisons. The resulting smoothed data reveals long term behavior which would otherwise be obscured by short term fluctuation. The graphs were compared by estuary to each other and then grouped according to the 5 estuary types defined by Orlando *et al.* The result shows distinct similar behaviour of long term seasonal flows by estuary type. The graphs provide an ability to observe the effects of climatic variation and, perhaps, systematic drainage ba-

sin modification such as dams, flood control, and urbanization. This type of analysis can provide a means to ascertain situations where freshwater inflow to an estuary may be exhibiting long term changes and should therefore be evaluated in greater detail for stress to the estuary due to these changes in fresh water inflow.

4.1 2 O I

Kneib, R.T., University of Georgia, Marine Institute, Sapelo Island, GA. **HOW ARE NEKTON ASSEMBLAGES INVOLVED IN THE EXPORT OF INTERTIDAL MARSH PRODUCTION?**

The role of salt marshes in the trophic support of adjacent estuarine and coastal environments has been debated for some time. Global and other large-scale whole system perspectives have demonstrated correlations between the amount of wetland habitat or regional annual primary production and fishery yields. However, the incorporation of this concept into issues relevant to management - including preservation, restoration and creation - of coastal wetlands requires additional insights into the mechanisms by which nekton populations are involved in the trophic coupling of coastal environments. Identifying the pathways and factors controlling the movements of nekton and their access to intertidal production is a key part of this process. Accessibility of tidal marsh production to nekton populations depends on the interplay among several abiotic and biotic factors including: tides, geomorphic characteristics of wetlands, species habits, life histories and interspecific ecological interactions. Variation in these factors may have important regional implications for the coupling of intertidal and subtidal systems. A conceptual model is proposed to provide a framework for exploring the relative roles of resident and migratory fishes and decapod crustaceans in a 'trophic relay' of intertidal production that can be traced across boundaries and along tidal corridors through the marsh landscape.

24.2 6 O C

Koch, E.W., Horn Point Environmental Laboratory, Cambridge, MD, and **Beer, S.**, Tel Aviv University, Department of Botany, Tel Aviv, Israel. **TIDES, LIGHT AND THE DISTRIBUTION OF *ZOSTERA MARINA* IN LONG ISLAND SOUND, USA.**

The disappearance of *Zostera marina* in western Long Island Sound has been attributed to the eutrophication-induced increase in light attenuation. In this work we explore whether the much higher tidal range in the western than in the eastern Sound could further reduce the light-availability. Assuming that the spring low water level determines the upper limit of distribution and the depth of minimum light required for growth, the lower limit, then the vertical zone for growth is limited to a 1 m fringe in the western Sound and a 4 m fringe in the eastern Sound. Eelgrass with a narrow vertical distribution is more vulnerable to exposure during storms than populations covering a broader vertical range. A further evaluation of tidal effects on the light availability was pursued by allowing surface irradiance and depth of the

water column to fluctuate over 24-h periods in a Lambert-Beer-law-based model. It revealed that the diel benthic light curves were skewed or had a bimodal shape and that the number of hours of growth-saturating light was smaller as light attenuation and tidal ranges increased. Therefore, the large tidal ranges may have contributed to the disappearance of eelgrass in the western Sound. We suggest that tides should be taken into account when managing seagrasses in coastal waters.

5.2 1 O C

Koepfler, E., Sellers, S., Coastal Carolina University, Marine Science Department, Conway, SC and **Lewitus, A.J.**, University of South Carolina, Belle Baruch Laboratory, Georgetown, SC. **SEASONAL CHANGES IN THE TROPHODYNAMICS OF PLANKTON IN A TIDAL CREEK OF NORTH INLET, SOUTH CAROLINA: I. CONTROLS UPON BACTERIOPLANKTON COMMUNITIES.**

The influence of substrates (NH_4 and glycine) and bacterivore activity (inferred from dilution and cycloheximide treatments) upon bacterioplankton communities in tidal creek waters, was examined between 1994 and 1995. In the summer, during high ambient NH_4 and DOM conditions, no influence of added substrates upon bacterial growth was observed. During this period bacterivores exerted strong "top-down" controls. In the winter when NH_4 and DOM were low, bacterivore grazing was reduced but still exerted an important control through its influence upon nutrient recycling processes. During this period, NH_4 addition alone did not affect bacterial abundance (compared to the control), however bacterial abundance increased when NH_4 and cycloheximide were added together, indicating that enhanced bacterial production in the NH_4 addition treatment was passed into the bacterivore trophic level. Thus both "top-down" and "bottom-up" controls were important in the winter. Antibiotic treatment results suggest that bacterioplankton interacted differentially with various phytoplankton taxonomic groups, and that these effects changed over the seasons. Results of this study, and the companion study by Lewitus et al., indicate that top-down controls upon bacterioplankton operate throughout the year, and that bacterioplankton, phytoplankton, and bacterivores form a temporally dynamic food web in this tidal creek environment.

12.3 5 O C

Kraus, N.C., **Brown, C.A.**, Conrad Blucher Institute for Surveying and Science, Texas A&M University- Corpus Christi, Corpus Christi, TX, and **McLellan, T.N.**, U.S. Army Corps of Engineers-Galveston District, Galveston, TX. **WIDE-AREA REAL-TIME MONITORING OF HYDRODYNAMIC AND SEDIMENT TRANSPORT PROCESSES IN THE LAGUNA MADRE, TEXAS.**

The Galveston District of the U.S. Army Corps of Engineers conducts maintenance dredging operations at several locations along the Gulf Intracoastal Waterway in the Laguna Madre, a hypersaline and ecologically productive es-

tuary that extends some 190 km from Corpus Christi to Port Isabel, Texas. To address concerns about environmental consequences of the dredging, and to assess the flow and sediment-transport conditions for reducing the cost and frequency of dredging, the Galveston District initiated two monitoring programs through the Blucher Institute. In the programs, four heavily instrumented stations measuring the current velocity, salinity, turbidity, chlorophyll *a*, and other parameters relay data to the Institute via a radio network. Electronically measured parameters are recorded at 6-min intervals, and water samples are also taken twice daily by automated means for ground truthing the turbidity sensor. The stations have been operating continuously for almost a year and provide unprecedented documentation on physical processes in the lagoonal system on temporal scales ranging from minutes to seasons. This paper discusses the background of the monitoring program, strategies and procedures for its implementation, and selected results. Wind appears as the dominant force that controls the magnitude of turbidity and transport through re-suspension of sediment by wave action and subsequent transport by the combined wind-generated and tidal current.

36.1 5 O C

Kreeger, D.A., Academy of Natural Sciences, Environmental Research Division, Philadelphia, PA and Newell, R.I.E., Stoecker, D.K., University of Maryland, Horn Point Environmental Laboratory, Cambridge, MD. **UTILIZATION OF CARBON FROM MICROHETEROTROPHS BY SUSPENSION-FEEDING MUSSELS.**

Suspension-feeding bivalves have traditionally been viewed as herbivores that graze solely on phytoplankton. We determined whether these animals can also ingest and assimilate carbon from heterotrophic microorganisms that abound in natural seston. Natural-sized cellulolytic bacteria and bacterivorous nanoflagellates were ^{14}C -labeled and delivered to two species of mussels, *Mytilus edulis* and *Geukensia demissa*. ^{14}C budgets were quantified to determine each species' ability to ingest and assimilate carbon from bacteria and protists. Both *G. demissa* and *M. edulis* ingested protists with an efficiency (58 %) only about 10 % lower than for a reference species of microalgae. Bacteria were ingested by *G. demissa* and *M. edulis* with lower efficiencies (39% and 19%, respectively). Both mussels were efficient at assimilating protists and microalgae (> 40 %); whereas, bacteria were better assimilated by *G. demissa* (42 %) than *M. edulis* (21 %). Ingestion and assimilation efficiencies were integrated to calculate a "utilization efficiency", which defines the food value of the labeled substrate. Mussels utilized protist carbon less efficiently (24-32 %) than microalgae (51 %). Utilization efficiencies for bacteria were 16 % for *G. demissa*, but only 4 % for *M. edulis*. Based on reported high abundances of protists and bacteria in estuarine environments, however, these data suggest that microheterotrophs contribute a large share of the carbon requirements of suspension-feeders. Further, since suspension-feeding bivalves are often the dominant consumers in aquatic habitats, they can potentially exercise "top-down" control on microheterotrophic populations.

15.3 3 O C

Kucklick, J.R., Scott, G.I., Sanders, M., Silversten, S., National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Charleston, South Carolina 29412-2607, Long, E.R., National Oceanic and Atmospheric Administration, National Status and Trends Program, Seattle, Washington 98115, Robinson, J.H., DHEC-OCRM Charleston Harbor Project, 4130 Faber Place, Suite 302, Charleston, SC 29405. **POLYCYCLIC AROMATIC HYDROCARBONS IN SOUTH CAROLINA ESTUARINE SEDIMENTS.**

Polycyclic aromatic hydrocarbons (PAHs) are a class of toxic and carcinogenic compounds that may serve as indicators of urbanization in estuaries. PAHs in sediments are derived from a variety of sources associated with urbanization including, atmospheric deposition, urban stormwater runoff and direct releases of petroleum products. To assess PAH contamination in South Carolina, several estuaries were surveyed over two sampling periods. In 1991, 30 samples were collected from the highly urbanized Murrells Inlet and the pristine North Inlet estuaries as part of the USES project. In 1993, a total of 47 samples were collected from Charleston Harbor (45) and North Inlet (2) as part of the Charleston Harbor Project and NOAA's Regional Sediment Quality Survey. Samples were analyzed for 10 non-alkylated PAHs by high performance liquid chromatography with fluorescence detection in both years. In the 1993 sampling, samples were also analyzed by gas chromatography electron impact ion trap mass spectrometry for both alkylated and non-alkylated PAHs. Concentrations of total PAHs in sediments ranged from an average of 104 + 55 ng/g dry weight in North Inlet to over 10,000 ng/g dry weight in certain areas of Charleston Harbor. The highest PAH concentrations were generally associated with either areas of intense urbanization or industry.

7.1 4 O C S

Kuhn, N.L., Zedler, J.B., San Diego State University, San Diego, CA. **DIFFERENTIAL EFFECTS OF SOIL SATURATION AND SALINITY ON NATIVE AND EXOTIC PLANTS OF A COASTAL SALT MARSH**

Salicornia subterminalis, a low-growing perennial and high marsh dominant, and *Polypogon monspeliensis*, an invasive, exotic, annual grass, responded differently to four levels of soil saturation and salinity. *Polypogon monspeliensis* grew equally well in soils saturated for periods of 2 to 32 weeks. Thus, irrigation at restoration sites will favor its establishment and growth. *Salicornia subterminalis* seeds and young plants had greater salt tolerance, and in greenhouse experiments, the native grew best (22% more biomass) at the two highest salinities (23 and 34 ppt), while the exotic did poorly (77% less biomass). These findings suggested that salt applications could be used to protect native vegetation in salt marshes where exotics are a problem. A field experiment verified that a 850 gm/m² Salt application was sufficient to control the exotic (i.e., it reduced the number of shoots by 91 %), while not noticeably affecting the native. Thus, moisture may facilitate establishment of *P. monspeliensis*, but salt can be used to control it.

-L-

15.1 2 O C

Lackey, K., Black and Veatch, Charlotte, NC, and **McCutcheon, S.**, Dept. of Civil Engineering, Clemson University, and Ramsden, J., Dept. of Civil Engineering, Clemson University, and McKellar, H., Dept. of Environmental Health Sciences and Marine Sciences, University of South Carolina **WETLAND FLUXES AND URBAN AND RURAL WATERSHED NONPOINT CONTRIBUTIONS TO ONE OF THE FIRST ESTUARINE TOTAL MAXIMUM DAILY LOAD (TMDL) CALCULATIONS FOR ORGANIC AND NITROGEN ALLOCATION**

The first TMDL for organics and nutrients is being calculated for Charleston Harbor by the State of South Carolina. The Charleston Harbor Project (CHP) is providing models for the estuary hydrodynamics, water quality (WQ), and watershed water quality. This project (1) estimates the flux of ammonia, nitrate, organic carbon, phytoplankton, orthophosphate, and organic phosphorus from measurements available, (2) compares those estimates with fluxes obtained from other estuaries of similar characteristics, (3) links loads from the watershed model and wetlands to the WQ model. A preliminary calibration and sensitivity analysis indicates that the dissolved oxygen and nitrogen balance are influenced to a limited degree by wetland fluxes. During the summer, ammonia is imported into adjoining wetlands, and exported at less critical times. Phosphorus is exported but does not effect the dissolved oxygen balance. There is a limited effect of phytoplankton and organic carbon export during the critical summer periods. Overall, the available flux measurements are too few in number to be used in the initial waste load allocation. A conservation analysis that neglects the wetland fluxes will probably be selected for 1995 allocations. South Carolina needs to develop a flux measurement program for better estimating the effects of wetlands on waste discharges for permitting in 2000.

12.4 3 O C

Lacouture, R.V., The Academy of Natural Sciences, Estuarine Research Center, St. Leonard, MD. **THE PRODUCTIVITY/BIOASS INDEX: A METHOD FOR QUANTIFYING PHYTOPLANKTON ENRICHMENT IN THE CHESAPEAKE BAY.**

A two-tiered index was developed in an effort to express the degree of phytoplankton enrichment at 14 sampling stations as part of the Chesapeake Bay Water Quality Monitoring Program. The qualitative tier of the index uses annual or seasonal mean surface layer chlorophyll a, phytoplankton carbon and primary productivity estimates in order to produce relative rankings for the stations. The quantitative tier of the index employs these same parameters with several

other data sets reflecting varying degrees of phytoplankton enrichment. The qualitative tier is designed for intra-estuary comparisons, while the quantitative aspect of the index can be utilized as a tool to compare phytoplankton enrichment between estuaries.

20 3 P-3 C S

Lambert, C.D., Bianchi, T.S., Department of EEO Biology, Tulane University, New Orleans, LA, and Santschi, P.H., Department of Marine Sciences, Texas A&M University, Galveston, TX, and Hatcher, P.G., Department of Geosciences, Penn State University, University Park, PA. **SOURCES AND TRANSPORT OF PARTICULATE AND DISSOLVED ORGANIC MATTER IN THE GULF OF MEXICO (TEXAS SHELF/SLOPE).**

Chemical biomarkers (plant pigments, lignin-phenols, and loliolides) were used to document sources and transport of particulate and dissolved organic matter (POM and DOM) on the Texas shelf/slope. Chlorophyll-*a* in the water column decreased significantly offshore (0.62 µg/l nearshore to 0.20 µg/l offshore), whereas percent organic carbon in the sediments increased offshore (2.19% nearshore to 7.20% offshore). As indicated by concentrations of fucoxanthin and zeaxanthin, diatoms and cyanobacteria represented the dominant classes of phytoplankton across the margin. Concentrations of lignin-phenols indicated that a significant fraction of land-derived POM found in Texas shelf waters was not deposited in shelf sediments - as evidenced by the low concentrations in sediments (Λ ranged from 0.02 to 0.38). Moreover, there was evidence of terrestrial sources in high-molecular weight DOM (HMW DOM) from slope waters. This was further supported by ¹³C-NMR spectra which indicated a strong aromatic signature in HMW DOM. The most likely pathway for transport of POM and HMW DOM to slope waters are advection of riverine and estuarine discharges. However, loliolides (stable pigment biomarkers) also indicated that net transport of organic matter from shelf to slope waters may occur via lateral transport in the nepheloid layer.

21.2 1 O C

Lantor, J., U.S. Fish and Wildlife Service, Olympia, WA., and Clark, R., National Oceanic and Atmospheric Administration, Seattle, WA, and McEntee, D., Simpson Tacoma Kraft Co., Tacoma WA. **FEASIBILITY OF RESTORING NATURAL COMPONENTS OF AN ESTUARINE SHORELINE IN AN INDUSTRIALIZED URBAN BAY.**

The Middle Waterway Restoration Project (Project) is an extension of a 1991 Natural Resource Damages Settlement. The Project, constructed in the summer of 1995, was a joint industry-government-public partnership. Formerly filled tide-

lands were excavated and recontoured to restore a natural shoreline with hummocks, tidal channels and other natural features, following an ecosystem approach to increasing habitats for injured species. One and one-half acres of industrial upland was converted to estuarine upper intertidal, including 1.2 acres of saltmarsh and 0.23 acres of mud/sandflat habitats. A riparian planting was established around the Project to buffer the restored habitats from surrounding industrial uses. The project will assess methods of saltmarsh establishment, including plant salvage, top dressing with native sediments, planting of nursery stock and no treatment; the potential migration of contaminants from adjacent mudflats; monitoring protocols and volunteer/stewardship models for future natural resources restoration in the Bay. The Project is being used as a pilot project to gain more information for planning future restoration in the Bay. Information will be incorporated into the adaptive Management Plan portion of the Programmatic Environmental Impact Statement, which forms the basis for the Commencement Bay Restoration Plan.

30.1 6 O C

Lapointe, B.E., Harbor Branch Oceanographic Institution, Big Pine Key, FL, and Tomasko, D., Southwest Florida Water Management District, Venice, FL. **EVIDENCE OF LONG-TERM, LARGE-SCALE EUTROPHICATION IN FLORIDA BAY AND THE FLORIDA REEF TRACT.**

Widespread macroalgal and phytoplankton blooms developed in Florida Bay in the late 1970s and early 1980s prior to the massive die-off of turtle grass that began in 1987. While these observations were symptomatic of eutrophication, some scientists and resource managers speculated that these phenomena resulted from: 1) increased salinity due to historical reductions in freshwater flow through the Everglades, and 2) reduced nutrient inputs to the bay from reduced freshwater flow. While little evidence was available to support these speculations over bay-wide scales, considerable evidence existed indicating nutrient enrichment of the bay with phosphorus from southerly flowing nearshore currents along southwest Florida and nitrogen-rich runoff from the Everglades. In an attempt to restore Florida Bay, water managers began increasing freshwater flows to the bay via Shark River Slough in 1991. Consequently, nitrogen loads to Florida Bay are currently two- to three-fold greater than those of the 1980's. Because of significant nitrogen limitation in western Florida Bay, large-scale hypereutrophication and severe water column light attenuation has resulted. Net cumulative flow of water from Florida Bay towards the Florida Reef Tract transports nutrient and chlorophyll loads offshore, increasing stress to sensitive coral reef communities.

23 20 P-3 C

Lara-Domínguez, A.L. Rivera Arriaga, E. Sánchez-Gil, P., Yáñez-Arancibia, A., Program of Ecology, Fisheries and Oceanography of the Gulf of Mexico (EPOMEX), University of Campeche, Campeche México. **A TROPHIC MODEL FOR TERMINOS LAGOON, CAMPECHE MEXICO A TROPICAL ECOSYSTEM.**

Terminos Lagoon is a shallow ecosystem with a high habitat diversity from coastal lowlands to near-shore Gulf of Mexico. In order to determine the trophic structure of this ecosystem, an ECOPATH II Model was constructed. The different components were grouped: primary producers (phytoplankton and benthic producers) and consumers (zooplankton, microzoobenthos, benthic mollusks and other macroinvertebrates, underlining shrimps and blue crabs that constitute a resource of commercial importance). The nekton component includes the more representative families: Gerreidae, Haemulidae, Sciaenidae, Ariidae and Tetraodontidae, and others fishes. The detritus is the high important component of the ecosystem in the one which converge the material flows originating from all the components. In average, the external subsystems provide 46% of the total flow of detritus and the rest is generated by the different components of the primary producers and in minor measured by the material of animal origin. The flow of exportation of detritus equals to about 78% of the total of the subsystems of the lagoon. The results permit to understand the coupling among the components and eventually to formulate hypothesis on the possible disturbances effects, and quantitative survey of the forms of response of the ecosystem and/or their components.

7.2 3 O C

LaSalle, M.W., Mississippi State University, Coastal Research and Extension Center, Biloxi, MS, and Rozas, L.P., NOAA/National Marine Fisheries Service, Galveston, TX. **A COMPARISON OF BENTHIC MACROFAUNAL ASSEMBLAGES FROM INTERTIDAL AND SHALLOW SUBTIDAL HABITATS IN A SUBMERGING LOUISIANA DELTAIC SALT MARSH.**

We compared infaunal assemblages from three vegetated, marsh-surface habitats and the adjacent unvegetated, shallow subtidal area in 12 of 15 months between April 1992 and June 1993. Habitats occurred along an elevational gradient (*Distichlis spicata* = high marsh; intact *Spartina alterniflora* = intermediate marsh, hummocky *Spartina alterniflora* = low marsh, and subtidal constantly-flooded tidal creek bottom) and therefore, were subjected to significantly different hydrological regimes. The infaunal assemblages of these habitats varied in numbers of taxa and numerically dominate taxa as follows: *Distichlis* = 11 taxa dominated by oligochaetes (2-3 species), intact *Spartina* = 15 taxa dominated by oligochaetes (3-4 species); hummocky *Spartina* 16 taxa dominated by the tanaid *Hargeria rapax* and the polychaete *Laeonereis culvert*, and subtidal = 22 taxa dominated seasonally by three species of amphipods. Overall, the greatest diversity and numerical densities were found in the more frequently flooded subtidal and low marsh areas. Infaunal densities peaked in late winter - early spring, whereas lowest densities occurred in summer. Depressed densities in summer were seen across all elevation zones and may be due to predation by nekton predators, even in the less flooded high marsh zone where marshresident killifishes are known to frequent when flooded.

Latimer, J.S., Davis, W.R., Keith, D.J., USEPA, NHEERL-Atlantic Ecology Division, Narragansett, RI. CHEMICAL DYNAMICS OF HYDROPHOBIC ORGANIC CONTAMINANTS DURING RESUSPENSION

Laboratory experiments were designed to study the chemical-particle dynamics of toxic hydrophobic organics during resuspension episodes using a particle entrainment simulator (PES). The purpose was to obtain insight into chemical transport mechanisms during resuspension. Information on these mechanisms would be useful in assessing effects of dredging, dredge spoil disposal, or ordinary sediment mobilization in urban estuaries. Sediments from Black Rock Harbor, CT and two sites in Narragansett Bay, RI, representing a range of contaminant and bulk sediment properties, were subjected to experiments using the PES. Results indicate that on a volume normalized basis contaminant concentrations in the water column became elevated as applied shear increased from 2 to 5 dynes cm^{-2} ; however, on a mass and organic carbon normalized basis, the loadings decreased with increasing applied shear. The differences observed were traced to textural and chemical properties in the bulk sediments. It was concluded that the distribution of the contaminants was likely related to the amount of, and contaminant load on, material entrained during resuspension events. These observations are the result of: (1) dilution of contaminants from depleted coarse grained material, (2) fortification from more highly loaded coarse grained materials (in the case of PAHs with $\log K_{ow} > 6$) and (3) the effects from fine grained, highly enriched material.

24.1 2 O C

Lee, K.-S., Dunton, K.H., The University of Texas at Austin Marine Science Institute, Port Aransas, TX. EFFECTS OF IN SITU LIGHT REDUCTION ON MAINTENANCE, GROWTH AND THE CARBON BUDGET OF THALASSIA TESTUDINUM IN CORPUS CHRISTI BAY, TEXAS.

The effects of *in situ* light reduction on *Thalassia testudinum* were examined from April 1993 to August 1994. The annual quantum flux at the seagrass canopy was 5207 $\text{mol m}^{-2} \text{yr}^{-1}$ or 46% of surface irradiance (SI). Two light manipulation treatments reduced underwater irradiance to 1628 $\text{mol m}^{-2} \text{yr}^{-1}$ (14% SI) and 864 $\text{mol m}^{-2} \text{yr}^{-1}$ (5% SI). Shoot densities in control cages (46% SI) ranged from 457 to 785 m^{-2} . All plants exposed to 5% SI died after 200 days of shade treatment and >99% of plants receiving 14% SI died by the end of the experiment (490 days). High growth rates occurred during summer (5.0 $\text{mg dry wt shoot}^{-1} \text{d}^{-1}$) and low growth rates occurred during early spring (1.5 $\text{mg dry wt shoot}^{-1} \text{d}^{-1}$). A similar pattern was evident in the treatment cages. Plant biomass in the 14% SI cages decreased by 80% after 345 days of shading and 98% after 457 days, relative to controls. Carbohydrate carbon content was highest in rhizomes (c.a. 125 mgC g dry wt^{-1}) and was lowest in leaves and roots (c.a. 60 mgC g dry wt^{-1}). In both treatments rhizome carbon content was 50% lower and leaf carbon con-

tent was c.a. 15% lower than controls. Blade chlorophyll (chl) content increased, while the chl *a* : *b* ratio and blade width decreased as a result of reduced light.

6.2 1 O C S

Lee, K.-S., Dunton, K.H., The University of Texas at Austin Marine Science Institute, PO Box 1267, Port Aransas, TX 78383. SEASONAL CHANGES IN BIOMASS, LEAF PRODUCTIVITY AND CARBOHYDRATE CARBON CONTENT OF THALASSIA TESTUDINUM IN CORPUS CHRISTI BAY, TEXAS.

The seasonal production dynamics of *Thalassia testudinum* in Corpus Christi Bay were evaluated through measurements of biomass, leaf growth and carbohydrate carbon content from December 1993 to March 1995. Daily photon flux densities (PFD) showed strong seasonal variations, ranging from 9.6 $\text{mol m}^{-2} \text{d}^{-1}$ in April to 21.7 $\text{mol m}^{-2} \text{d}^{-1}$ in July. Shoot density and biomass changed significantly with season; values ranged from 321 shoots m^{-2} (454 g dry wt m^{-2}) in March to 531 shoots m^{-2} (885 g dry wt m^{-2}) in September. Biomass of individual plant parts were significantly different over the sampling period; rhizome tissues tended to have the highest biomass while root tissue had the lowest. However, leaf biomass was higher than that of rhizome tissues during summer. Leaf productivities showed significant seasonal variation that were strongly correlated with temperature, ranging from 0.07 $\text{g dry wt m}^{-2} \text{d}^{-1}$ in December to 5.6 $\text{g dry wt m}^{-2} \text{d}^{-1}$ in July. Chlorophyll (chl) concentrations were significantly higher and chl *a*:*b* ratios lowest during the spring/summer period of maximum photosynthetic production and growth than during winter. Soluble carbohydrate carbon content was highest in rhizome tissues (111-203 mg C g^{-1} dry wt) and lowest in leaf tissues (46-70 mg C g^{-1} dry wt), which is consistent with the rhizome's role as a carbon storage tissue. Rhizome carbohydrate carbon content increased rapidly during June and July, which coincided with high water temperatures, underwater irradiance and blade chlorophyll concentrations. During winter and early spring, rhizome carbohydrate carbon content dropped nearly 50%, suggesting that these reserves were mobilized for maintenance and growth. Estimated annual biomass production of *Thalassia testudinum* in Corpus Christi Bay over the period of this study was 1320 $\text{g dry wt m}^{-2} \text{yr}^{-1}$, equivalent to 422 $\text{g C m}^{-2} \text{yr}^{-1}$. Overall, annual productivity appears to be primarily regulated by temperature and secondarily by irradiance, as reflected in the timing and magnitude of the strong seasonal variations in leaf productivity, total chlorophyll content, chl *a*:*b* ratios and rhizome carbohydrate carbon content in *Thalassia testudinum*.

9 3 P-2 C

Lee, W., Pulich, W., German, D., Green, A., Texas Parks and Wildlife Department, Austin, TX. SPATIAL RELATIONSHIPS BETWEEN OPTIMUM SALINITY ZONES AND RELATIVE ABUNDANCE OF SELECTED SHELLFISH IN THE GUADALUPE ESTUARY, TEXAS.

Estuarine organisms vary in their abundance both tempo-

rally and spatially. For example, white shrimp (*Penaeus setiferus*), occurs as a summer-fall species and is mostly abundant in regions with salinity of 5 to 19 ppt in the Guadalupe Estuary of Texas. It can be assumed that such salinity zones of seasonal peak abundance reflect zones of species' salinity preference (ZSP), and that survival and growth of the species are maximized in this special region. Therefore, changes in salinity distribution due to variations in freshwater inflow during those months of seasonal peaks should control the ZSP dimensions, and consequently, affect species abundance for that year. Using GIS techniques to analyze the TPWD trawl data, we studied the seasonal spatial distributions of white shrimp, brown shrimp (*P. aztecus*) and blue crab (*Callinectes sapidus*) in relation to salinity zones in the Guadalupe Estuary, and demonstrated dynamic relationships between species abundance and area of the ZSP. A non-linear relationship was observed for all three species, indicating that an increase in ZSP dimensions does not necessarily favor higher abundance for that species. Both white shrimp and blue crab preferred lower salinities (0 to 19 ppt) and were most favored when ZSP's were 20 % or > 80 % of bay area. Brown shrimp preferred higher salinities (5 to 29 ppt) and were most favored when ZSP's were 60 % or > 95 % of bay area. These bay area vs. abundance responses suggest other interactions at work among these species, including geographical location, predation and competition for food or space, in addition to the physiological effect of salinity by itself.

20.4 3 O C S

Lehrter, J.C., Pennock, J.R., University of Alabama/Marine Environmental Sciences Consortium (MESC), Dauphin Island, AL, and **McManus, G.B.,** MESC/University of South Alabama. **MICROZOOPLANKTON GRAZING AND NITROGEN EXCRETION ACROSS AN ESTUARINE/COASTAL INTERFACE.**

Microzooplankton (< 200 μm) grazing rates on phytoplankton were measured monthly from May 1994 to August 1995 in Mobile Bay, Alabama. Grazing experiments were performed with surface water samples collected from mid-bay, the bay-mouth, and a near-coastal station. Phytoplankton growth rates (d^{-1}) and mortality rates (d^{-1}) due to grazing followed a trend of near-coastal > bay-mouth > mid-bay. However, the percent of phytoplankton primary production consumed by the microzooplankton followed a trend of mid-bay > bay-mouth > near-coastal, with monthly rates ranging from 0 to 171%, 0 to 128%, and 0 to 102% at the three stations, respectively. The impact of microzooplankton grazing on phytoplankton primary production was higher at the mid-bay and bay mouth stations as a result of low phytoplankton growth rates coupled with relatively high grazing rates. Overall, microzooplankton nitrogen regeneration supplied 0 to 24% of the nitrogen required by the phytoplankton and displayed little spatial variability. Grazing by microzooplankton in Mobile Bay represents a significant loss term for phytoplankton and may act as a mechanism for the removal of nutrients from the bay by converting particulates to dissolved phases that can be advected out of the system.

15.2 2 O C S

Leitman, P., Comstock, D., University of Charleston, Charleston, SC, **Ross, P.,** The Citadel, Charleston, SC. **MONITORING HIGHWAY RUNOFF IN COASTAL SALT MARSH ECOSYSTEMS: A MULTI-TROPHIC LEVEL APPROACH.**

The Isle of Palms (SC) Connector, opened in 1993, crosses 3 km of valuable marsh and creek habitat. Previous studies indicated that highway runoff could contain contaminants harmful to this ecosystem. The causeway and span structure was designed with a unique system of collector drains, evaporation pans and spoil areas to reduce contaminant loading to the marsh. The current study monitors the effectiveness of this system with quarterly sampling of pans, spoil areas, and marsh sediments. Samples are subjected to toxicity bioassays from three trophic levels: bacteria, vascular plants, and bivalve mollusks. Samples from a pristine saltmarsh area (negative control) and a known contaminated area (positive control) were also tested. First year monitoring data indicated that sediments from the bridge site are slightly impacted relative to the negative control, but not as impacted as the positive control. Observed impacts suggest that stimulation from nutrient loading, or hormesis from trace levels of toxicants, may be occurring. Such reactions may be early warnings of inhibitory responses which will occur at higher loadings. Present bridge traffic is approximately 7,000 vehicles per day, which is below levels at which highway runoff impacts are reported in the literature. Monitoring of effects should continue as traffic increases.

28.1 4 O C

Leonard, L.A., Department of Earth Sciences, University of North Carolina at Wilmington Wilmington, NC. **SEDIMENT TRANSPORT AND DEPOSITION IN A NORTH CAROLINA MICRO-ESTUARINE MARSH.**

Sediment deposition in tidal marshes has been shown to be affected by variations in flooding frequency, inundation period, sediment supply, biologic productivity and storm activity. Measurements of total suspended solid (TSS) concentration and surficial sediment deposition collected in a micro-estuarine marsh near Wilmington, NC were combined with dye tracer experiments in order to determine pathways of sediment transport and patterns of sediment deposition on the marsh surface. TSS concentrations indicate that maximum sediment transport onto the marsh surface occurs in the lower 10 cm of the marsh water column during the initial stages of flooding when tidal creek velocities are at a maximum and when overmarsh flow pathways are creek normal. Once the entire marsh surface is inundated, sheet flow conditions prevail and the direction of flow becomes generally landward. TSS concentrations on the marsh surface decrease as high tide is approached due to decreased sediment supply from the adjacent creek and deposition on the marsh surface. Deposition on sediment traps ranges from 2 to 15 and 10 to 80 $\text{g}/\text{m}^2/\text{day}$ during the winter and summer, respectively. Preliminary analyses of sediment trap data indicate that deposition increases exponentially with increases in

water level and vegetation density. In addition, sediment deposition appears to increase linearly with plant canopy height. Sediment deposition is also strongly affected by storm activity. Maximum deposition rates occurred during the offshore passage of Hurricane Gordon in November 1994 when larger than normal waves, increased water levels and high competency spring tidal currents resulted in TSS levels one order of magnitude greater and deposition rates approximately 5 times those measured during non-storm conditions. For this marsh system, sediment deposition is most strongly influenced by marsh topography, flow pathways, canopy characteristics and storm activity.

15.2 5 O C S

Lerberg, S.B., Zimmerman, L.E., Holland, A.F. University of Charleston and South Carolina Marine Resources Research Institute, Charleston, SC. EFFECTS OF WATERSHED DEVELOPMENT ON MACROBENTHOS OF TIDAL CREEK ECOSYSTEMS

The major goal of this study was to define relationships between land cover, sediment contaminant concentrations, sediment toxicity, water quality, and the kinds and abundances of benthic organisms, which are a primary food for shrimp, crabs, and fish using tidal creeks as nurseries. Twenty four tidal creeks with watersheds ranging in size from 13 to 436 hectares were sampled. Twelve of the watersheds had developed drainage basins (>75% urbanized), and twelve had undeveloped drainage basins (>75% forests and wetlands). Quantitative replicated samples (50-cm² cores) of macrobenthos were taken longitudinally in each creek. In addition, benthic recruitment was evaluated by deploying azoic sand, and the effects of predation of benthic communities was evaluated using predator exclusion techniques. Benthic communities in all creeks were numerically dominated by stress tolerant species (e.g., oligochaetes). Benthic community parameters were not strongly related to the type and degree of development in the drainage basins; however, slight decreases in the abundances of benthic organisms were observed in the headwaters of highly urbanized creeks. Large differences in benthic community parameters were observed longitudinally within creeks. Predation and natural environmental conditions appeared to be the major factors controlling summer benthic distributions in these ecosystems.

24.2 3 O C

Leverone, J.R., Dixon, L.K., Mote Marine Laboratory, Sarasota, FL, and Dawes, C.J., University of South Florida, Department of Biology, Tampa, FL. GROWTH CHARACTERISTICS OF FOUR THALASSIA TESTUDINUM GRASSBEDS IN TAMPA BAY, FL: RESPONSES TO ANNUAL LIGHT CLIMATE.

Responses of *Thalassia testudinum* to seasonal and depth-related differences in light environment were investigated in lower Tampa Bay, FL from December, 1993 through October, 1994. Continuous *in situ* irradiance was compared to *Thalassia* biomass, growth and productivity at deep (light-limited) and shallow (non light-limited) meadows at four

locations. Seasonal patterns were evident for all biological parameters. Low water temperature appeared responsible for low winter growth rates, since daily light levels were similar to late summer. During spring, higher daily PAR resulted in higher leaf relative growth rates. Decreasing summer water clarity coincided with increased photosynthetic efficiency. Above ground biomass, shoot density and leaf area index decreased with depth at all stations. Rhizome soluble carbohydrate levels were higher at deep stations. Shallow stations typically received 2-3 hours more saturating irradiance per day than deep stations. Duration of compensation irradiance, averaging 9 hours during winter and 12 hours during summer, was only slightly higher at shallow compared to deep stations. At one deep station, average daily PAR (4-9 E m⁻² day⁻¹; adjusted for epiphytic attenuation) was lower than other deep sites. This station showed decreased shoot density, increased blade length, reduced below ground biomass and reduced blade production rates, suggesting a low light stress response.

34.2 4 O C

Lewitus, A.J., Baruch Marine Field Laboratory, University of South Carolina, Georgetown, SC, Glasgow Jr., H.B., Burkholder, J.M., North Carolina State University, Raleigh, NC. RETENTION OF CRYPTOPHYTE CHLOROPLASTS BY THE TOXIC DINOFLAGELLATE, *PFIESTERIA PISCICIDA*

Pfiesteria piscicida is a toxic ambush predator dinoflagellate with a complex life cycle that includes several heterotrophic stages. A common mode of prey ingestion by the zoospore stages is to take up prey contents through a peduncle (i.e., myzocytosis). In some other dinoflagellates, myzocytotic activity can lead to mixotrophic nutrition via retention of prey chloroplasts (i.e., cleptochloroplastidy). Using epifluorescence and electron microscopy, we examined the mechanism of myzocytosis and potential for cleptochloroplastidy in *Pfiesteria* zoospores grown with cryptophyte prey. With several prey species, the integrity of ingested chloroplasts was well-preserved relative to some other prey organelles. With those prey, the proportion of *Pfiesteria* cells containing chloroplasts but not cryptophyte nuclei increased over time, reaching 96% in *Rhodomonas* sp. The data indicate that ingested chloroplasts were selectively retained by *Pfiesteria*. Furthermore, starch production and photosynthetic measurements indicated that these sequestered chloroplasts were active. Although phagotrophy is the preferred nutritional mode of *Pfiesteria*, cleptochloroplastidy may be an important means of surviving periods when particulate food is scarce.

5.2 2 O C

Lewitus, A.J., Baruch Marine Field Laboratory, University of South Carolina, Georgetown, SC, Koepfler, E.T., Lyons, G.M., Coastal Carolina University, Marine Science Department, Conway, SC. SEASONAL CHANGES IN THE TROPHODYNAMICS OF PLANKTON IN A TIDAL CREEK OF NORTH INLET, SOUTH CAROLINA: II.

CONTROLS UPON PHYTOPLANKTON COMMUNITIES.

In North Inlet, the summer chlorophyll maximum is accompanied by an increase in ammonium concentration. Because ammonium is the major inorganic nitrogen source available to North Inlet phytoplankton, and phosphorus should not be limiting (N:P ratios are generally below 7), the concomitant increase in chlorophyll and ammonium suggests that phytoplankton densities during the summer bloom are limited by grazing (top-down control) rather than inorganic nutrient supply (bottom-up control). The seasonality in regulation of phytoplankton growth was examined in water collected from North Inlet and incubated under several treatments designed to differentiate between grazing and nutrient effects. In summer, ammonium addition did not affect phytoplankton biomass (cell numbers, chlorophyll) while a dilution treatment (i.e. reduction of grazing pressure) stimulated phytoplankton growth. In contrast, phytoplankton growth in winter was stimulated by ammonium addition, but not by the dilution treatment. The results support the hypothesis that, at North Inlet, phytoplankton are controlled by top-down processes during summer and bottom-up (ammonium supply) processes during the winter, when inorganic nitrogen is in relatively low supply. However, glycine addition stimulated phytoplankton growth in the summer (a form of bottom-up control), suggesting that phytoplankton may be carbon- and/or energy-limited during the bloom.

3 11 P-1 I

Li, Y., Reed Development Company, Dafeng County, Jiangsu Province, China, and Zhenhuan, T., Kangtai Health Company, Taixing City, Jiangsu Province, China. **THE ECOLOGICAL BEVERAGE FROM A SALT MARSH PLANT.**

This poster describes the ecological beverage from a new food additive, Biomineral Liquid (BML). BML was invented by professor Qin and his colleagues in Nanjing University and extracted from *Spartina alterniflora*. BML is a natural plant extraction without any chemical in its production, and is a dark brown liquid in normal temperature and pressure. BML contains rich bioactive materials, e. g. vitamins, polyphenols and flavonoids (the normal content of flavonoids in BML is 3.0-7.0 mg/g) and rich minerals, especially 14 essential trace elements (the normal electric conductivity of 1/400 dilution of BML is 1.0- 1.5 mS/cm, 25-28°C). According to the toxicology test, BML is nontoxic and is not the effect on deformation and mutation, the Ministry of Health, China permitted to use BML in drink production and the Ministry of Agriculture approved to use BML as an ecological food (or green food) additive. We have already developed a series of biomineral products and got better benefit. The new gross production of BML was over 80 million yuan and the new gross profit was over 20 million yuan. A number of experiments on animals and people proved the biomineral products functioning as cardiogenic, enhancing immunity and resistance, prolonging life, etc.

2 2 P-1 C

Libby, P.S., Battelle Ocean Sciences, Duxbury MA. **BENTHIC FLUX IN THE GREATER NEW YORK BIGHT REGION: AN ASSESSMENT OF THE SPATIAL AND TEMPORAL VARIABILITY OF OXYGEN AND NUTRIENT FLUX.**

The study was designed to collect data that describe the flux of dissolved oxygen and nutrients between the sediments and their overlying waters at 20 stations in the greater New York Bight including Long Island Sound and the Hudson and East Rivers. Concurrent data were collected for sediment characterization, water column chemistry, and productivity measurements. Benthic metabolism and community structure, nutrient flux, and sediment (porewater and solid phase) conditions are responsive to nutrient and organic matter loading. Infaunal communities in shallow marine ecosystems often play a significant role in nutrient cycling and oxygen dynamics, and the data obtained from this study help define this important aspect of the present benthic-pelagic coupling. These data will be invaluable to water quality modeling efforts as a verification/calibration data set, and will serve to describe some of the baseline spatial and temporal variability in fluxes and porewater conditions in soft-bottom areas of concern. This study provides baseline data with which to better assess the impact of potential changes in wastewater treatment practices, such as planned in the Newtown Creek Treatment Facilities Upgrade, on the benthic ecosystems of the greater New York Bight region.

5.1 3 O C

Limburg, K.E., Pace, M.L., Fischer, D., Arend, K. Institute of Ecosystem Studies, Millbrook, NY. **DO LARVAL FISH CARE ABOUT ZOOPLANKTON BLOOMS?**

Each spring in the Hudson River, NY, the cladoceran *Bosmina longirostris* population erupts in a spatiotemporally well-defined bloom. We investigated the importance of this bloom to the feeding, energy contribution, and growth of larval white perch (*Morone americana*) and striped bass (*M. saxatilis*). Gut content studies were combined with otolith microanalysis on larvae (SL range: 3.3 - 10.2 mm) collected prior to, during, and after the bloom. Food selection (measured by Chesson's index) was high for copepods prior to and after the bloom, and conversely were high for *Bosmina* during the bloom. Nevertheless, copepods contributed more energy in the gut contents than did *Bosmina*, even during the bloom. Growth rates (SL/estimated age) were highest ($p < 0.001$) outside the geographic range of the bloom, and second highest at the site where the bloom was most intense. Growth rates tended to increase over time and were correlated with water temperature. Also, growth rates were higher in white perch than in striped bass larvae, with site-specific variation evident. Evidence from this study suggests that the *Bosmina* bloom does not provide larvae a marked increase in energy yield and subsequent growth, but the contribution of the bloom to larval survival remains unassessed.

32.1 1 O C

Lin, J., Dept. Biol. Sci., Florida Institute of Technology,

Melbourne, FL, and Beal, J.L., Florida Dept. Environmental Protection, Melbourne, FL. **EFFECTS OF RED MANGROVE TRIMMING ON THE BENTHIC FAUNAL COMMUNITY.**

The mangrove ecosystems is an important component of central and southern Florida's coastal landscape. Rapid human population growth and development have a large impact on the mangrove habitats. In recent years, cutting or trimming of mangrove tree tops to provide access to or a view of water has become a common practice. We have an on-going project to examine the potential impacts of red mangrove trimming on the epi- and in-faunal communities under the canopy. Eight 5 x 10 m plots were selected, mangrove trees at four of the plots were trimmed and the other four plots served as controls. Macro-epifauna and -infauna were sampled at the day of trimming and one month after the trimming, and will be sampled again four months and ten months after the trimming. To estimate macro-epifaunal density, ten throw traps (0.5 x 0.5 m) were haphazardly placed at each plot during each sampling and the number of crab burrows and snails found were counted. Duplicate macro-infauna (>0.5 mm) samples were collected from each plot during each sampling using a corer (0.45 cm² surface area and 8 cm deep). Very few snails were found. There is no apparent short-term (one month) effect of the trimming on the density of crab burrows or density and composition of infauna. The infauna community is overwhelmingly dominated by polychaetes, especially Capitellid, Spionid, Phyllocid, and Orbiniid species.

29.2 6 O C

Linker, L.C., U.S. EPA Chesapeake Bay Program, Annapolis, MD and Benelmouffok, D., SAIC, Annapolis, MD. **CHESAPEAKE BAY NITROGEN REDUCTIONS DUE TO THE CLEAN AIR ACT.**

Linked models of the Chesapeake Bay airshed (Regional Acid Deposition Model), watershed, and estuary were used to determine atmospheric deposition of nitrogen to the watershed and delivery to the Bay. Atmospheric nitrogen loads were examined under existing conditions and future conditions of nitrogen reductions from the Clean Air Act implementation. Atmospheric inorganic nitrogen is loaded to watershed surfaces at a rate of between 7.8 and 13.4 kg/ha-yr, with the highest loading in the Northwest and the lowest loading in the Southeast portions of the basin. Clean Air Act reductions of atmospherically deposited nitrogen are between 5% and 17%, with the greatest reductions in the Northwest portion of the basin. Reductions of atmospherically deposited nitrogen to achieve ozone standards in the metropolitan regions of the basin result in increased atmospheric load reductions from 9% up to 29%, with the greatest reductions associated with mid-watershed urban regions and stationary sources in the Ohio River basin. Export of the atmospherically deposited inorganic nitrogen from land surfaces to the edge of stream, and the transport of the atmospheric deposition loads to the Bay varies with land use and river characteristics. Overall, atmospheric sources deliver 45.2 x 10⁶ kg

or 26.5% of the total nitrogen loads to the Chesapeake Bay. The costs of controlling nitrogen from atmospheric sources compare favorably with controls of traditional point and nonpoint sources.

15.3 8 O C

Little, L.S., Hughes Aircraft Corporation, Los Angeles, CA, and Edwards, D., Porter, D.E., Belle, W., Baruch Institute for Marine Biology and Coastal Research and Department of Statistics, University of South Carolina, Columbia, SC. **KRIGING IN ESTUARIES: AS THE CROW FLIES OR AS THE FISH SWIMS?**

Geostatistical methods are becoming a vital tool for understanding the spatial distributions and relationships of biological and chemical species in estuaries. These methods can construct statistically optimal predictions for data at unobserved locations using a relatively small, but spatially explicit, sample. The prediction at any given location is a weighted average of the sample values with weights assigned based on distances to sampling sites. The key question addressed in this research is *how should these distances be computed in an estuary?*. Historically, distances have been computed "as the crow flies", i.e. Euclidean distances. For measurements made in estuarine streams, however, intuition suggests that distances between sites should be measured "as the fish swims", i.e. the length of the shortest in-water route between two sites. We have studied the efficiency, as measured by cross-validation, of kriging using both Euclidean and inwater distance methods, both with and without trend, for seven key measure of estuarine health in the Murrells Inlet, SC estuary. The results of this NOAA-funded Urbanization and Southeastern Estuarine Systems substudy find no consistent and certainly no decisive advantage of using inwater distances.

16.1 2 O C S

Litvin, S., Wainright, S., 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.**

In a NOAA/COP-funded study, we are investigating trophic linkages between juvenile winter flounder (*Pleuronectes americanus*) and their habitat, using stable isotopes of C and N. To determine whether foraging in a particular habitat induces changes in the isotopic compositions of fish, juvenile fish were confined within cages for 10 days in five different estuarine habitats (*Zostera* and adjacent unvegetated, macroalgae and adjacent unvegetated, and marsh creeks) within three estuaries:Hammonasset Creek, CT (adjacent to Long Island Sound); the Navesink River nearSandy Hook, NJ; and Great Bay in southeastern NJ. Great Bay is a relativelypristine estuary compared with the other two estuaries. Differences in isotopic compositions of fish before- vs after-caging indicated that 10 days was sufficient

time to induce habitat-specific isotopic labeling of fish. Fish confined to all habitats were approximately 2 trophic levels removed from sedimentary organic matter, according to C and N isotopic results, and did not appear to feed directly on either macrophytes or macrophyte consumers. Nitrogen isotope values of fish, vegetation, and sediments were lower at Great Bay than at the other two sites, suggesting that it may be less impacted by anthropogenic N.

20.2 4 O C

Lohrenz, S., Redalje, D., University of Southern Mississippi, Center for Marine Sciences, Stennis Space Center, MS, and **Fahnenstiel, G., Lang, G.,** NOAA/Great Lakes Environmental Research Laboratory, Muskegan, MI. **PRODUCTIVITY AND NUTRIENT PROCESSES IN THE MISSISSIPPI RIVER PLUME.**

Enhanced primary production in the vicinity of the Mississippi River outflow plume was largely attributable to the high nutrient content of river water, but coupling between riverine nutrient loadings and areal primary production was seasonally variable. Distributions of primary production were characterized during July–August 1990, March and September 1991, and April–May 1992 using a photosynthesis-irradiance model. Maximum values of biomass and primary production were observed at intermediate salinities and coincided with non-conservative decreases in nutrients. An examination of dissolved inorganic N:P, Si:N and Si:P ratios revealed a transition from potential limitation by phosphorus at low salinities to the potential for nitrogen limitation at higher salinities for all cruises except September 1991. The potential for silicon limitation was indicated, primarily at intermediate and high salinities, for all cruises except July–August 1990. Comparisons of nitrogen requirements to support water column-integrated primary production with riverine inputs of dissolved inorganic nitrogen provided evidence that nutrient inputs were rapidly depleted by biological activity. An exception was during March 1991 when riverine inputs of dissolved inorganic nitrogen exceeded nitrogen requirements for areal primary production near the outflow region; possible fates of unutilized riverine nutrients included advection offshore or into adjacent shelf regions.

25.1 6 O C S

Lores, E.M., U. S. Environmental Protection Agency, Environmental Research Lab, I Sabine Island Dr., Gulf Breeze, FL, and **Pennock, J., McManus, G.,** MESC/ Dauphin Island Sea Lab, Dauphin Island, AL. **THE EFFECT OF HUMIC ACID ON UPTAKE AND TRANSFER OF COPPER FROM MICROBES TO CILIATES TO COPEPODS.**

This research is part of an ongoing project designed to determine the effect of humic acid on the uptake and transfer of metals by marine organisms at the lower end of the food chain. Binding affinities for Cu, Cd, Zn, and Cr were determined to Suwannee River humic acid were determined at various salinities. Copper was the only metal with more than 50% bound to the humic acid at 15‰. Subsequent experiments were then initiated to determine the effect of hu-

mic acid on uptake and transfer of copper through a microbial > ciliate > copepod food chain. Mixed cultures of microbes were allowed to grow to stationary phase in cultures with and without humic acid and copper. Ciliates (*Pleuronema* sp. in one experiment and *Euronema* sp. in another) were introduced to feed on the microbes. The resulting ciliates were then fed to copepods (*Acartia tonsa*). Early results suggest that the presence of humic acid significantly reduced the uptake of copper by copepods but had no effect on copper uptake by ciliates. Survival and reproduction of copepods exposed to copper were enhanced in the presence of humic acid. Ongoing experiments are being conducted to more closely examine the effects on uptake of copper in ciliates.

17.2 2 O C

Lowery, T.A., Monaco, M.E., Bulger, A.J., NOAA Strategic Environmental Assessment Division and the University of Virginia, Dept. of Environmental Sciences, VA. **CHARACTERIZING AND QUANTIFYING ESTUARINE-CATADROMY: A LIFE HISTORY STRATEGY COUPLING MARINE AND ESTUARINE ENVIRONMENTS.**

The estuarine-catadromy life history strategy is defined as species that spend most of their adult stage in the marine environment and spawn there, and in their early life history stages migrate to, and reside in, estuarine environments. Because these species migrate primarily through ocean inlets via passive migration mechanisms, they may be sensitive to the physical characteristics of inlets. Inlet physical and hydrological features affecting the recruitment of estuarine-catadromous larvae include tidal prism, mouth width, inlet current speeds, flushing and tidal plume characteristics. The objectives of our study were: 1) define and characterize the estuarine-catadromy strategy, 2) organize data and information on this life history strategy into a single document, and 3) conduct a series of analyses to determine the importance of ocean inlets to estuarine-catadromous species along the east coast. Larval relative abundance data from NOAA's Estuarine Living Marine Resources (ELMR) program and nine physical/hydrodynamic variables were regressed using stepwise logistic regression. The analysis revealed that the physical variables could be used to model estuarine-catadromous larval abundance. Based on the statistical analysis and synthesis of life history data, tidal currents were identified importance to the transport of estuarine-catadromous larvae into inlets. An index was developed based on an inlets' flood current volume and ELMR larval relative abundance rankings to estimate theoretical inlet utilization of 52 individual inlets by specific species. This relative screening index aids coastal managers in assessing potential impacts from physical modifications of ocean inlets on estuarine-catadromous species.

8.2 6 O C S

Lucas, L.V., Stanford University, Stanford, CA, and **Thompson, J.,** U.S. Geological Survey and Stanford University,

Stanford, CA, and Koseff, J., Monismith, S., Stanford University, Stanford, CA. **NUMERICAL MODELING OF COUPLED HYDRODYNAMICS AND PHYTOPLANKTON DYNAMICS IN SHALLOW ESTUARIES.**

The relationship between hydrodynamics and phytoplankton dynamics in shallow estuaries is highly complex, due to the interaction between factors such as density stratification, tidal mixing, bathymetric variations, turbidity, and grazing by benthic and pelagic organisms. With the goal of identifying the physical and biological conditions necessary for the inception and termination of a phytoplankton bloom in a typical shallow estuary, 1D and Pseudo-2D numerical models have been developed and refined. These models of coupled hydrodynamics and phytoplankton dynamics have helped in the formulation of general "rules" regarding the relative importance of the following factors: persistence of stratification (which, in turn, may be controlled by longitudinal density gradient, tidal energy, and water column depth), depth of the pycnocline, channel-shoal exchange, benthic grazing strength in the channel and shoal, light attenuation in the channel and shoal, and other factors. By comparing model results to South San Francisco Bay field observations (see Thompson et al. presentation), we are able to better understand the initiation, longevity, termination, and inhibition of blooms in this estuary and in shallow estuaries in general.

