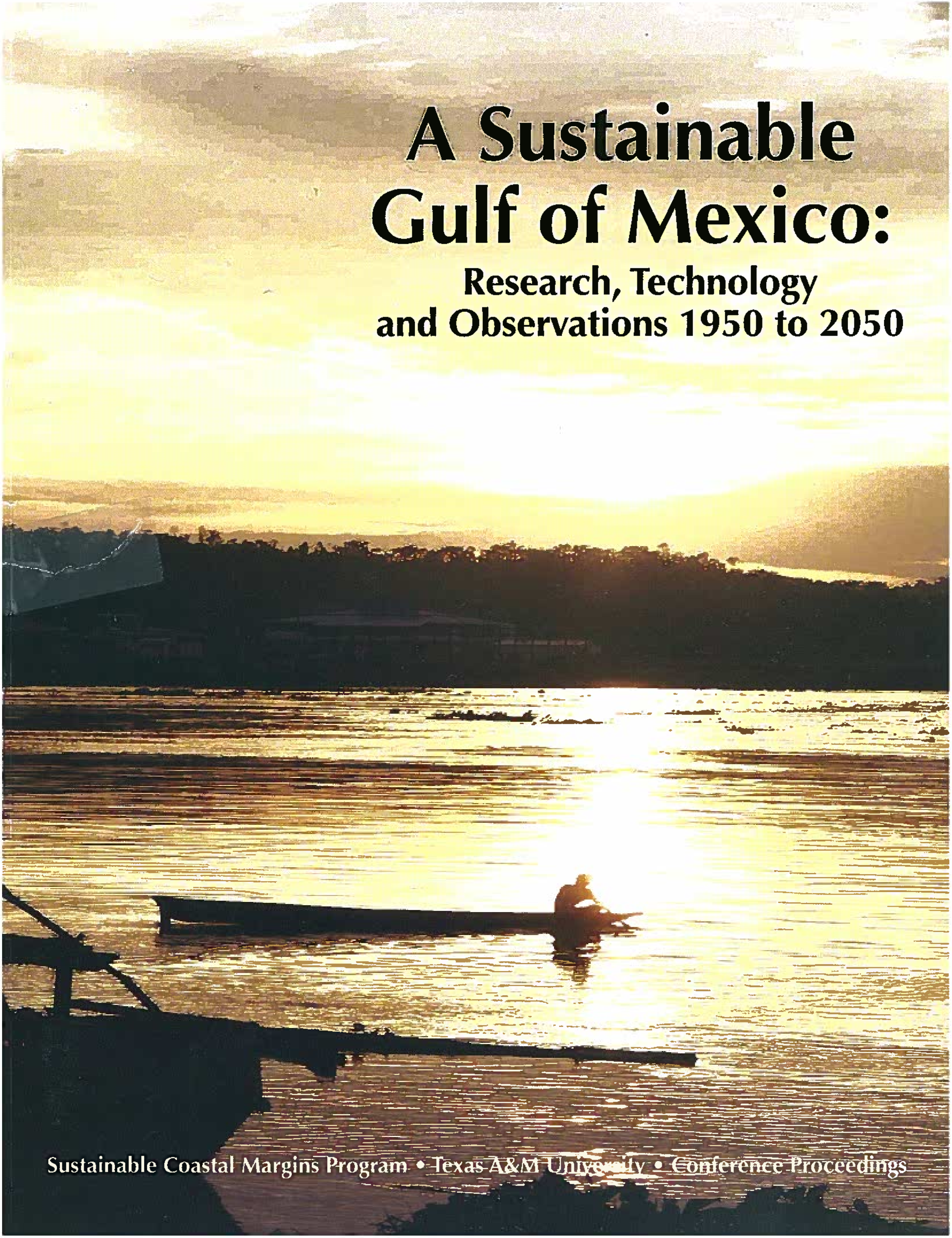
A Sustainable Gulf of Mexico:

