



2000 Annual Report

Environmental Institute of Houston



Environmental Institute of Houston

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Cover: The cover illustration was created to convey a double message. First, EIH works on both pollution and conservation issues. Second, EIH supports environmental solutions that balance economic status with environmental health.

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The Director's Report

James Lester, Ph.D., Director, Environmental Institute of Houston and
Professor, Department of Environmental Sciences, UHCL

AIR QUALITY HAS BEEN THE THEME OF THE LAST YEAR. 1999 and 2000 have been filled with discussion of the state implementation plan (SIP) and ozone. We are having trouble responding to this challenge for a variety of reasons. Houston and state leadership tried to minimize the serious nature of our air quality problem. The Environmental Protection Agency (EPA) and the Texas Natural Resource Conservation Commission (TNRCC) applied regulatory strategies to Houston that had been beneficial elsewhere, but were insufficient for our problem. Volatile organic compounds (VOC) were the focus of control strategies, but progress on VOC emissions did not translate into a sufficient decline in ozone accidents. Houston's atmospheric chemistry is unique among U.S. regions. Models developed to evaluate regulatory strategies in other regions do not adequately simulate conditions, reactions and processes in the Houston region. Now we are paying the price for slow response and inadequate research. The cost of NO_x control in dollars and human resources will be enormous. Given the crisis mode in which these regulations are being implemented, some of the costs will be misspent.

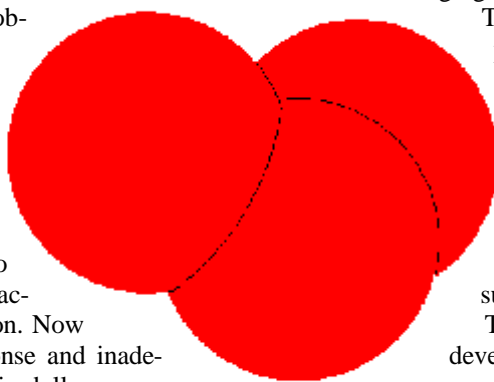
As usual, there can be silver linings to the dark clouds. Houston was the subject of the largest air quality study ever performed in August and September 2000. The data obtained on meteorology and atmospheric chemistry will be extremely valuable in designing control strategies. EIH hosted a small symposium for professionals in our community on the application of this data to Houston's air quality problem. Attending the symposium were members of a new research collaborative at

UH focused on finding improvements to current air quality models. The team is led by Professor Tony Haymet of the Department of Chemistry and contains members from mathematics and chemical engineering. They are the beneficiaries of a federal appropriation of \$2 million arranged by Vice Chancellor Art Vailas and U.S. Representative Tom DeLay. EIH will not administer the funds, but will cooperate with the team to facilitate interaction with a broad-based network of partners and leveraging the funding.

This crisis points out the potential value of proactive research on environmental issues. If EPA, TNRCC or other granting agencies had been doing or funding research directed toward air quality near coastal industrial megacities, we might have more hope of reaching compliance by 2005. EIH is seeking more opportunities to support and encouraging state officials to increase their support of air quality research.

The controversy that has accompanied SIP development is an indication of how little the process of regulation has changed. The current SIP is hopefully one of the last examples of a "command and control" regulatory process. It is

imperative that environmental policy be made with more public participation. Some will object that the public is environmentally illiterate. But that does not relieve us of our democratic responsibilities. It simply emphasizes the need for environmental literacy. The lack of public participation in the process and understanding of the justification for new regulations will be reflected in the political dialog in 2001. Representatives of EIH are participating in stakeholder groups on regional air quality and seeking funding to model better public participation



Molecular Model of Ozone



Photograph by Lisa Gonzalez

Glenn Aumann, Co-Director of EIH and Director of the Coastal Center, and Jim Lester, Director of EIH.

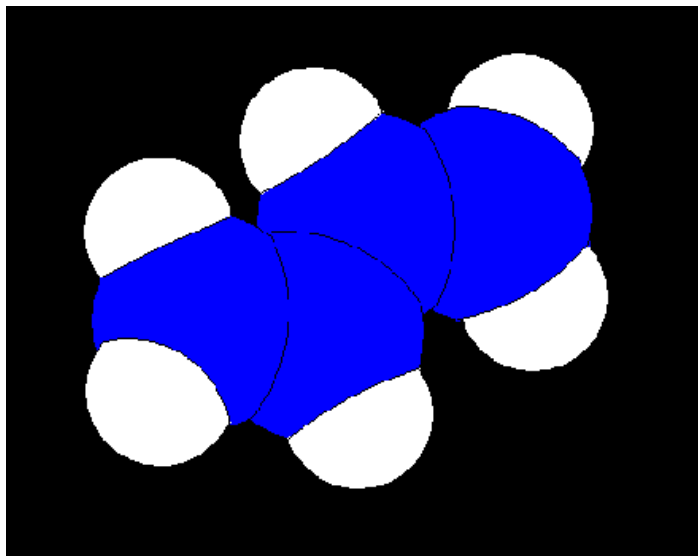
in regulatory decisions.

During the last year, I have started classifying EIH projects into three categories: Research, Public Participation and Environmental Education. Most of this annual report will describe research projects supported by EIH grants. They represent about half of EIH expenditures. Some readers may not realize that EIH has three staff members devoted to environmental education and provides more professional development for teachers than any other university organization in the state. During the past year, we also added a second staff member supporting public participation projects. We work closely with the Houston-Galveston Area Council and the Galveston Bay Estuary Program to facilitate and enhance public outreach and participation in environmental policy decisions. It is my intention to support growth in all three categories.

In this document there are six research reports on potential new technologies for pollution prevention. Three of them (Benedik, Blanke, and Fox) deal with monitoring or remediation via biological systems. Two reports (Kevan and Malki) are related to energy systems for the built environment. Lu describes new polymers that form porous grids. These studies demonstrate the importance of a multidisciplinary response to environmental challenges.

The majority of reports this year deal with some aspect of natural resource conservation. Two of the reports in this category are concerned with the population ecology or genetics of species of concern. Fire ants are significant because this exotic species has done severe damage to the ecosystems invaded. Large areas on the upper Texas coast have lost seagrasses (*Ruppia* and *Halodule*) and are now the focus of restoration efforts. Two other reports deal with restoration of local ecosystems. Brixey, Lester, and Aumann discuss the management of remnant prairies on the Gulf Coast. Wang and Williams describe an approach to improving marsh restora-

Molecular Model of Carbon Monoxide



Molecular Model of 1,3 Butadiene

tion. Two papers deal with sediments in aquatic systems. Chellam characterizes the materials dissolved in freshwater. Howard examines the impact of contaminants in sediments on the ecosystems of Galveston Bay tributaries. Finally, Wellington ties one of our regional ecosystems, the Flower Gardens coral reefs, to global climate change, specifically the effect of CO_2 concentration, and increasing temperature.

Three investigators address environmental policy issues. Rifai compared two models for determining the actual risk for children of exposure to Houston air. Air quality regulations are based on similar modeling. Concomitant with the development of new water plans in Texas, Gossett looked at Texas' legal structure for water districts and water authorities. Also, related to our state's policy response to drought, Melosi compiled information on the history of public water supply systems in the Galveston Bay area.

Four reports are classified as environmental education projects. Weiser is examining the efficacy of a competitive program for high school students for imparting environmental literacy. Rakow focused on a demonstration project at a single school. Weeks and Gallaway are compiling information on and explaining historical uses of resources in and around Galveston Bay for distribution to teachers and the public. Also, Weiser and Reistle have prepared a summary of the EE activities supported by EIH.

I would like to thank Dr. Glenn Aumann for his commitment to EIH and the Coastal Center. He has extended his time in service and forgone opportunities for activities he enjoys in order to administer EIH on the UH campus and keep the prairie from succumbing to Chinese tallow infestation at the Coastal Center. Also, the EIH staff has shown their dedication through sickness and family problems and have maintained productivity and professionalism. My thanks to Glenn and the EIH staff for a very good year.

Genetic Engineering for Enzymatic Cyanide Remediation

Michael Benedik, Ph.D., Professor, and Dakshina Jandhyala, doctoral candidate, Department of Biology and Biochemistry, UH, and Richard Willson, Ph.D., Professor, Department of Chemical Engineering, UH

UH RESEARCHERS ARE INVESTIGATING ENZYMES FOR use in creating an improved process for degrading cyanide in waste streams and contaminated sites. The family of cyanidase enzymes convert cyanide directly to the end products formate and ammonia, which are less toxic than cyanide. Cyanidases are capable of scavenging and destroying their substrate (i.e., cyanide) down to extremely low levels (< 0.01 ppm).

The research team set out to clone the genes for three different cyanidases, two from bacteria (*Pseudomonas stutzeri* and *Bacillus pumilus*) which are cyanide dihydratases and one from a fungus, *Gloeocercospora sorghi*, which is a cyanide hydratase. The *B. pumilus* gene has been cloned for the first time by this group.

These genes have been inserted in a high level expression system for *Escherichia coli* to obtain large amounts of protein. Through the use of genetic engineering, a six amino acid histidine tag was added to the C-terminal end of the three cloned genes. This process results in the protein expressed carrying the 6-His tag which is useful for one-step purification. Figure 1 shows whole cell extracts of *E. coli* carrying such an expression plasmid as well as the results of one step purification. Similar results have been achieved for all three cloned genes.

Molecular methods have been successfully applied to improve the cost of these enzymes by developing high level production and simple one step purification. The stability and metal-tolerance of the three cyanidases will be further investigated.

New methods of directed *in vitro* evolution will be used to generate novel enzymes with improved properties for these applications.

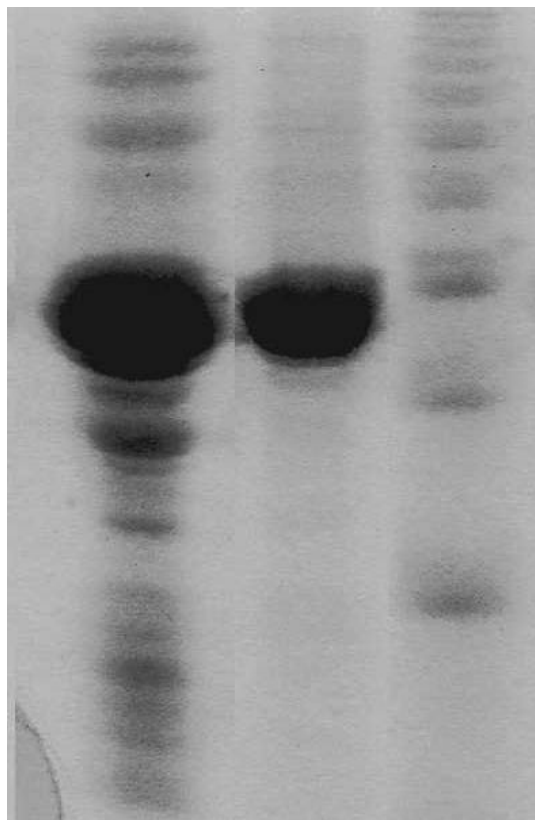


Figure 1. Profile of *G. sorghi* cyanidase (expression in the heterologous host *E. coli* demonstrating the achievable high level production). From left to right, the lanes are (1) total protein from *E. coli* expressing cyanidase, (2) purified cyanidase using one step His tag purification (size 41 kDa), and (3) MW size markers.

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Riddle, R., P. Gibbs, R. Willson, and M. J. Benedik. "Purification and Properties of 2-hydroxy-6-oxo-6-(2'aminophenyl)hexa-2,4-dienoic Acid Hydrolase Involved with Microbial Degradation of Carbazole," (2001) (*in preparation*).

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"The Role of Genetic Exchange in Evolution." Co-Principal Investigator: L. Meffert; Houston Coast Center, 1999-2000; \$15,000.

"Genetic Engineering of Enzymatic Cyanide Clearance." Co-Principal Investigator: R. Willson; Gulf Coast Hazardous Substance Research Center, June 2000-May 2003; \$47,500 per year.

Novel Approach to Identify Bacterial Genes that are Turned On During Environmental Bioremediation

Steven R. Blanke, Ph.D., Assistant Professor, and David Willhite, graduate student,
Department of Biology and Biochemistry, UH

BIOREMEDIATION HAS BECOME AN ACCEPTED AND important technology for restoration of contaminated environments. Moreover, the application of bioremediation to contaminated sites is an important step in preventing further pollution of outlying ecosystems in close proximity to the polluted site. Bacteria have been identified that can degrade organic and inorganic pollutants, but it is clear that bioremediation remains poorly understood at the genetic level. This proposal outlines a novel plan to generate molecular based tools called promoter traps for identification of genes in bacteria commonly used for bioremediation to restore polluted environments. Specifically, very little is known about the diverse array of genes that may be activated in response to an environment containing a pollutant. Clearly, understanding the response of bacteria to a pollutant on a global scale is critical for “improving” bacteria currently used for bioremediation. The work in this proposal, and in future work will address the following hypothesis:

The overall goals of this research is to test the hypothesis that bacteria sense pollutants as environmental signals resulting in the activation of specific genes and/or operons of genes. Bacteria have evolved exquisite systems for sensing and responding to changes in their environment. Catabolic and anabolic pathways, as well as virulence operons in bacterial pathogens, are regulated in strict response to available environmental signals. It is therefore a reasonable hypothesis that bacteria that can grow and degrade environmental pollutants will have genes that are upregulated in the presence of pollutant, and down-regulated in the absence of pollutant.

The research team is currently developing molecular tools called promoter traps for identifying bacterial genes that are turned “on” in the presence of environmental pollutants, but turned off in the absence of pollutants. Promoter traps are

genetic tools for studying gene expression in response to environmental signals. The bacterial pool are exposed to varying environmental conditions, and single bacteria are collected in which the reporter gene is expressed under one set of environmental conditions, but NOT expressed under a different set of environmental conditions. Those bacteria that express the reporter gene have fragments of genomic DNA including promoters that respond specifically to changes in environmental conditions. Bacteria is recovered, and the promoters and genes are identified by DNA sequencing.

This research is significant in that it represents a significant departure from current approaches for studying bioremediation. These investigations will represent the first attempts at generating tools for identifying potentially complex arrays of gene responses in the presence of specific pollutants. Investigators believe that the promoter trap technology presents a powerful and novel strategy for identifying genes applicable to environmental problems. UH researchers propose to use the promoter trap to identify those genes that are turned on with great specificity in response to pollutants. Importantly, this approach is potentially applicable to any bacterial system that is genetically tractable.

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Ye, D. and S. R. Blanke. "Mutational Analysis of the *Helicobacter pylori* Vacuolating Toxin Amino Terminus," 15th Lost Pines Molecular Biology Conference, Smithville, TX, Oct. 8-10, 1999.

Ye, D. and S. R. Blanke. "Probing the Structure-Function Relationships of the *Helicobacter pylori* Vacuolating Cytotoxin from within Intoxicated Cells," 14th Symposium of the Protein Society, San Diego, CA, Aug. 5-9, 2000.

Ye, D. and S. R. Blanke. "Structure, Function, and Intracellular Assembly of the *Helicobacter pylori* Vacuolating Toxin," Structural Biology Symposium, Galveston, TX, May 19, 2000.

Funding and proposals

"Molecular Mechanisms of the *Helicobacter pylori* Vacuolating Toxin." National Institutes of Health, April 1, 2000-March 31, 2005; \$953,525.

"Combinatorial Approaches to Probe Molecular Discrimination in Enzyme Catalysis." Welch Foundation, June 1, 1999-May 31, 2002; \$135,000.

"Regulation of Host Cytokine Networks by *Pseudomonas aeruginosa* Exotoxin A." American Heart Association, July 1, 1998-June 30, 2000; \$92,880.

"Novel Approach to Identify Bacterial Genes that are turned on During Environmental Remediation." Environmental Institute of Houston, Jan. 1, 2000-Aug. 31, 2000; \$13,376.

"PCR-Based Diagnostics for the Rapid Detection of Microbial Pathogens." UH/NASA Technology Commercialization Incubator, July 1, 1999-Sept. 30, 2000; \$96,920.

"Adaptive Cardiac Connective Tissue Remodeling through Directed Delivery into Cardiac Myofibroblast Cells." Principal Investigator: Daniel Martinez; American Heart Association, Jan. 1, 1999-Dec. 31, 2003; \$260,000 (consultant).