37 46 P-2 C

Luckenbach, M.W., Orth, R.J., Virginia Institute of Marine Science, College of William and Mary, Wachapreague, VA and **Muhammad, J.**, Department of Natural Sciences, University of Maryland Eastern Shore, Princess Anne, MD. **BIOTIC AND HYDRODYNAMIC FACTORS AFFECTING THE TRANSPORT AND BURIAL OF ZOSTERA MARINA SEEDS.**

Eelgrass, *Z. marina*, rely upon seed dispersal for colonization of new habitats. The seed are not readily transported in suspension; however, they have low erosion thresholds and are subject to transport as bedload at $u^* \geq 0.7 \text{ cm s}^{-1}$. Field germination patterns suggest that seeds rarely travel far from the point of release and quickly become buried in the sediment. In a series of flume experiments we manipulated the densities of the subsurface deposit-feeding polychaete *Clymenella torquata* and related trapping of seed to worm density, bioturbation rates and surface chlorophyll levels. Field observations of seeds released near the bed were used to relate burial rates to near-bottom flow velocity and faunal biomass. Our findings indicate that both biological and geophysical processes may affect the horizontal (bedload) and vertical (burial) transport of *Z. marina* seeds.

22.2 4 O I

Luoma, S.N., van Geen, A., Hornberger, M., Fuller, C., Pereira, W., Hostettler, F., Kvenvolden, K., Anima, R., US Geological Survey, Menlo Park, CA 94025, and Ritson, P., Flegal, A.R., Inst. Mar. Sci, Univ. Calif., Santa Cruz, CA., and Venkatesan, I., Inst. Geophysics Planetary Physics, UCLA, Los Angeles, CA., and Baskaran, M., Texas A&M

Univ., Galveston, TX. **RECORDS OF CONTAMINANT INPUT TO SAN FRANCISCO BAY.**

Trends in contamination in the sediments of San Francisco Bay have been affected by hydrologic disturbances as well as mining, agriculture, industrialization and urbanization. Agricultural development and hydraulic mining for gold changed sedimentation rates in the 1800's, and may have diluted pollutant concentrations in sediments. The estuary became a more efficient trap for contaminants coincident with dam construction, and when the water projects began diverting a sizable proportion of river flow away from the Bay. Both factors would residence time for SPM in the estuary. Urban and industrial growth also accelerated in the 1940-50's. In ~1950 the mixture of contaminants in the Bay sediments was dominated by high concentrations of mercury and PAH's. By ~1970, high concentrations of Ag, Cu, Zn, Pb, DDT and PCB's were added to that mixture. After investments in waste treatment began increasing, concentrations of many contaminants declined, although their residues continue to recycle within the Bay. The proportionate mixture of the different contaminants also changed. Concentrations of PAH's and some metals (Cu, Zn) have shown less response to modern regulation of toxic releases than concentrations of Hg, Ag, Pb, DDT and PCB. Waste treatment has been very successful in reducing contamination in San Francisco Bay, but significant problems remain unsolved.

31.3 1 O C

Lynch, J.C., Cahoon, D.R., National Biological Service, Lafayette, LA., and McKee, B.A. LUMCON, Chauvin, LA, and Pozo, M., Churute Ecological Preserve, Ecuador, and Twilley, R. R. University of Southwestern Louisiana, Lafayette, LA. **COMPARISONS OF RECENT RATES OF ACCRETION IN MANGROVE FORESTS IN THE NEOTROPICS.**

The intertidal nature of mangroves has lead to speculation regarding the continued existence of these ecosystems in relation to predicted estimates of sea level rise. Few studies exist that have examined recent rates of sediment deposition and accretion (last 100 years) in these forests. Accretion rates for mangrove forests in the U.S.A., Mexico, Belize and Ecuador measured by the 21OPb method, ranged from a low of 0.19 cm yr^{-1} (± 0.03 , $n = 6$) in Florida, U.S.A. to 1.02 cm yr^{-1} (± 0.02 , $n = 3$) in the Guayas Estuary, Ecuador. Rates for Belize and Mexico cores averaged 0.31 cm yr^{-1} (± 0.07 , $n = 2$) and 0.30 cm yr^{-1} (± 0.08 , $n = 4$), respectively. Some sites in Florida, Belize and Mexico were located in low energy environments with primarily autochthonous sources of matter (i.e., low bulk density and high organic matter content) while the remaining sites were located in higher energy environments with primarily allochthonous sources of matter (i.e., higher bulk density and lower organic matter content). Mechanisms controlling accretion are highly variable between mangrove forest types. Despite differences in the processes driving sediment deposition, these forests appear to be maintaining accretion rates equivalent to or greater than local rates of sea level rise.

-M-

6.1 6 O C

Madden, C.J., Kemp, W.M., Horn Point Environmental Laboratory, University of Maryland Box 775, Cambridge, MD 21613. **USE OF A SIMULATION MODEL TO INVESTIGATE PLANT-HABITAT INTERACTIONS IN A CHESAPEAKE BAY SUBMERSED PLANT COMMUNITY.**

Submersed vegetation in mesohaline Chesapeake Bay has undergone significant changes in distribution over recent decades, as areas of the estuary have variably experienced deterioration and improvements in water quality. A simulation model was developed to investigate interactions between submersed plants and their habitat. The model calculates biomass pools and biogeochemical rate processes over annual cycles ($dt=6h$). Simulation experiments were performed to investigate the influence of phytoplankton and epiphytes on the underwater light environment, how the balance of limiting resources controls growth and productivity of submersed plants, and conditions necessary for the restoration/maintenance of submersed vegetation. Non-linear feedbacks between submersed plant biomass and sediment-trapping effects and nutrient sequestration were significant. Output for plants was calibrated to baseline data from 1970s ($r^2=0.86$); simulations reproduced plant declines with nutrient enrichment matching the rate observed in the estuary. Experiments showed that when nutrient inputs were increased 40% above 1960s levels, submersed plants disappeared within 1-2 years from enhanced growth of phytoplankton and epiphytes. Small changes in suspended sediment and phytoplankton had significant effect on maximum depth of plant survival; lateral hydrologic exchanges with the central bay were important in nutrient and grazer flux to the plant bed.

29.1 4 O I

Magnien, R., Everitt, D., Naylor, M., Maryland Department of Natural Resources, Annapolis, MD, and **Boynton, W.,** University of Maryland, Chesapeake Biological Laboratory, Solomons, MD, and **LaCouture, R.,** Academy of Natural Sciences of Philadelphia, St Leonard, MD, and **Scott, L.,** Versar Inc., Columbia, MD. **REVERSING THE IMPACTS OF EUTROPHICATION IN THE PATUXENT ESTUARY, MARYLAND.**

The Patuxent Estuary has served as a model in the Chesapeake Bay region for managing the impacts of eutrophication. Goals for both N and P load reductions were set over a decade ago and aggressive wastewater controls have reduced these sources to the estuary by 50% and 75%, respectively. A comprehensive monitoring program initiated before the nutrient controls occurred, provides unique information to discern the nature of this system's response to significant

nutrient reductions and thereby guide future management programs in this and other estuaries. Water column concentrations of N and P responded almost immediately to load reductions, dropping by up to 60%. Phytoplankton biomass and production have not been reduced significantly although nutrient levels are much closer to limiting levels in many areas. Sediment recycling of both N and P show a strong relationship to interannual patterns of loading, and sediment P fluxes are much reduced when bottom water DO concentrations remain above 2 mg^{-1} . Benthic macrofaunal community condition has improved in the upper tidal fresh regions. Macrophyte communities, driven to near extinction by the highly eutrophic conditions of the past decade, are starting to expand their distribution in the tidal fresh region.

34.2 7 O C

Mallin, M.A., Williams, K.E., University of North Carolina at Wilmington, Center for Marine Science Research, Wilmington, NC. **EFFECT OF SEASON, SALINITY AND TIDE ON WATER QUALITY OF SHALLOW ESTUARIES.**

Various water quality parameters (chlorophyll *a*, nutrients, and fecal coliform bacteria) were sampled over a series of tidal cycles in several North Carolina tidal creeks. Sampling was conducted at both upstream mesohaline stations and downstream euhaline stations, during winter and summer. Chlorophyll *a* concentration was minimal at high tide and maximal at low tide, often showing bloom conditions. Fecal coliform bacterial abundance was minimal at high tide and maximal during mid-to-low tide. Both of these parameters were strongly negatively correlated with salinity and showed a weaker negative correlation with tidal height. Nitrate and orthophosphate periodically showed concentrations varying according to tide, although the relationships were weaker and more subject to seasonal and spatial influences. Ecological and water quality assessment sampling requires consideration of timing as well as location in shallow estuaries such as these.

0 5 O I

Malone, T., Brooks, A., Clegg, J., Greenberg, M., Hanlon, R., Grassle, F., Ramus, J., Shapiro, L., Stout, J., Tenore, K. NAML (National Association of Marine Laboratories Steering Committee). **ROLES OF MARINE LABORATORIES IN IMPLEMENTING THE NATION'S EMERGING PRIORITIES IN THE COASTAL ZONE: RESULTS FROM THE NAML WORKSHOP.**

At an October 1995 workshop convened by NAML over 50 representatives of the various segments of the marine science community examine the challenges and opportunities

that marine laboratories face in fulfilling their role in the marine science community. The workshop seeks a comprehensive assessment of how coastal laboratories should evolve to contribute most effectively in implementing the emerging national agenda for coastal studies by discussing six areas that marine labs should have a unique role: regional monitoring and data management; fostering transdisciplinary research; stability of long term research programs; nurturing the science-education interface; fostering the science-management interface in developing sound environmental policies and effective management; networking the dispersed coastal lab infrastructures. The NAML steering committee will report on the major findings from the workshop and seek the input from the ERF membership on how they view the potentially unique role of coastal laboratories in the coming decades.

2 3 P-1 C

Marino, R., Howarth, R.W., Ehrenfeld, E.A., Schaffner, W. Section of Ecology and Systematics, Cornell University, Ithaca, NY. **BIOGEOCHEMICAL CONTROLS ON PLANKTONIC N FIXATION: PRELIMINARY RESULTS FROM A MESOCOSM STUDY.**

Despite the fact that primary production is typically N limited in temperate coastal waters, dinitrogen fixation by planktonic cyanobacteria is not a significant process in these estuaries. We are conducting mesocosm experiments on the shore of Narragansett Bay, RI (U.S.A.) to investigate biogeochemical and ecological controls on the growth and fixation of N by planktonic cyanobacteria. In 1994 we ran a preliminary experiment to test the mesocosm system and to evaluate the importance of P and trace metals (Fe and Mo). Grazing pressure was minimized by reducing and trace metals (Fe and Mo). Grazing pressure was minimized by reducing zooplankton biomass using fish. Aliquots of water from a macrophyte nutrient stripper system previously shown to contain *Anabaena* sp. were added as a source of cyanobacteria. We successfully stimulated growth of cyanobacteria in the P and P+metals treatments, and heterocyst numbers were within the range observed in freshwaters where significant rates of N fixation have been measured. This is the first time that planktonic, heterocystic, cyanobacteria have been reported in full salinity seawater in a North American estuary. Acetylene reduction measurements indicated N fixation at low but measurable rates. Total N and N isotopic data strongly suggest that these cyanobacteria fixed dinitrogen in significant amounts over the eleven week experiment.

16.1 6 O C

Marshall, M., Leverone, J., Sprinkel, J., Mote Marine Laboratory, Sarasota, FL. **THE DISTRIBUTION OF HYPOXIA AND ITS EFFECTS ON SEAGRASS ASSOCIATED FAUNA IN SARASOTA BAY, FLORIDA, USA.**

Seagrass beds in Sarasota Bay experience hypoxia ($DO < 2.0$ mg/l) during early morning hours (0530 to 0930 hrs) from mid-summer to early fall. Hypoxia can last for

several hours each day within certain seagrass beds. Seagrasses (*Thalassia* and *Halodule*) in hypoxic areas were thickly coated with epiphytic algae. Drift algae were also abundant in certain seagrass beds. Algal growth is caused by eutrophic conditions produced by nutrients from urban sources. Seagrass, algal, and bacterial respiration during early morning hours presumably drive DOs to hypoxic concentrations. Faunal diversity and species-specific distribution patterns appeared, in most cases, to be negatively affected by low DO concentrations. Several normally abundant caridean shrimp species, for example, were absent from all areas that experienced severe hypoxia ($DO \leq 1.0$ mg/l). Pink shrimp and hermit crabs thrived in all areas. Aquarium tests and field caging studies support this explanation of the results of our faunal monitoring study. This project demonstrates that the mere presence of the primary producer in Sarasota Bay does not assure the existence of a functional ecosystem.

11.1 4 O C

Marvin, M., Capone, D.G., U.S. Geological Survey - Water Resources Division, Menlo Park, CA and Chesapeake Biological Laboratory, Solomons, MD. **SEASONAL AND INTERANNUAL CONTROLS ON BENTHIC SULFATE REDUCTION ALONG THE CHESAPEAKE BAY MAIN AXIS.**

As part of the Chesapeake Bay LMER program, the factors controlling both the seasonal and interannual trends of sulfate reduction (SR) were examined at three main channel stations (upper (UB), mid (MB) and lower (LB) bay) along the Bay's main axis from March-November (1989-1994). Multiple regression analysis indicates that while temperature played a dominant role in controlling seasonal rates, the influence of organic C was significant during spring at all sites. During the period of peak rates (June-July), 90% of the SO_4^{-2} required to fuel MB SR was supplied by rapid recycling within the sediment. During fall and early spring, 25-45% of the required SO_4^{-2} was supplied by molecular diffusion into the sediment. Interannual variations in the magnitude of summer SR rates may ultimately be a function of the timing, intensity and duration of spring river flow and its subsequent influence on the magnitude of spring production and deposition. July SR was a positive function of spring river flow for both UB and MB. LB SR was a negative function of spring flow. This latter trend was attributed to the up-estuary transport of organic matter, the degree of which is proportional to the strength of the spring freshet.

21 8 P-3 C

Matthews, G.A., NOAA/National Marine Fisheries Service, Southeast Fisheries Science Center, Galveston, TX. **USING A GIS TO TRACK SALT MARSH MITIGATION PROJECTS.**

With the increasing development of the coastal zone and an increasing concern for the preservation of fisheries stocks and their supporting habitats, data must be made easily available to managers of the coastal zone. By combining the use of digital line graph maps, attribute file and imagery files in

a GIS environment that functions on PC's or mini-computers, mitigation projects can be located, multiple users, and the data from many mitigation projects could easily and rapidly be updated. The database could also be queried for particular habitats, project types, acreage's alert in an area, and all results could be graphed, mapped and summarized in reports. Visualization of habitat changes also promotes understanding of when and where limitations are being reached. A cooperative effort between agencies responsible for the coastal zone could facilitate the establishment of such a GIS system.

15 22 P-2 C

McCutcheon, S.C., Dept. of Civil Engineering, Clemson University **EVALUATION OF THE TRAPPING EFFICIENCY OF RETENTION PONDS TO CONTROL NONPOINT SOURCE POLLUTION IN CHARLESTON HARBOR, SC**

Trapping efficiencies were determined from mass balances of inflow and outflow loads for two ponds in the Charleston Harbor area. Trapping varied from 100% when there was not outflow, down to 0% for dissolved conservative contaminants like chloride. Excellent water balances indicate that trapping is significantly effected by water trapping when the retention pond must fill before outflow occurs. Gross trapping of fecal coliform (FC) approached 99%; suspended solids, approximately 0 to 85%; BOD less than 50%; nutrients, 68 to 100% (when detected); and zinc, 12 to 78% — normally consistent with primary wastewater treatment levels. Ammonia, nitrite, bromide, copper, and lead were not consistently detected. The landuse in the two watersheds was commercial in one case and residential in the other. Event mean concentrations tended to be lower in both watersheds than those typically found in EPA's National Urban Watershed Program and were lower than receiving water concentrations. Only FC concentrations seemed to violate SC water quality standards. A first flush was observed for all four storms monitored except when back to back events occurred. A literature review indicates that both ponds performed well, trapping was consistent with ponds used elsewhere, and that retention ponds are well adapted to control coastal nonpoint source pollution to a limited degree.

15.1 6 O C

McCutcheon, S.C., Hayes, J.C., Williams, C., Weisskopf, C., Klaine, S. **EVALUATION OF VEGETATIVE FILTER STRIPS TO CONTROL URBAN RUNOFF IN CHARLESTON HARBOR**

Planted and natural vegetative filter strips, normally used as a pretreatment for infiltration practices and storm water ponds, were evaluated. Generally, filter strips provide only a limited degree of control due to the short residence time on the 25- to 200-foot long strips. Suspended solids and the associated organic material are primarily trapped by filtration. Heavy metals and other contaminants that sorb to solids and vegetation are trapped as well. The only nutrient trapping occurs due to infiltration and limited plant uptake during and

between storms. On controlled strips with comparable spiked tracer concentrations of solids, coliforms, nutrients, and metals, we varied antecedent moisture conditions, flow rates, and flow length. Slower flows under drier initial conditions allowed greater trapping. The development of a novel correction for water infiltration made it possible to correct trapping efficiencies and to obtain accurate mass balances of dissolved solids and nutrients. Solids retention was limited on our controlled strips but zinc was trapped in significant quantities. Coliforms added to the strips from horse manure seemed to be completely trapped but other coliforms were washed off from wildlife in the area, as evidenced by a change in the color of colonies from inflow to outflow.

0 4 O I

McDowell Capuzzo, J.E., Woods Hole Oceanographic Institution, Department of Biology, Woods Hole, MA. **BIOLOGICAL EFFECTS OF CONTAMINANTS ON SHELLFISH POPULATIONS.**

The toxic effects of chemical contaminants on marine organisms are dependent on bioavailability and persistence of contaminants, the ability of organisms to accumulate and metabolize contaminants, and the interference of contaminants with specific metabolic or ecological processes. Although a wide range of sublethal stress indices have been proposed for evaluation of chronic responses of organisms to contaminants, few have been linked to the survival potential of the individual organism or the reproductive potential of the population. Experimental studies directed at determining effects on energy metabolism or effects that influence growth and reproduction would be most appropriate for linking effects at the organismal and suborganismal levels with population consequences. When investigating biological effects of contaminants, many variables must be recognized and assessed. Differential sensitivity of different species of organisms, various life history stages, and species from different habitats may be related to contaminant bioavailability, capacity for contaminant biotransformation, and the metabolic consequences of contaminant exposure. The increased sensitivity of early developmental stages and the seasonal differences in the responses of adult animals may be related to stage-specific or seasonal dependency on particular metabolic processes (e.g., storage and mobilization of energy reserves, hormonal processes), with the result of altering developmental and reproductive success. Recent studies on marine bivalve molluscs illustrate the complexity of understanding the bioavailability and biological effects of contaminants in the marine environment and the utility of incorporating physiological and biochemical responses to contaminant exposure in population projection models.

32 41 P-3 C

McEachron, L., Campbell, P., Choucair, P., Texas Parks and Wildlife Department, Rockport, TX. **RED DRUM AND SPOTTED SEATROUT SIZE LIMITS: THEY WORK.**

Red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*) are important, recreationally sought

species in Texas. Size and bag limits are used to reduce mortality and optimize yield of these fishes. Three red drum (20-28 inches long) and 10 spotted seatrout (> 15 inches long) can be retained per day; one red drum > 28 inches can be kept per year with an attached trophy tag. If too many fish die of handling, then using size and bag restrictions may jeopardize management goals of allowing fish to spawn reducing growth overfishing, providing adequate escapement, and providing for quality or trophy fisheries. Knowing the numbers of caught and released fish and subsequent mortality of released fish allows managers to evaluate the success of harvest regulations. Bycatch of Texas private sport-boat anglers was determined during May-November 1993; estimates of released fish ranged from 347,000 to 378,000 red drum and from 803,000 to 902,000 spotted seatrout. About two each of red drum and spotted seatrout were released for every one landed. Studies in Texas report hooking mortalities of 4-10% for both red drum and spotted seatrout. Even with relatively high numbers of released fish, the corresponding low hooking mortality indicates Texas size and bag limits are appropriate options to allow spotted seatrout to spawn at least once, reduce growth overfishing, provide adequate escapement of red drum, and provide a quality red drum and spotted seatrout sport fishery. Because of these findings, Texas Parks and Wildlife Department fishery managers will continue using size and bag limits to manage red drum and spotted seatrout.

32 42 P-3 C S

McGrath, M., Serota, T., Jacks, S., USFWS Fishery Resources Office, Corpus Christi, TX, and Center For Coastal Studies at Texas A & M University, Corpus Christi, TX. **RANGE EXPANSION OF *PERNA PERNA*.**

Perna perna, the invasive brown mussel, first seen on the jetties at Port Aransas in February of 1990, has adapted a gradual range expansion southward along the Gulf coast as well as a slower northward invasion. A three year monitoring program has been initiated by the USFWS Fishery Resources Office in Corpus Christi, Texas. Research began in February of 1995 to document mussel invasion into the bay systems. Monitoring consists of sampling the many navigation buoys, channel markers and artificial substrates in the primary passes from Port Isabel to Galveston Bay. Scrapings help to determine not only the movement of *P. perna*, but the potential biofouling impacts. Substrates were constructed of PVC piping for areas of insufficient or absent bouys or channel markers. At each buoy or artificial substrate three scrapings were done with a long-handle putty knife from the mid to lower intertidal zone. A quadrat of 0.25 m² was used to assure standardization of sample. Length, width and height measurements on collected specimens were obtained to the nearest 0.01 mm using digital vernier calipers to determine age.

15 23 P-2 C

McKellar, H., Smith, A.D., Rao, R., Department of Environmental Health Sciences, University of South Carolina, Columbia, SC. **WETLAND NUTRIENT EXCHANGE IN**

AN URBANIZED ESTUARY: RELATIONSHIPS TO POINT-SOURCE DISCHARGES AND NONPOINT RUNOFF.

As part of a larger effort to quantify and model water quality dynamics in the Charleston Harbor Estuary (South Carolina), we quantified tidal and seasonal patterns of wetland nutrient exchange in a brackish marsh (7.4‰ median salinity) within a major sub-basin of the the study area(Goose Creek). With a mean tidal range of 2m, the marsh displayed a consistent tidal pattern of NO₃ + NO₂ uptake, where concentrations in ebbing water were 20-35 mgN/m² during summer and fall. Ammonium exchanges indicated a net daily export from the marsh(6-16 mgN/m²) although values were more variable and displayed less apparent seasonal pattern. Dissolved organic carbon fluxes were also variable but displayed a strong tendency toward net export (157 mgC/m²/d). Chlorophyll was exported from the marsh during the winter (0.1-0.8 mg/m²/d) and imported during the late summer and fall (1.4-1.9 mg/m²/d) yielding an approximate annual balance. The net removal of dissolved inorganic nitrogen by the marshes was a significant fraction of the overall nitrogen budget for the estuary and provided a buffer to potential impacts of point-source wastewater discharges as well as nonpoint urban runoff.

21.4 3 O C S

McNally, D., Kemp, P., Day, Jr.,J.W., Louisiana State University, Coastal Ecology Institute, Baton Rouge, LA. **EFFECTS OF A MANAGED STRUCTURAL IMPOUNDMENT ON WETLAND HYDROLOGY, SEDIMENTATION, AND SUBMERGED AQUATIC VEGETATION WITHIN THE MISSISSIPPI DELTAIC PLAIN.**

Wetland processes and parameters were measured during 1992-1993 within an managed impoundment operating under goals of reducing wetland loss. Impounded and non impounded areas showed no significant difference in salinity concentrations. Long term staff gage records and short term continuous records showed higher water level within the impoundment, causing a mean export of water and suspended sediments through weir structures. Water levels showed a 2.25 cm/yr rate of sea level rise inside the impounded area vs. 1.18 cm/yr outside. Submerged aquatic vegetation, sampled by quadrat, showed lower biomass production inside the impoundment and was attributed to losses from wind action and low sediment strength. Sediment deposition above feldspar marker horizons was dominated by passage of hurricane Andrew, with no significant differences between impounded and non impounded deposition. High accretion rates were attributed to reworking of hurricane deposits. Marsh elevation measurements using a sedimentation-erosion table (SET) indicated floating marsh existence in fresh marsh sections of the impoundment and may be an adaptive successional response to limited sediment input and rising water levels. The use of impoundments in fine-grain, high rainfall environments may be an inappropriate management practice for reducing wetland loss.

18.1 4 O C

McTigue, T.A., National Marine Fisheries Service, Lafayette Office, Lafayette, LA, and **Zimmerman, R.J.**, National Marine Fisheries Service, Galveston Laboratory, Galveston, TX. **POTENTIAL INFLUENCES OF JUVENILE *PENAEUS AZTECUS* IVES ON INFAUNAL POPULATIONS.**

Brown shrimp, *Penaeus aztecus* Ives, first occur in Texas salt marshes during the early spring. Their appearance, in conjunction with other juvenile predators, coincides with an annual decline in the abundance of infauna. Prey selection and growth studies have indicated that the brown shrimp may utilize surficial dwelling infauna as a significant faunal dietary element. A predator-exclusion caging study on the marsh surface and in an adjacent creek was used to determine both the response of infauna to natural predation levels and a lack of macroepibenthic and nektonic predators. This, coupled with laboratory data regarding the feeding rates of juvenile brown shrimp on the infaunal taxa, was used to model the potential role that penaeids play in the seasonal decline of the infaunal populations. Results suggest that brown shrimp may significantly affect polychaete populations in marsh areas, but their impact on amphipods on the marsh surface or any taxon living in open bay bottom is not clear and may be much less. Pressures defining infaunal populations may vary with habitat and group of animals considered. Brown shrimp appear to be trophically linked to infaunal populations, although their feeding alone may not be significant in the regulation of infaunal populations.

32.1 2 O C

Melancon, E., Soniat, T., Nicholls State University, Thibodaux, LA, and **Cheremie, V.**, LADNR, Baton Rouge, LA, and **Barras, J.**, NBS, Baton Rouge, LA, and **Dugas, R.**, LADWF, New Orleans, LA. **HABITAT CHANGES WITHIN THE OYSTER RESOURCE ZONES OF THE BARATARIA AND TERREBONNE ESTUARIES AND MANAGEMENT IMPLICATIONS TO COASTAL RESTORATION.**

Four oyster resource zones have been delineated by oysterman and biologists, digitized and stored in a GIS format (Arc Info). The resource zones are based on the premise that when all other physiological needs are met, the prevailing salinities during "wet" and "dry" periods within the estuaries will determine subtidal oyster survival. The four water zones are: a 120,596 acre upper-estuary *dry zone*, a 165,455 acre lower-estuary *wet zone*, a 258,796 acre mid-estuary *wet-dry zone* where salinities are conducive to long-term survival of subtidal oysters, and a 280,136 acre lower-estuary *high-salinity zone* where salinities are too high for long-term subtidal oyster survival due to predator abundance. Wetland losses and eventual conversion to open water have increased potential oyster habitat acreage in the oyster resource zones. In a preliminary comparison of the USFWS's 1958 to 1988/90 habitat data, water acreage during the 30 year period has increased 77% in the dry zone, 67% in the wet-dry zone, 41% in the wet zone, and 9% in the high-salinity zone. During this same period, leased acreage in three

of the four coastal parishes within the estuaries have increased 180% from 34,866 to 97,668. This information may be used by government agencies and Louisiana oysterman to find common ground for discussions as coastal restoration projects are implemented.

21.2 2 O I

Mendelsohn, I.A., Lin, Q., Henry, C.B., Roberts, P., Wetland Biogeochemistry Institute, Louisiana State University, Baton Rouge, LA. **BIOREMEDIATION: A TOOL FOR THE RESTORATION OF OILED SALT MARSHES.**

Bioremediation, the act of adding materials to contaminated environments to cause an acceleration of the natural biodegradation process, is a potential candidate for oil spill cleanup in wetlands. We conducted greenhouse experiments with salt marsh mesocosms to determine the effectiveness and ecological compatibility of bioremediation for salt marshes. Sods of marsh (soil and vegetation intact), approximately 30 cm in diameter and 25 cm deep, collected from a *Spartina alterniflora* dominated salt marsh in south Louisiana were used to identify the effects of the following treatments: (1) microbial product, (2) fertilizer product, (3) fertilizer plus soil oxidant products, and (4) control under drained and inundated conditions. Plant growth response was significantly increased above control levels in the fertilized and fertilized plus oxidant treatments. The microbial product had no effect on plant growth. Soil respiration, an indicator of hydrocarbon biodegradation, was significantly elevated by the fertilizer plus oxidant treatment but not by the fertilizer alone. An enhancement of the initial stages of oil biodegradation was observed for both the fertilizer and fertilizer plus oxidant treatments, however, the enhanced biodegradation was primarily limited to the alkane constituents. Bioremediation appears environmentally compatible with the salt marsh environment, but biodegradation potential requires further investigation both in the laboratory and the field.

2.4 4 O C S

Merickel, J.A., Wiebe, W.J., Institute of Ecology and Department of Marine Sciences, University of Georgia, Athens, GA. **MANGROVE SEDIMENT NUTRIENT DYNAMICS; DO PLANTS REALLY MATTER?**

Mangrove forests have a large storage capacity for nutrients. This storage can be biotic within plants and animals, as well as abiotic, within the sediments. Mangrove sediment nutrient loads were monitored in the Florida Everglades, following Hurricane Andrew in August 1992 at both impacted and unaffected sites. Mangrove forest sediment nutrient loads at impacted sites show little variability to those of non-impacted sites. Seasonal porewater data suggests some fluctuation of nutrient pools, but they do not correspond to the amount of tree destruction and regrowth. The ability of the sediments to retain nutrient loads following tree damage suggests a very resistant system in terms of nutrient storage. Further, the sediments retain their ability to sequester nutrients from the water (even at impacted sites). Nutrient data from mangrove sediments throughout the world, and our own

data from four different geographic sites throughout the Caribbean suggests similar nutrient storage patterns. These systems are very resistant to change and are capable of retaining high nutrient loads even when faced with significant forest destruction. While nutrient storage is almost certainly a result of mangrove forest growth, there does not appear to be a close coupling of these pools to plant growth.

6.1 2 O C S

Merrell, K.C., Stevenson, J.C., Horn Point Environmental Laboratory, Cambridge, MD. **SCALING TURBULENCE INTENSITY IN SAV MESOCOSMS.**

It has been suggested that due to lack of experimental studies, the influence of current on SAV (Submerged Aquatic Vegetation) may be severely underestimated. Conventional wisdom dictates that increased flow acts to reduce diffusion boundary layers at the leaf surface, allowing the plant to uptake nutrients (including CO_2 , and HCO_3^-) more efficiently, as well as bring more nutrients to the SAV community from the surrounding environment. This experiment investigated the effect scaling turbulence intensity, mixing time and flow velocity had on the growth and development of a community containing *Vallisneria americana*. Experimental treatments were High, Medium, and Low, and the control was No Mixing. Increasing the scale of turbulence intensity, mixing time, and flow velocity up to a threshold (the Medium treatment) increased the biomass of *Vallisneria americana*. The lowest *Vallisneria americana* biomass occurred in the High treatment. Epiphyte and wall growth biomass increased in a linear fashion from No Mixing to High. The high epiphyte and wall growth density in the High treatment may contribute to the sharp decrease in *Vallisneria americana* biomass in the high treatment.

16.1 4 O C

Meyer, D.L., Murphey, P.L., Fonseca, M.S., NOAA/NMFS, Southeast Fisheries Science Center, Beaufort Laboratory, 101 Pivers Island Road, Beaufort, NC. **PREFERENTIAL SEAGRASS STRUCTURE SELECTION BY TOZEUMA CAROLINENSE.**

The importance of the vegetative structure within seagrass beds and its influence on macrofauna is not well understood. The arrow shrimp (*Tozeuma carolinense*) has been reportedly associated with *Thalassia testudinum* and *Syringodium filiforme* in more tropical latitudes and with *Zostera marina* and *Halodule wrightii* in northern latitudes. Field and laboratory studies were conducted to examine seagrass structure preference by *Tozeuma*. Field collections occurred within sites containing *Thalassia* and recently transplanted *Halodule*, in Tampa Bay, Florida. Macroepifauna were collected using drop-traps. Laboratory observations of selection based on seagrass blade morphology and blade area included bare areas and *Thalassia*, *Halodule* and *Syringodium* mimics. Treatment pairs were randomly placed on opposite ends of aquaria separated by a buffer. During each trial run 29 *Tozeuma* were set in the buffer of each set up. After 8 hours partitions were placed in the buffer and shrimp col-

lected. Throughout field collections *Tozeuma* were more abundant in transplanted *Halodule* than in *Thalassia*. Significant differences ($p < 0.01$) between the *Halodule* and *Thalassia* treatments were detected. Laboratory observations were consistent with our field observations. *Tozeuma* selected *Halodule* over *Thalassia* treatments significantly more often ($p < 0.05$). Similar laboratory results were observed between comparison of *Syringodium* and *Thalassia* treatments with *Syringodium* selected significantly ($p < 0.05$) more often than *Thalassia*.

30.3 4 O C

Meyers, M.B., Buzzelli, C.P., Moore, K.A., Wetzel, R.L., Virginia Institute of Marine Science, Gloucester Point, VA. **NITROGEN DYNAMICS AND PRIMARY PRODUCTION WITHIN AN EELGRASS DOMINATED HABITAT: SIMULATION ANALYSIS.**

Information on carbon and nutrient fluxes and plant-light relations has been synthesized into a simulation model of primary production, nutrient recycling, trophic transfers, and tidally driven transport with adjacent salt marsh and tributary habitats. Simulation analysis has been used to examine the impact of environmental variability and the efficacy of habitat restoration criteria on the survivability of eelgrass. System primary production (macro- and microphyte), nutrient recycling and benthic exchange are sensitive to tidally induced variability of the submarine light field and the lateral exchange of organic matter and inorganic nutrients. While long term water quality and biomass data have been useful in deriving water quality criteria for SAV dominated habitats, modeling experiments and short term observational studies suggest that conditions within an eelgrass bed and associated levels of primary production are highly variable. This variability may provide clues to the spatial and temporal patterns of eelgrass in the lower Chesapeake Bay and the higher trophic levels which exploit this habitat, and the temporal pattern of material exchange with adjacent habitats. Additionally, problems with model development point to specific research needs.

29.1 2 O I

Michael, B., Romano, W., Magnien, R., Maryland Department of Natural Resources, Annapolis, MD, and Boynton, W., University of Maryland, Chesapeake Biological Laboratory, Solomons, MD, and Lacouture, R., Academy of Natural Sciences of Philadelphia, St. Leonard, MD, and Scott, L., Versar Inc., Columbia, MD and Carter, V., Rybicki, N., USGS Reston, VA. **REVERSING THE IMPACTS OF EUTROPHICATION IN THE POTOMAC ESTUARY, MARYLAND.**

The Potomac estuary suffered severe impacts from eutrophication during the 1960's and early 1970's. Aggressive wastewater treatment programs in the Washington Metropolitan area have reduced phosphorus loadings to the estuary by over 90%. Nitrogen loading has increased slightly, but not as dramatically as population and wastewater flows would indicate. A long-term record of water quality and habitat data exists in the Potomac estuary that was analyzed to

determine the estuary's response to nutrient loading reductions. Water column concentrations of P responded almost immediately to load reductions in the mid 1980s, dropping by up to 60%. BNR implementation for nitrogen removal has been slated for Blue Plains WWTP which is the source of over 60% of the WWTP flows to the estuary. Phytoplankton biomass and production were relatively high from the early to mid 1980s, but have decreased during the late 1980s to the early 1990s. An increase in phytoplankton during 1993 and 1994 in the estuary is possibly due to unusual climatic events. Benthic communities have shown improving trends in the upper tidal region. Submerged aquatic vegetation has increased from almost nonexistence prior to 1982 to a high of almost 8000 acres in 1991.

16.2 3 O C

Michot, T., National Biological Service, Southern Science Center, Lafayette, LA. **CARRYING CAPACITY OF SEAGRASS BEDS PREDICTED FOR REDHEADS WINTERING IN CHANDELEUR SOUND, LOUISIANA.**

The waters of Chandeleur Sound adjacent to Chandeleur Island, 40 km off the Louisiana coast, are a traditional wintering area for about 20,000 redheads (*Aythya americana*). We predicted the carrying capacity of the Chandeleur Sound study area to assess whether redheads could be limited by their winter habitat. Based on 190 esophageal food samples from 287 redheads collected over two winters, we determined that 83% of the diet was below ground parts (93% rhizomes, 7% roots) of the seagrass *Halodule wrightii*. We established from 17 vegetation transects that *Halodule* covered 24.2% of the 79-km² study area. We estimated belowground biomass of *Halodule* for October to be 119 g (dry mass)/m² from core samples (n = 60) taken from three 20 m-by-20 m study plots. *Halodule* belowground standing crop over the entire study area in October was estimated at 2287 metric tons (MT), of which 1077 MT was usable to redheads (171 MT rhizomes, 906 MT roots). Based on a published consumption rate for redheads of 77.5 g/m² and the average winter stay of 96 days/redhead, we estimated the carrying capacity to be about 25,000 redheads over the winter. We concluded from this that redheads at Chandeleur Sound could be limited by wintering habitat, specifically food (*Halodule*) resources.

28.1 2 O C S

Militello, A., Kraus, N.C., Conrad Blucher Institute for Surveying and Science, Texas A&M University-Corpus Christi, TX. **NUMERICAL SIMULATION OF THE CIRCULATION IN THE LOWER LAGUNA MADRE, TEXAS, AND IMPLICATIONS FOR DREDGING OF THE GULF INTRACOASTAL WATERWAY.**

Certain sections of the Gulf Intracoastal Waterway (GIWW) located in the lower Laguna Madre (LLM), Texas, require more frequent maintenance dredging than others. To understand the shoaling pattern, dredging records were analyzed and physical process data incorporated to define nine morphological compartments in the LLM. The compartment requiring the most frequent dredging is an area of decreas-

ing depth called the Transition Flat. Hydrodynamic numerical simulation modeling of the LLM for typical summer-time conditions revealed that water pushed toward the western edge of the lagoon by southeasterly winds is deflected to the northeast by the western boundary, creating a wide-area flow gyre within the two southernmost compartments. The northeast moving water can erode placement material located on the western side of the GIWW and subsequently deposit the material back into the GIWW. A limited-area bathymetric survey revealed areas of deposition and scour, supporting inferences from the modeling that scoured areas occur in regions of strong currents, and depositional areas occur in regions of weak currents. A recommendation for the reduction of transport of sediment into the GIWW is to build shallow flats of placement material to serve as seagrass beds which would provide shelter from erosional hydrodynamic stresses.

4.2 1 O I

Miller, J.M., Joyeux, J.C., Duchon, K.A., North Carolina State University, Raleigh, NC, and Neill, W.H., Texas A & M University, College Station, TX and van der Veer, H.W., Netherlands Institute for Sea Research, Den Burg, Texel, The Netherlands. **DOES PRIMARY PRODUCTION CONTROL JUVENILE FISH PRODUCTION IN ESTUARIES?**

In the context of the question: "What controls flatfish recruitment worldwide?", rather compelling evidence has been obtained that food is not limiting for the juvenile stages of 10 North Atlantic and Caribbean "estuarine-dependent" flatfish species. Since many important non-flatfish species inhabit estuaries as juveniles, the generality of this conclusion is examined. First, the evidence and arguments for flatfish are presented; of particular interest are the data from tropical systems, where food limitation seems most likely. We then examine productivity and fish production data from 274 other estuaries. The rather surprising conclusion is, except in the rare cases of oligotrophic estuarine systems, fish production seems to be negatively correlated with primary productivity, probably owing to periodic or episodic dissolved oxygen depletion in more eutrophic systems. Thus, in general, we expect a dome-shaped relationship between fish production and primary production. But for most systems there are insufficient data to critically examine alternative (to juvenile habitat limitation) hypotheses for most systems. Clearly we need a classification of both estuarine and fish ecotypes that will permit at least ordinal-level hypothesis-testing from a global perspective. Such a scheme is presented, along with arguments for which fish ecotypes are most likely to be limited by habitat, e.g., marsh, productivity.

16 29 P-1 C

Miller, R.R., Virnstein, R.W., St. Johns River Water Management District, Palatka, FL. **DEVELOPMENT AND USE OF A PHOTO-INDEX AS A TOOL FOR MONITORING EPIPHYTE BIOMASS ON SEAGRASS IN THE INDIAN RIVER LAGOON, FLORIDA**

Visual, nondestructive techniques for measuring epiphyte

abundance can be used to document epiphytic variations associated with depth and time. This technique provides a tool for estimating *in situ* epiphyte biomass to use in association with a large-scale seagrass monitoring program. The photo-index defines a variety of epiphytic loadings found on *Halodule wrightii* within the Indian River Lagoon (IRL). The photo-index consists of photographs that correspond to quantitative measures of seagrass and epiphyte biomass. The photo-index may be taken into the field to match the currently observed conditions with the most representative photo to estimate epiphyte biomass. Development of this technique required a test of variability to determine how well the selected photo corresponds to the "true" epiphyte biomass. Conference attendants may participate in a test to determine the variability associated with this photographic technique.

2.2 1 O I

Miller-Way, T., Cowan, J.L., Pennock, J.R., Marine Environmental Sciences Consortium, Dauphin Island, Alabama and Twilley, R.R., University of Southwestern Louisiana, Lafayette, Louisiana. **SPATIAL AND TEMPORAL PATTERNS OF BENTHIC NUTRIENT FLUX IN TWO GULF OF MEXICO ESTUARIES.**

Our current understanding of the importance of benthic nutrient regeneration in coastal systems is primarily based on data from temperate estuaries; there have been few studies of patterns in benthic inorganic nutrient flux for Gulf of Mexico estuaries. We have measured rates of benthic exchange quarterly in Fourleague Bay, Louisiana (FLB; 2 stations) and Mobile Bay, Alabama (MB; 4 stations), using open and closed sediment-water microcosms, respectively. Rates of sediment oxygen consumption ranged from 0.2 to 1.8 g m⁻² d⁻¹ for both estuaries and were positively correlated with temperature. Ammonium was the predominant form of nitrogen exchange. Flux was directed to the water column on all but one sampling. Rates ranged from -11 (uptake) to 225 μmols m⁻² h⁻¹ (release). Rates of NO₃+NO₂ exchange varied from -180 (uptake) to 29 μmols m⁻² h⁻¹ (release) in FLB but were consistently directed out of the sediment in MB, ranging from 0 to 105 μmols m⁻² h⁻¹. DIP flux varied in direction but with no apparent seasonal or spatial pattern; rates ranged from -13 (uptake) to 20 μmols m⁻² h⁻¹ (release). Comparisons with published rates for temperate systems indicate that these subtropical systems are characterized by lower rates of inorganic nutrient exchange.

9 4 P-2 C

Miller-Way, T., Schroeder, W.W., Pennock, J.R., Marine Environmental Sciences Consortium, Dauphin Island, AL. **DISSOLVED OXYGEN DYNAMICS IN MOBILE BAY, AL.**

From June through November of 1993 and 1994, we maintained continuously monitoring water quality units in upper Mobile Bay. Five Hydrolab Datasonde 3™ units were deployed in bottom and surface waters at an array of 4 stations. Units were configured to record temperature, pH, salinity, depth, turbidity (1994 only) and dissolved oxygen every 15

min. Data show that stratification due to salinity differences can be strong (>12 ‰) despite the shallow depth of Mobile Bay (average depth < 3 m). Destratification / restratification occurred rapidly, over periods of approximately 1-2 days, in this region of the bay. Fluctuations in bottom water dissolved oxygen occurred on similarly rapid time scales. During extended periods (as short as 2 or 3 days) of stratification, bottom waters typically became hypoxic. Hypoxic bottom waters were both temporally and spatially extensive during periods lasting several weeks. Rapid fluctuations in dissolved oxygen concentrations were due to vertical mixing and horizontal advection, both wind and tidally driven, and to high rates of sediment oxygen consumption. The dynamic nature of water column dissolved oxygen has important implications for biogeochemical processes in this region of the bay.

34.2 1 O C

Millie, D., Agricultural Research Service, U. S. Department of Agriculture, New Orleans, LA, and Pinckney, J., Paerl, H., Institute of Marine Sciences, University of North Carolina, Morehead City, NC, and Schofield, O., Institute of Marine & Coastal Sciences, Rutgers University, New Brunswick, NJ. **NEUSE RIVER PHYTOPLANKTON: USING PHOTOPIGMENTS TO CHARACTERIZE COMMUNITY DYNAMICS AND PHOTOPHYSIOLOGICAL PROCESSES.**

Microalgal photopigments, community production, and carbon-specific growth rates were assessed at sites ranging from fresh to estuarine in the Neuse River during 1994. Values of chlorophyll *a* biomass, as measured by high performance liquid chromatography, corresponded with the sum of phylogenetic group-specific chlorophyll *a* biomass, as predicted from chlorophyll *a*: accessory pigment ratios generated by regression analysis ($p < 0.0001$, $r^2 = 0.74$). Predicted chlorophyll *a* values were more highly correlated with measured chlorophyll *a* values in surface assemblages ($r = 0.94$) than in assemblages at depth ($r = 0.77$), indicating the decreased role of chlorophyll *a* and the increased roles of accessory chlorophyll and carotenoid pigments in light-harvesting at depth. States of photoacclimation were most identifiable in dinoflagellate assemblages during periods of a stratified water column. Measured chlorophyll *a* values corresponded with community production values at sites throughout the estuary ($p < 0.0001$). However, low values of chlorophyll-specific growth rate were observed during periods of high community production. Consequently, investigations addressing physical and/or chemical factors forcing the initiation and persistence of microalgal blooms should concentrate on periods of active cell growth.

35.1 4 O C

Minei, V., Dawydiak, W., Suffolk County Department of Health Services, Office of Ecology (Peconic Estuary Program, Program Office), Riverhead County Center, Riverhead, NY. **CONTROLLING NITROGEN INPUTS INTO THE PECONIC ESTUARY SYSTEM.**

In the Brown Tide Comprehensive Assessment and Man-

agement Program (BTCAMP), the predecessor to the Peconic Estuary Program (one of 21 National Estuary Programs), ambient surface water quality for the Peconic Estuary (Long Island, N.Y.) was characterized through an extensive monitoring program for surface waters, sediments, tributaries, point source discharges, and groundwater. An assessment of pollutant loadings was performed, and a state-of-the-art mathematical computer model of the Peconic estuary system (hydrodynamics and water quality) was used. Through an analysis which related nitrogen concentrations to chlorophyll *a* levels, and then compared chlorophyll *a* levels to diurnal dissolved oxygen (D.O.) fluctuations, a safe threshold level of nitrogen (i.e., "guideline") of 0.5 mg/l was established in Flanders Bay to prevent excessive dissolved oxygen depression. This guideline is routinely exceeded in western Flanders Bay. Eastern main bays water quality is excellent. The Peconic Estuary Program has adopted BTCAMP's point source "no net increase" nitrogen loading recommendations for the tidal Peconic River and Flanders Bay and is implementing point source nitrogen loading freezes while pursuing implementation of other land use controls for these areas (e.g., two acre zoning). The long-range goal of pollution abatement in the western Peconic Estuary is also being explored. Several mechanisms to protect water quality in the eastern main bays system and subwatersheds are being examined.

4.1 5 O I

Minello, T.J., National Marine Fisheries Service, Galveston, TX. **FISHERY LINKAGES TO WETLANDS: THE RELATIONSHIP BETWEEN BROWN SHRIMP PRODUCTION AND TIDAL FLOODING OF COASTAL SALT MARSHES**

Young brown shrimp *Penaeus aztecus* use flooded salt marshes as nursery grounds during spring months in the northern Gulf of Mexico. Annual variability in shrimp production is high, and from 1982 to 1991 brown shrimp landings off Texas ranged from 18.2 to 35.3 million pounds. An understanding of the mechanisms linking salt marshes with shrimp production, may help predict this variability. Brown shrimp growth and survival are both increased when the salt marsh surface is tidally inundated. Thus, productivity should be influenced by water levels in the marsh and availability of the intertidal vegetation. Marsh flooding was examined for the months of March and April using data from the NOS tide gauge at Pier 21 in Galveston Bay. From 1982 to 1991 salt marshes in lower Galveston Bay during this spring period had flooding durations ranging from 47 to 83%. This tidal flooding variable explained 47% of the variability in brown shrimp landings off the Texas coast. The relationship suggests that interactions between trophic and hydrologic dynamics are important in the link between estuarine habitats and fishery production for brown shrimp.

0 3 O I

Mitchell, J.R., Division of Ocean Sciences, National Science Foundation, Arlington, VA. **OPPORTUNITIES FOR**

UNDERGRADUATE RESEARCH

The Ocean Science Division, National Science Foundation, presently supports 14 Research Experiences for Undergraduates (REU) SITES, several individual REU supplemental awards, and seven undergraduate projects focused on underrepresented groups. These projects are aimed at providing meaningful research experiences to undergraduates, as well as to encourage a diverse pool of talented students to pursue careers in Ocean/Marine Science. A overview of the programs will include brief descriptions of important proposal elements, successful and unsuccessful strategies, and the range of activities available to undergraduates—highlighting aspects of on-going projects.

21.1 1 O I

Mitsch, W.J., School of Natural Resources and Graduate Program in Environmental Science, The Ohio State University, Columbus, OH. 43210 **CREATION AND RESTORATION OF WETLANDS: A CHALLENGE TO ECOLOGISTS.**

The creation and restoration of wetlands for habitat replacement, mitigation of lost wetlands elsewhere, or water quality enhancement, have had a history of both successes and failures. Some studies have indicated as low as 10% success rate on wetlands created or restored for mitigation purposes. Other studies have shown that wetlands can be restored or created with almost complete functional comparison to natural wetlands. Creation and restoration of both coastal and inland wetlands can be successful if a few general concepts are applied. These include the understanding and use of self-design concepts, the understanding of hydrology and its importance on ecosystem function, the recognition of the time required for ecological processes to develop, the understanding of wetland science, and the use of adaptive management techniques once the wetlands are created or restored. Examples will be shown from several wetland creation and restoration projects of the application of these general rules of wetland ecotechnology. Ecological modelling remains our best tool for predicting the dynamics of these created and restored systems.

36.1 4 O C

Møhlenberg, F., National Envir. Res. Inst., Dep. Marine Ecol. & Microbiol., Denmark, and Kemp, W.M., Madden, C., University of Maryland, CEES, Horn Point Envir. Lab., Cambridge, MD. **BIVALVE CONTROL OF PLANKTON BIOMASS DEPENDS ON VERTICAL MIXING**

A mechanistic mathematical model of the effect of bivalve suspension-feeders on pelagic auto- and heterotrophs was based on bivalve abundance and bivalve clearance efficiency that varied with prey size and turbulence intensity. The model was tested in a shallow (<5m), eutrophic, microtidal estuary for the years 1993 and 1994. Forcing functions of the model was nitrogen load, insolation and wind velocity. Model runs showed that the population of *Mytilus edulis* (ca. 4 gC m⁻²) was effective in limiting the biomass of microplankton during mixing (windy) conditions. The ef-

fect of mussels on the copepod population was due to a combination of competition for food and direct predation of the younger stages. During periods of water column stratification (low wind/high insolation) the populations of pelagic auto- and heterotrophs developed independently of the benthic mussel population. Under and after a prolonged stratification period during the hot summer in 1994 the concentration of chlorophyll reached 60 mg m^{-3} in the estuary or ca. 20 times the summer concentration in 1993. The chlorophyll concentration remained high during the autumn 94 due to hypoxia-induced mortality in the mussel population (i.e. reduced grazing potential) and/or suppression of clearance potential of the remaining population caused by high algal concentration.

24.1 3 O C

Moncreiff, C.A., Gulf Coast Research Laboratory, Ocean Springs, MS, and Heck, K.L., Marine Environmental Sciences Consortium, Dauphin Island, AL. **EFFECTS OF LIGHT REDUCTION ON A *THALASSIA TESTUDINUM* MEADOW IN ST. JOSEPH BAY, FL.**

Chronic stresses resulting from low light levels are potentially a major factor in the decline of seagrasses in coastal ecosystems. To assess the effects of light reduction on seagrasses, an *in situ* experiment was designed to monitor growth rates, above- and below-ground biomass, seagrass blade morphology, epiphyte development, and the faunal community present in a series of enclosures over a two-year period. The study was conducted in a *Thalassia testudinum* meadow located in St. Joseph Bay, FL, a coastal marine embayment with extensive seagrass meadows. Light levels were reduced using 2 m^2 (0.5 m height) black plastic mesh enclosures with the following mesh apertures and reductions in light reaching the seagrass blades: (1) 6 mm (1/4") mesh, reduction to 30-40% ambient light; (2) 19 mm (3/4") mesh, reduction to 60-70% ambient light, and; (3) a control (no reduction). Three replicates were established for each treatment. Chronic reductions in light available to the benthic macrophyte community resulted in reduced biomass and overall community production, with the 30-40% ambient light (6 mm mesh) treatment exhibiting a decrease in biomass over the period of reduced light level, and continued depressed growth rates during a recovery monitoring period. Only shoots initially present in these enclosures persisted, suggesting that 30-40% of ambient light is required for plant survival.

34 47 P-1 I

Montagna, P., Kalke, R. University of Texas Marine Science Institute, P.O. Box 1267, Port Aransas, TX 78373. **LOSS DIVERSITY AND FOOD WEB CHANGE IN CAUSED BY A BROWN TIDE.**

In 1990, there was an unusual brown tide bloom of an aberrant *Chrysophyte* sp. in Baffin Bay and Laguna Madre near Corpus Christi, Texas. The bloom was coincident with a loss of infaunal biomass and diversity in Baffin Bay and Laguna Madre. The dominant filter feeder, *Mulinia lateralis*

disappeared for a year and populations remained low for two years. However, we found that *M. lateralis* had high grazing and assimilation rates of brown tide indicating it is more likely that the bloom could have been due to loss of the clam population, rather than a negative trophic effect of the brown tide. For a 3-year period, overall benthic density, biomass and diversity has remained much lower than pre-bloom conditions. The loss of invertebrates is correlated with loss of seagrass habitat. A stable isotope study has indicated that there has also been a dramatic shift in the food-web structure of Baffin Bay. This study demonstrates that unialgal blooms can have a dramatic impact on ecosystems even when there are no apparent toxic effects.

