

Environmental Institute of Houston 1998 Annual Report

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(Photo by Irv Rothman)

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documents are installed in HTML format.

COVER—The green spaces of Houston begin at
its bayous.



**The Environmental Institute of Houston
1998 Annual Report**

**The University of Houston—Clear Lake
The University of Houston
Houston, Texas**



The City of Houston devotes considerable effort to the preservation of its natural habitat and forest land.

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Dr. Jim Lester, Director
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March 1999

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The Director's Message

THE RAPID APPROACH OF year 2000 appears to bring the promise of fundamental change. Perhaps we can fundamentally change the structure of our cities and our lives. Most of my life has been spent in Houston and my wish for the new millennium is a Green Houston. Changing this city from a mosaic of ugly sprawl and compromised natural space to a blend of healthy and sustainable, built and natural environments is possible. First, we need to ask what changes are needed to provide this impression and to deserve this label.

Once upon a time, Houstonians turned their backs on the bayous and streams running through this area and decided to use them as sewers and ditches. In a Green Houston, the primary value of bayous and creeks would be as aesthetic features and habitat. A major challenge to high quality running water comes from non-point source pollution and storm water. Dr. Ted Cleveland reports on a study of the water quality improvement in one of Houston's bayous suffering from nonpoint source pollution.

The National Wildlife Federation issued a report this year that Texas is a leader in multiple payments to owners of property damaged by floods. We in Houston need a new policy on development in flood plains, as our efforts to use bayous for the prevention of flooding seem futile.

Green Houston would have more green space, particularly along bayous and creeks. This region is subtropical, and flora and fauna were abundant and diverse

before settlement. Restoration of riparian forest and prairie is possible, but no longer easy. Too many introduced plants and animals, such as Chinese tallow and the imported fire ant, are vying for space. Also standing in the way of increased green space is our tolerance of urban sprawl and ugly cityscapes. Perhaps Dr. Basheer Khumawala's studies of "green giving" will shed some light on how to enhance philanthropy for this change.

Green Houston would not have a smog problem. There are many ways to reduce production of photochemical smog, but all of them require citizen cooperation, and some require new technology. Living in the subtropics means plenty of natural sources of volatile organic compounds (VOCs). The complex issue of anthropogenic and natural VOCs was examined and reported by two graduate students working with Dr. Susanne Gaddis. The Texas Natural Resource Conservation Commission (TNRCC) and the Environmental Protection Agency (EPA) recently changed their focus from VOC to NO_x reduction in the search for solutions to smog. Drs. Raj Chhikara and Floyd Spears are examining monitoring data from TNRCC to detect correlation and patterns to aid in the reduction of conditions that lead to ozone generation. Last year, Houston joined the Clean City program that encourages the use of alternative fueled vehicles. The Railroad Commission of Texas funded EIH to train teachers for an alternative transportation fuels curriculum. Dr. Robert Jones and Ms. Lynn Spachuk, the EIH Environmental Education Coordinator, managed this training program.

Smog elimination is impossible if we continue to develop in a haphazard manner, dependent as we are on highways and personal automobiles to overcome the lack of planning. We need livable



communities in which it is possible to walk or bike to stores and restaurants. How many people have died in vehicle accidents on trips necessitated by urban sprawl? How much tax money has been spent on highways to subsidize sprawling, unplanned growth?

While urban sprawl is a broad policy issue, EIH research is directed at the interface of specific environmental concerns and faculty expertise. Some EIH research is aimed at expanding our knowledge to aid in identifying harmful compounds and gauging their impact on ecosystems. For example, Dr. Michael Benedik is developing a test to determine if compounds cause chromosome damage. Dr. Dan



Wells is studying the developmental process of a frog that provides a model for testing the impact of environmental conditions on amphibians and other sensitive species. While Dr. Steven Blanke is using microbial populations as indicators of environmental degradation, Dr. Sam Chen is describing the breakdown products of a herbicide that may produce effects different from the parent product. The effects of mercury on human health are known, but Dr. Cynthia Howard is working to track the impact of this heavy metal throughout the Lavaca Bay ecosystem.

Characterizing impacts on ecosystems is difficult to accomplish with words and charts, so

Dr. Theron Sage is building a bank of spatial information to help construct GIS (geographical information system) datasets. This is a powerful method to demonstrate changes in the status of land and water.

Recent policies concerning wetlands and other natural resources coupled with voluntary efforts are enhancing the rehabilitation of some local areas. Two projects covering the history of the Galveston Bay region (Melosi and Closmann; Weeks and Gallaway) provide knowledge about the conditions that restoration should strive to obtain.

In some cases, the tools are available for ecological restoration, but in others, we need

GREEN SPACE—At the Armand Bayou Nature Preserve in Clear Lake, a lookout tower enables visitors to observe Texas prairies and wildlife.

research. Wellington and Angel are studying the genetic structure of seagrasses to guide the acquisition of material for replanting seagrass beds. Wells and Meffert are engaged in the development of fundamental information on the usefulness of keeping captive populations of rare organisms for future reintroduction into the

(Continued on page 56.)

A Model System to Detect Chromosomal Rearrangements



LARGE SCALE PHYSICAL changes to our chromosomes often lead to significant health problems. Some genetic diseases can be traced to chromosomal translocations leading to the inactivation or loss of essential genes or to their inappropriate expression. Such genetic defects can be inherited or can arise *de novo*. Chromosomal deletions or rearrangements can also lead to the activation of oncogenes, which has been shown in many cases to lead to neoplastic tumor formation. These types of events are often the result of an environmental insult leading to chromosome

*Michael J. Benedik,
Ph.D., Associate
Professor,
Biochemical Sciences,
UH*

damage.

This project establishes yeast as a model system for investigating the mechanism by which chromosomal translocations and rearrangements occur. The role that cellular recombination and repair enzymes, chromatin structure, chromosome location, and environmental insults play in these events will be investigated using a highly sensitive genetic system to select and analyze these events.

Long-term goals are to devel-

op an understanding of the processes leading to chromosomal rearrangements and to develop tools that readily determine which environmental factors contribute to these events. This study may have an impact upon the determination of which pollutants contribute to this class of genetic disease. Findings may affect regulatory policy regarding these agents.

Objectives

Development of a model system requires the completion of three tasks:

- Build test strains for detection of gene activation by deletion and translocation.
- Determine rates of translocation relative to other gene activation events.



chromosome 1 and 2. We were unable to obtain the clone for the chromosome 12 site. Using the genomic region from chromosomes 1 and 2, we successfully inserted the *HIS3* cassette in each orientation and reassembled these clones into the yeast integration plasmid system. These were then transformed into an appropriate yeast strain, and stable integrants were selected. This generated a total of four strains to test, two sites, and two orientations at each site.

The first criterion, that these strains all behave functionally as *his* mutant strains, was met. All the strains failed to grow on media in the absence of histidine. This accomplished the first objective.

The second objective was to test these strains for the rate of translocations as opposed to other events leading to *His*⁺ phenotype.

This task was performed by selecting for colonies able to grow in the absence of histidine (an *His*⁺ phenotype). Three of the strains failed to give *His*⁺ colonies at any frequency. The fourth strain gave such colonies at a low frequency, < 10 colonies per 10⁶ cells plated after 48 hours. Although a low rate, this was likely too high to be attributed to translocation events. To ascertain whether these colonies arose as a result of pre-existing events or not, plates were incubated and assayed over time. New colonies arose over time, suggesting these events were not pre-existing in the population but arose *de novo*. After 10 days about 30 colonies per 10⁶ plated cells were obtained.

Why did this one strain generate colonies at a much higher rate than others? Analysis of the adjacent genomic sequence suggested that a transcriptional promoter lay upstream and in the correct orientation in this one strain, but not in the other three, such that simple deletion events could lead

to the activation of *HIS3* expression. PCR experiments confirmed that this was a reasonable model for these events, which were likely not translocation events.

The three non reverting strains were then tested for their rate of *HIS3* activation at much lower frequencies. Larger scale experiments were performed beginning with > 10⁹ initial cells. We failed to obtain *His*⁺ colonies even from this large-scale experiment. This finding suggests that the rate of translocation may be lower than this, proving this experimental system impractical.

Lastly, different regimes of mutagenesis were tested to see if they had an effect on increasing the rate of translocation to a detectable level. Both UV light and chemical mutagens were tested. All failed to activate translocation events to a detectable level.

In conclusion, a system was developed to directly select and analyze chromosomal translocation. This system appeared to fulfill the required criteria but failed to detect the expected events. It is likely that the rate of spontaneous chromosome translocation is too low to be detected in such a simple microbial system. It would be worthwhile, however, to test this system using agents known to induce chromosomal breakage. This effort will be attempted in the near future.

GREEN SPACE—The Armand Bayou prairie in Southeast Harris County preserves the grasslands and the wetlands.

- Sequence a sample of junction points.

The first task was to build the tester strains to detect deletions and translocations. This was accomplished by using an *HIS3* cassette cloned into a yeast integration (non-replicating) plasmid and a yeast strain deleted for the *HIS3* gene. The *HIS3* cassette lacks a promoter to allow its expression; hence, the strain will be able to grow only on minimal medium if some event allows the transcriptional activation on *HIS3*.

Three regions of the yeast genome were selected into which to place the *HIS3* cassette, these lay on chromosome 1, 2, and 12. We successfully amplified by PCR and cloned the regions for

A Novel Approach to Monitor Microbial Populations as an Indicator of Environmental Change

Steven R. Blanke, Ph.D., Assistant Professor, and
Trey Mahoney, graduate student, Biochemical
Sciences, UH

ECOSYSTEMS CHANGE AS human beings continue to encroach upon the environment and consume precious natural resources. The effects of pollution and continued consumption of natural resources are revealed through subsequent changes in various ecosystems. Environmental conditions affect the composition and density of microbial flora in these ecosystems.

Factors affecting the ecological niche of a given microbial species include (1) moisture in the soil, which, in turn, modulates available oxygen supply, (2) acidity, (3) temperature, and (4) the availability of organic matter. Because specific microorganisms occupy precise ecological niches, a highly specific and rapid assay, targeting the presence and abundance of particular microorganisms, would provide an early detection system for subtle changes in microenvironments. Our research has focused on a novel plan to generate nucleic acid-based probes, called aptamers, to monitor the effects of pollution and natural resource consumption on microbial flora in the environment.

We have utilized an emerging powerful technology called *in vitro* selection (frequently termed SELEX) for generating nucleic

acid-based
p r o b e s
called apta-
mers target-

ing specific microorganisms. *In vitro* selection is a technology which mimics natural selection *in vitro* at the molecular level. The overall process is cyclic selecting and enriching for molecules with a desired properties from a complex, random pool. Through the repeated steps of enrichment and amplification under increasingly stringent selective pressures, the pool nears functional homogeneity such that all members possess the trait or property being selected. The advantages of using aptamers for diagnostic applications include (1) extreme generality of the approach, (2) potential for automation, (3) ease of analysis, and (4) the ability of aptamers to discriminate between closely related molecules.

We initially targeted bacterial products for the selection of aptamers. The RNA or DNA nucleic acid probes to be generated, called aptamers—from the Latin word *aptus*, meaning “to fit”—fold into complex structures that exhibit the ability to recognize and bind specific target molecules. A growing list of highly specific aptamers has been isolated and reported to target small molecules, proteins, nucleic acids, and even macromolecular complexes within human organs. These investigations represent the first attempts at generating aptamers targeting the complex matrix representing the surface of entire microorganisms.

We have performed seven rounds of selection and cloned the enriched pool of aptamers. We are currently analyzing the sequences of these aptamers to determine the consensus sequences that represent the selected aptamers. These aptamers will be further developed for analysis with novel detection probes called molecular beacons.

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- Blanke, S. R. “Entry of Bacterial Toxins into Mammalian Cells: Mechanisms and Applications,” Heart of Texas Microbiology Meeting, Houston, TX, Feb. 21, 1998.

Blanke, S. R. "Synthetic Gene to Investigate the Structure, Function, and Chemical Mechanism of the Cholera Toxin Catalytic Domain," 1998 National American Chemical Society Meeting, Boston, MA.

Guynn, L., T. Mahoney, S. R. Blanke, and M. J. Benedik. "A Putative *Serratia marcescens* Enterotoxin with Homology to *Clostridium difficile* Type AB Toxins," 1997 Lost Pines Molecular Biology Conference, Smithville TX, Oct. 10-12, 1997.

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Jin, W., C. Mazurek, K. Muthuswamy, and S. R. Blanke. "Design and Construction of a Synthetic Gene Encoding the Cholera Toxin Catalytic Domain," 1998 Lost Pines Molecular Biology Conference, Smithville TX, Oct. 9-11, 1998.

Ye, D., D. C. Willhite, and S. R. Blanke. "Mapping the Functional Subdomains of the *Helicobacter pylori* Vacuolating

Toxin," 1998 Lost Pines Molecular Biology Conference, Smithville TX, Oct. 9-11, 1998.

Funding

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

"A Novel Role for the *Helicobacter pylori* Vacuolating Toxin." PEER, June 1, 1998-May 31, 1999, \$5,000.

"Distribution of the Human Pathogen *Vibrio vulnificus* in Texas Coastal Waters." Coastal Center, Nov. 1, 1998-July 31, 1999, \$7518.

"Mechanico-Transduction in Regulation of Virulence Gene Expression." Arnold and Mabel Beckman Foundation,

July 1, 1999-June 30, 2001, \$200,000. (Pending.)

"PCR-Based Diagnostics for the Rapid Detection of Microbial Pathogens." UH/NASA Technology Commercialization Incubator, July 1, 1999-Oct. 31, 2000, \$96,926.

"Mechanisms of ADP-ribosyltransferase Regulation." NSF CAREER Award, March 1, 1999-Feb. 28, 2003, \$487,720. (Pending.)

"Modulation of Targeted Protein Delivery into Mammalian Cells by Flow-Induced Shear Stress." The Whitaker Foundation, April 1, 1999-March 31, 2002, \$210,000. (Pending.)

"Molecular Mechanisms of the *Helicobacter pylori* Vacuolating Toxin." National Institutes of Health, Aug. 1, 1999-July 31, 2004, \$925,437. (Pending.)



Photo by Irv Rothman

GREEN SPACE—The Tom Bass State Park at Hwy 288 and Beltway 8 not only harbors an amphitheater and picnic grounds, but it is a natural preserve.

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Effect of Habitat Fragmentation on Demographic Structure of Small Mammal Populations

Guy N. Cameron, Ph.D.,
Professor, and Edwin H.
Bryant, Ph.D., Professor,
Biology, UH



GREEN SPACE—The Armand Bayou Prairie Restoration Project retains habitat for Texas wildlife. The Project offers opportunities for research into restoration techniques. Armand Bayou offers a venue for the study of mammalian demography.

THE EFFECT OF HABITAT fragmentation on populations is a major concern for resource managers and conservation biologists. Most scientific studies of fragmentation have focused on forest habitats and bird populations. The few studies with mammals have focused on the impact of fragmentation of grasslands and forests. In the interest of seeking a new, broader understanding of the effects of fragmentation, this project sought to understand the effect of fragmentation of coastal salt marsh on the population dynamics of the dominant small mammal, the marsh rice rat (*Oryzomys palustris*).

Pilot studies and initial setup of field procedures were described in the 1996-97 annual report. The finalized program of field research began in August 1996 and terminated in December 1997. The research team fulfilled individual roles but worked together to collect field data. Post-doctoral fellow Dr. Julie

Robinson
studied
demo-
graphic

effects of fragmentation, M.S. student Beth Kruchek researched the importance of the upland/wetland interface for small mammals, and Ph.D. student Valerie Sparling analyzed small mammal movements in response to habitat fragmentation. Dr. Julie Robinson accepted a position with NASA in August 1997; consequently, Dr. Guy Cameron and Jan Williams helped complete the field collections.

Salt marshes are habitats characterized by fluctuating conditions. Heavy rains and coastal flooding hindered the beginning of fieldwork, and data could not be obtained from all sites. Capture/recapture methods require three consecutive days of trapping. These were sometimes prevented when the entire site was under water. At the termination of field collections in December 1997, we had gathered a total of 14 months of data depending on the manner in which data analysis techniques are used to allow for missing values (Table 1).

At the termination of field trapping, data were entered into our database and are available for

analyses. Different subsets of the data will be used for all three studies. For example, the demographic analysis will use all data, while the ecotone study and the radiotelemetry study will use subsets. Ms. Kruchek has finished analyzing the data for the ecotone study and is beginning to write the results. Basically, she found that rice rats used both the upland (coastal prairie) and lowland (marsh) during different seasons. She is now evaluating that usage to determine whether animals used upland habitats during the winter distinctively for refuge, reproduction, or food. Her finding that rice rats used both habitats adds substance to the concern that wetland animals have requirements for their life histories outside that habitat. This is a critical point because only wetlands are legally protected while destruction of upland habitats remains unchecked in the Galveston Bay area.

During the fall 1997 and early spring 1998, Ms. Sparling and Ms. Williams devoted themselves to the radiotelemetry portion of this study. Radios used in previous studies were remanu-

Table 1. Successfully completed trapping sessions. X indicates complete data obtained, 0 indicates data is suspect due to influence of severe flooding, and blanks indicate trapping could not be conducted. Trapping sites are identified as P = Pierce Marsh, B = Brazoria National Wildlife Refuge, S = Galveston State Park, H = Highland Bayou, J = Jamaica Beach.

Month	#	Pi	P2	BI	Unfragmented Sites						Fragmented Sites			
					B2	SI	S2	HI	H2	H3	H4	JI	J2	
Oct 96		X				O	O							
Nov	1	X	X	X	O	X	X	X	X				X	X
Dec	2	X	X			X	X							
Jan 97	3	X	X	X	X	X	X	X	X	X	X	X	X	X
Feb	4	X	X	X	X	X	X	X	X	X	X	X	X	X
Mar	5	X	X	X	X	X	X	X	X	X	X	X	X	X
Apr	6	O	O	X	X	X	X	X	X	O	O	X	X	X
May	7	X	X	X	X	X	X	X	X	X	X	X	X	X
Jun	8	X	X	X	X	X	X	X	X	X	X	X	X	X
July	9	X	X	X	X	X	X	X	X	X	X	X	X	X
Aug	10	X	X	X	X	X	X	X	X	X	X	X	X	X
Sept	11	X	X	X	X	X	X	X	X	X	X	X	X	X
Oct	12	X	X	X	X	X	X	X	X	X	X	X	X	X
Nov	13	X	X	X	X	X	X	X	X	X	X	X	X	X
Dec	14	X	X	X	X	X	X	X	X	X	X	X	X	X

factured to conduct pilot telemetry studies during late 1997. These studies provided data on distances traveled by rice rats, and the effect of weight of the transmitter. We concluded that rice rats moved very long distances but cannot tolerate a transmitter in excess of 3 grams. We now are ready to initiate a full-scale study on movements by rice rats to evaluate their use of fragmented habitats and to compare this use to their movements in unfragmented habitats.

Unfortunately, Dr. Cameron moved out of state, and further study on the Galveston Bay rice rat system will have to await the availability of a new Principal Investigator or a student sent to Texas by Dr. Cameron. The latter is feasible if discussions with EIH prove fruitful.