Novel Technology for Microbial Monitoring

George E. Fox, Ph.D., Professor, Pedro Moreno, research assistant, Zhengdong Zhang, graduate research assistant, and James Hurry, undergraduate research assistant, Department of Biology and Biochemistry, UH

BIOREMEDIATION IS A PROMISING APPROACH FOR cleaning up the hydrocarbon contaminated sites that are common in the Gulf Coast region. Currently, bioremediation is accomplished by using nutrient addition to increase the activities of indigenous microorganisms or by adding large numbers of microorganisms from another environment. In the future, it is expected that genetically engineered organisms carrying custom designed biodegradative pathways and enzymes will be added to the bioremediation arsenal. In any case, once bioremediation is chosen, it is essential to monitor the microbial ecosystem on an ongoing basis in order to insure that the process proceeds as planned and that process specific risks, such as the loss of the ability to provide oxygen and nutrients, are promptly detected and avoided. In addition, whenever bacteria are added to a local environment in large numbers, safety concerns will arise and these will be enhanced when the strain is genetically engineered. Thus, it is essential that tools be available to quickly and accurately determine what happens to the bacteria that are added to an environment.

UH researchers are seeking to develop a monitoring system that allows the simultaneous quantitative tracking of multiple organisms in complex ecosystems. This will be accomplished by having each target organism express a unique identifier RNA that accumulates in many thousands of copies per cell in correspondence with the relative metabolic activity of that cell type. In order to accomplish this, we originally incorporated a plasmid-borne *V. proteolyticus* 5S rRNA gene into *E. coli*.¹ This strain expressed *V. proteolyticus* 5S rRNA in *E. coli*, where it accumulated in large amounts in 50S ribosomal subunits, 70S ribosomes, and polysomes. A variant in which nucleotides encompassing positions 26-57 of the *V. proteolyticus* 5S rRNA were deleted and replaced with a unique sequence also accumulated to high levels.² It was later shown that detec-

tion by hybridization probes could be enhanced by incorporating multiple copies of the same target sequence.³

During the past year, the research team described the extension of the system to *Pseudomonas putida*⁴ and began studies to determine the extent the presence of an identifier does or does not significantly impact the cells carrying it. To this end, the research team has begun examining the global expression of proteins using high-resolution gels and mRNAs using array hybridization. The protein studies did not reveal any significant changes. Expression studies are now underway and several necessary control experiments have been completed. In collaboration with Richard Willson, the development of a solution based detection system using molecular beacons has been initiated. Using this system investigators were able to distinguish *E. coli* carrying the identifier from an otherwise identical *E. coli* strain.⁵ Studies of mixtures of labeled and unlabeled cells to determine the error boundaries associated with population measurements, the reproducibility of measurements, and the ability to monitor several bacterial species simultaneously have also been initiated. Fluorescence microscopy is being used for this purpose.

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“Microbial Monitoring with Artificial Stable RNAs.” Co-Investigator: R. C. Willson; Environmental Protection Agency, Feb. 1, 2001-Jan. 31, 2004; \$367,479 (pending).

“Microorganisms in the Space Craft Environment.” Co-Investigator: R. C. Willson; National Space Biomedical Research Institute, Oct. 1, 2000-Sept. 31, 2003; \$926,040.

“Noncanonical Base-Base Interactions in Synthetic RNAs.” Robert A. Welch Foundation, June 1, 2000-May 31, 2003; \$135,000.

“The Origins of Translation.” Co-investigator: S. Martinis; NASA-Exobiology Program, Feb. 1, 1999-Jan. 31, 2002; \$240,000.

Photooxidation of Alkylphenothiazines in SiMCM-48, AlMCM-48, and VMCM-48 Mesoporous Molecular Sieves

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PHOTOCHEMICAL SOLAR ENERGY CONVERSION BASED ON artificial photoredox systems is an important and active research area because solar energy is an inexpensive and ever renewable energy source. The conversion and storage of solar energy requires transformation of abundant and low-cost raw materials like H_2O , CO_2 , and N_2 into fuels like H_2 , CH_3OH , CH_4 , and NH_3 . Many studies in the field of solar photochemistry are devoted to the photo induced cleavage of water into H_2 and O_2 . For photo induced electron transfer, a molecule absorbs a photon of suitable energy and is converted to an electronically excited state which is a better oxidant or reductant than the ground state. Photoinduced electron transfer between such an excited state and a suitable reaction partner converts a fraction of the absorbed light energy into chemical energy. Usually, the raw materials to be converted into a fuel can not be electronically excited by visible light. For example, the electronic absorption of water occurs at 167 nm in the far ultraviolet region. In such a case, the process must be mediated by a suitable chemical species called a photosensitizer. Phenothiazine derivatives are good photosensitizers and efficient electron-donor molecules and can be photooxidized by near ultraviolet irradiation to form alkylphenothiazine cation radicals, which can be characterized by electron spin resonance (ESR) and optical absorption.

The efficiency of photoinduced electron transfer is generally limited by back electron transfer, so current research is oriented toward the design of efficient photoredox systems that can inhibit back electron transfer and lead to relatively stable charge separation between the electron donor and the electron acceptor. The back electron transfer rate is typically retarded in heterogeneous systems compared to a homogeneous solution. The photoionization efficiency in organic assemblies is typically higher than that in homogeneous solution, but the photoinduced

radicals are not stable at room temperature. However, photoinduced charge separation in porous inorganic materials such as zeolites and silica gel can achieve long lifetimes of photoinduced radical ions at room temperature.

Zeolites have a relatively small pore size (typically $< 13 \text{ \AA}$) which has been claimed as a main drawback for the extensive use of zeolites as microporous reactors. Mesoporous materials like silica gel are typically amorphous with irregularly spaced pores with a broad size distribution. However, ordered M41S-type mesoporous molecular sieves possess uniform hexagonal (MCM-41) and cubic (MCM-48) pore systems ranging from 10 \AA to more than 100 \AA . MCM-41 materials have been extensively studied, but MCM-48 materials have been less studied, probably due to the difficulty of reliable synthesis. For potential applications, MCM-48 with its three dimensional channel system seems to be more advantageous than MCM-41 with one dimensional channels, because three dimensional channels allow faster diffusion and are more resistant to pore blocking. Tetrahedral Si(IV) in the MCM-48 framework can be replaced by other metal ions such as V(V), Al(III), Zr(IV), and Mn(II). This makes it possible to modify the MCM-48 framework to enhance the photoionization efficiency of incorporated molecules such as alkylphenothiazine derivatives (PC_n).

In this research, a series of aluminum and vanadium containing MCM-48 molecular sieves with different Al and V contents have been hydrothermally synthesized and act as heterogeneous hosts for photoinduced electron transfer from PC_n . The photoinduced PC_n cation is characterized by ESR and diffuse reflectance (DR) UV-vis spectroscopy. V^{5+} in VMCM-48 acts as an electron acceptor because V^{4+} can be observed by ESR after photoirradiation. The PC_n^+ photoyields increase in the order MCM-48 $<$ AlMCM-48 $<$ VMCM-48, indicating that framework modification by incorporating aluminum and vana-

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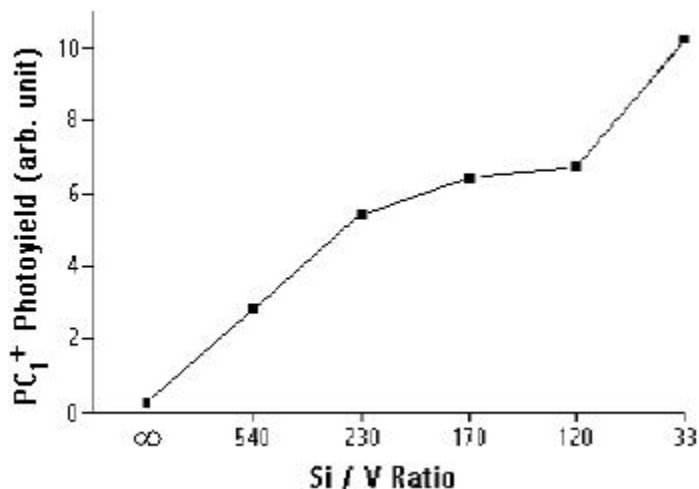


Figure 1. PC₁⁺ photoyields in VMCM-48 samples versus V content after 20 minutes irradiation with 320 nm at room temperature.

Spectroscopic Studies of the Photoionization of N-Alkylphenothiazines in Synthetic Microporous M-Clinoptilolite (M = Na⁺ & K⁺, H⁺, Li⁺, N⁺, K⁺, Ni²⁺, Co²⁺, Cu²⁺) Molecular Sieves at Room Temperature," *Phys. Chem. Chem. Phys.* (2000): 3335-39.

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Funding and proposals

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Synthesis of Porous Materials with Environmental Significance

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EXPLORATIONS OF THE NOVEL POROUS METAL-ORGANIC polymers for ion-exchange, enclathration, and separation research have led to the discovery of several new porous materials in our laboratory: $\{(H_2O)_{19}[Cu(N_2C_{10}H_8)_2NO_3]_2\} \cdot 22H_2O$, $[Cu(N_2C_{10}H_8)_2NO_3](H_2O)_{16}(CH_3COCH_3)$, $[(H_2O)_2Co(N_2C_{10}H_8)(N_2C_{12}H_{10})_2] \cdot 1.6(N_2C_{12}H_{10}) \cdot 0.4(N_2C_{10}H_8) \cdot 2NO_3 \cdot 2.5H_2O$, and $[(H_2O)_4Co(N_2C_{10}H_8)(N_2C_{10}H_8)_2] \cdot 2NO_3 \cdot 3.5H_2O$.

Among them, $\{(H_2O)_{19}[Cu(N_2C_{10}H_8)_2NO_3]_2\} \cdot 22H_2O$ has an unprecedented single-net three-dimensional non-interpenetrating structure with large open channels and the channels are filled by ions and solvent molecules (see Fig. 1). This framework polymer can undergo reversible anion/molecule exchanges without destruction of the original framework. $[(H_2O)_2Co(N_2C_{10}H_8)(N_2C_{12}H_{10})_2] \cdot 1.6(N_2C_{12}H_{10}) \cdot 0.4(N_2C_{10}H_8) \cdot 2NO_3 \cdot 2.5H_2O$ has a novel mixed-ligand network structure with large channels filled by solvents and anions (see Fig. 2). This material is acentric and represents the first mixed-ligand and mixed bonding guest-containing rectangular grid frameworks. The *Co-Co* separation in the rectangular grid is about 11.20 x 12.80 Å. Solvents and anions can be removed by thermal treatment and retained in a reversible process.

$[(H_2O)_4Co(N_2C_{10}H_8)(N_2C_{10}H_8)_2] \cdot 2NO_3 \cdot 3.5H_2O$ displays a covalent bonding one-dimensional chain where the *Co* metal centers are in octahedral coordination surrounded by two 4,4'-bipyridine and four water molecules. Chains are then linked by four 4,4'-bipyridine hydrogen bonding to four water molecules on the chain to form a novel two dimensional square grid network. This is the first cationic guest-inclusion framework with both unique coordinated and hydrogen bonded 4,4'-bipyridine. The pocket-like cavities are occupied by water molecules and nitrate anions in the structure (see Fig. 3).

Results show that year one milestones—synthesis, single crys-

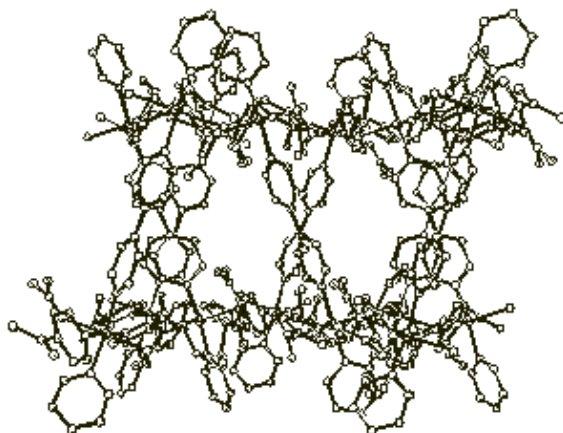


Figure 1. Diagram of $\{(H_2O)_{19}[Cu(N_2C_{10}H_8)_2NO_3]_2\} \cdot 22H_2O$. For clarity, inclusion solvents are omitted.

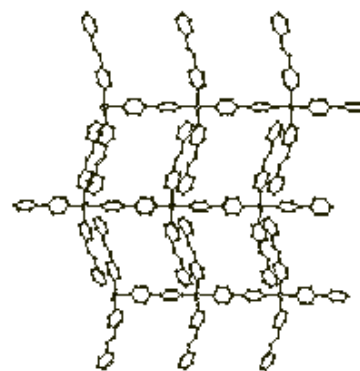


Figure 2. Diagram of $[(H_2O)_2Co(N_2C_{10}H_8)(N_2C_{12}H_{10})_2] \cdot 1.6(N_2C_{12}H_{10}) \cdot 0.4(N_2C_{10}H_8) \cdot 2NO_3 \cdot 2.5H_2O$. For clarity, solvents and anions are omitted.

tal growth, isolation and characterization of new porous metal-organic polymers—have been reached. Investigation of the properties and applications of the materials based on their crystal structural data will require further research.

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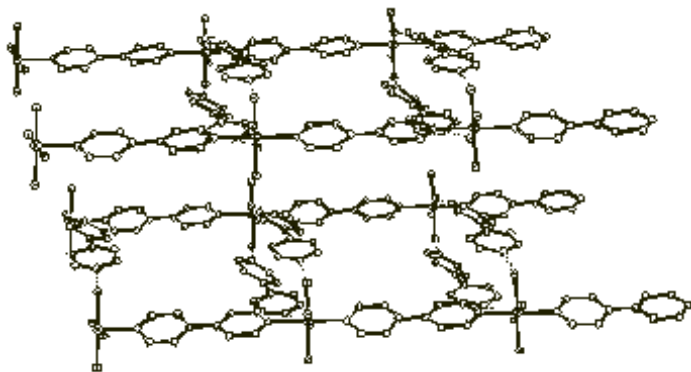


Figure 3. Diagram for $[(H_2O)_4Co(N_2C_{10}H_8)(N_2C_{10}H_8)_2] \cdot 2NO_3 \cdot 3.5H_2O$. For clarity, the water molecules and nitrates are omitted.

A Harmonic Detection/Filtering Method for Energy Efficient High Rise Buildings by Optimizing the Size and Location of Active Power Filters

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THE USE OF MODERN ELECTRONIC EQUIPMENT HAS changed the load characteristic of modern facilities. Electronic loads have earned the name “nonlinear load” to describe the way they draw power. Some of the adverse effects of concentrated nonlinear loads upon a facility are: voltage distortion within facilities, excessive neutral return currents, high levels of neutral-to-ground voltage, overheated transformers and large magnetic fields emanating from transformers, etc. Active Power Filters (APF's) or Active Power Line Conditioners (APLC's) are devices, which compensate for the harmonics generated by non-linear loads. The objective of the current research is to determine the placement of APF's in 3-phase circuits for reducing the harmonics generated, to a minimum. There are two lines of research that were pursued in this context. The first was by the Utilization of Fuzzy Logic to determine the total number of APF's required and the second was the use of an iterative procedure to determine the placement of APF's based on a value known as the Total Harmonic Distortion (THD). The first method concentrates on determining the number of APF's required based on the bus current and the second stresses determination of the placement of available APF's based on the bus THD.

Utilization of fuzzy logic for determination of number of APF's in a bus based on the bus current

The function principle of a fuzzy logic system is mapping from a given input to an output. This process is called fuzzy inference and consists of five main procedures: fuzzifying inputs, applying fuzzy operators, applying an implication method, aggregating all outputs, and finally defuzzifying outputs.

The first step, fuzzifying inputs, determines to what degree the input variables belong to different input fuzzy sets. With the fuzzified inputs, it is now possible to perform the fuzzy

operations in the antecedent of the rule base, thereby determining the degree to which the premise of each rule is satisfied. The degree is a single crisp value that is applied to the output membership function of the corresponding rule. Applying the result of the operations in the antecedent to the output functions can be compared with weighing each single rule and its output action. The fourth step is aggregating all outputs, which means joining all membership functions together into one single membership function and joining all fuzzy sets into one single fuzzy set, respectively. The final output of each output variable of the fuzzy inference system is generally a crisp value. Therefore, a representation of the crisp number for the derived output membership function has to be found. This transformation is called defuzzification.