10.1 1 O C

Moore, A.D., Sullivan, M.J., Phipps, S.W., Department of Biological Sciences, P.O. Drawer GY, Miss. State, MS 39762. **PATCH DYNAMICS AND THE STRUCTURE AND FUNCTIONING OF SEAGRASS BEDS IN BIG LAGOON, PERDIDO KEY, FLORIDA, USA.**

Monotypic beds of shoal grass, *Halodule wrightii* Ascherson, having areas of 1X, 2X, and 4X and approximately circular in shape were sampled to determine the effects of patch size on primary production (as ^{14}C uptake), biomass (dry weight), and total chlorophyll *a* (measured by HPLC) of the seagrass and its epiphytic algae. Sampling began in August 1995 and will continue through August 1996. In addition, the possible confounding effect of grazing was evaluated by placing enclosure cages in all beds. Measurements of the above variables were made at the edge (outer 10 cm) and the geographic center of each bed in order to test the null hypothesis that the structural and functional properties of a square meter of seagrass bed do not differ within a given patch or between patches of differing size. Edge effects are expected to be significant in all bed sizes (edge vs. interior) whereas the effect of patch size on community properties is less certain. The results of this study are important because human activities are increasingly disturbing and fragmenting seagrass habitat.

30.1 1 O C

Moore, K.A., Goodman, J.L., School of Marine Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. **SHORT-TERM VARIABILITY IN WATER QUALITY ASSOCIATED WITH EELGRASS BEDS.**

Seagrass communities may moderate or enhance the measurable standing stocks of water quality constituents such as dissolved oxygen, nutrients, suspended particulates and chlorophyll *a* in water masses exchanged with adjacent channel areas over short time periods. Seasonal, 10-day studies investigating changing levels of water column constituents over intervals of minutes to hours, demonstrated distinct effects of an eelgrass bed on the overlying water, reflecting both tidal and diurnal components. Concentrations of water column constituents in the shallows can therefore be quite distinct from that of the adjacent channel and suggest the active

processing of materials in these areas. These effects can vary with season and bed development. In spring, during the period of highest seagrass biomass and primary production, the community significantly reduced levels of dissolved inorganic nitrogen (mostly NO_3), Chlorophyll *a* and suspended particles. During the summer, in contrast, the bed was quite heterotrophic, and served as a source of NH_4 . Higher levels of chlorophyll *a* and suspended particles were observed in the bed than out, as well. PO_4 concentrations were relatively conservative throughout much of the year. Distinct pulses in levels of water column PO_4 in the summer which corresponded to nightly DO minima, suggest PO_4 release from the sediments can occur.

17.2 6 O C

Moore, R.H., Coastal Carolina University, Conway, SC. **ECOLOGY OF JUVENILE SPHYRAENIDS (BARRACUDAS) IN A SOUTH CAROLINA MARSH INLET.**

The great barracuda, *Sphyraena barracuda* is not commonly thought of as a member of the southeastern estuarine fish fauna. However, twenty years of collection data from Singleton Swash in Myrtle Beach, SC demonstrate that juvenile barracuda occur regularly in this habitat. A second species, the northern sennet, *Sphyraena borealis*, occurs sporadically. Young of the year first appear in March or April and recruitment continues through mid-summer. Growth is more rapid than in most other inlet species and larger juveniles emigrate from the inlet in the late fall. Stomach contents reveal that juvenile barracudas, like the adults are piscivores. Although they may use *Spartina* marsh or oyster reefs as refuges, a majority of individuals were collected from open water habitats in mid-creek.

2.4 1 O C

Morris, J.T., Dept. of Biological Sciences, Univ. of South Carolina, Columbia, SC 29208. **DETERMINANTS OF THE CHEMISTRY AND FERTILITY OF INTERTIDAL MARSH SEDIMENTS.**

The chemistry of intertidal marsh sediment reflects the history of terrestrial loadings to the coastal zone, marine inputs, and local biogeochemical processes. Cooper River, SC marshes have significantly greater ammonium and soluble reactive phosphorus (SRP) concentrations than North Inlet, SC marshes and are probably more fertile as a consequence of nutrients supplied in terrestrial runoff. The most fertile marshes along the Cooper R. occur in brackish sediments adjacent to the location in the river where dissolved materials transported downstream tend to flocculate upon mixing with salt water. North Inlet marshes receive little or no terrestrial runoff. Sulfide concentrations are also significantly greater in the Cooper River salt marshes, and this may increase SRP by reducing Fe(III). Even a North Inlet site fertilized for 10-yr with PO_4 at $15 \text{ mol m}^{-2} \text{ yr}^{-1}$ had lower SRP concentrations ($16.1 \mu\text{mol/liter}$) than the Cooper River salt marsh ($21.9 \mu\text{mol/liter}$). Thus, phosphorus appears to be less soluble at North Inlet. Although SRP concentrations at North Inlet are extremely low, primary production there is limited

by nitrogen, probably due to the ability of *Spartina* roots to precipitate ferric-phosphate.

16 30 P-1 C

Morris, L.J., Virmstein, R.W., Miller, R.R., St. Johns River Water Management District, Palatka, FL. **A MULTI-MEDIA APPROACH TO MONITORING FIXED SEAGRASS TRANSECTS IN THE INDIAN RIVER LAGOON, FL.**

Seagrass has been mapped in the Indian River Lagoon (IRL) on a large-scale, Lagoon-wide basis since 1986. Although these maps have been instrumental in distinguishing healthy and problem seagrass areas, they have been unable to detect short-term changes due to either natural or anthropogenic events. Therefore, fixed transects are now being used as a technique to monitor for short-term, smaller-scale changes. The protocol includes a combination of visual estimates and actual counts to determine percent cover, canopy height, and a shoot density for each species of seagrass present. The entire transect is also video-taped to provide a visual archive. All data are entered into the Geographical Informational System (GIS) with the use of a CD ROM. A layered approach is used to include the Lagoon-wide seagrass maps, the individual transect sites, data, and video. The entire data base is then setup so that the data may be retrieved from the computer using a "point and click" procedure off the screen. This new, multi-media technique has made great advances in not only allowing a large number of scientists to obtain transect data but to also repeatedly view a particular seagrass bed from a specific archived date.

37 47 P-2 C

Morris, M.R., Beckwith, A.M., University of Maryland Eastern Shore, Department of Natural Sciences, Princess Anne, MD. **THE FUNCTIONS OF VERTICAL BARS AS A SEXUALLY SELECTED SIGNAL IN THE SWORDTAIL FISH XIPHOPHORUS CORTEZI.**

The vertical bar pattern found on males in *X. multilineatus* appears to function as signal to deter rival males and attract females. Here we examined the function of the bars in the closely related species *X. cortezi*. In laboratory experiments, we determined if males responded more aggressively to males that had their bars removed by freeze-branding than to control males of the same size that were freeze-branded between the bars. We also tested females to determine if they preferred to associate with control males over males of the same size that had their bars removed. The roles that male-male competition and female choice may have played in the evolution of the bars were further examined by comparing the responses of *X. cortezi* males and females to those of *X. multilineatus* and *X. nigrensis* males and females. Our results show that males fought more aggressively with males without bars; therefore, bars appear to function in repelling rival males (male-male competition). Also, females did not show a preference for association with males with bars over males without bars.

25.1 4 O C

Morse, J.W., Department of Oceanography, Texas A&M University, College Station, TX. **SEASONAL VARIATION OF SEDIMENT GEOCHEMISTRY AND TOXIC METAL SPECIATION IN ORGANIC CARBON RICH AND POOR CHESAPEAKE BAY SEDIMENTS**

Time-dependent processes influencing the potential bioavailability of toxic metals residing near the sediment-water interface of anoxic estuarine sediments were investigated at two sites in Chesapeake Bay over a 10 month time span. The sites were chosen because the sediments, although sulfidic at both sites, differ considerably in grain size (S<50% and M>95%, <63 μm size fraction) and organic carbon content (S~0.4 wt% and M~3 wt%). Other components such as reactive-Fe, AVS, TRS and toxic metal content also exhibit large differences between sites. Although seasonal variations in the absolute concentrations of reactive solid phase components is much larger at site M than site S, the relative variations are often similar. Comparisons made between sediments very near (0-2 cm) the sediment-water interface and at depths close to where maximum sulfate reduction rates occur (6-9 cm) indicate that for some metals (e.g., Hg) concentrations of reactive plus sulfide (HCl+HNO₃ leachable) fractions vary seasonally more at depth than near the sediment-water interface. A possible explanation for this observation is the large seasonal changes in AVS and TRS concentrations occurring at depths within the sediment where redox processes are most dynamic.

3.2 2 O I

Mountford, K., USEPA Reg.III, Chesapeake Bay Program, Annapolis, MD. **ENVIRONMENTAL INDICATORS: A LONGER VIEW.**

Communicating information from technical and regulatory programs is a continuing dilemma, the horns of which are scientific accuracy and simplicity. Environmental indicators are buzzwords for today's manager and attempt-driven by the government performance requirements act-to bridge that gap. This paper addresses the realities of setting measurable environmental goals, when, in fact, results may not be directly connected to actions; what to do when you fail to attain the objective, when success stories are overwhelmed by events, when analytical or survey resources are lost but you still need to get out a responsible message to the people who support your work and a public that's entitled to results from their tax dollars. You can do it.

14.1 2 O C

Muehlstein, L.K., University of Richmond, Richmond, VA. **LONG-TERM CHANGES OF A SEAGRASS COMMUNITY, GREATER LAMESHUR BAY, ST. JOHN, US VIRGIN ISLANDS.**

Greater Lameshur Bay is located within the boundaries of the Virgin Islands National Park and is suffounded by an undisturbed watershed. Analysis of aerial photographs starting in 1954 indicated the dynamic nature of this seagrass habitat. Total seagrass area increased significantly from 1954

to 1971, declined significantly after a large disturbance in 1989 (Hurricane Hugo), and gradually increased in area by 1994. Following Hurricane Hugo, three permanent seagrass transects were established in Greater Lameshur Bay in cooperation with the Virgin Islands National Park, at depths ranging from 4-10 meters. Yearly, monitoring of the transects indicated a typical successional pattern following a disturbance event, with the deeper seagrass community recovering at a slower rate. *Thalassia testudinum* decreased significantly following the hurricane and gradually increased during the fourth and fifth years. *Syringodium filiforme* increased following the hurricane and gradually decreased during the fourth and fifth years. Data from these transects indicate that recovery will take more than five years. This continuing long-term study is an important contribution to resource management within Virgin Islands National Park which will be used in assessment of new regulations that eliminated anchoring in this part of the park.

5.2 3 O C S

Murrell, M.C., Silver, M.W., Institute of Marine Sciences, University of California, Santa Cruz, CA 95064, and Hollibaugh, J.T. Tiburon Center, San Francisco State University, P.O. Box 855 Tiburon, CA 94920. **THE ROLE OF MICROZOOPLANKTON IN THE NORTHERN SAN FRANCISCO BAY FOOD CHAIN.**

Suisun Bay, a sub-embayment of Northern San Francisco Bay, is characterized by high turbidity, low phytoplankton production and relatively high bacterial production (2 to 5 times phytoplankton production). The fate of this bacterial production is poorly understood, but may be important in the food web. We hypothesized that microzooplankton, particularly phagotrophic ciliates and flagellates, were dominant grazers of bacterial production. Dilution experiments results, however, suggest weak coupling between bacteria and microzooplankton. To explain these results we believe the Asian clam, *Potamocorbula amurensis* may be a significant predator on microzooplankton. We did predator exclusion experiments to examine external controls on microzooplankton. Size fraction treatments were whole water, <20 μm and <5 μm , which progressively excluded clams, microzooplankton and nanozooplankton. We monitored growth of prey organisms (bacteria and nanoflagellates) for several days. Data from these experiments may suggest top-down control of microzooplankton. Additionally we measured heterotrophic nanoflagellate abundance with the aim of establishing their potential grazing impact on bacteria. Measurements of total flagellate abundances are on the order of 1000 to 2000 ml^{-1} , which is similar, but slightly lower than other systems. Earlier measurements did not distinguish between autotrophic and heterotrophic forms, which is critical for assessing their potential grazing impact of these organisms.

22.2 1 O I S

Nakanishi, K., Chesapeake Biological Laboratory, University of Maryland, P.O.Box 38 Solomons, MD 20688; and **Baker, J.E.**, Chesapeake Biological Laboratory, University of Maryland, P.O.Box 38 Solomons, MD 20688, and **Cornwell, J. C.**, Horn Point Environmental Laboratory Cambridge MD 21613. **A GEOCHRONOLOGICAL RECONSTRUCTION OF ORGANIC CONTAMINANT LEVELS IN CHESAPEAKE BAY.**

Hydrophobic organic contaminants such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) are largely associated with the particulate phase in the natural waters. Sediments are the final destination for many of these particle-bound contaminants. In our study, we have evaluated concentrations of about seventy PCB congeners and fourteen PAHs in Chesapeake Bay sediments by gas chromatography-electron capture detection (GC-ECD) and gas chromatography-mass spectrometry (GC-MS), respectively. Surface sediments were collected throughout the Chesapeake Bay. In addition, a core sample (50 cm long) was taken from the middle of the Bay. Using Pb-210 dating, the sedimentation rate was estimated to be 0.5 cm/yr. The total PCB concentration is between 10 and 50 ng/dry g sediment and tends to decrease with depth. The total PCB concentration (77 congeners) in surficial sediment (0 - 1 cm) in the mesohaline Chesapeake Bay is 40 ng/dry weight, and is surprisingly uniform with depth to 22 cm (year of deposition about 1962). In contrast, levels of PAHs in surficial sediments are approximately one third of their maximum concentrations deeper in the core.

18.1 5 O I

Nance, J.M., National Marine Fisheries Service, Galveston, TX. **STATUS OF THE COMMERCIAL SHRIMP STOCKS IN THE GULF OF MEXICO.**

The need to better manage the Gulf of Mexico penaeid shrimp stocks, to insure that all involved may benefit from this common resource, has prompted this research effort. This assessment deals only with brown (*Penaeus aztecus*), white (*P. setiferus*) and pink shrimp (*P. duorarum*) from the U.S. Gulf of Mexico. Catch for the three species has varied greatly over the past 35 years. Brown shrimp has had the greatest yield, followed by white shrimp and then pink shrimp. Brown shrimp yield reached an apex in 1990, while white shrimp was greatest in 1986. Pink shrimp had its greatest catch in 1980. Brown shrimp catch has dropped the last four years, while white shrimp catch has declined away from the maximum over the past eight years. Pink shrimp dropped dramatically in 1986 and reached a low 1991. Pink shrimp catch increased the past two years. Recruitment of shrimp is greatly

dependent on conditions in the nursery areas. Recruitment for brown shrimp showed a steady increase from 1960 until 1990, but has dropped the last four years. The recruitment of white shrimp reached a peak in 1986 and has since shown a fluctuating decline. Pink shrimp recruitment showed a great decline in 1986 and has since been near this low level.

12.3 2 O I

Neckles, H.A., National Biological Service, Lafayette, LA, and **Durako, M.J.**, Florida Marine Research Institute, St. Petersburg, FL. **INDICATORS OF ECOLOGICAL CONDITION OF SUBMERGED AQUATIC VEGETATION BEDS.**

Management of submerged aquatic vegetation (SAV) beds depends on the ability to detect spatial and temporal changes in habitat condition and to identify mechanisms responsible for these changes. In 1992 approximately 60 researchers, State and Federal regulators, and environmental managers met to compile a suite of indicators of the ecological condition of SAV beds. Workshop participants suggested parameters that could be measured to quantify integrated responses of SAV to environmental stressors and parameters that could be measured to quantify pollutant exposure or habitat degradation. Ideal indicators would function across SAV habitat types over broad spatial and temporal scales. Proposed indicators fell into three classes according to their readiness for incorporation into a monitoring program. Parameters ready for implementation included macrophyte depth limit, shoot density, biomass, and species composition of SAV and macroalgae; parameters for which field tests are needed to further define ecological relationships and variability included algal biomass, macrophyte leaf width, and plant constituents; and parameters in developmental stages included automated measurement of leaf area index and genetic diversity. Water quality parameters should be measured continuously at permanent stations. The proposed indicators must be field-evaluated before they are used to assess regional long-term trends in SAV ecosystem condition.

16 31 P-1 C

Neckles, H.A., **Rizzo, W.M.**, National Biological Service, Lafayette, LA, and **Griffis, M.R.**, **Meaux, D.R.**, Johnson Controls World Services, Lafayette, LA, and **Boustany, R.G.**, National Biological Service, Lafayette, LA. **EFFECTS OF ELEVATED DISSOLVED INORGANIC CARBON ON GROWTH OF TWO SUBMERGED MACROPHYTES.**

Two species of submerged macrophytes were grown in greenhouse mesocosms for 6 weeks under conditions of ambient or enriched (3X ambient) concentrations of dissolved inorganic carbon (DIC). *Halodule wrightii* was grown in ar-

tificial seawater at 20 ‰ and *Vallisneria americana* was grown in a freshwater culture solution. Treatments were applied through continuous aeration of mesocosms with ambient or CO₂-enriched air. There was no difference in final shoot density or total biomass between treatments. However, in both species the proportion of total biomass allocated to aboveground tissue decreased significantly under enriched conditions. There was very little epiphyte accumulation on leaves of *V. americana* and the C:N ratio of the leaves increased with enrichment. In contrast, epiphyte density on *H. wrightii* increased with enrichment while the C:N ratio of the leaves declined. Results suggest that some communities may respond to rises in DIC concentrations with a shift in the balance between epiphytes and macrophytes. Photosynthetic enhancement by CO₂-addition was greater for plants of both species grown under enriched than ambient conditions, indicating increased photosynthetic capacity following growth at elevated DIC.

32.2 2 O C S

Nelson, T.A., Lin, J., Florida Institute of Technology, Melbourne, FL. **EVALUATION OF THE ABUNDANCE AND COMPOSITION OF EPIMANGLE COMMUNITIES AS EFFECTED BY MOSQUITO CONTROL IMPOUNDMENTS IN ST. LUCIE COUNTY, FLORIDA**

Mangrove marshes of the Indian River Lagoon, Florida, have been impounded (surrounded by systems of dikes) to control mosquito production. Epifaunal organisms growing on the roots of the red mangrove, *Rhizophora mangle*, were studied to detect possible effects of impounding on percent cover and community structure. A series of censuses were conducted to compare percent cover and community structure of epifaunal organisms between the roots located exterior and interior of the dike at three replicate sites of each of two impoundments. Temporal and spatial recruitment patterns were monitored using settlement plates. Preliminary data indicated that barnacles were significantly more abundant on the exterior of each site, while bryozoans and ascidians were significantly more abundant on the interior. However, total percent cover was not significantly different between the exterior and interior of the impoundments. Sets of four settlement plates were deployed at the six locations of each impoundment. Each set consisted of two permanent and two temporary plates. Permanent plates were deployed to monitor patterns in community development and will be examined every three months. Temporary plates were deployed to determine temporal differences in recruitment and will be examined and replaced every month.

8.2 2 O C

Nepf, H., M.I.T., Cambridge, MA. **THE INFLUENCE OF MARSH VEGETATION ON DISPERSION PROCESSES.**

Marsh vegetation, such as *Spartina alterniflora*, can affect dispersion processes, and thus the ability of a marsh system to dilute wastes. In addition, the dispersal effects of seagrasses can influence benthic recruitment. Vegetation modi-

fies dispersal processes in several competing ways. Velocity shears introduced by variations in plant population density on a large scale and by stem wakes on a small scale may enhance the process of shear-flow dispersion. In addition, turbulence produced in the stem wakes may increase both vertical and horizontal eddy diffusivity. While enhancing dilution on a local scale, this increase in diffusivity can diminish shear-dispersion on a larger scale. At very low flows and high population density two additional mechanisms are observed to increase the net dispersal of particles. First, mechanical dispersion, similar to that observed in porous media, arises from differences in individual particle trajectories created as the flow navigates within a dense field of obstructions. Second, at low stem Reynolds numbers, regions of slow or no flow are observed around the stem. These 'dead zones' enhance dispersion by capturing a portion of the dispersing material and re-releasing it after some delay.

21.3 1 O C

Nicolau, B.A., Adams, J.S., Ruth, B.F., Tunnell, J.W., Center for Coastal Studies at Texas A&M University-Corpus Christi, TX. **ESTUARINE FAUNAL USE IN A MITIGATION PROJECT, NUECES RIVER DELTA, TEXAS: 1989 THROUGH 1994.**

Long-term monitoring is essential in comprehending the impacts of regulatory decision-making regarding functional wetland mitigation. This project represents the continued commitment of the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and the Center for Coastal Studies at Texas A&M University-Corpus Christi to monitor the faunal and hydrological aspects of a failed mitigation project. Although mitigation goals of providing replacement *Spartina alterniflora* habitat failed, the project produced estuarine habitat in the form of nonvegetated bay bottom. Faunal sampling is essential in determining whether projects such as these are in fact 'total failures,' regarding habitat creation. Sampling occurred monthly at mitigation and natural marsh stations from June 1989 through August 1994. Habitat alteration caused by severe flooding during 1992 produced short term effects on epifaunal invertebrate and nekton populations and positively stimulated benthic macrofaunal production. While functional habitat differences exist, changing environmental conditions and time reveal faunal convergence between locations. Experimental plantings by researchers produced mixed results in 1992. Design modifications to 2.4 hectares of this site resulted in the creation of successful salt marsh habitat in 1994. Continued comparisons are necessary to provide a valid framework for evaluating further design modifications necessary to ensure total project success.

13.3 5 O C

Nieder, W.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 pollu-

tion 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.

2.4 5 O C S

Nietch, C.T., Morris, J.T., University of South Carolina, Department of Biological Sciences, Columbia, SC. **INTERSTITIAL WATER CHEMISTRY MONITORING AND METHANE PRODUCTION POTENTIALS TO ASSESS VARIATION IN THE ANAEROBIC METABOLIC PATHWAYS OF INTERTIDAL MARSH SEDIMENTS.**

Interstitial water chemistry was monitored at four marsh sites along a salinity gradient in the Cooper River over an annual cycle to evaluate temporal and spatial variation in methanogenesis and factors that may affect this metabolic pathway in tidal marshes. Depth profiles to 250 cm of chemical constituents were measured monthly at sites 15 m inland from the river bank. Pore water constituents analyzed included indicators of anaerobic microbial activity (dissolved CH₄ gas, S²⁻, and SO₄²⁻), major inorganic nutrients (NH₄⁺ and PO₄³⁻), and salinity. Methane production potentials determined from sediments collected at 5 cm depth intervals to 70 cm followed trends in organic matter at both freshwater and saline sites. Across a salinity gradient of 1 to 13 ppt methane concentration and production potential at the surface decreased from 116 to 17 μM and 1.3 to 0.06 μmol g⁻¹ d⁻¹, respectively. Winter dissolved methane concentrations were higher than summer values at the freshwater and mid-estuarine sites, highlighting the role of plant senescence in regulating methane production and transport. Sulfate availability had a major effect on the concentration of methane between sites, but the within site depth distribution of methane could not be explained by sulfate depth profiles alone. At the brackish and freshwater sites the occurrence of high methane concentrations below a zone of sulfate depletion, but within an area of relatively high sulfate concentration,

suggests that substrates other than sulfate may be limiting to sulfate reducing bacteria at these depths.

21 9 P-3 C S

Noe, G., Zedler, J., Pacific Estuarine Research Laboratory, Biology Department, San Diego State University, San Diego, CA. **SPARTINA FOLIOSA ABOVEGROUND AND BELOWGROUND GROWTH RESPONSE TO NITROGEN FERTILIZATION IN MICROCOSMS.**

Unlike results from field experiments, nitrogen-fertilized *Spartina foliosa* plants grown in microcosms retained nitrogen over winter and had increased stem density the following spring. Plants were subjected to three treatments in a vermiculite medium: fall fertilization, spring fertilization, and a control. Fertilized plants responded by increasing live aboveground biomass (fall: 406% increase, p=0.018; spring: 227% increase, p=0.053), and rhizome biomass (fall: 270% increase, p=0.012; spring: 197% increase, p=0.042), while root biomass was similar (p=0.208) between the treatments. Live aboveground:belowground ratios were similar in the fall (mean=0.41) and spring fertilized plants (mean=0.29, p=0.170), but the control (mean=0.20) was lower than the fall (p=0.038) and spring (p=0.026) treatments. Mean stem length was very similar between the three treatments. Fall-fertilized plants retained an estimated 21% of the added nitrogen and spring-fertilized plants 16%. Estimates calculated using only live stems and leaves are 5% in the fall and 2% in the spring treatment. The importance of belowground biomass to the analysis of plant allocation and nitrogen retention underscores the need to include belowground components in field studies of *S. foliosa*.

7.2 5 O C

Nordlie, F., Haney, D., University of Florida, Gainesville, FL. **SALINITY CONSTRAINTS IN THE DISTRIBUTION OF TELEOST FISHES IN GULF COAST SALT MARSHES.**

Salinity, once regarded as the ecological "master factor" in determining community structure in estuaries and salt marshes, may be the principal factor, assuming that physical factors are prime limiters to habitation in these systems. Salinity appears to operate as a threshold or boundary condition in determining the relative locations of various teleost populations in salt marshes of the Florida Gulf coast. Evaluations have been carried out of salinity tolerance patterns and osmotic regulatory capabilities of 10 teleost species whose abundances vary spatially and temporally in the salt marsh systems of Florida's Gulf coast. These species are grouped as follows: (1—transitory residents but widely ranging) *Mugil cephalus*; (2—outer edges) *Floridichthys carpio*; (3—widely ranging) *Adinia xenica*, *Cyprinodon variegatus*, *Fundulus confluentus*, *F. grandis*, *F. similis*, *Poecilia latipinna*; (4—inner edges) *Gambusia holbrooki*, *Jordanella floridae*. Each pattern is directly correlated with salinity tolerances and osmotic regulatory abilities of the species showing that pattern. The most euryhaline species are in groups 1 and 3. Five of the 10 species have freshwater populations as well as salt marsh populations.

2.1 I O C

Nowicki, B.L., Requentina, E., and Van Keuren, D., Graduate School of Oceanography, Narragansett, R.I. 02882. and Kelly, J.R., Battelle Ocean Sciences, Duxbury, MA. 02332. **SEDIMENT DENITRIFICATION: IS IT IMPORTANT IN REDUCING THE NITROGEN LOAD TO BOSTON HARBOR AND MASSACHUSETTS BAY?**

Sediment denitrification is a microbial process which converts dissolved inorganic nitrogen in sediment porewaters to N_2 gas, which is lost to the atmosphere. In coastal waters, it represents an important pathway for the loss of fixed nitrogen, which might otherwise be available to primary producers. Generally, little is known about the role of denitrification in reducing or remediating the effects of large anthropogenic nitrogen loads to the coastal zone. In Boston Harbor and Massachusetts Bay, denitrification was measured as a direct flux of N_2 gas from 88 sediment cores taken over a 3-year period (1991-1994) from 6 stations in the Harbor and 9 stations in the Bay. Rates of denitrification were significantly higher in Boston Harbor (mean = 54, range = 5-206 $\mu\text{mol } N_2 \text{ m}^{-2} \text{ h}^{-1}$) than in Massachusetts Bay (mean = 24, range = 1-64 $\mu\text{mol } N_2 \text{ m}^{-2} \text{ h}^{-1}$), and were correlated with temperature, sediment organic content, and macrofaunal activity. Highest rates occurred in highly organic sediments in the Harbor (mean = 64 $\mu\text{mol } N_2 \text{ m}^{-2} \text{ h}^{-1}$), with lowest rates at deep stations in Stellwagen Basin (mean = 13 $\mu\text{mol } N_2 \text{ m}^{-2} \text{ h}^{-1}$). Denitrification rates for Boston Harbor were often high relative to rates reported for other east coast estuaries, however, sediment denitrification accounted for only 12% (range 0-23%) of the daily N load to Boston Harbor.

31.1 2 O I

Nuttle, W.K., Ottawa, Ontario. **HYDROLOGIC RESPONSE TO RISING (AND FALLING) SEA LEVEL.**

Mean sea level is rising, some times, and it is failing other times. True, there is a general trend of rising sea level linked with global climate change. However short-term, non-tidal fluctuations in mean sea level exert a much stronger influence on coastal and near-shore areas, mediated by the response of coastal hydrology. For example in the record of monthly mean sea level at Key West, the long-term trend accounts for only 33% of the total variance; 44% of the variance is contained in a regular, 20-cm seasonal fluctuation. Seasonal and multi-year fluctuations in mean sea level have a direct influence on the amount and distribution of fresh groundwater inflow into the intertidal zone and on tidally-driven residual circulation in shallow coastal waters. These factors are often associated with the position of ecotones, and the productivity of near-shore ecosystems. It is suggested that a better appreciation of the ecological effects of relatively short-term sea level fluctuations will help us understand better the consequences of long-term sea level rise.

7 21 P-1 C S

Nyman, J.A., **McGinnis, T.E.**, University of Southwestern Louisiana, Lafayette, LA. **STUDYING THE EFFECTS OF MINIMAL MANAGEMENT AND HERBIVORY ON MARSH BREAK-UP.**

Marsh loss at Marsh Island, Louisiana is caused by internal erosion unrelated to tidal action. Unlike perceptions regarding marsh loss elsewhere in Louisiana, previous work at Marsh Island showed that marsh loss was relatively slow, unaffected by weir-management, and unrelated to plant stress. A new strategy to slow future marsh loss, implemented during the summer of 1993 in 2 areas at Marsh Island, controls water-levels in the isolated marsh interior where erosion occurs and requires no levees. Prior to installation of the minimal management structures, 2 similar unmanaged areas were selected for experimental controls. Six erosion stations were established in each of the 4 areas. We will measure soil Eh, soil strength, live root density, and shoreline position for 20 months to determine the new management's impact on marsh break-up. Field observations suggested that feeding and tunneling activities by nutria (*Myocastor coypus*) and muskrats (*Ondatra zibethicus*) contribute to marsh break-up; therefore, herbivory exclosures and additional erosion stations were constructed in each area to account for grazing pressure variability among areas.

33 42 P-1 C

Olson, D., Luther, M., University of South Florida Department of Marine Science, St. Petersburg, FL and MacAuley, G., Florida Department of Environmental Protection Florida Marine Research Institute, St. Petersburg, FL. **INVESTIGATION OF FLORIDA BAY DYNAMICS WITH SATELLITE DATA.**

Dramatic reductions in populations of seagrasses, sponges, fishes, birds, and crustaceans are occurring in Florida Bay, a shallow coastal lagoon encompassing 2200 km². Bounded by the Florida mainland to the north, the Florida Keys to the southeast, and the Gulf of Mexico to the west, this body of water is experiencing a complex phenomenon resulting in an overall decline in the health of the Bay. A cooperative effort is underway with the Florida Department of Environmental Protection's Florida Marine Research Institute, the US Geological Survey, and the University of South Florida's Department of Marine Science to compare three Landsat Multispectral Scanner (MSS) images to determine the feasibility of using historical remotely sensed data to map local conditions. MSS scenes interpreted include February 1975, April 1986, and May 1992. Preliminary results indicate that long-term changes are visible in the MSS data even though this sensor was not specifically designed for oceanographic applications. Project results will complement other Florida Bay studies at the FDEP and USGS including investigations of reflectance and sea surface temperature using Advanced Very High Resolution Radiometer (AVHRR) data, phytoplankton studies, and monthly aerial surveys. Additionally, this project has strengthened interagency communication and cooperation among the agencies involved.

24.2 5 O C

Onuf, C., National Biological Service, Corpus Christi, TX. **BROWN TIDE, SEAGRASSES AND LIGHT IN LAGUNA MADRE, TEXAS.**

A brown tide caused by a very dense bloom of an undescribed species of the new class *Pelagophyceae* was first reported in upper Laguna Madre in June 1990 and has been there continuously since. No change in response to reduced light was evident in the distribution of the seagrass *Halodule wrightii* along transects sampled before the brown tide in 1988 and resampled after the brown tide in 1991 and 1992; however, in winter 1993-94 losses were documented over 2.6 km² of bottom and by winter 1994-95 the area of vegetation lost had more than tripled to 9.4 km². Changes in biomass presaged the changes in distribution. Decreases in biomass at depths >1.4 m were evident 2 years before bare areas were detected. Reductions in biomass were more pronounced toward the south, consistent with a gradient of in-

creasing light attenuation from north to south. Apparently, *Halodule* is able to persist for relatively long periods under conditions of insufficient light by utilizing stored reserves. This capability accounts for the pattern of diminishing biomass over time where the seagrass persists in deeper areas and the long lag between light reduction and change in distribution where the seagrass succumbed.

31.1 6 O I

Orson, R.A., Warren, R.S., Niering, W.A., Arboretum and Botany Dept., Connecticut College, New London, CT. **TIDAL MARSH DEVELOPMENT STUDIES IN CONNECTICUT: INTERPRETING SEA LEVEL RISE FROM PEAT DEVELOPMENT.**

One of the most important assumptions made when investigating changes in rates of sea level rise through time, is that the sediments gathered for analysis are indeed not only tracking submergence rates, but are also capable of recording those rates for interpretation in future investigations. However, only rarely has this assumption been tested and, therefore, much of the evidence for accelerated sea level rise may be considered circumstantial. The Barn Island marshes in Stonington, CT offers a unique set of horizon markers which have been used to carefully assess the development of peat during the last century. The results suggest that marsh accretion may vary significantly between plant communities, with stable *Spartina patens* zones able to track sea level rise and *S. alterniflora* zones responding to influences other than direct sea level variations (i.e. decomposition rates). Further, the marshes do not appear to be adjusting to short term sea level changes, but rather trends which span 50 years in time. The results from this study may explain some of the high variability noted for accretion rates within and between systems and force a reevaluation of how to interpret sea level rise from sediment/peat accumulation investigations.

16 32 P-1 C

Orth, R., Nowak, J., Wilcox, D., Moore, K., Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, VA, and Bergstrom, P., U. S. Fish and Wildlife Service, Annapolis, MD, and Olson, M., NOAA, Annapolis, MD. **SUBMERGED AQUATIC VEGETATION IN CHESAPEAKE BAY: TRENDS IN DISTRIBUTION AND ABUNDANCE AND WATER QUALITY.**

Populations of rooted submerged macrophytes have been monitored annually in Chesapeake Bay since 1984, using low level aerial photography. Following the baywide decline of all species in the late 1960's and 1970's resulting in the lowest levels of plants in recent history, populations in many

locations have been generally increasing up to 1993, from 15,400 hectares in 1984 to 29,600 hectares in 1993, paralleling an apparent improvement in water quality parameters. Generally, populations were most abundant in mainstem bay areas or in close proximity of the mainstem. A decrease to 26,500 hectares in 1994, with declines primarily in lower or middle bay mainstem areas, may have resulted from two strong spring freshets in 1993 and 1994. Populations of several native as well as exotic species have shown expansions and contractions, both in depth distribution and horizontally up or down an estuary. These changes suggest that population shifts may be coupled to not only water quality changes but potentially to dispersal strategies of each species, with biological, as well as physical factors, influencing dispersal of propagules.

7.1 2 O C

Osgood, D.T., Ziemann, J.C., University of Virginia, Department of Environmental Sciences, Clark Hall, Charlottesville, VA. SUBSURFACE HYDROLOGY, NUTRIENT FLUX, AND SPARTINA ALTERNIFLORA PRODUCTION IN A DEVELOPING BARRIER ISLAND MARSH.

The mechanism of nitrogen limitation along a *Spartina alterniflora* production gradient was investigated in a developing marsh (~15 years of development) on the Virginia barrier islands. A fertilization experiment confirmed nitrogen limitation across the entire production gradient. Without a significant difference in nitrogen standing stocks along the same gradient, the mechanism of nitrogen limitation was unclear. Variables known to affect nutrient uptake (salinity, hydrogen sulfide, E_H , and pH) also failed to explain spatial patterns of production. Nutrient standing stock, when combined with porewater flow rates, gives an estimate of nutrient flux. Hydraulic head was measured hourly over seven tidal cycles along intertidal transects. Porewater flow volume was calculated based on changes in hydraulic head. There was 4.1 times higher porewater volume input over the tidal cycle through the more productive portion of the marsh. The root zone nutrient flux rate showed significantly more ammonium passing through the more productive portion (227 $\mu\text{moles tide}^{-1}$) compared to the less productive portion of marsh (36.8 $\mu\text{moles tide}^{-1}$). There has been speculation in the literature that an increased root zone nutrient flux may alleviate nutrient limitation. This study demonstrates that this mechanism may be important in developing marshes where nutrient stocks are poorly developed.

22.1 6 O I

Owens, M., Simons, M.L., Zelenke, J.L., Cornwell, J.C., Horn Point Environmental Laboratory, University of Maryland CEES, Cambridge, MD. ESTIMATION OF TRACE METAL INPUTS TO CHESAPEAKE BAY SUBTIDAL AND MARSH SEDIMENTS.

Modern geochronological methods and contaminant analytical procedures have made it possible to determine the burial fluxes of contaminants at individual sites within estuaries. Extrapolation of such information to create contami-

nant budgets is hindered by highly variable sedimentation rates and contaminant burial rates which can occur at both small (a few km or less) and larger (>10 km) spatial scales. At small spatial scales within the Chesapeake Bay, sediment focussing can account for much of the difference in sedimentation rates while at larger spatial scales, changes in sediment sources (ie. fluvial, oceanic, shore line erosion) may be more important. In the Chesapeake mid-bay region, the 15 km lateral transect variability in sedimentation rates is over one order of magnitude, the same as that observed for 300 km north-south transects. Limnological studies have used the sediment 210Pb inventory to correct for sediment focussing, and this approach has some utility in the estuary. In the relatively uncontaminated mid-bay area, our regional Pb burial rates suggest that Pb inputs are primarily from non-atmospheric sources. Tidal marsh cores show similar Pb profiles as subtidal cores and may be useful for establishing time trends and burial fluxes of metals.

-P-

5 15 P-1 C S

Pace, M., Carman, K., Department of Zoology, Louisiana State University, Baton Rouge, LA, **RESOURCE PARTITIONING AMONG MEIOBENTHIC HARPACTICOID COPEPODS IN A LOUISIANA SALT MARSH.**

Resource partitioning is an important factor in aquatic food webs. Knowledge of this partitioning is necessary to understand energy transfer among trophic levels, the degree of benthic/pelagic coupling, and organismal interactions in an ecosystem. This study tested the hypothesis that meiobenthic copepods living in the same environment exploit different nutrient resources. Radiotracer grazing experiments, and gut-pigment, fatty-acid, and visual (scanning electron microscope) analyses were performed to determine the feeding behavior of a natural assemblage of meiobenthic copepods. *Pseudostenhelia wellsi*, *Coullana* sp., *Cletocamptus deitersi*, and *Microarthridion littorale* were studied to ascertain whether copepod grazing *in situ* was on benthic and/or planktonic microalgae or nonalgal resources. Data suggest that *Coullana* sp. feeds predominantly on planktonic diatoms and secondarily on benthic diatoms. *P. wellsi* feeds at reduced rates on both benthic and planktonic diatoms and a nonalgal food source is suspected. *M. littorale* appears to be grazing on an algal source. It is not clear whether this source is benthic or planktonic. *C. deitersi* feeds predominantly on benthic diatoms and at a reduced rate on planktonic diatoms.

17.2 7 O C

Pace, M.L., Fischer, D., Institute of Ecosystem Studies, Millbrook, NY. **DECLINES IN MICRO- BUT NOT MACROZOOPLANKTON IN RESPONSE TO A BI-VALVE INVASION.**

Zebra mussels invaded the Hudson estuary in 1990-91 and have spread throughout the freshwater section. Increased grazing by zebra mussels has resulted in an 85% reduction in summer phytoplankton biomass since mid-1992. We used time series intervention models to analyze zooplankton abundance data over the period 1987-95 for changes coincident with the zebra mussel invasion. Significant declines in tintinnid ciliates, rotifers, and copepod nauplii have occurred. Surprisingly, the dominant macrozooplankton, *Bosmina longirostris* and cyclopoid copepods, have not declined. Declines in microzooplankton may be related to both loss of phytoplankton food resources and direct predation by zebra mussels. Macrozooplankton are likely less affected by mussel predation. Given the reductions in phytoplankton, macrozooplankton are either able to exploit alternative food resources or are not strongly food limited. Since macrozooplankton are primary food for most Hudson larval

fish, current results suggest the zebra mussel will not negatively impact use of the Hudson as a nursery by anadromous and resident fish populations.

34.2 3 O C

Paerl, H., Pinckney, J., Institute of Marine Sciences, University of North Carolina, Morehead City, NC, and Millie, D., U.S. Department of Agriculture, New Orleans, LA, and Schofield, O., Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ. **NEUSE RIVER PHYTOPLANKTON: SYNERGISTIC NUTRIENT AND HYDROLOGICAL CONTROLS OF BLOOM DYNAMICS - TIMING IS EVERYTHING (WELL ALMOST).**

A multi-year (1987-93) field and *in situ* bioassay study evaluated impacts of nutrient loading events on nuisance phytoplankton bloom (cyanobacterial, dinoflagellate) potential in the N-sensitive Neuse River Estuary, NC. Amounts and timing of external "new" N loading events, coupled with water residence time, salinity, and advection were overriding forcing features controlling phytoplankton productivity, biomass, community composition, and bloom potentials. Hydrological events indirectly controlled O₂ depletion and release of internal N (NH₄⁺) and P (PO₄³⁻) supplies. Large contrasts in phytoplankton production dynamics were observed between low discharge and high discharge years. Phosphorus was co-limiting only during high N discharge and loading events in late winter and spring. Rainfall-based N was an important new N source. Maintenance of bloom-free conditions will rely on substantial reductions in acute N loading, especially during high rainfall/runoff periods. Reductions can be achieved through timely and prudent applications of fertilizers, construction of vegetation buffer zones, no-till farming practices, close scrutiny and control of accelerating waste discharge from livestock and poultry operations, and adherence to wastewater effluent standards. Reduction of atmospheric N inputs must rely on statewide and national efforts to control escalating N emissions from fossil fuel combustion and agricultural sources.

29.2 1 O C S

Parsons, M.L., Turner, R.E., Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA 70803, and Dortch, Q., Rabalais, N.N., Louisiana Universities Marine Consortium, 8124 Highway 56, Chauvin, LA 70344. **A PALEOINDICATOR STUDY OF THE DEVELOPMENT OF EUTROPHICATION IN THREE LOUISIANA ESTUARIES.**

Riverine nutrient loading has increased significantly since the 1950's, although the development of estuarine eutrophi-

cation is not well known. Sediment cores were taken in three estuaries influenced primarily by external riverine input (Fourleague Bay), local processes (Terrebonne Bay), and both (Barataria Bay), representing from 55 to 330 years BP. Each core was split into 1 cm increments and analyzed for diatoms, sediment pigments, organic carbon and nitrogen, biogenic silica, and sediment grain size. A total of 33,726 diatom valves were counted among the three sites, representing 201 species from 60 genera. At all three sites, diatom valve concentrations and eutrophic species abundances increase upcore, as mesotrophic and oligotrophic forms decrease. The diatom assemblage shifts several times upcore at all three sites, with a trend towards more lightly silicified forms, suggesting increased competition for silica. Sediment pigment concentrations and biogenic silica content also exhibit increases upcore, indicating increased productivity.

3.2 3 O I

Pederson, J., Massachusetts Institute of Technology Sea Grant College Program, Cambridge, MA. **USING SCIENCE TO IMPROVE MANAGEMENT DECISIONS**

Current data and information on the impacts of contaminated sediments on organisms, populations and communities fall short of management needs in determining disposal of dredged materials. Although federally required chemical and biological testing results are available, there are gaps in understanding physiological or, more broadly, ecosystem responses. Two programs, one within and one external to the Commonwealth initiated a series of studies that focused on providing sediment transport, fate and effects information to managers and those involved with developing Massachusetts sediment quality criteria. This applied research approach has been valuable in assisting, albeit within a limited scope, those responsible for the state regulatory program, and is illustrative of the issues relating to governance, timely response expectations, differences in communication, and levels of certainty regarding conclusions that are held by managers and scientists. Lack of funding, weak commitment by high level administrators, and communication barriers are continuing impediments, whereas mutual trust, clear presentation of results to an informed audience, and flexibility in regulatory approaches are some of the criteria for success.

13.3 2 O C

Peele, E.R., Muller-Parker, G., Brainard, M.A., Western Washington University, Department of Biology, Bellingham, WA. **SEASONAL NUTRIENT LIMITATION OF PHYTOPLANKTON BIOMASS IN PADILLA BAY NATIONAL ESTUARINE RESEARCH RESERVE.**

Puget Sound is a complex system of interconnected fjords and coastal embayments. Primary productivity in the fjords is high (400-500 g C m⁻² y⁻¹), and nutrient limitation is not a major feature due to surface entrainment of nutrient-rich water from depth. However, in shallow embayments seasonal changes in nutrient availability may limit primary productivity. To test this, surface waters from three stations in Padilla Bay, WA were enriched with N, P and NP and growth of

photosynthetic microorganisms measured by chlorophyll fluorescence. When dissolved inorganic nitrogen was high (winter-spring), natural phytoplankton assemblages did not respond to N enrichment. Growth was slow (chlorophyll doubling time, 1.53 days) and limited by seasonal reduction in light and temperature. During summer when light and temperature were optimal, chlorophyll doubling times were short (0.55 days). Growth rates of microplankton did not change in response to the nutrient additions, although high accumulations of chlorophyll a biomass were obtained in N-enriched samples during summer. These results suggest that the addition of anthropogenic nutrients does not result in increased phytoplankton biomass in Padilla Bay during low light and low temperature conditions. However, there is the potential for seasonal nutrient limitation in some Puget Sound areas.

2.3 5 O C

Pelegri, S., Rivera-Monroy, V.H. and Twilley, R.R., University of Southwestern Louisiana, Dept. of Biology, P.O. Box 42451, Lafayette, LA 70504. **COMPARISON OF NITROGEN FIXATION AMONG TWO SPECIES OF MANGROVE LITTER AND SEDIMENTS.**

Leaf litter of *Rhizophora mangle* and *Avicennia germinans*, and sediment samples, were collected at the Shark River slough, the Everglades. The samples were incubated and nitrogenase activity assayed by the acetylene reduction method. All samples were dried and their C:N ratio determined in a CHN analyzer. Old litter leaves showed the highest ethylene production. A negative correlation was found between C:N ratio and ethylene production rates in mangrove leaves, while sediments had the lowest C:N ratio and ethylene production rates. Our hypothesis is that nitrogen fixation varies during leaf decomposition and in relation to the chemical composition of the leaves.

2.2 2 O I

Pennock, J.R., Schroeder, W.W. Marine Environmental Sciences Consortium, University of Alabama, Dauphin Island, Alabama. **NUTRIENT BIOGEOCHEMISTRY OF MOBILE BAY, ALABAMA: A RIVER-DOMINATED WARM-TEMPERATE ESTUARY.**

Biogeochemical processes in Mobile Bay are strongly influenced by the discharge of the Mobile and Tombigbee Rivers. DOC makes up ~80% of the total organic carbon in the estuary with concentrations averaging ~400 μM. TN concentrations range between 43 and 15 μM along the estuarine salinity gradient, of which DON, PON and DIN contribute ~40%, ~40% and ~20%, respectively. TP concentrations average ~2 μM of which 30-50% occurs as POP with the remainder occurring as DOP and PO₄. Of these nutrients, the dissolved inorganic species display distinctly non-conservative behavior during all seasons of the year as a result of phytoplankton uptake. However, neither phytoplankton biomass nor production display strong and repeatable seasonal patterns, averaging 2-7 μg chlorophyll l⁻¹ and < 300 gm C m² y⁻¹. Organic matter deposition leads to high rates of sediment oxygen demand. As a result, 'hypoxic' condi-

tions were observed over 50% of the time in bottom waters (<3 m) during the summers of 1993 and 1994. Several features of biogeochemical cycling in Mobile Bay (e.g. the nutrient/phytoplankton relationship and shallow water hypoxia) do not fit with classical paradigms of estuarine biogeochemistry but are likely important to warm-temperate estuaries in general.

20 51 P-3 C S

Perez, B.C., Wang, M., Rouse, Jr., L.J., Department of Oceanography and Coastal Sciences, and Rouse, Jr., L.J., Coastal Studies Institute, and Day, Jr., J.W., Coastal Ecology Institute, Louisiana State University, Baton Rouge, Louisiana. SUSPENDED SEDIMENT TRANSPORT ON AN ESTUARINE-COASTAL GRADIENT BETWEEN FOURLEAGUE BAY, LOUISIANA AND THE GULF OF MEXICO.

Transport of suspended sediments between Fourleague Bay, Louisiana and the Gulf of Mexico was estimated from TSS and current measurements eight times daily from 1 February 1994 to 1 May 1994 in Oyster Bayou. The bayou and adjacent marshes are influenced by the Atchafalaya River discharge, tides, and storm events. Peak cold front activity and river discharge characterized the study period. Net fluxes were ebb-directed and the suspended sediment loads fluctuated with wind direction and strength, and cold front activity, timing, and strength. Total suspended sediment levels ranged from 11 to 1527 mg/l. The highest TSS concentration recorded corresponds to the most intense winter storm of the study period and occurred on an ebb tide. Instantaneous sediment fluxes out of the estuary (ebb-directed, toward the Gulf of Mexico) were as high as 869 kg/s and fluxes into the estuary (flood-directed) were as high as 466 kg/s through the 1000 m³ cross section bayou. Time series analysis of the TSS record identifies characteristic time scales of 2 to 10 days, scales associated with the winter weather band.

9.2 2 O C

Perez, K.T., Davey, E.W., Johnson, R., Dettmann, E.H. Abdelrhman, M.A., Atlantic Ecology Division, US EPA, National Health and Ecological Effects Laboratory, Narragansett, RI. RIVERINE INPUTS OF AMMONIA INTO TWO NORTHEASTERN ESTUARIES.

Concentrations of ammonia in two watersheds were measured over a six month period. Differences in the levels and temporal behavior of ammonia were observed. Selected sampling revealed the source for the observed differences. Loading of total ammonia from riverine sources for each estuary were estimated over this six month period. These data show that land use within watersheds is a critical consideration when attempting to establish the suitability of a single estuary as a reference or control system for another.

32.1 3 O C S

Perez-Bedmar, M., Parkinson, R.W., Florida Institute of Technology, and Poole, B.D., Florida Department of Environmental Protection, Melbourne, FL. WINDOWING EF-

FECTS OF THE ABOVE-GROUND PRIMARY PRODUCTIVITY OF A FRINGING RED MANGROVE FOREST, EAST CENTRAL FLORIDA.

Prior to 1984, Florida statutes did not clearly regulate mangrove alteration (to cut, remove, defoliate, or otherwise destroy mangrove). In 1984, the "mangrove protection rule" was enacted and henceforth no person could alter mangroves without a site-specific permit. Provisions for selective trimming, assumed not to eliminate the biological integrity of the individual plant, were also included. Unfortunately, the permitting process was cumbersome and difficult to enforce. In addition, even the effects of selected trimming were debated by homeowners, regulators, and environmentalists. The paucity of scientific data ensured nonresolution of this controversial rule. This project was undertaken August 1993 to evaluate the effects of windowing (one form of selective trimming) on the above ground primary productivity of a fringing, monospecific, red mangrove forest. Four paired and statistically similar plots were monitored biweekly (litterfall) to monthly (DBH, light penetration) until April 1995. Then as much as 50% of the canopy was eliminated from four plots by removing lateral branches originating between five and fifteen feet above the forest floor (windowing). Post-impact monitoring will continue for one year, at which time trimming effects will be evaluated using standard statistical methods (e.g., ANOVA, BACI). To date (June 1995), windowing has had no effect, although long term trends will provide a more reliable measure of the impact.

11.2 5 O C S

Petersen, J.E., Kemp, W.M., University of Maryland, Horn Point Environmental Laboratory, Cambridge, MD. SCALING BIOLOGICAL, MATERIAL, AND ENERGETIC INPUTS TO EXPERIMENTAL BENTHIC-PELAGIC ECOSYSTEMS

A series of experiments were conducted in 1.0 m³ benthic-pelagic experimental ecosystems to assess the importance of different degrees of biological, material and energetic exchange with the outside world. Mesocosms in the material exchange series received an exchange of filtered estuarine water at a rate of 0%, 10% and 35% per day. Treatments in the biological exchange series consisted of 0% exchange, 10% filtered water and 10% raw estuarine water. In a pulsed series all mesocosms received an average exchange of filtered water at 10% per day, but treatments were delivered as 10% every day, 30% every 3 days, 70% every seven days. The energetic exchange series was subjected to three levels of mixing energy. The impact of different degrees of exchange is evaluated at several levels of ecological organization by tracing changes in total system production and respiration, nutrient status, and taxonomic diversity. Results indicate that biological, material and energetic exchange are all important factors governing experimental ecosystem development.

16 33 P-1 C

Peterson, B., University of South Alabama, Department of Marine Sciences, Mobile, AL, and Dauphin Island Sea Lab,

Dauphin Island, AL. **ENERGY FLOW FROM THE WATER COLUMN TO THE BENTHOS: THE POTENTIAL FOR A SUSPENSION FEEDING BIVALVE TO EFFECT SEAGRASS PRODUCTIVITY.**

One conspicuous plant-animal association within seagrass habitats of the Gulf of Mexico and Caribbean Sea is between turtle grass, *Thalassia testudinum*, and the semi-infaunal suspension feeding tulip mussel, *Modiolus americanus* (Leach). Biodeposits of some suspension feeding bivalves have been shown to be high in nitrogen and phosphorus. Therefore, filter feeding bivalves may act as a benthic-pelagic couple bringing planktonic production to the benthos and thereby elevate submerged aquatic vegetation growth by increasing the nutrients available to the rhizosphere. Feeding experiments were conducted to estimate the filtration and consumption rates of *Modiolus*. Nutrient content of the feces and C:N:P ratios of *Thalassia* were determined. These estimates allow the potential for *Modiolus* to effect *Thalassia* production to be examined.

34.2 2 O C

Pinckney, J., Paerl, H., Institute of Marine Sciences, University of North Carolina, Morehead City, NC, and Millie, D., U.S. Department of Agriculture, New Orleans, LA, and Schofield, O., Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ. **NEUSE RIVER PHYTOPLANKTON: TAXA-SPECIFIC GROWTH RESPONSES TO NUTRIENT ADDITIONS.**

Phytoplankton communities are mixed species assemblages that exhibit complex competitive interactions associated with nutrient acquisition and utilization. The outcome of these interactions determines community structure, function, and, sometimes, the formation of nuisance algal blooms. Manipulative experiments, using natural phytoplankton assemblages, provide insight into the primary factors structuring these communities. Using nutrient addition bioassays, we quantified taxa-specific growth rate responses of Neuse River phytoplankton to a range of nutrient concentrations and delivery rates. Carbon-specific growth rates were determined using the photopigment radiolabeling method which measures the rate of ^{14}C incorporation into chemotaxonomic carotenoids and chlorophylls. Photopigments were purified by HPLC and ^{14}C specific activity determined for each pigment using an inline flow scintillation counter. Phytoplankton growth in the Neuse River is generally N-limited, but nitrate, phosphate, and nitrate+phosphate nutrient additions stimulate growth rates of different taxonomic groups. The implication is that "non-limiting" nutrients may play a major role in the formation of nuisance algal blooms.