A preliminary analysis of our demography data was presented at the American Society of Mammalogists meeting in Oklahoma in June 1997 and at the International Theriological Congress in Mexico in September 1997. A preliminary analysis of the ecotone study was presented at the American Society of Mammalogist meeting

in Virginia in June 1998. Results from these studies were well received. Feedback is currently being used to refine the analyses.

Analysis of the demography of rice rats in fragmented and unfragmented habitats will commence in January 1999.

Environmental Issues

Contamination Caused by S-Triazine Herbicides

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Assistant Professor, and
Cynthia Howard, Ph.D.,
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Biology and
Environmental Science,
UHCL

THE S-TRIAZINE HERBICIDES are widely used pesticides for the control of weeds in corn and other crops. The extended use of these compounds has led to contamination problems. At present, triazine herbicides can be found in many areas of the United States including the Gulf of Mexico. Photolysis of these and other pesticides in aquatic environments is an important process in determining the fate of these synthetic chemicals. Although the toxicity of triazine herbicides is considered mild, no published data are available to prove that the photolysis products are toxic or not toxic. Obviously, there is a need for more research in order to answer the question. As part of an ongoing research project to understand the reaction products and mechanism, UHCL researchers initiated a study of the toxicity of the photolysis products.

The extraction and purification of photolysis products are labor intensive. A typical procedure calls for dissolving the compounds in water, exposing the solution to simulated sunlight, extracting the parent and daughter compounds with an organic sol-

vent, concentrating the extract, separating the compounds by chromatography, and re-dissolving the individual compounds. Since most products gradually decompose as photolysis proceeds, the yield of products is very low. In addition, all the triazine herbicides are hydrophobic and have very low water solubilities; consequently, the starting concentration is low. The combination of these two findings increases the difficulty of obtaining a large amount of photolysis products. A larger volume of solution and a longer period of time are required to produce adequate quantity of products for toxicity tests. The second reason is self-explanatory. The use of animals for toxicity tests demands tremendous amounts of time and labor. In this study, *Daphnia pulex* was selected as the test species, and atrazine and cyanazine were chosen to represent the triazine herbicides.

Methods

A larger volume (approximately 30 liters) of aqueous stock solutions of atrazine and cyanazine was prepared. For each photolysis experiment, about 500 ml of stock solution was exposed to simulated sunlight (filtered Xe light) for 30 minutes in the presence of light-activated semiconductor TiO_2 as the catalyst. The suspension was extracted with methylene chloride twice. The extract was then concentrated by evaporation of the solvent, and the individual compounds were separated by thin layer chromatography (TLC). The TLC gel containing the compounds was removed from the TLC plates and extracted with methylene chloride. The identification of the isolated degradation products was carried out by gas chromatography-mass spectrometry (GC-MS) technology. The major stable degradation products of atrazine were deethyl atrazine (DEA), dechloro atrazine (DCA) and deisopropyl atrazine (DIA).

However, DEA alone had high enough yields to be separated and isolated from the extract. Similarly, for cyanazine, the stable photolysis products were deethyl cyanazine (DEC) and deisopropyl cyanazine (DIG).

Acute and chronic tests were performed to determine the toxicity of the triazine herbicides atrazine and cyanazine in *Daphnia pulex*. Ms. Monica Schumann Pettigrew, a UHCL graduate student in the environmental science program, was responsible for maintaining laboratory cultures of *Daphnia* and for running the toxicity tests. A total of 20 range-finding and definitive acute tests were conducted for atrazine and cyanazine to determine LC50 concentrations and NOECs (no effect concentrations) to be used in the chronic life table studies on each herbicide. GC-mass spectrometry was employed to verify concentrations of each pesticide in the test solutions.

Stock individuals of *D. pulex* for these experiments were obtained from Stillmeadow Environmental in Houston. Organisms were cultured in the laboratory at UHCL. Prior to the start of each test, gravid individuals were removed from the culture and observed for the next 24 hours as they dropped neonates. The 0-24 hour old neonates were then used in the tests. In the range-finding experiments, *Daphnia* were exposed to one of up to eight concentrations of herbicide in dilution series of 1:10 to determine the range of concentrations to be utilized in the definitive experiments. In subsequent definitive tests, *Daphnia* were exposed to a control or one of five concentrations of herbicide; each test ran 48 hours and involved 10 replicates per concentration.

Results

An LC50 for atrazine and an LC50 for cyanazine were estimated using Probit analysis.

Definitive tests on each herbicide were run multiple times in order to reduce statistical variation in the estimated LC50s.

Chronic toxicity tests are currently underway. NOECs determined from the acute tests are being used as the concentrations to which *Daphnia* are being exposed in 40-day complete life cycle tests. Organisms are being monitored for survival and reproduction. Life tables comparing individuals exposed to herbicide versus control organisms will be constructed.

Still to be tested are the breakdown products of atrazine and cyanazine. These toxicity tests will be conducted during the fall semester as they become available.

Presentations

Chen, S., C. Howard, M. Pettigrew, and H. Teague. "Assessment of Aquatic Toxicity of Photolysis Products of

Atrazine and Cyanazine in Water," *Abstracts of the 18th Annual SETAC Meeting, Society of Environmental Toxicology and Chemistry, San Francisco, CA, 1997.*

Chen, S., C. Howard, M. Pettigrew, and H. Teague. "Molecular Modeling Estimation of Water Solubility and Bioconcentration Factor of Organic Pollutants," *Abstracts of the 18th Annual SETAC Meeting, Society of Environmental Toxicology and Chemistry, San Francisco, CA, 1997.*

Funding

"Photolysis of Organophosphate Pesticides in Water." Welch Foundation, \$73,416, April 1998 (*not funded*).



GREEN SPACE—The Texas Gulf Coast sustains marshland and prairie providing natural habitats for wildlife 25 miles from downtown Houston.

Toxic Air Pollution Evaluation and Patterns in the Houston Area

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Spears, Ph.D.,
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UHCL

Table 1. VOCs with Significant Changes from 1992 to 1997

Increasing Trend	Decreasing Trend	No Trend
n-nonane	c-2-Pentene	Trichlorofluormethane
	2,3-Dimethylbutane	a-Pinene
	1,2 Dichloroethane	Toluene
	4-Methyl-1-Pentene	c-2-Hexene
	1,2,3-Trimethylbenzene	b-Pinene
	Ethylbenzene	n-Butane
	2,2-Dimethylbutane	Propane
	2-Methylheptane	
	o-Xylene	
	2,4-Dimethylpentane	
	1,3,5-Trimethylpentane	
	1,2,4-Trimethylbenzene	
	p-Xylene	
	3-Methylheptane	
	n-Propylbenzene	
	Methylcyclopentane	

AIR POLLUTION DATA FROM the Texas Natural Resources Conservation Commission (TNRCC) has been evaluated, obtained from air monitoring sites in the Houston-Galveston area from 1992-1997. Data comprise measurements of numerous variables from the 11 air monitoring sites in the Houston-Galveston corridor. The variables measured and frequency of measurement vary from one location to another. The variables of interest in this study include criteria pollutants such as ground level ozone, carbon monoxide, sulfur dioxide, and nitric oxide, as well as numerous volatile organic compounds (VOCs) that might contribute to the formation of ground-level ozone. Data include meteorological measurement such as wind speed, wind direction, and ambient temperature.

VOC Analysis

A statistical analysis was conducted of 71 VOCs, available from at least one of the air monitoring sites from 1992-1997. Less than half of these were being measured at any of the monitoring sites during the first year of study, in 1992. VOCs were added for measurement each year at the various sites. The

scope of analysis is limited to those VOCs measured each year from 1992 to 1997. The VOCs having the highest measured concentration in the Houston-Galveston area during that time period were n-Butane (16.8 %), Isobutane (14.4 %), Toluene (13.3 %), Isopenane (12.7 %), and Benzene (8.5 %). There was a statistically significant decrease ($p < 0.05$) in the concentration of measured VOCs during that time period. Among the 19 VOCs with significant changes in measured concentrations, only one, n-Nonane, increased significantly ($p < 0.05$) (see Table 1). Most of the significant changes were decreases that occurred in the years after 1994.

It is difficult to compare the VOCs across sites, since different VOCs were measured at each site. It was clear, however, that the monitoring site in Galveston consistently showed the lowest concentration of VOCs. Monitoring sites in Clute and at Haden Road and Clinton Drive in Houston were consistently among the locations with the highest concentrations of VOCs.

Predicting Ozone

Recently, Davis and his team of researchers (1998) reported the outcome of an extensive analysis

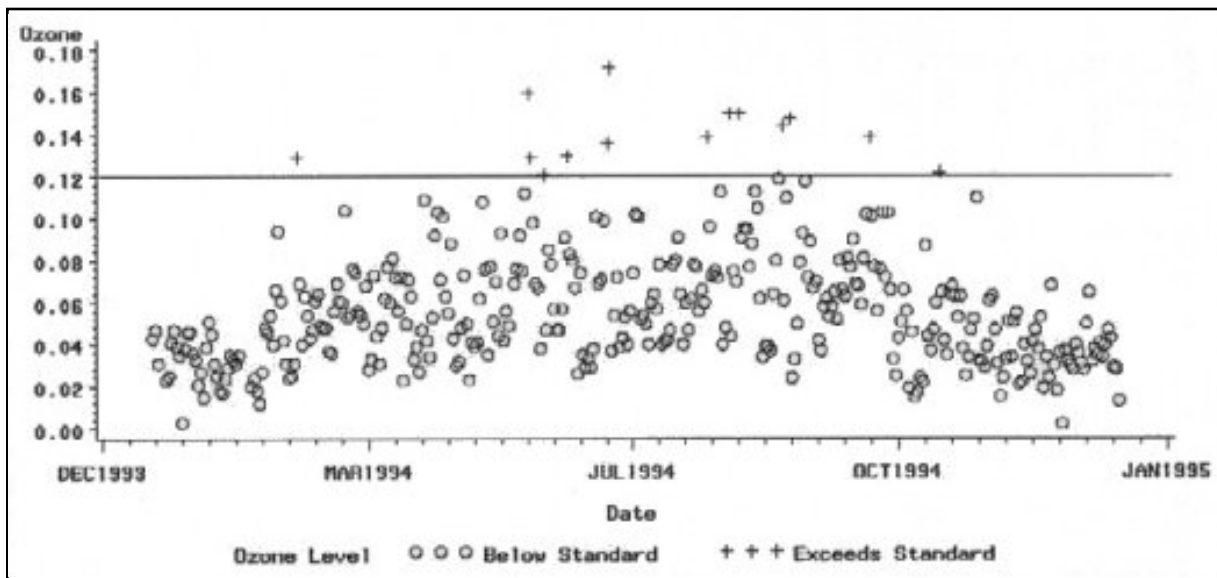


Figure. 1. Maximum Daily 1-Hr Average Ozone Concentrations

of hourly ozone records from the Houston-Galveston area monitoring stations from April to October, 1981-1991.

In terms of modeling hourly ozone concentrations, the most significant factors were the daily mean ozone profile, the ratio of maximum to the minimum daily ozone, and the timing of the peak ozone level. These three statistical factors were obtained based on the singular value decomposition of the data matrix, which allows a determination of principal components. Although the factors listed above explained a substantial amount of the variability in ozone, the effectiveness of these statistics for classifying days with respect to ground-level ozone concentration was not attempted, nor did we seek further analysis of the effect of meteorology on the ozone level.

Our initial step in developing a statistical model to include meteorological and other variables in predicting ground-level ozone concentrations was to study its relationship to other criteria pollutants, VOCs, and meteorological variables. A data analysis, involving both inter- and intra-correlations was performed with respect to the different types of variables. None of

the variables, considered individually, showed a strong correlation to ground-level ozone concentrations. This low correlation could be attributed, in part, to the large amount of variability in the daily ozone concentrations shown in Fig. 1, which represents a typical monitoring site in the Houston area in 1994. A set of variables considered together could, however, explain the variability in ground-level ozone.

Some potentially relative meteorological variables were not included in data provided by TNRCC. When we obtain these additional variables, i.e., rainfall, relative humidity, dew point, and solar radiation, we will perform a principal component analysis to identify the important statistical factors to be used in modeling ground-level ozone.

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Investigation and Demonstration of Intervention Strategies to Improve Water Quality on Country Club Bayou

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COUNTRY CLUB BAYOU, known by nearby residents as “Slaughterhouse Ditch,” is located in southeast Houston. The bayou drains from east to west connecting to Brays Bayou. The upper portion of the bayou is conveyed in a concrete channel that was initially poured in the early 1900’s. The lower portion of the bayou from the Hughes Street railroad bridge to the confluence with Braes Bayou is an open, unlined channel.

Figure 1 is a portion of a recent USGS map of the study area. Sometime between 1922 and the late 1930s, the bayou west of Evergreen Cemetery was covered over—reportedly as part of a WPA project. In 1948, the open portion from Evergreen Cemetery to Hughes Street (the Hughes Tool Complex) was covered. Figure 1 shows the result of these two periods with the remaining portion from Hughes Street Bridge east to Brays Bayou, being all that remains of the original riparian corridor.

Pollution of the bayou has been a problem for at least a dozen years. Currently suspected high nutrient loading somewhere in the covered portion of the bayou contributes to observed low dissolved oxygen values, a septic odor, and septic (black) color. The out-fall from the covered portion of the bayou to the open

portion is immediately upstream of the

Hughes Street Bridge. Samples collected at the bridge by the City of Houston Health Department confirm these historical observations.

At times, the water at the out-fall just upstream of the Hughes Street Bridge does not meet state water quality standards for a non-designated stream. While symptomatic treatment is technologically feasible, the purpose of this research is to document an investigation protocol to locate sources of pollution and evaluate possible intervention strategies to mitigate the effects of pollution.

The investigation protocol uses thematic mapping to generate a scoring system to identify locations where sources of pollution are likely.¹ Field monitoring of selected water quality parameters and computer simulation of water quality are also key components of the investigation.

Once source locations are identified, computer simulation of selected intervention strategies will be used to rank different approaches to improve the water quality based on predicted effectiveness, initial cost, and operational complexity.

Important findings to date reveal that the black water is not in the water column but rather is the color of the bottom sediments of the bayou. The black sediments are ferrous sulfide, and their presence is correlated with low dissolved oxygen and high dissolved sulfide that appear in the bayou at different times.

Twice-weekly sampling and analysis indicate that the open portion of the bayou recovers with distance—low dissolved oxygen at Hughes Street (<0.8 ppm) reaches expected ambient concentrations (4-5 ppm) by 66th Street (about one-fourth river-mile). The bayou responds to rainfall events with an increase in turbidity and improvement of the other water quality parameters, suggesting dilution by runoff but increased loading of solids.

The current land-use in the area ranges includes residential, light-industrial, and several large manufacturing facilities. The covered portion of the storm sewer system appears to belong to the City of Houston, while the ownership of the open portion is still under investigation. The ownership is important in determining intervention strategies. Our investigation has not discovered any discharge permits issued by any authority for discharge into Country Club Bayou.

On-going effort includes expansion of the field-monitoring program upstream of Evergreen Cemetery, use of the USEPA-QUAL2 model to simulate the covered portion (negligible reaeration and zero photosynthesis), and scoring of the map themes to identify high-risk portions of the bayou for intensive investigation.

Partners involved in this project are the Environmental Institute of Houston (\$12,600), the Texas Natural Resources Conser-



Figure 1. USGS Map of Country Club Bayou Area. (Circa 1980s). Dashed Line Represents Historical Open Ditch Portion. Solid Line is Present Day Open Ditch. Circles are Water Quality Monitoring Locations. The campus of the University of Houston is located at the south of the map. The parallelogram at the north entrance of the campus at the intersection of Cullen and route 45 is the area identified as the Hughes Street Bridge area.

vation Commission (in-kind services), and the City of Houston's Wastewater Program (\$56,000).

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Funding

"Investigation and Demonstration of Intervention Strategies to Improve Water Quality on Country Club Bayou." Montgomery Watson Americas, Ltd., Program Manager for the Houston Wastewater Program, \$56,479.

"Sediment Control and Slope Stability in Earthen Channels," Harris County Flood Control District Award, \$59,946.

Environmental Issues
Houston: The Nation's "Hot Spot" for Studying Volatile Organic Compounds

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AFTER STUDYING RESEARCH and consulting several private and government sources on volatile organic compounds (VOCs) over the course of several months, we were gratified to realize that the rationale behind focusing the VOC study in the Houston-Galveston area was indeed well founded. For example, as shown in the following Texas Natural Resource Conservation Commission (TNRCC) study (see Fig. 1), VOC emissions in the Houston/Galveston/Brazoria area far exceed VOC emissions in other major Texas cities like Austin, Dallas, and San Antonio.

During our research, we attended a variety of symposiums and sites, including a State Implementation Plan public hearing (March 20), the TNRCC VOC monitoring site located on Clinton Drive (June 3), and the Mayor's Air Pollution Summit in Houston (June 24).

We collected VOC information through research literature and interviews from several sources, including the City of Houston Health

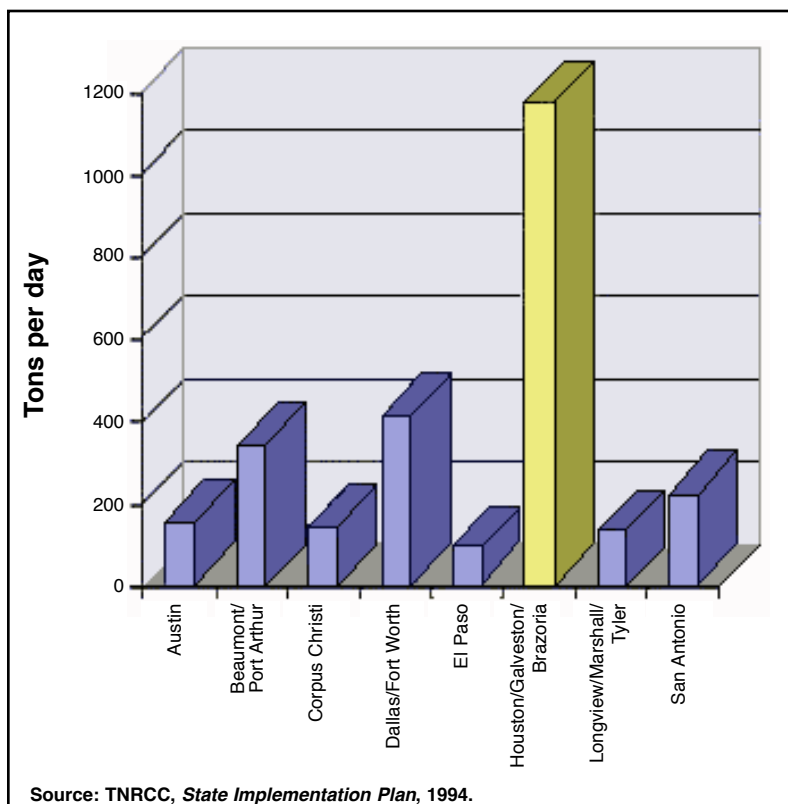


Figure 1. VOC emissions in major Texas cities.