This method utilizes the above five steps to calculate the number of APF's required for a bus based on the maximum current in that particular bus. The steps involved in calculation of the number of APF's are detailed below. This research utilizes programming in Matlab.

1. The current as an input to the program in a particular bus is determined.
2. A 3-rule base is used to fuzzify the current.
3. The number of APF's is calculated using the Takagi-Sugeno-Kang (TSK) method.

The problems faced with this approach are:

1. The only input value is the bus current.
2. There is no means of determining the placement of individual APF's.
3. There is no means of utilizing the APF data available or determining the rating of APF's to be inserted in the circuit.

Therefore, an alternative method to determine the exact placement of APF's available has been researched.

Utilization of THD as a factor for the placement of APF's in a bus system

Total harmonic distortion, is present with most electrical and electronic devices. It is a measurement of how a piece of equipment draws current from the power line. Current may be drawn at the fundamental frequency or combined with harmonic currents, which are multiples of the fundamental, third, fifth and seventh harmonics. The THD number represents the effective value of all of the harmonic currents added together, compared to the value of the fundamental current. For example, a 20 percent THD means the total harmonic current is equal to 20 percent of the total fundamental current. Another definition of THD is that, it is the ratio of the sum of the powers of all harmonic frequencies above the fundamental frequency to the power of the fundamental frequency. It is an effective measure of the harmonics present in a bus and can be used as a measure for determination of the ideal bus candidate for APF placement. The second method utilizes the following algorithm for determination of APF placement in a bus system.

Input Values

1. Number of buses and the values of harmonics i.e. 1st Order, 3rd Order....(I1,I3...) in each bus.
2. Number of APF's available and their ratings in Amperes, and the maximum values of harmonics that the APF can handle.

Algorithm

1. Calculate the THD for each bus.
2. Rate the buses according to THD.
3. The bus with the maximum THD gets the APF of the highest rating.
4. Compare the rating of the APF and the total harmonic current. If the rating of the APF is greater than the total harmonic current then the bus is removed from contention or else the harmonics remaining in the bus are calculated and the bus is in contention for another APF.
5. Check if any more APF's are available. If so, go to step 1; else end the calculation and generate a report of the buses and the APF's to be inserted into each bus.

In step 4 of the algorithm, there are two cases that might result. One case is that the APF allotted may satisfy the bus harmonic current and therefore, there may not be a need for further placement of an APF. In this case the bus is removed from the calculation and that particular APF is the only one that is allotted to it. The other case is that the APF allotted may not remove all the harmonics from that particular bus. In this case, the APF is allotted to the bus no matter what, and a new set of harmonics remaining in that bus is calculated using the APF harmonic data and the bus harmonic data. The bus remains in contention for another APF.

This method is under development. The algorithm has been coded in Matlab. It is being tested with some real-time data. Also proposed is the conversion of the algorithm to utilize active and reactive power components to generate similar results.

Heidar A. Malki

Publications

Hsu, Y.-C., G. Chen, and H. A. Malki. "Design and Analysis of A New Neuro-Fuzzy Control System," *International Journal*

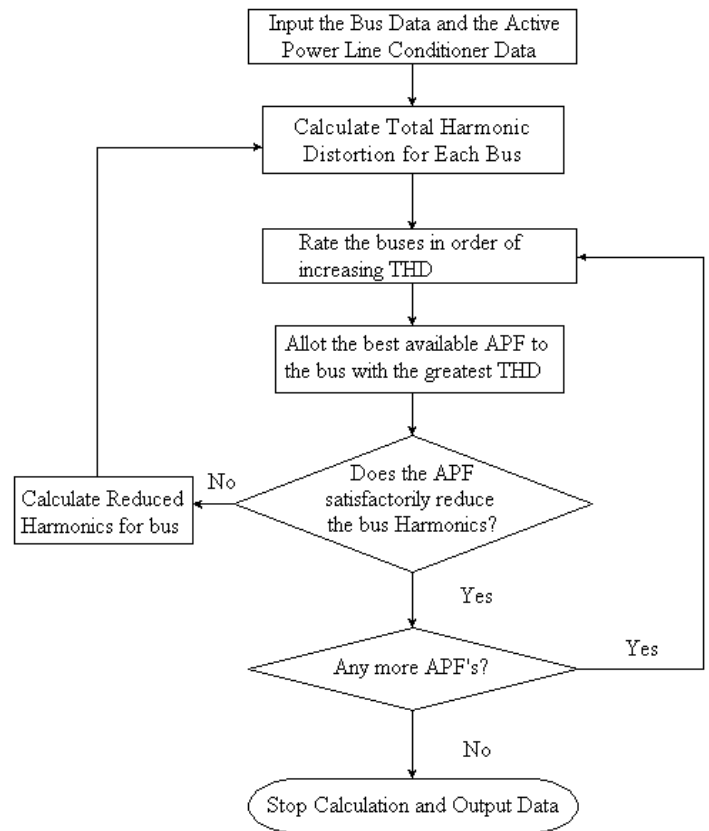


Figure 1. The algorithm is shown in the form of a flowchart.

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Funding and proposals

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Wajiha Shireen

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Shireen, W., M. S. Arefeen, and D. Figoli. "Controlling Multiple Motors Utilizing A Single DSP Controller," IEEE *Applied Power Electronics Conference Records*, 1999.

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"Development of a MCT Based Solid State DC Switch and Circuit Breaker." National Science Foundation; \$70,000.

"A DSP Based Power Electronics Interface for Alternate/Renewable Energy Systems." Department of Energy; \$40,000.

"An Energy Efficient Motor Drive System." UFH; \$20,000.

Vegetation Analysis of a Coastal Prairie Under Different Management Regimes

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PRAIRIES HAVE BEEN LARGELY CONVERTED TO agricultural uses in this country and very little of the native habitat remains. Restoration of prairies is an important objective of natural resource agencies. Best management practices for native and restored prairies are still debated. The University of Houston Coastal Center holds one of the best examples of native coastal prairie in Texas. It has been managed for over 25 years by periodic mowing, but recently an effort was made to add burning to the management regime. This study compared the effect of mowing and fire on prairie areas that had been maintained for many years and areas that had recently been restored by clearing trees.

Vegetation analysis employed a list of 48 species of plants commonly found in coastal prairies that were indicative of high, neutral or low prairie quality. Plants associated with low quality are introduced exotic species. Neutral species are native, but associated with succession to other non-prairie ecosystems. The remainder are grasses and forbs associated with mature coastal prairies. Fifteen transects were monitored in seven prairie areas that differed in time under prairie management. One square meter areas were located at random compass positions and distances from evenly spaced points along each transect. All plants on the list were identified in the sample plots, except Bermuda grass. Samples were taken in the fall (1999 and 2000) and spring (2000). Species abundance data were used to calculate species diversity indices. The values assigned to species relative to prairie quality were then used as coefficients to calculate a prairie quality index similar to the Shannon-Weiner species diversity index, i.e. $\text{Exp}[-(\text{value of species: } -1, 0, \text{ or } +1) p_i \ln p_i]$.

Nine transects were in areas that had been managed as prairie for more than 15 years. These are all transects in areas 2 and 4 plus transects 6B and 7A. The other six transects are in areas



Views of the University of Houston Coastal Center prairie where this study was performed.

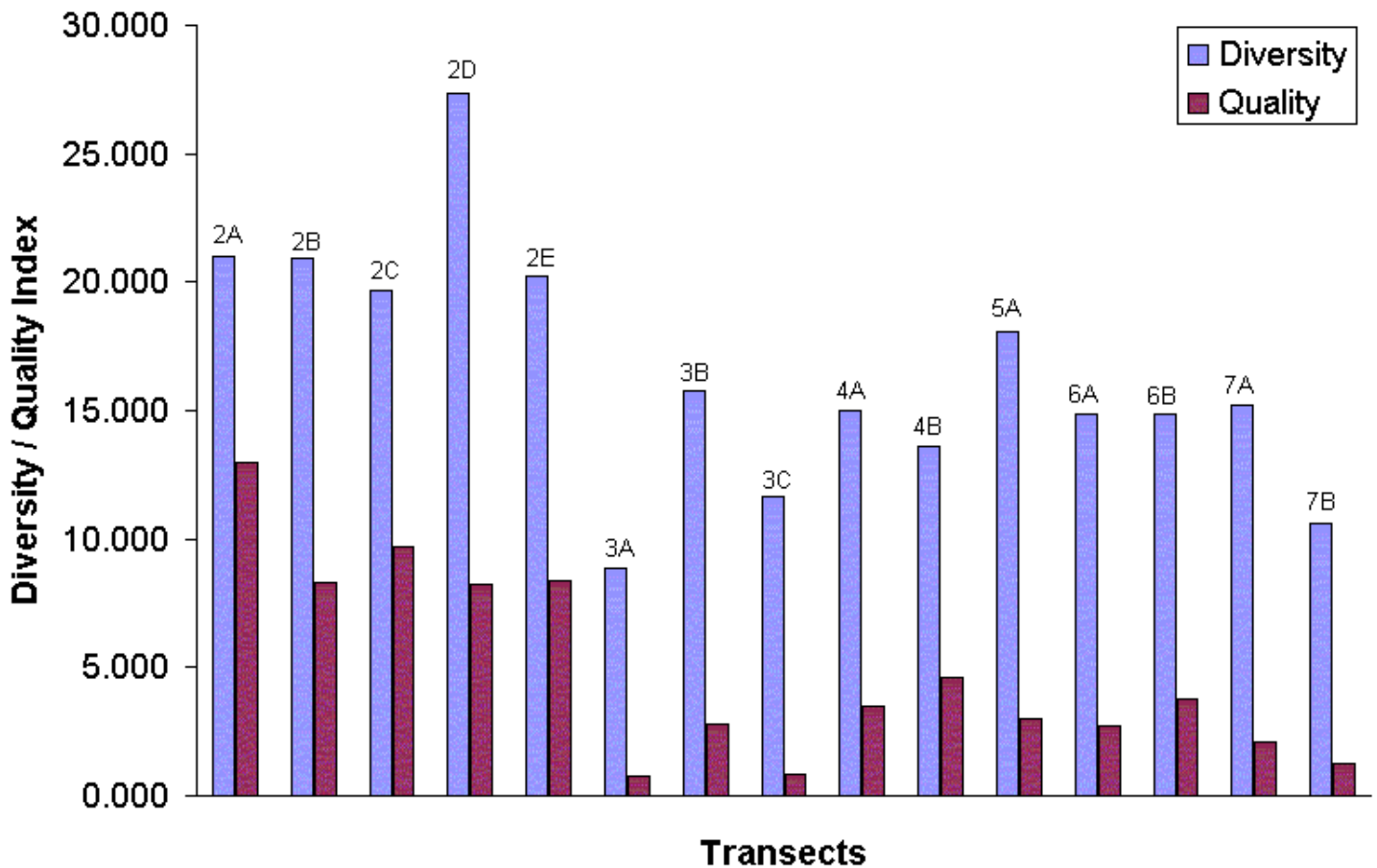


Figure 1. Species Diversity and Prairie Quality Index Values for Spring 2000

restored to prairie less than 10 years ago. In the spring of 2000, areas that had been managed for more than 15 years as prairie had higher vegetation diversity than those that had been managed less than 10 years (Fig. 1). The average species diversity of the long-term management areas was 18.65 and the short-term average was 13.30. The prairie quality indices were also higher for the long managed areas. In fall of 2000, the diversity comparison was not significantly different as shown in Fig. 2. However, the prairie quality indices were significantly higher for the long-term management areas in both seasons. The comparison in spring 2000 was an average of 6.83 for the long term transects and 1.89 for the short term. Fall mean values were 4.45 and 3.03 for long term and short term, respectively.

In the spring of 1999, Area 2 was subjected to a prescribed burn managed by U.S. Fish and Wildlife and Texas Parks and Wildlife. In fall of 1999, two transects that had been burned in spring were compared to five that had not been burned. Species diversity and prairie quality were significantly higher in the burned areas.

Seven of the transects were mowed prior to the spring 2000 sampling. None of them were in the area that was burned in 1999. These were compared to eight transects that were not mowed. In the fall 2000 analysis, the mowed areas were significantly more diverse than those that were not mowed. Five of seven mowed transects increased in diversity between the spring and fall analysis. Six of eight unmowed transects showed a decrease in species diversity from spring to fall. However, the prairie quality index was not significantly differ-



Area 2C is a part of the Prairie restoration project being undertaken by the U.S. Fish and Wildlife Service and the Houston Coastal Center for the purpose of conserving, protecting, and enhancing a remnant coastal prairie parcel.

ent between the two treatments in the fall analysis. Some of the unmowed areas had been burned in the previous year. Using three unburned, unmowed transects as controls resulted in no significant improvement in diversity or prairie quality after mowing.

Managed disturbance affects plant species diversity and community composition. Long managed prairie sections were more likely to have grasses and perennial forbs as dominant

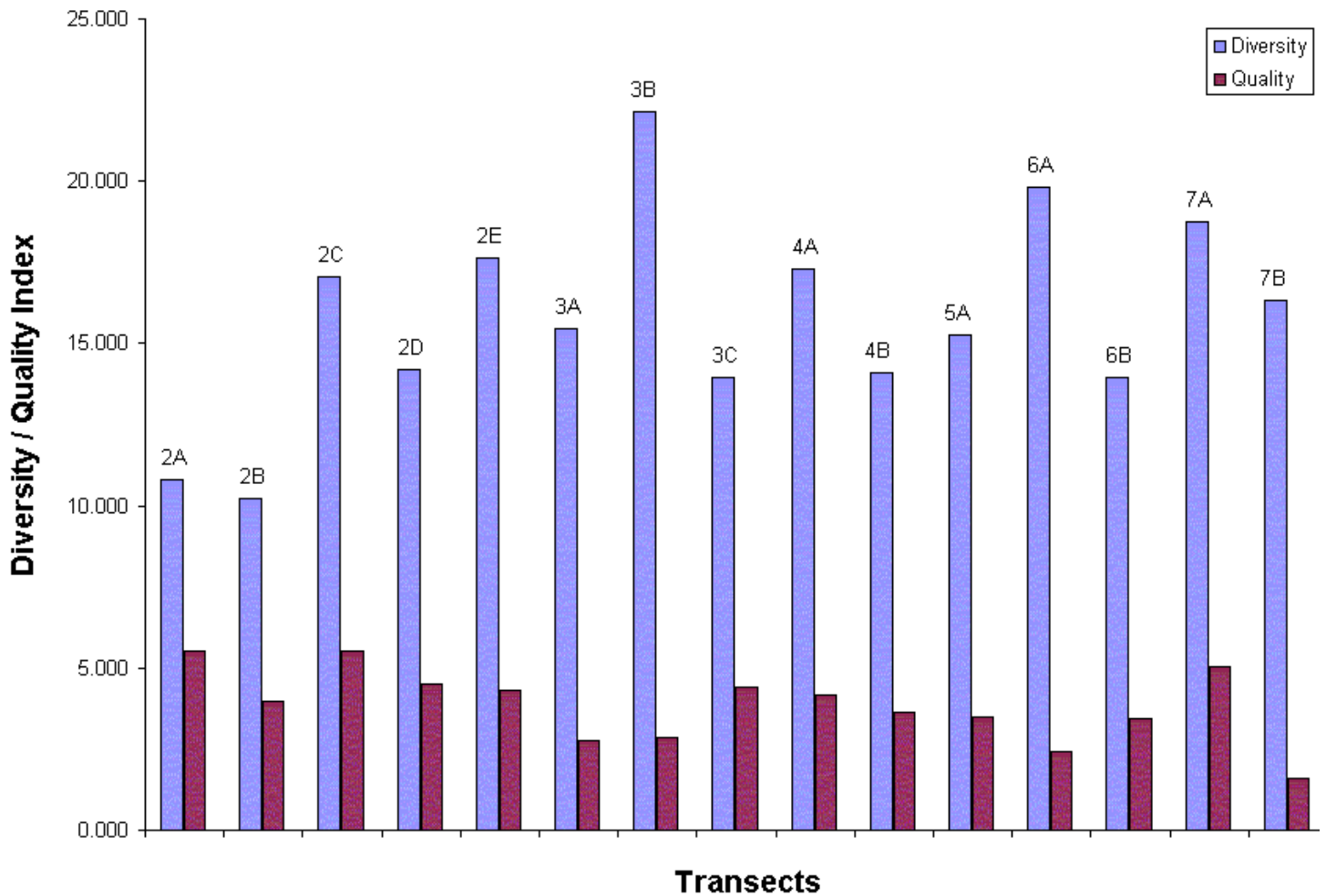


Figure 2. Species Diversity and Prairie Quality Index Values for Fall 2000

species. Prairies managed for less than 10 years were more likely to be dominated by annual forbs. Prairies that were burned were more likely to have dominant grasses than forbs.