31.2 4 O C

Pont, D., Nicolas, J., Franquet, E., Centre National de la Recherche Scientifique, Lab. d'Ecologie, Arles, France, and Day, J., Hensel, P., Louisiana State University, Dept. of Oceanography and Coastal Sciences, LA, and Ibanez, C., Univ. of Barcelona, Dept. d'Ecologia, Barcelona, Spain, and Coulet, E., Reserve Nationale de Camargue, Arles, France.

IMPACTS OF RHONE RIVER FLOODS OF 1993-94 ON THE RHONE DELTAIC PLAIN

In October 1993 and January 1994, there were 50 and 100 year floods of the Rhone River which resulted in dike failures and flooding of large portions of the Rhone delta. Peak discharge of the October and January floods was 9450 and 10572 $\text{m}^3 \cdot \text{s}^{-1}$ compared to an average discharge of 1700 $\text{m}^3 \cdot \text{s}^{-1}$. Peak suspended sediment levels reached 3055 and 3534 $\text{mg} \cdot \text{l}^{-1}$ and sediment transport during the two floods was respectively 10.8 and 8.1 $\cdot 10^6$ Tonnes, which represent 125 to 166% of the mean annual solid discharge. 135 $\cdot 10^6 \text{ m}^3$ and 45 $\cdot 10^6 \text{ m}^3$ flowed in through the dike breaks representing 51 % of average annual freshwater inflow to the delta. Water levels in the main coastal lagoon were raised by 46 cm and the entire deltaic area went fresh, an impact which persist until now. At the sites of the dike failures, small subdeltas of coarse sediment were formed up to 1 m thick and covering about 10 ha. Accretion of fine sediment ranged up to 8 cm in different parts of the delta. Such floods were a part of the delta cycle in the past and in the future, controlled flooding of the Rhone delta will be necessary to offset rising sea level.

33 43 P-1 C

Porter, D.E., Jones, B., Jefferson, W. Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC. **THE UTILIZATION OF GEOGRAPHIC INFORMATION PROCESSING AND ADVANCES IN TELECOMMUNICATIONS FOR THE INTEGRATION AND DISSEMINATION OF DATA AND INFORMATION IN A MULTI-DISCIPLINARY, MULTI-LOCALE RESEARCH PROJECT.**

The problems associated with developing integrated environmental models for sustainable development range from understanding the physical/chemical mechanisms of transport and fate of potential pollutants, nutrients and water to validating predictive models of how ecosystems respond to developmental pressures to determining the most effective avenues for the assimilation and dissemination of data and information needed by multi-disciplinary researchers to develop their models. Fortunately, the development of newer technologies such as Geographic Information Systems (GIS), remote sensing, Global Positioning Systems (GPS) and environmental statistics will enable researchers and resource managers to develop integrated research techniques which were previously too complex or disparate to quantify. The utilization of these technologies can be integrated under the umbrella of Geographic Information Processing (GIP). When combined with advances in telecommunications and expanding use of the Internet and World Wide Web (WWW), new avenues for the assimilation and dissemination of data, metadata and derived information are being explored. As part of the NOAA-funded Urbanization and Southeastern Estuarine Systems Project, a multi-agency, multi-locale GIS has been developed in conjunction with an on-line information server to facilitate the flow of data, information and communication among a group of multi-disciplinary researchers.

21.4 4 O C

Portnoy, J.W., National Biological Service, Cape Cod National Seashore, South Wellfleet, MA. **EFFECTS OF DIKING, DRAINAGE AND SEAWATER RESTORATION ON BIOGEOCHEMICAL CYCLING IN NEW ENGLAND SALT MARSHES.**

Nutrient, iron and sulfur cycling were compared in adjacent natural and altered Cape Cod (Massachusetts) salt marshes to describe the effects of diking and to predict the effects of tidal restoration on sediment chemistry. Changes caused by the blockage of seawater flow, flushing of salt, and drainage were interpreted by comparing the modern hydrology, porewater chemistry and solid phase composition of both seasonally flooded and drained diked marshes with natural salt marshes. Porewater alkalinity, sulfide, ammonium and orthophosphate were much lower in the flooded than in the natural marsh, where sulfate reduction predominates. Porewater of the drained marsh was acidic (pH <4) and contained more than 1000 times the ferric and ferrous iron of the natural marsh, as a result of pyrite oxidation. Wetland subsidence of 80 cm in the drained marsh is due to the aerobic decomposition of organic matter. In greenhouse microcosm experiments, the addition of seawater to cores from the flooded marsh accelerated organic decomposition by sulfate reduction, evident in porewater changes, sediment subsidence, and significant losses of organic solids. Addition of seawater to the drained peat increased porewater pH, alkalinity, ammonium, orthophosphate and ferrous iron. Seawater restoration should proceed cautiously in diked salt marshes where the mobilization of nutrients may stimulate eutrophication in adjacent surface waters.

13.2 4 O I

Posey, M.H., Powell, C.M., Alphin, T.D., University of North Carolina at Wilmington, Wilmington, NC. **USE OF OYSTER REEF HABITAT BY FISH AND DECAPODS.**

Oyster have received considerable attention as an important fishery. However, the 3-dimensional structure of oyster reefs also may provide refuge and forage habitat for many fish and decapods. In areas where seagrasses are absent (southeastern North Carolina through Georgia), oyster beds may represent the major structural habitat in the low intertidal and shallow subtidal. Yet, relatively little attention has been directed towards their habitat function, especially compared to work on seagrass or salt marsh systems. We have conducted field sampling and laboratory experimentation to assess the use of oyster habitat as a refuge by selected fish and decapods, especially transient species such as blue crabs and shrimp. Field observations indicate greater use of intertidal oyster habitat compared to adjacent tideflats by a variety of decapods and fish. Laboratory mesocosm experiments indicate that certain decapods may be utilizing the oyster reefs as a refuge, with significantly greater use of oyster shell patches in the presence of predators compared to treatments lacking predators. These results and other studies confirming the importance of oyster beds as refuge and/or forage areas emphasize the need to manage these reefs not only for

oyster yields but also as a critical habitat for other species.

26 30 P-3 C

Poucher, S., Science Applications International Corp., Narragansett, RI, and Cairo, L., Miller, D.C., Environmental Protection Agency, Narragansett, RI. **THE KINETICS OF RESPONSES OF MARINE ORGANISMS TO REDUCED OXYGEN UNDER CONSTANT AND CYCLIC HYPOXIC REGIMES.**

In development of the dissolved oxygen (D.O.) criteria for salt waters of the northeast the EPA has recognized the need for a kinetic response database. Many marine and estuarine systems are characterized by variable oxygen concentrations with episodic, diurnal or tidal signatures. We have addressed the temporal aspect of hypoxic effects with a rigorous empirical approach which can be used to predict effects from any exposure condition. The approach has been exercised with a crustacean larvae (*Palaemonetes vulgaris*) and a juvenile fish (*Paralichthys dentatus*). Survival effects for *P. vulgaris* were determined using a two-tiered experimental design. Time to death was established over a range of constant low oxygen concentrations, providing a matrix of time:concentration dependent responses. Cyclic D.O. exposures were then designed to test the hypothesis that this matrix would be predictive of hypoxic regimes of extreme and moderate amplitudes. Results, in general, confirmed the hypothesis. A similar two tiered approach was used to predict the effects of cyclic exposures on growth for both species. Effects were more adverse than those predicted from the constant exposure model. These results can now be used to predict biological impacts from continuous field records of D.O.

9.1 1 O C

Powell, G.L., Matsumoto, J., Texas Water Development Board, Austin, TX, and Loeffler, C., Texas Parks and Wildlife Department, Austin, TX. **FRESHWATER INFLOW NEEDS OF SAN ANTONIO BAY AND THE GUADALUPE ESTUARY, TEXAS**

The Texas Water Development Board and Texas Parks and Wildlife Department are working jointly under legislative mandate to develop and apply scientific and engineering methods for determining the effects of and needs for freshwater inflow to the state's seven major estuarine systems. One such tool, the Texas Estuarine Mathematical Programming (TXEMP) Model, is a non-linear, stochastic, multiobjective, optimization model that is used to solve up to six objective functions that deal with sediments, nutrients, salinity gradients, biological productivity and fisheries of these valuable coastal areas. This paper presents modeling results for San Antonio Bay and the Guadalupe Estuary, a 579 km² area of open water bays, intertidal flats, seagrass beds and adjacent marshes on the central Texas coast that produces sport and commercial fisheries with a total economic value to the state of more than \$154 million per year. This estuary is also unique in Texas because large artesian spring flows in south-central Texas provide approximately

25% of the average annual inflow. A special TXEMP model solution set, the non-inferior set, is used to estimate optimal solutions for maximizing fisheries harvests over a feasible range of freshwater inflows from the minimum (MinQ) to the point of maximum harvest (MaxH). MinQ flows were calculated to be $1.27 \times 10^9 \text{ m}^3$, while the MaxH solution occurs at $1.41 \times 10^9 \text{ m}^3$.

17 30 P-2 I S

Powers, S.P., Harper, Jr., D.E., Rabalais, N.N., Marine Laboratory, Texas A & M University at Galveston, Galveston, TX and The Louisiana Universities Marine Consortium, Chauvin, LA. **EFFECT OF SEASONAL STRATIFICATION ON THE LARVAL SUPPLY OF BENTHIC INVERTEBRATES.**

During the summers of 1994 and 1995 experiments were conducted off the Louisiana continental shelf to determine the effect of stratification on the larval supply of benthic invertebrates. Samples of larvae were taken at three depths (above the pycnocline, just below the pycnocline and at the sea bed) using a modification of the passive larval collector (larval tube trap) both during and after stratification events. In addition to larval supply, larval settlement of infaunal and encrusting species, and adult community structure, were measured throughout the experiment. During the 1994 stratification event, larval supply was significantly higher in samples taken above the pycnocline as compared to samples below the pycnocline and at the sea floor. After the stratification event, no difference in larval supply at the three different depths was detected. Was a result of decreased larval supply, settlement of encrusting species was reduced under the pycnocline, but remained high above the pycnocline. Results of our study, indicated that the pycnocline can be a significant barrier to the supply of larvae during these stratification events. Results of this year's experiments will be presented and compared to these 1994 results.

22.1 4 O I

Presley, B.J., Baskaran, M., Boothe, P.N., Texas A&M University, Oceanography Department, College Station, TX. **HISTORICAL TRENDS OF METALS IN SEDIMENT AT TWO COASTAL LOCATIONS**

A radiometrically dated core from near the SW Pass of the Mississippi River shows constant sedimentation over the past 100 years. Al, Fe and Sc vary little over this time period, suggesting little change in mineralogy and grain size. A number of trace metals (Co, Cr, Cu, Ni, Zn, etc.) also show little change. On the other hand, some metals show large changes. Pb, for example, is constant at ~25 ppm until about 1950, then steadily increases, leveling off at ~35 ppm through the 1970s. It then decreases through the 1980s and 1990s to ~27 ppm. Starting about 1960, Cd and Ag increase from 0.1 ppm to 0.3 ppm before decreasing through the 1980s and 1990s. Ba was at a background 450 ppm until the 1950s and peaked at 1200 ppm about 1985. Another approach to historical trends was used in the highly disturbed Houston Ship Channel. Surface sediment there was greatly enriched in trace

metals in the 1970s and 1980s, according to university and state agency data. In 1994 we sampled at 35 locations along the inland portion of the ship channel and found much lower metal levels than those reported earlier, e.g., Pb avg. 50 ppm, max., 100 ppm and Zn avg. 150 ppm, max., 600 ppm.

7.2 6 O C S

Proffitt, C.E., Louisiana Environmental Research Center, McNeese State University, Lake Charles, LA, and **Devlin, D.J.,** Department of Biology, University of Southwestern Louisiana, Lafayette, LA. **DYNAMICS OF MANGROVE LEAF LITTER DECOMPOSITION: THE CONTRIBUTION OF GRAZING BY THE PULMONATE GASTROPOD *MELAMPUS COFFEUS* L.**

Two field experiments (beginning 8/93 and 7/95) assess grazing by the gastropod *Melampus coffeus* on mangrove leaf litter. In the 8/93 study, treatments consisted of individual tethered leaves exposed to snail grazing, individual leaves enclosed in mesh bags to exclude snails, and groups of leaves in bags. Decomposition of unbagged leaves was rapid, with 75 % dry weight loss at 3 weeks for *Avicennia germinans* and 4 weeks for *Rhizophora mangle*. Breakdown of bagged leaves was slower, with 75 % dry weight loss at 6 weeks for *A. germinans* and 26-40 weeks for *R. mangle*. Applying grazing rates (1.9 %/day on *A. germinans* and 1.4 %/day on *R. mangle* leaves) to the leaf litter standing crop provides an estimate of the total leaf litter consumed: 0.46 - 1.04 g/(m² day). Thus, grazing by *M. coffeus* accounts for the decomposition of from 34 - 76 % of the leaf fall of 1.37(0.47) g/(m² day). Because of high assimilation rates it is likely that *M. coffeus* larvae (>30,000 /snail year) and feces may account for a substantial proportion of the mangrove organic material exported to estuarine food webs. Data from the 7/95 experiment will be available by the meeting date.

21 10 P-3 C

Proffitt, C.E., Louisiana Environmental Research Center, McNeese State University, Lake Charles, LA, and **Devlin, D.J.,** Department of Biology, University of Southwestern Louisiana, Lafayette, LA. **SURVIVAL, GROWTH, AND SUCCESSION IN A SOUTHWESTERN FLORIDA MANGROVE RESTORATION SITE: YEARS 6-13.**

The 1.3 ha restoration site was planted in 1982 with *Rhizophora mangle* (about 2 propagules/m²). At site age 6.5 yr 85 % of site area was still vegetated with mangroves and the rest was open ground or water. In vegetated areas, *R. mangle* trunks/m² (not including seedlings and saplings) ranged from 0.87 ± 1.25 to 2.60 ± 1.24 . *Laguncularia racemosa* was the dominant or co-dominant throughout the site (mean & 1 S.D. tree trunk numbers/m² range: 2.13 ± 2.17 - 10.33 ± 6.17). *L. racemosa* densities were greatest near the outer edge of the site and in areas characterized as scrub (apparently stunted mangroves) and lowest in the middle of the restoration site. This may be because the middle of the site is further from the natural forest seed source that surrounds the restoration site. *Avicennia germinans* densi-

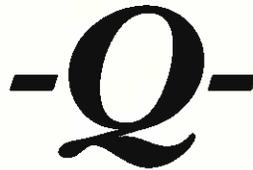
ties ranged $0.33 \pm 0.62 - 0.87 \pm 1.06 / m^2$ with trees occurring in a random distribution throughout the site. From years 6.5 - 8, heights of the co-dominants *R. mangle* and *L. racemosa* were very similar and growth rates essentially the same. Between years 8 and 11.4 *R. mangle* shows an apparent upturn in growth not seen in the other two mangrove species. Data from site age 13 yr will be available by the ERF meeting.

33.2 1 O I

Pulich, Jr., W., Blair, C., Texas Parks & Wildlife Department, Resource Protection Division, Austin, TX, and White, W.A., University of Texas, Bureau of Economic Geology, Austin, TX. REMOTE SENSING AND GIS ANALYSIS OF SEAGRASS LANDSCAPE DYNAMICS IN A MID-COASTAL TEXAS ESTUARY.

The Redfish Bay-Harbor Island complex near Port Aransas, TX, contains the most extensive seagrass (SAV) beds in the Corpus Christi Bay system. In order to document landscape-level dynamics and impacts to these SAV beds from environmental disturbances, distribution of SAV beds was analyzed from vertical aerial photography collected over 40 years. Seagrass beds were photointerpreted and mapped

at 1:24000 scale from 1952, 1958, 1974-75, 1979, 1987, and 1994 photos according to recommended NOAA-CCAP procedures. Digital, rectified thematic maps were produced by orthographic digitizing and map coverages were entered into an ARC/INFO GIS database. The GIS also included spatial data on physical factors (eg. dredged channels and spoil deposits, shoreline developments, boat propeller scarring, bathymetry, and wastewater discharges). GIS analyses revealed different site-specific correlations between SAV landscape changes and disturbance factors. Trend analysis showed a twofold increase in SAV acreage (mostly *Halodule* and *Ruppia*) between 1958 and 1979 for eastern Redfish Bay which was partially correlated with a rise in relative sea level after a mid-1950's drought. In contrast, significant decrease in SAV (mostly *Thalassia*) occurred between 1952 and 1974 in western Redfish Bay near the mainland due to channel dredging. Since the 1970's, continued SAV decrease in this area appears related to motorboat traffic and massive accumulations of seaweed wrack. The latter effects may reflect the increased urban development on the adjacent mainland.



3 12 P-1 C

Qin, P., Jiang, Y., Zhans, K., Xie, M., Department of Biology, Nanjing University, Nanjing China. A NEW FUNCTION FOOD AND A POTENTIAL DRUG FROM SPARTINA ALTERNIFLORA.

Biomineral Liquid (BML) is a dark brown concentrated extraction from *Spartina alterniflora*. The BML effective contents, that are essential mineral and bioactive materials from the salt marsh plant, drew our much interest. So we designed and arranged some researches and experiments on BML for food use. The toxicology research on BML proved that BML is nontoxic. A series of function tests showed that BML has significant role in resistance to lack of oxygen, prolonging life, cardiotoxic and especially in improving im-

munity of animal and human. The Ministry of Agriculture, China made a high appraisal of BML as first set of scientific items of Chinese green food. And the Ministry of Health, China approved the formal production of BML. During 10 years we have developed a series of biomineral beverage and food by BML, e. g. biomineral beer, drink, tea, milk, nutrition, etc.. In BML production we can set a bioactive material which is total flavonoid of *Spartina alterniflora* (TFS). TFS is a potential drug and its future is exciting. The initial research results showed that TFS can expand the cerebral blood vessel and dissolve the cerebral thrombus, and other research results indicated that TFS could reduce blood sugar content.

-R-

33.1 3 O C

Raabe, E.A., Stumpf, R.P., USGS Center for Coastal Geology, St. Petersburg, FL. EVALUATION OF FLORIDA'S BIG BEND TIDAL MARSHES: SATELLITE IMAGERY 1986-1995.

A 250 km stretch of coast encompassing Florida's Big Bend tidal marshes is examined with satellite imagery for signs of change between 1986 and 1995. Although the vast expanses of *Juncus roemerianus* (black needlerush) marsh do not exhibit seasonal change, as occurs in other coastal wetlands, winter/spring imagery is utilized to separate the deciduous wet-forest interior from the tidal-marsh environment. Short-term modifications such as bums, wrack lines, seasonal change, and water-level variations are documented with the imagery. Areas of vegetation recovery, succession, and loss correlate with regional variations in geology, hydrology and climate. Classification, vegetation indices, and field verification distinguish between temporary, recoverable losses and significant changes in habitat. Regional variations occur in the conversion between marsh, barren and transitional environments at the marsh interior, and along the southern mangrove belt. However, processes and anomalous conditions along the shoreline itself are less easily detected from imagery in this tidal environment. The extent and importance of the narrow bands of levees and low marsh habitat are clarified by comparison with earlier coastline documentation and by conducting supplemental field reconnaissance.

35 48 P-3 C

Rabalais, N.N., Cole, B., Dortch, Q., Louisiana Universities Marine Consortium, Chauvin, LA, and Justic, D., Temple, P.H., Turner, R.E., Louisiana State University, Baton Rouge, LA, and Klerks, P.L., University of Southwestern Louisiana, Lafayette, LA, and Kilgen, M.B., Nicholls State University, Thibodaux, LA. STATUS AND TRENDS OF EUTROPHICATION, TOXICS, AND PATHOGENS IN BARATARIA-TERREBONNE NATIONAL ESTUARY.

The status and trends of three priority problems (eutrophication, toxic substances and pathogen contamination) were identified for the Barataria-Terrebonne National Estuary. There is little evidence for changes in nutrient concentrations, but chlorophyll levels in parts of the estuary have increased substantially over the past decades. In some places, oxygen trends were improving, but overall the trends showed no change, and over half of the locations were classified as having poor water quality based on oxygen saturation. The toxic and noxious algae present in the system, to date, have not harmed human health, but they have discolored the water and caused some fish kills. The appearance of harmful algae may match a worldwide trend of increases with in-

creasing eutrophication. The amounts of toxic discharges to the Mississippi River have decreased but within the estuarine system have increased, and produced water discharge volumes are high. Contamination problems were found in water, sediment and fish and shellfish. There were no significant trends in fecal coliform counts over the past 15 years, and it appeared that there were no more areas closed to oyster harvesting in 1994 than in 1983. Fish kills, as a sign of acute stress in the ecosystem, were categorized.

12 10 P-2 C

Rabalais, N.N., Louisiana Universities Marine Consortium, Chauvin, LA. MACROINFAUNA COMPONENT OF EMAP-WETLANDS.

The EMAP-Wetland research program addresses the use of a suite of indicators in *Spartina alterniflora* marshes (as well as wetlands dominated by other plants) for assessing the ecological condition of U.S. wetlands and for classifying them as "healthy" or "impaired." Field sampling in 1993 re-sampled "correctly" classified sites from 1991 within the Mississippi Deltaic Plain and new Estuarine Emergent sites across Texas and Louisiana. A macroinfauna and epifauna component were added to the 1993 sampling which also measured vegetation and soil properties. Preliminary analyses indicate the following: Variability within sites and between sites is high. Epifauna are more abundant in the "healthy" than "impaired" marshes. As reported previously, samples with culms differ from samples without. Salinity and plant community-type are dominant factors in determining the faunal composition and density. However, some organisms, such as oligochaetes may be more abundant in the "impaired" habitats. Diversity is higher in the "healthy" habitats. Variability within "healthy" sites appears lower than in "impaired" sites. Final analyses should indicate which of these statements is supported and what environmental variables of the various marsh types are most important in structuring the infaunal community.

29 32 P-3 C

Rader, D.N., deFur, P.L., Environmental Defense Fund, Raleigh, NC and Washington, DC. CONTROLLING EUTROPHICATION AT THE WATERSHED LEVEL.

Eutrophication is a common occurrence in coastal and estuarine regions of North America. Numerous efforts are underway to develop management programs that control or manage input of nitrogenous pollutants to estuaries. Several programs, including Chesapeake Bay, Long Island Sound and Tar-Pamlico Sound attempt to go beyond controlling discharges from identified point sources. In Chesapeake Bay, atmospheric deposition is an acknowledged source of sub-

stantial nitrogen input, yet no measures control air emissions specifically to protect Bay water quality. In NC, a novel approach is under development to control nitrogen input at the watershed level. This approach includes non-point as well as point sources in a trading program which achieves rigorous nitrogen reduction targets and minimizes costs. We describe the criteria and method of constructing a nutrient management plan at the watershed level that includes land based sources of estuarine pollution, especially atmospheric emissions from large and small sources, such as hog farms. The plan is based on equivalencies among different forms of nitrogen and on relations among sources and aquatic systems. This quantitative basis for determining basin-wide loading and allocation systems improves on the current system that does not include most sources of nitrogen pollution in estuaries.

22 15 P-3 I

Rae, J.E., Allen, J.R.L., Postgraduate Research Institute for Sedimentology, The University of Reading, Whiteknights, Reading, RC, 6 6AB, UK. **TOWARD AN IMPROVED TECHNIQUE FOR THE DETERMINATION OF THE HISTORICAL PATTERN OF CONTAMINATION IN OXIC SEDIMENT.**

This study aims to explore a technique for the determination of historical contamination using oxic sediment depth profiles, which is more sensitive than the currently widely favoured technique in which total metals are determined. A salt-marsh sediment depth profile representing approximately the last 100 years from the Severn Estuary, UK, was intensively sampled at 10 mm intervals over a depth of 1-5 m. Total trace metal contents and sequentially extracted trace metals were determined in addition to the organic and inorganic carbon content of the sediment. Results indicate that the acetic acid extractable fraction of the sediment provides the most sensitive information for reconstructing historical pollution levels. Furthermore, the extraction step is particularly straightforward. It is tentatively suggested that this technique might be more widely adopted, and indeed, in many instances it would be more appropriate than determination of total metal profiles.

2 4 P-1 C S

Rafferty, P., Twilley, R., University of Southwestern Louisiana, Department of Biology, Lafayette, LA. **COUPLED VS DIRECT DENITRIFICATION IN TWO COASTAL LOUISIANA WETLANDS.**

A study was conducted in July, 1993 to determine the relative role of coupled and direct denitrification in two Louisiana coastal wetlands. One site, Old Oyster Bayou, is a mesohaline *Spartina alterniflora* marsh. The other site, Otter Bayou, is an oligohaline floatant marsh dominated by *Spartina patens* and *Scirpus olnii*. Replicate vegetated cores from each site were amended with either $^{15}\text{NO}_3$ or $^{15}\text{NH}_4$ and allowed to incubate for 7 days. Calculated denitrification rates from headspace gas samples indicated that coupled denitrification was important at the oligohaline site and not

at the mesohaline site. Rates of direct denitrification for Old Oyster Bayou ranged from 2.17 to 16.76 $\mu\text{mol m}^{-2} \text{h}^{-1}$ while coupled denitrification rates were 0 to 11.28 $\mu\text{mol m}^{-2} \text{h}^{-1}$. Coupled denitrification rates at Otter Bayou were 4.89 to 39.55 $\mu\text{mol m}^{-2} \text{h}^{-1}$ and direct denitrification rates were 3.12 to 36.78 $\mu\text{mol m}^{-2} \text{h}^{-1}$. Differences in the rates of denitrification in these marshes and the importance of coupled denitrification may be related to the relative availability of nitrate in each marsh.

15 24 P-2 C

Raj, P.¹, Aelion, C.M.^{1,2}, University of South Carolina, Department of Environmental Health Sciences¹, and Marine Science Program², Columbia, South Carolina. **DENITRIFICATION IN COASTAL FRESHWATER STREAM SEDIMENTS.**

Development in coastal areas can contribute significant quantities of nitrogen contamination to surface and ground waters. To determine whether denitrification, bacterial reduction of nitrate to nitrogen gas, impacts nitrogen cycling, experiments were carried out using sediment collected from two coastal streams, one located in a suburbanized area near Georgetown, South Carolina and the second in an undeveloped, protected area approximately 20 miles south. Slurries were prepared using approximately 3 g sediment per vial and acetylene was added to the vial headspace to inhibit the final step of denitrification, the conversion of nitrous oxide to nitrogen gas. Vials were amended with 0.1% glucose and nitrate concentrations ranging from 0 to 10 mM (per g dry wt sediment). At specified time intervals, vials were sacrificed and nitrous oxide was measured on a gas chromatograph equipped with an electron capture detector. Preliminary results indicate that approximately 700, and 1-2 ppm nitrous oxide was produced in sediments incubated with 1.0 mM and 0.015 mM NO_3 , respectively. Denitrification appears to contribute to nitrate removal from ground water and aquifer sediments, particularly at the suburbanized site at which initial denitrification rates were significantly greater than the protected site.

12.1 3 O I

Rakocinski¹, C.F., Brown², S.S., Gaston², G.R., Heard¹, R.W., Walker¹ W.W., Summers, J.K.³ ¹Gulf Coast Research Laboratory, Ocean Springs, MS, ²Biology Department, University of Mississippi, MS, ³U.S. Environmental Protection Agency, Gulf Breeze, FL. **ESTUARINE BENTHIC ASSEMBLAGES: BRIDGING THE GAP BETWEEN RESOURCE MANAGERS AND SCIENTISTS.**

Macrobenthic assemblages are good indicators of biotic integrity, but highly variable conditions confound the identification of estuarine macrobenthic indicators. Aside from anthropogenic stresses, natural gradients also impose physical limitations on the estuarine biota. Confounding occurs whenever correlations exist between natural variables and contaminant variables. Considering these limitations, we used diagnostic whole-community models to clarify relationships between benthic communities and multiple environmental

factors. Whole-community models reveal actual changes in ecosystem function and structure, just as biotic indices provide clear criteria for making sound resource management decisions. Relating whole-community models with biotic indices should build a bridge of communication between resource managers and scientists. Two whole-community approaches we used to assess anthropogenic changes in macrobenthic function and biodiversity in EMAP estuaries included trophic (feeding) analyses and Canonical Correspondence Analyses (CCA). Trophic analyses showed clear functional responses to both natural and contaminant gradients, while CCA showed distinct structural responses. Individualistic responses by characteristic indicator taxa revealed information regarding effects of specific contaminants.

11-2 6 O C

Ramsden, J., Dept. of Civil Engineering, Clemson University, Clemson, SC, Elder, B., Engineering Services, Tennessee Valley Authority, Chattanooga, TN, and McCutcheon, S. Dept. of Civil Engineering, Clemson University, Clemson, SC. **WETLAND WETTING AND DRYING IN A TWO-DIMENSIONAL HYDRODYNAMIC AND WATER QUALITY MODEL, CHARLESTON HARBOR, S.C.**

The Charleston Harbor Project includes development of a combined hydrodynamic and water quality model to be used by the State of South Carolina to allocate waste loads. The scope of this work includes modifying the water quality model to simulate wetting and drying, linking the hydrodynamic and water quality models together, and verifying the combined model transport using measured salinities. A two-dimensional vertically-averaged hydrodynamic model which is capable of simulating the wetting and drying of tidal flats was used to model the flow. The hydrodynamic results are spatially and temporally averaged for the water quality model which has computational cells about an order of magnitude larger than the cells in the hydrodynamic model. The combined models are currently being tested with a constant salinity to verify that the system conserves mass when simulating Charleston Harbor. The linked system conserves mass quite well for water quality model segments that remain wet continuously. A few mapping problems in the linkage between the hydrodynamic and water quality models are currently being corrected to eliminate some mass conservation errors in the wetland segments that become dry.

9.2 5 O C

Ranasinghe, J.A., Weisberg, S.B., Versar, Inc., Columbia, MD, and Gallagher, E.D., University of Massachusetts, Boston, MA. **MACROBENTHIC INFAUNAL ASSEMBLAGES OF VIRGINIAN PROVINCE ESTUARIES.**

The dominant benthic assemblages of the Virginian Province, and the environmental factors differentiating them, were identified using data collected with the same methodology in estuaries from Cape Cod to Chesapeake Bay. Assemblages were identified using cluster analysis and MANOVA. ANOVA was used to determine whether salinity, grain size, depth, and latitude differed significantly among sites where

the different assemblages occurred. Fourteen distinct assemblages were identified. Salinity was the primary environmental factor differentiating ten of the fourteen assemblages. Sediment type and latitude (estuarine system) were important in differentiating the other four assemblages, but were important only at salinities above 14 ppt.

32 43 P-3 C

Randall, T.A., Carlson, J.K., University of Mississippi, Dept. of Biology, University, MS, and Mroczka, M.E., Cedar Island Marine Research Laboratory, Clinton, CT, and Pellegrino, P.E., Southern Connecticut State University, New Haven, CT. **COASTAL MARINA BASINS AS POTENTIAL NURSERY HABITAT FOR JUVENILE WINTER FLOUNDER (*PLEURONECTES AMERICANUS*).**

The relative abundance of winter flounder (*Pleuronectes americanus*) was examined in a coastal marina basin to determine the potential importance of this habitat as a nursery ground. Juvenile winter flounder were sampled and collected from March-November of 1990 and 1991. A total of 564 winter flounder were collected for both sampling years with a one meter beam trawl. Young of the year were not present until May and growth and abundance increased until September. Although we found seasonal variation in physical parameters, there was no relationship between relative abundance and salinity, temperature, or dissolved oxygen levels throughout the study period. Avoidance from predation and an abundant food source may be an important factor in the selection of the habitat. We propose that the extensive nature of pilings and floats within the marina increase habitat complexity and thus provide a refuge from predation. These analyses provide evidence that marina basins may be important nursery areas for winter flounder.

3.1 2 O C

Ray, G.L., Clarke, D., U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, and Diaz, R, Virginia Institute of Marine Science, Gloucester Point, VA, and Bass R., U.S. Army Engineer District, Galveston, Galveston, TX. **BENTHIC CHARACTERIZATION OF OPEN-WATER DREDGED MATERIAL DISPOSAL AREAS IN GALVESTON BAY, TEXAS.**

The impact of repeated disposal of maintenance dredge materials in Galveston Bay have been examined by a characterization of channeledge, disposal area, and open bay habitats. Habitats in each of four transects located along the length of the bay were sampled semiannually for three years. Sediments and benthic communities were sampled with a Gulf of Mexico Box Corer while additional information was obtained by Sediment Profile Imagery. Results indicate that sand content and mean grain size of sediments were elevated within the disposal areas. These alterations, most likely due to winnowing of sediments resuspended by wind, waves, or navigation traffic turbulence, had little or no effect on benthic community diversity, abundance, biomass, and species composition. However, in sites where the concentration and mean grain size greatly exceeded that of ambient sediment, diver-

sity, abundance, and biomass were depressed and species composition was substantially altered. Such impacted sites were generally located near the center of the disposal areas where shoaling is most prominent.

20.4 1 O C

Raz-Guzman, A., Laboratorio de Ecología del Bentos, Instituto de Ciencias del Mar y Limnología, UNAM. AP 70-05, DF, México. **WHAT RELATION IS THERE BETWEEN THE LAGUNA DE TERMINOS AND THE SONDA DE CAMPECHE, MEXICO?**

It has long been thought that the estuarine system of Laguna de Términos in the southwestern Gulf of Mexico exports terrestrial organic matter available to consumers to the adjacent Sonda -de Campeche. A hypothesis based on this was tested considering the $\delta^{13}\text{C}$ of the dominant community components of both systems. This was not accepted for several reasons: *the isotopic composition of the marine fauna is close to that of marine phytoplankton, *isotopic values recorded inside the inlet of El Carmen through which materials are exported are lighter (-23.8‰) than those of the shelf (-18.8‰), *the littoral current carries the water that leaves the lagoon towards the west along the coast of Tabasco and away from the Sonda de Campeche, *the water that bathes the Sonda de Campeche carries carbonate-rich and isotopically heavy resuspended organic matter from the Campeche shelf. However, the lagoon can very well export energy to the shallow infralittoral area as inorganic and organic nutrients provided by the rivers, and this will be confirmed in the near future.

31.2 3 O C

Reed, D.J., LUMCON, Chauvin, LA, and Foote, L., Cahoon, D.R., Southern Science Center, National Biological Service, Lafayette, LA. **MANAGING COASTAL MARSHES IN THE FACE OF RELATIVE SEA-LEVEL RISE: IMPOUNDMENTS AND SEDIMENTATION.**

A four year study of structural marsh management in the Mississippi deltaic plain included assessment of sediment deposition and organic matter accumulation in four paired impoundment and control sites. The relative sea-level rise rate at these sites is approximately 1 cm per year. The purpose of the study was to assess the impact of this marsh management practice on sediment deposition and vertical soil development on brackish and intermediate marshes. Field techniques included marsh surface sediment traps, sediment settling traps, feldspar marker horizons and sediment-erosion table measurements. Cryogenic coring was used to obtain soil cores for the estimation of organic and inorganic accumulation rates. Three years of sediment deposition data show significantly lower rates of sediment deposition in impounded areas compared to controls. Vertical accretion rates are also lower. Management by impoundment reduces sediment inputs which may be vital to marsh survival in the face of sea-level rise. Soils data show some increase in organic content within impounded areas, but the organic accumulation rates do not appear to be adequate to compensate

for the lack of sediment. Improved methods of marsh management, now being planned for coastal Louisiana, must allow for sediment input to impounded areas.

25.1 2 O I

Reilly, Jr., F.J., The Reilly Group Inc. Stafford, VA and Mulhearn, J.B., ENSAFE Inc., Raleigh, NC. **COMPARING THE USE OF THERMODYNAMIC EQUILIBRIUM PARTITIONING DATA TO TISSUE RESIDUE DATA FOR RISK ASSESSMENTS.**

Risk assessments often involve predicting potential risks without a complete data set. One method used to predict uptake of neutral organic compounds from sediments that is gaining widespread usage is the Thermodynamic Bioaccumulation Potential (TBP). TBP estimates use bulk chemical sediment data and Total Organic Carbon (TOC) to predict the body burden of organisms exposed to sediments. Risk assessment decisions made using TBP to estimate body burden and Hazard Quotients at several estuarine locations were compared to risk assessment decisions at the same locations using more complete data sets. TBP estimations gave consistently higher estimates of body burdens in several marine organisms than actual chemical determinations of tissue residues in field collected organisms. TBP also gave higher estimated body burdens than were obtained by chemical determinations of organisms exposed to bedded sediment in 28-day bioaccumulation assays. Clearly TBP estimations give a very conservative estimate of potential body burdens, and provide a useful (if environmentally conservative) screening tool for estimating potential ecological and human health risks.

5.1 1 O C

Riera, P., Richard, P. CNRS-IFREMER, Centre de Recherche en Ecologie Marine et Aquaculture de l'Houmeau, France. **$\delta^{13}\text{C}$ ANALYSIS IN OYSTERS AND THEIR POTENTIAL FOOD RESOURCES WITHIN AN ESTUARINE ENVIRONMENT.**

We here address the question of sources of organic matter supporting food webs in the Marennes-Oléron Bay (France). Filter feeding bivalves are the main component of its animal biomass. The $\delta^{13}\text{C}$ method was used to point out the significance of intraspecific variability in *Crassostrea gigas* inhabiting along a longitudinal estuarine trophic gradient. Four characteristic oyster sites from the most "terrestrial" one to the most "marine" one were sampled. $\delta^{13}\text{C}$ values indicated an estuarine POC gradient from riverine (-27.4 to -29.2‰) toward marine littoral (-21.7 to -19.5‰) environments. The POC trend was followed in specimens of oysters from three locations with $\delta^{13}\text{C}$ values ranging from -19.13 to -25.2‰. Particularly, a significant contribution of fluvial terrestrial -derived POC to the diet of *Crassostrea gigas* is shown in upper estuarine reaches. However, this trend was not followed in oysters located at the mouth of the river showing heavier $\delta^{13}\text{C}$ values than would be expected taking into account their intermediate position along the trophic gradient. These values are the consequence of a preferential

assimilation on benthic diatoms locally produced by intertidal mudflats and suggest the ability of oysters to discriminate between various types of organic particles.

12 11 P-2 C

Ringwood, A.H.¹, Keppler, C.², 1Marine Resources Research Institute, Charleston, SC. **2**University of Charleston, SC. **SEED CLAM GROWTH, A NEW BIOASSAY DEVELOPED DURING EMAP STUDIES IN THE CAROLINIAN PROVINCE: METHODS AND COMPARISON TO OTHER BIOASSAYS.**

Sediment bioassays are an important component of monitoring programs. Bioassays should be characterized by a number of attributes: balanced sensitivity, minimal time and effort, low incremental costs, and high value of information gained. The EMAP program has primarily relied on acute toxicity tests as indicators of potential toxicity of sediments, but these may not be valuable for estimating potential chronic toxicity. A new sediment bioassay based on a sublethal endpoint (growth) that was developed in conjunction with EMAP activities in the southeast (Carolinian Province) is described in this poster. Juvenile seed clams (*Mercenaria mercenaria*) are incubated in sediments for 7 days and the effects on growth rate ($\mu\text{g}/\text{clam}/\text{day}$) are determined. Optimization components include: use of hatchery-reared clams, size-sieving to insure a similar size range, standardized feeding regimes, use of juvenile animals in rapid growth phases, etc. When the results were compared to other bioassays conducted concurrently, seed clam assays were more sensitive than Ampeliscid amphipod assays and slightly less sensitive than Microtox.

12.2 4 O I

Ringwood¹, A.H., Keppler², C., Wert², M., Holland¹, A.F., Hyland,³ J., Marine Resources Research Institute, Charleston, SC., ²University of Charleston, SC., ³NOAA, Carolinian Province Office, Charleston, SC. **DEPLOYED OYSTERS AS INDICATORS OF ESTUARINE CONDITION.**

Hatchery-reared oysters (*Crassostrea virginica*) were deployed simultaneously at reference and degraded sites in SC estuaries for approximately 1 month. Juvenile bivalves with endogenously high growth rates were used because effects on growth can be detected in a short time frame. The effects on growth and bioaccumulation of metal contaminants were determined. Adverse effects on growth were observed at degraded sites. Metal concentrations of sediments were also measured. Many of the sediments were characterized by elevated concentrations of multiple metals (Cu, Pb, Cr, Zn, etc.). In most cases, the accumulation of metal contaminants in tissues was a function of sediment metal concentrations. However, the concentrations of Pb in oyster tissues was inversely related to sediment concentration. These data indicated high bioavailability of some metals but low availability of others. Therefore measurement of the effects on growth provides an important index of the physiological effect of elevated contaminants. Furthermore, measurement of the

metal concentrations in a well-defined group of test animals provides an important index of bioavailability of metal contaminants. These studies suggest that physiological and bioaccumulation studies with deployed oysters may be used as in-situ indicators of habitat condition.

2.3 4 O C

Rivera-Monroy, V.H., Twilley, R.R., University of Southwestern Louisiana, Department of Biology, Lafayette, LA. **DENITRIFICATION IN MANGROVE SEDIMENTS IN TERMINOS LAGOON, MEXICO.**

Rates of direct and coupled denitrification were measured using ¹⁵N isotope techniques in intact sediment cores from fringe, basin, and riverine mangroves between 1990-1992 in Terminos Lagoon, Mexico. Sediments were injected with ¹⁵NO₃⁻ and ¹⁵NH₄⁺ and the distribution of ¹⁵N was measured over time in the headspace, overlying water, and sediments. The highest direct rates were measured in the fringe mangrove ($9.4 \mu\text{mol m}^{-2} \text{h}^{-1}$), while rates in the basin mangrove ranged from 0.7 to $7.7 \mu\text{mol m}^{-2} \text{h}^{-1}$ depending on concentration of NO₃⁻ added to the core. The lack of ¹⁵N production in cores from the fringe, basin, and riverine mangroves amended with $\leq 200 \mu\text{mol}/\text{core}$ ¹⁵NH₄⁺ and the high recovery of ¹⁵N in the sediment indicate that coupled nitrification-denitrification was not an important nitrogen transformation. Direct and coupled denitrification could be stimulated with enrichment of $450 \mu\text{mol}$ ¹⁵NO₃⁻ and ¹⁵NH₄⁺, respectively. Most of the applied ¹⁵N was recovered as particulate nitrogen in the sediment. High nitrogen demand in mangrove litter results in the immobilization of inorganic nitrogen and limits loss due to denitrification.

13.3 1 O C

Rizzo, W.M., National Biological Service, Southern Science Center, Lafayette, LA, and Dailey, S.K., Christian, R.R., Department of Biology, East Carolina University, Greenville, NC. **EFFECTS OF LIGHT REDUCTION AND NUTRIENT LOADING ON MATERIAL EXCHANGES BETWEEN EUPHOTIC SEDIMENTS AND THE WATER COLUMN IN ESTUARINE MICROCOSMS.**

Light reduction and nutrient loading associated with eutrophication have the potential to erode the functions of organic matter and oxygen production and limitation of nutrient release characteristic of benthic microalgal communities. We carried out microcosm studies with sediments from the Currituck Sound, National Estuarine Research Reserve, North Carolina, and Galveston Bay, Texas to determine the effect of light reduction (30-50%) and/or increased nutrient loading (8-10x ambient) on material exchanges. In the Texas experiment, chlorophyll *a* was significantly lower in the low light/low nutrient treatment than in the others. There was a significant interactive effect of light and nutrient treatments on light-saturated oxygen and ammonium flux rates. Phosphate fluxes were significantly reduced (87%) only by nutrient treatment. In the North Carolina experiment, oxygen production overall was affected by light treatment but not nutrient treatment and there was a borderline effect ($P=0.0764$)

on chlorophyll *a*, due to light effects. On the final day of the experiment, 92% of the variance in oxygen production was explained through multiple regression with light and chlorophyll *a* as significant variables. Oxygen uptake in the dark had 93% explained variance with significant effects due to light and nutrient treatment and to bacterial and meiofaunal densities.

16 34 P-1 C

Rizzo, W.M., Neckles, H.A., Boustany, R.G., National Biological Service, Southern Science Center, Lafayette, LA., and Meaux, D/R., Griffis, M.R., Johnson Control World Services, Lafayette, LA. **PHOTOSYNTHETIC RESPONSE OF FIVE SPECIES OF SUBMERGED MACROPHYTES TO INORGANIC CARBON ADDITIONS.**

Five species of submerged macrophytes (*Ceratophyllum demersum*, *Vallisneria americana*, *Hydrilla verticillata*, *Ruppia maritima*, and *Halodule wrightii*) representing freshwater, brackish and Gulf coastal salinity environments were assayed over an annual cycle for their photosynthetic response to additions of CO₂ and HCO₃⁻. In each experiment five treatment levels of CO₂ were used (0 to 600 μM) and one level of HCO₃⁻ addition (either 0.3 or 1 mM). In nearly 40 assays only *C. demersum* responded to HCO₃⁻ addition and only in one experiment. *C. demersum* and *V. americana* responded significantly to CO₂ addition in all experiments, *R. maritima* in none. The other species responded on some occasions and not on others. Rates of photosynthetic enhancement ranged from 1.4 - 8.3 times ambient. Highest rates of enhancement were found in *V. americana* and *H. wrightii*. Enhancement tended to be minimal in winter, but were highly variable in other seasons. Changes in CO₂ concentrations due to rising atmospheric CO₂ concentrations have the potential to alter the structure and function of communities of submerged aquatic vegetation across the entire salinity gradient.

1.1 I O C S

Robbins, B.D., Bell, S.S., University of South Florida, Department of Biology, Tampa, FL. **PATTERNS OF SEAGRASS DISTRIBUTION IN THE SHALLOW SUBTIDAL: QUANTIFYING TEMPORAL TRENDS IN FRAGMENTATION.**

Recent interest in shallow subtidal landscapes has focused upon the impact of human disturbance (e.g. propeller scars, urban effluent) on seagrass habitats. However, a paucity of information is available on seasonal and/or annual change in seagrass. This study documents variation in seagrass distribution at both a local (100's m) and a landscape (100's km) scale in Tampa Bay, FL. Our results show that seagrass areal extent varied both seasonally and annually. At the local scale, a net increase of 18% was recorded seasonally. An annual increase was also found. At the landscape scale, a net increase of 14% was documented over a four year survey. A decrease in fragmentation (i.e. seagrass habitat coalescence) was also recorded at both scales. Temporal and seasonal changes in seagrass meadows appear to be related to varia-

tion in seagrass species, water depth, sedimentation rate, and exposure. Our findings demonstrate that a landscape approach facilitates detection of spatial patterns in seagrass. In addition, we present a caveat to managers that factors other than readily apparent anthropogenic events may impact seagrass beds in the shallow subtidal at both a small and large scale.

13 17 P-2 C

Robertson, A., Gottholm, B.W., NOAA, Coastal Monitoring and Bioeffects Assessment Division, Silver Spring, MD. **TOXIC CONTAMINANT LEVELS IN OR NEAR ESTUARINE RESEARCH RESERVES.**

The National Estuarine Research Reserves system was established to provide a series of field laboratories for studying natural and human processes and for monitoring long-term changes affecting estuaries. Inputs of toxic chemicals provide one of the major types of anthropogenic stress threatening these areas. To assess this threat, sites for monitoring about 70 toxic chemicals have been established in or close to 14 of the 22 Research Reserves. These sites are part of NOAA's Mussel Watch Project and use measurements of bioaccumulation of toxic chemicals in bivalve tissues as a measure of the status and trends in ambient contaminant conditions. The levels for 8 metallic elements and 4 categories of the most problematic organic chemicals have been examined. In general the levels in or near the Reserves are close to the national mean for these chemicals at Mussel Watch sites. However, there are exceptions where high values relative to the national means are found. Specifically arsenic values are relatively high near the Reserves along the southeast coast; cadmium, copper, nickel, and zinc are high near Blackbird Creek in Delaware; copper and PAH's are high near the Rachel Carson site in North Carolina; total DDT's are high near Tijuana River Reserve, and total PCB's are high in the Narragansett Bay Reserve.

15.1 I O C

Robinson, J.H., Conner, S.D., Charleston Harbor Project, Charleston, SC. **THE CHARLESTON HARBOR PROJECT, AN OVERVIEW.**

The Charleston Harbor Special Area Management Plan (SAMP) is a multi-year effort designed to produce a comprehensive and enforceable management plan to address growth management and natural resource protection concerns throughout the Charleston Harbor estuary system. Its objective is to provide local leaders with the information required to manage growth and sustain the area's rich economic, cultural, and natural resources. Precursors to the SAMP concluded that while the estuarine system faces many problems and stresses related to the population and industrial growth in the area, the estuary appears to be in relatively good shape from a biological/ecological perspective. These studies concluded that with proper management of impacting activities, resource utilization and adjacent land use, it should be possible to maintain existing levels of estuarine quality and use. The SAMP research team is an interdisciplinary group comprised of individuals from local, state and federal agencies,

state universities, and the private sector. Projects are organized into four general topics: water quality model and nutrient dynamics, water quality management and best management practices, biological habitats, and land planning and cultural resources. Project staff and researchers have completed the planning and data collection phases and are currently developing the management strategy.

2 5 P-1 C

Roman, C.T., National Biological Service, University of Rhode Island, Narragansett, R.I. and Doering, P.H., South Florida Water Management District, South Palm Beach, FL. **PRIMARY PRODUCTIVITY AND NUTRIENT DYNAMICS IN A NORTHERN NEW ENGLAND FJORD-TYPE ESTUARY (SOMES SOUND, MAINE, USA).**

Somes Sound, located on Mount Desert Island (Maine, USA), is a fjord-type estuary with a long (8 km) and narrow (1 km) configuration, deep basins (50 m) and a shallow sill (10 m). Nutrient loading and primary productivity were evaluated seasonally as a baseline for long-term monitoring to assess the ecological status of this estuary. Less than 50% of the Sound's watershed lies within the protective boundaries of Acadia National Park. Mean concentrations of dissolved inorganic nutrients (e.g., NH_3 , 0.65 $\mu\text{moles/l}$; NO_3+NO_2 , 0.44 $\mu\text{moles/l}$) and chlorophyll *a* (0.8 $\mu\text{g/l}$) are low. Primary production was measured at four stations throughout the estuary, along a depth profile from the surface to 1 % light levels, during five seasonal periods. Mean production, as measured by the oxygen method, was 19.9 $\text{mg C/m}^3/\text{hr}$ throughout a photic zone that often exceeded 10 m. Despite low nutrient levels, Somes Sound could be classified as a mesotrophic estuary.

37 48 P-2 C

Romero, L., Fourqurean, J.W., Smith, III, T., Department of Biological Sciences and National Biological Service, Florida International University, Miami, FL. **DISTURBANCE INFLUENCES ON DEAD WOOD DYNAMICS AND NUTRIENT CYCLES IN MANGROVES.**

Dead wood comprises a significant proportion of the biomass in mangrove forests. The rates at which material cycles through the dead wood compartment is unknown. Furthermore, mangroves are subjected to disturbance at several spatial scales, from small lightning strikes (~0.05 ha) to large, catastrophic hurricanes (>10,000 ha) which may impact the dead wood compartment and nutrient storage and cycling in the forest. Here we report very preliminary estimates of N and P in the dead wood (branches and stems) component of mangroves and the impact of Hurricane Andrew. Dead wood biomass was increased 100X by the hurricane to some 160 ± 60 metric tons/ha. This represents some 0.14 ± 0.05 metric tons/ha of N and 79 ± 20 kg/ha of P. Standing dead stems, which remained dry, appear to have higher %N than fallen trunks which are regularly wetted by tidal action (0.76 ± 0.09 vs. 0.50 ± 0.10). Similar trends were noted for P. Turnover appears to be very slow. This latter observation being based on the presence in the forest of large numbers of downed

stems from Hurricane Donna in 1960. Based on these results it appears that dead wood comprises an important component in mangrove forest nutrient cycles.

17.1 6 O I S

Rooper, J.R., Holt, G.J., Univ. of Texas, Marine Science Institute, Port Aransas, TX. U.S.A. **APPLICATION OF RNA:DNA RATIOS TO ASSESS THE CONDITION OF LARVAL AND JUVENILE RED DRUM (*SCIAENOPS OCELLATUS*) IN ESTUARINE NURSERY HABITATS.**

RNA:DNA ratios were measured on laboratory-reared larval and juvenile red drum (*Sciaenops ocellatus*) to assess the effects of growth and starvation on biochemical condition. RNA:DNA ratios were correlated positively with both standard (mm d^{-1}) and instantaneous ($\% \text{d}^{-1}$) growth rates and decreased continuously with starvation (day 0-5). These results support the utilization of RNA:DNA ratios as indices of growth and nutritional condition for laboratory-reared red drum and led to investigating field applications of RNA:DNA ratios. Nucleic acids were quantified for individual larval and juvenile red drum (6-20 mm standard length) collected from estuarine seagrass habitats located near Port Aransas, Texas. Multivariate analyses were performed to determine biotic and abiotic factors affecting RNA:DNA ratios. Potential factors included: water depth, standard length, salinity, temperature, time of collection, and water clarity. Length and temperature were identified as significant factors and accounted for 55% of the variability in RNA:DNA ratios of individuals from natural populations. RNA:DNA ratios increased approximately 1.4-1.8 per degree centigrade and 1.0-1.4 per mm length. The effects of site (bay system) and habitat type (*Thalassia testudinum*, *Halodule wrightii*), were also assessed and significant difference in RNA:DNA ratios were detected between bay systems, but not between habitat types. Diel variations in RNA:DNA ratios were also investigated in controlled (constant) and natural (cyclical) temperature environments over a 48 h period. Since RNA:DNA ratios from controlled and natural temperature environments did not significantly differ, cyclical variations in temperature did not appear responsible for diel variations in biochemical condition. RNA:DNA ratios were highest during diurnal periods and showed marked declines at night.