Department, the Houston Air Excellence and Leadership program, and from Dr. Winifred E. Hamilton (Galveston-Houston Association for Smog Prevention), Enayat Zareian (TNRCC Houston bureau), Elizabeth Hendler (TNRCC Austin bureau), Neil Carman (Sierra Club), Walter Crow (Radian International), Richard Gay (new VOC emission control technologies), and Dr. Marty Spears (University of Houston-Clear Lake).

In addition, we investigated many sources via the Internet, including *Environmental Abstracts*, industrial trade publications, and articles/information from the Energy Information Administration, TNRCC, the Environmental Protection Agency, and the *Houston Chronicle*.

Though several industrial/chemical sources were contacted (Shell, Solvay, OxyChem, and Texas Chemical Council) to either refute and/or comment on various VOC and grandfathered

studies and industry allegations, none were able and/or willing to comment prior to our research deadline.

Dr. Marty Spears gathered raw TNRCC VOC data into comprehensive and original statistical elements (see Table 1 in Chhikara and Spears, p. 12).

Our research enabled us to draw several generalized findings:

- Biogenic sources often contribute larger amounts of VOC emissions than anthropogenic (man-made) sources, based upon TNRCC data.
- Controversies exist (even among researchers) regarding the definition, reactivity or ozone-forming abilities, and health/economic costs of VOCs and the role of biogenic VOC-producing sources.
- An overall decrease in the amount of VOC emissions in the Houston-Galveston area, based upon City of Houston, Houston Regional Monitoring, and TNRCC data.
- External factors (such as wind,

Table 1. Health effects of a selection of toxic VOCs

VOC	Ethylene	Benzene	Methanol	Propylene	Toluene	Xylene
Carcinogen						
Cardiovascular/Blood Toxicity						
Developmental Toxicity						
Endocrine Toxicity						
Gastrointestinal/Liver Toxicity						
Immunotoxicity						
Kidney Toxicity						
Neurotoxicity						
Reproductive Toxicity						
Respiratory Toxicity						
Skin or Sense Organ Toxicity						

temperature, moisture, location, time of day, and season) can complicate the isolation of VOC sources, as well as the measurement of VOCs.

- Several VOCs, such as benzene, toluene, and xylene have numerous adverse health effects, including cardiovascular/blood, reproductive, respiratory, kidney, skin or sense organ, endocrine, developmental, immuno-, and neuro- toxicity (see Table 1 and Fig. 2).

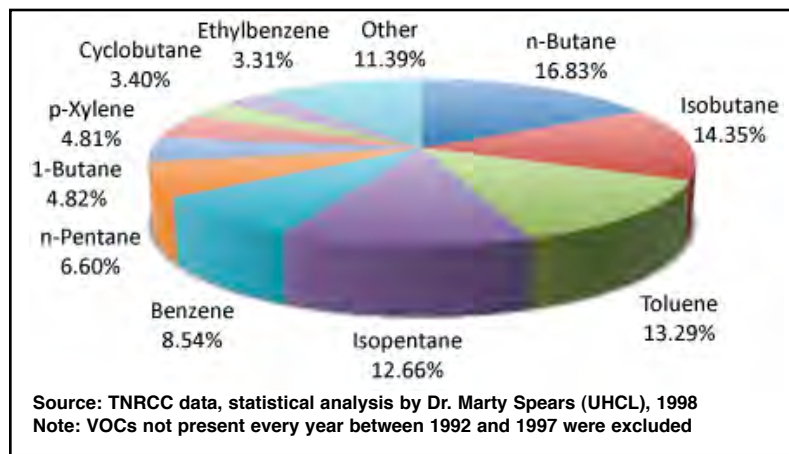


Figure 2. Portion of measured VOCs in the Houston-Galveston area, 1992-1997

Environmental Issues

Green Giving: The Role of Financial Reporting in the Decision to Support Environmental Organizations

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UH

A PRIMARY CONCERN OF those who contribute money to not-for-profit organizations is how much of each contribution directly benefits the cause for which the charity has been established. Expenditures for items other than program expenses, such as administrative and fund-raising costs, deplete the resources available for providing services to the intended beneficiaries of the organization.

It is not usually possible to operate a successful not-for-profit organization without incurring some level of fund-raising costs. There is incentive, however, to minimize the amount of reported fund-raising costs in order to present results from operations which seem efficient. One way that charitable organizations can minimize amounts reported as fund-raising costs is by allocating a portion of the costs of joint activities, such as those performed jointly for educational and fund-raising purposes, to program services.

Overview

The merits of allocating joint costs have been the subject of debate for over thirty years. Critics against the allocation issue argue that the “educational” material included in fund-raising appeals is not related to a charity’s primary mission. They believe that classification of any portion of these expenses as program costs is misleading and should not be permitted.^{1,2} Others reason that without the ability to allocate costs, the fund-raising expenses for organizations, which include legitimate educational material in fund-raising appeals, are unfairly burdened. The inability to assign joint costs to multiple expense categories violates generally accepted accounting principles.³

Before 1964, neither the accounting regulatory bodies nor industry offered guidelines regarding allocation of these costs. Each entity was free to allocate costs as management deemed appropriate.⁴ In 1964, the National Health Council and the National Social Welfare Assembly issued its *Standards of Accounting and Financial Reporting for Voluntary Health and Welfare Organizations*, which forbade the practice of allocating joint costs. Introducing a standard that became known as the “primary purpose” rule, the industry began to require that the entire amount of joint costs be recorded as either program expenditures or fund-raising costs, depending on the primary purpose for which such costs were incurred.⁵

In 1967, the American Institute of Certified Public Accountants (MCPA) published *Audits of Voluntary Health and Welfare Organizations*, its industry audit guide for certain not-for-profit organizations. This audit guide did not specifically prohibit or permit allocation of joint costs.⁵ When the audit guide was updated in 1974, no additional clarifi-

cation of the MCPA’s position on this issue was provided.⁶

In 1978, the MCPA issued its Statement of Position (SOP) No. 78-10,⁷ which attempted to clarify the joint cost allocation issue. The intent of SOP 78-10 was to permit joint cost allocation to a limited group of charities. However, its requirements for allocation were so general that any organization could justify allocating these costs.⁴ The next effort was the AICPA’s SOP 87-2,⁸ which stated that allocation of joint costs was acceptable only if it could be demonstrated that a program function has been completed in conjunction with the appeal for donations.

Despite continued attempts to settle the issue of joint cost allocation involving fund-raising expenditures, the risk remained that true fund-raising costs could be camouflaged. Thus, the latest effort to resolve the issues was issued by critics in the MCPA’s SOP 98-2.⁹ This standard permits the allocation of joint costs, but requires any entity with allocated joint costs to disclose the following: (a) the types of activities for which joint costs have been incurred, (b) a statement that such costs have been allocated, and (c) the total amount allocated during the period and the portion allocated to each functional expense category (MCPA SOP 98-2).

Objective and Methodology

Our study seeks to examine the impact of the new allocation disclosures on donors’ allocation of contributions among competing environmental organizations. An experiment will be conducted as follows. Subjects will be given an income statement and certain related footnotes for two environmental organizations. Individuals will be asked to assume the role of a member of a corporate committee responsible for selecting a recipient for a corporate contribution. Financial information provided is available to

assist participants in the selection of a beneficiary.

Some subjects will be provided with one income statement that includes the joint cost allocation disclosures required by SOP 98-2 and one that does not. Participants will be asked to analyze the available financial information and decide whether to select either organization as the contribution recipient. We expect that subjects will view more favorably (and more often select as the recipient of the corporate contribution) the organization which provides the joint cost allocation disclosure.

Another set of subjects will review two income statements that include the joint cost allocation disclosures required by SOP 98-2. However, one organization will have a large percentage of joint costs allocated to program services while the other will have a large proportion of these costs allocated to fund-raising expenses. If financial information users utilize the information provided in the joint cost footnote, we expect the organization that allocates more of the joint costs to fund-raising will be viewed more positively by the participants.

Expected Contribution

The results of this study will shed light on the effectiveness of the AICPA's new SOP 98-2. The outcome may help policy makers and standard setters establish guidelines for the allocation of costs for joint educational and fund-raising activities.

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⁹American Institute of Certified Public Accountants (MCPA). Statement of Position No. 98-2: *Accounting for Costs of Activities of Not-for-Profit Organizations and State and Local Governmental Entities That Include Fund Raising*. New York: MCPA, 1998.



Photo by Irv Rothman

GREEN SPACE—Nature trails are inviting in Memorial Park where landscapers protect nature by embedding stairs for hikers that protect against erosion.

Publications

"Green Giving: The Role of Financial Reporting in the Decision to Support Environmental Organizations," *J. of Accounting and Public Policy*. (To be submitted.)

Presentations

"Green Giving: The Role of Financial Reporting in the Decision to Support Environmental Organizations," American Accounting Assoc., Annual Mtg., San Diego, CA, Aug. 1999.

Full Costing of Remediation Alternatives to Improve Corporate Decisions with Environmental Impacts

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Neelima Jain, graduate student, Industrial Engineering, UH

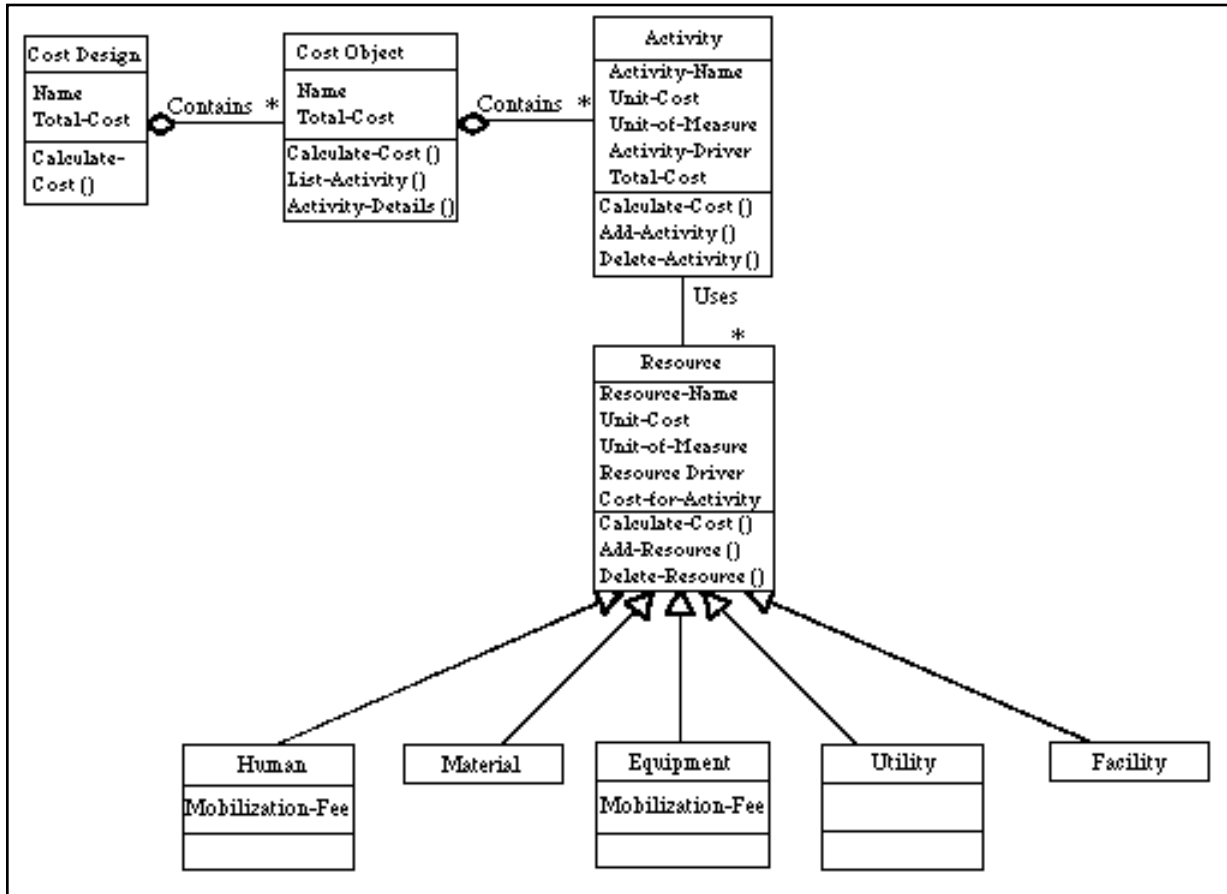


Figure 1. Class Diagram for Remediation

ENVIRONMENTAL COMPLIANCE costs have reached staggering proportion. The largest share of these costs is applied toward remediation, which is now approaching \$1 trillion.¹ The Gulf Coast, which houses the largest petrochemical complex in the world, is particularly sensitive to remediation costs. Costs associated with remediation are typically included in non-manufacturing overhead. Some of these costs are capital in nature; other costs involve

permitting, monitoring, regulatory, and maintenance activities. Additionally, contingency factors may require adjustment using the probabilities of environmental incidents, such as spills. Remediation costs are distinguished from manufacturing costs in accounting methodology. Yet, remediation activities directly compete for financial and human resources with production as well as proactive environmental programs, such as pollution prevention. Remediation is consequently related to production decisions through the budgeting process. Thus, inefficient remediation

decisions can translate into inefficient production and business decisions. Remediation costs must be properly accounted for and integrated with other costing systems in a firm.

This research has built on prototypical software that focused on environmental costing to address the full costs of alternative remediation activities. This has entailed redesigning and implementing the tool in an object-oriented platform, to facilitate three primary analyses:

- activity-based costing to ensure proper capture and accumulation of significant

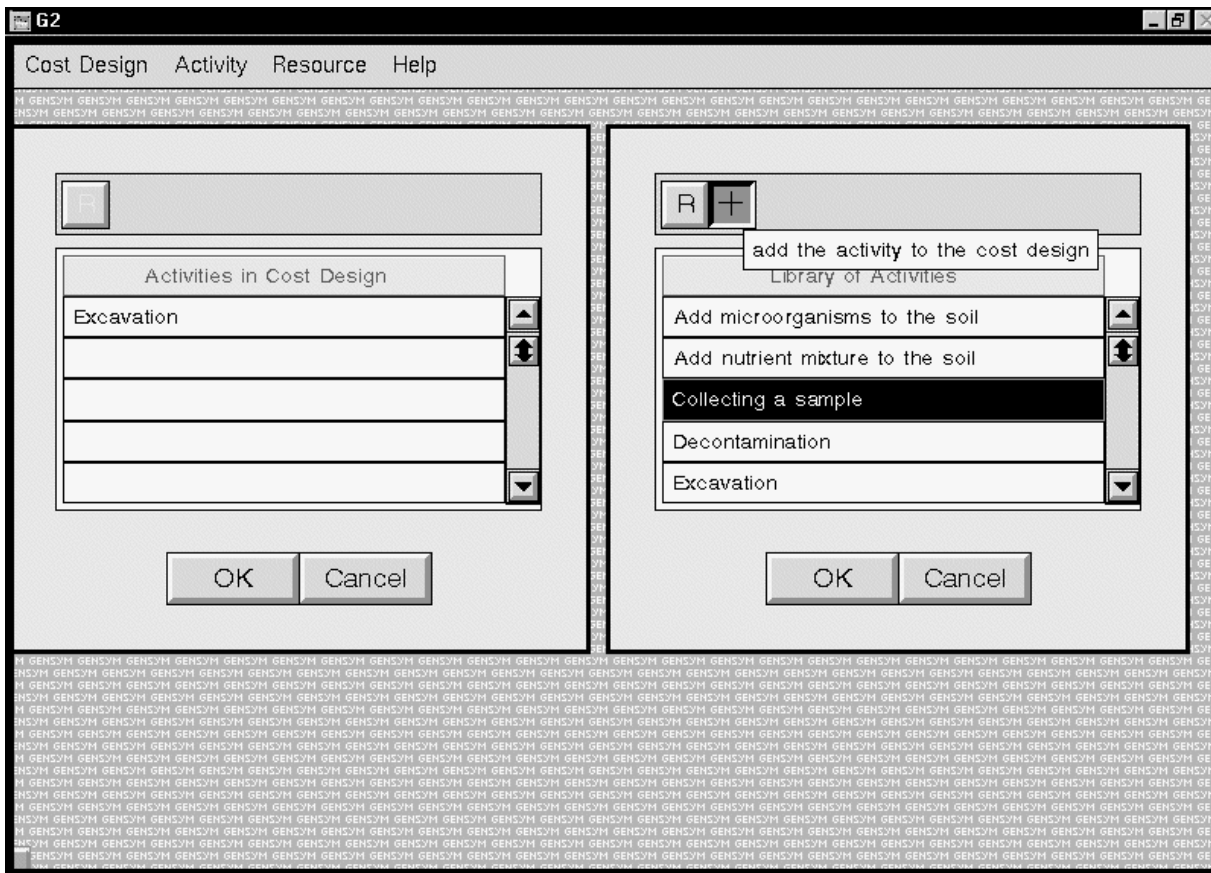


Figure 2. Select Activities from the Activity Library to Build the Cost Scenario

costs;

- extensibility so that new activities, costs, and information can be added in real time; and
- analysis of costs as they progress through the system life-cycle and treatment trains.

In object-orientation, a primary product is the structure of the objects: the class hierarchy. The class hierarchy depicted in Fig. 1. has been developed for remediation activities. The hierarchy is based on business object-oriented architecture, developed in the predecessor tool, ABECAS, which extended Taylor's² work. The computer architecture consists of three types of objects or object classes: organization, process, and resource. This structure also facilitates aggregation along any of the classes. Aggregation of costs around any object essentially renders that object a "cost object," a traditional cost accounting term. However, the class hierarchy devised here

allows any object to be a cost object. Several new, non-traditional cost objects have been identified to inform corporate decisions involving environmental as well as remediation costs.

Providing cost information along the organization hierarchy is useful for validating the system and comparing alternatives with the status quo. Rolling-up costs according to remediation type yields the life-cycle cost of that alternative. Total requirements for any resource are calculated by rolling-up all costs associated with that resource.

The survey of traditional and some innovative remediation technologies has enabled identification of 40 remediation activities and 80 resources. Empirical cost data from industrial-based costing manuals as well as government reports have been collected for the resources, the elements that incur cost or accrue benefit. These data are embedded

in the tool as activity and resource libraries that the user can employ to construct a scenario, as shown in Fig. 2. The tool is undergoing validation against a hypothetical site and actual sites for which estimated and actual costs exist are being assembled.

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Heller, M. "Information Architecture Needs for Sustainable Corporate Decision-Making," World Resources Institute's BELL Workshop at Univ. of Houston, Houston, TX, Feb. 20, 1998.

Heller, M. "Overview of Life-Cycle Assessment," Department of Environmental Science and Engineering, Environmental Science and Engineering 490, Rice Univ., Houston, TX, Feb. 6, 1998.