Our findings are preliminary. They are based on observations over a limited time period. The comparisons lacked adequate controls for some treatments. Area 2 is the historical remnant of coastal prairie on the property. It has been mowed periodically to prevent succession by invasive woody species. It was noted for the quality of its prairie plant diversity prior to the prescribed burn. Therefore, the fact that the diversity of this area was higher than the unburned area was not surprising. Also, mowing was applied to areas that had been restored from woody dominance. These areas were not equal in prairie quality to Area 2 prior to their treatment.

These studies support some conclusions reached for other types of prairies. It takes time for plant diversity to return to a restored prairie. Disturbance is beneficial (or neutral) to prairie plant communities. But the answer of which management regime, burning or mowing, is best for this type of prairie will require more study.



Area 3C—Re-establishment of native prairie grasses and forbs

Characterization of Natural Colloidal and Organic Materials in Lake Houston

Shankar Chellam, Ph.D., Assistant Professor, Jiang Tao, research assistant, and Ramesh Sharma, research assistant, Department of Civil and Environmental Engineering, UH

LAKE HOUSTON IS A RELATIVELY SHALLOW ARTIFICIAL reservoir located in North Houston. High values of color, turbidity, and concentrations of suspended solids, and nutrients such as nitrogen and phosphorus have been measured in the lake.¹ However, measurements of size distributions and electrokinetic properties of suspended particles have not yet been undertaken. In spite of its relatively poor water quality, Lake Houston may be the designated source for a new water treatment plant.

Colloid transport in the water column is a strong function of their size, zeta potential, and ultimately their stability. A better understanding of these properties would enhance our ability to predict their contribution to sediments in Lake Houston as well as their effects on the Lake's water quality. Unstable colloids in Lake Houston can be expected to aggregate and eventually contribute to the sediment load. Further, the structure and morphology of these aggregates would ultimately determine the dewaterability and transport characteristics of the sediment itself. On the other hand, stable colloids would persist in the water column for longer durations and can contribute to increased solids loading and coagulant demand in the proposed water treatment plant.

The stability of colloidal matter was measured by conducting coagulation studies similar to jar tests except in some cases no coagulant was added. The stability or collision efficiency factor (\mathbf{a}) was calculated by employing a simple rectilinear coagulation model in laminar shear as given in Equation 1.²

$$\mathbf{a} = \frac{\mathbf{P}}{4fGt} \ln\left(\frac{n_o}{n_t}\right)$$

Where, \mathbf{a} is the stability factor or collision efficiency factor, f is the particle volume fraction (assumed to be constant), G is

the shear rate ($= 33 \text{ s}^{-1}$ in all experiments), n_o is the number of particles at the beginning of the experiment, n_t is the number of particles at time t . Samples from Lake Houston water were obtained at various dates representing different flow conditions for measurements of colloidal stability. Particle size distributions were measured using an electrical sensing zone device (Coulter MultiSizer III, Beckman Coulter, Miami, FL) using a 20 μm aperture. Using this aperture allowed the measurement of particles in the size range 0.4-12 μm .

Representative results from one experiment are depicted in Fig. 1 in terms of volume based size distributions. Little change in the size distributions were observed over a period of seven

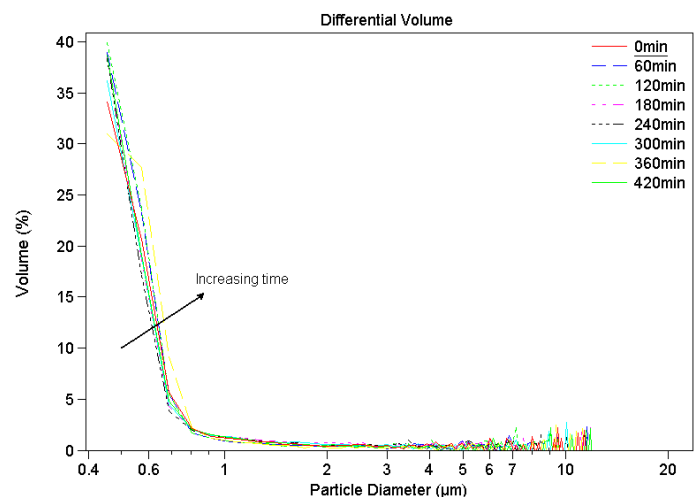


Figure 1. Volume based PSDs in Lake Houston Water at different times following stirring at a shear rate of 33 s^{-1} without the addition of any electrolyte.

hours suggesting that particles in Lake Houston water were highly stable. Additionally, the total number of particles increased as a function of time suggesting the formation of particles in the range 0.4-12 μm due to aggregation of particles smaller than the lower detection limit of 0.4 μm (data not shown). Similar results were obtained for samples collected on other dates and flow conditions suggesting that Equation 1 may not be a valid method of quantifying stability of natural colloidal matter that span a wide size distribution. To further test this hypothesis, experiments were also conducted by adding reagent grade NaCl to increase the background ionic strength of Lake Houston water to 0.68 M (four percent by weight NaCl). By increasing the background ionic strength to ~ 0.7 M, particles were destabilized as evidenced by the growth of large particles with time (Fig. 2). The initial peak in the volume distribution of colloids in Lake Houston water was 0.57 μm . Upon stirring at 33 s^{-1} for 30, 150, 270, and 390 minutes the peak volume based diameter of particles in ~ 0.7 M NaCl solution increased to 0.8, 0.92, 1, and 1.4 μm respectively.

Similar experiments were also conducted using relatively monodispersed silica particles rated at 0.45 μm (SnowTex, Nissan Chemicals, Houston, TX). As seen in Fig. 3, no change in particle size distributions were observed, again suggesting the high degree of stability of the colloids when suspended in low ionic strength waters. However, Eq. 1 was found to accurately describe the kinetics of coagulation of these initially monodispersed particles. As shown in Fig. 4, a plot of $\ln(N/N_0)$ measured experimentally is linear with time. Using the slope of this line, the collision efficiency factor (α) of the silica particles was calculated to be $\sim 5 \times 10^{-4}$ using Equation 1. Thus, the simple rectilinear model for orthokinetic flocculation (Eq. 1) may only be strictly valid for initially monodispersed suspensions.

Natural organic matter comprised of flexible anionic polyelectrolytes such as humic acids can adsorb on to particles and typically enhance their stability due to either electrostatic or steric interactions.³ For a fixed chemical composition, the extent of steric stabilization by organic materials can be expected to be a function of the molecular weight. Hence, molecular weight distributions of organics in Lake Houston water were measured using the technique of successive ultrafiltration. Under background flow conditions, the distribution is monomodal with a peak in the 5,000-1,000 Da range. However, following rainfall, the molecular weight distribution becomes bimodal with peaks in the 10,000-5,000 Da and 1,000-500 Da ranges. These data suggest that the nature of organic materials in Lake Houston is dependent on volumetric flow of water also. More research is necessary to better define changes in organic characteristics as well as their implications for municipal water treatment upon precipitation.

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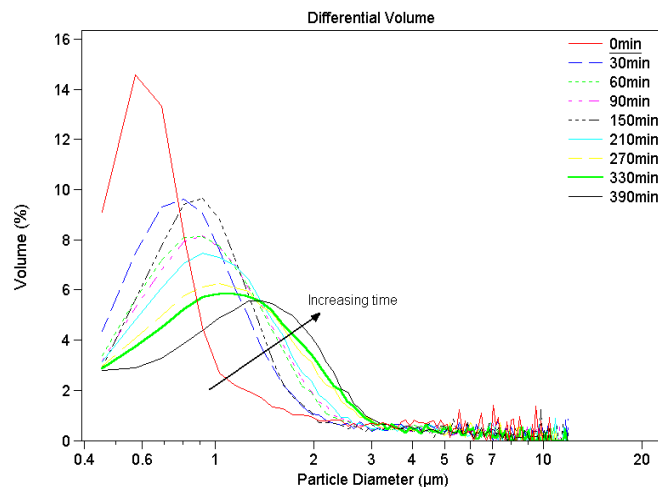


Figure 2. Volume based PSDs in Lake Houston Water at different times following stirring at a shear rate of 33 s^{-1} at an ionic strength of 0.68 M (4% NaCl).

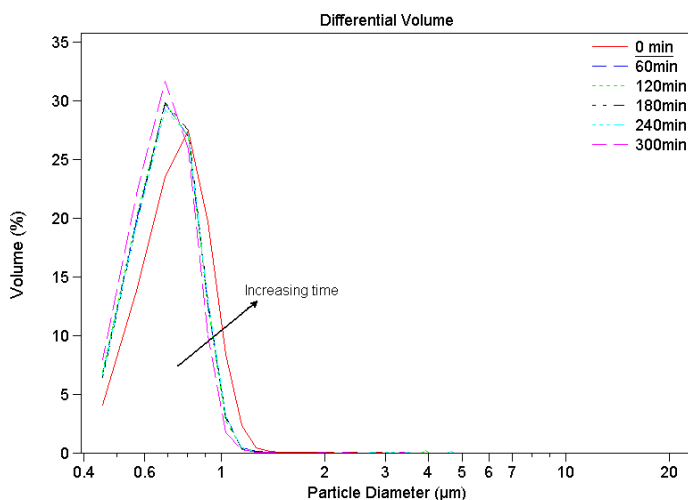


Figure 3. Volume based PSDs of inorganic silica colloids at different times following stirring at a shear rate of 33 s^{-1} without the addition of any electrolyte.

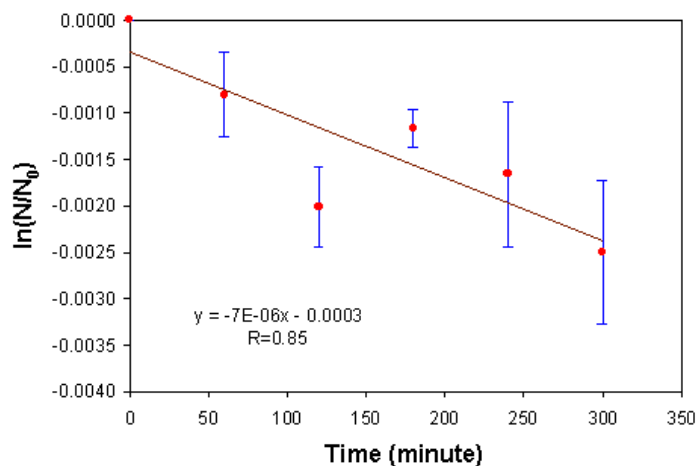


Figure 4. Fit of Eq. 1 using number concentrations of silica particles at different times following stirring at a shear rate of 33 s^{-1} without the addition of any electrolyte.

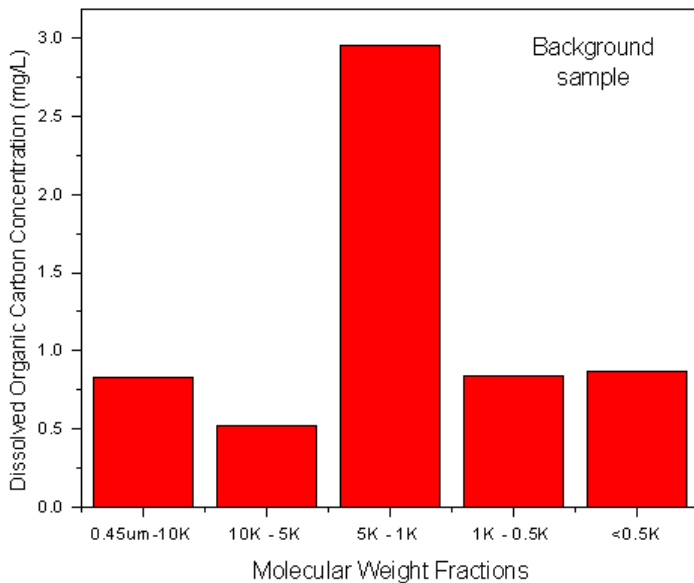


Figure 5. Molecular weight distribution of organics in Lake Houston water under background flow conditions.

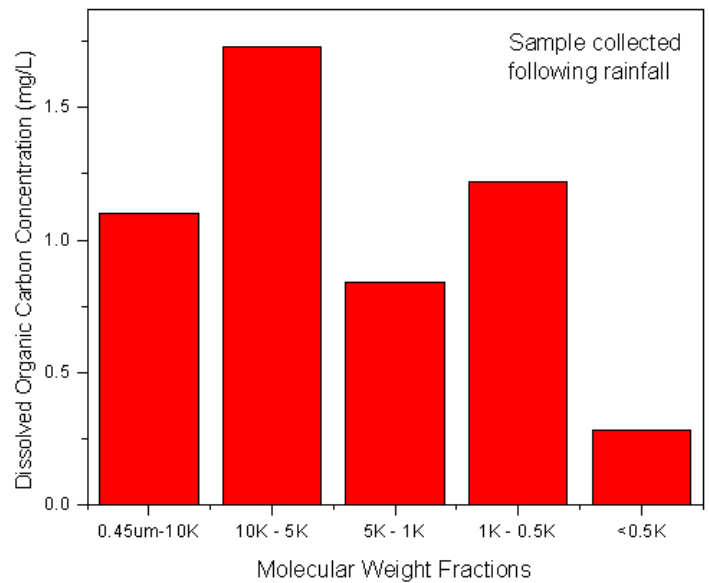


Figure 6. Molecular weight distribution of organics in Lake Houston water two days following a rainfall event.

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"Developing Portable Membrane Systems for Producing Drinking Water in Texas Border Areas." Co-Principal Investigator: D. Clifford; Texas Higher Education Coordinating Board–ATP; \$149,760.

"ICP-MS to Quantify Metals in Fine Particulate Matter in Houston." Co-Principal Investigator: Matthew Fraser, Rice University; Texas Air Research Center; \$108,000.

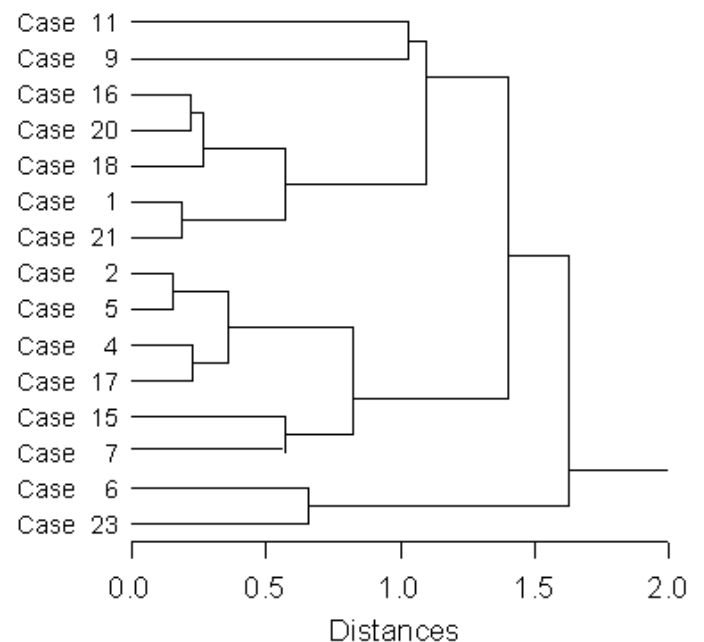
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Population Demography and Spatial Dynamics in Polygynous Population of the Imported Fire Ant *Solenopsis invicta*

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THE IMPORTED RED FIRE ANT, *SOLENOOPSIS INVICTA* IS A highly-visible, well-known, and unwelcome introduced species in much of the southeastern United States. This species has been enormously effective at invading, and the product of the invasion has been serious effects on native ecosystems. Fire ants influence populations of vertebrates and have had catastrophic effects on the invertebrate fauna of the areas that they invade. The fire ants themselves have undergone considerable change from their early introduction. Two forms of the fire ant occur in the United States: the monogyne form and the polygyne form. The monogyne form has a single queen, the colonies are very distinct from one another, population density reaches intermediate levels and these populations can spread very rapidly. The population spreads by dispersal of new queens. By contrast, the polygyne form, which is the numerically dominant form in parts of the U.S., but is almost absent from its native site of Brazil, has many queens per colony. Colonies are not formed when a new queen flies off, but when the colony splits into parts. While the fire ants in polygyne populations do not spread very rapidly, they can reach extraordinary densities. Polygyne populations can have almost 10 times as many colonies as monogyne populations. The ecological effect of polygyne fire ants is devastating.