4.1 4 O C

Rozas, L.P., Zimmerman, R.J., NOAA/National Marine Fisheries Service, Southeast Fisheries Science Center, 4700 Avenue U, Galveston, TX 77551. **DIRECT HABITAT USE BY FISHES AND DECAPOD CRUSTACEANS OF COASTAL WETLANDS AND SHALLOW SUBTIDAL AREAS IN GALVESTON BAY, TEXAS.**

We compared animal densities between two marsh systems (high vs low habitat interspersed) and among different types of intertidal and shallow subtidal habitats (pond, channel, cove, open bay, and three marsh types: *Spartina alterniflora* edge, inner *S. alterniflora*, and *Juncus roemerianus*) in lower Galveston Bay using a 1 m^2 drop sampler. In 140 drop samples, we collected 35 species of fishes

and 18 species of decapod crustaceans. Although none of the marsh or subtidal habitats was preferred by all species, most fishes and decapod crustaceans, which include several important fishery species, were more abundant in the marsh habitats than in the open bay. Fishery species were most abundant in low marsh edge habitat. Furthermore, marsh with a high degree of habitat interspersion supported a much higher standing crop of fishery species than marsh with low habitat interspersion. Our results support the hypotheses that in Galveston Bay: (1) nekton biodiversity in coastal marsh systems is related to the variety and quantity of marsh and shallow subtidal habitats present and (2) the primary nursery habitat for fishery species that use the marsh surface is low marsh interspersed with a dense network of shallow channels and interconnected ponds.

9.2 4 O C

Rudnick, D., Everglades Systems Research Division, South Florida Water Management District, W. Palm Beach, FL; and Halley, R., USGS, St. Petersburg, FL; and Robbins, J., CLERL, NOAA, Ann Arbor, MI; and Swart, P., Healy, C., RSMAS, U. Miami, Miami, FL. **RETROSPECTIVE STUDIES OF FLORIDA BAY.**

A vital part of any ecosystem restoration effort is knowing the ecosystem's historical condition, prior to anthropogenic disturbance. For Florida Bay, recent ecological problems, including widespread seagrass mortality and phytoplankton blooms, have been attributed to long-term changes in freshwater inflow, as well as changes in circulation patterns and nutrient inputs. These changes, however, have not been documented. We are assessing historical changes of Florida Bay by analyzing coral and sediment cores. In coral cores, the chronology of carbonate bands was estimated and $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ in these bands measured. This isotopic record indicates the impact the Florida Keys railroad, which was constructed around 1910 and restricted water exchange through Keys passes. No evidence of a long-term pattern of increasing salinity was found. Sediment cores were taken throughout the bay and analyzed to determine if chronologically undisturbed sediments exist in the bay. Despite the bay's shallow water and frequent hurricanes, cores with finely laminated sediments were found. Excess ^{210}Pb decreased exponentially in these cores, yielding a sedimentation rate of about $0.8 \text{ g cm}^{-2} \text{ y}^{-1}$. Calcareous benthic fauna preserved within these sediments indicate that Florida Bay had a more variable salinity regime in the 19th century than in recent decades.

17 31 P-2 C

Russell, D.E., Washington College, Chestertown, MD. **THE DIURNAL VERTICAL MIGRATION OF *MARENZELLERIA VIRIDIS* (POLYCHAETA: SPIONIDAE) IN THE CHESTER RIVER, A TRIBUTARY OF CHESAPEAKE BAY**

Marenzelleria viridis, a polychaete common in estuaries along the east coast of North America (and recently introduced to Europe), exhibits a diurnal vertical migration in

which individuals leave the bottom at night and swim in the overlying water. One objective of current research is to describe the temporal patterns of this behavior in the oligohaline portion of the Chester River. Plankton tows were made every two hours over a 24-hr period, during which sunset and sunrise corresponded with slack tide. Two distinct size classes were collected: juveniles (34-67 setigers, about 5-18 mm) and adults (>100 setigers, about 30-50 mm). The density of juveniles increased within an hour of sunset, exceeded $600/\text{m}^3$ by 2200 hrs, remained $>300/\text{m}^3$, and declined rapidly in the hour prior to sunrise to $1/\text{m}^3$, a density typical of daylight hours. Adults were rare. Emergence of juveniles immediately following sunset and the reverse migration at sunrise, both during slack water, suggest a response to light intensity as opposed to tidal flow. Weekly night plankton tows, begun in February, 1995, recorded juvenile densities $>600/\text{m}^3$ in February, increasing to $>1000/\text{m}^3$ in March, and thereafter decreasing through April to $<8/\text{m}^3$ in May and June. Juveniles were collected on ebb and flood tides; adults only on ebb tides and only occasionally. Neither contained gametes, nor appeared to be feeding in the water.

31.1 4 O C

Rybczyk, J.M., Day, J.W., Louisiana State University, Dept. of Oceanography and Coastal Sciences, Baton Rouge, LA, and Rismondo, A., Scarton, F., Are, D., Biotechnica Inc., Venice, Italy, and Abrami, G., University of Venice, Institute of Architectura, Venice, Italy. **MODELING THE EFFECT OF SEA LEVEL RISE ON THE PO DELTA, ITALY.**

As part of a European Community project to assess the effects of relative sea level rise on Mediterranean deltas, a STELLA model was developed to determine the importance of different biotic and physical factors affecting the ability of wetlands to survive rising water levels. The model consists of four sectors: primary production (above and belowground), decomposition, soil dynamics and elevation. Simulated plant production is controlled by temperature, soil salinity, hydroperiod and self shading. The soil dynamics sector utilizes a sediment cohort model that simulates changes in organic matter, bulk density and compaction with time and depth. Maximum rates of mineral sediment deposition are entered into the model as a forcing function, but are modified by simulated changes in wetland elevation. The model was initialized and calibrated using an extensive data set collected as part of the project and is designed to predict changes in surface elevation over several decades. The factors which were most sensitive in affecting wetland survival and surface elevation change were plant production, mineral sediment inputs, and the rates of eustatic sea level rise and subsidence. Given reported values for subsidence in the Po delta, the model predicts that mineral sediment input is critical for wetland survival.

14.1 4 O C

Rybicki, N.B., Carter, V., U.S. Geological Survey, Reston, VA, and McFarland, D.G., U.S. Army Corps of Engineers, Vicksburg, MS. **REVEGETATION AND PROPAGULE**

TRANSPORT IN THE TIDAL POTOMAC RIVER.

Revegetation of sites, even under the best conditions, will not occur unless macrophyte propagules are available. In the tidal Potomac River, flux of macrophyte propagules was measured on hardware-cloth traps at three unvegetated sites (April through September) to determine if adequate plant material was moving through unvegetated sites to result in revegetation if water clarity and other factors were favorable. The dominant species at all sites was *Hydrilla verticillata*. The mean biomass flux of *H. verticillata* at the three sites ranged from 1.05 to 0.06 grams dry weight $m^{-2} d^{-1}$. Laboratory tests of the viability of a subset of seven species transported to the sites ($n=641$ propagules) was > 70 percent. The light-attenuation coefficient (range = 3.5 to 4.5 m^{-1}), chlorophyll-*a* concentration (range 150 to 260 $\mu g l^{-1}$), and total suspended solids (range = 20 to 37 $mg l^{-1}$) were high at the three unvegetated stations. Deposition of viable propagules occurred throughout the season but revegetation was probably inhibited by poor water clarity.

23.2 2 O C

Saad, M.A.H., Abdel-Moati, A.R., Abdel-Atty, N.A., University of Alexandria, Faculty of Science, Oceanography Department, Moharem Bey, Alexandria, Egypt. **NUTRIENT SPECIES IN LAKE EDKU, AN EGYPTIAN COASTAL LAGOON TRANSPORTING CONTAMINATED DRAINAGE WATER TO THE MEDITERRANEAN SEA.**

Lake Edku, located at 30 km to the N.E. of Alexandria, receives annually $980 \times 10^6 \text{ m}^3$ of drainage waters from agricultural lands. This main water supply causes a rise of the lake level above sea level inducing a lake-sea current. Thus, this huge contaminated lake water is discharging into the Mediterranean Sea, via lake-sea connection, and affects the sea water at the area of discharge. Lake Edku and the other three coastal Nile delta lakes became efficient estuaries to the Mediterranean Sea after storage of the Nile water in the High Dam Lake. High concentrations of dissolved inorganic phosphorus (DIP) and nitrate were found in the vicinity of the main drains. Huge macrophytic populations in the mid-lake region regulate phosphorus levels. DIP constituted 38% of the total phosphorus (TP), while 40% of total dissolved phosphorus (DOP) in the lake water was dissolved organic phosphorus (DOP) showing dominance in macrophyte dominated area. Particulate phosphorus (PP) constituted between 25 and 49% of TP. Nitrate dominated dissolved inorganic nitrogen (DIN) species. Dissolved organic nitrogen (DON) constituted only a minor fraction of less than 24% of total nitrogen (TN). The averages DIN/DIP and DON/DOP were high, due to the high nitrogen content of the lake water. Silicon behaved nonconservatively during mixing of the lake and sea waters. Monthly variations of nutrient species were governed by fluctuations in drainage water discharges. More than half the amount of nutrients entering into Lake Edku via drainage waters are discharging into the sea.

37 49 P-2 C S

Saenz, L.L., Herzka, S.Z., Dunton, K.H. The University of Texas at Austin Marine Science Institute, Port Aransas, TX. **DIEL CYCLE IN THE MAXIMUM PHOTOSYNTHETIC RATE OF *THALASSIA TESTUDINUM* FROM EAST FLATS, CORPUS CHRISTI BAY, TEXAS.**

We examined diel changes in photosynthesis, as measured by oxygen evolution at saturating irradiance, in the seagrass *Thalassia testudinum*. PVC coring devices were used to collect whole plants from the study site for use in the laboratory. They were kept outdoors in an aerated tank exposed to saturating light at an *in situ* temperature of 33°C to prevent disruption of natural rhythms. Over the course of two consecutive days, the maximum photosynthetic rate (P_{max}) of

Thalassia testudinum was measured during seven pre-selected time periods each day. Clean blade segments were incubated in BOD bottles using an Endeco YSI oxygen electrode system; temperature was regulated with a circulating water bath. Three blade segments were irradiated with saturating light for an hour prior to data collection. Data were collected at five minute intervals over incubation periods ranging from 0.5 to 1.5 hours. Photosynthesis was determined from slopes by regression analysis of recorded time series for each incubation period. Results show that P_{max} was highest at dawn and early afternoon; P_{max} decreased briefly in the early morning, but the largest sustained drop occurred during the afternoon. The highest P_{max} , $448.01 \pm 76.61 \mu\text{M O}_2 \text{ g dry wt}^{-1} \text{ hr}^{-1}$, was seen on the first day at approximately 0800 h. The lowest P_{max} , $230.65 \pm 30.72 \mu\text{M O}_2 \text{ g dry wt}^{-1} \text{ hr}^{-1}$, was observed on the first day at approximately 2030 h. The second day showed a similar trend. This data suggests that photosynthesis in *T. testudinum* may follow a diel cycle that may be related to an endogenous rhythm or cumulative exposure to UV radiation.

36 50 P-3 C

Samocha, T.M., Lawrence, A.L., Lopez, M., McKee, D., Texas Agricultural Experiment Station, Shrimp Mariculture Project, Port Aransas, TX. **SHRIMP FARMS EFFLUENT WATER AND THE ENVIRONMENT.**

Management of a 450-acre shrimp farm in Texas, requires a daily water replacement of more than 100,000,000 gal/day at peak production. The nutrient-rich effluent water poses a potential threat to the environment. It is particularly true for Texas, in which the discharge is going into bays and estuaries behind barrier islands that have limited water exchange with the Gulf of Mexico. TNRCC requires aquaculture effluent to meet quality standards set for industrial and municipal discharge waters. Preliminary characterization of effluent water from three farms in south Texas, suggests that TSS levels are about six times higher than the 15 mg/l limit. Ammonia levels for one of the farms were lower than the 1 mg/l limit, while the CBOD₅ levels were higher than the 4 mg/l limit. Ammonia levels in the other two farms were above the limit, while CBOD₅ levels were below the limit. Preliminary monitoring of selected water quality parameters suggests a limited impact from the farms' effluent waters on the receiving waters. To ensure future growth of coastal aquaculture, researchers from TAES and TAEX are working with the farmers to develop cost-effective treatment methods to improve the farms' effluent water.

2 6 P-1 C

Sampou, P., HPEL-Univ. MD., Cambridge, MD, and **Barnes, J., Boynton, W.R.** CBL-Univ. MD, Solomons, MD.

BENTHIC RESPIRATION AT LOW OXYGEN CONCENTRATIONS, EVIDENCE OF OXYGEN INDEPENDENCE.

Sediment oxygen consumption (SOC) has been used to estimate total rates of respiration, integrating both aerobic + anaerobic pathways. A commonly observed phenomenon in sediment flux experiments has been the dependence of SOC on the overlying concentration of dissolved oxygen; as dissolved oxygen decreased rates of SOC also decreased. This has led to the interpretation that the rate of sediment carbon catabolism is dependent on oxygen availability. Inherent in the use of SOC as a total metabolic integrator is the requirement that sediment pools sizes of reduced endproducts of anaerobic respiration are in steady state and that reduced species are not exchanged across the sediment water interface. Time course sediment incubations (4 hours, 5 time points) were run from a variety of stations in the tidal reaches of Chesapeake Bay. Concurrent measurements of dissolved oxygen consumption and total carbon dioxide (a terminal endproduct of both aerobic + anaerobic metabolism) along with measurements of reduced species fluxes will be presented which suggest that the relationship observed between dissolved oxygen concentration and SOC is not the result of decreasing rates of sediment carbon catabolism but rather due to non-steady state concentrations of carbon reduced terminal electron acceptors, notably sulfides.

23.1 1 O C

Sanchez, A.J., Raz-Guzman, A., Barba, E., Florido, R., Peralta, P., Laboratorio de Ecología del Bentos, Instituto de Ciencias del Mary Limnología, DF, Mexico. **DISTRIBUTION OF DECAPODS IN THE GREATEST LAGOON SYSTEMS OF THE SOUTHWESTERN GULF OF MEXICO.**

The characteristics of salinity of the estuarine systems of Madre, Tamiahua, Alvarado and Terminos in the southwestern Gulf of Mexico are markedly contrasting. However, of the 62 species of carideans, penaeids, brachyurans and anomurans that have been registered, 45% is distributed in more than one lagoon. This overlap is attributed to the fact that 90% presents an ample or restricted distribution pattern that is associated with the habitat (AAH and RAH), whereas the other 10% are species of which the distribution is ample and not associated with the habitat (ANAH). The ample distribution is reflected in the marked physiological tolerance to the variation in salinity of the euryhaline species. The habitats that harbour the greatest percentage of species of decapods are submerged aquatic vegetation and shallow soft substrates without vegetation and with a great amount of detritus.

20.3 1 O C S

Sands, T.K., Millward, G.E., Turner, A., Department of Environmental Sciences, University of Plymouth, Drake Circus, Plymouth, UK. **TRACE METAL FLUXES AT AN ESTUARINE-COASTAL INTERFACE: THE HUMBER COASTAL ZONE, (UK).**

The Humber coastal zone (UK), situated off the North East coast of Great Britain, is a key boundary region comprising the dynamic estuarine-coastal water interface of the Humber Estuary and North Sea. Transport processes and particle-water interactions of trace metals in this region are highly complex due to the mixing of suspended particulate matter (SPM) from seasonally active sources. The Humber Estuary supplies 10^5 t/a of anthropogenically-modified SPM, 10^6 t/a of boulder clay is produced from coastal erosion to the north of the estuary and biogenic particulate matter is generated during spring/summer phytoplankton blooms within the plume. Comprehensive survey campaigns have been undertaken in the Humber coastal zone between 1990-95. Samples were collected, using clean ship-board techniques, over tidal cycles at anchor stations located in the mouth of the Humber Estuary, adjacent to the eroding coastline and at the entrance to the Wash. Dissolved and particulate trace metals (Fe, Mn, Zn and Ni) were determined to assess the transport and ultimate fate of trace metals at this estuarine-coastal interface. Flux calculations, derived from dissolved and particulate trace metal determinations and concurrently logged ADCP current data, indicate that the Humber Estuary is a primary source of trace metals to the region with fluxes exhibiting significant seasonal variation. Estimates of total metal fluxes at the Humber mouth anchor station varied from 19 kg/d in summer to 130 kg/d in winter for Ni and 34 kg/d in summer to 550 kg/d in winter for Zn. Elevated trace metal concentrations detected adjacent to the relatively pristine coastline indicate that a significant tidal mediated northward flux of contaminant estuarine SPM is occurring, a previously unquantified transport pathway with repercussions on the dispersion and uptake of trace metals throughout the region. The flux estimates were used in a fine sediment transport model of the Humber outflow to aid future strategies for the management and recovery of polluted coastal zones.

8.1 4 O C

Sanford, L., Suttles, S., UMCEES, Horn Point Environmental Laboratory, Cambridge, MD, and Halka, J., Ortt, R., Maryland Geological Survey, Baltimore, NM, and Maa, J.P.-Y., Virginia Institute of Marine Sciences, Gloucester Pt., VA, and Conley, D., National Environmental Research Institute, Roskilde, Denmark. **FIELD STUDIES OF SUSPENDED SEDIMENT TRANSPORT IN BALTIMORE HARBOR, MD.**

Baltimore Harbor, MD (the Patapsco estuary) is a broad, shallow (4 m) tributary of upper Chesapeake Bay, incised by narrow, deep (16 m) dredged shipping channels. Field studies of processes controlling rates of suspended sediment transport in the Harbor were carried out during late 1994 and early 1995, and modeling studies are ongoing. The field studies included side scan sonar and grab sample surveys, underway ADCP/CTD surveys, water samples, settling tube measurements, short term bottom tripod deployments, and detailed erosion rate measurements using an *in situ* benthic flume. The sediment surface usually consisted of a thin, flocculent surface layer with a more compacted silt/clay bed

beneath. Tidal currents were generally too weak to resuspend surface sediments, but wind-forced surface waves did resuspend sediments in the shallow reaches of the outer harbor. Wind-forced currents dominated short-term transport in both the shallows and the channels, with very large vertical shears and strong stratification especially apparent in the channels. Prop wash from shipping traffic was the most apparent cause of resuspension in the channels. A likely sediment transport pattern is episodic erosion from the shallows, deposition in the channels, and redistribution by shipping traffic (and dredging) and wind-forced currents in the channels.

15.2 4 O C S

Sanger, D.M., Holland, A.F., Riekerk, G.H.M., University of South Carolina, Columbia, SC., and South Carolina Marine Resources Research Institute, Charleston, SC. **WATER QUALITY, SEDIMENT METAL CONTAMINATION, AND MICROTOX® TOXICITY OF THE TIDAL CREEK ECOSYSTEM IN DEVELOPED AND UNDEVELOPED WATERSHEDS OF CHARLESTON, SOUTH CAROLINA**

Tidal creeks serve as conduits for non-point source runoff as well as access corridors for biota to the marsh. Development of tidal creek drainage basins has the potential to alter physical, chemical, and biological characteristics of these ecosystems. Defining the relationships between ecological condition of tidal creeks and watershed development is a major environmental issue associated with increasing development of the coastal environment. For this study, numerous parameters in tidal creeks were measured longitudinally in twelve developed (>75% urban) and twelve undeveloped (>75% wetland or forest) watersheds including grain size, sediment metal contamination, the solid phase microtox® bioassay, and water quality (dissolved oxygen, salinity, depth, pH, and temperature recorded every thirty minutes for two to three days). The developed and undeveloped creeks are both characterized by frequent exposure to low dissolved oxygen, especially during nighttime low tides. The average and the range of dissolved oxygen values were not statistically different between the developed and undeveloped creeks, however, the periodicity appears to be different. The chemistry and the microtox® bioassay indicate significantly higher chemical contamination in the headwaters of the developed creeks with some values in ranges known to cause biological effects.

0 1 O I

Scavia, D., NOAA, COP, Silver Springs, MD. **STEERING A COURSE THROUGH TROUBLED WATERS - CHARTING A WAY TO IMPACT PUBLIC POLICY.**

The current attack on sciences in the public forum arises both from a general misunderstanding of the purposes and role of science but also from a poor public image sometimes portrayed by scientists themselves. For one thing, science is somehow being linked inappropriately to regulation and to a variety of issues that arise relative to that regulation or to

long-term projects that do not appear to relate to real questions. Secondly, scientists' naturally combative approaches among colleagues, while constructive in debating scientific discoveries, often present a disconcerting image to others. Thirdly, scientists could improve the focus in applying public efforts where they count. To impact public policy at the science-policy interface coastal ocean scientists need to become proactive and positive in the following ways: Emphasize the predictive role of science in problem solving-science for solutions; think and act together in achieving consensus goals; develop partnership watershed efforts (including the study of uplands, estuaries, and offshore) aimed at achieving the consensus priorities; and make the consensus view known where it counts.

25.1 1 O I

Schaffner, L.C., Dickhut, R.M. Mitra, S., Lay, P.L., Thompson, M., School of Marine Science, The College of William and Mary, Gloucester Pt., VA 23062. **ROLE OF MACROFAUNAL BIOTURBATION AND METABOLISM IN ORGANIC CONTAMINANT TRANSPORT AND FATE IN ESTUARINE AND COASTAL ECOSYSTEMS.**

We have used laboratory and field experiments to evaluate macrofaunal effects, via bioturbation and metabolism, on organic contaminant (PAH, PCB) transport and fate. Our major findings are: 1) macrofauna may greatly enhance fluxes of compounds across the sediment-water interface via processes such as biodeposition and direct resuspension via feeding and burrowing; 2) bioadvective processes such as burrow irrigation and head-down feeding lead to rapid, localized, contaminant burial on short time scales (days to weeks); 3) diffusive processes, a function of bioirrigation, alterations in sediment porosity and contaminant physical chemistry, have important impacts on the final fate of compounds; 4) metabolism by macrofauna influences the trophic transfer of contaminants to demersal predators; 5) the relative importance of macrofauna-mediated processes varies as a function of community type. Macrofauna-mediated processes will serve to enhance the residence time of some compounds in aquatic ecosystems, but may enhance degradation rates of others. The final fate of organic contaminants is influenced by interactions among macrofaunal communities, microbial processes, contaminant physical chemistry and the physical environment.

9.1 4 O C

Scharler, U.M., Baird, D., University of Port Elizabeth, Department of Zoology, Port Elizabeth, South Africa. **A COMPARISON OF BIOTIC RESPONSES TO VARIABLE FRESHWATER INFLOW INTO ESTUARIES.**

Increasing freshwater abstractions from rivers to satisfy human water demands obviously effect natural freshwater users such as estuaries where a number of different habitats are created through an axial salinity gradient. Consequently reduced freshwater input results in decreased habitat diversity. Three temperate estuaries on the south-east coast of

South Africa (namely the Kromme, Swartkops and Sundays estuaries) were chosen for a study to assess the effects of an altered salinity regime on the diversity and productivity of its biotic communities. Their differences in the amount and frequency of freshwater input (Kromme: $1.16 \text{ m}^3/\text{sec} \pm 3.07$; Swartkops: $1.52 \text{ m}^3/\text{sec} \pm 2.14$; Sundays: $2.74 \text{ m}^3/\text{sec} \pm 1.03$, annual mean \pm SD) are reflected in salinity ranges (Kromme: 35 - 34; Swartkops: 35 - 15; Sundays: 35 - 4), as well as in nutrient and chlorophyll-*a* levels which are both positively correlated with higher freshwater input rates. The least number of species are found in the Kromme estuary, and the most in the Swartkops estuary, whereas the Sundays estuary occupy an intermediate position. Primary as well as secondary productivity is highest in the Sundays estuary because of high nutrient concentrations supplied by continuously inflowing freshwater. The Kromme estuary exhibits lowest secondary productivity ($967 \text{ mg C/m}^2/\text{d}$) of the three, but due to its extensive macrophyte beds its primary productivity ($2312 \text{ mg C/m}^2/\text{d}$) is higher than the Swartkops estuary ($1823 \text{ Mg C/m}^2/\text{d}$).

9 5 P-2 C

Schneider, R.L., Howarth, R.W., Cornell University, Section of Ecology and Systematics, Ithaca, NY. **CONTROLS ON ESTUARINE WATER QUALITY BY RIPARIAN ZONES ASSOCIATED WITH UPSTREAM TRIBUTARIES.**

There is growing concern about excess anthropogenic nitrogen inputs entering stream tributaries of the northeastern United States and impacting water quality in the downstream estuaries. Individual wetlands have been evaluated for their role as buffers in filtering out various contaminants, however, little research has considered the relative importance of different types of wetlands in a landscape context. The overall goal of this project is to understand how stream riparian habitats differ in their availability, structure, and ability to process nitrogen, along a gradient of increasing stream size within a large tributary network. GIS techniques have been used to characterize the availability of riparian habitats among different stream orders in different subwatersheds of the Hudson River in New York. These analyses indicate that first and second order streams dominate the tributary networks of most subwatersheds. An intensive field study is currently underway to examine the processing of groundwater nitrogen in the riparian zones of four sites from different stream orders. Preliminary data suggest that there are important differences in hydrologic processes and riparian structure between lower and higher order streams. The results of these studies suggest that riparian habitats in certain portions of the landscape may be "hot spots" for influencing downstream water quality.

17 32 P-2 C S

Schoedinger, S.E., Epifanio, C.E., University of Delaware, Lewes, DE. **THE EFFECTS OF VARYING PREY DENSITY ON THE GROWTH AND SURVIVAL OF EARLY-STAGE LARVAE OF TAUTOG (FAMILY:LABRIDAE).**

Very little is known about the early life history of the tautog, *Tautoga onitis*, a temperate reef fish. Few field or laboratory experiments on the larvae of this species or other labrid species have been successful beyond the earliest stages of development. We reared larvae from hatching to settlement on diets of natural zooplankton. We developed a detailed morphological description of development for the first 96 h and then reared groups of larvae to settlement. Time to settlement was comparable to field-derived estimates. In a separate set of experiments we investigated the effect of varying prey density on growth and survival. One group of experiments was conducted in large (425-l) laboratory tanks. Another was conducted in field-deployed enclosures (1400-l) Variation in prey density had a strong effect on larval growth in the laboratory, but there was little impact on mortality. Preliminary analysis suggests that the influence of prey density was muted in enclosures. This may have been due to the formation of dense patches of prey in the large enclosures.

20.1 6 O I

Schoudel, A.J., Loder, III, T.C. Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, NH. **COMPARATIVE NUTRIENT BEHAVIOR IN THREE MAINE ESTUARIES.**

Nutrient behavior was observed in the Damariscotta, Sheepscot and Kennebec River estuaries during six surveys conducted from Sept. 1993 to Aug. 1994. All three estuaries exhibited a seasonal variation. Some nutrient concentrations reached their maxima in the winter (eg. Damariscotta nitrate: 11-155M) and minima following the spring bloom and through the beginning of the summer (Damariscotta nitrate: 0 - 45M). The three systems, however, behaved differently with respect to the factors controlling nutrient distributions. In the Damariscotta nutrient removal is closely related to the nearly continuous phytoplankton bloom from Feb./March to October and appears to be a nutrient sink for coastal waters. The Sheepscot behaved much like a conservative mixing chamber between river and coastal zone. Only in the beginning of the summer was there evidence of in situ nutrient removal. In the Kennebec the nutrient behavior was a product of conservative mixing, biological transformation and geochemical interactions. Total N was observed to be conservative throughout the year. This was due to a biologically mediated phase change between PON and DIN which were non-conservative. Phosphorus underwent a similar transformation. Total P was not conservative due to the interactions between particulate P and suspended particulate material.

3 13 P-1 C

Schraga, T.S., Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, and Roman, C.T., National Biological Service, University of Rhode Island, Narragansett, RI. **SPATIAL AND TEMPORAL VARIABILITY OF WATER QUALITY PARAMETERS IN NAUSET MARSH (CAPE COD, MASSACHUSETTS, USA).**

This study was initiated to determine the variability of

water quality parameters and to identify patterns that persevere in the Nauset Marsh System. A suite of water quality parameters (chl a, dissolved oxygen, NO₂⁻, PO₄, NH₄, total nitrogen, total phosphorus, total suspended solids, organic suspended solids, inorganic suspended solids) and additional factors that affect these parameters (light, temperature, salinity, tide stage, wind speed, precipitation) were monitored at two physically different sites within Nauset Marsh. Sampling was conducted over the duration of a lunar tidal cycle (14-16 sequential days), with one cycle sampled each season of 1994. The data set was analyzed to determine the temporal and spatial variability related to tidal stage, season, weather condition, and location within the marsh system. Principal Components Analysis reveals distinct patterns that occur at each site and in the system as a whole. These results can be applied to the design of estuarine water quality monitoring programs.

8.1 6 O C

Schroeder, W.W.^{1&2}, Miller-Way, T.² and Pennock, J.R.^{1&2}, ¹Marine Science Program, The University of Alabama, Dauphin Island, AL and ²Marine Environmental Sciences Consortium, Dauphin Island, AL. **THE ROLE OF PHYSICAL PROCESSES IN STRUCTURING THE DISSOLVED OXYGEN REGIME IN A SHALLOW, RIVER DOMINATED ESTUARY.**

Oxygen dynamics in the waters of the upper reaches of Mobile Bay, Alabama, are shown to be directly related to water column stratification developed by salinity gradients. Mobile Bay is a shallow, river dominated system that exhibits characteristics of both drowned river valley and bar-built estuaries. On an annual cycle the upper bay shifts from non-stratified fresh water conditions during the annual flood period (normally February through April) to principally halocline stratified conditions during the remainder of the year. During June through November of 1993 and 1994, time series records of temperature, salinity and dissolved oxygen were collected at moorings in the northeastern region of the bay. These data sets document the spatial and temporal variability in the water column including the intensity of stratification and destratification-restratification cycles as well as the resulting trends and fluctuations in the dissolved oxygen regime. Physical processes that have been identified as playing important roles in the structure of both the water column and the dissolved oxygen regime are river discharge, winds, and tidal and subtidal currents. These processes are observed to operate both as individual components or in complex interactions.

6.2 4 O C

Schwarzschild, A.C., Kenworthy, W.J., Gruccio, Lt. D.J. NOAA/NMFS Beaufort Lab, Beaufort, NC and NOAA Corps, Beaufort Lab, Beaufort, NC. **VARIATIONS IN SYRINGODIUM FILIFORME MORPHOLOGY AND DEMOGRAPHICS BETWEEN A DISTURBED AND UNDISTURBED GRASSBED IN OUTER FLORIDA BAY, FL.**

The morphology, growth and demographics of

Syringodium filiforme were analyzed in a disturbed grassbed in outer Florida Bay, FL and compared with those from an adjacent undisturbed site. Demographic analysis of short shoots from the undisturbed area indicated a stable population with balanced rates of mortality and recruitment along with an apparently stable age distribution. *S. filiforme* was actively recruiting into the disturbed area, primarily by vegetative reproduction, with recruitment rates greater than mortality. Short shoot mortality rates in the disturbed area were consistently lower than those in the undisturbed grassbed. Percent rhizome apical branching and the average number of branches produced on a rhizome were higher in the disturbed area. Whereas, production of new leaves and leaf growth rates were higher in the undisturbed area. Short shoot size in the disturbed area was significantly lower than in the undisturbed population. Aerial branching was common in the undisturbed population, but not seen in the disturbed area. Plants in the disturbed area appeared to preferentially allocate resources to spreading horizontally while plants in the undisturbed population allocated more resources to vertical growth.

12.2 3 O I

Scott, J., Mueller, C., Science Applications International Corporation, Narragansett, RI, and Albrecht, B., TRAC Laboratory, Pensacola, FL, and Van Dolah, R., South Carolina Department of Natural Resources, Charleston, SC. **SEDIMENT TOXICITY AS AN INDICATOR OF CONTAMINANT STRESS IN EMAP-ESTUARIES.**

Toxicity of sediments is widely used in EPA, ACOE, and NOAA monitoring and regulatory programs as a complement to measurement of chemical concentrations as it provides an indication of the bioavailability of sediment contaminants. Sediment toxicity was included as an abiotic condition indicator as part of EMAP-Estuaries in the Virginian, Louisianian, and Carolinian Provinces in the sampling years 1990-94. Toxicity was measured using the 10-day solid phase test with the amphipod *Ampelisca abdita* after ASTM and EPA standard methods. A sediment was deemed toxic if survival was significantly different from that in the control and it was < 80 % of the control response. Toxic sediments were found in approximately 10% of the area of both Virginian and Louisianian Provinces; the estuarine classes with the highest proportion of toxicity were small estuaries of the Virginian and the large tidal river (Mississippi River) in the Louisianian. Sediment toxicity was found in only 2-3 % of the area of the Carolinian Province. Overall, there was general agreement between the degree of toxicity and chemical concentrations. Uncontaminated sediments (i.e., those with concentrations < Long et al. (1994) ER-L values) were non-toxic. Contaminated sediments (i.e., concentrations > ER-M values) generally were toxic and that toxicity was most strongly associated with concentrations of cadmium, copper, lead, nickel, zinc, mercury, and polychlorinated biphenyls.

29.1 3 O I

Scott, L.C., Ranasinghe, J.A., Weisberg, S.B., Versar Inc.,

Columbia, MD., and Friedman, E.S., Butler, W.L., Maryland Department of Natural Resources, Annapolis, MD. **TRENDS IN BENTHIC MACROFAUNAL COMMUNITY CONDITION IN THE POTOMAC RIVER, MARYLAND.**

Management actions during the 1970s and 1980s to reduce nutrient loadings to the Potomac River watershed (a major tributary to the Chesapeake Bay) have reduced nutrient loadings to the tidal portion of the river. Additionally, management actions have improved water quality parameters such as pH in the nontidal portion of the river. To ascertain whether the condition of the benthic macrofaunal community changed concurrently with the improvements in water quality, temporal trends in several measures of benthic community health were examined using data collected by the state of Maryland's Water Quality Monitoring Program. Data were available from eleven stations in the nontidal river that have been collected annually since 1976, and from 8 stations in the tidal portion of the river that have been collected approximately quarterly since 1980. Trends were examined using the Van Belle and Hughes (1984) nonparametric approach. In the nontidal portion of the Potomac River, benthic community condition improved significantly at 9 of the 11 sampling locations. In the tidal portion of the river, most improving trends were detected in the upper tidal (lower salinity) portion of the river. In the lower portion of the tidal river, where water quality improvements have not been detected, trends in benthic condition were not detected.

12.3 6 O C S

Seguin, R.J., Whitedge, T.E., University of Texas, Marine Science Institute, Port Aransas, TX. **DISSOLVED INORGANIC NITROGEN IN THE NUECES RIVER AND BAY: DEVELOPMENT OF AN AMMONIA MONITOR USING AN ION SELECTIVE ELECTRODE.**

The impact of a sewage treatment plant on the levels of dissolved inorganic nitrogen (DIN) in the Nueces river and bay was studied for 18 months, using traditional analytical methods. A self-calibrating field instrument to monitor ammonia was also developed, using an ammonia gas electrode, automated reagent mixing, and a data acquisition system. The instrument did not have the salinity interference present with commercial ammonium ion sensors and compared well to lab analyses using colorimetric methods. The monitor was deployed for several one-week periods, and revealed large daily and hourly variations in the ammonia output of two sewage treatment plants that had not been obvious during previous studies relying on monthly sampling.

19.1 1 O C

Seitzinger, S.P., Rutgers University, Institute of Marine and Coastal Sciences, Rutgers/NOAA CMER Program, New Brunswick, NJ and Sanders, R.W., Academy Natural Sciences, Division of Environmental Research, Philadelphia, PA. **ESTUARINE EUTROPHICATION: CONTRIBUTION OF ORGANIC NITROGEN FROM NON-POINT AND POINT SOURCES.**

Organic inputs of nutrients comprise a significant frac-

tion of total N and P inputs to estuaries. Often 25-60% of the total N and P inputs from non-point and point sources, atmospheric deposition (N), rivers, and ocean boundary waters is in the form of particulate or dissolved organic matter. The biological availability of these organic forms of N and P generally has not been quantified. Recent studies indicate that a substantial fraction of dissolved and particulate organic matter from all of these sources can be readily mineralized by estuarine microbes and result in stimulation of phytoplankton production. Mineralization rates of dissolved and particulate organic matter (N, P and C) from 42 different sources (4 tributaries, 6 ocean boundary stations, 21 sewage treatment plants, 6 combined sewer overflows, 5 storm water drains) from the New York/New Jersey Harbor area were measured during spring and summer. Decomposition rates were most rapid during the first 10 days, and decreased during the subsequent 40 days. Approximately 55-75% of the DON, 20-45% of the DOC, 40-60% of the PN, and 40-70% of the PC was biologically reactive within typical residence times of water in estuaries. The implications of these findings for estuarine eutrophication will be presented.

32 44 P-3 C

Seliskar, D.M., Halophyte Biology Laboratory, College of Marine Studies, University of Delaware, Lewes, DE. **THE EFFECTS OF GRAZING BY FERAL HORSES ON AMERICAN BEACHGRASS AT ASSATEAGUE ISLAND, MARYLAND.**

Approximately 170 feral horses graze on the dunes and marshes of Assateague Island National Seashore. American beachgrass (*Ammophila breviligulata*) is a primary forage grass for the horses and is also the major dune stabilizing grass. With the increase in the horse population from 21 in 1965 to 170 today, concern over destabilization of the dunes due to overgrazing and the subsequent erosion has become a concern. To assess grazing along a 13 mile stretch of foredunes on the Maryland portion of the island, 18 enclosure plot pairs, i.e. fenced and unfenced plots, were established. Based on the shape and size of the dunes, four distinct dune types were identified: ridges, flats, knolls, and buttes. Plant response to grazing in the fenced and unfenced plots was determined over a two-year period. Plant cover and vegetative spread were significantly greater in the enclosures than in the unfenced plots, as was the percent of culms flowering. Reducing the photosynthetic surface by grazing and forcing stored reserves to be used to rebuild the canopy lowers seed quantity by both lowering frequency of seed head production and reducing the size of the ungrazed heads. This reduces the number of potential propagules for colonization of blow-out sites or sites of recent sand deposition.

21.3 4 O C

Seliskar, D.M., Halophyte Biology Laboratory, College of Marine Studies, University of Delaware, Lewes, DE. **PERSISTENT DIFFERENCES IN SPARTINA ALTERNIFLORA ALONG A LATITUDINAL GRADIENT: IMPLICATIONS FOR SALT MARSH RESTORATION.**

During the fall of 1989, a newly created 0.5 acre salt marsh was planted in Lewes, Delaware with short-form *Spartina alterniflora* originating from Massachusetts, Delaware, and Georgia. The marsh is connected via creeks through a natural marsh to the Delaware Bay estuary. Five years later, these three selections remain distinct and reflect characteristics of plants at their site of origin. Genotypes differed in canopy height, stem density, and in potential detritus production. Decomposition rates of aboveground material also varied among genotypes. The quantity and depth distribution of carbon allocated belowground were dependent upon genotype, as was the carbohydrate concentration and composition of the rhizomes. The persistent differences exhibited by the various genotypes can be exploited for use in accelerating the functional development of newly created salt marshes. For example, depending on the created marsh site, the amount of detritus produced may or may not be an important consideration, or perhaps the height of the canopy may be a concern relative to animal usage.

34 51 P-3 C

Sellner, K.G., Olson, M.M., Brownlee, S.G., The Academy of Natural Sciences, Estuarine Research Center, St. Leonard, MD. **ZOOPLANKTON HERBIVORY IN BLOOMS OF NUISANCE ALGAE.**

Zooplankton grazing in recurring summer blooms of *Aphanizomenon flos-aquae* and *Nodularia spumigena* has been estimated in 3 of the last 4 summers. Grazing by the copepods *Acartia bifilosa* and *Eurytemora affinis* is minimal with clearance rates rarely exceeding 0.1ml (copepod h)⁻¹. Low rates, in turn, are accompanied by minimal egg production, declining from 16-21 eggs (copepod d)⁻¹ when feeding on an autotrophic flagellate to <3 eggs (copepod d)⁻¹ when feeding in bloom assemblages. In summer, 1995, rotifer herbivory and egg production was also estimated in bloom assemblages. Results suggest that zooplankton herbivory of bloom production is minimal, with the majority of bloom production supporting a large and highly productive "microbial loop". The latter community likely supports zooplankton production, either through zooplankton ingestion of microheterotrophs or herbivory of non-bloom phytoplankton production fueled by intensive microheterotrophic remineralization activity in the bloom. These results and conclusions will be contrasted with carbon cycling in other nuisance algae blooms (e.g., dinoflagellates).

6.1 3 O C S

Seufzer, W., Wetzel, R., College of William & Mary, School of Marine Science/VIMS, Gloucester Point, VA. **APPLICATION OF COMPUTATIONAL SCIENCE TO SEAGRASS PHYSIOLOGICAL ADAPTATIONS**

In order to survive and reproduce a seagrass plant must manage its resources relative to its environment. The plant integrates short-term changes in temperature, light, and nutrient availability and must 'decide' how much energy to use for plant growth, seed production, and root storage. Short-term (hours to days) behaviors must collect into long-term

(years) survival. This study attempts to investigate these behaviors using computational science. A simulation defines a plant as a construction of building blocks that represent root, rhizome, seed, and leaf tissues. Each building block contains plant functions, for example leaf tissue would include chlorophyll *a* and *b* dynamics. A computational search procedure based on the mechanics of natural selection (genetic algorithm) is then given the task of constructing a plant capable of surviving in an environment defined by a long-term data set. This paper compares this method to other simulation based approaches and summarizes progress on a model of chlorophyll *a* and *b* dynamics in leaf tissue. If this methodology is successful it will aid in defining seagrass habitat and restoration requirements based on multiple environmental parameters. At the ecosystem level this methodology could help predict ecosystem responses to global scale environmental changes.

21.1 2 O I

Shaffer, G., Greene, M., Llewellyn, D., Myers, R., Forder, D., Southeastern Louisiana University, Hammond, LA. **SWAMP RESTORATION IN LOUISIANA: AMELIORATION OF MULTIPLE STRESSORS - IS IT WORTH THE COST?**

In the early 1900s, old-growth baldcypress (*Taxodium distichum*) was completely logged out of most of Louisiana's swamps. Natural regeneration of swamp was limited and many areas converted to marsh or open water. This effort was conducted to isolate the major factors prohibiting cypress regeneration. Specifically, hundreds of baldcypress seedlings were planted in several factorial treatment arrangements that included nutrient augmentation, management of entangling vegetation, herbivore protection (Tubex tree shelters, PVC sleeves, Tanglefoot), elevation, substrate type, silvicultural practices (clear cut, select cut, uncut), and salinity inundations. Nutrient augmentation nearly doubled growth in an estuarine location, but decreased growth in a riparian location. Seedlings that were managed grew nearly two times greater in diameter, but less in height, than unmanaged seedlings. Relatively inexpensive, recyclable, PVC sleeves were more effective at prohibiting herbivory than Tubex Tree Shelters; unprotected seedlings experienced 100% mortality. Successful coppicing of cypress, but not tupelo (*Nyssa aquatica*), is occurring in clear- and select-cut areas. Cypress can tolerate *in situ* salinity pulses of up to 10 ppt. In all, these studies indicate that biotic factors are primarily responsible for the lack of cypress regeneration in Louisiana, not the prevalent, but largely untested, hypothesis of salt water intrusion. Moreover, it is likely that, with a combination of management techniques, it is possible to restore swamp habitat in this area. Though labor intensive in the short run (i.e., first few years), once established these trees may survive for centuries.

28.1 4 O C

Sharma, V.K., Hollyfield, S., Baggett, A.T., Center for Coastal Studies, Texas A&M University-Corpus Christi,

Corpus Christi, TX. **THE TRANSFER OF METALS FROM POINT AND NONPOINT SOURCES INTO COASTAL WATER.**

The transfer of metals from point and nonpoint sources into coastal water is of major interest in estuarine chemistry. Urban and industrial wastes containing metals discharge directly into coastal environment. The Oso Bay is located at south Texas and is of a brackish water makeup with the Oso Creek serving as its main source of replenishment. This bay receives pollution from sources such as military facilities, landfill, municipal and industrial discharges, and dumping. The impact of contamination can be assessed by measuring the concentration of metals in sediments. Metal concentrations in sediments were determined to assess the extent of contamination in Oso Bay. Metals in sediments were analyzed at nine selected sites by atomic absorption spectrophotometry after dissolution with HF, HClO₄ and HNO₃. Metals determined were Cu, Cd, Cr, Zn, Pb, Ni, and Fe. Metal concentrations in sediments, in general, were below those that elicit biological responses. The metal concentrations are controlled by the proximity to the sources.

17.2 1 O I

Shaw, R.F., Cope, J.S., Ditty, J.G., Farooqi, T., Louisiana State University, Coastal Fisheries Institute, Wetland Resources Bldg., Baton Rouge, LA. **COASTAL OCEAN-ESTUARINE PHYSICAL FORCING AS A FISHERIES RECRUITMENT ENHANCEMENT MECHANISM.**

We conducted a field test of a recently-published, recruitment enhancement hypothesis for postlarval brown shrimp to evaluate its applicability to larval fish. The postulated mechanism involves the interaction of tidal and wind-forced currents resulting from atmospheric cold front passages and postlarvae who use cold-front associated changes in water temperature and salinity as environmental clues to elicit either a passive or behavioral response in combination with a diel activity cycle. This behavior facilitates utilization of the appropriate directional flow, thereby affecting their resultant transport and estuarine recruitment/retention. We collected near surface and near bottom, diel and tidal plankton collections 8 times/d for a 90-d interval during 1 Feb. - 30 Apr. 1994 in Oyster Bayou, a tidal pass connecting the Gulf with Fourleague Bay, Louisiana. In addition to the 1440 plankton samples, we collected vertical profiles of temperature, salinity and current velocity; samples for suspended sediment, chlorophyll *a*, and nutrient chemistry; data from near-surface and near-bottom current meters; data from water level gauges at either end of the pass; and data from an on-site meteorological station. We attempted to definitively link observed transport to weather/wind conditions and to compare transport under astronomically-driven flows ("normal tides") and meteorologically-driven flows (which can totally override the "normal tide" in either an additive or counteractive manner).

21.1 4 O C

Sheridan, P., McMahan, G., Henderson, C., Hammerstrom,

K., National Marine Fisheries Service, Galveston, TX. SEAGRASS RESTORATION IN WESTERN GALVESTON BAY, TEXAS.

Seagrass acreage in Galveston's West Bay declined from 890 ha in 1956 to 0 by 1982. Loss was attributed to waterfront development, dredge material placement on seagrasses, and increased turbidity and erosion. Now, water clarity has improved, development and dredging are controlled, and seagrass restoration is a mitigation option. Our objectives were to create one hectare of viable seagrass habitat, to determine survival and growth rates of transplanted seagrasses, and to obtain evidence of increased faunal densities above those in non-transplanted substrates, all with reference to extant beds in neighboring Christmas Bay. Shoalgrass (*Halodule wrightii*) from Matagorda Bay was transplanted into two sites during May 1994. We periodically test effects of location, planting depth and density, and fertilizer use on floral, benthic and macrofaunal densities. In April 1995 (after the first winter), average seagrass survival was 65%, 94% of survivors were spreading, and coverage was 50%. Long-term survival and coverage were influenced by site, planting density and depth. Fertilizer provided short-term benefits only. Transplanted habitats supported greater densities of benthic and macrofaunal organisms. Seagrass and faunal densities remain 1-2 orders of magnitude below those in natural beds. Updates for June and September 1995 will be provided.

32.2 3 O C

Sheridan, P., National Marine Fisheries Service, Galveston, TX. **FORECASTING THE TORTUGAS PINK SHRIMP FISHERY FROM FLORIDA BAY PARAMETERS.**

Since 1987, NMFS has forecasted expected harvests for the Tortugas pink shrimp (*Penaeus duorarum*) fishery northwest of Key West, FL. Forecasts for the November-October "fishing year" are usually released in December. Florida Bay habitats are the primary nurseries for juvenile pink shrimp. Because there are no long-term data on juvenile pink shrimp abundance, factors affecting this area are used as predictor variables in multiple regression models. Temporally congruent, long-term data bases (1967 forward; monthly mean or total values) for south Florida include: NMFS catch and effort statistics; NWS air temperature, wind, and rainfall and NOS sea level for Miami and Key West; and Everglades National Park rainfall, well water levels, and surface water inputs. Predictor variables are all recorded during June-October, but model equations change each year as new environmental conditions are encountered (e.g., drought, seagrass die-off). Six of eight forecasts have come within 15% of actual landings. Everglades hydrological data are critical since without them the forecast fails. Functional relationships between key abiotic variables and pink shrimp survival and recruitment need explanation.

13.2 5 O C

Shields, J.D., Chesapeake Bay National Estuarine Research Reserves in Virginia, Virginia Institute of Marine Science,

Gloucester Point, VA. **FIDDLER CRAB EXCAVATIONS AND THEIR RELATION TO SUBSURFACE AREA.**

The burrowing dynamics of *Uca pugnax* and *U. minax* were examined in relation to habitat type (high, low and barren marshes) and location along a salinity gradient. The frequency of crab burrows was strongly correlated with crab density; hence, burrow counts and sizes could be used as direct estimates of crab abundance. The frequency of burrows and burrow sizes varied significantly between locations, but not between marsh types. Sandy habitats had significantly larger, but fewer burrows than muddy habitats. Salinity did not affect the number or size of burrows but it did affect the species of crab present in the tidal freshwater habitat. Burrowing activity increased the secondary surface area of the marsh from 12 to 124%. While there were significant localized differences among marsh habitats, no pattern in the secondary surface area was apparent. Crab burrows represented an excavation of 508 to 6228 cm³/m². Over an active month of burrowing activity, the amount of sediment excavated by crabs ranged from 294 to 3968 cm³/m². Excavation rates appeared dependent upon sediment type and the immigration/colonization and growth of crabs. Burrowing activity may potentially affect important aspects of several biogeochemical cycles, because burrows markedly increase the surface area of the marsh and the turnover of sediments.

21.1 6 O I

Short, F.T., Davis, R., Burdick, D.M., McHugh, D., Bosworth, W.S., University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Department of Natural Resources, Durham, NH. **RESTORATION AND CREATION OF EELGRASS, SALT MARSH AND MUDFLAT HABITATS IN THE PISCATAQUA RIVER, NEW HAMPSHIRE.**

Eelgrass, mudflat, and saltmarsh habitat were restored during 1993-95 as part of a mitigation project required to compensate for projected losses of estuarine habitat associated with expansion of the Port of New Hampshire. Port expansion will eliminate 6.2 acres of estuarine bottom for pier construction, and modify 6 acres by dredging. As a result of construction, 1.0 acres of eelgrass, 3.0 acres of potential eelgrass habitat, 0.8 acres of saltmarsh, and 4.8 acres of intertidal mudflat will be impacted. Eelgrass mitigation of 6.2 acres was designed to compensate for losses of eelgrass and potential eelgrass habitat, in order to satisfy regulators that no longer-term loss of eelgrass habitat would result. One acre of saltmarsh was created within 1/2 mile from the Port expansion and 0.6 acres of saltmarsh were created in a nearby tidally restricted area. Mudflat mitigation included creation of 1 acre of new mudflat from existing upland, and the enhancement of 10 acres of previously degraded mudflat. Mitigation-to-loss ratios were established depending on restoration technique, projected time to recovery, and habitat type. Overall, the mitigation package is expected to slightly over-compensate for the wetland function loss resulting from the NH Port Expansion Project.

15.3 7 O C

Siewicki, T.C., NOAA, National Marine Fisheries Service, Charleston, SC. **MODELING OF SEDIMENT-ASSOCIATED FLUORANTHENE AND ENVIRONMENTAL RISK DUE TO URBANIZATION OF SMALL, NON-RIVERINE ESTUARIES.**

Risks caused by fluoranthene in urban runoff were estimated by 1) determining oyster kinetic rate constants, loading and distribution; 2) conducting statistical and environmental modeling; and 3) assessing exposure in Murrells Inlet, SC. Kinetic rate constants for sediment-associated fluoranthene were lower than estimates determined from dissolved analyte. A continuous non-point source monitoring and sampling apparatus was designed and used to sample storms ranging from 7.4 to 97.8 mm total rainfall. Runoff fluoranthene concentrations ranged from below detection limits to 491 ng/l (mean=130) and flux averaged 128 mg/km²/cm rain. Multivariate, linear regression and Kriging analyses of oyster and sediment fluoranthene concentrations and other variables from 30 sites throughout the inlet indicated concentrations were elevated near paved roads, docks and boat passageways. Factors that were predictive of oyster fluoranthene levels were identified. The Exposure Analysis Modeling System (EXAMS-11) was used to examine relationships between land uses and fluoranthene distribution and fate. Factors affecting oyster exposure were: non-point source loading > steady state loading > non-point source hydrologic flows. Pulse loads caused only nearby, short-term increases. These results suggest that bioconcentration of fluoranthene by oysters is related to adjacent land uses and can be predicted by understanding the major factors affecting their transport and fate. An approach is described that can be used to test alternate landscape modifications for minimizing impacts on oysters and the consuming public.

35.1 1 O C

Sigman, M.J., Miller, J.A., Garono, R.J., Oregon State University, Tillamook Bay National Estuary Project, Corvallis, OR. **FROM THE FOREST TO THE SEA. TBE USE OF WATERSHED ANALYSIS TO ADDRESS ENVIRONMENTAL DEGRADATION IN A NATIONAL ESTUARY PROJECT.**

In 1992, Tillamook Bay, OR was accepted into the EPA-sponsored National Estuary Program, a community-based effort to develop a comprehensive conservation and management plan (CCUP). Environmental problems identified include 1) fecal coliform bacteria contamination affecting shellfish harvest and water-contact uses, 2) sedimentation, and 3) habitat degradation. Watershed analysis, a systematic procedure for characterizing watershed and ecological processes to meet specific social and management needs, was chosen as a tool to address these problems. The development of an analysis framework for the Tillamook watershed is unique because- 1) the social and management concerns driving the process are not based primarily on harvest and/or endangered species issues; 2) cooperation with agricultural landowners is being sought; and 3) additional assess-

ment methods for agricultural Best Management Practices (BMPs) are being developed. TBNEP is coordinating with federal, state, and local agencies and a non-profit organization on a pilot analysis on the Kilchis River subbasin. Existing information, combined with landscape change analysis, sediment erosion studies, aquatic habitat inventories, and stream flow and temperature data will be used to develop and refine assessment methodologies, target highly erosive areas, develop restoration strategies, and direct monitoring programs

16 37 P-1 C

Sigua, G.C., Tweedale, W.A., Steward, J.S., Environmental Sciences Division, St. Johns River Water Management District, Palatka, FL. **NUTRIENT LOAD REDUCTION ASSESSMENTS FOR INDIAN RIVER LAGOON BASIN.**

Establishment of pollution load reduction goals (PLRGS) in the Indian River Lagoon Basin (IRLB) is an integral component of water quality management because the current rate of nutrient loading is increasing. On the average, the IRLB is receiving annual loadings of 3,381, 319, and 54,408 metric tons of N, P, and total suspended solids (TSS), respectively. Stormwater discharges and agricultural runoff are the main sources of this loading. One method of accomplishing loading reductions may be reduction or elimination of freshwater discharges, which also would restore the salinity regime necessary for a healthy estuary. Another measure is to develop a pollution load reduction goal for N, P, and TSS for the IRLB. Establishment of technically defensible PLRGs is being pursued by the SJRWMD/NEP SWIM Program, and loading reductions will be based on the environmental (water quality) requirements of selected living resources of IRLB, such as seagrasses and oysters. Some of the desired results of PLRGs for the IRLB are: 1) desirable salinity regimes for improvement and maintenance of estuarine biological integrity and diversity; 2) restoring macrophyte dominance of primary productivity from algal dominance; 3) restoring 20% to 35% of incident light at lagoon bottom in all areas; and 4) maintaining N, P, and TSS annual loading rates of 2.2, 0.22, and 39.2 kg/ha/yr.