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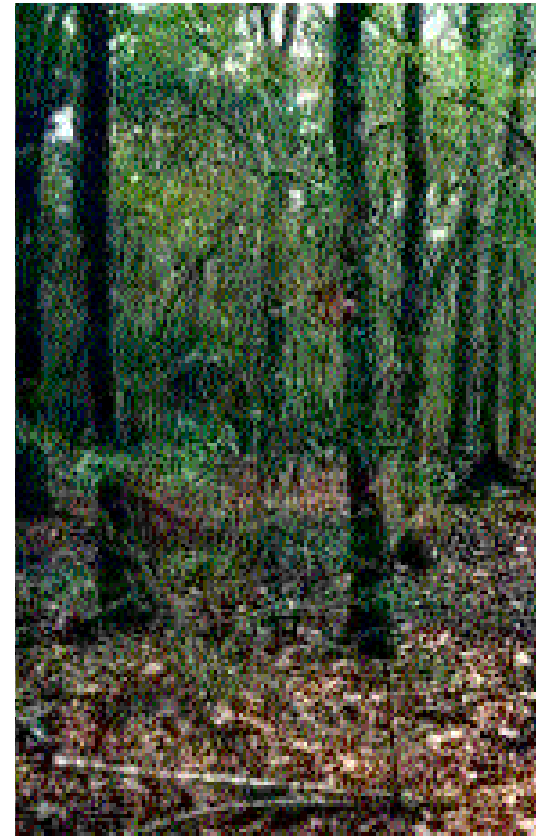
Funding

"Bioremediation: Scientific, Social and Business Issues," Co-PI:Name; Shell Interdisciplinary Scholars Program for 1996-1998, Feb. 1998-Jan. 1999, \$100,000.

"Feasibility Study to Develop an Artificial Intelligence System for Optimization of Water Treatment Plant Operations." American Water Works Association, submitted May 1998, \$199,000. (*Not funded.*)

"Material Flows Analysis in the Semiconductor Industry." Fulbright Scholarship Board, Sept. 1999-Aug. 2000; stipend.

"Membrane Systems Cost Estimator Expert." American Desalting Association/U. S. Bureau of Reclamation, Sept. 1998-Aug. 1999, \$40,000.



GREEN SPACE—Young hardwoods in Memorial Park, approximately eight miles from the University of Houston campus, show the fruits of conservation practices.



Environmental Issues

Development of a GIS Data Set for Studying Environmental Problems in Southeast Texas

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SOUTHEAST TEXAS, THE AREA comprised of Harris, Fort Bend, Brazoria, Chambers, and Galveston counties, is currently experiencing rapid growth. This growth has brought with it serious challenges in the form of (1) natural environmental hazards inherent in the area and (2) anthropogenic pollutants introduced into the soil, air, and water of the region.

Environmental problems represented by these challenges are a major concern among the social, political, and economic sectors of the population. All too often these groups have made decisions without the benefit of accessible data in a form readily

usable in environmental studies, a form capable of examining more than one parameter at a given location or analyzing the interaction of parameters that differ spatially.

The purpose of this proposal was to develop a GIS data set which could be used to (1) aid interested non-profit parties seeking to solve environmental problems, either by supplying data or conducting the GIS study on their behalf and (2) study environmental problems within a GIS course scheduled at UHCL.

Objectives of the study were met by developing an extensive GIS database for use in monitoring the status and trends of subsi-

dence within the Houston-Galveston County Subsidence District (HGCS D). The data set was then used for instructional purposes in Geology 3037: Introduction to GIS. Raw data for the project were obtained from a variety of sources. Data on groundwater levels in the two major aquifers were obtained from the U.S. Geological Survey. Well data, provided by the HGCS D, listed the location, size, and pumpage rates of over 5000 water wells located within the subsidence district. HGCS D data described the relative changes in surface elevation (subsidence) over time.

The most recent topographic maps of the study area (1957) were digitized and added to the data set. By combining the 1957 topographic maps with changes in elevation attributed to subsidence, a new digital elevation model (DEM) represented current elevations. Since surface water hydrology is directly affected by changes in surface elevations, researchers added a map of the bayous within the study area to the data set. We included census data, obtained from TIGER files, so that the impact of subsidence on humans could be quantified. Upon its completion, we demonstrated the GIS project to members of the Harris-Galveston County Subsidence District, Harris County Flood Control District, and the Houston-Galveston Area Council. Partnerships for the exchange of data and maintenance have been formed with each of these agencies.

Subsidence is an environmental process that can be grasped easily by students of various disciplines. Thus, GIS subsidence data provide pragmatic tools for students in introductory GIS classes.

Environmental Issues
**Experimental
 Tests of
 Captive
 Breeding
 Strategies**

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 Research Associate
 Professor; Dan E. Wells,
 Ph.D., Professor; and
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 graduate research assis-
 tant, Biology, UH*

THROUGH THE COURSE OF the Twentieth Century, the threat to biological diversity has increased at an alarming rate, and the fate of many species depends upon captive breeding.¹ Captive breeding programs assume that levels of genetic variation, fitness, and evolutionary flexibility are positively correlated. Consequently, the standard captive breeding strategy is to minimize inbreeding and balance the genetic representations of the founders with the intention of maximizing adaptive potential for reintroduction of the species into the wild.¹

Theoretical and empirical studies have contested the central tenets of this restoration strategy. If population bottlenecks increase the frequencies of detrimental genes,^{2,3} a strategy to maximize genetic diversity could actually accelerate extinction. This EIH experiment was explicitly designed to test this potential confound in attempts to save endangered species. In particular, the objective of the project was

to assay the short- and long-term effects of

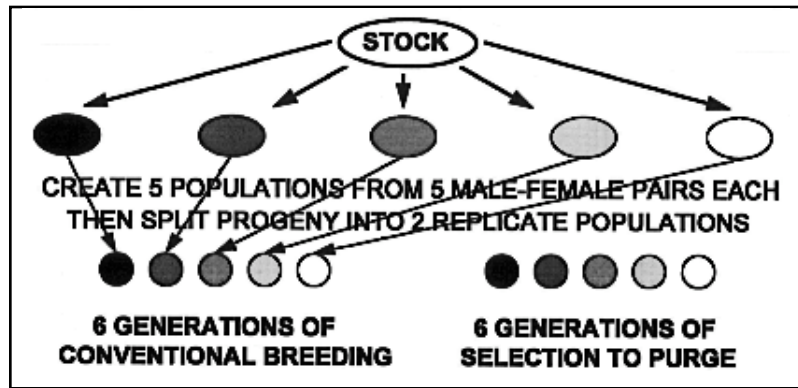


Figure 1. Schematic diagram of the EIH protocol. A stock population was used to derive five initial populations of five male-female pairs each. These populations were then split into two lines (five male-female pairs each), which underwent six generations of one of the two breeding schemes (i.e., the conventional design to minimize inbreeding versus a selection scheme to purge detrimental genes).

the conventional captive breeding strategy, compared to an alternative scheme to purge detrimental genes.

Progress

Housefly populations were subjected to six generations of captive breeding under either the conventional captive breeding design or a scheme to purge detrimental genes (Fig. 1). Fitness measures at the end of the breeding protocol showed highly significant differences for the genetic constitution of the founders and their responses to the two breeding schemes (Table 1). Additionally, the breeding scheme to restrict incest to the level of the first cousin matings (i.e., the conventional breeding strategy) resulted in significantly

higher fitness than the selection scheme that allowed full-sib matings (i.e., the selection scheme).

Pilot investigations into developing microsatellite techniques for assays of neutral genetic variation have resulted in a genomic library and identification of a monomorphic locus. Specifically, a *Musca* genomic library was prepared using Stratagene's λ Zap II cloning vector. The genomic DNA was isolated from adult flies adapting a protocol for fruit flies, digested to completion with EcoRI, ligated into the λ Zap II vector, and packaged using Stratagene's packing extract. The amplified library has a titer of 4.3×10^{10} pfu/ml with a total volume of 80 ml. The mean insert size is 3 Kb. The preliminary

Table 1. Analysis of Variance

SOURCE	DF	SS	MS	F	P
Model	8	1.73	0.22	4.17	0.0001
Founder	4	0.84	0.21	4.03	0.0037
Scheme	1	0.60	0.60	11.56	0.0008
Scheme (Founder)	3	0.80	0.27	5.13	0.0019
Error	194	10.06	0.05		
Corrected Total	202	11.78			

Analysis of variance on the fitness of bottlenecked populations subjected to two different breeding schemes for six generations. Significant effects were found for the differences among founders ("Founder"), breeding design ("Scheme"), and the responses of the founder populations to the breeding designs ("Scheme (Founder)").

screen for microsatellite variation was conducted by Mohamed Noor at Cornell University, from whom the fruit fly protocol was obtained.

Future Directions

With such encouraging results, the project is being continued with partial support from the National Science Foundation. The populations are now being “reintroduced” into an unpredictably variable environment to test for evolutionary flexibility. Additionally, archived specimens will be assayed for genetic variation at allozyme loci. The pilot investigations into developing microsatellite techniques are also ongoing.

Significance

Experiments such as this EIH project have documented the pervasive threat of inbreeding depression from prolonged periods of low population size. Ongoing research to examine the relationships among fitness, adaptability, and genetic variation is critical for understanding how natural, captive, or invading populations recover from near-extinctions.

References

¹*Creative Conservation: Interactive Management of Wild and Captive Animals*. Eds. P. J. S. Olney, G. M. Mace, and A. T. C. Feister. Chapman and Hall, London, 1994.

²J. H. Willis and H. A. Orr. “Increased Heritable Variation Following Population Bottlenecks: The Role of Dominance,” *Evolution* 47 (1993): 949-56.

³L. M. Meffert. “Experimental Tests of Founder-Flush Speciation and their Implications for Conservation Biology,” *Bio-Science*. (In review.)

GREEN SPACE—The bank along Buffalo Bayou in Metropolitan Houston. Allen Parkway on one side and Memorial Drive on the other were designed to follow the path of the bayou, not to hide it.

Publications

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Funding

“Partitioning the Effects of Immigration and Selection in Finite Populations.” NSF Program in Population Biology. (Not funded.)

“Developing High Resolution Molecular Assays for Metapopulation Experiments.” NSF POWRE Program in Biology. (Not funded.)

“Experimental Tests of Captive Breeding Strategies.” NSF Conservation and Restoration Biology Program in Population Biology, PI: L. M. Meffert; 1998-2001, \$245,000.



Photo by Irv Rothman

Environmental Issues

Effect of Environmental Pollutants on the Early Development of the Rio Grande Chirping Frog, *Syrrhophus cystignathoides campi*, a Direct Developing Frog

Dan E. Wells, Ph.D.,
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AMPHIBIAN POPULATIONS throughout the world have recently experienced a decline and/or reduction in range. Even though in some cases these declines can be directly attributed to natural epidemics and to human disturbance, in most cases there is no clear correlation. Researchers have postulated that environmental pollutants (global warming, UV radiation, acid rain, pesticides, petroleum contaminants, etc.), acting singly or synergistically, are indirectly responsible for these declines. Environmental pollutants can affect the immune system making organisms more susceptible to diseases, retard growth and metamorphosis, or impair reproduction.

The Rio Grande Chirping frog, *Syrrhophus cystignathoides campi* (*Leptodactylidae*), is a direct developing

frog inhabiting the Houston area. Unlike *Xenopus*, the model of anuran development, *Syrrhophus* is confined to a more terrestrial existence throughout its life. It buries its eggs under moist soil from where the froglets hatch. Because of these strikingly different modes of development, it is important to study direct developmental pathways and understand the factors which regulate and affect these pathways before we can start addressing the effects of specific pollutants. The objectives were twofold: to establish a captive breeding program which provides easy access to frogs at various stages and to document early morphological changes.

With respect to our first objective, we now have a captive population of 24 adults (at least three gravid females—eggs are visible through the abdomen) and about 30 froglets. These individuals are being kept in 55 gallon terraria mimicking their natural environment. The substrate is made up of gravel and potting soil. Pothos plants provide vegetation for cover and perching areas for the frogs. Dead leaves, pieces of wood, and rocks supply additional cover. The frogs are fed daily with fruit flies and crickets. Once a week these insects are dusted with vitamins to supplement the frogs' diet.

We have started intraperitoneal hormonal injections (synthetic gonadotropin releasing hormone—GnRH) to induce mating. At this point we are trying to optimize the hormonal dosage. Our first trial (~10-20 μ l of 0.1mg/ml) resulted in some sporadic chirping by the males throughout the night. For the second trial, we injected the same dosage for two days in a row. We observed an increased level of activity by all the males as well as almost immediate chirping upon injection. We have yet to obtain a response from the females. Our current plans are to

double the dosage for the females (~10-20 μ l of 0.2mg/ml) and to inject several days in a row.

As for our second objective, we have documented embryological development from the time eggs were laid until the resorption of the yolk, post-hatching. The tail is the only remnant feature of the tadpole stage. It is a thin membrane, highly vascularized, which might serve as a respiratory organ during embryological development. We have divided *S. cystignathoides campi* development into 15 stages¹ based on major developmental features (Fig. 1).

We will construct a time table to complement our stage table by following development at different temperatures. At that point, we will be ready to expose the frogs to various pollutants and compare their development against our stage/time table.

Reference

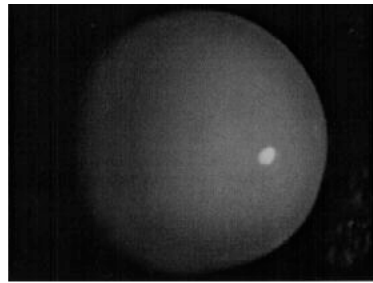
¹D. S. Townsend and M. S. Stewart. "Direct Development in *Eleutherodactylus coqui* (Anura: *Leptodactylidae*): A Staging Table," *Copeia* 2 (1985): 423-36.

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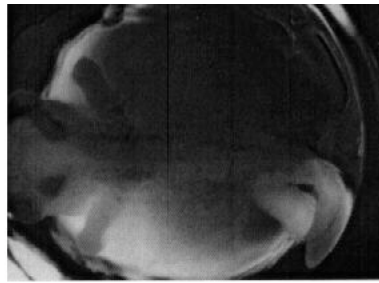
Gutiérrez, L., C. Dai, and D. Wells. "Direct Development of *Syrrhophus cystignathoides campi*." (*In preparation.*)

Presentations

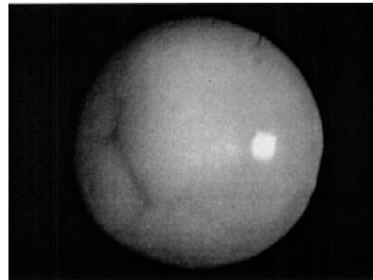
Wells, D. "The Rio Grande Chirping Frog, *Syrrhophus cystignathoides campi*, A Web Page," <http://wimp.nsm.uh.edu/Syrrhophus>.



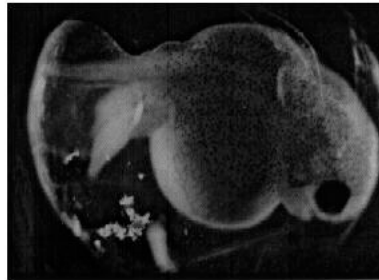
Stage 1: Fertilized egg (3mm)



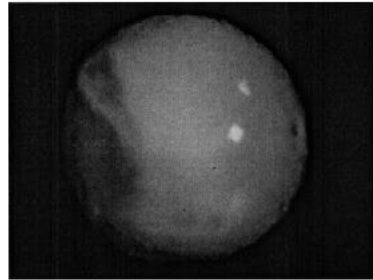
Stage 7: Tail and foot paddles



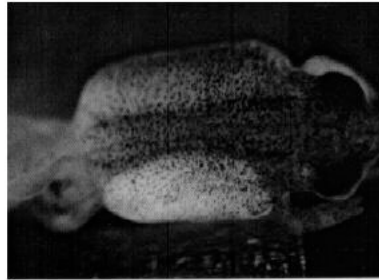
Stage 1: Cleavage furrows



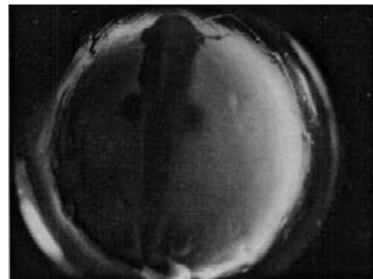
Stage 11: Trunk disc pigmentation



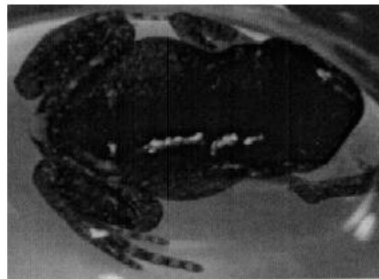
Stage 3: Neural groove



Stage 14: Embryo outside membrane



Stage 4: Limb and tail buds



Final Stage: Newly hatched frog

Figure 1. The Stages of the Development of the Chirping Frog

Gulf Coast Area Evaluation of the Ecotoxicology of Mercury in Lavaca Bay, Texas

Cynthia Howard, Ph.D.,
Associate Professor,
Biology and
Environmental Sciences,
UHCL

THE HEALTH OF TEXAS waterways and ecosystems can be maintained only by constant monitoring. Monitoring standards are determined by measurement models that enable assessment and help government establish guidelines for effluents and clean-up.

The study objectives of this research were to (1) use the Sediment Quality Triad approach¹ to determine mercury impacts in Lavaca Bay compared to Carancahua Bay, (2) determine *Hg*-metallothionein (*Hg*-Mt) and stress protein (SP) induction and accumulation in different species occupying the Lavaca Bay food web, and (3) compare tissue levels of mercury in benthic macroinvertebrates, epifauna and nekton between contaminated and reference sites. These findings would be utilized to develop a model for the ecotoxic impact of mercury on an estuarine ecosystem.

Sediment Quality Triad evaluations integrate sediment chemistry with toxicity studies and benthic macroinvertebrate community studies to measure pollution degradation. The project design required field sampling for sediments, benthos and nekton; cold vapor atomic absorption spectrophotometry (AAS) for mercury and *Hg*-Mt analyses; and polyacrylamide gel electrophoresis for SP analysis.

Two sampling trips were taken to Lavaca and Carancahua Bays. On the first trip, sediment samples were collected from two test sites in Lavaca Bay and from a reference site in Carancahua Bay. At each site, approximately three gallons of sediment were collected for the lab bioassays; sediment cores were collected in triplicate and stored in lexan plastic tubes for mercury analysis. Approximately 50 grass shrimp (*Palaemonetes pugio*) were seined at the three sites and immediately frozen on dry ice for *Hg*, *Hg*-Mt and SP analyses.

Lastly, cage studies were set up at each site, using approximately 150 live grass shrimp collected previously from a non-polluted site on Galveston Island.

During the second sampling trip which occurred one week later, the grass shrimp in the cage studies were retrieved, frozen, and transported to UHCL for *Hg*, *Hg*-Mt and SP analyses.

Bioassay sediments were sieved gently through a No. 18 mesh screen to remove large debris and organisms, then used to set 10-day exposure tests (six replicates per site and reference; each replicate contained 1 L sediment overlain with 3 L lab seawater; 10 grass shrimp per replicate).