Polygyne fire ants have been casually distinguished as being very non-aggressive to one another (although they are very aggressive to anything that is not a fire ant). The rationale given for this observation is that since all colonies have split off from one another, colonies gain very little in aggression to one another. This proposal was to study aggression between polygyne colonies and measures the effect of geographical and genetic distance between colonies. Research was carried out at the University of Houston Coastal Center. Researchers mapped colonies, collected samples for genetic analysis and conducted



Aggressive Behavior Among Red Fire Ant Colonies

aggression trials among all pairs of colonies. Aggression trials were carried out over a period of months with multiple samples to ensure that aggression did not result from a few aggressive individuals or a particular time of year. Aggression trials, in neutral arenas, were scored as either non-aggressive, slightly aggressive or highly aggressive.

Contrary to the common characterization that polygyne ants are non-aggressive to one another, the research team found consistent aggression occurred between particular pairs of

colonies. Aggression was still clearly lower than that expected in monogyne fire ants, where every colony is aggressive to every other colony. The pattern of aggression among colonies is represented in the dendrogram. Colonies (the case numbers) are closely joined together if they are not very aggressive to one another and are distantly joined together if they are more aggressive to one another. Although the overall level of aggression is moderate, some colonies (e.g. colonies 11 and 9) are aggressive to most other colonies.

Aggression level was unrelated to the distance between colonies. Researchers suspected that since polygyne colonies are formed when older colonies split into two, nearby colonies were more likely to be relatives and therefore less likely to be aggressive.

Colonies tend to become more aggressive to each other during the time of the experimental trials. The research team compared the aggression level between pairs during the first trial with that during the second. UH researchers found that, overall, colonies had a significantly higher level of aggression during the second trial than the first, but that this increase in aggression level was driven by the most aggressive colonies. Colonies which were more aggressive to start with became even more aggressive, while the least aggressive colonies showed little change. This time period between the first and second measure of aggression correlates with increased production of queens and males (although reproduction in fire ants is nearly aseasonal in the Houston area, the greatest reproduction occurs in late spring). Although polygyne colonies are related to each other, they will not be genetically identical because of the unequal contribution of the multiple queens. This may favor competition over cooperation during the period most favorable for reproduction. Overall aggression levels remained high during the third trial (late June).

UH researchers genotyped 10-20 workers per colony for five polymorphic allozyme loci (phosphoglucosmutase, esterase, amylase, aconitase, and glyceraldehyde 3-phosphate dehydrogenase). Most colonies displayed genetic variation consistent with multiple queens, and there were no significant differences in the pattern of allele frequency distributions among colonies. Colonies with high levels of aggression to each other were not more different in genotype than colonies which never displayed aggression to each other.

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Sediment Quality Triad Comparison of Armand Bayou, Horsepen Bayou, and Mud Lake, Harris County, Texas

Cynthia L. Howard, Ph.D., Associate Professor of Biology and Environmental Science, and Charles F. Dingman, graduate student, School of Natural and Applied Science, UHCL

MANY CONTAMINANTS ENTERING ESTUARINE WATERS bind with salts or organic matter in the water column and are eventually deposited in the sediments. The Sediment Quality Triad (SQT) approach was developed by Chapman¹ to evaluate the degree to which contaminants are responsible for the degradation of sediment health. The SQT approach is an effects-based technique that involves three components: sediment chemistry (a measure of contamination), sediment toxicity testing (a measure of biological effects and bioavailability) and *in situ* community parameters (benthic macroinvertebrate community structure).² The purpose of this project is to evaluate and compare the ecosystem health of Armand Bayou (a designated Coastal Preserve), Horsepen Bayou and Mud Lake, using a modified SQT approach, and link these results to the current TMDLs (Total Maximum Daily Load criteria) and sediment quality guidelines for this area.

This study is being conducted by Charles Dingman, a UHCL graduate student in the Environmental Science program, as his Master's thesis research. Twelve stations, four each along the reaches of Armand Bayou, Horsepen Bayou and Mud Lake, were established and have been sampled twice. Samples were collected for the sediment chemistry component of the SQT using EPA standard protocols for heavy metals, total organic carbon, total PAHs, organochlorine pesticides and PCBs. Additional sediment samples were collected for 10-day *Hyalalela azteca* amphipod toxicity tests and for benthic macroinvertebrate community analysis.

Tests completed to date include heavy metals analyses by inductively coupled plasma spectroscopy, total and volatile solids and particle size distribution analyses, two separate *Hyalalela azteca* tests, and the benthic macroinvertebrate community analysis. Preliminary results indicate that the three water bodies are in relatively good ecological health, but are influenced by

anthropogenic contaminants. A third set of samples was collected in September 2000 for pesticides, PCBs, acid volatile sulfides, and an additional toxicity test.

The results of the complete SQT sediment chemistry, toxicity and biological community data was analyzed during October 2000 and presented at the annual national meeting of the Society of Environmental Toxicology and Chemistry in November 2000.

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Enhanced Wetlands Habitat Restoration through use of a Flexible Porous Wave Barrier

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THE TEXAS COASTAL WETLAND HABITATS ARE important living marine resources that contribute to the food supply, economy, welfare, health, and recreational opportunities of the state. However, these habitats are under constant threat of marsh loss as the results of erosion by significant wave and tidal actions. A primary method of habitat restoration for salt and brackish marshes involves replenishing the area with dredged sand followed by the introduction of cordgrass seedlings. Improved efficiency can be achieved in the wetland restoration process by protecting the cordgrass seedlings from wave action by using a floating type wave barrier during the initial months after planting.

In this experimental study, a flexible porous membrane structure anchored to the sea-bed and kept under tension by a buoyant cylindrical float (shown in Fig. 1) was tested to examine the behavior of the wave barrier under wave action and to analyze the effectiveness in reducing transmitted wave height. The experiments were conducted in Civil and Environmental Engineering Wavetank Laboratory at UH. The wavetank is approximately 120-ft long, 4-ft deep, and 4-ft wide, with steel bottom and glass sidewalls. Waves were generated by a piston-type wavemaker. The wave profiles in front of and behind the barrier were measured by means of an array of resistance-type wave gauges. Measured data were recorded by a PC-driven 8-channel data acquisition system. The complete experimental setup is shown in Fig. 2.

The porous membrane used for the construction of the wave barrier is a type of window screen. After a sequence of preliminary tests, we selected three types of plastic screen (defined as Net1, Net2, and Net3) having porosity of 0.7, 0.4, and 0.1 respectively. The net with 0.1 porosity has the smallest opening. Waves with five different periods ranging from 1.1 sec. to 2.2 sec. were generated for model tests. The undisturbed water

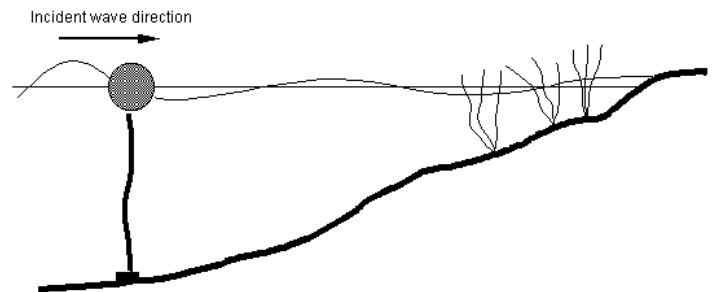


Figure 1. Flexible Porous Wave Barrier Shown Protecting Cordgrass Seedlings from Wave Action

depth used for the tests is 0.67 meter. Under each test, the wave barrier was setup with a porous screen anchored to the tank bottom and tied to a surface-buoyant cylindrical float. A photo showing the test of a flexible porous wave barrier in the wavetank is presented in Fig. 3.

The transmission coefficients were calculated to determine the performance of test barriers. The transmission coefficient is defined as the ratio of transmitted wave height to incident wave height. Smaller transmission coefficient indicates better performance in reducing wave height of transmitted waves. Figure 4 shows the variation of transmission coefficient versus wave period for various wave barriers. The coefficients, in general, vary from 0.8 to 0.9. In practical application, the coefficients should be reduced to be less than 0.5. From Fig. 4 we notice that the effectiveness of wave barrier with the finest mesh (or barrier Single-Net 3: single layer of screen with the lowest porosity) is better than that with a greater porosity. The transmission coefficients for barrier Single-Net1 are less than those of Single-Net2 because of the effect of the rigidity of the test screens. To improve the performance of the proposed wave

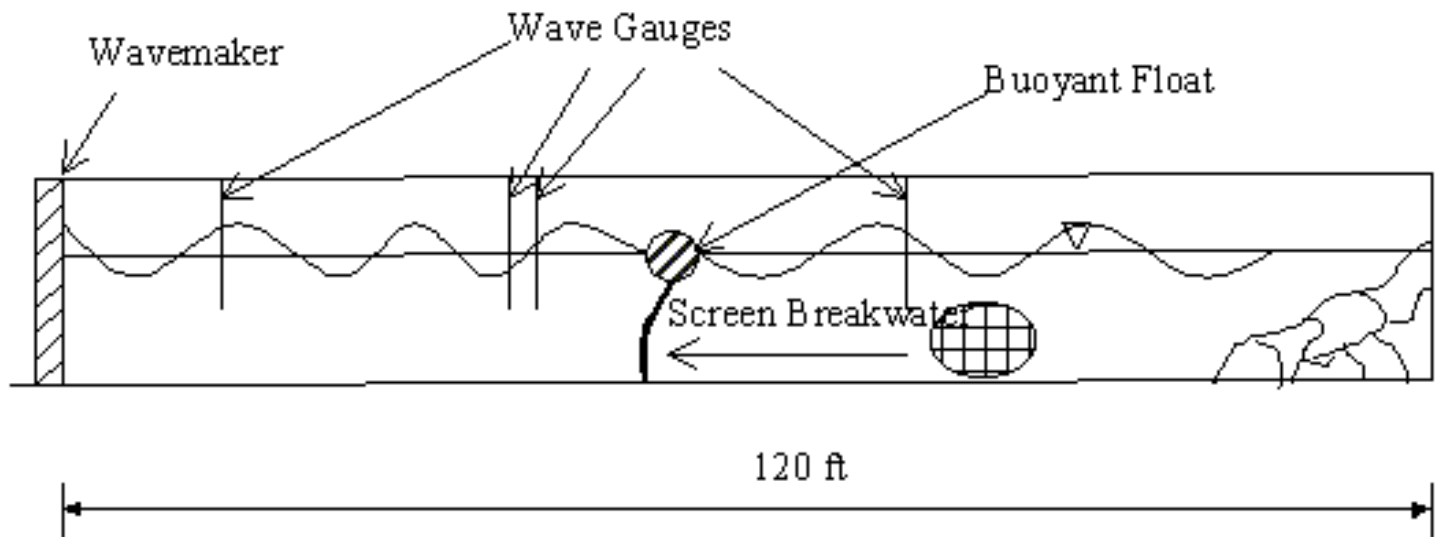


Figure 2. Experimental Setup and Testing of A Flexible Porous Breakwater in a Wavetank



Figure 3. A photo showing the test of a flexible porous wave barrier in the wavetank.

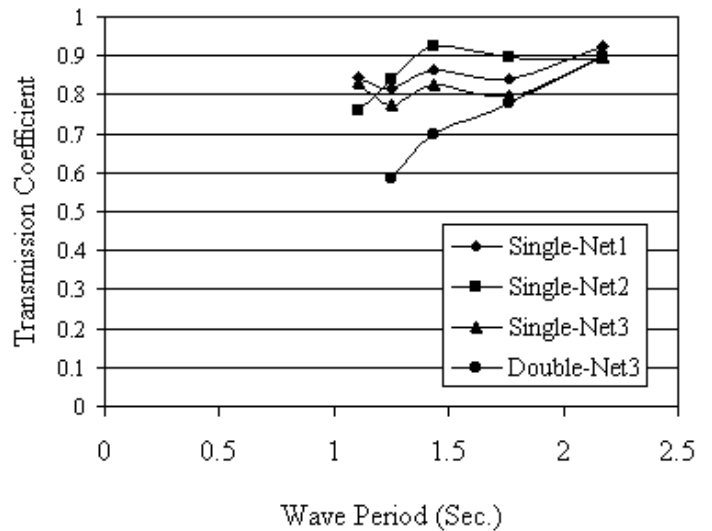


Figure 4. The Variation of Transmission Coefficient versus Wave Period for Various Breakwaters.

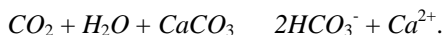
barrier, investigators modified the barrier with the addition of one layer of screen (decreasing the porosity) and increased rigidity with limited supporting frame. The results are also shown in Fig. 4 under a legend of Double-Net3. It is clearly demonstrated that the newly modified wave barrier has shown the improvement in reducing transmitted wave height. Further tests to explore the best design of a floating flexible porous

wave barrier in reducing transmitted wave height are necessary before a field study can be conducted. The continuing tests will be exercised to determine a consistent set of design guidelines in terms of membrane porosity, membrane stiffness, and float size for the use of porous, flexible wave barriers to enhance wetlands habitat restoration projects.

Changes in Coral Growth Rates Associated with Rising Ocean-Atmosphere Carbon Dioxide Levels

Gerard M. Wellington, Ph.D., Professor and Kevin P. Helmle, research assistant, Department of Biology, UH

CORAL REEFS DEVELOP AND GROW VIA THEIR NET accretion of calcium carbonate ($CaCO_3$), termed calcification. The intent of this study was to quantify the historical change in calcification rates to assess the impact of rising carbon dioxide (CO_2) levels. Calcification rates are subject to variations in the aragonite saturation state (Ω -arag) of the surrounding waters.^{1,2} Increases in ocean-atmosphere carbon dioxide (CO_2) lower the aragonite saturation state leading to the dissolution of $CaCO_3$ as illustrated by the following equation:



The entire ocean acts as a buffer over a long time period, but rapid increases in atmospheric CO_2 levels can strongly affect pH levels in surface waters and biologically-mediated calcification. Estimated effects from recent changes in CO_2 indicate a 30 percent decrease in Ω -arag with a resultant 14-30 percent decrease in coral calcification.² Other estimates reflect a 10 percent decrease in calcification rates over the past 100 years with a potential 20 percent decrease over the next 100 years.¹ Recent research has shown that calculation of change in Ω -arag is relatively straightforward and reliable.² The relationship between changes in Ω -arag and coral growth rates, however, has yet to be confirmed experimentally, and is the basis of this study.

The research focused on calcification rates, with a total of seventeen parameters of coral growth measured. Measurements were based on annual skeletal density bands. Each consecutive year is recorded in the skeleton as a high- and low-density band. From these annual bands, measurements of linear extension and density were used to calculate calcification rates. Coral cores from several collections representing the Florida

Keys and Flower Gardens in the Atlantic, as well as the eastern and western Pacific were used in this analysis.

The Florida Keys collections were the most extensive and served as the focal point for initial measurements. Five cores of *Montastraea faveolata* representing a range of 67 to 87 years of growth were used to construct a master chronology. The data from the cores showed a significant decrease of approximately eight percent in the calcification rates over the length of the chronology (Fig. 1). This decline in calcification rate is consistent with the estimated decrease in calcification associated with increase in global CO_2 levels and potentially represents the first

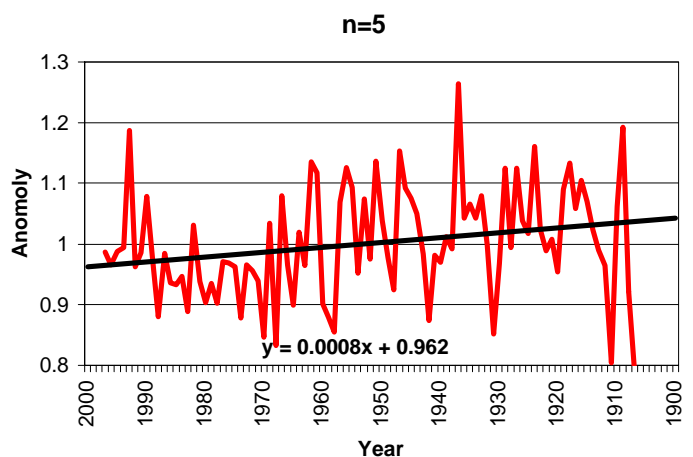


Figure 1. Annual calcification anomaly data for the Florida Keys. The slope of the line is significantly different than zero ($p < 0.028$) and illustrates a clear decline over the past 87 years. The shortest record represents only 67 years and the average is 77 years.