3.2 I O I

Sklar, F.H., Everglades Systems Research Division, South Florida Water Management District, West Pahn Beach, FL. **MANAGING COASTAL ENVIRONMENTAL IMPACTS BROUGHT ABOUT BY ALTERATIONS TO FRESHWATER FLOW.**

Freshwater inflows are the most influential landscape process affecting community structure and function in lagoons, estuaries, and deltas of the world; yet few reviews of coastal impacts associated with altered freshwater inputs have been written. A conceptual model of the possible influences of freshwater inflows on substrates and trophic interactions was used to structure this review, evaluate dominant effects, and discuss tools for coastal management. Landscape alteration, impacting the timing and volume of freshwater inflow, is the most common stress on estuarine systems because it impacts

wetland and open water salinity patterns, nutrients, sediment fertility, mineral content, bottom topography, dissolved oxygen, and concentrations of xenobiotics. These, in turn, influence productivity, structure, and behavior of all coastal plant and animal populations. New multiobjective statistical models and dynamic landscape simulations, used for freshwater inflow management, assume that optimum estuarine productivity and diversity is found somewhere between the "stress" associated with altered freshwater flow and the "subsidy" associated with unimpeded flow. These models attempt to maximize the area of spatial overlap where favorable substrates coincide with favorable trophic characteristics. A statistical performance model is presented to demonstrate how organism viability can be used to constrain sediment, freshwater, and nutrient loading limits. A spatial ecosystem simulation model is presented to demonstrate how cumulative impacts can be predicted as a function of landscape alterations.

25 24 P-3 C

Skrabal, S.A., Donat, J.R. (Dept. of Chemistry and Biochemistry) and Burdige, D.J. (Dept. of Oceanography), Old Dominion University, Norfolk, VA. **THE SPECIATION OF DISSOLVED COPPER IN PORE WATERS AND BOTTOM WATERS OF CHESAPEAKE BAY: IMPLICATIONS FOR SEDIMENT-WATER EXCHANGE.**

Copper titrations using anodic stripping voltammetry (ASV) show that 97 to >99% of total dissolved copper (TDCU) in the pore waters and bottom waters of Chesapeake Bay exists in non-ASV-Labile forms, probably as organic or mixed organic/inorganic (e.g., sulfur-containing) complexes. At least two classes of ligands of different copper-complexing strengths were detected in all pore waters. TDCU concentrations in the pore waters of the upper sediment intervals (2-12 nM) are generally similar to bottom water concentrations (5-12 nM), suggesting that any fluxes into or out of the sediments are likely to be small. However, concentrations of copper-binding ligands are at least 10 times greater in the pore waters of the upper sediment intervals relative to the bottom waters, suggesting that sediments may be a potentially significant source of Cu ligands to the overlying waters. Preliminary results from core incubation experiments indicate a net flux of ligands out of Chesapeake Bay sediments. The copper-complexing character of the fluxing ligands and their significance to copper speciation and exchange between pore waters and bottom waters are presently being evaluated using a variety of techniques, including ASV, ligand competition/adsorptive cathodic stripping voltammetry, and ligand competition/chemiluminescence detection.

3.1 5 O C

Smaal, A.C., de Vries, I., National Institute for Coastal and Marine Management/RIKZ, Middelburg, The Netherlands, and Heip, C.H.R., Herman, P.M.J., Cadée, N., Netherlands Institute of Ecology Centre for Estuarine and Coastal Ecology, Yerseke, The Netherlands. **TOWARDS A FUNC-**

TIONAL TYPOLOGY OF ESTUARIES: THE SCHELDT ESTUARY IN COMPARISON WITH NINE OTHER EUROPEAN ESTUARIES.

The Scheldt estuary in the delta area in the South-West of the Netherlands (length 150 km; surface area 350 km²; watershed 20,000 km²) is one of the few estuarine systems left over in the Netherlands with a free connection to the sea. There is a strong anthropogenic impact, owing to high inputs into the river of nutrients, organic matter and micropollutants, and extensive dredging operations in the estuary to maintain the shipping route to the port of Antwerp. In order to develop a geographical reference for the restoration and management of the Scheldt estuary, a comparison has been made with nine other macro-tidal estuaries within Europe: Elbe, Ems (G), Loire, Gironde (Fr), Ythan, Humber, Dee, Mersey (UK) and Shannon (Eire). Data were derived from European research projects, such as the Joint European Estuarine Project database (JEEP92). A number of characteristic and quantifiable parameters was chosen to develop an estuarine typology, based on physical, chemical and biological processes and structures. Also anthropogenic impacts were compared. The physical characteristics of the Scheldt estuary are within the range of the references. With respect to chemical characteristics, phosphate and ammonium concentrations in the Scheldt are markedly higher than in all reference systems. Pelagic primary production is within the reference range but microphytobenthos production is higher. Macrobenthos densities and biomass, and number of fish species are within reference ranges. Overwintering waterbird numbers are among the highest of all estuaries. Comparison between the estuaries was restricted by the limited availability of comparable data. However, the study permits some generalizations on the typology of estuarine systems, and the use of indices which are valuable for understanding estuarine processes and for restoration scenarios.

29.2 2 O C

Smaal, A.C., Peeters, J.C.H., National Institute for Coastal and Marine Management/RIKZ, P.O. Box 8039, 4330 EA Middelburg, The Netherlands, and Prins, T.C., Escaravage, V., Netherlands Institute of Ecology Centre for Estuarine and Coastal Ecology, Vierstr 28 4401 EA Yerseke, The Netherlands. **THE IMPACT OF BENTHIC FILTER FEEDING ON NUTRIENT AVAILABILITY AND PHYTOPLANKTON DYNAMICS: RESULTS OF A MESOCOSM STUDY.**

In an ongoing study on the relations between nutrient loading, phytoplankton development and primary and secondary productivity, a series of 4-week mesocosm studies have been conducted in the period 1992-1994. In the experiments nutrient loading and grazing pressure have been manipulated, with the objective to study the interrelations between nutrient loadings, phytoplankton dynamics and benthic grazing. The research was conducted in the framework of a study on de-eutrophication. The mesocosms are MERL like systems with a volume of 3 m³, and a light climate and turbulence that is comparable with a field reference site in Dutch estua-

rine water. The nutrient loading was adjusted to the nutrient loading of the reference site, and P and N loads were reduced according to measures agreed at North Sea Ministers conferences. The grazing intensity on phytoplankton was varied by manipulating the mussel densities in separate benthic grazing chambers that were connected to the mesocosm units. During the experiments, phyto- and zooplankton biomass, species composition and primary production was measured twice a week. Fluxes of particulate matter between the water column and the mussels were measured on line, and dissolved matter fluxes were measured three times a week. At the end of the experiment mussel growth was determined. Results showed effects of mussel grazing on the nutrient pool in the water column, on phytoplankton production and species composition. Mussel grazing effectively controlled phytoplankton biomass under eutrophic conditions. Nutrient availability increased at higher mussel grazing rates; phytoplankton growth rates were stimulated by mussel grazing under nutrient limiting conditions. The effect of bottom-up (nutrients, light) and top-down (grazing) control on phytoplankton biomass and primary production will be discussed.

20.4 2 O C

Smith, B., Mullins, L., Hutchison, K., Texas General Land Office, Austin, TX. **RIO GRANDE COASTAL IMPACT MONITORING PROGRAM; RESEARCH, FINDINGS, AND STRATEGIC PLAN.**

The Rio Grande Coastal Impact Monitoring Program (CIMP) is an EPA sponsored effort directed by the Texas General Land Office to establish and maintain a center for research into pollutants and their impacts on the lower Rio Grande and associated coastal waters. Rapid development, algal blooms, and human birth defects have caused widespread concern for the area. The five year project encompasses a binational study area extending 100 km north, south, and inland from the mouth of the Rio Grande. First year accomplishments include: 1. establishment of a CIMP study center at the Coastal Studies Lab of UT-Pan American with GIS and real-time monitoring capabilities, 2. installation of water quality and hydrological real-time monitoring equipment in the Arroyo Colorado, 3. collection, analysis, and screening of water, sediment, and fish tissue toxic chemical samples, 4. study of nutrient assimilation and growth of the brown tide in the lower Laguna Madre, 5. literature survey, and 6. five year strategy for binational research and monitoring. CIMP research projects have identified and prioritized degraded areas in the Arroyo Colorado due to toxic substance pollution and eutrophication, and in the Rio Grande due to toxic substance pollution. The CIMP has also provided a research facility and laboratory for binational cooperation to protect coastal waters and human health.

26.1 2 O I S

Smith, G., Weis, J., Rutgers University, Department of Biological Sciences, Newark, NJ. **ECOLOGICAL RISK IN A MERCURY-CONTAMINATED ESTUARY: REDUCED**

PREY CAPTURE IN MUMMICHOGS (*FUNDULUS HETEROCLITUS*).

Subtle changes in behavior can act as indicators of sublethal estuarine pollution. Previous research has shown that mummichogs (*Fundulus heteroclitus*) from a mercury-polluted tidal creek show reduced growth rates compared with conspecifics from an uncontaminated environment. Analysis of predatory behavior 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 rate or a decrease in their levels of brain mercury. Videotape analysis of predatory behavior showed that fish from the polluted creek made significantly fewer attempts to capture prey. It is suggested that this reduced activity may be due to lower levels of the neurotransmitter serotonin (5-HT) in the fishes brains as a result of mercury intoxication.

16.2 6 O C

Smith, G.F., Greenhawk, K.N., Cooperative Oxford Laboratory, Maryland Department of Natural Resources, Oxford, MD. **OYSTER REEF DESTRUCTION: HISTORICAL DEMONSTRATION OF COUPLING WITH SHORELINE FEATURES AND SHALLOW WATER LITTORAL PROCESSES IN SELECTED MARYLAND CHESAPEAKE BAY SYSTEMS.**

Nineteenth and twentieth century Chesapeake Bay survey data suggest that the physical alteration of the oyster reef structure may be linked to widespread changes in the adjacent shallow water benthos, as well as to shoreline and littoral zone configuration. Applying landscape ecology concepts to GIS technology, we will explore existing data maps of bathymetry, bottom characterization, and shoreline morphology against changes in oyster bottoms and sediment type. GIS gives us the graphic tools to examine two and three dimensional aspects of oyster reef types in the Tangier Sound, Patuxent River, and Choptank River areas of the Chesapeake Bay at different times. At the landscape level, oyster reef structure can be related to energy moderation and nutrient entrapment and the GIS provides the analytic tool in which to explore the structural relationships. This presentation will provide insight into reef destruction and its links to changes in habitat character of reef backshore environments that were once conducive to shallow water vascular plant (SAV) and marsh development.

31.3 2 O I

Smith, III, T.J., South Florida/Caribbean Field Laboratory, National Biological Service, Miami, FL. **CHANGES IN THE POSITION OF MANGROVE - NONMANGROVE ECOTONES IN RELATIONSHIP TO RISING SEA LEVEL AND ALTERED FRESHWATER INFLOW.**

Mangrove forests dominate the southwest Florida coast-

line forming a band 150km long by 10-35km wide. Embedded in the forest are large patches of brackish marsh. At the upstream limit of mangroves the ecotone is with freshwater marsh vegetation. Relief along the coast is extremely low, ~1 to 10,000. Since 1930 sea level has been increasing at a rate of 3-4mm yr⁻¹. Additionally, water management practices have decreased the hydrolic head of the freshwater Everglades. Observations along the coast indicate movement of mangroves into what formerly was marsh or forest. For example cabbage palm stumps can be found 100s of meters inside mangrove areas. I used aerial photographs to quantify movement of the mangrove - nonmangrove ecotone from 1929 to present at 24 locations along the coast, including areas of highly altered freshwater inflow regimes and relatively pristine areas. Infilling of isolated coastal brackish marshes by mangroves was greater than upstream movement of mangroves into the freshwater Everglades. The larger measured shifts of the ecotone (>1500m) were associated with some form of hydrologic alteration (reduced freshwater inflow or channelization). It is hypothesized that slower upstream movement into the freshwater Everglades is related to low rates of organic soil development.

15.1 5 O C

Smith, P., South Carolina Department of Health and Environmental Control, Columbia, SC, and **Conrads, P.**, U.S. Geological Survey, Columbia, SC. **SIMULATION OF NUTRIENT AND DISSOLVED-OXYGEN CONCENTRATIONS IN THE COOPER AND WANDO RIVERS NEAR CHARLESTON, SOUTH CAROLINA.**

Nutrient and dissolved-oxygen concentrations in the Cooper and Wando Rivers were simulated using the Branched Lagrangian Transport Model (BLTM). The Cooper and Wando Rivers are tidally affected systems which are major tributaries to Charleston Harbor, is located near the middle of the South Carolina coast. The model domain of the two river system includes six open-water boundaries. Gauging stations with continuous monitors of salinity, temperature, and dissolved oxygen are located at the open-water boundaries and at four interior locations. The model was calibrated and verified for salinity, temperature, algae, organic nitrogen, ammonia, nitrate, dissolved phosphorous, ultimate carbonaceous biochemical oxygen demand, and dissolved oxygen. Calibration and verification were achieved when the mean predicted constituent concentration for the period of observed data fell within the range of observed concentrations. Overall, 74.5% of the constituents in the calibration data set met the stated criteria. For the validation simulation, overall, 67.7% of the constituents met the criteria. Examination of the individual river systems indicates that simulated constituent concentrations for the combined data sets were more accurate in the Wando River part of the model with 75.7% (53/70) of the predictions falling within the range of observed data. In the Cooper River, 67.7% (84/124) of the predictions met the criteria.

32.2 4 O C

Spagnolo, R., Ambrogio, E., Raffile, R. US EPA Region III,

Philadelphia, PA, and Reilly, F., Reilly Group Inc., Stafford, VA. **A DEFINITION OF SHALLOW WATER FOR MANAGEMENT AND REGULATORY USAGE.**

The critical zone of importance to regulation and management of "Shallow Water" is that zone where conflicting uses require a management or regulatory decision to be rendered. Inconsistencies in the regulatory approaches to, and definitions of, shallow water environments spurred a survey of managers, regulators and scientists to assess the state of the science and management of shallow water ecosystems and have been the catalyst for two conferences on the issue. Survey respondents felt it critical that information gaps be identified, the state of the science be communicated, and management of shallow water habitats be approached with scientific rigor and consistency. Initial attempts to define "Shallow Water" as a resource caused considerable controversy among academicians and environmentalists who maintained that the act of defining "Shallow Water" would give the impression that shallow water resources were unconnected from neighboring resource areas, and that management could not be accomplished by arbitrarily establishing a definition. However, it was the consensus of the meetings that management of a resource required the clear and defined understanding of what was to be managed. It is critically important that the definition be functionally based. The "Shallow Water zone" is the area of maximum interaction among human activities and biological resources - most likely the first 4 m below the mean lower low water (MLLW) where critical functions such as biological productivity and ecological balance must be reconciled with human activities. Without the inclusion of functional characteristics in a legal definition of "Shallow Water" it is likely that a consistent approach to the management of "Shallow Waters" as a resource will be an unattainable goal.

32 45 P-3 C

Spiller, K., Hensley, R., Texas Parks and Wildlife Dept., Coastal Fisheries Div., Corpus Christi, TX. **STATUS OF TWO BAY SPAWNED SCIAENIDS, *C. NEBULOSUS* AND *P. CROMIS*, IN THE UPPER LAGUNA MADRE, TEXAS FOLLOWING THE 1989 FREEZES AND THE ONSET OF THE BROWN TIDE.**

Data on two sciaenid species that spawn in the upper Laguna Madre, *C. nebulosus* and *P. cromis*, were analyzed to determine potential effects of the 1989 freezes and the ongoing Brown Tide. Bag seine data for both species, show the highest recorded juvenile abundances since 1977. Recruitment increased for *C. nebulosus* following the freezes and peaked during 1992 and 1993. *P. cromis* showed the highest levels of recruitment for 1990-91 with 1995 being the third highest level recorded. Gill net samples for both species showed increases above the pre-1989 freeze levels with catch rates, in 1994, for *P. cromis* reaching the highest ever recorded. Even during the phytoplankton bloom, these two species in the upper Laguna Madre, have rebounded from the 1989 freezes with size classes tracking juvenile abundances and expected year class frequencies.

21 11 P-3 C

Stanton, L., Alley, R., University of South Alabama, Mobile, AL, and Stout, J., Marine Environmental Sciences Consortium/University of South Alabama, Dauphin Island, AL. **RESTORATION OF AN INTERTIDAL GULF OF MEXICO SALT MARSH: CAN FUNCTION BE RESTORED?**

Approximately one acre of Alabama salt marsh, filled by the Air Force in the late 50's for septic tank field lines, was restored by removal of fill to intertidal elevations, restoration of tidal flow and transplantation of nursery-reared marsh plants (*Spartina alterniflora*) and *Juncus roemerianus*) in January, 1993. Permanent 1 m² quadrats were monitored for plant survival, cover, plant height and standing biomass for three growing seasons in the restored marsh and a nearby natural marsh. Weirs enclosing 25m² of the marshes were sampled monthly for comparisons of faunal utilization and resident species recruitment. Transplant survival was high but varied with location within the marsh. Within two growing seasons, coverage by *Spartina* was similar to the reference marsh, but open patches were still evident in the *Juncus* zone at the end of three seasons. Twenty-seven species of fish and 6 species of invertebrates have been collected from the restored marsh. Fifteen of the fish and 5 of the invertebrates are the same as found in the reference marsh. Though common marsh species of pelagic fish and crustaceans quickly recruited to the restored marsh, epifaunal fiddler crabs and periwinkle snails were not observed until the end of the first summer and second summer, respectively.

7.1 1 O C S

Stemmy, L.M., Hackney, C.T., University of North Carolina at Wilmington, NC. **FACTORS DETERMINING DISTRIBUTION OF VEGETATION IN TIDAL MARSHES OF NORTH CAROLINA.**

The physical habitat of *Juncus roemerianus* was examined along a salinity gradient in the Cape Fear River, North Carolina. Redox potential, pH, soil salinity, soil drainage, elevation, percent sand, organic content, above-ground biomass and plant height were measured at nine sites. Mean pH was 7.0 and redox potential was 117 mV. All parameters varied over the gradient which had a salinity range of .5 to 35 ppt. Upriver sites were sandiest with high redox potentials. Mesohaline sites had high organic fractions and low redox potentials. Discriminant Analysis indicated that each site was statistically different from other sites due to salinity, elevation and organic matter. Biomass averaged 687 g m⁻² with no statistical differences among sites. Vegetative zones adjacent to *Juncus* were also examined. Extensive overlap in physical variables occurred between *Juncus* and adjacent zones, however, *Spartina alterniflora*, *Distichlis spicata*, *Scirpus robustus*, and *Juncus roemerianus* microhabitats could be statistically separated based on elevation and redox potential. *Juncus roemerianus* tolerates a range of physical conditions but only occupies a portion of its potential habitat. Zonation is caused by tolerance to physical conditions and interactions among species. Competitive exclu

sion restricts *Spartina alterniflora* to the low marsh. Interference competition may occur via root mat formation or sediment accumulation.

30.1 3 O C

Stevenson, J.C., Sundberg, K.L., Merrell, K.C., University of Maryland, Horn Point Environmental Laboratory, Cambridge, MD. **SCALES OF VARIABILITY OF NUTRIENTS, SUSPENDED SEDIMENTS, CHLOROPHYLL AND LIGHT IN SAV BEDS IN UPPER CHESAPEAKE BAY: IMPLICATIONS FOR WATER QUALITY.**

Past field studies have suggested there are critical thresholds of dissolved nutrients, Chlorophyll *a*, suspended sediments, and light attenuation necessary for survival of submerged aquatic vegetation (SAV). To investigate how these parameters varied over the growing season, and for insight into the temporal scaling of inputs to mesocosms, intensive monitoring within an SAV bed and an adjacent unvegetated area was undertaken at the head of Chesapeake Bay. Automated water samplers (ISCO), PAR sensors, and Hydrolabs, were employed to obtain fine scale records (every 3 hours) of nutrient inputs and physical forcing over three 10-d periods. In 1993, the Susquehanna Flats data revealed very high temporal variability with nitrate levels varying as much as 10-190 μM on a time scale of hours, whereas ammonium and nitrite were more stable. While nitrogen exceeded threshold levels, phosphate was usually less than 0.1 μM and appeared to be limiting in the water column with mean concentrations in the SAV bed reduced to half those outside. In contrast, a marginal bed in the Choptank River which was monitored for three ten day periods in 1994 had high light attenuation and suspended sediments and confirmed the previously established water quality parameters.

34.1 1 O C

Stockwell, D.A., Whitley, T.D., The University of Texas, Marine Science Institute, Port Aransas, TX. **BIOMASS AND PRODUCTIVITY STUDIES OF THE BROWN TIDE BLOOM IN LAGUNA MADRE, TEXAS.**

The Laguna Madre in South Texas has experienced a dense brown tide algal bloom since June 1990. This persistent bloom has reduced the penetration of sunlight to less than 50% of pre-bloom levels. Chlorophyll *a* reached concentrations as high as 120 $\mu\text{g/liter}$ with an annual mean of about 50 $\mu\text{g/liter}$ while mean monthly primary productivity rates measured over a 4 year period at 3 stations ranged from 1.1 to 2.0 $\text{gC/m}^2/\text{day}$. Laboratory and mesocosm pond studies determined that the brown tide organism consumed ammonium but could not utilize nitrate as its nitrogen source, even in the absence of ammonium. Bioassay multiple enrichment studies were performed to assess the degree of nutrient limitation on carbon fixation rates. Nutrient overenrichment in the Laguna Madre ecosystem with its very long residence time is one of the proposed causative factors.

13 18 P-2 C

Stokesbury, K.D.E., Ross, S.W., North Carolina National Estuarine Research Reserve, Center For Marine Science

Research, University of North Carolina at Wilmington, Wilmington, NC. **SPATIAL DISTRIBUTION AND ABSOLUTE DENSITY ESTIMATE OF JUVENILE SPOT, *LEIOSTOMUS XANTHURUS*, IN THE TIDAL FRINGE NEAR A SALT MARSH BORDER.**

The salt-marsh is an important nursery for juvenile fishes, but absolute fish density estimates and spatial distributions are difficult to obtain. We used a nested quadrat design to estimate the absolute density and spatial distribution of juvenile spot, *Leiostomus xanthurus*, in the tidal fringe, (5 to 50 cm water depth). Fifty white quadrats (10 of each areas 32, 64, 128, 256, and 512 cm^2) were randomly placed within two 10 m^2 plots adjacent to a wharf. The number of fish over each quadrat was counted on seven dates between 17 March and 7 April 1995. Control experiments indicated that plates did not attract or repel fish and the observer's experimental bias was low. Spot were the most abundant fish in the tidal fringe (95 to 99.5 % of total catch). Spot distribution was contagious and aggregations covered approximately 128 cm^2 . Spot densities ranged from 18.3 to 28.3 m^{-2} (3.0 to 5.4 % level of precision), while densities estimated from shore seines ranged from 5.3 to 1.8 spot m^{-2} (94 to 193 % level of precision). This technique counts the actual numbers of fish present, compared to traditional, inefficient net sampling, and more accurately reflects spot density and spatial distribution.

13.1 5 O C

Stokesbury, K.D.E., Ross, S.W., North Carolina National Estuarine Research Reserve, Center For Marine Science Research, University of North Carolina at Wilmington, Wilmington, NC. **SMALL SCALE VARIABILITY OF WATER QUALITY PARAMETERS AND THE RISK OF PSEUDOREPLICATION.**

Instruments which continuously measure water parameters are expensive, therefore, a single instrument may be deployed to represent a large area during monitoring. These data often represent simple pseudoreplication, one replicate per treatment, temporal pseudoreplication, treating data from successive dates as independent replicates, or both. To examine small scale water quality variability and pseudoreplication five Hydrolab datasonde-3s, each measuring temperature ($^{\circ}\text{C}$), salinity (ppt), dissolved oxygen (mg l), depth (m), and pH at 30 min. intervals, were randomly deployed for 24 h in a tidal creek on Masonboro Island (600 m strip), and in Zeke's Island Basin (1.6 km^2 area) in December 1994, and April 1995. Most differences between means were not biologically significant. However, during the spring at Zeke's Island, DO and salinity means ranged from 6.6 to 8.9 mg l, and 28.3 to 33.7 ppt, respectively, while during the spring at the tidal creek salinity ranged from 35.4 to 38.5 ppt. Repeat measure ANOVAs, ($\alpha=0.05$, $\beta>0.80$) indicated significant differences for all variables between hydrolabs. Our results indicated that each instrument represented a point measurement, and that small scale spatial variability occurred in areas which initially appear homogeneous, therefore one instrument may not represent a specific area.

Stonehill, S.C., Kjerfve, B., Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC. CHARLESTON HARBOR PROJECT DATABASE FOR HYDRODYNAMIC, WATER QUALITY AND NPS MODELING.

The Charleston Harbor Project is a multi-disciplinary project to establish a coupled set of numerical models (hydrodynamics, transport, water quality, non-point-source pollution, and land use) to help the South Carolina Department of Health and Environmental Control simulate better water quality scenarios in the Charleston system and other South Carolina estuaries. For model calibration and verification, large quantities of field measurements are needed. The Charleston Harbor System is very data rich, but required data are not usually easy to locate. This project has gathered and synthesized existing hydrological and water quality data for the Charleston estuarine system, including current speed and direction, tide, salinity, water temperature, suspended sediment, water quality, wind speed and direction, atmospheric pressure, air temperature, rainfall, river discharge, nutrient concentrations, dissolved oxygen, suspended solids, chlorophyll, pollutant concentrations, satellite images, and GIS coverage's. We have edited and synthesized the data, which primarily include measurements made since 1986 along with some significant earlier data sets. The sources of the data are disparate, including NOS/NOAA, WRD/USGS, Corps of Engineers, state agencies, and state universities. The data have been edited into a uniform format for easy access and manipulation, been subjected to quality control, and subjected to time series, spatial, and statistical analyses. Incorporated into a comprehensive on-line database for the Charleston system, this data can now be shared with researchers and managers needing the data for model comparisons or for decision-making. Only the time series portion of the database occupies more than 2 Gb of space, which is dwarfed by the storage space needed for the image and GIS layers. The data are available on-line to Charleston Harbor Project scientists and will in the future be made available to the public. Although similar data available for many US estuaries, they are of little use for management unless they are brought together in unified formats, grid sizes, and time steps in readily available formats. In our case, the estuarine data are available both on-line and written into compact disks. The database is not only of necessity for model verification, but provides a unique opportunity for further analyses of estuarine variability and function.

Stordal, M.C., Wen, L.-S., Santschi, P., Gill, G.A., Texas A&M University at Galveston, Galveston, TX. PHASE SPECIATION OF AS, HG, SB, AND SE IN GALVESTON BAY AND CORPUS CHRISTI BAY: SIGNIFICANCE OF COLLOIDAL FORMS.

Ultrafiltration techniques have been developed which allow for the isolation of particles between 0.45 μ m and 1kDa defined as colloids. Filtered (0.45 μ m) surface water samples

from a wide range of salinities (0-32) have been collected from Galveston Bay and Corpus Christi Bay and analyzed for As, Hg, Sb and Se in the filter-passing (0.45 μ m), retentate (1kDa to 0.45 μ m) and permeate (<1kDa) fractions. The dissolved concentrations ranged from 6.8 to 67 nM for As, 1.3 to 9 nM for Sb, 0.12 to 13.6 pM for Hg and <0.05 to 5.1 nM for Se with the highest values from Corpus Christi Bay. Colloidal As and Sb was generally constant at approximately 10% and 7%, respectively. Colloidal Se ranged from 0 to 45% and colloidal Hg ranged from 12 to 93%. These results indicate that a major portion of the filter passing As and Sb is "truly dissolved", while Hg is significantly associated with particles greater than 1kDa and selenium is highly variable. Correlation between organic carbon content of these particles and Hg concentration indicates that a majority of the mercury is probably associated with large organic macromolecules rather than iron oxyhydroxides.

Stritholt, J.R., Garono, R.J., Earth Design Consultants, Corvallis, OR and Oregon State University, Tillamook Bay National Estuary Project, Garibaldi, OR. THE ROLE OF REMOTE SENSING IN ECOLOGICAL ASSESSMENT OF TILLAMOOK BAY, OREGON.

Priority problems identified for the Tillamook Bay NEP include: excessive sedimentation of the bay as a result of land use activities, water-borne pathogen contamination, and habitat degradation. Computer mapping technologies, GIS (geographic information systems) and remote sensing, were chosen to assess existing and historical ecological conditions, and develop the necessary infrastructure for ongoing ecological monitoring throughout the watershed. Remotely sensed imagery was acquired from three different sensors: Landsat MSS, Landsat TM, and multispectral airborne video. A triplicate series of Landsat MSS scenes (1975, 1986 and 1992) were acquired from the North American Landscape Characterization program. Analysis of classified data resulted in change detection for the Tillamook watershed at a coarse resolution of 80 meters. Two Landsat TM map scenes were also analyzed (1985 and 1993) to capture landscape changes at the finer resolution of 30 meters. Finally, multispectral airborne video was employed to analyze the current physical condition of the bay and immediate surrounding area. This sensor provided comparable multispectral data to Landsat platforms, but at a spatial resolution of approximately 1 meter which allowed for detailed mapping of bay elements. Using data from different sensors, we were able to address ecological concerns at the most appropriate spatial scale.

Strobel, C.I., Nelson, W., Benyi, S.J., Campbell, D.E., U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI. CUMULATIVE EFFECTS RESEARCH PROGRAM (CERP): NEW BEDFORD HARBOR/SLOCUM'S RIVER BENTHIC COMMUNITY RESULTS.

CERP's goal is to provide scientific and management tools

to quantify, characterize and predict cumulative effects on coastal ecosystems. A case study was conducted using New Bedford Harbor (NBH), MA and the adjacent Slocum's River as test sites. NBH is heavily contaminated with PCBs, metals, and nutrients; Slocum's River is relatively unimpacted by man. Sediments were collected at 79 stations in NBH and 31 stations in the Slocum's River in the summers of 1993 and 1994, and analyzed for PCBs and metals, toxicity, and benthic invertebrate community parameters. PCB concentrations in sediments ranged from 16 to 431,000 ng/g, and showed a general decreasing trend from the upper harbor (Superfund site) to the outer harbor. Benthic community condition was evaluated based on species richness, EMAP's benthic index, and species dominance. The mean number of species per station for the upper, lower and outer harbors was 20, 31 and 72, respectively, with no significant salinity or grain size gradient measured. The benthic index and species dominance indicators showed the same trend of degraded conditions in the upper harbor and non-degraded conditions in the outer harbor. Evaluation of results from the Slocum's River survey, where PCB concentrations did not exceed 40 ng/g, is currently underway.

3.1 4 O I

Studer, M., Wallace, G., Massachusetts Bays Program, Boston, MA. THE MERRIMACK RIVER: ITS IMPORTANCE AS A SOURCE OF METALS TO THE MERRIMACK ESTUARY, THE GULF OF MAINE AND MASSACHUSETTS BAY.

The Merrimack River basin is New England's fourth largest river basin and the river is a primary source of freshwater to the Gulf of Maine in Massachusetts. Due to its central location in New Hampshire and Massachusetts, and its history as the birthplace of the American Industrial Revolution, the Merrimack has been, and continues to be, heavily used as a waste receptor for municipal and industrial discharges. For this reason, the river is also a major source of contaminants to the estuary, the Gulf of Maine and possibly Massachusetts Bay. Therefore, the Merrimack River has been the focus of several research projects to quantify and characterize the flux of contaminants from the river to the marine environment. The transport of selected metals from the Merrimack River to its estuary was studied for a two-year period under different season and flow conditions. In addition to seasonal and annual metal flux estimates, the distribution of metals between dissolved and particulate phases and enrichment of metals on particles, relative to average crustal metal values, were also determined. The results of this study indicate that the Merrimack is a significant source of metals to the estuary, and possibly the Gulf of Maine, especially during spring melt. These data provide an important database for assessing the relative magnitude of this riverine source with other sources of metals to coastal Massachusetts and for use in developing a management strategy for the region's coastal resources.

3.1 1 O I

Stumpf, R.P., Haines, J.W., Raabe, E.A., U.S. Geological Survey, Center for Coastal Geology, St. Petersburg, FL. HISTORICAL SEA LEVEL VARIATIONS IN THE GULF OF MEXICO AND COASTAL WETLANDS STUDIES.

Mean sea level has shown a steady rise over the last 100 years throughout the Gulf of Mexico. Superimposed on this trend are additional cycles in water level that can be an order of magnitude greater than the trend. Marshes and associated upland vegetation boundaries are controlled by the position of mean high water (MHW). The interaction of the sea level cycles with flooding at the level of MHW may have significant impact on the response of coastal ecosystems to sea level rise. Long-term change in mean sea level should not then be inferred to influence changes in marsh characteristics observed in short-term (less than five-year) studies. Evaluations of the impact of sea level rise on coastal wetlands should consider these complex fluctuations, particularly in MHW, instead of the long-term trend in sea level.

12.3 1 O I

Summers, K., U.S. EPA, Gulf Ecology Division, Gulf Breeze, FL. DEVELOPING THE TOOLS TO MONITOR LONG-TERM CHANGES IN THE ESTUARINE ENVIRONMENT: EMAP- PHASE II.

EMAP is unique among national environmental monitoring efforts because it uses indicators of condition and a probability-based sampling design to monitor all ecological resources. While the needs that led to the creation of EMAP are even more important today than in 1988 and many of EMAP's fundamental design concepts have proven sound, the program now faces major change dictated primarily by funding limitations. EMAP's original plan was to become a comprehensive, national, interagency ecological monitoring program. EMAP-II will now focus on demonstrating the scientific validity and practicality of ecological monitoring approaches in specific geographic areas and continuing to develop, jointly with other Federal agencies and the States, a plan for integrating EMAP into a comprehensive, national, ecological monitoring network. To this end, EMAP-II will focus its efforts on the role of biological integrity in determining the condition of aquatic resources, the use of an integrated, watershed perspective, the development of intensive monitoring components to complement its existing extensive network of sampling sites, the establishment of a solid scientific foundation of its techniques through regional studies, and the development of new and better ecological indicators through the support of ORD's investigator-initiated research program. The culmination of these efforts will result in the development of a design for a comprehensive, national, ecological monitoring effort.

-T-

29 33 P-3 C

Taylor, D., Connor, M., Rex, A., Coughlan, K., McSweeney, N., Massachusetts Water Resources Authority, Charlestown Navy Yard, 100 First Ave., Boston, MA 02129. **CHANGING EUTROPHICATION STATUS OF BOSTON HARBOR.**

Boston Harbor is one of the most highly enriched bays in the USA. Over 90% of the nutrients entering the harbor do so via sewage discharges. In 1997, implementation of the Massachusetts Water Resources Outfall pipe will divert almost all the sewage inputs out of the harbor, offshore. As for Thames Estuary, England, and Tampa Bay, Florida, this diversion provides a real-life opportunity to track the recovery of a highly eutrophied, temperate bay system. Over the past three years bay-wide monitoring has been conducted to establish the current eutrophication status of Boston Harbor, and to provide a base line with which to compare conditions after diversion. This poster will summarize the baseline findings, and compare the current eutrophication status of the system with that of other bays and estuaries.

30.2 3 O C

Taylor, D., Nixon, S., Granger, S., Buckley, B., Graduate School of Oceanography, The University of Rhode Island, Narragansett, RI. **THRESHOLD NITROGEN LOADINGS FOR SEAGRASS-BASED LAGOONS OF THE NORTHEAST USA.**

Nutrient enrichment has been identified as a threat to coastal systems along the entire east coast of the USA. Much of the research conducted on enrichment of marine systems has focused on large, deep bays and estuaries. Much less is known of the impacts of enrichment of shallower lagoons and embayments, that under unenriched conditions can support extensive seagrass beds. This paper presents the results of a gradient enrichment experiment, designed to quantify the loading-response relationships for key plant components (phytoplankton, seagrasses and macroalgae) of the shallow lagoons of the northeast. The experiment was conducted using mesocosms designed as living models of the lagoons. N loadings in the order of 300 to 400 mmol m⁻² y⁻¹ generated mean phytoplankton biomasses (10 to 20 µg l⁻¹) sufficient to cause the complete demise of the eelgrass beds, suggesting these loading may serve as a threshold for purposes of managing the basins feeding the lagoons. This threshold is small relative to the extent to which the N loadings can be increased, indicating the high sensitivity of the natural lagoons to enrichment.

4.1 3 O I

Teal, J.M., Woods Hole Oceanographic Institution Woods

Hole, MA. **DID MARINE WETLANDS PRODUCE FISH? SOME DATA FROM OUR FOREFATHERS**

I will report on data taken by the U.S. Commission on Fish and Fisheries in 1880 from all the fishing ports around Long Island, N.Y. and compare the catches with the area of salt marsh, area of shallow waters, and area of deeper waters for each port. Though there are obvious difficulties with such data sets, they do come from a time before much of the disturbance of our coastal wetlands had occurred. The results should give some insight into our current questions on the relationship between coastal wetlands and fisheries.

13.1 3 O C

Theberge, S.F., Florida Department of Environmental Protection, Rookery Bay National Research Reserve, Naples, FL. **TARGETING ADULT AUDIENCES WITH ESTUARINE ISSUES AND SCIENCE.**

Southwest Florida and Naples has experienced rapid growth in the past 20 years. Rapid growth has threatened to destroy the very resources that have attracted new residents and also support a very important tourism industry. Most of the new arrivals have limited knowledge about South Florida's unusual ecosystems. Rookery Bay education programs have tried to reach this divergent audience by offering a variety of programs and events targeting adult audiences. These include adult evening and weekend courses, fishing tournaments and fishing colleges, community college courses, outreach programs on water quality issues, and ecotourism workshops. Through these programs and events, the Reserve disseminates the results of its research and resource management efforts. It is hoped that by providing participants with this information they will be better able to make informed decisions about the ecological problems affecting estuaries and then take the appropriate actions (letters and telephone calls to influence local, state, and national government officials and politicians, joining support groups, participation in coastal clean-ups and restoration efforts).

30.3 2 O C

Thom, R., Shreffler, D., Battelle/Marine Sciences Laboratory, Sequim, WA, Cordell, J., Simenstad, C., Fisheries Research Institute, University of Washington, Seattle, WA, and Olson, A., Wyllie-Echeverria, S., School of Marine Affairs, University of Washington, Seattle, WA. **MITIGATING IMPACTS OF FERRY TERMINALS ON EELGRASS IN PUGET SOUND.**

The objectives of this study are to understand effects of ferry terminals and ferry operations on eelgrass *Zostera marina* L. meadows in Puget Sound and to design appropri-

ate measures to avoid, minimize and compensate for associated impacts. Dramatic increases in population and ferry traffic in western Washington have resulted in the need to expand existing terminals. Our studies have shown that eelgrass meadows near ferry terminals are affected by light reduction, and other initial and long-term disturbances associated with terminal construction and maintenance, propeller wash, and bioturbation by macroinvertebrates (i.e., seastars and Dungeness crab). Experimental work on light is directed at documenting the annual irradiance requirements for eelgrass. Modeling of the shadow print from a terminal will allow estimates of the impact zone to be calculated. Technological measures to mitigate impacts, including use of concrete piles, placement of plastic materials into the dock structure, grating over offloading ramps, reorienting slips to minimize propeller wash, and a variety of other measures are being evaluated. Restoration is also proposed for portions of meadows previously destroyed by ferry operations.

8.2 7 O C

Thompson, J., U.S. Geological Survey and Stanford University, Stanford, CA, and Lucas, L., Koseff, J., Stanford University, Stanford, CA. **BENTHIC GRAZING BY BIVALVES AS A CONTROL ON SOUTH SAN FRANCISCO BAY, CA (USA) PHYTOPLANKTON BIOMASS: FIELD OBSERVATIONS IN SUPPORT OF A NUMERICAL MODEL.**

Results from a numerical model of phytoplankton dynamics in South San Francisco Bay (see Lucas *et al.* presentation) in conjunction with 5 years of field observations of chlorophyll a, benthic grazer biomass, and water column density has allowed us to examine the causes for intra-annual and interannual differences in phytoplankton biomass. Previous studies show that phytoplankton blooms in South Bay occur only during a short time in spring. During our study, the phytoplankton blooms started in the shallow regions of the estuary in early spring, when benthic grazing pressure and tidal energy were very low, and the water was stratified for at least part of the bloom period. As predicted by the model, phytoplankton biomass levels were highest in years when vertical stratification was greatest and blooms were most persistent during years when shallow-water benthic grazer biomass was lowest. A second bloom, expected in fall when low mixing is seen due to reduced tidal and wind energy, was seen only during those years with very low shallow-water benthic grazer biomass. These observations confirm the models finding that phytoplankton blooms are generated without water column stratification, if light attenuation and shallow-water benthic grazing pressures are low.

36.1 6 O C S

Thompson, M., Schaffner, L., Patterson, M., College of William & Mary, School of Marine Science, Virginia Institute of Marine Science, Gloucester Point, VA. **CHAETOPTERUS VARIOPEDATUS'S ROLE IN BENTHIC-PELAGIC COUPLING: THERE'S MORE**

TO WATER QUALITY THAN SHELLFISH.

Phytoplankton production in the water column and subsequent consumption by the benthos are important factors in the carbon dynamics of shallow estuarine and coastal subsystems such as Chesapeake Bay. The shallowness of these systems allows for a close coupling between the water column and the benthos. Important links in benthic-pelagic coupling are suspension/filter feeding organisms which function as coupling agents. Within the lower Chesapeake Bay the suspension feeding polychaete *Chaetopterus variopedatus* is a biomass dominant. Hence, this polychaete is the focus of our study on organism mediated flux of material between the water column and the benthos. Measurements made in situ indicate that these worms have a filtration rate comparable to oysters. *In situ* observations indicate that about 25% of worms are filtering at a time. Worm densities range between 40 and 100 worms per m² seasonally. A high chlorophyll a content within the gut and a high assimilation efficiency suggest that these worms are ingesting mostly new carbon compared to resuspended material from the benthos. Further, the chlorophyll a content of the fecal pellets is an order of magnitude greater than sediment concentrations. Thus, these worms are supplying a significant amount of new carbon to the benthos.

10.1 3 O C S

Thomson, K., Peterson, B.J., Cowan, Jr., J.H., Heck, Jr., K.L., University of South Alabama, Department of Marine Sciences, Mobile, AL and Dauphin Island Sea Lab, Dauphin Island, AL. **COMPARISON OF PREDATION PRESSURE IN TEMPERATE AND SUBTROPICAL SEAGRASSES BASED ON CHRONOGRAPHIC TETHERING.**

Tethering has been shown to be a useful tool in predation studies. The standard technique involves connecting a prey item to a thin monofilament tether and anchoring the animal in different types of habitats. Observations can then only be made as to the presence or absence of the prey item after some standardized unit of time. With the use of inexpensive timing devices, presence/absence data can be augmented with the time of the predation event and subsequently, tidal state and day versus night predation. In the present study, predation pressure between three habitat types (seagrass bed interior, seagrass bed edge, and unvegetated substrate), two different prey types (soft versus hard body), and two latitudinally distinct regions was determined by the use of chronographic tethering devices. Results are compared for the Damariscotta River, Maine, a high tidal energy temperate system and Saint Joseph Bay, Florida, a low tidal energy subtropical system.

5 16 P-1 C S

Thomson, K.M., Peele, E.R., Strom, S.L., Western Washington University, Bellingham WA. **IMBALANCE BETWEEN BACTERIAL PRODUCTION AND BACTERIVORY IN MICROLAYER AND SUBSURFACE WATERS OF PADILLA BAY, WASHINGTON.**

Bacterial numbers, bacterial production and protistan bacterivory were measured in microlayer (100 µm) and subsurface (25 cm) waters of Padilla Bay, Washington. Objectives were to compare bacterial numbers and heterotrophic activity at both depths, and to investigate the fate of bacterial production. Bacterial abundance was higher in microlayers than in subsurface waters. In contrast, subsurface bacterial communities were metabolically more active than microlayer communities. Bacterial production in the microlayer may have been limited by substrate composition or inhibited by pollutants concentrated in the surface film. Differences in grazing pressure may also explain lower metabolic activity in microlayers. Small flagellates <5 µm were the most abundant members of the heterotrophic protistan community in both the microlayer and subsurface waters. Bacterivory occurred in both microlayer and subsurface waters and was attributed largely to heterotrophic flagellates. Grazing rates were low and usually less than 1% of the estimated bacterial cell production. It appears that bacterivory by heterotrophic protists is not a major path of energy transfer in microlayer or subsurface waters of Padilla Bay. Other factors may be more important in balancing bacterial growth, such as physical advection and viral lysis.

2.3 3 O C S

Tobias, C.R., Anderson, I.C., Berry, B.E., School of Marine Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. **THE POTENTIAL FOR DISSIMILATORY NITRATE REDUCTION TO AMMONIUM IN SALT MARSH SEDIMENTS.**

Nitrate is a source of "new" nitrogen in salt marshes exposed to N-contaminated ground or surface waters. Salt marshes, either natural or constructed, are often used to remediate nitrogen-loaded surface waters. An additional source of nitrate is wet deposition. Allochthonous nitrate introduced to a salt marsh may be reduced either by denitrification to N₂ (DNR) or by dissimilatory nitrate reduction to ammonium (DNRA). Depending upon which of these microbial processes is dominant, nitrogen will either be conserved in the marsh sediments as NH₄⁺ or organic N or lost to the atmosphere as N₂O and N₂. We have measured DNR, DNRA, ammonium production, and nitrate disappearance in cores and slurries taken from a *Spartina alterniflora* salt marsh. DNRA was measured using ¹⁵NO₃⁻ (1mM) as a tracer. DNR was measured using both acetylene blockage and ¹⁵N₂O pool dilution techniques. In anaerobic slurries DNRA accounted for all of the nitrate reduced; in aerobic cores DNRA accounted for 60 - 100% of the nitrate disappearance. Rates of denitrification determined by acetylene block appeared to be overestimates. We conclude that in salt marsh sediments enriched with "new" nitrate from anthropogenic sources most of the nitrate reduced is conserved in the sediments.

31 37 P-3 C S

Tolley, P.M., Christian, R.R., Department of Biology, East Carolina University, Greenville, NC. **EFFECTS OF TIDAL INUNDATION AND WRACK DEPOSITION ON HIGH SALT MARSH MACROPHYTES.**

A randomized block design was used to examine the effects of increased inundation and wrack deposition on high salt marsh macrophytes at the Virginia Coast Reserve. In particular we studied the effects of increased inundation and wrack deposition on the growth and senescence of *Juncus roemerianus*, on above-ground biomass, and on the recolonization of bare patches after wrack deposition. We recorded the life histories of tagged leaves of *J. roemerianus* over the course of 19 months, collected plant material to determine biomass at the end of two growing seasons, and analyzed the ground cover in the plots at the height of the growing season. The rates of growth and senescence by tagged leaves were influenced by increased inundation, ponding water, and previous wrack coverage. The combination of inundation and wrack deposition decreased the overall biomass greater than wrack alone. After wrack removal, *Distichlis spicata* recolonized areas previously dominated only by *J. roemerianus*. Both *Spartina patens* and *D. spicata* regrew in areas dominated by those two species before the wrack deposition. Results generally confirm our hypothesis that *J. roemerianus* is likely to be replaced by other species through combined effects associated with sea-level rise.

30.1 5 O C

Tomasko, D.A., Southwest Florida Water Management District, Venice, FL, and Hall, M.O., Courtney, F.X., Florida Marine Research Institute, St. Petersburg, FL. **SPATIAL AND TEMPORAL VARIATION IN WATER QUALITY AND SEAGRASS GROWTH PARAMETERS IN CHARLOTTE HARBOR: CAN THALASSIA TESTUDINUM BE USED FOR SETTING RESOURCE-BASED POLLUTANT LOAD REDUCTION GOALS?**

Based on methodology developed and refined in Tampa Bay and Sarasota Bay, turtle grass, *Thalassia testudinum*, was chosen as a "target species" for determining pollutant load reduction goals for Charlotte Harbor, Florida. However, preliminary work suggests that Charlotte Harbor might have various unique characteristics that prevent direct application of earlier techniques for determining resource-based pollutant load reduction goals. In Charlotte Harbor, meadows of turtle grass adjacent to the largest modelled watershed nitrogen loads are characterized by low biomass and low productivity, but they also have low amounts of epiphytic algae and drift macroalgae. In contrast, meadows farther away from the highest nitrogen loads have greater biomass and productivity, but they also have greater amounts of epiphytic algae and drift macroalgae. One current hypothesis is that due to the reduced water clarity in those regions that directly receive the major nitrogen loads (due to high concentrations of dissolved organic matter), blooms of epiphytic algae and macroalgae are spatially (and temporally?) separated from the sources of nitrogen that eventually control their abundances. The management implications of such a phenomenon are considered.

20.2 1 O C

Townsend, A., Howarth, R.W., Swaney, D., Billen, G., Jaworski, N., Lajtha, K., Downing, J., Elmgren, R., Caraco,

N., Jordan, T., Cornell Univ., Ithaca, NY; Univ. of Brussels, B-1050 Brussels, BEL; US EPA Lab, Narragansett, RI; Oregon State U., Corvallis, OR; U. of Iowa, Iowa City; Stockholm Univ., S-106 91 Stockholm, SWE; Institute for Ecosystem Studies, Millbrook, NY; Smithsonian Env. Res. Ctr., Edgewater, MD. **EFFECTS OF ANTHROPOGENIC NITROGEN ON RIVER N EXPORT TO THE NORTH ATLANTIC.**

Industrial and agricultural activities have caused dramatic increases in N inputs to terrestrial and aquatic ecosystems in recent decades, particularly across much of the U.S. and Europe. As part of the SCOPE Nitrogen Project, we pooled the watersheds draining into the North Atlantic Ocean into 14 major basins, and compiled available data to estimate river N fluxes to the coast, atmospheric N deposition, application of N fertilizers, leguminous crop N fixation, and the net movement of N in food and feed for each of the 14 basins. We also used data on river N from relatively undisturbed regions along with modeled values for pre-industrial N deposition to estimate pre-industrial river N fluxes from each watershed basin. Our analysis suggests that river N fluxes in most North American and European basins have increased 5-20 fold since pre-industrial times, and shows that they are highly correlated with the sum of all anthropogenic N inputs to the basin. Finally, despite the substantially elevated river values, only about 20-25% of total anthropogenic N inputs to the basins can be accounted for in the rivers, thus it is critical to identify how the remainder is partitioned among potential atmospheric, terrestrial and groundwater sinks.

32.2 5 O C

Townsend, D.W., Wall, R.E., University of Maine, Orono, ME. **THE REGIONAL MARINE RESEARCH PROGRAM, 1990-1995: AN INITIAL STEP TOWARD ECOSYSTEM SIMULATION AND PREDICTION IN THE GULF OF MAINE.**

Marine environmental management issues often translate into the following fundamental questions: What are, and what will be, the impacts of human activities on the marine environment? What likely will be the effects of these impacts on our society, and how can they be quantified? Neither marine environmental managers nor the marine science community have been well prepared or organized to cope with these fundamental questions, due in part to the barriers created by various institutional, political and reward systems in our society. We believe that to deal effectively with these questions in the long term requires a continuing investment in research designed to increase our understanding of the workings of marine ecosystems. The appropriate application of this understanding as it accrues will be a necessary condition for pursuing the concepts of cumulative impacts, risk assessments, sustainability and ecosystem management. The Regional Marine Research Program (RMRP), created by an act of Congress in 1990 and overseen nationally by NOAA and EPA, offers ways of overcoming these barriers and addressing these questions. In principle, the RMRP provides an effective means for developing high quality, scientifically

credible information on a regional basis in support of efforts to safeguard water quality and ecosystem health in the coastal regions around the nation. The RMRP for the Gulf of Maine (GOM), with significant assistance from the management and research communities, has developed the following long-term goal: to develop a set of models that collectively simulate what we know and what we can learn about the Gulf of Maine ecosystem and its interacting components — how they function in their natural state, and how they would function under stress and/or when perturbed. In pursuit of this goal, the GOM RMR Program has attempted to articulate the primary societal problems facing us, to translate them into classes of scientific questions, and to identify and prioritize the related scientific information that will be needed. The GOM RMRP is presently in the final stages of its initial phase. A total of 29 scientific research activities have been funded over the past three years, totalling almost \$7M, and involving investigators from 15 institutions in the northeast. Ongoing research activities encompass interdisciplinary aspects of the physics, chemistry, biology and geology of the Gulf of Maine system, and will be reviewed in this presentation.

13 19 P-2 C

Trueblood, D.D., Stratton, A.L., NOAA, Sanctuaries and Reserves Division, Silver Spring, MD. **OVERVIEW OF THE NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM'S NATIONAL MONITORING PROGRAM.**

NOAA's National Estuarine Research Reserve System (NERRS) is implementing Phase I of its national monitoring program this year. The poster will present an overview of the program and highlight examples of the monitoring data currently being collected. The goal of the national monitoring program is to "...identify and track short-term variability and long-term changes in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purposes of contributing to effective national, regional, and site-specific coastal zone management." In Phase I, three dataloggers have been deployed at each of the Reserves to monitor changes in water quality. Phase II, which is slated for implementation in 1996, will begin monitoring changes in ecological conditions such as biodiversity and the abundance or percent cover of key wetland species. Phase III of the monitoring plan will develop a geographic information system database of coastal watershed land-use patterns for the NERRS. The baseline information collected from the NERRS National Monitoring Program will be used as the touchstone from which the effectiveness of different coastal watershed management practices will be gauged within the NERRS. Summary products of the monitoring data will soon be available over the internet.