Bioassay test organisms had been collected from Galveston Island and acclimated to lab conditions for 72 hours. Water quality parameters (temperature, salinity, dissolved oxygen, and pH) and survivor counts were recorded every day. Upon completion of the 10-day exposure period, survivors were removed and frozen for *Hg*, *Hg*-Mt and SP analyses.

Bioassays were completed and during the next four months, we began the *Hg*-digestion procedures on the sediment core samples and completed *Hg* analysis by cold vapor AAS on some of the samples. After a number of grass shrimp tissues for the SP analyses were processed, we began techniques for polyacrylamide gel electrophoresis. More sample testing is required. Therefore, continuation funding has been provided for completion during FY99.

Reference

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Gulf Coast Area

An Environmental History of Galveston Bay: Bibliographic Sources

*Martin V. Melosi, Ph.D.,
Professor, and Charles
Closmann, graduate
student, History, UH*

A COMPREHENSIVE BIBLIOGRAPHY and source book has been prepared on the environmental history of Galveston Bay. Although the original plan for this project emphasized the “environmental” history of this region, UH researchers wanted to include enough sources on the economic, social, and political history of Southeast Texas so that prospective researchers could study the ecological evolution of Galveston Bay in relation to changing human impacts over time. Hence, we decided to produce not only a guide to the scientific and environmental history of this region, but a useful resource on the social, economic, and political history of the Bay area.

The research did not attempt to duplicate a five-volume Galveston Bay Bibliography on the oceanographic, biological, and ecological aspects of this region and its history published by the Texas A&M University at Galveston in 1993 under the sponsorship of the Galveston Bay National Estuary Program. UH researchers chose to emphasize the major archival and special document collections on Galveston Bay, a slightly different task and one more relevant to the scholar interested in primary research.

We used a variety of research methods to complete our project. In order to gather data on local collections, Mr. Closmann conducted personal interviews with key archivists and librarians in the Houston-Galveston Area. These included, but were not limited to, personnel at Texas A&M University in Galveston; the University of Houston—Clear Lake; the Rosenberg Library; the Galveston County Historical Museum; the Houston Public Library, Texas and Local History Room; the Woodson Research Center at Rice University; and the Davis Conservation Library, in League City. Mr. Closmann also conducted telephone interviews with a much greater number of reference librarians, museum directors, and archivists at locations throughout the region. When personnel at important locations proved inaccessible, he referenced recent published guides to archives and libraries.

In each case, Closmann focused on the history of Galveston Bay and the needs of prospective researchers. Hence, entries in the first part of this finding guide include not only pertinent addresses, telephone numbers, and e-mail addresses, but descriptions of key manuscript collections on the environmental and ecological history of the Bay. Mr. Closmann also created a subject file index so that scholars interested in a particular topic could go directly to the back of this finding guide, look up their subject, and cross-reference to an archive or library with useful documents.

Finally, the guide includes a bibliography with approximately two hundred separate entries. These include books, articles, and primary source documents on the history of Galveston Bay and on the relationship between the physical environment and the development of this region. This bibliography, while not compre-

hensive, is a useful starting point for any scholar seeking background on the Texas Gulf Coast and its history.

The research was conducted and documented by Charles Closmann from January until the first week of July, 1998. Martin V. Melosi supervised the project while Christine Womack, project administrator for the Institute for Public History, assisted. Between ten and fifteen bound copies of this guide will be distributed to local libraries and archives. This document will be transmitted on the History Department’s website at the University of Houston. Texas A&M University in Galveston has offered advice on this project and expect to include this guide on their website.

Presentations

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Grants

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“Federal Dam Development in the United States.” Energy Laboratory, Aug. 1998, \$5,183.

Gulf Coast Area

A History of the Shrimp Fishery in Galveston Bay

*Priscilla Weeks, Ph.D.,
Research Associate,
and Alecyia Gallaway,
Environmental Historian,
EIH, UHCL*



Photo courtesy of Alecyia Gallaway

Shrimp ready for barrels on Galveston dock, 1920s

THIS HISTORY OF THE SHRIMP fishery combines the work of two researchers—oral historian Alecyia Gallaway and anthropologist Dr. Priscilla Weeks. As such, it forms an important part of Ms. Gallaway's social and natural history of the region and Weeks' policy oriented study of shrimp management.

History of Natural Resource Use on Galveston Bay

Alecyia Gallaway

First Nations and settlers were attracted to the Galveston Bay area for its land based and aquatic natural resources. Fish, crustaceans, and mollusks were an important part of the resource complex. Although First Nations favored mollusks, and early settlers favored finfish and mollusks, shrimp became the most important fishery by 1930. The capacity to freeze shrimp in the 1920s gave rise to their export to other parts of the country as well as to several countries abroad, the most notable being Japan. The region had several packing plants and canneries by the 1930s. Although shrimp harvested from natural waters cannot satisfy current market demand, it remains the

most economically important fishery in Texas.

Through their extractive activities, settlers (and their descendants) changed the landscape and seascape in dramatic ways. Concerns about overfishing and the waste of unwanted species caught in the net (bycatch) arose as early as the late 1800s, foreshadowing current management issues such as bycatch reduction devices and limited entry. During this period, the U.S. government tried to bolster the fishing industry by introducing exotic species, such as shad and Pacific salmon to state waters. This move foreshadowed recent strategies for enhancing the recreational fisheries with the introduction of rainbow trout into lakes and rivers. Promotion of the culture of exotic carp species at the turn of the century foreshadowed current shrimp aquaculture strategies, which rely on Latin American shrimp species.

Managing the Shrimp Fishery

Priscilla Weeks

Agencies are increasingly exploring new ways to involve the public in management decisions on commonly held natural resources. A cluster of negotiated decision making processes involving stakeholders—i.e.

interested parties—are used to resolve environmental issues related to the Galveston Bay region. Representatives from environmental groups, businesses, natural resource agencies, and local governments meet to discuss watershed management, wetland preservation, environmental risk, environmental education, and the subject of this study, fisheries management. Using the shrimp fishery as a case study, this project investigates processes that support or hinder such participatory approaches.

What does history have to do with these new policy strategies? Stakeholder negotiation does not happen in a vacuum. Researchers are becoming increasingly aware of the myriad ways in which negotiation occur in a larger social context. A broader understanding contributes to successful solutions. Factors originating outside of the facilitation itself come into play when members of different stakeholder groups meet. Such factors include historic unequal relations between stakeholders, past failed agreements, conflicting values, and varied economic relationships to the resource. These factors are rooted in the historic relations stakeholder groups have with the resource and with each other.

Furthermore, each group invests the bay with a unique set of meanings that guide their characterization of the bay and relationship of human beings to the natural life of the bay. It is variously understood as a site of work, a site of recreation, a site of scientific understanding, and as a site of religious sanctity. These meanings are forged over time and are related to wider values and economic strategies.

The shrimp fishery in Galveston Bay was chosen as a case to

study the impact of historical factors on negotiation for several reasons. First, it has historically been and continues to be an important industry. Second, the principal investigator has worked with fishery managers and shrimp fisherman for about five years and participated in their negotiations to frame a limited entry program. Her involvement in the limited entry negotiation offers a good vantage point from which to compare past with present and future negotiations.

Third, the contours of the shrimp fishery are still changing as a result of limited entry and the initiation of bycatch reduction devices. Fourth, new stakeholders in the form of national level environmental groups have visited the area and are pressing to be included in any new negotiations that might occur between the state and fishermen.



Photo courtesy of Alecyia Gallaway

Net Shrimpers, 1920s, moored at Galveston Wharf

ALMOST 90 PERCENT OF seagrasses in the Galveston Bay system have been decimated by coastal residential development and dredging. This may have serious consequences on Texas's commercial fisheries and shrimp. Seagrasses such as *Ruppia maritima* and *Halodule wrightii* provide a nursery environment for fish and shrimp larvae. Recent efforts to restore *Ruppia maritima* by transplanting have been relatively unsuccessful. This failure may be attributed to low genetic diversity of the donor population. Populations with a greater degree of genetic variation have a higher probability of withstanding the shock of a rapid change in environmental conditions that results from being transplanted to a recipient site.

Amplified fragment length polymorphisms (AFLP) provide a way to determine the genetic diversity within and between populations without having to know the sequence of the genome. Restriction digestion sites have adapters ligated to them which become the primer binding sites. Selective primers limit the number of restriction fragments that are amplified allowing the restriction fragments to be analyzed on a polyacrylamide gel (see Fig. 1). AFLPs are able to identify individuals in a population, which restriction fragment length polymorphisms (RFLP) have been unable to do. Restriction fragments provide a pattern unique to individuals or clones, identified as fingerprints. With this information, we hope to determine the clonal structure of a population to see how this characterization might affect inbreeding depression.

Results will identify the populations most suitable for transplanting which will facilitate repatriation of this important species.

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UHCL/UH

Gulf Coast Area

Genetic Diversity in *Ruppia maritima* and *Halodule wrightii*

Gerard Wellington, Ph.D., Professor, and Rachel Angel, graduate research assistant, Biology, UH

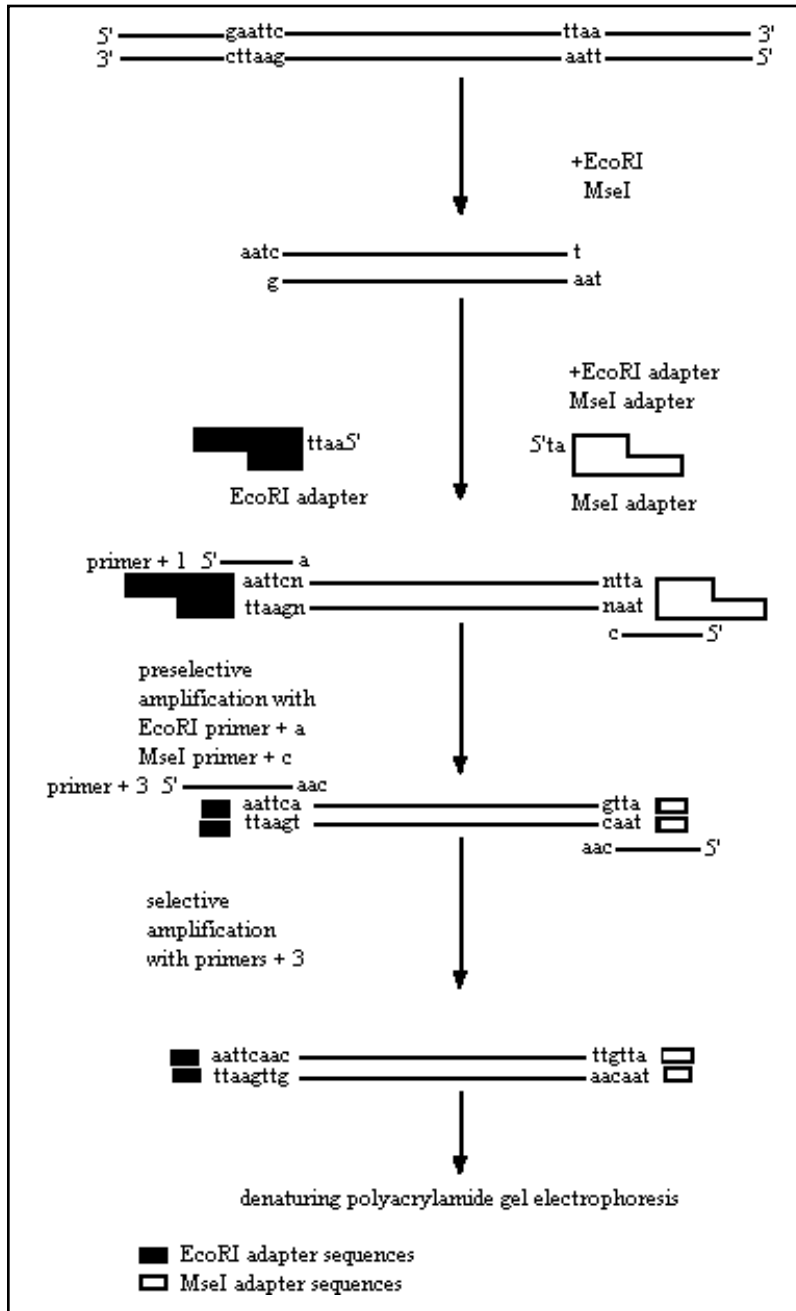


Figure 1. The AFLP Procedure

Funding

“Genetic Diversity in *Ruppia maritima* and *Halodule wrightii*.”
U. S. Fish and Wildlife, \$2,500.

GREEN SPACE—Fifteen miles north of Clear Lake and seven miles south of the UH campus, life at the ranch carries on in nineteenth century Texas tradition. Urban cowboys raise cows and run barbed wire—to keep the animals in and the people out. Scenes above and below are found at the southernmost point of Cullen Boulevard, a street that writes history as it extends its city miles past grazing cattle, country-style homesteads, and unpainted storefronts; past shopping centers and oil derricks awaiting shipment overseas; past Robertson Stadium, and the Texas Center for Superconductivity on the University of Houston Campus; and under the Gulf Freeway to the railroad tracks east and west.



Photos by Irv Rothman

Gulf Coast Area
**Population Age
Structure of
Reef-fishes
on an
Isolated
Western
Atlantic Reef
(Flower
Gardens,
Texas)
and the
Belize Barrier
Reef**

*Gerard Wellington,
Ph.D., Professor, and
Chris Caldwell, graduate
student, Biology, UH*

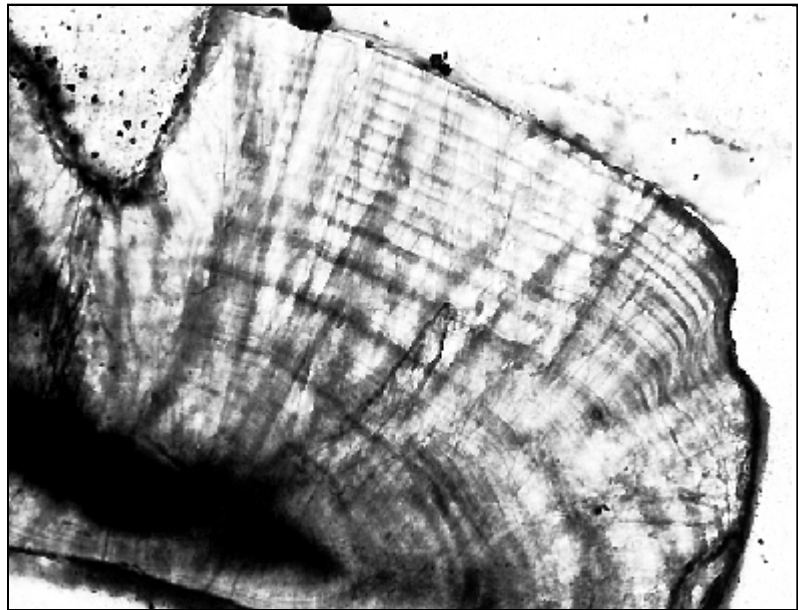


Figure 1. Transverse section through the sagittal otolith (earbone) of a 90.1 mm (SL) adult Threespot damselfish (*Stegastes planifrons*). Dark horizontal lines represent annual growth checkmarks. Based on the growth lines, this individual was 14 years old when collected.

REEF FISHES HAVE A LARVAL stage that they produce in vast numbers.¹ Larvae are dispersed into the planktonic milieu where they are subjected to currents that can advect them far from their natal reefs.² Despite a dispersive larval stage, viable populations of reef fishes are maintained at localities great distances from other potential sources of larvae. To examine the consequences of such isolation, we analyzed the population age structure of damselfish species at the Texas Flower Gardens (a potentially isolated offshore location) and compared it with the Belize Barrier Reef (an expansive reef system near the mainland). Age structure analysis can be utilized to demonstrate annual variation in recruitment of the fish to the reef, as well as, illustrate differences in mortality rates, life expectancies, and other life history traits.³

Information on age structure of a reef fish population can be gained from the otoliths or ear bones of the fish. As reef fish grow, alternating bands of translucent and opaque materials

are deposited on the otolith⁴ (Fig. 1). In addition to distinct daily bands that are deposited in larvae and newly-settled young, bands are formed at yearly intervals in many adult fishes.⁵ Age can be estimated by counting the number of bands within an otolith. By repeating the process for a number of individuals, the age composition of the population can be constructed. For the purposes of investigation, we chose to examine the otoliths in two species of damselfish known to be common throughout the Caribbean Sea and the Gulf of Mexico, Bicolor damselfish (*Stegastes partitus*) and Threespot damselfish (*Stegastes planifrons*).

Initial research reveals that otoliths from different locations and different species have varying degree of clarity in annual rings. This observation is concordant with Fowler⁴ who found that only two of three damselfish species examined had readable annual rings; one of those species had rings that were readable at one location only. Of the four damselfish populations we studied, only the Threespot dam-

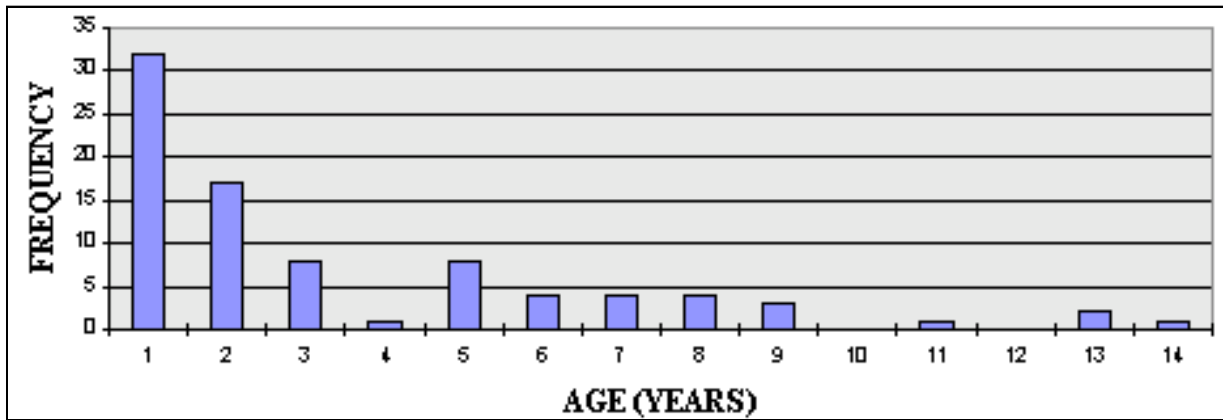


Figure 2. Age-frequency distribution of the Threespot damselfish (*Stegastes planifrons*) collected from the Texas Flower Garden Reef in June 1998. Absence of representative cohorts at years 4, 10, and 12 indicate lower recruitment episodes or periods of high juvenile mortality.

selfish from the Texas Flower Gardens had clearly visible rings (Fig. 1). Since only one species showed clear annual lines, we postulate that genetic factors play a role in ring deposition. In addition, since the rings were only clear at one location, we suspect that environmental factors also play a role.