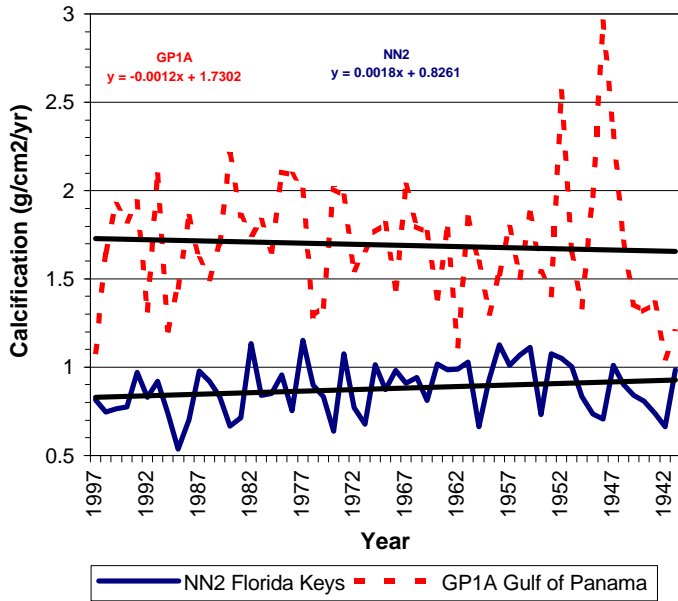


Figure 2. Comparison of calcification rates between Florida Keys and the Gulf of Panamá. Both lines are significantly different than zero ($p < 0.05$).

evidence that coral growth rates may be in a state of decline in the Florida Keys.

Research is in progress to develop master chronologies for Biscayne National Park and the Flower Garden Banks. Analysis of calcification rates in an eastern Pacific core from the Gulf of Panamá was compared to a core from Biscayne National Park, results indicated a disparity between these two environments with the calcification of the eastern Pacific coral increasing and the Atlantic corals decreasing (Fig. 2). The disparity may indicate that factors such as upwelling, latitudinal position, temperature and taxa may affect the susceptibility of corals to changes in global CO_2 levels. Further research will assess these factors by developing long-term growth averages from several sites and taxa.

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¹J. P. Gattuso *et al.* "Effect of Calcium Carbonate Saturation of Seawater on Coral Calcification," *Global and Planetary Change* 18 (1998): 37-46.

²J. A. Kleypas *et al.* "Geochemical Consequences of Increased Atmospheric Carbon Dioxide on Coral Calcification," *Science* 284 (1999): 118-20.

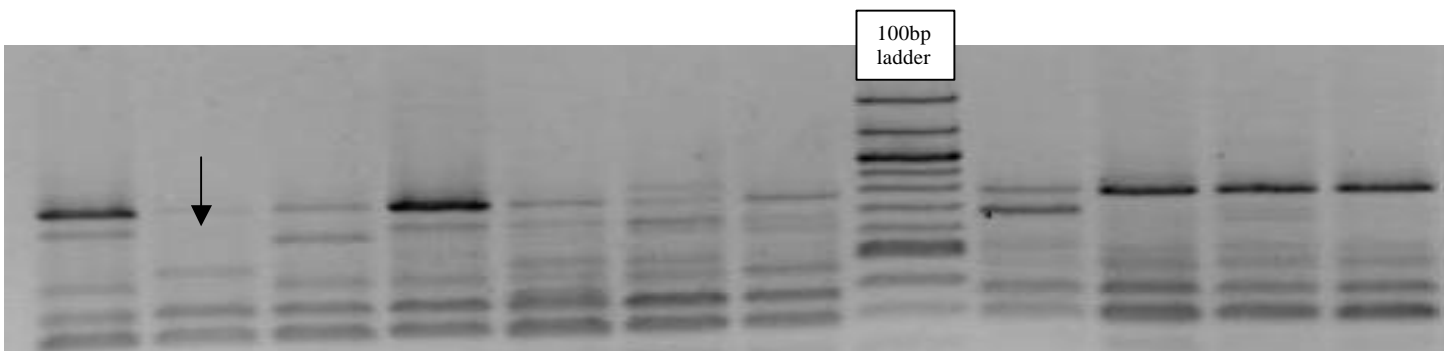
Determining Genetic Diversity of the Seagrass *Halodule wrightii* Using Random Amplified Polymorphic DNA

Gerard M. Wellington, Ph.D., Professor and Rachel Angel, graduate student, Biology and Biochemistry Department, UH

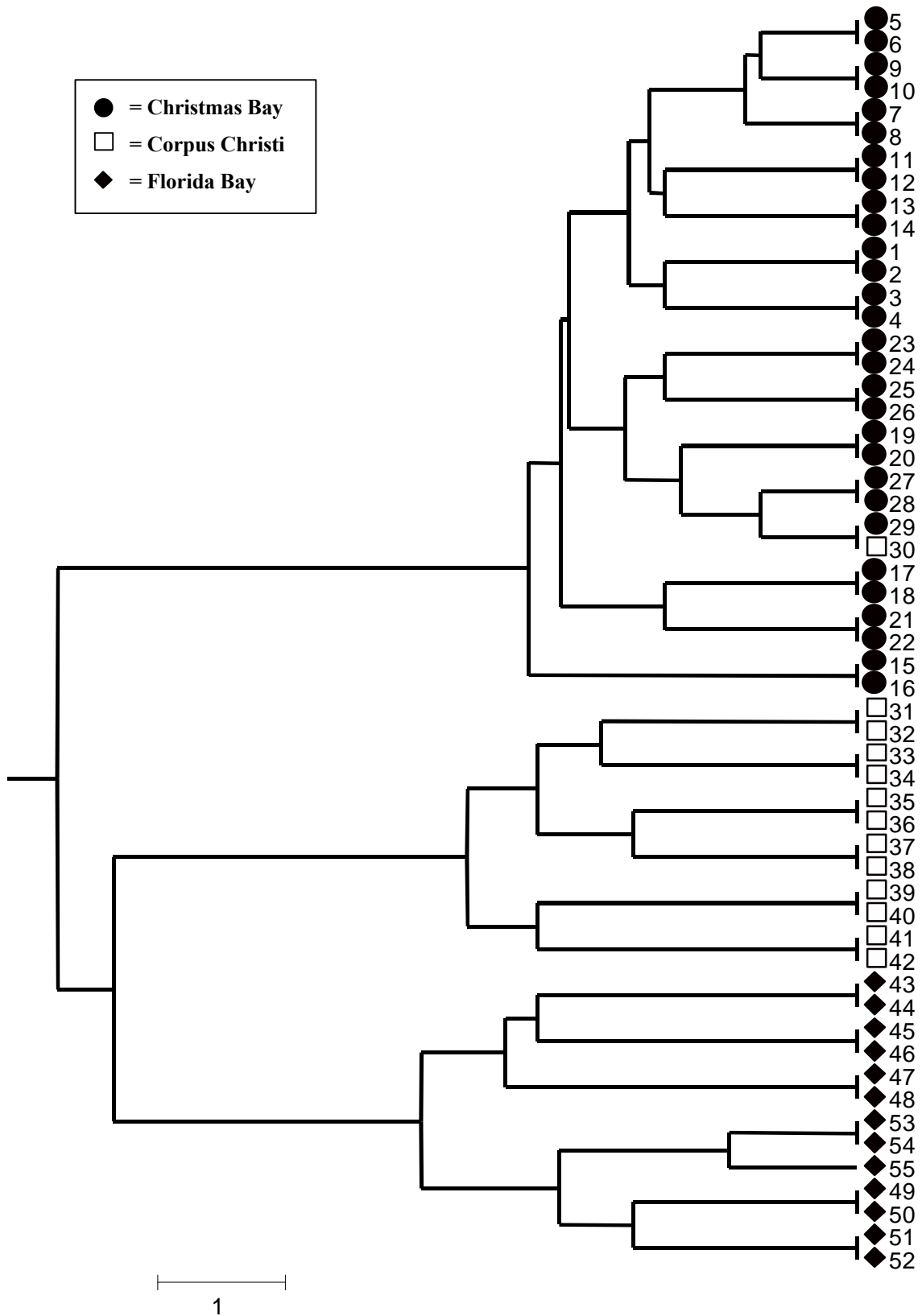
THE GENETIC DIVERSITY OF TWO POPULATIONS OF THE seagrass *Halodule wrightii* from Christmas Bay and a Flour Bluff cooling pond in Corpus Christi was determined using Random Amplified Polymorphic DNA (RAPD). *H. wrightii* from Florida Bay was used for comparison. *H. wrightii* with a high level of genetic diversity has the best chance of adapting to a recipient site after being transplanted to Galveston Bay, Texas, which has lost over 90 percent of its seagrass since 1956. Seagrass beds are economically important because they provide a nursery habitat for 28 percent of commercial fish species and 30 percent of blue crab and shrimp populations in Galveston Bay. Isozyme analysis had shown that *H. wrightii* populations in Texas had low genetic diversity. RAPD is more sensitive to detecting genetic diversity than isozymes because it samples coding and noncoding sections of the genome. Genetic diversity is determined by the presence or absence of a band at a particular locus. RAPD revealed a high level of genetic diversity. An Analysis of MOlecular VAriance (AMOVA) showed that approximately 60 percent of genetic

variation was found among populations indicating a heterogeneous species. UPGMA cluster analysis showed every individual except one clustered within its population. All individuals appeared to have unique genotypes. Corpus Christi clustered more closely to Florida Bay than to Christmas Bay. These results were not expected since Corpus Christi and Florida Bay are separated by 1600 km whereas Corpus Christi is only 400 km from Christmas Bay. The similar habitats of Corpus Christi and Florida Bay may be acting as a selection agent or mating time may differ between Christmas Bay and Corpus Christi thus preventing gene flow.

Christmas Bay was chosen as a potential donor site for transplanting *H. wrightii* because of its close proximity to Galveston Bay and similar habitat. This may make *H. wrightii* from Christmas Bay genetically representative of the *H. wrightii* that lived in Galveston Bay. However, transplanting seagrass from Christmas Bay would be labor intensive because it is only accessible by boat. If *H. wrightii* populations were genetically similar, then the Flour Bluff cooling pond in Corpus Christi



RAPD-PCR profile of *Halodule wrightii* individuals from Corpus Christi. Arrow points to an example of a polymorphism.



would be an ideal donor site because it would share the same genotypes as Christmas Bay and have easy access. Even though Corpus Christi has a high degree of genetic diversity, it may not be the optimal population to use as a donor site. Gene flow from transplanted Corpus Christi plants could destroy adaptive gene complexes in nearby Christmas Bay.

UPGMA cluster analysis of *H. wrightii* populations. All individuals appear to have unique genotypes.

Ozone Nonattainment: Policy Challenges

Lisa B. Gossett, J.D., Associate Professor of Environmental Management, and Terri Porter, research assistant, School of Business and Public Administration, UHCL

IN 1999, HOUSTON SURPASSED LOS ANGELES AS THE CITY with the greatest number of ozone non-attainment days for the year. Houston had 52 non-attainment days, compared to 40 for Los Angeles. Surpassing Los Angeles as the nation's smog capital was hardly a victory for the Houston area. The subsequent publicity has served as a wake-up call that air quality issues need to be addressed seriously.

Ground level ozone, a primary constituent of smog, has presented considerable air quality challenges nationally. Few sources directly emit ozone into the air. Rather, ozone is formed in the atmosphere from volatile organic compounds (VOCs) and nitrogen oxides (NO_x). This complex reaction is influenced by many factors, including weather and geography. Ozone formation tends to increase in the presence of sunlight and decrease in windy conditions.

In response to the federal Clean Air Act (CAA), many cities have greatly improved their air quality since the early 1970s. The CAA established national ambient air quality standards (NAAQS) for ozone and other designated criteria pollutants. Cities with air that exceed these concentration-based standards for specific pollutants are classified as non-attainment.

Houston and Los Angeles still have a long way to go before they are in attainment. The initial research on ozone policy concentrated on these two cities. Professor Gossett and Terri Porter, research assistant, gathered information on the sources of ozone precursors in both areas, as well as historical, current, and planned approaches for reducing high ozone levels.

The Los Angeles area addressed air pollution issues long before the CAA was enacted in 1970. The South Coast Air Quality Management District (SCAQMD) was created in 1947, and has broad authority. Houston does not have a local agency with comparable powers. The Los Angeles area has been simultaneously and aggressively addressing non-attainment concerns for

three or four criteria pollutants, while ozone is the only non-attainment pollutant in the Houston area. The SCAQMD's recent Regional Clean Air Incentives Market (RECLAIM) program is a market driven approach that has been successful in reducing emissions from sources as small as four tons per year. On the other hand, Texas continues to allow some "grandfathered" facilities to emit air pollutants without requiring installation of pollution control equipment.

In Houston, industrial sources emit half the precursors of ozone, while mobile sources are the greatest contributors in the Los Angeles area. In both cities, the types of sources are very diverse, and meeting attainment deadlines (2010 for Los Angeles and 2007 for Houston) will require stringent regulation of many activities.

Continued improvements will require both better scientific information on how ozone is formed and transported, and alternative regulatory or market approaches to minimize emissions. One issue to examine is possibly regulating the more reactive VOCs more aggressively. Educating the public also will be an important component of any successful plan to minimize emissions. No single, simple approach can solve the ozone problem.

Publications

Gossett, L. B. and T. P. Gross. "Competing Smog Capitals: Houston v. Los Angeles," *Proceedings* of the 25th Annual Conference of the National Association of Environmental Professionals, June 2000.

Funding and proposals

"Competing Smog Capitals: Houston v. Los Angeles." School of Business and Public Administration, UHCL (funding for paper presentation).

Fresh Water for Galveston, the Development of a Supply System from the Texas Mainland

Martin V. Melosi, Ph.D., Distinguished UH Professor, and J. Rane Clark, graduate student, Department of History, UH

BUILDING TOWARD A COMPREHENSIVE DATA BASE OF environmental history on Galveston Bay, in 1998 graduate history student Charles Closmann developed a bibliography and source guide including 81 pages of archival listings for a variety of depositories holding collections relevant to Galveston Bay. In 1999, public history graduate student Vicki Garcia prepared a 25 page paper that focused on flood control along Galveston Bay. Ms. Garcia reported on the relationship among different structures of government and how their relationship affected flooding issues, and concluded with a discussion of the Galveston Bay Plan. During the 2000 grant period, public history graduate student J. Rane Clark completed a master's thesis on the development of a fresh water supply for Galveston Island.

The development of a fresh water supply helped to define the role of government as a provider of public services in Galveston. However, Ms. Clark claims that for Galveston officials, improvement of the city's infrastructure was secondary to the commercial development of the port between 1870 and 1895. Only when Galveston secured a position as a nationally recognized port did city officials actively seek a fresh water supply. Financial obligations and limitations of the city as granted by legislative charter and the state of engineering knowledge dictated the choices. To frame her argument, Ms. Clark begins with an assessment of the financial and political struggles of the municipal officials and details the failed attempts to provide the city's residents with fresh water from sources on the island. Between 1860 and 1885, citizens and local engineers put several plans for providing fresh water before the city council, and all were rejected as too costly or were delayed in the political process. In 1885, Galveston developed a system of artesian wells on the island; however, fresh water was not obtained; only salt water used for fire fighting purposes.