17 33 P-2 C S

Tull, K.A., Rulifson, R.A., East Carolina University, Greenville, NC. **TRANSPORT OF STRIPED BASS EGGS IN A TIDAL BORE RIVER: THE SHUBENACADIE-STEWIACKE SYSTEM, NOVA SCOTIA.**

The last self-sustaining population of striped bass, *Morone*

saxatilis, in the Bay of Fundy spawns in the tidal bore-dominated Shubenacadie-Stewiacke watershed, Nova Scotia. Exactly how striped bass eggs are transported and retained in this estuary is undocumented. Egg deposition and water quality were monitored in the Stewiacke River downstream of the primary spawning grounds from 20 May to 15 June, 1994, taking replicate samples every 1.5 hours (16 times per day) cued to one hour after the tidal bore and 15 minutes after high slack tide. The tidal bore changed the river elevation 3.7 m and the salinity up to 20 ppt within one hour. Four major spawning peaks were on 2 June, 6-9 June, 13-14 June, and 20 June. Approximately 67% of the 20,006 eggs collected were <10 hours old; and 9% were 30+ hours old. Only 61 larvae were collected. Most eggs <10 hours old were collected during ebbing tides when salinities were lowest. Laboratory results indicated that youngest eggs were most buoyant (1 ppt at 17°C) and oldest eggs were least buoyant (9 ppt). This suggests that the eggs are retained in the estuary through hatching by the severe density gradient of the tidal bore.

28. 2 P-3 C

Turner, D., Striplin Environmental Associates Olympia, WA, and Collins, M., Gao, S., University of Southampton Department of Oceanography Southampton, UK. **SEDIMENT DYNAMICS ON AN ESTUARINE BEACH: A COMPARISON OF DIFFERENT METHODS.**

Sediment transport studies often rely on a mixture of field and analytical methods. This study investigated the sediment dynamics, net transport pathways, transport rates, and chemical fate on an intertidal sand beach in Southern England. The methods included the use a grain size based model (the "Gao & Collins trend analysis"), fluorescent tracers, hydrographical measurements, and meteorological data. Both tidally-dominated and wave- and current- dominated conditions were investigated. Two well known empirical equations were analyzed vectorially by a FORTRAN computer program to provide sediment transport due to tidal current and combined waves and tidal currents, and also net direction of movement. Wave periods and heights were estimated from a wave forecasting diagram, which, in the absence of direct wave measurements, was found to be adequate for this particular investigation. It was found that the area is tidally dominated, with rotatory currents that move in a counterclockwise direction, and that sediment transport is primarily to the northeast/east direction of the area under investigation. Bedload transport rates were low, reflecting the lack of significant wave and tidal influence. The influence of waves on sediment transport and direction is minimal, as the area is protected from significant wind speeds and fetches by the unusual geology of the area.

26.1 5 O C S

Turner, K.A., Baker, J.E., Chesapeake Biological Laboratory, The Center for Environmental and Estuarine Studies. The University of Maryland System, Solomons, MD. **THE SPECIATION AND COMPLEXATION OF TRACE METALS IN MESOCOSMS.**

The complexation of trace metals to dissolved and particulate matter strongly influences their bioavailability to biota. The binding capacity quantitatively describes the extent of contaminant sequestration in aqueous systems. The objective of this study was to determine the relationship between the speciation and complexation of a model trace metal, copper, and the dimensions and trophic complexity of benthic-pelagic mesocosms. Copper binding capacity was examined over time using a solvent extraction procedure and a fluorescence quenching technique. The solvent extraction procedure involves a liquid-liquid partition, ligand exchange procedure in which copper forms complexes with acetylacetone, followed by back extraction with acid. Acetylacetone competes with natural ligands for copper, and the equilibrium concentration of the acetylacetonate complex is used for speciation and binding capacity calculations. Graphite furnace atomic absorption spectroscopy was used to determine the concentration of the copper-acetylacetonate complex. The fluorescence quenching technique makes use of the fact that DOC naturally fluoresces; this fluorescence is quenched upon complexation to copper. The binding curves generated from titration data were mathematically modeled to determine the binding capacity. The results of this trace metal binding capacity study are incorporated into a time-variable, scale-independent model of contaminant speciation in mesocosms.

12.2 6 O I

Turner, R.E., Louisiana State University, Baton Rouge, LA. **THE RELATIVE INFLUENCE OF INORGANIC AND ORGANIC SOURCES ON SURFACE ELEVATION IN COASTAL MARSHES.**

Several experimental (ongoing) and regional analyses (EMAP) indicate the strong influence of organic material accumulation in the expansion, maintenance and regression of coastal wetlands. Tidal restrictions often result in surface elevation changes similar to that observed in freshwater wetlands following agricultural reclamation. Organic accumulation is more strongly related to vertical accretion than inorganic accumulation in many riverine wetlands. Various hypotheses explaining Louisiana's wetland loss rates as a function of reduced riverine sediment supplies this century were tested and rejected. Plant organic material is a much larger contributor to soil pore space than inorganic materials in deltaic plain salt marshes. Causal biological/hydrologic linkages are known to significantly affect the vertical accumulation rates. All of this means that plants are not merely an ancillary consequence of the geological dynamics, but dominant agents controlling factors relevant to coastal restoration and management efforts.

12 37 P-1 C

Tweedale, W.A., Sigua, G.C., Steward, J.S., Environmental Sciences Division, St. Johns River Water Management District, Palatka, FL. **WATER QUALITY STATUS OF THE BANANA RIVER LAGOON: SPATIAL AND TEMPORAL PATTERNS.**

The Banana River Lagoon (BRL) is a blind estuary comprising 32 miles of the 150 mile-long Indian River Lagoon system, located on the east coast of Florida. Physical, chemical and biological parameters of water quality were measured at 10 sites in the BRL. Data were analyzed to detect spatial and temporal patterns in water temperature, secchi depth, turbidity, total suspended solids (TSS), color, salinity, conductivity, pH, dissolved oxygen (DO), dissolved orthophosphate, and total phosphorous (TP), total Kjeldahl nitrogen (TKN), and nitrate+nitrite nitrogen. Biological activity and trophic state of the water was assessed by analyzing chlorophyll *a* and pheopigments. Assessment of data from 1987-1992 confirms that spatial and temporal differences occur in these water quality parameters. Temporal significance was evident in the levels of salinity, TSS, turbidity, TKN, TP and chlorophyll *a*. Spatial significance was found in salinity, TP, and chlorophyll *a*. WQ values were compared with State of Florida Waterbody Class III criteria: critical levels were noted in 16% of DO and 0.5% of pH samples. WQ values were also compared with the 10th, 50th (median) and 90th percentile values for Florida Streams and Estuaries from the EPA 305 (b) reports: BRL WQ values usually fell within the percentile boundaries.

2 7 P-1 C

Twilley, R.R., Chen, R., Lawton, L., Rivera-Monroy, V., Foret, J., Pelegri, S. University of Southwestern Louisiana, Department of Biology, Lafayette, LA, and Koch-Rose, M. RSMAS, University of Miami, FL. **BIOGEOCHEMISTRY OF MANGROVES ALONG THE SHARK RIVER SLOUGH, FLORIDA.**

There are several questions concerning the ecological significance of nutrient cycling as a constraint on the development of mangrove ecosystems; and these ecological processes may be dependent on the fertility of different geomorphological settings of a region. We report on the biogeochemistry of mangrove ecosystems along Shark River Slough in the Everglades National Park. There is a distinct decrease in forest structure among four sites studied from the euhaline to oligohaline extremes of the slough; suggesting a limitation as salinity decreases from 33 to 8 psu (sulfide levels are <0.5 mM along the transect). Bulk density estimates of carbon, nitrogen, and phosphorus show a distinct decrease in bulk density concentration in sediment and nutrients more inland of the slough; particularly for phosphorus. Pore water concentrations of inorganic nitrogen and phosphorus are low; but mineralization rates indicate high turnover. Regeneration of nutrients in the canopy (retranslocation) may contribute to nitrogen demand in the litter along the nutrient gradient; some of which is supplied by nitrogen fixation. Fluxes at the sediment-water interface are negligible; indicating that exchange of inorganic nutrients is low. Nutrients are highly conserved along the salinity gradient and indicate more fertile conditions at the marine section of the Shark River Slough.

2.3 6 O C

Twilley, R.R., University of Southwestern Louisiana, De-

partment of Biology, Lafayette, LA, Lynch, J.C., National Biological Service, Lafayette, LA, McKee, B., LUMCON, Chauvin, LA, and Pozo, M., Churute Ecological Preserve, Guayaquil, Ecuador. **SEDIMENT AND NUTRIENT ACCUMULATION IN MANGROVE ECOSYSTEMS IN THE NEOTROPICS.**

Rates of sediment and nutrient accumulation were determined for a variety of mangrove forests in Ecuador (Guayas River Estuary) and Gulf of Mexico (Florida, Belize, Mexico) representing different geomorphological and ecological types of mangrove ecosystems. Bulk sedimentation rates (organic plus inorganic material) ranged from 371 to 5099 g m⁻² yr⁻¹; and this wide range was associated with source of inorganic solids from rivers. The accumulation of carbon (65-387 g m⁻² yr⁻¹) and nitrogen (2.5-13.4 g m⁻² yr⁻¹) were associated with deposition of organic matter among the sites. Accumulation of phosphorus ranged from 0.2 to 3.6 g m⁻² yr⁻¹, much larger range among sites than for carbon or nitrogen. Atomic carbon:nitrogen ratios of accumulated material ranged from 16 to 33; however, ratios of accumulated N:P ranged from 6 to 81, demonstrating the large difference in P loading among the 15 mangrove forests. Higher rates of P loading were associated with sites with high loading of inorganic matter from rivers. The higher productivity and biomass of riverine mangroves may be linked to greater inputs of P; while burial of N is much higher than estimates of N loss via denitrification in all mangrove forests.

2.4 3 O C S

Tyler, A.C., Zieman, J.C., University of Virginia, Department of Environmental Sciences, Charlottesville, Virginia. **DEVELOPMENT OF TIDAL CREEKS ON A BARRIER ISLAND OVERWASH MARSH: NUTRIENT AND PARTICULATE FLUXES, AND CREEK BANK GEOCHEMISTRY.**

The purpose of this study is to examine chemical processes in different age tidal creeks in a barrier island overwash marsh chronosequence. Four creeks (aged 4, 5, 13 and 150+ yr) and the adjacent source lagoon, were examined for ammonium, nitrate and phosphate concentrations, suspended particulate carbon, nitrogen and organic matter concentrations, and chlorophyll *a* concentration twice monthly. In addition, sediment carbon and nitrogen, chlorophyll *a*, and pore water nutrient concentrations, pH and redox potential were measured along transects perpendicular to each creek on a monthly basis. Early data analysis shows that nutrient concentrations are higher on ebbing tides than on rising tides in all creeks; however, the magnitude of the difference in concentration between flooding and ebbing tides is much greater in younger creeks. Suspended particulate carbon and nitrogen, and chlorophyll *a* were higher in young creeks during flooding tides, and higher in older creeks during failing tides. Sediment carbon and nitrogen decrease with increasing distance from the creek bank in all creeks. These preliminary data suggest that young overwash marsh creeks may export nutrients and import particulates, provided that the tidal exchange volumes are similar between different aged creeks.

-U, V-

22 16 P-3 I

Unger, M.A., School of Marine Science, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA, and **Brush, G.S.**, Department of Geography and Environmental Engineering, The Johns Hopkins University, Baltimore, MD. **TRENDS IN BUTYLTIN CONCENTRATIONS IN CHESAPEAKE BAY SEDIMENT CORES: A COMPARISON WITH LONG-TERM WATER COLUMN MONITORING DATA**

Sediment cores were collected from three locations in Chesapeake Bay for dating and chemical analyses to evaluate the recent historical trends in butyltin contamination. Tributyltin (TBT) and dibutyltin (DBT) concentrations increased with depth up to a maximum value which correlated to peak use of TBT in antifoulant paints in the mid 1980's. The trends in these data are similar to long-term trends in water column monitoring data from several stations in Chesapeake Bay which show decreasing TBT concentrations since federal legislation restricting the application of TBT paints was enacted in 1988. The ratio of TBT to DBT (the degradation product of TBT) in sediment cores was constant suggesting that little TBT degradation is occurring after burial or the rates of TBT and DBT degradation are similar. Unlike many sediment associated contaminants which can be deposited in sediments from multiple sources, TBT leaches from boat paints into the water column and sorbs to sediment particles at the time of settling. The distinct TBT profile seen in these cores and water column monitoring data suggests that this compound would show a similar trend in sediment cores at other locations. If additional work demonstrates this trend to be consistent, TBT may become a useful chemical marker for the late 1980's in estuarine sediments.

10.1 4 O C

Valentine, J.F., Heck, Jr., K.L., Zande, J.M., Marine Environmental Sciences Consortium/University of South Alabama, Dauphin Island, AL. **SEDIMENT NUTRIENT SUPPLY V. HERBIVORY: EVIDENCE FOR THE IMPORTANCE OF BOTH IN STRUCTURING TURTLEGRASS HABITATS.**

Interactions between nutrients and grazers are known to determine the productivity and abundance of most freshwater primary producers. By comparison, seagrass ecologists usually focus singularly on grazers or nutrients as they control seagrass productivity and abundance. In a short-term (summer-fall) experiment, we simultaneously manipulated sediment nutrients and herbivores to estimate their relative influence on turtlegrass production, biomass, leaf width and length, leaf elemental composition and shoot density in St. Joseph Bay, Florida. Sediment nutrients were amended with

Osmocote™ tree spikes twice monthly. Sea urchin densities were manipulated at 0, 10 and 20 inds/m². Monthly comparisons show that sediment nutrients control leaf nitrogen and phosphorus concentrations and leaf width at the end of the experiment, but had no effect on shoot abundance or biomass. In contrast, sea urchin grazing decreased leaf length and biomass initially, and led to elevated shoot density for a short period of time. Interactions between grazers and sediment nutrients significantly affected shoot growth and density later in the experiment. We conclude that interactions between herbivory and nutrient supply are significant factors determining turtlegrass growth and density.

22 17 P-3 I

Valette-Silver, N.J., and **Robertson, A.**, NOAA, N/ORCA2, 1305 East-West Highway, Silver Spring, MD 20910. **THE "CORE PROJECT" SPONSORED BY THE NOAA NATIONAL STATUS AND TRENDS PROGRAM.**

The NOAA National Status and Trends (NS&T) Program has sponsored a number of studies since 1989 to determine historic trend in chemical contamination in the coastal and estuarine areas of the United States. The study areas include: Long Island Sound, the Hudson-Raritan Estuary, Chesapeake Bay, and Savannah River Estuary on the East Coast; Puget Sound, San Francisco Bay, and the Southern California Bight on the West coast; and the Mississippi River delta, Galveston Bay, and Tampa Bay in the Gulf of Mexico. The studies are based on collection of sediment cores, dating of core segments using pollen stratigraphy and/or radionuclides such as ²¹⁰Pb, ¹³⁷Cs, and ²³⁹⁺²⁴⁰Pu, and chemical analyses to determine concentrations of a suite of trace metals and persistent organic compounds. All of the studies showed an increase in the level of sediment contamination from the early 1900s to the late 1970s when the level of contamination reached its maximum. Since then, there has been a slow decrease in contaminant concentrations. The results of the NS&T Core Project demonstrate the beneficial consequences of environmental protection legislation enacted in the 1970s.

22.2 2 O I

Valette-Silver, N.J., Tera, F., DTM, Carnegie Institution of Washington, D.C., Klein, J., University of Pennsylvania, PA, and van Geen, A., Luoma, S., Fuller, C., USGS, Menlo Park, CA. **THE USE OF ¹⁰Be IN RECONSTRUCTING THE HISTORICAL CONTAMINATION OF SAN FRANCISCO BAY SEDIMENTS.**

Upon reaching the earth's surface, the cosmogenic radioisotope ¹⁰Be is quickly adsorbed onto soil and sediment particles. Typical ¹⁰Be profiles in soils show a very high concentration in top-soils followed by an exponential decrease

at depth. In estuarine sediments, subsurface peaks correspond to the deposition of land-derived ^{10}Be enriched material. Three cores collected in San Francisco Bay (Richardson and San Pablo Bays) were dated using ^{14}C , ^{210}Pb and ^{137}Cs and analyzed for trace metals and organic compounds. Modern sedimentation rates at the mouth of the estuary are $\sim 10\times$ greater than rates determined for the 4000 years preceding the modern era. On selected core sections, ^{10}Be concentrations measured using a Van de Graaff tandem accelerator range from $1.309 \times 10^8 \text{ atom/g}$ ($\pm 3.8\%$) to $2.345 \times 10^8 \text{ atom/g}$ ($\pm 3.7\%$). Sub-surface peaks in ^{10}Be concentrations are observed in core horizons older than 70 years BP (based on ^{210}Pb penetration). In the San Francisco Bay watershed, deforestation, agricultural development, and urbanization increased after the gold rush (1849) and accelerated in the 1860's. By 1890, most agricultural development was completed. The onset of the broad ^{10}Be peaks observed in the cores could correspond to the 1860-1890 change in land-use, when top-soil erosion and related estuarine sedimentation of ^{10}Be -rich material increased.

0 2 O I

Valiela, I., Foreman, K., Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA, and Lajtha, K., Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR. COUPLING BETWEEN ESTUARIES AND ADJOINING WATERSHEDS.

The function and structure of receiving coastal and estuarine water ecosystems are strongly altered by transport of sediments, fresh water, organic matter, and nutrients from watersheds. Land use on watersheds determines the degree of export of these materials. Human alteration of land mosaics and land use have demonstrated the magnitude and key role of such exports from land to sea. Anthropogenic activities are most pervasive in increasing delivery of nutrients to coastal waters. Nutrient exports are the fundamental mechanism behind the pervasive eutrophication of coastal waters; nitrogen exports are the principal agent of changes in coastal ecosystems today, and can be linked to atmospheric, fertilizer and wastewater sources on land. More rarely, the sea affects adjoining land; sea-level rise has a minimum role in most projections, but salt aerosols may have more significant consequences, at least within a few km of the shore. The effect of exports from land to sea is by far, however the dominant influence, and the effects of this influence on ecosystems are evident at considerable distances from shore.

8.1 2 O C

Valle-Levinson, A., Miller, J.L., Wheless, G.H., Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA. EFFECTS OF HURRICANE FELIX ON THE HYDROGRAPHY OF THE LOWER CHESAPEAKE BAY.

Hydrographic data obtained at a transect across the lower Chesapeake Bay before and after Hurricane FELIX are presented. The hydrographic transect was occupied on August 11, 1995, before FELIX, and on August 21, after weakening

of the strong northeasterlies caused by the passage of FELIX off the Chesapeake Bay between August 16 and 19. The passage of the hurricane prolonged a period of persistent northeasterly to northerly winds, which began on early August, and caused similar storm surges to those of early August. The hydrography before the passage of FELIX suggested encroachment of coastal waters into the estuary as reflected by high salinities and nearly-homogeneous vertical distributions over the shoals of the transect. The suggested encroachment was consistent with the wind forcing (northeasterlies) in the area. Two days after weakening of the winds related to FELIX, the hydrographic distribution across the transect suggested drainage of the volume gained by the Chesapeake Bay during the period of northeasterly winds. Near-surface salinities were typically 3 units lower than those observed before FELIX, and near-bottom salinities were comparable. The water column showed strongly stratified conditions. This behavior indicates that the net inflow into the lower Bay and the wind forcing related to FELIX produced a vertically uniform along-estuary density gradient that relaxed after the winds weakened. This weakening of the winds coincided with neap tides, which also must have allowed the self-adjustment of the density gradient and the seaward advection of relatively buoyant waters near the surface. These mechanisms are further illustrated with process-oriented numerical simulations.

11.1 2 O C

Vallino, J., Bahr, M., Buffam, I., Deegan, L., Garritt, H., Giblin, A., Hobbie, J., Hopkinson, C., Tucker, J., Marine Biological Laboratory, Woods Hole, MA. MESOCOSM STUDY TO ASSESS IMPACT OF DOM INPUT ON ESTUARINE FOOD WEBS.

In order to assess the impact of dissolved organic matter (DOM) input on estuarine food webs, a mesocosm experiment, employing four 7.5 m^3 bags, was conducted in Woods Hole, MA from Sept. 10 to Sept. 30, 1994. The four treatments investigated were designed to stimulate either the heterotrophic microbial food web, the autotrophs, or both and consisted of the following manipulations: a control bag with no additions; an organic matter bag with a one-time addition of DOM from leaf liter leachate ($350 \mu\text{M C}$); a nutrient bag with daily additions of $5 \mu\text{M NO}_3$, $0.5 \mu\text{M PO}_4$, and $7 \mu\text{M SiO}_3$; and a bag with both DOM and daily nutrient additions. All bags received 12 larval *Menidia menidia* and H^{13}CO_3 to elevate the $\delta^{13}\text{C}$ of the DIC pool to 120 ‰ . Samples were taken for organic and inorganic nutrients, primary and bacterial production, zoo- and phytoplankton abundance, and $\delta^{13}\text{C}$ enrichment in five different size classes. While initial phytoplankton blooms occurred in all bags except the control, the bag receiving only inorganic nutrient additions produced a second large phytoplankton bloom. Analysis of the data, in conjunction with modeling studies, indicate that the addition of DOM may stabilize the base of the heterotrophic food web which results in more stable zooplankton abundance and increased top down control of phytoplankton.

1.2 2 O C

van Montfrans, J., Lipcius, R.N., Metcalf, K.S., Orth, R.J., Virginia Institute of Marine Science, School of Marine Science, The College of William and Mary, Gloucester Pt., VA 23062. **SOURCES AND SINKS IN THE POPULATION DYNAMICS OF THE BLUE CRAB IN CHESAPEAKE BAY.**

We are investigating mechanisms embodied within the framework of source and sink habitats to understand population fluctuations of the blue crab in Chesapeake Bay. We concurrently examined abundance and size distributions of crabs in 12 broad zones characterized by shallow vegetated and sand habitats throughout Chesapeake Bay in August, 1994 and June, 1995. These zones encompassed all major seagrass beds in the bay. Crab abundance was highly variable and differed significantly between habitat types and between vegetated areas. In contrast, mean crab size differed only between habitats. Furthermore, blue crab density did not differ significantly with grassbed area; consequently, crab abundance was directly proportional to grassbed area. Thus, seagrass areal coverage directly affects blue crab population size in Chesapeake Bay.

17 34 P-2 C

Van Den Avyle, M., Reinert, T., Wallin, J., Georgia Cooperative Fish and Wildlife Research Unit, and D.B. Warnell School of Forest Resources, University of Georgia, Athens, GA. **RESTORATION OF SALINITY AND FLOW REGIMES FOR STRIPED BASS REPRODUCTION IN THE SAVANNAH RIVER ESTUARY.**

Past alterations of river channels in the Savannah River estuary eliminated successful reproduction of striped bass by increasing salinity at spawning grounds and accelerating transport of eggs and larvae to areas with excessive salinity. Remediation has been attempted by ceasing operation of water control structures and blocking artificial channels constructed in the 1970's. These actions have reduced salinity on spawning grounds and slowed the seaward transport of water masses in some parts of the estuary; however, sedimentation in other channels or deepening by dredging have countered re-establishment of conditions necessary for successful striped bass reproduction. Despite a successful fish stocking program that has provided an adult striped bass population capable of spawning, true restoration continues to be threatened by the lack of suitable salinity and flow regimes.

22.1 1 O C

Van Metre, P.C., Callender, E.C., U.S. Geological Survey, Austin, TX, and U.S. Geological Survey, Reston, VA. **IDENTIFYING TRENDS IN POLYCHLORINATED BIPHENYLS AND ORGANOCHLORINE PESTICIDES IN RIVERS USING DATED SEDIMENT CORES FROM RESERVOIRS**

Sediment cores were collected from 10 reservoirs in the central and southeastern United States for the USGS National Water-Quality Assessment (NAWQA) Program with

the objective of defining historical trends in water quality in their influent rivers. Cores were sectioned into vertically discrete subsamples which were analyzed for major, minor, and trace elements, ^{137}Cs , polychlorinated biphenyls (PCB's), and organochlorine pesticides. ^{137}Cs data showed continuous deposition of sediment over the life of each reservoir and provided sediment deposition dates. Large increases in concentrations of PCB's and DDT metabolites occurred beginning in the 1940's. Concentrations peaked in the 1960's, then declined to the present in response to regulatory controls and decreased usage. Differences in concentrations and temporal trends of PCB's, DDT metabolites, and chlordane reflect differences in land use within each drainage area. For example, PCB accumulation rates and core burdens for two reservoirs in urban settings greatly exceeded rates and burdens in rural reservoirs and atmospheric fallout rates estimated from cores in peat bogs and natural lakes. Much greater rates and burdens indicate local sources of PCB's in the urban drainages.

6.2 5 O I

van Tussenbroek, B.I., Universidad Nacional Autonoma de Mexico, Estacion Puerto Morelos, Quintana Roo, Mexico. **THE BIOLOGY OF THE SEAGRASS *THALASSIA TESTUDINUM* IN A TROPICAL MEXICAN REEF LAGOON.**

The environment of the reef lagoon in front of Puerto Morelos, Mexican Caribbean, is almost completely governed by oligotrophic marine conditions. Surface drainage of rivers is absent due to the limestone underground of the Yucatan Peninsula, and mangrove swamps are isolated from the sea by a sand-barrier. Well developed beds of *Thalassia testudinum* in this lagoon had lower biomass and production values in comparison with beds from other geographical areas. Additionally, leaves accounted for a very low proportion of the total plant biomass. Extreme low values were reported for a population situated in a relatively wave-exposed back reef area. From July 1990 until July 1991, average leaf biomass was $24.5 \text{ dry g m}^{-2}$ (5.2 SD), above-/below ground biomass ratio averaged 4.8 % (1.1 SD), and the leaves produced on average $0.88 \text{ dry g m}^{-2} \text{ d}^{-1}$ (0.24 SD). The leaves were small: the longest leaves per shoot had a mean length of 8.45 cm (2.67 SD) and a mean width of 0.76 cm (0.19 SD). However, mean leaf Specific Growth Rate (SGR) was high ($5.2 \% \text{ d}^{-1}$, 0.7 SD), indicating the plants were very efficient as producers of new leaf material. The maximum age of the shoots exceeded 20 years, which is twice the maximum age reported for *T. testudinum* elsewhere. Future physiological studies of such a back reef population could reveal interesting facts concerning the physiology of *T. testudinum* growing under such extreme circumstances.

25 26 P-3 C

Vazquez, F.G. I., Reyes, M.C.H., Instituto de Ciencias del Mar y Limnologia, UNAM, Cd. Universitaria, D.F., A.P 70-305, C.P. 04510, Mexico, and Sharma, V.K., Center for Coastal Studies, Texas A&M University-Corpus Christi,

Corpus Christi, TX. **CONTAMINATION OF SEA TURTLE HABITATS IN PLAYON DE MEXIQUILLO, MEXICO.**

Playon de Mexiquillo, Mexico is a reservation for sea turtles. This area is near the mouth of Rio la Manzanilla flowing between Sierra Madre del Sur and the Pacific ocean. The study was done to examine the effect of contaminants on the marine turtles. The samples consisted of beach sand, egg shell, and seawater which were collected in period 1992-1993. Contaminants investigated were oil and grease, and metals (nickel, zinc, lead, copper, and cadmium). High levels of oil and grease were found, therefore continuous monitoring is needed to find maximum tolerance for growing sea turtles. Lead and cadmium concentrations were of high toxic levels, while zinc, copper, and nickel were in low concentration levels which are essential as micronutrients.

23.1 3 O I

Vega, C.M.E., Gonzalez A.F., Hernández M., CINVESTAV-Unidad Mérida, Depto. de Recursos del Mar. Mérida, Yucatan, México. **MANGROVE ECOSYSTEM: A CRITICAL HABITAT IN THE DYNAMICS OF THE MARINE AND ESTUARINE FISH COMMUNITIES.**

Fish communities utilizing fringing mangroves in a coastal lagoon of the Yucatan Peninsula were compared between day and night in two contrasting habitats. Fish sampling carried out with a drop net over two annual cycles (Feb. 1992 Feb. 1994) resulted in 70 species for the two habitats and revealed distinct faunas during the day from that occurring at night for the same zone in terms of density, standing crop, species composition and diversity-index values. Standing crop and species richness were about two times greater during the day for both habitats. The average density was controlled by large schools of juvenile herrings species (*Anchoa mitchilli*, *A. hepsetus* and *Sardinella anchovia*) which confer greater values during the day (10 fish/m²) in the inlet of the lagoon and at night (9.0 fish/m²) in the lower-salinity habitat (inner zone). Variations in seasonal abundance and species composition were related to changes in environmental parameters. The data showed that mangroves are very important nursery and feeding grounds for juvenile marine and estuarine fish species and for higher consumers that feed on them. This work contributes to a better general understanding of tropical coastal lagoons as well provides information base for management of the high productive mangrove ecosystems.

22 18 P-3 I

Venkatesan, M.I., Institute of Geophysics and Planetary Physics, University of California at Los Angeles, Los Angeles, CA, and Ruth, E., Department of Civil and Environmental Engineering, University of California at Los Angeles, Los Angeles, CA, and Mirsadeghi, F., Institute of Geophysics and Planetary Physics, University of California at Los Angeles, Los Angeles, CA. **RECORD OF POLYCHLORINATED BIPHENYLS AND DDT'S IN SEDIMENT CORES FROM SANTA MONICA/SAN PEDRO BASINS, CALIFORNIA.**

Historic profiles of organic contaminants such as poly-

chlorinated biphenyls (PCBs) and DDTs in six sediment cores dating back to 1900 from Santa Monica/San Pedro basins were reconstructed. Total PCBs content ranges from 50-250 and DDTs from 1 to 13,800 ng/g dry sediment. The common use of PCBs apparently began to escalate from ~1940s peaking around 1970s. The decline in PCB content in surface sediments, however, has been slow. DDTs progressively increase from the 1940s to a subsurface maximum around 1965-70. The distribution of PCBs and DDTs in some cores mimic the wastewater input and subsequent source control in the region. The ratios of 2,4'-DDT to 4,4'-DDT in specific sections from a few cores are characteristic of caustic or acid wastes from DDT manufacture. The anomalously high concentration of DDTs (especially DDT isomers) and the elevated internal ratios of the DDT isomers suggest significant to major inputs of DDTs in these sections from dumpsites in the vicinity. From the data, it can be estimated that 4 to 6 fold excess of the expected DDTs, for example in station V (near dumpsite II), must have originated from offshore dumping during 1960-70. The elevated PAH contents in the same horizons suggest that the DDT wastes were dumped along with petroleum refinery wastes.

15.3 1 O C

Vernberg, F.J., Belle W. Baruch Institute for Marine Biology and Coastal Research, and Vernberg, W.B., School of Public Health, University of South Carolina, Columbia, SC. **URBANIZATION AND SOUTHEASTERN ESTUARIES (USES): AN OVERVIEW.**

The coastal region of the southeastern United States is being developed at a rapid rate. The USES project, funded by NOAA, studies the comparative responses to human perturbations of a developed estuarine system (Murrells Inlet, SC) with system responses of a relatively pristine estuary (North Inlet, SC). These two estuaries, which are within 20 miles of each other, are similar in geomorphology, size, geological history, and other environmental features. Although not identical, one can regard North Inlet as the "control" site and Murrells Inlet as the "experimental" site. An interdisciplinary research team studies chemical contaminants, bacteriology, toxicology, eutrophication and nutrients, watershed dynamics, and geographic information processing and spatial modeling. Similar sampling regimes and analytical procedures are used to study 30 stations in each estuary. The project is designed to undertake research that will systematically develop a knowledge base that takes into account urban development, fisheries management requirements, and impacts of land use patterns on water quality and systems dynamics. Models are being developed that will provide a scientifically valid basis for land-use management decision-making in the coastal zone. This paper provides an overview of the project. Following presentations will deal with specific substudies of this project.

8 25 P-1 C

Vieira, M.E.C., United States Naval Academy, Oceanography Department, Annapolis, MD. **THE SEVERN RIVER**

ESTUARY: INITIAL ASSESSMENT OF ITS CIRCULATION.

The Severn River is a small tributary estuary of the Chesapeake Bay. Its small watershed encompasses some 78 square miles entirely within Anne Arundel County in Maryland, resulting in low fresh water inflow. Even though its mean depth is on the order of 6 meters, the navigable portion of the Severn River stretches over 15 miles of highly anthropogenically affected waters. With the objective of studying the circulation of the Severn estuary a mooring was maintained for 97 days close to its confluence with the Chesapeake Bay, in water 8 meters deep. The mooring was equipped with two Interocean S4 current meters installed at 2 and 5 meters above the bottom. Time series of current, temperature and conductivity were obtained from August 17 to November 21, 1994, at 20 minute intervals. The column lacked a vertical gradient in temperature, but showed vertical stratification due to a weak salinity gradient. The current data clearly shows a classical estuarine circulation with inflow in the bottom layer and outflow in the top layer. The Hansen and Rattray circulation and stratification parameters were computed and utilized to classify the Severn Estuary on the Hansen and Rattray diagram: type 2b, partially mixed with some stratification.

14.1 5 O C

Virnstein, R.W., Morris, L.J., Miller, R.R., St. Johns River Water Management District, Palatka, FL. DEVELOPMENT AND TESTING OF FIXED TRANSECTS AS A TOOL FOR MONITORING CHANGES IN SEAGRASS BEDS.

As a complement to Indian River Lagoon-wide seagrass mapping, fixed transects were developed as a tool for monitoring changes in seagrass depth distribution, abundance, and species composition. Each of the 74 transects consists of a marked line perpendicular to shore extending past the deep edge of the seagrass bed. Within a m² frame at fixed intervals, along a measured line between permanent stakes, non-destructive measurements are made twice a year of: percent cover, canopy height, and shoot density for each seagrass species. To estimate the power to detect change, repeated measures of transects are used to measure variability and thus to calculate confidence intervals. Several people run the same entire transect, each repeating all the measurements in order to measure variability of the entire method. Much of the person-to-person variability of entire-transect results is due to differences in placement of the quadrat along the transect (e.g., if the line is not straight). In addition, repeated measurements are made within single fixed m² quadrats in order to measure variability of individual measurements or counts. Tests are in progress (summer 1995). The tested transect method will provide a method for quickly, non-destructively, and quantitatively measuring changes in seagrass with known error.

35.1 2 O C

Volk, R., Corpus Christi Bay National Estuary Program, Texas Natural Resource Conservation Commission, Corpus Christi, TX. PROBLEM-FRAMING IN THE CONTEXT

OF REGIONAL-SCALE RESOURCE MANAGEMENT.

How we make maximum use of human energies, time, and skills toward resolving the needs of regional-scale resource management, largely depends on our ability to make people responsive to calls for environmental action and more effective problem-solvers. The capacity for problem-solving is directly proportional to effective problem-definition or problem-framing, which, in turn, is enhanced when new information is provided in a manner or context that is congruent with a person's existing mental model or mental 'map' of a given problem. This paper provides perspective on environmental problem-framing offered by cognitive psychology and the literature on resource management techniques and practices at the regional-scale. Implications are drawn for the consensus-building process inherent in National Estuary Programs, and for the process of setting objectives in ecosystem management.

3.3 4 O C

Voyer, R., Pesch, C., Nelson, W., Garber, J., U.S. Environmental Protection Agency, National Health and Ecological Effects Laboratory, Atlantic Ecology Division, Narragansett, RI, and Copeland, J., Cameleo, R., R.O.W Associates, Narragansett, RI. CUMULATIVE ECOLOGICAL EFFECTS ON NEW BEDFORD HARBOR: HISTORICAL CONNECTIONS.

Analysis of historical data represents a significant adjunct to scientific examination of polluted sites. It offers insight into causes and interrelationships between ecology and urban pollution and provides a valuable context for design of remediation activities. Located on the Acushnet River and Buzzard's Bay, New Bedford is a former whaling center and former producer of fine quality textiles. Historical information indicates that, since European settlement in 1650, New Bedford has undergone four developmental phases: agricultural, whaling, textile, fishing/industrial. Changes in coastline morphology and loss of habitat accompanied wharf building during the whaling period (1750-1870). Wetlands were filled and used as building sites in the course of textile development (1850-1940). Also, population expanded six-fold and resulted in increased raw sewage discharges to the estuary. Shellfish beds were closed in 1904 due to outbreaks of typhoid fever, and remain closed. In the fishing/industrial phase a hurricane barrier constructed to protect the fishing fleet and city altered estuarine hydrology. PCB contamination of the harbor has further limited fishing and restricts harbor revitalization.

-W-

35.1 5 O C

Wade, T., Jackson, T., Gardinali, P., Chambers, L., Geochemical and Environmental Research Group, College Station, TX. **CONCENTRATIONS OF DIOXINS/FURANS AND PLANAR PCB IN CASCO BAY SEDIMENTS**

The concentrations of dioxins/furans (PCDD/PCDF) and planar PCB were assessed in Casco Bay sediments as part of the EPA National Estuary Program. PCDD/PCDF and planar PCB were detected in sediments from all areas of Casco Bay. The concentrations were highest near potential input sources (i.e. the Presumpscot River) with the exception of the higher concentrations in East Bay which may be the result of transport into the bay from the Androscoggin River. The concentrations found in Casco Bay sediments are not low when compared to other estuarine areas. In spite of the low concentration in sediment, the detection of 2,3,7,8-TCDD/TCDF in lobster tissue and tomalley indicate they are bioavailable and have resulted in an advisory regarding consumption of lobster tomalley for Casco Bay. Because of their wide spread presence in sediments, additional data is needed to determine if other PCDD/PCDF isomers and planar PCB also pose a human health concern for Casco Bay.

12.2 1 O I

Wade, T., Jackson, T., Requejo, A., Geochemical and Environmental Research Group, Texas A&M University, College Station TX, and Presley, B., Trace Element Research Laboratory, Texas A&M University, College Station TX, and Summers, J., Macauley, J., US EPA, Sabine Island, Gulf Breeze FL. **SEDIMENT CONTAMINANTS AS MONITORS OF ESTUARINE HEALTH**

Concentrations of selected organic and metal contaminant were monitored in recent surface sediments by the EPAs Environmental Monitoring and Assessment-Estuaries (EMAP-E) program for the Virginian and Lousianian Provinces. The concentrations of over 125 contaminants were determined at over 1 000 sites. The EMAP-E program utilizes a probability-based sampling design in order to provide unbiased, statistically valid estimates of contaminant concentrations. Most of the organic and metal concentrations found were low when compared to concentrations reported in the literature from sampling programs biased to be near input sources. Principal component analyses was applied to this unbiased EMAP-E data and provides a better understanding of the importance of specific input sources. The extent of contaminant concentrations estimated to be of biological significance was estimated and will be discussed.

15 26 P-2 C

Wahl, M., McKellar, H., Department of Environmental Health Sciences, University of South Carolina, Columbia, SC, and Williams, T., Baruch Forest Science Institute, Clemson University, Clemson, SC, and Aelion, M., Department of Environmental Health Sciences, University of South Carolina, Columbia, SC. **WATER TABLE DYNAMICS AND NUTRIENT CHEMISTRY IN FORESTED AND URBANIZED COASTAL STREAMS.**

As part of a larger investigation of the effects of coastal urbanization, water table (WT) dynamics and nutrient concentrations were examined over a range of conditons at a forested and an urbanized blackwater stream in coastal SC. Both streams behaved like outcrops of their sandy WT aquifer during stormflow, exhibiting consisten lag time to peak discharge (~3 hrs) synchronized to shallow WT fluctuations. Detailed pressure gradients under the channels suggest groundwater seepage contributed the bulk of discharge (>80%) at the urbanized site. Flow reversals of water movement into the channel bank to water seeping out of the bank resulted in the greatest concentrations of $\text{No}_x\text{-N}$ (200-300 $\mu\text{g N L}^{-1}$). More summer unsaturated soil at the urbanized site and smaller WT fluctuations (~24% less than at the forest) are associated with a moderation of both stream stage and stream water quality changes during stormflow. High winter stream concentrations at the urbanized stream resulted in greater annual mean concentrations of sediment (21 vs. 12 mg L^{-1}), Nox-N (112 vs. 50 $\mu\text{g N L}^{-1}$), and PO4-P (38 vs. 10 $\mu\text{g P L}^{-1}$). Lower WT and stream stage fluctuation at the suburbanized site are associated with lower mean concentrations of DOC (13 vs. 26 mg C L^{-1}) and NH4-N (70 vs. 158 $\mu\text{g N L}^{-1}$).

15.3 5 O C

Wahl, M., McKellar, H., Department of Environmental Health Sciences, University of South Carolina, Columbia, SC, and Williams, T., Baruch Forest Science Institute, Clemson University, Clemson, SC, and Aelion, M., Department of Environmental Health Sciences, University of South Carolina, Columbia, SC. **PATTERNS OF NUTRIENT LOADING IN FORESTED AND URBANIZED COASTAL STREAMS.**

As part of a larger investigation of the effects of coastal urbanization, patterns of stream nutrient loading (October 1993 - September 1994) were examined over a range of hydrologic and seasonal conditions for a forested and an urbanized watershed (37 vs. 12 ha). Despite the smaller watershed size, there was 54% greater annual streamflow volume at the urbanized stream than the forested stream (0.20 vs. $0.13 \times 10^6 \text{ m}^3 \text{ yr}^{-1}$), reflecting the added groundwater drain-

age due to channel excavation (1.2 vs. 0.4 m). Although more erosion and bank instability at the urbanized stream resulted in twice the annual sediment load as the forested stream (4.2 vs. 1.8×10^6 kg TSS yr^{-1}), the greater stream capture of leachable organic carbon at the forested stream resulted in 30% more DOC (3.4 vs. 2.6×10^6 kg C yr^{-1}). The urbanized stream also transported 5x more $\text{PO}_4\text{-P}$ (8 vs. 1.5×10^3 kg P yr^{-1}) and 4x more $\text{NO}_x\text{-N}$ (24 vs. 6×10^3 kg N yr^{-1}) than the forested site, reflecting the additional anthropogenic nutrient sources and less recycling at the urbanized site. During the winter, both streams delivered a simple loading pattern of early supply and depletion in TSS and $\text{NO}_x\text{-N}$, and a more complex pattern delayed supply in DOC and $\text{NH}_4\text{-N}$.

20 4 P-3 C

Wainright, S., Fuller, C., McGuinness, L., Hughes, J., Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ. **CONTRASTING WATER COLUMN PROPERTIES, INCLUDING STABLE ISOTOPIC COMPOSITIONS, AT AN OLIGOHALINE AND A MARINE SITE WITHIN THE MULLICA RIVER ESTUARY.**

Two sites within the Mullica River, a relatively pristine estuary in southeastern New Jersey, were characterized over a period of 16 months. Seston at the marine site had $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ values of ca. -21‰ , $4\text{--}7\text{‰}$, respectively, and DI^{13}C values were -0.7 to 1.5‰ . DIC, DOC and POC concentrations were $1600\text{--}2000$ μM , $200\text{--}400$ μM , and $15\text{--}90$ μM , respectively, and pH was relatively constant at ~ 8 . Seston at the oligohaline site had $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ values of ca. -26‰ , $1\text{--}5\text{‰}$, respectively, and DI^{13}C values were -18 to -2‰ . DIC, DOC and POC concentrations were $20\text{--}250$ μM , $400\text{--}1200$ μM , and $50\text{--}120$ μM , respectively, and pH varied seasonally between ~ 4 in late winter to ~ 6 in late summer. DO was nearly saturated all year at the marine site, but averaged 21% undersaturated at the oligohaline site. Phytoplankton bloomed in late winter and again in midsummer at the marine site, and in June at the oligohaline site (14 and 24 mg chlor/ m^3 , respectively). While DIC content was much lower at the oligohaline site, much of it is present as CO_2 . In contrast, most of the DIC at the marine site was HCO_3^- , with less CO_2 than at the oligohaline site.

18.1 6 O I

Wallace, R.K., Rikard, F.S., Auburn University Marine Extension and Research Center, Mobile, AL. **RELATIONSHIPS BETWEEN BROWN SHRIMP *PENAEUS AZTECUS* LANDINGS AND ENVIRONMENTAL FACTORS IN MOBILE BAY, ALABAMA.**

Penaeid shrimp landings exhibit large interannual variability. This variability, particularly in brown shrimp, is often attributed to the short life cycle (one year) and environmental factors that postlarvae and juveniles encounter in the estuarine nursery habitat. Multiple linear regression models using abiotic environmental factors from a 20 year data base (1975 - 1994) explain 75 to 81 % of the variation in brown shrimp landings from Mobile Bay. River discharge is the

most important factor in all models accounting for 55 to 66% of the variation. High river discharge is associated with low shrimp landings and is related to low salinity in the shrimp nursery areas. Low salinity is believed to be a major factor affecting shrimp survival although brown shrimp are found in very low salinity waters (0 - 5 ppt). Wind direction and velocity account for 15 to 20% of the variation in landings but the causal relations are not obvious. Quantifying and exploring relations between environmental factors and penaeid shrimp production can lead to a better understanding of penaeid habitat requirements as well as provide explanations for short term trends in shrimp abundance.

7.2 1 O C S

Walsh, J.P., Zieman, J.C., University of Virginia, Department of Environmental Sciences, Charlottesville, VA. **LOW MARSH SUCCESSION ALONG AN OVERWASH SALT MARSH CHRONOSEQUENCE.**

The purpose of this study is to describe the process of ecological succession within a *Spartina alterniflora* dominated low marsh along an overwash marsh chronosequence. Through the use of aerial photographs, the ages of re-growth marshes following a severe overwash event on Hog Island, Virginia were determined. Sampling plots were established along this chronosequence in marshes of age 1, 6, 13, 21 and 150+ yrs of age. Data were collected either within 1 m^2 permanent sampling quadrats located in each of the three *S. alterniflora* height zones (short, medium, and tall) inside each plot, or within randomly tossed 0.25 m^2 quadrats. Significant physico-chemical differences along this chronosequence include monotonic decreases in sand grain % in surface sediments and pore water oxidation-reduction potentials, as well as a significant (and monotonic) increase in pore water sulfide concentration with age. Marsh age-related differences in the epifaunal invertebrate community were most significant in the tall *S. alterniflora* zone. Principal Components Analysis illustrated that the population densities of the marsh surface community change in a non-linear way with marsh age, and that this successional pattern is different for each *S. alterniflora* height zone.

8.2 5 O C

Walters, R.A., U.S. Geological Survey, Tacoma, WA. **MODEL STUDIES OF FLOW AND TRANSPORT IN PUGET SOUND, WASHINGTON.**

Puget Sound is a glacier-carved fjord that forms the southern part of the inland marine waters of British Columbia, Canada, and Washington State, USA. This is an area of rapid population growth which usually leads to reduced water quality. The study described herein is an ongoing study whose purpose is to quantify the fate and transport of various solutes and particulates that are of biological interest. The first part of this study has concentrated on the creation of flow and transport models that correctly depict the important physical processes, and that couple local and non-local effects to the coastal ocean. The second part of the study will examine fate and transport of selected solutes and of sus

pendent sediments. The methods are constructed so that detailed local studies can be conducted while maintaining the far-field coupling by way of the large-scale model. The mathematical formulation uses the wave-continuity equation coupled with the horizontal-momentum equations and the hydrostatic equation. The numerical approximation in space uses the finite element method with 3-dimensional triangular brick elements. For the time discretization, a tidal harmonic expansion is used with the result that the governing equation for sea level is a form of the Helmholtz equation. This formulation is free of spurious computational modes, is highly efficient as compared to time-stepping methods, and is ideally suited for exploratory analysis in regions of highly irregular geometry, such as the fjord considered in this study. A grid of triangular elements was constructed for the entire Puget Sound region south of Juan de Fuca Strait, an area of approximately 75 by 155 km. Grid resolution varies from 200 to 700 m along the boundaries to several kilometers in the interior. This resolution provides a reasonable resolution of the numerous islands and channels, yet can accommodate high resolution subareas for other specific studies. In essence, this grid provides the coupling between local sources and the far field as represented by the coastal ocean. Simulations reproduce the observed amplitude and phase of sea level for the major tidal constituents. Comparison with the large data base of current meter observations is in progress. Calculations of the tidally forced residual circulation reproduce many features known from observations, such as the clockwise circulation around Vashon Island. The model was coupled to a locally-refined model for Sinclair Inlet where the purpose was to assess the relative importance of wind-driven and tidally-driven circulation on sediment movement. The former is important in the inner part of the inlet, and entrains bottom water landward. These are examples of some of the results obtained so far in this study that serve to increase understanding of physical processes and provide a basis for the transport studies.

28 31 P-3 C S

Wang, M., Louisiana Transportation Research Center, 4101 Gourrier Avenue, Baton Rouge, LA, and **Wang, F.C.**, Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA. **SEDIMENT DEPOSITION IN LOUISIANA COASTAL MARSHES.**

The objectives of this study are to understand the mechanism of sediment deposition, to quantify spatial and temporal distributions of sediment deposition rates, and to determine the effects of hydrodynamic processes and meteorological forcing on coastal sediment transport. Sediment deposition rates were measured in Louisiana coastal marshes over individual tidal cycles using sediment traps. Two study sites were selected at Bayou Chitique near Terrebonne Bay, and at Old Oyster Bayou near Atchafalaya Bay respectively. During tidal inundations under weak wind conditions, it is found that (1) water from the bayou enters the marsh at higher suspended sediment concentration and returns to the bayou from the marsh at lower suspended sediment concentration, resulting in a net sediment import into the marsh, (2) most

sediment deposition occurs during flood periods and little occurs during ebb periods, and (3) sediment deposition rates at the streamside are higher than those in the inland marsh. During tidal inundations under strong wind conditions, sediments are uniformly distributed along the marsh transects.

20.3 4 O C S

Wang, M., Perez, B., Department of Oceanography and Coastal Science, and Rouse, L., Coastal Studies Institute, and Day, J., Coastal Ecology Institute, Louisiana State University, Baton Rouge, LA. **ESTUARINE-COASTAL COUPLING BETWEEN THE GULF OF MEXICO AND FOURLEAGUE BAY, LA.**

Current, water level, total suspended sediment concentration and wind data were collected within Oyster Bayou, Louisiana, during an 86-day period from February to April 1994. The objectives of this study are to quantify the tidal and subtidal exchanges between the Gulf of Mexico and Fourleague Bay through Oyster Bayou, and to determine the effect of winter cold front passage and the Atchafalaya River discharge on the exchanges. Tides in Fourleague Bay are mixed, with an average tidal range of 0.5m. Tidal currents in Oyster Bayou during flood and ebb periods are asymmetric. Nontidal variations of water level, and water and sediment fluxes are related to the along-channel component of the wind stress, indicating that the winter cold front passage plays an important role in the low-frequency coupling of the two systems.

35.1 3 O C

Ward, G.H., Armstrong, N.E., Center for Research in Water Resources, University of Texas, Austin, TX. **THE CHANGING ENVIRONMENT WITHIN GALVESTON BAY.**

The environment within the Galveston Bay estuarine system is fundamentally determined by its morphology, its water circulation and transports, and its distributions of waterborne substances. In the characterization studies of the Galveston Bay National Estuary Program, historical trend analyses have established that all of these have been gradually changing, a fact with important implications for the ecology of the bay. Since the turn of the century, the bay has been extensively channelized and its shoreline and watershed modified. Relative to its 1900 configuration, its volume has been increased 30% due to a combination of navigation projects, shell dredging, subsidence and other factors. In the last three decades, the usual indicators of water and sediment contamination have exhibited generally negative trends, suggesting that the quality of the bay has been improving. No doubt much of this is related to the great reductions in wasteloading to the system. But also there have been declining trends in salinity and temperature, at present unexplained and certainly not directly associated with freshwater inflow. There are, as well, declining trends in inorganic nitrogen, suspended sediment and chlorophyll, which have raised concerns about maintenance of bay productivity.

Ward, L.A., Texas A&M University-Galveston, Galveston, TX, and **Montagna, P.A.**, University of Texas at Austin, Marine Science Institute, Port Aransas, TX. **LONG-TERM CHANGES IN NUECES ESTUARINE BENTHOS DUE TO CLIMATIC INFLUENCE.**

The Nueces Estuary lies in a semi-arid environment where rainfall averages only about 76 cm/yr. However, years with average amounts of rainfall are rare. There are cycles of floods and droughts, which influence long-term climatic trends. Wet years in the Nueces Estuary generally occur during El Niño periods, and dry years during intervening periods. There are changes in benthic abundance, biomass, and community structure that can be linked to the long-term cycle of wet and dry years in the Nueces Estuary. High-inflow results in nutrient enrichment that stimulates recruitment and productivity. This is followed by nutrient depletion and invasion by marine species. Productivity declines until the next wet period. The length of the cycle period is not clearly defined, but it may be coincident with El Niño events, suggesting it is 3-7 years in length.

32.1 5 O C

Ward, R., Bowers, K.L., Texas Parks and Wildlife Department, Perry R. Bass Marine Fisheries Research Station, Palacios, Texas and **Fuls, B.E.**, Texas Parks and Wildlife Department, Rockport Marine Laboratory, Rockport, TX. **POPULATION STRUCTURE OF THE ATLANTIC CROAKER, *Micropogon undulatus*, ON THE TEXAS COAST.**

Texas Parks and Wildlife Department (TPWD) data suggest growth over-fishing has occurred in the Atlantic croaker (*Micropogon undulatus*) on the Texas coast. Populations which have been heavily impacted by shrimp fishery bycatch mortality are now being subjected to a small, but growing, directed commercial baitfish fishery. In an effort to assess the effect of these perturbations on the Atlantic croaker the Coastal Fisheries Division of TPWD has collected data on the genetic structure of the species in the nine major bays of the Texas coast. Allozyme electrophoresis was utilized to explore within and between bay population subdivision and gene flow. The implications of these analyses are discussed in terms of management options.