Preliminary data show an exponential decline in growth rate of the Threespot damselfish collected from the Texas Flower Gardens. Threespot damselfish appear to achieve maximum growth at about three years of age, increasing by about 10 mm in length over the succeeding 11 years. As expected, the Threespot damselfish population is composed mainly of fish 1+ and 2+ years old with a large decline in numbers of the older age classes through the 14+ year class (Fig. 2). Patterns of variation in age-class structure indicate that there were periods of low recruitment (or high juvenile mortality) in years 4, 10, and 12 (1994, 1988, and 1986, respectively). These preliminary results indicate large variations in damselfish recruitment on reef at the Texas Flower Gardens.

Knowledge of variation in recruitment is important in developing effective management policies since exploitation of stocks with high variability in

recruitment can jeopardize the stability of those stocks and others that are dependent on them.

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- "ENSO Temperature Influences on Larval Fish Growth Rates, Planktonic Durations, and Recruitment Success." NSF-OCE, \$254,614. (*Pending.*)

Environmental Technology

Quantum Studies of Polymer Semiconductors

Eric R. Bittner, Ph.D.,
Professor, Chemistry, UH

ORGANIC-BASED POLYMER semiconductors exhibit a wide range of optical associated with the quasi-one-dimensional nature of the first few excited states. These properties can be easily tuned over a wide range through chemical modification of the side chains. The tunability of these materials and their mechanical properties make conjugated polymer devices very attractive for technological devices. Furthermore, the synthesis and manufacturing of these materials does not involve the production of heavy-metallic byproducts, such as *GaAs*, *Th*, and *Rb*, thus minimizing the environmental impact of their production.

In this project, we focused upon the development of new theoretical methods specifically aimed towards understanding and predicting the optical and electronic properties of organic based polymer semiconductors. The two methods being developed are based upon a unified treatment of the coupled time-dependent electronic and nuclear motions of photo-excited systems. These methods are summarized below.

First Principles Treatment

We developed a hybrid quantum/classical method to perform *ab initio* molecular dynamics in electronically excited systems.¹ Our method uses a dynamical variational treatment² of the excitation ener-

gy of the system. We derive, within the Random Phase Approximation (RPA) coupled equations of motion for the excited state amplitudes, the occupied single particle orbitals and the nuclear coordinates. The RPA becomes very accurate as the density of states near the excitation energy becomes large. Hence, our methodology is well suited for extended systems in the condensed phase, such as π -conjugated polymers and antenna molecules. Model

calculations on an interacting N -electron $SU(2)$ model give excellent results compared to exact solutions of the model. (See Fig. 1.)

For realistic molecular calculations, the method scales roughly as $\sim M \times N^2$, where M is the number of plane wave basis functions used to represent the electronic wavefunctions and N is the number of electrons. This scaling arises through the imposition of holonomic constraints which require the single particle orbitals (the Kohn-Sham³ orbitals in Density Functional Theory) to be orthogonal, while the computation and propagation of the RPA wavefunction require the computation of two-body Coulomb integrals between particle/hole states. Such terms are computed by Fast Fourier Transform (FFT) methods and can be computed easily. In short, our current estimate is that the evolution of the excited state dynamics occurs with a modest increase (by a factor of four to 10) in computational effort over an ordinary ground state Car-Parrenello molecular dynamics run. In Fig. 2 we compare computational efforts for

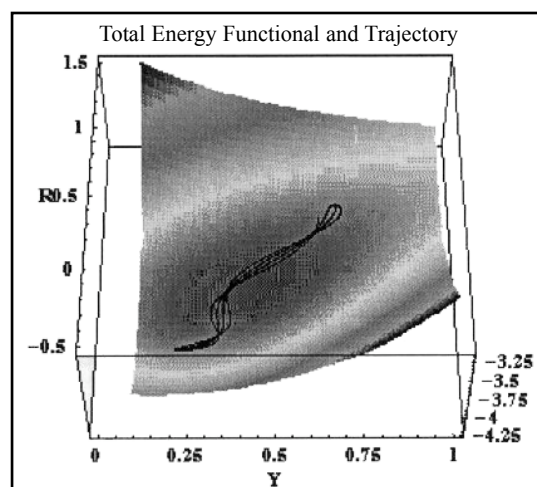


Figure 1. RPA energy plotted as a function of the excited state amplitude, Y , and classical coordinate R . The trajectory follows the optimal adiabatic Born-Oppenheimer energy surface via the RPA equations of motion. Along this path, the quantum excited state wavefunction and classical variables evolve according to a unified set of dynamical equations.

computing the excited state dynamics in a linear polyene using our RPA method (CP/RPA) and using a standard configuration interaction (CI) approach. In all cases, our methods ran at least four to six times faster than the standard approach.

We are currently working on implementing our methods into a full-scale simulation package which will optimally run on parallel processing supercomputers. Future applications include modeling of polaron formation in optically excited conjugated polymers, photo-induced reactions such as cis to trans isomerization in stilbene, and similar systems which are of current experimental interest.

Time Dependent Model

The photoluminescence of conjugated polymer systems is apparently controlled by the migration and eventual decay of particle/hole excitons. In quasi-one dimensional systems, such as trans-polyacetylene, the lifetime and dynamics of a particle/hole exciton is determined by at least three factors: (1) the dielectric screening by the polymer chain and surrounding media, (2) the

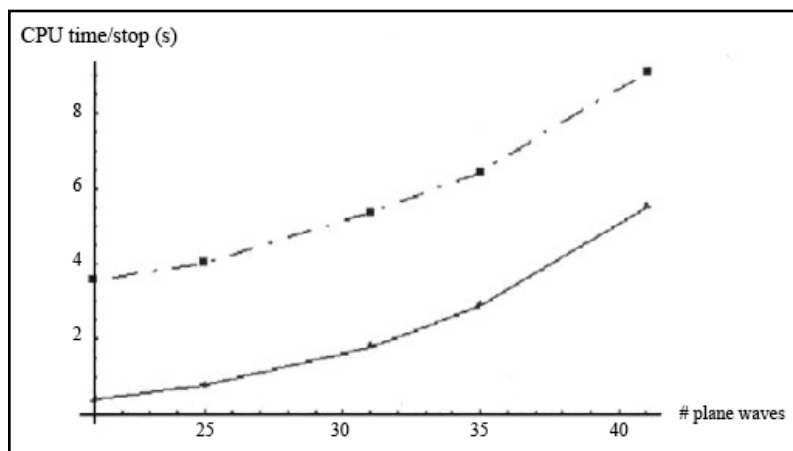


Figure 2. Comparison between CP/RPA method vs. configuration interaction (CI) with single excitations per MD time step as a function of number of plane waves for a linear polymer. The triangles are the CP/RPA results and the squares represent the CI results.

concentration of defects such as random *cis* (versus *trans*) lattice sites, and (3) the relaxation of polymer lattice through phonon excitation. Amongst the open questions which we are attempting to address is the extent to which each of these effects plays a role in determining the photoluminescence of conjugated polymer systems.

We are developing a time-dependent Wannier model of particle-hole dynamics which explicitly treats the particle and hole as independent degrees of freedom coupled by a screened Coulomb interaction. In the absence of this coupling, the particle and hole evolve on potential energy surfaces generated by the ionization potential (IP) and electron affinity (EA) of the individual atoms in the chain. Defects are introduced by increasing or decreasing the energy gap between the surfaces. We also include the response of the lattice via a phonon expansion. This model provides an unbiased test of the dependencies of the exciton lifetime, binding energetics and migration upon the three factors listed above.

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Design of Agents for the Control of Environmental Pathogens

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TO CONTROL THE SPREAD OF drug-resistant biological environmental pathogens, we are developing a new class of antibiotic compounds that will be effective against many penicillin-resistant bacterial strains. Toward this end, we have determined the three-dimensional crystal structure of an enzyme that catalyzes the production of a critical component of bacterial outer membranes. This essential biochemical building block is unique to Gram negative bacteria, is not present in humans, and acts completely independently of the biochemical pathway that is inhibited by penicillin and penicillin derivatives.

The three-dimensional crystal structure of the enzyme, KDO8P synthase (Fig. 1), may be used to design effective inhibitors for this enzyme. Such enzyme inhibitors will inhibit the growth and spread of environmental pathogens such as the bacteria *E. coli* and *Salmonella typhimurium* that pose a potential threat to the viability of food and water supplies. The present molecular model of the protein is being refined to ensure that the atomic structure is consistent with measured x-ray

diffraction data, which now extend

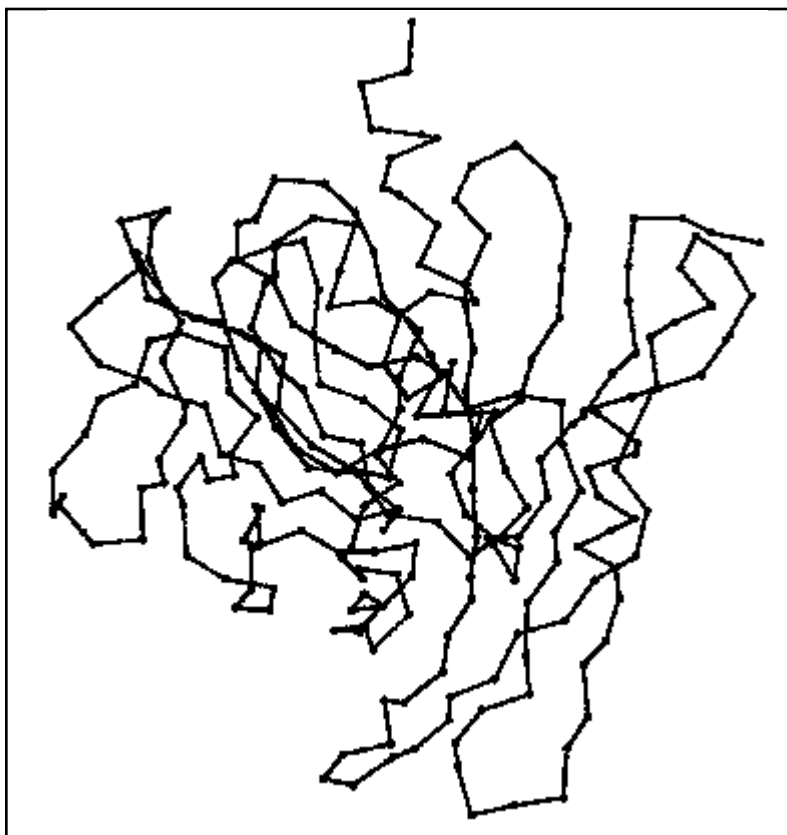


Figure 1. A preliminary crystal structure (α -Carbon atom backbone trace) of 2-keto-3-deoxy-D-arabino-octulosonate-8-phosphate synthase.

to a resolution of 2.45 Ångstroms. This refinement process will enable us to approach the next stage of the drug design process from a more reliable basis than is presently available.

In the course of the project period, we have collected multi-wavelength x-ray diffraction data at the Brookhaven National Synchrotron Light Source and have obtained an improved molecular model of the protein that better agrees with these higher resolution data. Further corrections are currently being incorporated into the three-dimensional molecular model. Crystallographic agreement factors for x-ray structures of proteins that have been accurately determined (to about 2.5Å resolution) typically lie in the range of 19 percent to 24 percent. In the course of the project, the agreement factor between the model and the x-ray diffraction data has improved

from about 45 percent to 27 percent at 2.6Å resolution.

In the course of this project we have also developed a new statistical method for the improved automatic identification of regions of disagreement between the model and experimental electron density. This experimental three-dimensional crystallographic electron density defines the shape and connectivity of the protein molecule within the crystal and is obtained by direct Fourier transform of crystallographically-phased diffraction data. The new statistical method has aided us in the structure refinement process for KDO8P synthase.



GREEN SPACE—A short walk from downtown Houston are the banks of Buffalo Bayou where one may watch the reflection of the light in the water or study nature.

Photos by Irv Rothman

Energy Conserving Window Coatings

David M. Hoffman,
Ph.D., Associate
Professor, and Murielle
Valet, graduate student,
Chemistry, UH

THIN FILMS OF ZIRCONIUM nitride (*ZrN*) exhibit low reflectance in the thermal IR region. Architectural glass coated with a thin film of *ZrN* would allow visible light to pass while it would at the same time reflect heat generating IR radiation, thereby saving energy in warm and cold weather climates.

The best method for preparing films for large scale applications is metal-organic chemical vapor deposition (CVD), a technique in which films are formed from vaporized reagents via chemical reactions. The technique itself is relatively simple and inexpensive, yet it typically produces dense, powder-free films with high growth rates and uniform coverage on substrates that need little preparation. Remarkably few reports may be found in the literature on the chemical vapor deposition of *ZrN* films, and they involve very high deposition temperatures.

The goal of this research is to develop new low-temperature (< 700°C) atmospheric-pressure CVD routes to *ZrN* films that can accommodate window glass and other thermally sensitive substrates. Research includes the synthesis of new metal precursors, film depositions, and extensive film characterization.

Our initial studies have focused on the

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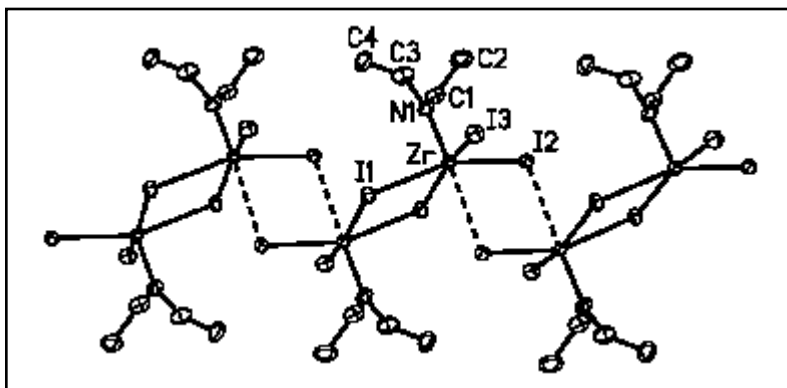
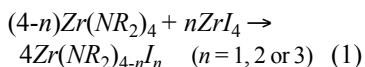


Figure 1. Thermal ellipsoid plot of $Zr[N(CH_2CH_3)_2]_3I_3$, a possible precursor to *ZrN* films, obtained from an x-ray crystallographic study.

synthesis of new zirconium precursors. The class of potential precursors targeted for synthesis, zircon amide-iodide compounds, is based on the idea that they can be readily reduced during the film deposition process, a step we believe will be critically important to successfully deposit *ZrN*. A series of six zirconium amide-iodides, $Zr(NR_2)_{4-n}I_n$ ($n = 1, 2$ or 3 and $R = CH_3$ or CH_2CH_3), have been prepared by using the synthetic method illustrated in equation (1).



Three of the new compounds, $Zr[N(CH_2CH_3)_2]_3I_3$, $Zr[N(CH_2CH_3)_2]_2I_2$, and $Zr[N(CH_3)_2]_3I$, have been definitively characterized by single-crystal x-ray crystallographic studies (Fig. 1). The most promising precursor candidates are $Zr[N(CH_2CH_3)_2]_3I$, a distillable liquid, and $Zr[N(CH_3)_2]_3I$, a sublimable solid. Precursor volatility is an important attribute if the compounds are to be used in a practical chemical vapor deposition process. Preliminary chemical vapor deposition studies are in progress.

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Photo by Irv Rothman

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GREEN SPACE—An expansive greensward competes with the Houston skyline. The forested site fronts Memorial Freeway across from the Houston Police Memorial. Bounded on the south by Allen Parkway, Buffalo Bayou flows past downtown and the Port of Houston to Galveston Bay.

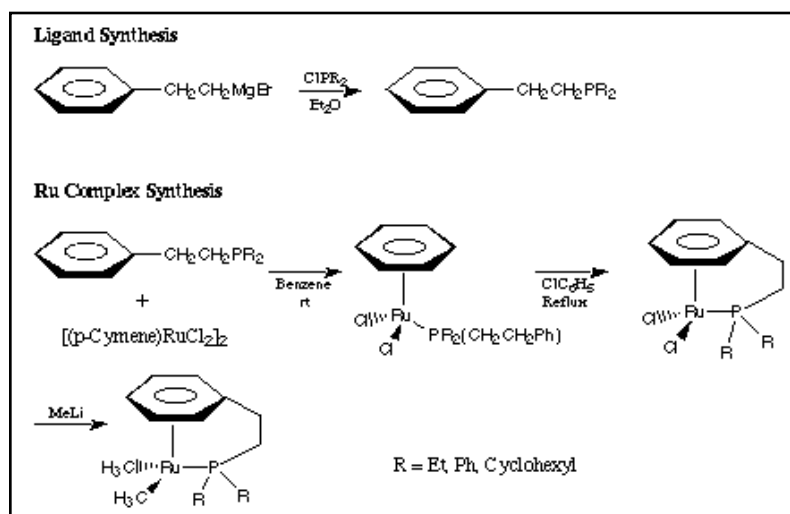
The Development of Environmentally Benign Routes to the Synthesis of Polyolefins

T. Randall Lee, Ph.D.,
Assistant Professor, and
Kayo U. Vizzini and
June-Ho Jung, graduate
students, Chemistry, UH

THE ZIEGLER-NATTA polymerization of olefins is an economically viable synthetic method for the preparation of technologically important polyolefins that serve as durable materials, fibers, and films.^{1,2} Current Ziegler-Natta polymerization techniques, however, require the use of hydrocarbon solvents. Because of the negative impact of these solvents on the environment, increasing pressure has been placed on chemists and chemical engineers to develop water-based methods for the synthesis of polymeric materials.

Water-based synthetic methods are more environmentally friendly than conventional hydrocarbon-based technologies because hydrocarbons, which are derived from oil, can pollute the air and ground. In addition, catalysts that are active in aqueous solution will likely tolerate the polar functional groups present in monomers, such as vinyl alcohols, esters and carboxylic acids. The

aqueous polymerization of polar mon-



Scheme 1. Synthesis of New *Ru*-based Catalyst Precursors

omers would not only circumvent the use of hydrocarbon solvents, but would also permit the direct synthesis of functionalized polyolefins. Furthermore, the presence of functional groups in the product polyolefins will permit facile degradation and disposal of used polyolefin products.

At present, there are few examples of Ziegler-Natta catalysts that can polymerize either functionalized olefins³ or unfunctionalized olefins in aqueous solution.⁴ We have targeted the development of ruthenium-based catalysts after finding recent reports testifying that related group eight metal complexes are capable of initiating the ring-opening metathesis polymerization of polar functional monomers in aqueous environments.⁵⁻⁸ Correspondingly, we anticipate that new ruthenium-based Ziegler-Natta catalysts will be able to tolerate a wide variety of olefins and/or solvents that contain polar functionalities.

We have synthesized a new family of ruthenium-based catalyst precursors having the general formula $[Ru(\eta^6\text{-arene})CH_2CH_2PR_2(CH_3)_2]$ ($R = \text{phenyl, cyclohexyl, ethyl}$) as shown in Scheme 1.^{9,10} We characterized these species by NMR spectroscopy and elemental analysis. Two of the precursors ($R =$

phenyl and cyclohexyl) were also characterized by single crystal x-ray crystallography. As an example, Fig. 1 shows the x-ray structure of $Ru(\eta^6\text{-arene})CH_2CH_2PPh_2(CH_3)_2$. This compound possesses a piano stool geometry with the two methyl groups *cis* to each other.