Toward the end of the nineteenth century, the state government played an increasing role in the sanitation issues and utility infrastructures of the growing municipalities. In the second chapter, she discusses the sanitary condition of Galveston during the nineteenth century with respect to the issues of water supply and public health. Ms. Clark then turns to the development of a fresh water supply on the Texas mainland. By 1890, Galveston had secured a position as a nationally recognized port and officials made a concerted effort to obtain fresh water by hiring prominent engineer Wynkoop Kiersted to design the system. A site was selected on the mainland approximately 18 miles from Galveston, and a supply line was constructed under Galveston Bay to the pumping station located on the island. The system was completed in 1895 and continued in use for more than a century.

The thesis concludes with a discussion of changes made to the 1895 system during the twentieth century. Although most historians consider the 1900 hurricane the turning point for Galveston's development, Ms. Clark claims this may be true in the case of the seawall, grade raising, and causeway that were built during the reconstruction process. However, the theory is false in relation to public utilities. Little attention has been paid to the fact that the water system predated, and in fact survived, the great storm.

Presentations

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Melosi, M. V. "Creating the Sanitary City: Service Delivery

and Urban Growth in America,” Swedish Environmental Institute, Stockholm, 1999.

Melosi, M. V. “Economic Globalization and Social Welfare,” Commentator, GADE Conference, Houston, TX, 1999.

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Funding and proposals

Federal Dam Development in the United States, funded by the National Parks Service, Corps of Engineers, and Bureau of Reclamation; \$221,000 (*on-going*).

Simulating Air Quality Using a Gaussian Dispersion Model

Hanadi S. Rifai, Ph.D., Assistant Professor, Fariba Mehdizadeh, graduate student, and Paul LaWare, graduate student, Department of Civil and Environmental Engineering, UH

AIR POLLUTION IS CAUSED BY EMISSIONS FROM POINT sources, area sources, mobile sources, and biogenics. About 60 percent of the emissions in the U.S. are from point sources. Monitors are used to measure the air quality in the vicinity of industrial facilities. However, operating monitoring stations is not always technically and economically feasible. Therefore, models have been used as alternative tools for demonstrating the impact of emissions from different sources on air quality. UH researchers are evaluating the applicability of gaussian dispersion models for simulating air quality data resulting from stack emissions. A gaussian dispersion spreadsheet model is being developed and calibrated to data collected in 1997 at the Sandow Steam Station near Waco, Texas. Air quality data had been collected by Baylor University under a separate contract with the Texas Natural Resource Conservation Commission (TNRCC). The Baylor data collection efforts are conducted using a specialized aircraft.

The meteorological conditions and the stack parameters from Sandow Steam Station were obtained for the date when the air quality data were conducted (August 25, 1997). An Excel Spreadsheet model was developed that incorporated all the required conditions for evaluating the transport of pollutants from Sandow. The model was calibrated to the site data and the prevailing atmospheric conditions. Model simulations were undertaken to predict the centerline maximum concentrations as well as crosswind concentrations (see Figs. 1 and 2). Results from the model development and application indicate that the gaussian dispersion models provide useful tools for predicting air pollution resulting from stack emissions. These models, however, are very sensitive to wind speed, wind direction, and the stability of the prevailing meteorological conditions. The models tend to underestimate observed pollution by as much as 100 percent for days where meteorological conditions are variable.

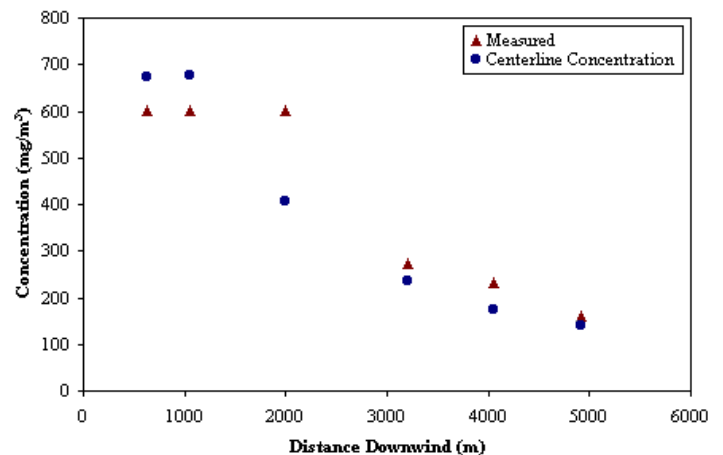


Figure 1. Centerline Concentration Compared with the Baylor Aircraft Measurements

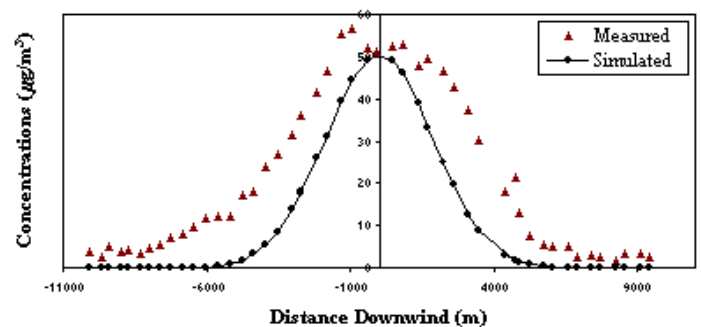


Figure 2. Crosswind Concentration at a Distance of 6,000 m Downwind from the Source

Figure 3 demonstrates the impact of wind speed on the dispersion of pollutants. The developed model was calibrated by variations in wind speed. The simulated center-line concentrations, assuming wind speed of about 2 m/s, is very comparable to the measured aircraft data.

Figure 4 shows the Sandow Steam Station simulated plume and Fig. 5 shows the measured plume from the Baylor aircraft. Comparing the two graphs, it is observed that the developed model can predict the transport of the emissions.

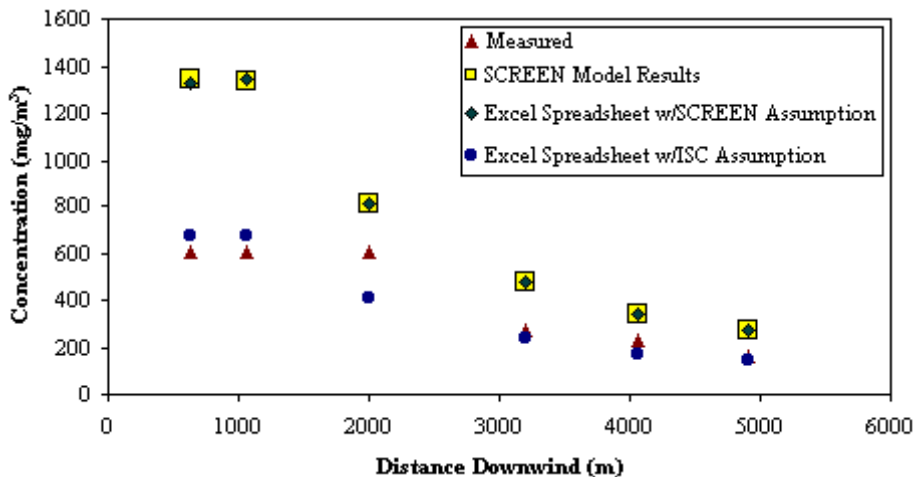


Figure 3. Centerline Concentrations Varying Wind Speed A - Measured B - SCREEN Model Results C - Excel Spreadsheet w/SCREEN Assumption D - Excel Spreadsheet w/ISC Assumption

Publications

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Rifai, H. S., P. B. Bedient, and G. L. Shorr. "Monitoring Hazardous Waste Sites: Characterization and Remediation Considerations," *J. Environ. Monit.* 2.3 (2000): 199-212.

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Rifai, H. S., S. M. Brock, K. B. Ensor, and P. B. Bedient. "Determination of Low-Flow Characteristics for Texas Streams," *J. Water Resources Planning and Management* 126.5 (2000): 310-319.

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Suarez, M. P. and H. S. Rifai. "Evaluation of BTEX Remediation by Natural Attenuation at a Coastal Facility," *Ground Water Monitoring and Remediation* (2000) (submitted for publication).

Presentations

Rifai, H. S. "Natural Attenuation of Fuels and Chlorinated Solvents," Rice University, Department of Environmental Science and Engineering, Houston, TX, March 28, 2000; University of Houston, Department of Geosciences, Houston, TX, March 31, 2000.

Rifai, H. S. and M. P. Suarez. "Estimating Biodegradation Rates for Fuel Hydrocarbons and Chlorinated Solvents," NGWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection and Restoration, Houston, TX, Nov. 17-19, 1999.

Rifai, H. S. and M. P. Suarez. "Natural Attenuation of Fuels at a Coastal Facility," 1999 Thesis Conference, "Remediation of Subsurface Contaminants: The Meaning and Measures of Success," Amelia Island Plantation, FL, Nov. 12-15, 1999.

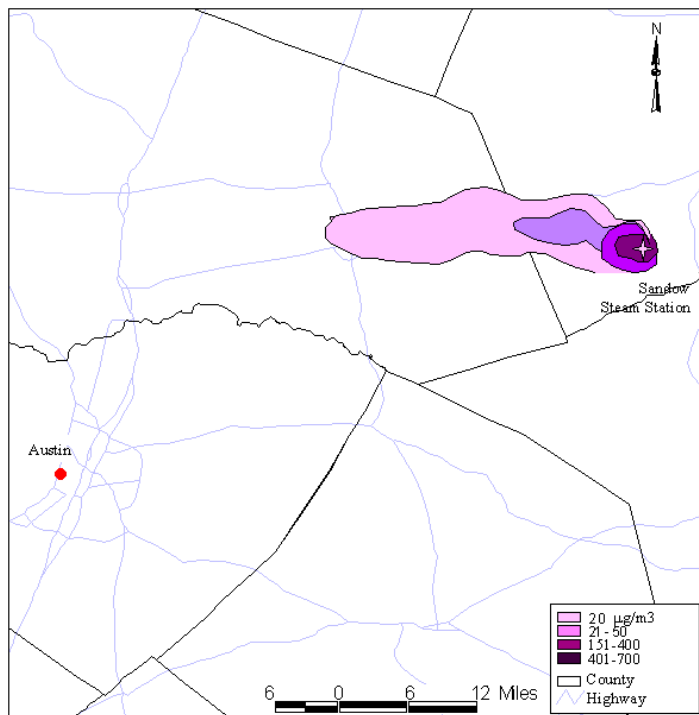


Figure 4. Simulated Sandow Steam Station Plume

Rifai, H. S., M. Ling, C. J. Newell, S. L. Lita, and M. Faille. "Development of Decision Support Tools for Designing Long Term Monitoring Plans (LTMPs)," International Conference on Groundwater Research, Copenhagen, Denmark, June 6-8, 2000.

Suarez, M. P. and H. S. Rifai. "Assessing Natural Attenuation of Petroleum Hydrocarbons at a Coastal Facility," 6th Annual International Petroleum Environmental Conference, Houston, TX, Nov. 16-18, 1999; *Integrated Petroleum Environmental Consortium* (1999): 55.

Funding and proposals

"Characterizing the Intrinsic Remediation of MTBE at Field Sites." Co-Principal Investigator: B. Rixey; Gulf Coast Haz-

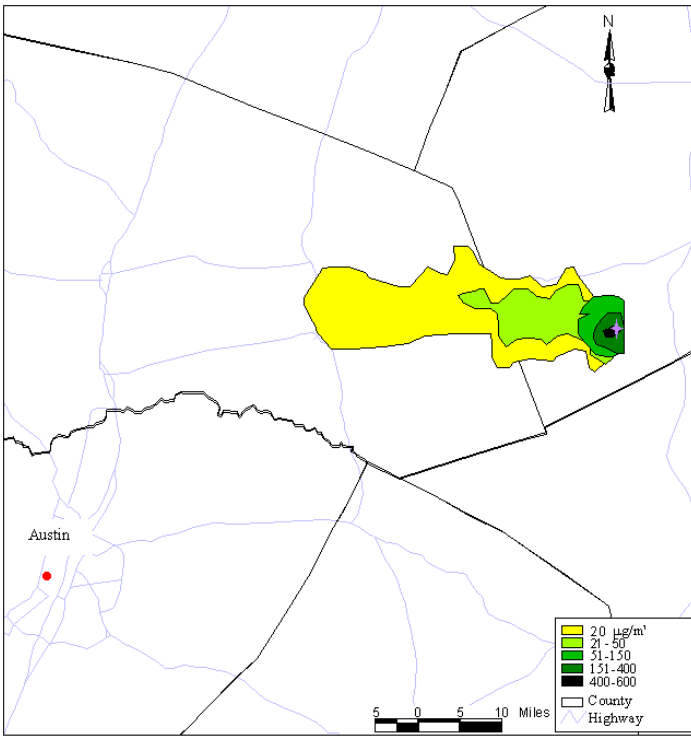


Figure 5. Measured Sandow Steam Station Plume

ardous Substance Research Center, 2000-2003; \$199,830.
 “Continuous On-Line Non-Point Source Monitoring Network.”
 Galveston Bay Estuary Program, 1999-2000; \$126,783 (*not funded*).

- “Developing A Guidance Manual for Modeling Natural Attenuation at Field Sites.” Air Force Center for Environmental Excellence, 1999-2000; \$62,420.
- “Evaluating Source Grouting and ORC for Remediating MTBE Sites.” Co-Principal Investigators: B. Rixey and D. Roberts; Gulf Coast Hazardous Substance Research Center, 2000-2002; \$250,000.
- “A Galveston Bay Barometer for Communicating the State of the Bay.” Galveston Bay Estuary Program, 1990-2000; \$70,614 (*not funded*).
- “Integration of Artificial Neural Networks and GIS for Environmental Forecasting.” Texas Higher Education Coordinating Board, 2000-2001; \$130,000 (*not funded*).
- “Integration of Artificial Neural Networks and GIS for Spatial and Temporal Forecasting of Natural Hazards.” National Science Foundation, 2000-2004; \$200,000 (*not funded*).
- “Internet Tool for Conceptual Optimization of Groundwater Pump-and-Treat Systems.” Air Force Center for Environmental Excellence, 1999-2000; \$78,639 (*not funded*).
- “Models, Stakeholder Values, and Education: Integrated TMDL Development for Armand Bayou.” Environmental Protection Agency, 1999-2002; \$899,976 (*not funded*).
- “Multi-Purpose Water Management Technology for the Texas-Mexico Border.” Texas Higher Education Coordinating Board, 2000-2001; \$600,000.
- “Total Maximum Daily Loads for Dioxins and Fecal Pathogens.” Texas Natural Resource and Conservation Commission, 2000-2002; \$166,738.
- “Wet in the City: Galveston Bay Connections.” Galveston Bay Estuary Program, 1999-2000; \$98,318.

Increasing Public Involvement in Environmental Decision Making

Priscilla Weeks, Ph.D., Research Associate, and Lisa Gonzalez, Research Associate,
Environmental Institute of Houston, UHCL

THIS YEAR THE ENVIRONMENTAL INSTITUTE OF Houston added a new program—Public Participation and Outreach. The Institute has been involved in these areas through facilitation of stakeholder groups and research on democratic decision making since 1994. The formalization and expansion of this interest area into a program represents EIH's awareness of the importance of public participation in both the formation and acceptance of policy initiatives.

The program is directed by Dr. Priscilla Weeks, a cultural anthropologist who has worked in the area of democratic decision making and natural resource policy for 10 years. She brings to the program an anthropological understanding of diverse social groups, world views, and values. Joining her is Ms. Lisa Gonzalez who holds a Masters degree in Environmental Management. One barrier to effective public participation is the lay person's inability to access and understand technical information and the scientist's inability to translate that information into lay language. One of Ms. Gonzalez's primary functions is to help non-scientist stakeholders understand the technical and regulatory contexts in which their work takes place.

EIH's first foray into public participation was the facilitation of a series of meetings between the Texas Parks and Wildlife Department (TPWD) and the commercial shrimp fishery to design a Limited Entry program for the bay and bait shrimp fisheries. In addition to facilitating meetings between the agency and fishermen, the Institute worked with TPWD to provide written materials in lay language to fishermen, translate materials into Vietnamese, and ensure open communication between regulators and fishermen.

The number of requests for facilitation has been slowly but steadily growing since the Limited Entry project in 1994. Most requests have come from state and federal agencies, but services are available to any organization that needs them. EIH

has facilitated two day-long meetings called by Congressmen Lampson and Bentsen and attended by state and federal agencies and environmental groups to discuss Army Corps of Engineers permit procedures. U.S. Fish and Wildlife has employed EIH to facilitate a meeting with rural residents of Southeast Texas about issues of water management and land acquisition.