2 8 P-1 C S

Warnken, K.W., Griffin, L.L., Gill, G.A., Department of Oceanography Marine Sciences Program, Texas A&M University at Galveston, Galveston, TX 77553-1675 **BENTHIC FLUXES OF INORGANIC NUTRIENTS IN UPPER GALVESTON BAY- SEASONAL TRENDS IN DIFFUSIVE AND BIOTURBATIVE EXCHANGE**

Analysis of historic trends in phosphate concentration has suggested that benthic regeneration during summer months may be a significant component in the cycling of primary nutrients in Galveston Bay. We have studied this issue by determining diffusive and bioturbative fluxes of dissolved PO_4 , NH_4 , H_4SiO_4 , NO_3/NO_2 at three stations along the sa-

linity gradient from the Trinity River (major freshwater source) in Trinity Bay in the upper Bay. Diffusive fluxes are determined via the concentration gradient between interstitial and overlying water, and bioturbative exchange by *in situ* flux chamber incubation. Phosphate fluxes estimated for diffusive exchange in March and May of 1994 (ca 45 $\mu\text{M}/\text{m}^2/\text{d}$) could be significant in the annual phosphate budget. For February 1995 both the computed diffusive fluxes and bioturbative exchange of PO_4 (< 10) are lower than for the previous spring and summer. These data suggest seasonal effects. Results from 1995 will be presented and used to compare the two methods of determination and to quantify seasonal effects.

32.1 6 O C

Warren, T.A., Blankinship, D.R., Texas Parks and Wildlife Department, Brownsville, TX. **BIOLOGICAL MONITORING OF THE LOWER RIO GRANDE.**

The objective of this on-going study is a characterization of the abundance, distribution, and size of species caught from the mouth of the Rio Grande to river mile (RM) 30. Bimonthly otter trawls, bag seines, and hydrological data were obtained at random sites. Estuarine conditions were typical of RM 0 to 15, while riverine conditions were typical of RM 16-30. Species with the greatest catch rate (CPUE) were white shrimp, atlantic croaker, striped mullet, and Gulf menhaden. Trawl catch rates were greatest in the estuarine region, while bag seine catch rates were more evenly distributed from RM 0 to RM 30. The lower Rio Grande serves as a nursery area for the common snook and is providing new information on snook biology. The lower Rio Grande is valuable because it provides estuarine habitat in a geographic area where such habitat is extremely scarce, and functions as a nursery for high concentrations of a variety of species.

27.1 3 O C S

Wear, D.J., Sullivan, M.J., Moore, A.D., Department of Biological Sciences, Mississippi State, MS. **EFFECTS OF NUTRIENT ENRICHMENT ON PRIMARY PRODUCTION DYNAMICS AND COMMUNITY STRUCTURE OF EPIPHYTIC ALGAE IN SEAGRASS BEDS (BIG LAGOON, PERDIDO KEY, FLORIDA, USA).**

Monotypic beds of the seagrasses *Halodule wrightii*, *Syringodium filiforme*, or *Thalassia testudinum* were enriched with a slow-release Osmocote™ (N-P-K) fertilizer from August 1993 through September 1994. Measurements of primary production (as ^{14}C uptake), biomass (dry weight), and total chlorophyll *a* (measured by HPLC) of epiphytes in enriched beds were significantly greater than values obtained for epiphytes in control beds. Based on microscopic observations, the dominant epiphytic algae were diatoms and red and brown algae. Populations of the brown alga *Myriotrichia subcorymbosa* and the red alga *Acrochaetium flexuosum* increased greatly in enriched plots of all three seagrass species. Data from multiple linear regression supported observational data and showed that the pigment signatures selected for the dominant epiphytes (fucocanthin, zeaxanthin, and

violaxanthin) explained 97% of the variation in total chlorophyll *a*. There was a strong correlation between measured and predicted chlorophyll *a* ($r = 0.98$), suggesting that total chlorophyll *a* is an excellent indicator of epiphytic biomass in seagrass systems. Enrichment had a significantly positive effect on production rates of seagrass blades, but this effect was not significant for biomass of blades. The strong response of epiphytes to enrichment suggests that eutrophication is a potential threat to seagrass beds of Big Lagoon.

12.4 5 O C

Weaver, M.J., Deegan, L.A., The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA. **EXTENSION OF THE ESTUARINE BIOTIC INTEGRITY INDEX ACROSS BIOGEOGRAPHIC REGIONS.**

We have extended the estuarine biotic integrity index (EBI) to another biogeographic region. The EBI, based on fish community composition, was correlated with estuarine status, based on a wide range of human-induced stress levels, in two biogeographic regions (Cape Cod and Chesapeake Bay). In both regions, the total number of fish species in submerged aquatic vegetation ecosystems declined with increased stress and nursery fishes were more sensitive to habitat degradation than were other fishes. However, the metrics that comprise the EBI differed between the two regions in their sensitivity to stress. Sites within estuaries were classified based on stressors, such as landuse, population density, and pollution loading and on environmental condition, as determined by abiotic variables such as nutrients and chlorophyll *a*. Degradation of habitat and increased eutrophication were related to a decrease in eelgrass density and an increase in macroalgae biomass.

6.1 4 O C S

Webb, D.M., University of South Alabama, Department of Biological Sciences, Marine Environmental Sciences Consortium, Dauphin Island, AL, and Vaughn, K.C., U.S. Department of Agriculture-Agricultural Research Service, Stoneville, MS, and Sherman, T.D., University of South Alabama, Department of Biological Sciences, Mobile, AL. **EXAMINATION OF THE CARBON FIXING MECHANISM IN THE SEAGRASS *THALASSIA TESTUDINUM*.**

The photosynthetic mechanism of *Thalassia testudinum* previously has been reported to be of the C4 type found in many terrestrial grass species. This early research was based mainly upon carbon isotope discrimination ($\delta^{13}C$ values) and the results of short-time ^{14}C pulse-chase experiments. *Thalassia*, however, does not possess the specialized Kranz anatomy normally associated with these C4 plants. This contradiction raises the question of whether *Thalassia* possesses a yet undescribed mechanism of fixation or perhaps utilizes aspects of both C3 and C4 carbon capture mechanisms. Additionally, the photorespiratory pathway in this species has been reported to be dependent upon glycolate dehydrogenase rather than glycolate oxidase. If so, this is the only case of this occurrence in higher plants. It is possible that the photosynthetic carbon fixation mechanisms of *T. testudinum*

and other seagrasses are not obligate and may function in response to varying growth conditions in the marine environment. The research to be presented utilizes in vitro enzyme assays as well as cytochemical assays and immunogold electron microscopy to characterize the photosynthetic processes of *T. testudinum* by examining the activity and intracellular localization of RuBisCo, PEP carboxylase, carbonic anhydrase, glycolate oxidase, and glycolate dehydrogenase in this enigmatic species.

4.1 1 O I

Weinstein, M.P., TEVA Environmental Associates, Inc. 854 Ridgewood Road Millburn, NJ 07041. **WHAT CAN THE SPOT TELL US ABOUT THE LINK BETWEEN MARSHES AND FISH PRODUCTION?**

Spot (*Leiostomus xanthurus*) spawn offshore and postlarvae and early juveniles are recruited to estuaries primarily in the early spring. Among the marine transient species that are characterized by this life history strategy, spot display one of the strongest associations with salt marshes. Although relatively weak swimmers, postlarvae typically seek deeper water during the day and on ebb tides; conversely, they tend to accumulate at or near the surface at night, particularly on flood tide. This behavioral pattern results in the rapid accumulation of young spot at both the head of the estuary and in tidal creeks along the estuarine border. A short time later spot appear to be far more abundant, by an order of magnitude or more, in tidal creeks than in deeper waters of the estuary, and where comparisons were made, young fish were significantly larger earlier in the growing season in these habitats. Although intermarsh differences in population density, growth and survival rates are evident, it is apparent that young spot do best in salt marshes compared to other regions in the estuary, at least for the first three months of residence. Marking studies confirm an extended period of residency, about 90 days on average, but lasting up to seven months when remaining individuals return to the lower estuary and ocean. However, at any one time, it appears that the larger members of the population tend to move downstream first. During the time that spot are resident in marshes, production rates are extraordinarily high, of a magnitude approaching that of marsh residents (e.g., the mummichog, *Fundulus heteroclitus*), and among the highest values reported for fishes. Average calculated production during two years of study was about 4.4 g m^{-2} , or $22,590 \text{ cal m}^{-2}$. Because spot reside in marshes for extended periods, it can be assumed that the addition of biomass is directly linked to the energy subsidy of the salt marsh itself, rather than derived from an external source. When individual spot exit the marshes, they constitute readily available packets of energy to larger predators in the estuary and coastal zone. Thus, export of fish biomass from the marshes also represents a potentially critical link between primary and secondary production in estuaries.

29.2 4 O I

Weisberg, S.B., Versar, Columbia, MD, and Himchak, P.,

Baum, T., Allen, R., New Jersey Dept. of Environmental Protection, Nacote Creek Research Station, Port Republic, NJ, and Wilson, H. T., Coastal Environmental Services, Linthicum, MD. **TEMPORAL TRENDS IN BEACH SEINE ABUNDANCE OF FISH FROM THE TIDAL DELAWARE RIVER**

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, 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 abundance patterns in the tidal Delaware River and that in other East Coast systems were poor, suggesting that the improvements in the fishery were related more closely to improving conditions within the Delaware than to factors affecting coastal stocks.

12.2 2 O I

Weisberg, S.B., Versar, Columbia, MD, and Heimbuch, D., Wilson, H.T., Coastal Environmental Services, Linthicum, MD, and Windom, H.L., Skidaway Oceanographic Institute, Skidaway, GA, and Summers, J.K., US EPA, Gulf Breeze, FL. **COMPARISON OF ALUMINUM-METAL RELATIONSHIPS IN ESTUARINE SEDIMENTS FROM THREE GEOGRAPHIC AREAS OF THE EASTERN UNITED STATES.**

Aluminum-normalization is a popular technique for separating anthropogenic enrichment from natural mineral weathering as sources of heavy metals in estuarine sediments. Region-specific aluminum-relationships have been developed for numerous areas of the country. Such region-specific aluminum relationships could be warranted based on natural differences in source material or crustal weathering properties among study areas. Alternatively, they may be a function of different data analysis approaches (e.g. data transformations, use of an intercept term, methodology for censoring data) that have been used by the various investigators developing these relationships. These unresolved alternative scenarios presently confound regional or inter-system comparisons of anthropogenic input. This paper addresses that problem by applying a common analytical methodology to data collected throughout the Atlantic and Gulf coasts to identify appropriate spatial scales for developing independent aluminum-normalization curves.

25 27 P-3 C

Wen, L.-S., Stordal, M.C., Tang, D., Gill, G.A., Santschi,

P.H., Department of Oceanography, Texas A&M University, Galveston, TX. **AN ULTRACLEAN CROSS-FLOW ULTRAFILTRATION TECHNIQUE FOR THE STUDY OF TRACE METAL PHASE SPECIATION IN SEAWATER.**

Cross-flow ultrafiltration, CFUF, is an efficient way to isolate the bulk of organic matter from fresh and sea water, and also has great potential for aiding in studies of metal organic interactions. A series of laboratory and field studies were conducted to test the suitability and identify optimal conditions of an Amicon ultrafiltration system for the collection of colloidal material in different size classes for trace metal phase speciation studies in marine environments. A cleaning procedure is required between each sample processed to eliminate carry-over artifacts and achieve a low system blank. A mass balance recovery of 88-109% was achieved for ultrafiltration for estuarine samples. Results of sample storage experiments indicate that ultrafiltration should ideally be performed within 4 hours of sample collection to prevent phase shifts. The concentration of trace metals in the permeate fraction as a function of concentration factor was found to fit the macromolecular permeation model of Kilduff and Weber (1992). A retentate concentration factor between 5 and 10 was optimal for most metals based on modeling permeate metal concentrations. For Galveston Bay, the colloidal fraction accounts for 65-85% of the Cu, 35-40% of the Ni, and 30-95% of the Pb in the total dissolved concentration (<0.45 μ m).

25 28 P-3 C

Wendt, P.H., Van Dolah, R.F., Bobo, M.Y., Mathews, T.D. South Carolina Marine Resources Research Institute, Charleston, SC. **EFFECTS OF WOOD PRESERVATIVE LEACHATES FROM DOCKS ON CERTAIN ESTUARINE SPECIES.**

Concentrations and biological effects of wood preservative leachates from docks in South Carolina tidal creeks were examined. Copper, chromium, arsenic, and PAHs were measured in sediments and oysters from creeks with and without high densities of docks. Sediments from most sites had metal concentrations which were below levels reported to cause biological effects. Pore water and whole sediment bioassays showed no significant differences in acute toxicity between creeks with and without docks. Oysters growing on dock pilings had significantly higher concentrations of copper than oysters growing at least 10m away; however, there was no significant difference in the physiological condition of these oysters. Four-day field bioassays measuring percent survival of mummichogs, mud snails, juvenile red drum, and juvenile white shrimp showed no significant differences between sites near and distant from newly constructed docks. Laboratory-reared oysters placed near and away from docks showed no significant differences in percent survival, growth, or bioaccumulation of metals after six weeks of exposure. Our results suggest that, in macrotidal estuarine environments, wood preservative leachates from docks have no acutely toxic effects on four common estuarine species, nor

do they affect the survival or growth of oysters over a six-week period. In some cases, metal leachates may accumulate in sediments and oysters immediately adjacent to pilings, but do not appear to be concentrated in sediments or oysters elsewhere in the same creeks.

30.3 3 O C

Wetzel, R.L., Moore, K.A., Meyers, M.B., College of William and Mary, School of Marine Science, Virginia Institute of Marine Science, Gloucester Point, VA. **ASSESSING LIGHT REQUIREMENTS OF SEAGRASSES: AN ECOSYSTEM PROCESS MODELING ANALYSIS.**

Of the various environmental parameters affecting seagrasses, the intensity and spectral quality of submarine light has been shown to be a principal factor influencing their growth and survival. In fact, recent efforts at both state and federal levels have attempted to establish minimum light requirements for particular seagrass species to establish target levels for water quality management. Over the past decade we have integrated field studies, mesocosm experiments and ecosystem process modeling of temperate seagrasses in the Chesapeake Bay region to address eelgrass light requirements. Field studies at three sites in the York River suggest the K_d values greater than 1.0 m^{-1} are suboptimal leading to loss of eelgrass and high spring values are especially critical at particular sites. Modeling analyses support these in situ observations and suggest stochastic processes associated with both incoming solar radiation, K_d and tidally varying water depth must be considered in attempts to establish the minimum light requirements for seagrasses.

4.2 3 O I S

Whaley, S.D., Minello, T.J., National Marine Fisheries Service, Galveston, TX and Texas A&M University, Department of Wildlife and Fisheries Sciences, College Station, TX. **THE RELATIONSHIPS BETWEEN MARSH EDGE, ELEVATION, AND BENTHIC INFAUNA IN A TEXAS SALT MARSH.**

Infauna found in the salt marsh are known to be a valuable food source for many estuarine species. Marsh surface elevation, tidal patterns, and distance to the marsh/open water interface define microhabitats which may differ in foraging value. To examine prey abundance among these microhabitats, we collected infauna on subtidal bottom and within the marsh at distances of one, three, five, and ten meters away from the edge. Inundation patterns were determined by correlating microhabitat elevation with water level data. During February, a period of high abundance, Analysis of Covariance revealed that both distance from the edge and elevation significantly affected polychaete and crustacean densities. Marsh densities of polychaetes and crustaceans were significantly higher one meter away from the edge compared with subtidal densities and densities farther from the marsh edge. Density on the marsh surface was positively related to the amount of tidal inundation. These data suggest that areas near the marsh edge may have more foraging value to estuarine predators than subtidal and inner marsh habitats.

20 5 P-3 C

Wheless, G.H., Center for Coastal Physical Oceanography, Crittenton Hall, Old Dominion University, Norfolk, VA. **TIDALLY INDUCED TRANSPORT BETWEEN AN ESTUARY AND THE COASTAL OCEAN: A MODELING STUDY.**

The circulation and particle transport due to tidal forcing through a narrow inlet is numerically examined using a three-dimensional hydrodynamic model. The case of well-mixed buoyant fluid emptying into stratified shelf fluid will be presented. A flat inner basin is connected to a sloping outer shelf by a narrow inlet. Inlet width and salinity differential between the basins describe a small Kelvin number system. Forcing is supplied by semi-diurnal tides and buoyancy differential. Tidally-induced asymmetric eddies appear on both sides of the inlet and a series of radial density fronts corresponding with outflow due to the ebbing tide are found on the seaward side of the inlet at mid depth or lower are more prone to enter the inlet and remain there than those particles released farther offshore or near the surface. This result has implications for the transport of material between the estuary and the coastal ocean.

31 38 P-3 C S

Wiegman, G.J., Parkinson, R.W., Florida Institute of Technology, Melbourne, FL, and DeLaune, R.D., Louisiana State University, Baton Rouge, LA. **EFFECTS OF SPOIL DEPOSITION AND ROTARY DITCHING ON TIDAL WETLAND VERTICAL ACCUMULATION RATES, EAST-CENTRAL FLORIDA, U.S.A.**

This project was initiated to evaluate the effects of spoil deposition and rotary ditching on the vertical accumulation rates of a backbarrier, microtidal wetland. The study area is located within the temperate to subtropical transition zone of east-central Florida: both salt marsh and mangrove vegetation are present. Around 1930, the terminus of Lost Creek was blocked by spoil deposition during the construction of the Intracoastal Waterway. Subsequently, the marsh surface was only flooded by sheet flow associated with exceptional astronomical tides or wind forcing. In 1992, Lost Creek was subjected to rotary ditching to restore hydrological connection to the adjacent estuary; spoil removal was cost prohibitive. Estimates of long-term (^{137}Cs) and short-term (marker horizons, accumulation rods) accumulation rates are being determined at the impact site, as well as at Dead End Creek, a control site in close proximity. Evaluation of historical photographs suggests that Lost Creek and Dead End Creek were initially similar, although recent vegetation analysis indicates they are now high- and low-marsh, respectively. Assessment of long- and short-term accumulation rates will allow evaluation of the effects of coastal construction and restoration techniques on the evolution and sustainability of east-central Florida's remaining tidal wetlands.

6.1 1 O C

Wigand, C., Findlay, S.E.G., Institute of Ecosystem Studies, Millbrook, NY. **VARYING SEDIMENT BIO-**

GEOCHEMISTRY OF SUBMERSED MACROPHYTES.

Submersed macrophytes alter sediment biogeochemistry by providing oxygen to the root zone. Oxygenation of these otherwise anaerobic sediments can change phosphate availability via reactions with iron and manganese. *Vallisneria americana*, *Potamogeton pectinatus*, *Hydrilla verticillata*, and *Myriophyllum spicatum* in tidal freshwater estuaries including the Hudson River (NY) and the upper Chesapeake Bay (MD) showed significantly different depth profiles of porewater nutrients, solid-phase phosphate, and reactive iron and manganese among species and compared with bare sediment. There were significant relationships between solid-phase metals (Fe, Mn) and inorganic phosphate in the grassbed sediments. Differences in allocation of biomass to belowground tissue among macrophytes was evident by varying root/shoot (r/s) ratios. Redox profiles suggest deep-rooted macrophytes such as *V. americana* have a greater effect on sediment oxygenation than shallow-rooted plants. In a laboratory experiment, homogenized Hudson River sediment was planted with zero, low, medium, and high densities of *V. americana* and *P. pectinatus*. Transparent cores collected after 6 weeks showed extensive rhizosphere oxygenation by *V. americana* as observed in field-collected plants.

2 9 P-1 C

Wigand, C., Institute of Ecosystem Studies, Millbrook, NY, and Andersen, F.O., Odense University, Campusvej 55, DK-5320, Odense M, Denmark, **FUNGAL SYMBIONTS OF AQUATIC MACROPHYTES—A REVIEW.**

Observations of mycorrhizae of aquatic plants are common in the eastern hemisphere, and more recently, reports from the western hemisphere suggest mycorrhizae of aquatic plants may be more widespread than previously suspected. It is unclear what environmental conditions promote or inhibit the symbiotic associations, but we present a summary of some of the environmental parameters that are associated with estuaries or lakes where the infected plants occur. The function of mycorrhizae of aquatic plants is not well-studied but may be similar to that in terrestrial plants. Experimental results suggest that root fungi of aquatic plants facilitate phosphate uptake and growth. In fact, in radiolabel experiments, mycorrhizal *Vallisneria americana* had over 75% greater phosphate uptake than fungicide-treated plants. However, in some instances, the fungi may be a carbon drain on the plant. In addition, we present preliminary data suggesting that aquatic plants (i.e., *Littorella uniflora*) with high fungal infection have greater oxygen consumption by roots than plants with low infection. We hypothesize that mycorrhizal fungi require oxygen that is provided by oxygen release into the roots and rhizoplane via aerenchyma of the plant host. Methods to describe fungal infection in aquatic macrophytes include staining techniques, electron microscopy, DNA probes, and ergosterol measurements. The ecological significance of mycorrhizae of aquatic plants may prove as important as root fungal symbionts of terrestrial plants.

21.3 2 O C

Williams, G.D., Zedler. J.B San Diego State University, Pacific Estuarine Research Laboratory, San Diego, CA. **INFLUENCE OF HABITAT STRUCTURE ON FISH ASSEMBLAGE COMPOSITION IN CREATED AND NATURAL SALT MARSH CHANNELS IN SAN DIEGO BAY.**

Annual collections have been made of fish assemblages from created and natural salt marsh channel habitats in San Diego Bay since 1989 to assess whether 'restored' areas meet minimum established biological criteria for habitat restoration. Recolonization of restored channel habitats by fish is rapid, with two common indices of fish community structure, total density and species richness, showing few differences from natural control sites over a 6-yr. time scale. Multivariate clustering of fish assemblages from these sites suggests that samples are more likely influenced by physical attributes (including channel depth, bank slope morphology, and sediment composition) than restoration history. Longjaw mudsuckers (*Gillichthys mirabilis*) dominate in narrow, steep banked channels, California killifish (*Fundulus parvipinnis*) are most abundant in broad shallow channels with high sand content, and topsmelt (*Atherinops affinis*) are dominant in deep-water channel samples. In some cases, more differences exist in the physical structure of channels across restored and natural habitats than between them, complicating simple decisions of restoration success or failure. These results suggest that more complex analyses of fish assemblages should be followed in developing restoration monitoring programs and also demonstrate that control site selection strongly influences a restoration project's ultimate success rating.

31.3 7 O C

Williams, K., University of Florida, Department of Botany, Gainesville, FL. **EFFECTS OF STORMS AND SEA LEVEL RISE ON COASTAL WETLAND FOREST IN FLORIDA.**

Forests at the coastal margin are patterned, in part, by exposure to salt water and to violent storms. Studies carried out over the past three years at Waccasassa Bay, Florida, have examined the relationship between tidal flooding and forest stand structure in the zone where hydric hammock (a freshwater wetland forest type) meets the salt marsh. The occurrence of a major storm surge in March, 1993, allowed us to observe effects of a violent storm on this ecotone. Forest composition was fairly well predicted by the frequency of tidal flooding at a site and the salt tolerance of seedlings of hydric hammock tree species, as determined in greenhouse studies. The storm of March 1993 caused high seedling mortality and high mortality among large southern red cedar trees. Because some seedlings have been observed in the most damaged stands in the years following the storm, stands might recover to pre-storm composition given time. However, if seas continue to rise at historical rates, tree regeneration will be eliminated before stand structure completely recovers.

Williams, M.R., Millward, G.E., University of Plymouth, Drake Circus, Plymouth, UK, and Morris, A.W., Plymouth Marine Laboratory, Prospect Place, Plymouth, UK, and Jago, C.F., Jones, S.E., University of Wales Bangor, Menai Bridge, Gwynedd, UK, **THE ROLE OF SETTLING IN THE TRANSPORT OF PARTICULATE TRACE METALS IN COASTAL WATERS OF THE IRISH AND NORTH SEAS.**

In highly turbid estuaries the transport of particulate trace metals is critical in the transfer of metal contaminants from the estuary to the adjoining shelf sea. However, the development of fine sediment transport models is hindered by a lack of knowledge of the differential behaviour of the permanently and temporarily suspended particles. Samples of suspended particulate material (SPM) were collected in coastal waters adjacent to major estuarine sources, by deploying a modified Owen Tube of 5 litres capacity under various tidal conditions. The sample was allowed to settle under gravity and five aliquots of SPM were retrieved from the tube over a 4.7 hour period. Determinations of particle diameters of each fraction were made via a laser particle sizer. After filtration, the SPM fractions were digested with 1M HCl and analysed for trace metals (Cd, Co, Cu, Fe, Mn, Pb, Zn) using spectrographic techniques and ICP-MS for the determination of $^{206}/^{207}\text{Pb}$ isotopic ratios. The median settling velocities were in the range 10^{-1} to 10^{-3} mm s^{-1} with median particle diameters from 5.3. to 20.8 μm . Estimates of SPM densities were typically <1200 kg m^{-3} suggesting the presence of fine permanently suspended flocculated material. Settling velocities were determined for each metal from the chemical analyses of each fraction. These identified the association of the metals with either a slow or fast settling fraction. Calcium and Cu were linked with fast settling material whereas Pb and Co were associated with a permanently suspended fraction and intermediate behaviour was shown by other metals. The reactivities of the various fractions with trace constituents were tested using radiotracers. Approaches to the coupling of these results with hydrodynamic models are proposed thereby leading to an improvement in their predictive accuracy.

Wirth, E., Fulton, M., Scott, G., National Marine Fisheries Service, Charleston Laboratory, Charleston, SC. **THE TOXICITY THRESHOLD FOR SEDIMENT-ASSOCIATED POLYCYCLIC AROMATIC HYDROCARBONS IN LARVAL GRASS SHRIMP.**

The grass shrimp, *Palaemonetes pugio* is a common shrimp species found in tidal marsh systems along the Atlantic coast and Gulf of Mexico. These shrimp are a major force in accelerating the breakdown of detritus in the estuary and are an important prey item for a variety of fish species. Murrells Inlet is an urbanized, high salinity estuary located on the northern coast of South Carolina. Sediments collected from sites within Murrells Inlet have been found to contain elevated levels of polycyclic aromatic hydrocar-

bons (PAHS) in comparison to sediments collected from more pristine estuarine sites in South Carolina. The objective of this study was to evaluate the effects of PAH-contaminated sediment on the survival of larval grass shrimp. Sediments were spiked with a PAH mixture containing the six dominant PAHs measured at sites in Murrells Inlet. Exposure concentrations were 1, 0 and 100x the mean sediment PAH concentration from the four most contaminated sites in Murrells Inlet. Survival in grass shrimp larvae was reduced in the 10x and 100x treatments. An LC_{50} value of 7.5x was estimated from the mortality data. These results suggest that sediment PAH concentrations ~ 7 x higher than the mean Murrells Inlet levels would be expected to cause mortality in grass shrimp larvae.

Woli, U., Lee, W., Lacson, J., Texas Parks and Wildlife Department, Resource Protection Division, Aquatic Studies Branch, Austin, TX. **AN EVALUATION OF FISH ASSEMBLAGES OF THE UPPER LAGUNA MADRE, TEXAS, BEFORE AND AFTER THE INCURSION OF THE 1990 BROWN TIDE.**

Alteration of the fish assemblages within the Upper Laguna Madre coincided with years (1989-1991) surrounding the incursion of the 1990 brown tide. Despite constant sampling effort, the number of species caught by gill net declined from 28 (1988) to 22 (1989), then increased to 31 (1992). The number of species caught by trawl declined from 35 (1988), to 25 (1990), and then increased to 32 (1991). Annual bag seine sampling effort increased from 120 (1986) to 240 (1993) seines. Nevertheless, the standardized number of species caught per bag seine declined from 0.26 (1986) to 0.16 (1990). Percent similarity (PS) for the 1990-1991 gill net comparison dropped to 74.2 % from a background of about 85%. PS for bag seine catches remained constant throughout most of the study. A minimum PS of 66.6 % was estimated for the 1989-1990 trawl comparison. A significant increase in the abundance of *Pogonias cromis*, and moderate increases in the frequencies of collections of *Cynoscion nebulosus* and *Leiostomus xanthurus* by gill net were observed in 1991. Substantial increases in abundance of *P. cromis* and in the frequencies of collection of *P. cromis*, *M. cephalus*, *L. xanthurus*, and *Lagodon rhomboides* by bag seine were observed in 1990. Such punctuated changes in abundance are attributed to exploitation of alternative nutritional resources in the face of an atypical trophic structure.

Wong, K.-C., College of Marine Studies, University of Delaware, Newark, DE. **ON THE VOLUME AND SALT TRANSPORT IN A COASTAL LAGOON.**

The volume and salt exchange between a coastal lagoon (Indian River Bay, Delaware) and the ocean are examined based on data obtained from three current meters deployed at separate depths along a mooring located in the inlet connecting the lagoon with the ocean. Strong M_2 tidal current with an amplitude of about 100 cm/s exists in the inlet. The

energetic first order tidal current, coupled with the abrupt change in bathymetry between the narrow but deep inlet and the shallow interior of the bay, produces strong tidal rectification effect. This is reflected in the presence of a significant M_4 current as well as a tidally generated residual circulation of about 15 cm/s. The vertical salinity distribution shows large asymmetric variation between the flood and ebb phases of the tidal cycle. This asymmetric intratidal variation is caused by a combination of differential tidal straining, tidal stirring, and hydraulic effects. Results indicate that tidal pumping may represent a significant fraction of the total residual salt transport between the bay and the ocean.

20.3 5 O C

Wong, K.-C., College of Marine Studies, University of Delaware, Newark, DE. **ON THE COUPLED EXCHANGE BETWEEN DELAWARE BAY AND THE ADJACENT CONTINENTAL SHELF.**

The coupled exchange between Delaware Bay and the adjacent continental shelf are examined based on data derived from seven moored current meters. The mean currents exhibit large lateral variations across the bay mouth. Near the Delaware shore the surface layer shows a mean outflow of about 15 cm/s while the lower layer shows an inflow of about 11 cm/s. In the central portion of the bay mouth the mean flow is in the across-bay direction with a magnitude of about 10 cm/s. Near the New Jersey shore the mean flow is weak with large statistical uncertainties. At subtidal frequencies the currents over the deep channel near the Delaware shore exhibit a strong baroclinic response to atmospheric forcing, with surface and bottom currents fluctuating in opposite directions. Near the shallow areas off the New Jersey shore the surface and bottom currents show in-phase fluctuations. At tidal frequencies the dominant M_2 currents vary by 20 cm/s in amplitude and 30° in phase across the bay mouth. The mean and subtidal fluctuations in the salinity distributions across the bay mouth are significantly correlated with the current distributions. The salinity variations at tidal frequencies, however, cannot be explained by advective processes alone.

20.1 5 O I S

Wong, M.W., Townsend D.W., University of Maine, Orono, ME. **COMPARATIVE PHYTOPLANKTON DISTRIBUTIONS IN THREE MAINE ESTUARIES.**

Phytoplankton distributions in the Damariscotta, Sheepscot and Kennebec River Estuaries in Maine were examined with respect to the order-of-magnitude differences in freshwater discharge among the three, and the resulting patterns of vertical mixing and stability that may affect the biological and geochemical processes. Longitudinal surveys were carried out in 1993-1994 in each estuary to measure the hydrography, chlorophyll concentration, phytoplankton cell numbers, nutrients and suspended particulate material. Chlorophyll maxima were observed in different parts of the three estuaries. In the Kennebec Estuary, chlorophyll maxima were found at the mouth and head. The phytoplankton as-

semblages at the riverine end were different from those at the seaward end. In the other two estuaries, chlorophyll maxima were found only at the riverine ends with similar phytoplankton assemblages observed throughout the estuaries. The species compositions at various regions in the three estuaries were related to salinity, while the abundance of phytoplankton (productivity) was closely related to the availability of light. The amount of suspended particulate material and the vertical stability of the water column play important roles in determining the availability of light to the phytoplankton in these estuaries.

16.2 4 O C

Woodin, M., National Biological Service, Texas Gulf Coast Field Station, Corpus Christi, TX. **REDHEADS AND HABITAT ON THE BREEDING AND WINTERING GROUNDS.**

Redheads (*Aythya americana*), a migratory species of diving duck, breed throughout a wide range in interior North America but occupy only a few traditional winter ranges, mostly along the rim of the Gulf of Mexico. Numbers of redheads on the breeding and wintering grounds and quality of habitat for breeding birds, broods, and birds in winter were investigated. Results from aerial surveys showed highly variable redhead populations on the breeding grounds and in winter, but which nevertheless exhibited relatively stable long-term trends. The mean population of breeding redheads (1955-94) was 565,000, with a peak of 829,000 birds in 1975. The mean population of gulf coast redheads (1979-94) was 726,000, with a peak of 1,042,000 birds in the winter of 1979-80. Southern Texas and northern Tamaulipas, dominated by the two lagunas, supported an annual average of 83% of redheads in the Gulf of Mexico. Numbers of breeding redheads were regressed against numbers of May wetlands, shoalgrass area in the Laguna Madre (Texas) during the preceding winter, and numbers of wetlands during the preceding July. Numbers of redheads in the Laguna Madre (Texas) in winter were regressed against shoalgrass area in the Laguna Madre and numbers of wetlands during the preceding May and July. Results indicated that the only significant ($P < 0.01$) independent variable, for abundances of both breeding and wintering redheads, was quality of the winter range.

33.2 4 O C S

Woodruff, D.L., NOAA/NMFS, Beaufort, NC, and Stumpf, R.P., U.S. Geological Survey, Center for Coastal Geology, St. Petersburg, FL, and Paerl, H.W., UNC-CH Institute of Marine Sciences, Morehead City, NC. **SIGNIFICANCE OF ORGANIC MATTER CONTRIBUTIONS TO REMOTELY SENSED LIGHT ATTENUATION MEASUREMENTS IN PAMLICO SOUND, NORTH CAROLINA.**

High levels of organic matter in the Neuse and Pamlico Rivers, tributaries of Pamlico Sound, significantly impacted remotely-sensed measurements of light attenuation in the study area. We collected thirteen concurrent data sets of AVHRR visible imagery, and *in-situ* measurements of light

attenuation and other water quality parameters from 26 stations between 1991 and 1993. While a predictive relationship between satellite reflectance and the diffuse attenuation coefficient, k_d , was developed for Pamlico Sound, reflectance in the rivers was not measurable, precluding remote measurements of light attenuation in the rivers. Decreased reflectance at red (580-680 nm) wavelengths observed by the satellite was due primarily to increased absorption of light by dissolved organic and particulate detrital matter, based on absorption coefficient measurements of phytoplankton, dissolved organic matter and particulate detritus. A slight decrease in dissolved organic matter was found in the summer months, but this change was not sufficient to alter the satellite-observed reflectance in the rivers.

21.1 3 O I

Wright, B.A., National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Oil Spill Damage Assessment and Restoration, Program Manager, Juneau, AK. **RESTORATION OF THE EXXON VALDEZ OIL SPILL**

In 1989, 11,000,000 gallons of crude oil spilled from the *Exxon Valdez* into one of the most pristine coastal seascapes in the world. The impacted area extended several hundred miles, oiling more than 1,500 miles of beaches and injuring or killing thousands of organisms including marine mammals, seabirds, and intertidal species. The subsequent cleanup activities devastated the predominantly rocky intertidal habitat. Restoration began by understanding the spill impact; damage assessment. Restoration actions were identified and implemented with guidance from the *Exxon Valdez* Oil Spill Restoration Plan. This plan embraces a comprehensive balanced approach to restoration allowing for habitat protection, research and monitoring, and active restoration. Much of the \$900,000,000 settlement will go to protecting habitat important to the recovery of injured species through land purchases and conservation easements. Monitoring is important to track recovery and to identify resources needing further investigation. Research provides information needed to restore injured resources. Much of the research now being undertaken in the spill area consists of ecosystem investigations designed to determine why some of the injured resources are not recovering. Most of the recovery from the oil spill is a natural process. However, some active restoration actions have been undertaken to improve the rate of natural recovery.

13.2 6 O C

Wrona, A.B., Wiegert, R.G., Covert, J.S., University of Georgia, Athens, GA. **GROWTH RATES OF FREE RANGING JUVENILE BLUE CRABS DETERMINED FROM MICRO-WIRE TAGGED INDIVIDUALS IN THE SAPELO ISLAND NATIONAL ESTUARY RESERVE OFF THE COAST OF GEORGIA, USA.**

Laboratory studies have established growth rates of juvenile and adult blue crabs, *Callinectes sapidus*. They also show micro-wire tags as an effective permanent tagging technique

for blue crabs. Other mark and recapture studies using micro-wire tags have been used to investigate population dynamics of adult blue crabs. Our study utilizes individually coded micro-wire tags to determine growth rates of free ranging juvenile blue crabs. Crabs ranging from 2.85 cm carapace width (CW) to 9.17 cm CW were tagged and released in the upper reaches of the Duplin River in the Sapelo Island National Estuary off the coast of Georgia. Within the period of July 30th to October 16th 1993, 618 juvenile crabs were marked. Of these, 8 were recaptured. From April 19th to August 19th 1994, 535 crabs were tagged and 16 recaptured. The longest period between mark and recapture was 176 days in which a male crab marked October 11, 1993 was recovered April 5th, 1994. Growth rates were similar to those grown simultaneously in the lab under optimal laboratory conditions. Although return rates were low, and tagging effort was high, this study provides the first information on growth rates for individually marked, free ranging blue crabs.

17 35 P-2 C

Wrona, A.B., Wiegert, R.G., Bishop, T.D., **Covert, J.S.**, Saucerman, S.E., University of Georgia, GA. **SETTLEMENT PATTERNS OF BYACHYURAN MEGALOPAE ON ARTIFICIAL PASSIVE COLLECTORS OFF THE COAST OF GEORGIA, USA.**

Considerable data is available on populations of adult blue crabs, *Callinectes sapidus*, from the Duplin River, Sapelo Island, GA. Little is known, however, about recruitment of blue crab or other brachyuran megalopae. Settlement timing and abundance measurement of brachyuran megalopae on passive samplers was first attempted at Sapelo by Fitz and Wiegert from August - November, 1989. Although many crab megalopae were collected, only few were blue crab. The current study expands on those initial efforts and our common objective with other Atlantic and Gulf coast initiatives to incorporate blue crab settlement information into a region wide network of megalopae studies. Passive samples were collected and crabs were identified and enumerated from fall, 1992; spring through fall, 1993; and fall of 1994. In all three years of sampling, many brachyuran megalopae were collected, but the blue crab megalopal settlement peaks failed to materialize as they had in studies conducted at other areas along the Atlantic coast. In addition, passive samplers were deployed at other locations in the Sapelo Island estuary in an attempt to ascertain why the expected fall peaks at the mouth of the Duplin River have not materialized. However, these additional samplers have not resolved the issue.

-Y, Z-

23.1 4 O C

Yáñez-Arancibia, A., Rojas Galaviz, J.L., Villalobos Zapata, G.J., Lara-Domínguez, A.L., Zárate, D.J., Sánchez-Gil, P., Program of Ecology, Fisheries and Oceanography of the Gulf of Mexico (EPOMEX), University of Campeche, Campeche México. **INTEGRATED COASTAL MANAGEMENT PLAN AND ECOLOGICAL PLANNING FOR TERMINOS LAGOON, CAMPECHE MEXICO (PIMECO).**

The coastal waters of the State of Campeche have some of the Gulf of Mexico's richest ecosystems characterized by extensive seagrasses, mangrove forest, low-land tidal wetlands, a broad deltaic environment, including the Usumacinta / Laguna de Terminos estuarine ecosystem, and extensive low salinities and brackish wetlands. Commercial and artisanal fishing, maritime transport, agriculture and cattle grazing in low-land areas, urban expansion, building of highways, and tourism, are important economics activities that are increasing in the State of Campeche. However, the growth needs to occur in a sustainable manner with adequate protection of the coastal ecosystems. From 1990 to the present, a number of projects have been completed which serve as case studies of coastal management coupling science and policymaking in the southern Gulf of Mexico. The theoretical approach and conceptual basis of the integrated coastal management plan are based on twenty years of scientific research in the region. The plan considered four main actions: Gathering, analysis and dissemination of information related to coastal resources management policies and capabilities; Provision of technical solutions to coastal resources use conflicts; and Promotion of institutional arrangements, so that the multi-sectorial planning approach be considered in coastal resources development.

15 27 P-2 C

Zarbock, H., Coastal Environmental, Inc., St. Petersburg, FL, and Morrison, G., Southwest Florida Water Management District, Tampa, FL. **ESTIMATION TN, TP, AND TSS LOADINGS, AND IDENTIFICATION OF PRIORITY SUB-BASINS, IN THE WATERSHED OF CHARLOTTE HARBOR, FLORIDA**

Charlotte Harbor, located on Florida's southwest coast, is the state's second largest estuary. Water quality within the system is affected by pollutant loadings from the 8,700 km² watershed, which is drained by two major tributaries (the Peace and Myakka rivers). Nutrient and chlorophyll concentrations are elevated in the estuarine reaches of both rivers, and water quality in those areas is characterized as "fair" based on existing state criteria. We estimated monthly and annual loadings of selected pollutants (TN, TP, TSS) to the

estuary for the period 1985-1991. Loading estimates for gauged sub-basins were based on measured (streamflow and constituent concentration) data. An empirical, regression-based model was used to estimate loadings from ungauged sub-basins. Nonpoint sources, atmospheric deposition, and permitted point sources were estimated to be the largest loading sources during the study period. The Peace River drainage basin contributed the majority (61%, 55%, and 78%, respectively) of the estimated TN, TP, and TSS loads. Within that basin, two sub-basins (Peace River above Bartow and Peace River above Zolfo Springs) generated particularly large loadings per unit area, and were identified as priority sub-basins for future watershed management efforts. Industrial point sources were large contributors of loadings in both priority sub-basins.

21.2 3 O C

Zedler, J.B., Callaway, J.C., Pacific Estuarine Research Laboratory, San Diego State University, San Diego, CA. **NON-TRAJECTORIES OF CONSTRUCTED SALT MARSHES IN SAN DIEGO, CALIFORNIA: A 9-YEAR RECORD.**

Two restored marshes (6 and 11 years old) at San Diego Bay had lower sediment organic matter, sediment nitrogen content, and *Spartina foliosa* canopy development than a nearby natural marsh throughout the sampling record. Sediment organic matter in the constructed marsh appears to have increased over the last decade but is still less than 75% of that in the natural marsh. The marsh soil has not accumulated nitrogen, and total Kjeldahl nitrogen levels have remained very close to 1 mg N/g since 1988. *Spartina foliosa* canopy development was assessed as total stem length (tsl); at the older constructed marsh, tsl was ~53% of that in the natural marsh in 1987 and 1988 and ~59% in 1994. In contrast to the above variables, total below-ground biomass (0-25 cm) was similar at all three sites. These constructed ecosystems are not on a trajectory toward functional equivalency; they remain leaky, and low sediment nitrogen concentrations continue to slow the development of critical ecosystem functions.

13.3 4 O I S

Zelenke, J.L., Cornwell, J.C., Horn Point Environmental Laboratory, University of Maryland CEES, Cambridge, MD. **LONG-TERM NUTRIENT RETENTION IN THE TIDAL MARSHES OF THE PATUXENT RIVER SUBESTUARY.**

Despite intense scientific and legislative attention in recent years, the role of tidal marshes in the nutrient budgets of the Chesapeake Bay remains largely unknown. The pur-

pose of our study was to determine if the burial of N and P in tidal marshes was quantitatively important to the nutrient balance in the upper Patuxent River, a region which includes the Jug Bay NERRS site and which has historically experienced high N and P concentrations and loading rates. Using ^{210}Pb -derived sedimentation rates and sediment nutrient concentrations at fifteen sites, we found sediment burial rates from 100 to 8,600 $\text{g m}^{-2} \text{y}^{-1}$, N burial rates of 1 to 105 $\text{g m}^{-2} \text{y}^{-1}$, and P burial rates of 0.05 to 6.1 $\text{g m}^{-2} \text{y}^{-1}$. Phosphorus occurred primarily in inorganic forms. Comparison of marsh sediment composition to that of subtidal areas indicated that marshes both passively filter particulates from the overlying water as well as actively incorporating N and P into organic forms. When integrated over the marsh area, burial can represent as much as 25% and 21% of the sum of total N and P inputs respectively. This study suggests that tidal fresh and brackish marshes in the upper parts of subestuaries may provide important water quality benefits to the lower estuary.

7.2 4 O C

Zengel, S., Research Planning, Inc., Columbia, SC, and Glenn, E., Environmental Research Laboratory, Tucson, AZ, and Meretsky, V., School of Renewable Natural Resources, University of Arizona, Tucson, AZ. **CIENEGA DE SANTA CLARA, AN "ACCIDENTAL" WETLAND IN THE LOWER RIO COLORADO DELTA, MEXICO.**

The formerly extensive wetland and estuarine systems of the lower Rio Colorado delta and the upper Gulf of California have been drastically altered by water diversion projects. The Cienega de Santa Clara is the largest wetland remaining in the lower delta. The Cienega is an "accidental" wetland, formed by diversion of water originally slated for the Yuma Desalting Plant. Due to delays in construction and operation of the desalination plant, the wetland has been in existence since 1977. Prior to water quantity and quality reductions concurrent with future operation of the plant, we determined baseline vegetation distribution patterns in the Cienega using aerial video surveys and GIS. We additionally examined the effects of an 8-month water delivery interruption on live-vegetation cover and the occurrence of the endangered desert pupfish (*Cyprinodon macularius*). Vegetation distribution patterns were mainly attributed to salinity and water depth. The dry-down period resulted in a 60-70% reduction in living above-ground vegetation. Following the return of water, vegetation regrowth was observed and desert pupfish were found in one of four locations where they were previously reported. Pupfish may have survived the dry-down due to the presence of "refuge" areas which retained water.

24.2 1 O C

Zieman, J.C., Environmental Sciences Department, University of Virginia, Charlottesville VA, and Carlson, P.R., Marine Research Institute, Dept. of Environ. Protection, St Petersburg, FL, and Dunton, K.H., Marine Science Institute, Univ. of Texas at Austin, Port Aransas, TX, and Durako, M.J., FL, Marine Research Inst., Dept. of Environ. Protection, St. Petersburg, FL, and Heck, K.L., Marine Environmental Sci-

ences Consortium, Dauphin Island AL, and Fourqurean, J.W., Biology Dept., Florida International University, Miami, FL. **THE EFFECTS OF CHRONIC LIGHT REDUCTION ON SEAGRASSES ACROSS THE GULF OF MEXICO: THE EPA COASTAL SUBMERGED AQUATIC VEGETATION INITIATIVE.**

The project reported on here was a component of the EPA Coastal Submerged Aquatic Vegetation Initiative, focusing on the effects of chronic light reduction on seagrasses across the Gulf of Mexico from the spring of 1993 to the fall of 1994. There were three field sites: Sunset Cove and Rabbit Key Basin in Florida Bay, Port Saint Joseph in the Florida panhandle, and Corpus Christi Bay in Texas. This gave the project both longitudinal and latitudinal variation. Light reduction cages were composed of Vexar and were 1.75m on a side with a height of 0.6m, and were enclosed on sides and top. Light reduction was at two design levels, 70% transmission (3/4" mesh), and 50% transmission (1/4" mesh) although this declined with fouling growth. Plant growth and chemical parameters, sediment and water chemistry, and PAR measurements were routinely measured in the field, and leaf P/I in the lab. Declines in biomass and productivity were seen in rough proportion to light reduction. After the first year, seagrasses in the fine mesh cages died except at RKB. Areal productivity and biomass declined faster than specific productivity. Sediment sulfide levels showed high variation among sites, with Florida Bay samples being consistently the highest.

24.1 1 O C

Zieman, J.C., Environmental Sciences Department, Univ. of Virginia, Charlottesville VA, and Frankovich, T.A., Fourqurean, J.W., Biology Dept, Florida International Univ., Miami FL and Robblee, M.B., Natl. BioL Survey, FIU, Miami, FL. **THE EFFECTS OF CHRONIC LIGHT REDUCTION ON SEAGRASSES IN FLORIDA BAY.**

Florida Bay seagrasses have declined significantly in the past decade, and stress imposed by reduced light from the effects of seagrass dieoff is one potential causal factor. Rabbit Key Basin (RKB) and Sunset Cove (SC) were the FB sites of the EPA Coastal Submerged Aquatic Vegetation Initiative, which focussed on the effects of chronic light reduction on seagrasses across the Gulf of Mexico from the spring of 1993 to the fall of 1994. Cages were constructed of Vexar plastic to target 70% and 50% light transmission. This periodically decreased due to fouling and repeated cleaning was necessary. Most plant parameters at RKB and SC-control showed appropriate seasonal patterns, but the caged plots showed progressive declines. The experimental plots at SC responded more rapidly to light reduction with steady decreases in biomass and productivity without a seasonal pattern. Plants in fine mesh (50%) cages declined faster than those in coarse-mesh cages. The fine-mesh cages were removed after year one and the plants responded with increased growth. Stressed plants attempted to maintain turnover rates, but total and photosynthetic biomass showed progressive declines with light reduction.

Zimba, P.V., University of Florida, Gainesville, FL and Hanisak, M.D., Harbor Branch Oceanographic Institution, Fort Pierce, FL. **PRIMARY PRODUCTIVITY IN THE INDIAN RIVER LAGOON: GROWTH, BIOMASS, AND TURNOVER TIME OF PHYTOPLANKTON, BENTHIC MICROALGAE, SEAGRASS, AND EPIPHYTES.**

As part of a site specific analysis of PAR, water quality, and seagrass-epiphyte standing stock in the Indian River Lagoon (Florida), primary productivity was estimated using ^{14}C methodology at six sites on a quarterly basis for one year. Seven seagrasses are found in the IRL, *Halodule wrightii* Ascherson had the most ubiquitous distribution and was analyzed from sites. *In situ* plexiglass chambers (either 5.25 or 10 cm diameter) were placed over seagrass shoots, and incubated for two hours between 1000-1400 h local time. Samples were subsequently partitioned into plankton, sediment associated microalgae, seagrass, and associated epiphytes. Epiphytic biomass was estimated by dry weight and chlorophyll *a* measures. Turnover time was calculated from the carbon uptake rate and standing stock of carbon. Epiphytic biomass (as dry weight) exceeded host weight during all sampling events. No statistical differences were found between "mid-bed" and "deep-edge" epiphytic biomass. Primary productivity rates for microalgae were highest in early Spring - Summer, whereas maximal *Halodule* uptake was site dependent. Relative productivity of the microalgal fraction exceeded that of the seagrass during all seasons except summer; epiphytic microalgae and benthic algae were more important than plankton.

16.2 1 O C

Zimmerman, R.C., Kohrs, D.G., Biology Dept., UCLA, Los Angeles CA, and Alberte, R.S., Office of Naval Research, Arlington, VA. **OUTBREAK OF A RARE COMMENSAL LIMPET (*TECTURA DEPICTA*) CAUSES CARBON LIMITATION OF EELGRASS PRODUCTION IN MONTEREY BAY**

An unusual appearance of the commensal eelgrass limpet *Tectura depicta* from southern California coincided with the catastrophic decline of a subtidal *Zostera marina* L. meadow near Del Monte Beach, in Monterey Bay, California. This study tested the impact of grazing the chlorophyll-rich leaf epidermis by limpets on C balance, allocation and plant growth. Plants were grown with and without limpets in a mesocosm for 45 d. Growth rates, C reserves, root proliferation and metabolic activities were measured and daily C budgets were calculated. Growth rates, C reserves, root proliferation and metabolic activity of grazed plants were low, and the daily period of irradiance-saturated photosynthesis (H_{sat}) needed to maintain positive C balance approached 13.5 h. Plant size, growth, photosynthesis and sugar content all increased in ungrazed plants. C allocated to roots was 800% higher for ungrazed plants and daily H_{sat} requirements were only 5.5 to 6 h. By grazing the chl-rich epidermis of eelgrass leaves, *T. depicta* induced C limitation in

eelgrass growing in an otherwise light-replete environment. Clearly, understanding the interface between top-down and bottom-up forces that influence seagrass distribution and productivity will be necessary for enlightened management and protection of these critical ecosystems.

6.1 5 O C

Zimmerman, R.C., Steller, D.L., Kohrs, D.G., Biology Dept., UCLA, Los Angeles CA and Alberte, R.S., Office of Naval Research, Arlington, VA. **THE IMPACT OF TRANSIENT LIGHT LIMITATION ON CARBON PARTITIONING AND H_{sat} REQUIREMENTS OF *ZOSTERA MARINA* L. (EELGRASS)**

Whole plant C balance is the principal mechanism by which light availability controls abundance, productivity and colonization depths of seagrasses. Transient periods of light limitation, however, can disrupt C partitioning between shoots and below-ground tissues, inducing C limitation in roots before shoots or rhizomes. Short-term light limitation may not affect photosynthesis, respiration or growth of *Zostera marina* leaves for up to 30 d if C reserves are high. Roots, however, are affected within a few days and dramatic effects on C allocation, protein content and respiration are evident after 30 d. Short daily periods of irradiance-saturated photosynthesis (H_{sat}) increase the period of root anoxia, blocking translocation and inducing C limitation in roots. A C partitioning model based on these results predicted C levels in the shoot to be unaffected by brief (5 to 10 d) periods of extreme light attenuation, while root C reserves fluctuate dramatically, and frequently approach 0, inducing severe metabolic stress. By disrupting C allocation, transient turbidity events can stress eelgrass roots well before impacts on shoots are measurable. Consequently, the daily H_{sat} period required to maintain root C balance and anoxia tolerance may be longer than to maintain shoots, producing shallower colonization depth limits for seagrasses growing in highly variable light environments than predicted from whole plant C balance.

7.2 2 O C S

Zipperer, V.T., Cordell, J.R., Simenstad, C.A., University of Washington, Seattle, WA. **ECOLOGICAL EFFECTS OF EXOTIC CORDGRASS, *SPARTINA ALTERNIFLORA*, ON THE BENTHIC MACROFAUNA OF WILLAPA BAY, WA.**

Accidental and intentional introductions of *Spartina* spp. into world estuaries are increasing concerns over the consequences of converting indigenous mudflats to exotic *Spartina* marshes. As part of a larger study investigating community responses to *Spartina* colonization in Willapa Bay, WA. we are examining macrofauna changes across gradients of *Spartina* patch sizes. We are comparing the composition and abundance of macrofauna in benthic core samples from the centers of four progressively larger *Spartina* patches to cores from adjacent uncolonized mudflats. Subsurface temperature regime was recorded within *Spartina* patches and mudflats. Short-term accretion rates were measured with

sediment accretion disks along a within patch gradient. Preliminary data indicate differences in total invertebrate densities; relative densities of polychaetes, amphipods, oligochaetes, and insects; and proportions of functional feeding groups between *Spartina* centers and uncolonized mudflats and between patch sizes. Sediment accretion is highest at patch edges and decreases towards patch centers. *Spartina* patches fluctuate temperature less than mudflats. Ultimately, a chronosequence of progressively larger/older *S. alterniflora* patches may be used to better model the conversion of mudflats to *Spartina*: marsh to better understand the long-term response of estuarine communities to exotic invasions.

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