Catalyst precursors were "activated" by exposure to methylaluminoxane (MAO) or boron compounds such as $[H(Et_2O)_2]^+ [B(C_6H_3(CF_3)_2)_4]^-$ and $B(C_6F_5)_3$. These agents abstract one of the methyl groups leaving a coordinatively unsaturated metal center. In the presence of ethylene, however, we found no evidence of homopolymerization using these "activated" species, despite using high pressures of the olefin.

We are currently investigating several different ligand systems in an attempt to modify the electronic and steric factors of these and related *Ru* complexes. Our modifications will be designed to promote the insertion of the olefin moiety into the methyl-*Ru* bond, which is essential for the occurrence of polymerization. Once we have demonstrated the ability to generate an active *Ru*-based polymerization catalyst, we will explore the polymerization of polar olefins as well as the development of aqueous polymerization systems.

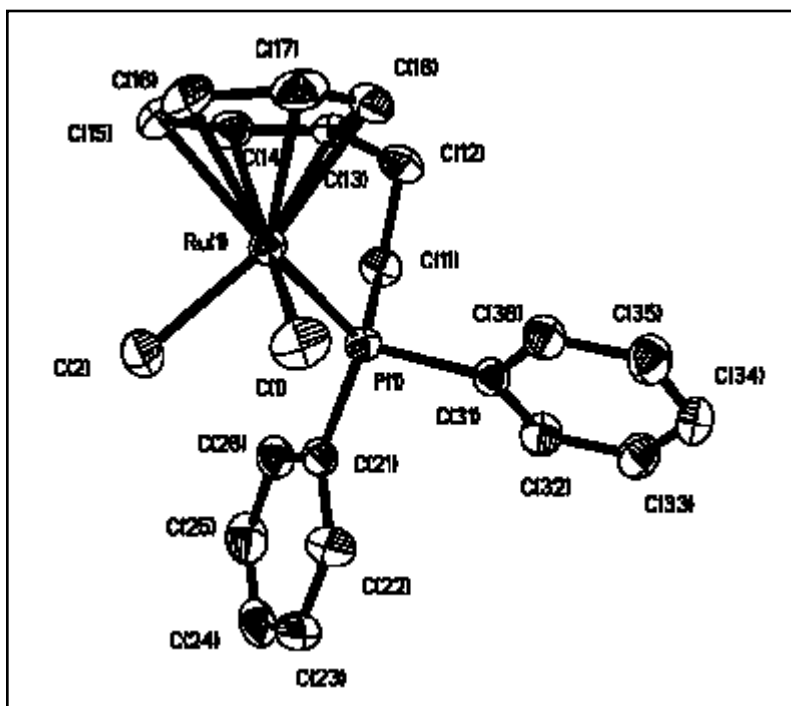


Figure 1. The Single Crystal X-Ray Structure of $Ru(\eta^6\text{-arene})CH_2CH_2PPh_2(CH_3)_2$

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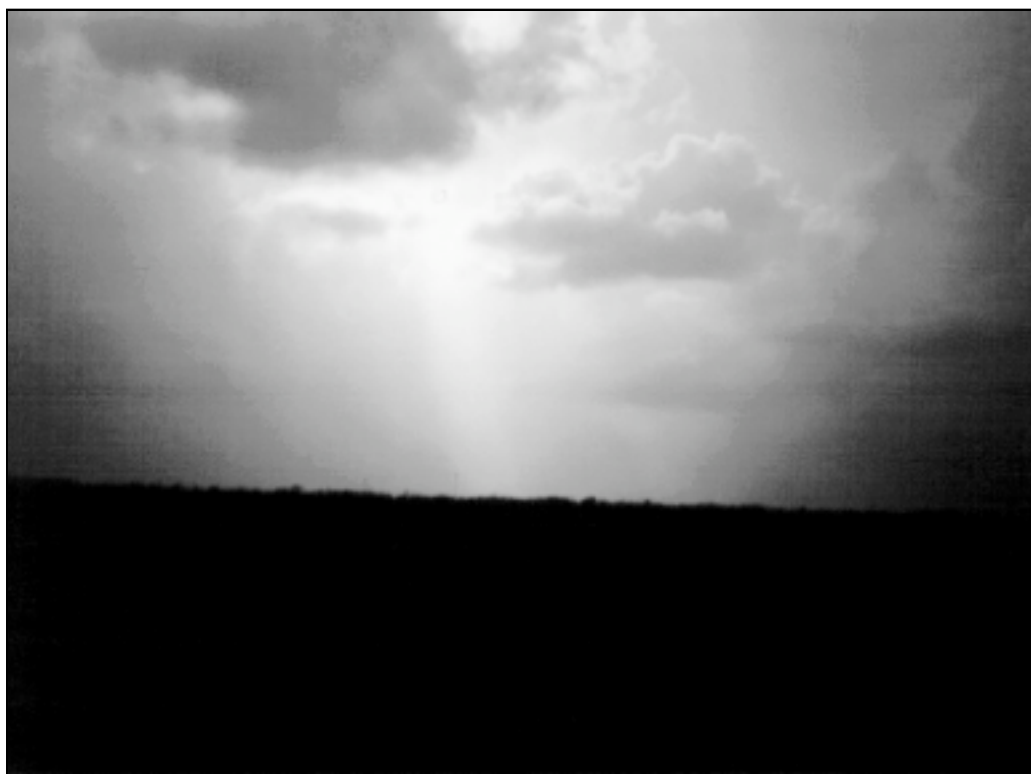


Photo by Irv Rothman

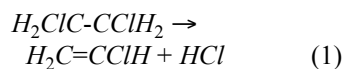
GREEN SPACE—Drivers on Highway 288 at sunset experience Texas' big sky.

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Environmental Technology Improved Technology for Pollution Prevention in Polyvinyl Chloride Manufacturing

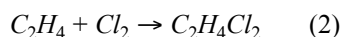
James T. Richardson,
Ph.D., Professor, and
Laurene Girin, graduate
student, Chemical
Engineering, UH

POLYVINYLCHLORIDE (PVC) is the second largest selling plastic, consuming almost one-third of the chlorine produced worldwide.¹ Used to manufacture pipe, conduit, fittings, wire insulation, packing and home furnishings, PVC was produced in the U. S. at the rate of 20 billion pounds per year in 1996 (with 60 percent of this along the Texas Gulf Coast), and will grow by about three percent per year for the foreseeable future.² Polyvinylchloride is made from vinyl chloride monomer (VCM), which in turn comes from the pyrolysis of ethylene dichloride (EDC) by Reaction (1).

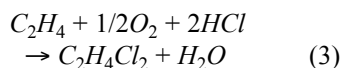


Since over 98 percent of EDC is consumed by VCM production, an integrated EDC plant comprises an important part of the modern PVC process. Current technology in the United States for making EDC is based on the "balanced" process, in which two routes are used to produce the EDC.³ The

first is direct chlorination, Reaction (2), a liquid phase reaction between Cl_2 and C_2H_4 in the range 60-150°C.



The second is oxychlorination, Reaction (3), using a supported $CuCl_2$ catalyst in the range 210-310°C.



Direct chlorination is very efficient, with the yield of EDC from C_2H_4 in excess of 99 percent. However, economic considerations favor combining Reaction (2) with Reaction (3), even though EDC selectivities in the latter are lower at around 96 percent. The reason is that HCl produced during pyrolysis, can be used completely, thus avoiding HCl disposal and decreasing Cl_2 import. Reactor outlet gases are combined and quenched by washing with water, splitting the stream into vent gas and a two-phase liquid mixture, which is decanted into an aqueous phase and crude EDC. The vent gas contains a few percent EDC, which is typically recovered by further condensation and solvent absorption. The aqueous stream contains HCl and must be treated before it is discharged.

The majority of organic contaminants are in the crude EDC stream, which is treated with dilute caustic and then distilled. Concentrations vary considerably with operating conditions, but typical values are given in Table 1.⁴ These emerge in the light and heavy ends of the distillation stage and amount to about one percent of the crude EDC fed to the unit. This product totals 200 million pounds per year of chlorocarbon contamination in the United States.

In the past, these compounds were sold for recovery of chlorinated solvents, etc., but current

regulations on the use of chlorocarbons have restricted this market. The current practice is to destroy the chlorocarbons by thermal incineration or catalytic oxidation. Incineration requires very high temperatures for efficient combustion. It can produce toxic intermediate compounds (PICs), gives NO_x emissions, and is very expensive. Catalytic oxidation requires lower temperatures, but conversions do not exceed 98 percent unless extreme processing conditions are practiced. In addition, many of the catalysts used are sensitive to Cl poisoning. Both methods emit large amounts of CO_2 and the only recycle in the process is HCl .

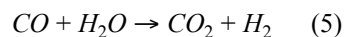
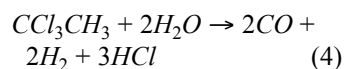
Strategies to reduce and control these wastes require forethought and planning, especially since health and regulatory requirements now play a greater part in the overall economics. The catalyst used in the oxychlorination stage has been well developed, and no further refinements in selectivity appear likely. Similarly, reactor and process design and operations have already been perfected to minimize by-products. Further steps in making the EDC/VCM process more benign will require considerable improvement in recovery, recycling, and disposal of the chlorinated by-products from the EDC purification section.

The purpose of this research is to perfect an alternate to catalytic incineration that promises not only to eliminate chlorocarbon emissions by converting all the by-products to HCl for recycle, but also to recover carbon and hydrogen as fuel. Recycle of all components is maximized with a process that will be essentially emission-free. This alternative, recently developed at the University of Houston, involves conversion of chlorinated hydrocarbons by catalytic steam reforming, which proceeds via

Table 1. Typical contaminate concentrations in crude EDC

Compound	Concentration ppm
<i>Light ends:</i>	
Methylene chloride	trace
Chloroform	1,000
Carbon tetrachloride	2,000
Vinyl chloride	100
Chloroethane	400
2-chloroethanol	200
1,2-dichloroethylene	trace
1,1-dichloroethane	trace
1,1,2-trichloroethylene	200
<i>Heavy ends:</i>	
1,1,2-trichloroethane	4,500
trichloroacetaldehyde	trace
1,1,2,2-tetrachloroethane	500
Pentachloroethane	trace
Dichlorobutene	100
Other	500

the following reactions (e.g. for 1,1,1-trichloroethane):



During earlier research,^{5,7} we conducted experiments on a wide range of chlorocarbons such as aliphatic solvents, chlorinated aromatics, and PCBs. Among those in Table 1 covered in this work were methyl chloride and trichloroethane. The chlorocarbon, typically a liquid, was

vaporized, mixed with steam and N_2 and injected just below the catalyst bed to minimize thermal side reactions. Space velocities ranged from 5000 to 500,000 hr⁻¹ and temperatures from 400 to 1000°C. Water and HCl were removed from the product and the gas analyzed for chlorocarbons, CH_4 , CO_2 , CO , and H_2 with appropriate gas chromatographs. With a chlorocarbon detection limit of 0.3 ppm and a large sampling loop, destruction levels of up to 6-nines were measured. Typical results for trichloroethylene are given in Table 2.

Parallel pyrolysis reactions also occur, producing a variety of intermediate compounds that quickly destruct catalytically. These also lead to heavy deposits of pyrolytic carbon that deactivate the catalyst. To avoid this, the reactor was designed to minimize pyrolysis in the preheat section and in the free space of the catalytic bed. Also, the catalyst must have very high activity so that catalytic routes predominate. We demonstrated that the most active catalysts (e.g. Pt , Rh and Pd) are at least 103 times faster than thermal decomposition. Consequently, very little carbon deposition

occurs through pyrolysis if catalytic conversion is maintained at high levels (> 99.99 percent).

We designed a catalyst bed in the form of a radial reactor made from ceramic foam and heated by radiant infrared lamps, so that the catalyst reaches a higher temperature than the surroundings.⁸ Conversion was constant at better than 99.9999+ percent for over 400 hours, at which time activity decreased and unconverted TCE appeared. This led to carbon formation and to further deactivation. Although the carbon was removed by combustion with oxygen and the original activity returned, conversion declined at an accelerated rate. This indicated that the original deactivation was irreversible and did not result from carbon deposition.

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Table 2. Steam Reforming of Trichloroethylene

Time, hr	Conv %	Product Composition, vol% (dry)			
		H_2	CO	CO_2	HCl
0.87	99.999	33.1	4.6	21.7	40.6
2.1	99.999	34.0	4.6	21.7	39.8
2.6	99.999	34.6	4.7	21.9	38.8
3.3	99.999	34.5	4.9	20.9	39.7
4.0	99.999	34.2	4.8	21.8	39.2
5.6	99.999	34.5	5.0	21.0	39.4

Catalyst: 23%Ni/ α - Al_2O_3
 Temperature: 800°C
 GHSV: 1.0×10^4 hr⁻¹
 H_2O/C : 13

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Funding

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\$53,000; Sept. 1, 1999-Aug. 31, 2000, \$53,000. (Submitted.)



Environmental Law
**Case Studies
in the
Resolution of
Volatile
Environmental
Disputes**

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SOME EXPLOSIVE ENVIRONMENTAL disputes in the Houston and Gulf Coast areas have been peaceably resolved, with formerly combative participants now embracing a common remedy. In contrast, other environmental disputes simply fester until the wounds consume the project, and no one wins. Several factors lead to success or failure in these instances.

Two notable examples of success in this arena are the Brio Superfund Site and the project for deepening and widening of the Houston Ship Channel. In the early 1990s, the community near the Brio Superfund Site was divided, and the Environmental Protection Agency became the object of distrust as much as the parties potentially responsible for the contamination and cleanup. However, by the time of a public meeting in the spring of 1997, the community leaders, the EPA, and the industry group jointly supported a revised remedy.

During a 1989 referendum on the deepening and widening of the Houston Ship Channel, various state and federal agencies were divided. The environmental community opposed the project, and proverbial war was threatening to erupt on the issue. At present, these agencies, environmental organizations, and the Port of Houston have reached consensus on a modified project that appears to address the major concerns of all parties.

This study examined the history of these two case studies and other environmental disputes, and analyzed factors leading to success. This process included a review of documents relating to these cases and interviews with people involved in the resolution of these cases. The analysis looked beyond just traditional conflict resolution and mediation practices into technical and procedural factors that contributed to success.

Among factors contributing to

the resolution of environmental disputes were providing a forum for open, genuine communication among stakeholders, addressing scientific or technical deficiencies when feasible, and developing trust not only among the various stakeholders but with the procedures or process.

Results to date have been the presentation of a conference paper at a national conference and acceptance of a paper for publication in a national journal.

Publications

Gossett, L. B. "Case Studies in the Resolution of Environmental Disputes," *Proc. of the 23rd Annual Conference of the National Association of Environmental Professionals*, June 1998.

Gossett, L. B. and L. W. Lam. "Stakeholder Management: Case Studies in Resolving Environmental Disputes," *Environmental Regulation and Permitting* (1998). (Accepted for publication.)

Presentations

Gossett, L. B. "Legal Implications of Certification and Registration of Environmental Professionals," 23rd Annual Conference of the National Association of Environmental Professionals, June 1998.

Gossett, L. B. "Section 401 Water Quality Certification in Federal Permitting," *Environmental Regulation and Permitting*, 7.4 (1998): 81-89.

Grants

Faculty Research Support Fund (FRSF) at UH-Clear Lake for presentation of "Case Studies in the Resolution of Environmental Disputes" at the 23rd Annual Conference of the National Association of Environmental Professionals, June 1998, \$600 from FRSF and \$675 from SBA.

Environmental Law
**The Impact
of
Key Federal
Legislation
on
U.S. Patent
Production
with
Environmental
Applications**

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Center, Economics;
Hiren Desai, graduate
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Management
Information Systems;
and Hardik Kansupda,
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THE RELATIONSHIP BETWEEN U.S. patent issuance dates for environmentally related claims and reported levels of selected effluents for the period 1970 to 1997 shows that government pressure encouraged investigation. The logical argument underpinning the investigation was that key federal legislation promoted patent activity in response to environmental degradation. Broadly construed, some statistical relation seemed feasible between rates and flows of selected effluents and patents designed to aid in their control.

Methodology and Data Sources
Investigation was entirely empirical and based on secondary data. The U.S. patent office web site provided access to all U.S. patents by keyword and category. The search facility of greatest value was the hypertext tool applied to patent abstracts. Other key information and data sources included the Environmental Protection Agency, the U. S. Department of Commerce, and the Bureau of Labor Statistics.

The first approach to the problem was to select an environmental effluent, measure it nationally over the period of interest, and compile related economic measures by which to assess any patent generation influence. After several rounds of discussion and preliminary investigation, it became clear that limited resources prevented a full-scale investigation on air or water pollution. Hazardous waste was also excluded because of its specific nature and fairly recent legislative history. The default choice became municipal solid waste.

Research was to focus on national measures of solid waste volume, then proceed to regional and state levels. Inconsistent geographical bounds and missing data prevented all but the national geography to be explored meaningfully. Further, the initial data design called for both annual and quarterly data. However,

solid waste data are reported only annually. Hence, U. S. patent counts related to annual solid waste collection, nationally, defined the data collection process.

Filtering and reviewing patent abstracts became a formidable task. To simplify research as much as possible, key words related to solid waste were identified through a review of works focused in that area. A short list of terms that appeared to be distinct and reasonably complete guided the patent abstract search effort. Any patent containing one of the search terms became a candidate for review. One researcher reviewed each candidate patent abstract for relevance. The selected abstracts were then reviewed by the principal investigator. One researcher arrayed the filtered patent pool by patent issuance date. A total of 452 patents comprised the relevant abstracts.

Key words used for screening the patent abstracts appear below:

Keyword List

Chemicals	Pollution
Data	Prevention
Emissions	Properties
Hazardous	Reduction
Level	Solid
Measurement	Standards
Monitoring	Toxic
Non-hazardous	Waste
Pollutants	

Other data collected included annual U.S. population, U.S. industrial output, U.S. personal income, U.S. total employment, and the consumer price level, U.S. city average. A researcher entered these data into a spreadsheet for analysis. All variables, including the annual patent "production" count formed the base file for analysis. The complete time period covered by the database was 1976 to 1993.

Table 1 relates key federal legislation by year to municipal solid waste generation nationally. It can be argued, but not proved,

Table 1. Key Legislation by Year

Year	Legislation
1960	<i>Stevenson-Wydler Technology Transfer Act</i>
1965	Solid Waste Disposal Act
1970	Resource Recovery Act
1976	Resource Conservation and Recovery Act
1986	<i>Federal Technology Transfer Act</i>
1987	Marine Plastic Pollution Research and Control Act
1989	<i>National Competitiveness Act</i>
1995	<i>National Technology Transfer and Advancement Act</i>
[Technology Transfer Acts in Italic and Solid Waste Acts in Bold]	

Table 2. Statistical Analysis

N = 18		degrees of freedom = 14	
<u>Regression Equation</u>	<u>Coefficient</u>	<u>t-Statistic</u>	<u>Significance</u>
Intercept	0.321570	3.96566	0.001
PI	5.91E-06	4.07763	0.001
PC	0.822140	3.08701	0.008
IO	0.000876	1.74083	0.103
R Square = 0.94	F Statistic	73.22	0.000

that legislation in the 1960s, middle 1970s, and middle 1980s opened the way for patents directed at municipal solid waste reduction, modification, and accommodation. It can be said, with more confidence, that legislative awareness of environmental issues was rising over the 1960 to 1990 period.