Current projects include facilitation of the Galveston Bay Freshwater Inflows Group (GBFIG) and two Total Daily Maximum Load (TMDL) allocations. The GBFIG stakeholder group is composed of state agencies, environmental groups, and water rights holders. The goal is to reach consensus on strategies to provide freshwater inflows to Galveston Bay. The group has been meeting since 1996.

The impetus for the transition from an ad hoc facilitation-upon-request approach to a program was a contract with the Houston-Galveston Area Council (H-GAC) to facilitate two TMDLs—Buffalo and White Oak Bayous for bacteria and the Houston Ship Channel for dioxin. Lisa Gonzalez was hired at this time. Two TMDL stakeholder groups have been composed. Members include citizens, environmental groups, state agencies, and industry. Stakeholders review technical information and provide input to representatives of the Texas Natural Resource Conservation Commission.

In the coming year, the Public Participation and Outreach Group will begin work on air quality issues. Specifically it will explore methods to get public input into the State Implementation Plan mid-course correction early in the process. Central to this effort will be the testing of appropriate methods for getting the input of those social groups that are not usually involved in formal stakeholder groups—homeowner's associations, low income communities, and peoples of color.

Public participation is broadly conceived with meeting facilitation being but one facet. Public participation also includes the

public's ability to access, understand, and utilize technical and policy information. As educated and empowered citizens, the public can become informed participants in the process. Citizens can then more effectively communicate their views and

concerns to the scientific community and policy makers. EIH is committed to the establishment of such a dialogue to foster sustainable solutions to regional and local environmental issues.

The Trees of North Pointe Elementary School

Steven J. Rakow, Ph.D., Professor and Program Area Chair for Curriculum and Instruction, Susan Millsap, undergraduate student, and Stacey Milam, undergraduate student, School of Education, UHCL

NORTH POINTE ELEMENTARY SCHOOL IS LOCATED IN the Clear Creek Independent School District. Built five years ago, the school is located about five miles north of the campus in the Northfork Subdivision. In 1995, there was a grounds improvement campaign to purchase trees for the school campus. The campaign was so successful that they were able to plant 106 trees. These trees represent an interesting variety of species, including some trees that have historical significance (such as one that was planted with a seedling from a tree at Betsy Ross' house and another that was obtained from an astronaut).

The school would like for these trees to be an educational resource for the students as well as for the community. Prior to this project, the only documentation of the plantings is a draft landscape plot that was completed prior to the planting. While this served as a useful starting point, it needed to be checked for accuracy. In addition, the information was not presented in a manner that was "user friendly" for the school or community. Therefore, the purpose of this project was to tag the 106 trees that have been planted on the property of North Pointe Elementary School and to develop three field guides to the Trees of North Pointe Elementary School—one for students in kindergarten through second grade, one for students in grades three through five, and one for the Northfork community.

Tasks Accomplished:

1. Publicized research opportunity, interviewed students and selected two to work on the project (Susan Millsap and Stacey Milam).
2. Cross-referenced the initial landscape plot map with current plantings and updated map.
3. Researched the background of the trees that have been planted.



Entrance to North Pointe Elementary School

4. Order and obtain materials to identify and tag the trees.
5. Develop a draft of the field guide for the community audience.
6. Review existing environmental education materials related to trees.
7. Identify additional materials that might supplement the Clear Creek ISD science program related to this topic.
8. Draft a teacher's resource guide.



Bald Cypress leaf scan used to create the Field Guide

Family Aceraceae
(maple family)

- Fruit is paired, winged seeds
- Bark can be used to make pink dye

Species Name: Acer rebrum

Common Name: Red Maple

Tag #: 23, 31, 33, 58



- Native to the United States
- Highly tolerant of both wet and dry extremes
- Height: 40-80 ft., although a height of 120 ft. is possible
- Diameter: 1.5-2.5 ft., although a width of 5 ft. is possible
- Leaves: deciduous; arrangement = opposite; type = simple; venation = palmate; green in spring and summer; turn red or orange in fall
- Bark: thin; smooth; light gray
- Flowers: very small; red; appearing before the leaves in early spring
- Fruit/Seeds: wings are less than 1 in. long; red to brown; mature in late spring
- Uses: Ornamental; wood from larger trees used to make furniture; wood from smaller trees used to make paper

Sample of Community Field Guide Text

Harvesting the Bounty of Galveston Bay: An Educational CD

Alecya Gallaway, Environmental Historian, and Priscilla Weeks, Ph.D., Research Associate,
Environmental Institute of Houston, UHCL

A PROTOTYPE FOR AN EDUCATIONAL CD, *Harvesting the Bounty of Galveston Bay*, on the history of natural resource use in the area has been developed. The material describes the social and environmental changes that have occurred since Galveston Bay's settlement almost 200 years ago. Early settlers migrated to the area to tap the natural resources of the lands surrounding the bay, and in so doing altered it. The vast prairies have been replaced first by pastures and agricultural fields, then by homes and businesses. Oyster

reefs have been mined and the bay bottom dredged. *Harvesting the Bounty of Galveston Bay* integrates archival maps, photographs, and oral interviews to chronicle these changes. The CD is designed to be used by students, teachers, and the lay public.

Features of the CD

Users will view a particular area temporally, increasing their understanding of anthropogenic changes to the landscape.



Photo courtesy of Bill Porter

An aerial view in the 1950s showing the island left after the huge shell midden was mined and sold for 75 cents a railcar load and hauled to be used for the base for the Galveston, Houston, & Henderson Railway tracks.



Photos courtesy of Alecya Gallaway

Above: Archeological excavation of midden on East Bay, 1997. Below: An eroding midden on Trinity Bay, 1995.



Courtesy of Chapman-Christy Family

Seabrook plat map showing the midden that extended into the bay in front of the entrance to Clear Creek channel, circa 1900.

Settlers to the bay area came from diverse backgrounds, with many social groups contributing to its development.



Photos courtesy of Wallisville Heritage Park

Morris Banks, second generation Black Cowboy from Chambers County, Texas



Photo courtesy of Mary Kathryn Broussard

Italian strawberry farmers at Dickinson, 1905

The 1900 Storm wiped out the coastal plain strawberry farms in Genoa, Webster, Dickinson, League City, Hitchcock, Alta Loma, Arcadia, Alvin, Manvel, Arcola, and Pearland.

When Clara Barton brought her relief teams to Galveston they toured the destruction of six storm-swept counties on the mainland. In her report she wrote:

“The winds had swept over them and leveled their buildings and destroyed their homes. The sea had rolled over them and washed away not only every growing plant, but also the soil it grew upon. All small animals, such as hogs, sheep, and fowls were destroyed. The heavy cattle, mules and horses that survived had nothing left for them to eat. After closing at Galveston the Red Cross removed to Houston, agents were sent out over the country to learn the needs of the people and how best to serve them.”

Along with the clothing, food, and lumber, Clara Barton had 1,428,000 strawberry plants sent to the ruined farmers in these communities. By March, crates of fresh strawberries were shipped to the Red Cross offices in Washington by the coastal farmers.

MANY OF THE first settlers on the prairies around Galveston Bay were cattlemen. The majority of the families came from Louisiana with both cattle and slaves. These slaves worked the cattle from horseback in the Spanish style, and it was from these early Black Cowboys that the skills that they became famous for were passed on to future generations. The legends of these men traveled with them into the west during the 1870s and 1880s, but the birth of the Black Cowboy can be traced to the edge of the bay in Chambers County when they were riding the Atascocito Trail driving cattle from Mexican Texas to New Orleans during the 1820s.



Photo courtesy of Chapman-Christy Family

A Japanese family home near Webster that was damaged during the 1915 storm.

At the turn of the century immigrants from Japan moved to the coastal lands around Galveston Bay to farm rice. The lands that supported rice farming were soon found to be lands which held deposits of oil. This booming new industry soon pulled in a variety of “Rough-necks”—from the cowboys of the prairie range to the newly immigrated Japanese rice farmers.



Photo courtesy of Chapman-Christy Family

Goose Creek Roughnecks

First hand accounts taken from oral interviews will be incorporated in a sound track.



Photo courtesy of Dave Scott

Going to Saltgrass

The Houston Chronicle said the freeze of 1924 froze 60 percent of the cattle wintering in the saltgrass on the Texas coast.

Todd Furness of Manvel Texas in Brazoria County is 92 years old. He was one of the cowboys working for Bassett Blakely at the TF Ranch who were sent to skin the frozen cattle where they fell. The hide was worth almost as much as the meat so the men had to work fast to salvage as many hides as possible before they spoiled. The following is an excerpt of an interview with Mr. Furness on March 7, 2000.



Photo courtesy Todd Furness

Todd Furness, cowboy, 1930

“Sleet drove ’em off into the marsh. You could walk on cattle from Bastrop Bayou to the Causeway and never step on the ground. Fifteen or 20 of us men skinned them cattle carcasses for more’n five days. Just skinned and peeled them in 14 or 15 minutes. Got them hides off and hauled about 50 hides a wagon to a big old warehouse between Liverpool and Danbury. Bassett Blakely’s son was at the warehouse. We salted them at the warehouse. At Alvin there were 604 head piled up in the corner of a fenced pen, waitin to be shipped. Right on top of that pile of cattle was a big ol’ Brahma bull.”

Canon Envirothon: Assessing the Environmental Literacy Level of High School Participants

Brenda Weiser, Environmental Education Program Manager, and Tammie Sutcliffe, research assistant, Environmental Institute of Houston, UHCL

THE CANON ENVIROTHON IS AN INTERNATIONAL, environmental education competition for high school students. It integrates the study of wildlife, soils, aquatics, forestry, and environmental issues using a hands-on approach to learning. Teams of students demonstrate their knowledge and understanding of natural resources through participation in the competition with the top team advancing to the next level, culminating at the national competition. In addition, this program promotes the development of critical thinking skills and the ability to solve real-life environmental problems using good science while considering societal, economical, and ecological perspectives. Over 1.5 million high school students, teachers, and family members are impacted yearly from the local level to the national level.

The Canon Envirothon strives to increase environmental literacy of high school students. The purpose of this project was to determine the level of environmental literacy of those high school students who have participated in the Canon Envirothon program as compared to those high school students who have not participated in the program.

Environmental literacy assessment (pre- and post-testing) occurred during November 1999 through May 2000. The method of data collection was a direct administration of the instrument by the teacher or advisor. The Wisconsin Environmental Literacy Assessment Instrument (WELAI) developed by the Wisconsin Center for Environmental Education was used for this study.

Teachers and advisors were asked to identify five students not participating in the Envirothon that would match the five students participating in the Envirothon. The instrument was distributed to teachers and advisors who agreed to participate in the survey and had students participating in the Envirothon. Directions were included in all pre-packaged material instruct-

ing the teacher or advisor about assessment procedures. Students were informed that the survey was not a test and had no influence on their participation in the Envirothon competition nor their grade. The pre-test was administered and collected from the students. The instruments, responses, and consent forms were returned to the researcher upon completion of the assessment.

The same ten students that participated in the pre-test were assessed in the post-test. The instrument was once again pre-packaged and distributed to the participants. The same format for distribution, administration, and return of the pre-tests was followed for the post-tests.

The results of the assessment are being analyzed. The assessment will help determine if the national goals and objectives of the Envirothon are being accomplished. The assessment will also identify the strengths and weaknesses of the program and be used to direct the long-range plan of the program.

Funding and proposals

“Bridging History, EE, and Urban Citizens’ Knowledge of Wildlife.” National Fish and Wildlife Foundation, 2000-2001; \$89,750 (*pending*).

“Incorporating Technology in Teacher Training Workshops.” UHCL-TQM; \$4,183 (*not funded*).

“Linking EE to Your Classroom: A Training Course for Educators.” National Environmental Education and Training Foundation, 1999-2000; \$8,500.

“Linking TEKS to Your School Habitat.” U.S. Fish and Wildlife Service, 2000; \$14,997; Reliant Energy, 2000; \$15,000.

“A Training Initiative for K-12 Educators With Emphasis on Water Education and Connections to Galveston Bay.” Texas National Resource Conservation Commission, GBEP, 2000-2001; \$60,000.

Making a Difference through Environmental Education and Outreach

Brenda Weiser, Environmental Education Program Manager, and Wendy Reistle, Habitat Curriculum Specialist, Environmental Institute of Houston, UHCL

OUTREACH TO THE COMMUNITY AND LOCAL EDUCATORS is one of the primary focuses of the Environmental Institute of Houston. The environmental education program of EIH assists in achieving this goal through educator workshops and providing guidance to local community groups and corporate volunteers. This past year, EIH conducted 23 educator workshops reaching over 700 formal and non-formal educators. Included in these workshops were facilitator training, pre-service and in-service workshops focusing on WET in the City, Project Learning Tree, Project WILD, and school habitat curriculum development. Many of these workshops were conducted in partnership with Galveston Bay Foundation, Galveston Bay Estuary Program, Council for Environmental Education, Friends of Hermann Park, City of Houston - Water Conservation Division, Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service, and Texas Forestry Service. Reliant Energy, Galveston Bay Estuary Program, and U.S. Fish and Wildlife Service sponsored many of these workshops.

In addition, other workshops, presentations, and exhibits were conducted over the year, reaching over 1200 individuals. These events provided information on environmental education, Envirothon, various environmental education programs and opportunities offered by EIH, and ideas on how to build environmental education partnerships. Through representation at various local, regional, state, and national meetings, EIH participated in meetings and reached leaders in EE. Thus, EIH is a leader within the community.

EIH is considered a leader at the local and state levels in the field of environmental education. Over the past year, the EE Program Manager has served on the following committees locally: Bay Day Steering Committee, Trash Bash Steering Committee, Bayou Preservation Association Advisory Board, Galveston Bay Estuary Program Public Participation and Edu-



Teachers plant a tree for the new school habitat at San Jacinto Elementary School.

cation Committee, and Water Smart Conference Planning Committee. EIH also provided volunteers for Marsh Bash, Trash Bash, and Bay Day. The EE Program Manager has also served on the Houston Children's Museum EcoStation Advisory Committee to assist in the design and development of a new environmental exhibit. The exhibit opened on March 8, 2001. At the state level, the EE Program Manager represents EIH on the Texas Project Learning Tree State Steering Committee and the Texas Envirothon Committee. Through these committees and advisory boards, EIH provides environmental education expertise and assistance to other organizations.

EIH assumed a leadership role at the national and international level in the field of environmental education when the



Activities such as this are an important part of habitat curriculum teacher training.



Students experience hands-on learning at various educational events sponsored by EIH.

Environmental Education Program Manager volunteered to chair the 2000 Annual Conference of the North American Association for Environmental Education (NAAEE). The conference was held October 17-21, 2000, at South Padre Island, Texas, and over 1100 environmental educators from across the world attended the event. There was a large contingency of Houston area environmental educators and from across the state. EIH staff also provided additional support to the conference through the development of the Registration Packet and assisting during the conference with registration. In return, EIH was listed as a partner in the conference and was identified on all promotional materials. The Environmental Education Program Manager also presented at the International Project Learning Tree Coordinator's Conference focusing on how to incorporate Project Learning Tree into Secondary Science Methods Courses.

EIH and the School of Education at UHCL offered a Summer Institute for elementary educators. Dow, Phillips Petroleum Company, and Celanese provided funding for these local educators. The three-week summer course, centered on the



Project WET teacher training.



Models are a useful tool in demonstrating the processes that impact the environment.

Galveston Bay Watershed, included field trips, environmental education workshops, and guest speakers. Participants learned about the watershed, how the watershed is impacted by various entities, and discovered how to teach about the watershed in their own classroom.

In partnership with Texas A&M Extension, Texas Sea Grant Program, Galveston Bay Estuary Program, and others, EIH hosted a Water Smart Conference at UHCL with over 85 participants. A second Water Smart Conference was held on March 3, 2001.

EIH continues to reach out and develop partnerships with a variety of organizations. In addition to those partners identified previously, EIH joined forces with Gulf Coast Waste Disposal Authority, Texas Nature Conservancy, Keep Houston Beautiful, Eddie Gray Wetlands Center in Baytown, Western Fifth Ward Community Services, Houston Zoo, Texas Forestry Association, Stephen F. Austin State University, and Armand Bayou Nature Center to provide high quality environmental education to the Houston-Galveston area.



Environmental Institute of Houston