Findings

Ordinary least squares regression became the assessment tool of choice by which to analyze the data. With no compelling reason to apply any other technique(s), this widely accepted tool was the logical first choice. Results from the best multiple linear regression model, applied to the 18 observations, appear in Table 2. The dependent variable was total municipal solid waste in thousands of tons per capita (MSW). The independent variables were personal income per capita (PI), industrial output per capita (IO), and patent count (PC). A general form of the regression equation

is:

$$MSW = f(PI, IO, PC)$$

The linear regression application produced the following results.

The equation has an overall significant fit. Each independent variable in the equation is highly statistically significant, except patent count. The patent count variable is significant at the 10 percent level, which is moderately significant. At 10 percent significance, and other things equal, the investigator will err one time in ten rejecting the implicit hypothesis that there is no relationship between patent counts and municipal solid waste in the model above.

Somewhat troublesome is the algebraic sign on the patent count variable. On first thought, one might wish to see a negative sign to support the view that more patents mean less municipal solid waste. On deeper reflection, however, the coefficient can take

either sign. No theory exists to mandate the expected sign and other “stories” can be told of the patent count influence on solid waste. For example, the argument that rising waste volume begets additional patent generation suggests a positive relationship.

A plot (unadjusted) of the relevant patent counts by year appears in Fig. 1. While the trend is upward, much variation exists in the annual rate.

Results Interpretation

The results indicate that some relationship appears to exist between per capita municipal solid waste generation and related patent count production on a concurrent year basis, after accounting for the effects of income and output per capita. While the statistical reliability of the patent count variable is not highly significant, the result is suggestive.

Other issues pertaining to the model must be discussed. First, the structure of the model is in reduced form. That fact combined with the question of causality (which truly comes first, patent generation or solid waste?) permits much specification error to exist. Second, measurement error exists in all the variables, most blatantly in the municipal solid waste and patent count variables. Municipal solid waste per capita data are precise only to the second digit. Patent counts suffer from the choice of key word choice and quality of patent abstract screening applied to them. Third, only 18 serial data records are assessed. After a “degrees of freedom” correction, 14 degrees of freedom remain. The minimum ideal number of degrees of freedom is about 30. Hence, deductions made from this analysis should be studied with caution. Finally, a good case can be made that the patent count vari-

able should be lagged in time compared to the municipal solid waste data. Regression runs with a one, two, and three year lag, for the patent counts produced statistically insupportable results.

Conclusion

A statistical investigation into the influence of national legislation on U. S. patent production relevant to municipal solid waste generation provided some evidence that relevant patent generation was positively related, after accounting for population and production effects. Data for the analysis were drawn from official sources. The results are suggestive but not conclusive.

Limitations may be attributed to several sources. The data contain measurement error, the causal direction of the variables is arguable, the number of observations is small, and the regression test model quite simple. Additional work, using a similar approach, as well as alternative tests, would help to support or weigh against the conclusions drawn here.

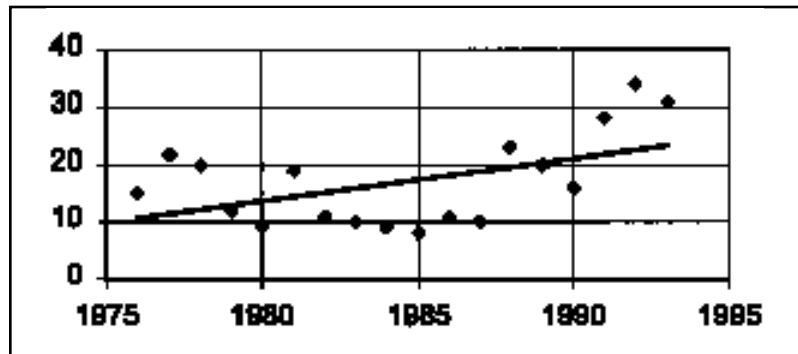


Figure 1. Municipal Solid Waste-Related Patent Count



GREEN SPACE—Within the environs of Houston, Memorial Park provides virgin woodland, trails designed to protect the habitat, running tracks for physical conditioning, tennis courts, playing fields, a nature resource center for classroom instruction.

Environmental Education
**Schoolyard
Ecoscapes in
Houston:
A Website
Catalogue
Project Report**

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Photo by Irv Rothman

GREEN SPACE—A great oak tree in the ecosystem of Sam Bass State Park.

SCHOOLYARD ECOSCAPES ARE gaining popularity across the country. These outdoor science laboratories provide students with opportunities to (1) increase their knowledge and understanding of the natural environment and humankind's relationship to its resources, (2) develop a sense of responsibility towards the natural environment, (3) study the features of the area, such as native plants, ponds, and/or animals and their interrelationships, (4) create a viable habitat for native plants and animals, and (5) promote minds-on learning in an authentic ecosystem. Many organizations and agencies, including the National Wildlife Federation, Texas Parks and Wildlife, and U. S. Fish and Wildlife, are promoting schoolyard ecoscapes as a learning environment for students of all ages.

As a result of this project, 15 schools in the Houston metroplex will have an opportunity to share with others their thoughts, advice, and resources regarding the building and maintaining of

schoolyard habitats. Through a series of photographs and anecdotes, schools who are beginning to think about schoolyard ecoscapes can visualize and learn from projects others have completed. In addition, they will have access to resource lists on a website that provide references to background information, children's literature, and curriculum materials about Texas wildlife, plants, and birds. A section has been created for tips from local wildlife experts. This website will be an extension of the Environmental Institute website.

The following schools participated in the project:

- River Oaks Elementary School
- Welch Middle School
- Lantrip Elementary School
- Red Elementary School
- Piney Point Elementary School
- Berry Elementary School
- Baker Jr. High School
- College Park Elementary
- San Jacinto Intermediate
- Pearl Hall Elementary
- Bondy Intermediate
- Wild Peach Elementary
- League City Elementary
- Teague Middle School
- Alice Johnson Jr. High School
- LaPorte High School



Photo courtesy of Terrell Dixon

NATURE WRITERS and friends on the Orion Society Forgotten Language Tour. Front row: (l. to r.) Richard Nelson, Laurig John Lane-Zucker, Janisse Ray, and Terrell Dixon. Back row: Carter Smith, Gary Nabhon, Gwentyth Wagner, Jack Archer, Alison Deming, Tate Hills, M. G. Gilliam, Sueellen Campbell, Walter Isle, Linda Walsh, and Robert Michael Pyle, author of *The Thunder Tree: Lessons from an Urban Wildland* (1993).

Environmental Education

Environment and Literature

Terrell Dixon, Ph.D., Associate Professor, and James Langston, doctoral student and research assistant, English, UH

AMERICAN ENVIRONMENTAL literature has traditionally been focused on wilderness experience and the preservation of remote and wild landscapes. Henry David Thoreau, John Muir, John Burroughs, and others in the historical mainstream of America nature writing specialized in the genre of literary non-fiction, celebrating nature as a source of pleasure, knowledge and solace, and advocating wildland preservation. The academic study of literature and the environment has tended, in the main, to focus on such literature of celebration and preservation.

In American literature of the second half twentieth-century, however,

serious and accomplished environmental literature has begun to expand its range of subject matter. Writers have begun to look at the environmental significance of urban landscapes, to consider the increasingly important subject of environmental restoration, and to deal with the pressing health and social problems created by toxic substances in our air, land, and food. Since the publication of Rachel Carson's *Silent Spring* (1962), creative writers have grown progressively more concerned with the problem of toxicity, creating a distinguished body of literary non-fiction and fiction on this problem.

Dixon's research and literary criticism now in progress looks at this literature and at what it tells us about America in the sec-

ond-half of the twentieth-century, studying first how American literary history (Nathaniel Hawthorne, Edith Wharton, and others) has dealt with the problem of poisons and how they are understood in the collective historical psyche. After studying closely Rachel Carson's work, research moves to a study of contemporary fiction including such key works as Don DeLillo's *White Noise* and Jane Smiley's *A Thousand Acres*. The book will deal with questions of environmental racism, environmental justice, and environmental restoration as they appear in American literature of the last three decades. It will also explore why American literature differs from the literature of other nations in having a literature of toxicity.

“Everyone has at least a chance of realizing a pleasurable and collegial wholeness with nature. But to get there, intimate association is necessary. A face-to-face encounter with a banana slug means much more than a Komodo dragon seen on television. With rhinos mating in the living room, who will care about the creatures next door? At least the skimmers are aware of nature. As for the others, whose lives hold little place for nature, how can they even care?”



Photo courtesy of Terrell Dixon

Robert Michael Pyle

The extinction of experience is not just about losing the personal benefits of the natural high. It also implies a cycle of disaffection that can have disastrous consequences. As cities and metastasizing suburbs forsake their natural diversity, and their citizens grow more removed from personal contact with nature, awareness and appreciation retreat. This breeds apathy toward environmental concerns and, inevitably, further degradation of the common habitat.

So it goes, on and on, the extinction of experience sucking the life from the land, the intimacy from our connections. This is how the passing of otherwise common species from our immediate vicinities can be as significant as the total loss of rarities. People who care, conserve; people who don't know, don't care. What is the extinction of the condor to a child who has never known a wren?"—
Robert Michael Pyle, *The Thunder Tree: Lessons from an Urban Wildland*. Boston: Houghton Mifflin, 1993. 146-47.

Research will identify the nature of the American character and literary traditions and expressions that serve as major themes in literature at the end of the century and at the beginning of a new millennium. The work will attempt to explain why American writers are more caught up with this social problem than writers in the other parts of the world.

Publications

Dixon, T. "Environmentalism and Progress," *Interdisciplinary Studies in Literature and the Environment* (Fall 1998).
Dixon, T. "Getting and Spending and the English Department

Chair," Association of Department of English *Bulletin* 120 (Fall 1998): 40-46.

Dixon, T. "Inculcating Wildness: Rick Bass, Robert Michael Pyle, John Hanson Mitchell, and Teaching Urban Nature," in *The Nature of Cities*. Eds. Michael Bennett and David Teague, U. of Arizona Press. (Forthcoming, Fall 1999).

Dixon, T. "Knowing Nature in Katherine Anne Porter's Short Fiction," *Southwestern American Literature* 24.2 (1999).

Dixon, T. "Review of Arturo Longoria, *Adios to the Brushlands*," in *Texas Books in Review*. 18.1 (1998).

Dixon, T. and L. Smith. "Service Learning and Environmental Writing," *The Modern Language Association Newsletter, Special Issue on Innovations in Undergraduate Teaching A* (1998): 3-4.

Presentations

Dixon, T. "Ana Castillo and Barbara Kingsolver: Environmental Literature and the Problem Toxicity," Annual National Meeting of the Western Literature Assoc., Albuquerque, NM, Oct. 1997.

Dixon, T. "Inculcating Wilderness: Rick Bass, Robert Michael Pyle, John Hanson Mitchell and Teaching Urban Nature," Annual National Meeting of the American Studies Association, Baltimore, MD, Nov. 1997.

Dixon, T. "Interrogating Place: The Example of Katherine Anne Porter," Katherine Anne Porter Symposium, San Marcos, TX, May 1998.

Dixon, T. "Service Learning: A Way to Teach Environmental Literature in an Urban Setting," Annual National Meeting of the Conference on College Composition and Communication (CCCC), Chicago, IL, March 1998.

Dixon, T. "Teaching Urban Nature through University-City Partnerships: The Writers in Herman Park Program at the University of Houston," 8th Annual Interdisciplinary Wilderness Conference, Reno, NV, Feb. 1998.

Dixon, T. "The UH Scholars' Community: Building Community and Academic Success at a Commuter Campus," Annual Meeting, Texas Deans of Humanities and Liberal Arts, Austin, TX, March 1998.

Environmental Education **Implementation of an Alternative Transportation Fuels Curriculum**

*Robert M. Jones, Ed.D.,
Professor, Education,
UHCL*

SEVERAL AGENCIES OF THE Texas state government collaborated to create a supplementary curriculum titled "Alternative Transportation Fuels" (ATF) to integrate clean-fuels information into middle-school science courses. To encourage acceptance, the agencies (1) developed the materials with professional educators, most of whom were classroom teachers; (2) correlated the materials with statewide standards established by the Texas Assessment of Academic Skills; and (3) budgeted fifty dollars extra-duty pay or substitute-teacher pay for each teacher attending a workshop. This curriculum has been disseminated to Texas schools and shows potential for use in other regions. It may appear to schools on a national basis.

The composite curriculum materials themselves consist of a Telly-award-winning 13-minute video introduction (Way Cool Fuels), 22 hands-on classroom activities, full-color posters and other resources. Activities were field-tested by 50 Texas science teachers and reviewed for accuracy by eighteen technical experts. Workshop participants' written evaluations rate the overall quality of the training materials 9.3 on a scale of 10 and the overall quality of the trainer, 9.5 on a scale of 10. Ratings of the quality of materials range from a low of 8.7 to a high of 9.7, and ratings of trainer quality range from a low of 9.2 to a high of 9.9.

During the fall semester, 1997, Lynn Spachuk, Environmental Education Coordinator for the Environmental Institute of Houston and Prof. Robert Jones conducted training for teachers using the ATF curriculum. In order to develop a broad capability needed to service this curriculum, course designers must achieve two primary objectives. Related tasks need to be defined and completed.

The first of these objectives is

the complete field-testing of the ATF curriculum to resolve minor discrepancies in content and pedagogy. The second objective is the correlation of the ATF curriculum with the newly adopted TEKS for science and social studies. The accomplishment of these two objectives will enable the Texas Education Agency to certify the ATF curriculum as "conforming."

Next, one or two lessons have yet to be developed on electric-fueled vehicles to balance the ATF elements now in existence. A materials package and trainer's support kit are under development for implementing the curriculum.

Course designers and evaluators reviewed the entire ATF curriculum unit, resulting in corrections of errors and inconsistencies.

The cooperative learning model derived from the "Teaming Up!" model developed at the University of Houston Clear Lake was adapted for course instruction. Alternative role titles and descriptions will be developed to supplement the "Race Team" model described in the curriculum.

Since the curriculum is interdisciplinary and involves science, mathematics, social studies, and language arts, current TAAS targets and TEKS objectives have been located in the curriculum and documented. A complete correlation of the curriculum to the TEKS for grades 6, 7 and 8 was completed.

The following example of a Grade 7 Science Knowledge and Skills statement indicates the cognitive and analytical skills one hopes to develop through course design: "*The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to analyze, review, and critique scientific explanations, including hypotheses and theories as to their strengths and*



Photo by Irv Rothman

GREEN SPACE—Henry Moore, himself, chose the site of a sculpture he provided the City of Houston. It is placed on the bank of Buffalo Bayou for viewing by drivers heading toward downtown office buildings.

weaknesses using scientific evidence and information.”

Designers compiled a less on-by-lesson list of materials and consumables, identified sources of information, and analyzed production costs. Usability factors have been analyzed, such as ease of reproduction, paper quality, and related concerns. Changes based on these findings were designed for dissemination.

Supplemental activities from the public domain will be developed and tested for incorporation into the curriculum. An example is model “milk carton cars” developed by the Society of Motion Engineers (SAE) for the *World in Motion* curriculum. Other activities from air pollution curricula are also pertinent.

Researchers also developed a model for supplementing traditional curricula by means of a “best-fit” curriculum strand. Strands of lessons from the fields of science, social studies, mathematics and language arts will be located and coded for incorporation into available curricula.

A trainer’s kit with all materials will be assembled and published. The training session evaluation instrument will be rewritten into a quantifiable, machine scorable format with an open comment section.

An ongoing support, documentation and updating service for the rapidly changing area of alternative transportation fuels will be established.

A follow-up study with first generation teachers in curriculum training will be developed and returns analyzed for patterns and trends.

The Director's Message

(Continued from page 3.)

wild. Wellington is also part of the effort to characterize the Flower Gardens coral reefs and to provide baseline data for the management of this national marine sanctuary. On a pragmatic note, EIH is partnering with the U. S. Fish and Wildlife Service to establish and maintain nature areas on schoolyards that provide opportunities for environmental education.

Environmental awareness or concern can have many effects. Some people exposed to the degradation of nature become inspired and contribute to a literary legacy that includes some of our greatest writers as explained by Dixon. Some people become angry and litigious. The resolution of such rancorous environmental disputes is the subject of Dr. Lisa Gossett's study.

Technology development is a role often played by universities and EIH supports those efforts that will yield a greener, more sustainable Houston. Dr. Jonathan Friedman is developing agents to control environmental pathogens. New resource efficient semi-conductors are being engineered by Dr. Eric Bittner. Dr. David Hoffman is synthesizing chemicals that can be used for energy saving window coatings. A new process for polyolefin production is the goal of Dr. T. Randall Lee. Dr. James Richardson is developing process changes to provide pollution prevention measures in PVC production, a major component of new construction.

The development of new environmental technology is a burgeoning field. It is difficult to perceive how much of the pressure for new technology is due to regulatory requirements and how

much is due to economic benefits from pollution prevention. Dr. Robert Hodgin has analyzed the correlation of environmental legislation and solid waste technology patents filed.

The contributions made by UH and UHCL faculty are very heartening. Our institutions play a major role in the greening of Houston, but so much more could be done, particularly with student involvement. I hope faculty affiliates will continue to submit even more Green Houston projects for EIH to support.

GREEN SPACE—Buffalo Bayou winds eastward toward Allen Landing where the City of Houston began.

Principal Investigators



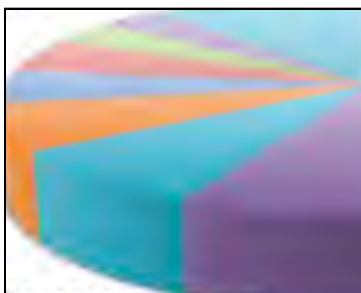
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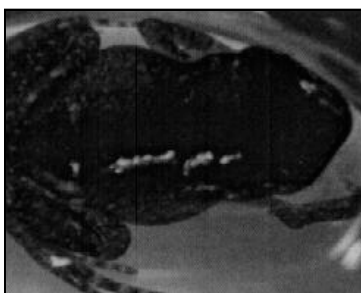
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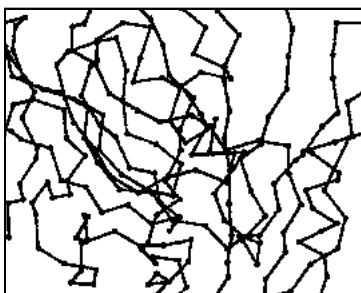
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GREEN SPACE—A pond in Memorial Park provides habitat for wildlife. In a natural environment, the nearby nature park museum provides classes on the environment for school children and conservationists.

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