Research, Technology and Observations 1950 to 2050



Sustainable Coastal Margins Program • Texas A&M University • Conference Proceedings

foreward

Dr. Mahlon C. Kennicutt II
Chair, Symposium Organizing Committee

The Gulf of Mexico has been a focus of education, research, and technology development for Texas A&M University for much of the institution's history. The Gulf of Mexico is a major state and national resource and its sustainable utilization is important to the state and nation's future development and well-being. The Gulf of Mexico supports a $20 billion tourist industry, 40 percent of US commercial fisheries, six of the nation's top ten ports, waterways that handle one-half of the total U.S. import/export tonnage, 75 percent of US migratory water fowl that utilize coastal wetlands, 72 percent of the U.S. offshore oil reserves, 97 percent of the US offshore gas reserves, and provision of US government revenues from mineral leases that are second only to income tax. The projected migration of the U.S. population to coastal regions over the next several decades will only increase the pressure on marine resources including current impacts such as tens of thousands of acres of critical habitat lost each year, freshwater diversion from estuaries threatening fisheries nursery grounds, fish stocks being exploited at or near sustainable limits, tons of debris washing ashore each year, 50 percent of shellfish beds are closed due to public health threats, nutrient enrichments cause harmful alga blooms, and the introduction of non-indigenous species disrupt natural ecosystems. In addition, the Gulf Coast is particularly vulnerable to natural hazards such as hurricanes, coastal erosion, and increasing sea level due to global climate warming. As a Land Grant and Sea Grant Institution, Texas A&M University faculty, researchers, alumni and students have been and will be instrumental in providing the scientific basis for the sound management of these resources. The 125th Symposium is intended to highlight the University's contributions to facilitation of safe and efficient marine operations, ensuring national security, managing living resources for sustainable use, preserving healthy marine ecosystems, mitigating the effects of natural hazards, and protecting public health.

The Symposium celebrates Texas A&M University's contribution to Gulf of Mexico science over its 125 year history, promotes Texas A&M University as a regional and national leader in the science and technology of sustainable utilization of coastal and marine resources, facilitates and encourages communication and dialogue among Gulf of Mexico stakeholders, and introduces Texas A&M University's new Sustainable Coastal Margins Program to the Gulf Region.

Texas A&M University's
125th Anniversary Celebration Symposium

A Sustainable Gulf of Mexico:

Research, Technology and Observations 1950 to 2050

Sustainable Coastal Margins Program
Texas A&M University College Station, Texas
February 19 - 21, 2002

Program

Tuesday, February 19, 2002

Morning Session

Afternoon Session

U. S. Commission on Ocean Policy Site Visit at Texas A&M University

Wednesday, February 20, 2002

Morning Session

Sponsors

Texas A&M University's

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welcome

Dr. Ray M. Bowen
President, Texas A&M University

Good morning. I'm delighted and honored to be here today to welcome you to this important gathering, and also to congratulate the symposium organizers for assembling such an extraordinary program.

As you know, this symposium is being held as part of our yearlong celebration of Texas A&M's 125th anniversary.

But this year offers us more than an opportunity to reflect on our history. It also is a time for us to take stock of how far we have come – as a university, a state and a nation – and to consider our course for years to come.

Over the next few days, this is exactly what you will do.

It is our hope that this symposium will:

- Begin a dialogue about the present state of the Gulf;
- Assess how and why today's conditions came to be;
- And move toward setting a course for the long-term viability of one of our nation's most valuable resources:

Each year, nearly half of all cargo enters or leaves our nation through a Gulf of Mexico port – six of which are among our top 10 ports. It is the source of 97 percent of U.S. offshore natural gas produced, and 72 percent of offshore oil production. Commercial and recreational fishing in the Gulf is worth some $1.5 billion to the Texas economy alone, including spending on food and lodging – part of a $20 billion a year tourist industry shared among the five Gulf states.

In addition to its economic value, the Gulf is a valuable ecosystem, whose bays and estuaries are birthplace to countless marine species. And three-quarters of North America's migratory waterfowl rely on them for feeding grounds and winter nesting places.

So, when we speak of "sustainability," we must think beyond its long-term economic value, and consider the impact of human activity on the Gulf's ecological value. Sustainability requires broad-ranging experience and expertise – an interdisciplinary approach to understanding and mitigating problems, and setting policy for the future.

This is precisely the approach that this symposium hopes to employ, and which led to the recent formation of Texas A&M's Sustainable Coastal Margins Program, or "scamp."

SCMP's faculty and scientists represent not only our colleges of geosciences and agriculture and life sciences, but also liberal arts, architecture and engineering, and the Bush School of Government and Public Service, to name just a few of the program's many partners.

I believe scamp is on the way toward establishing itself as a leader in sustainability science – and programs such as this symposium will help to pave the way.

Today, we take one early – but major – step in what we know will be a long-term, but tremendously rewarding, process that will involve many partnerships both on and off this campus.

As president of Texas A&M, I am proud to be here today, and to welcome you as partners in ensuring a healthy and productive, and sustainable, future for our Gulf of Mexico.

Thank you.

Coastal Margin Studies at Texas A&M University: An Historical Perspective

James M. Coleman
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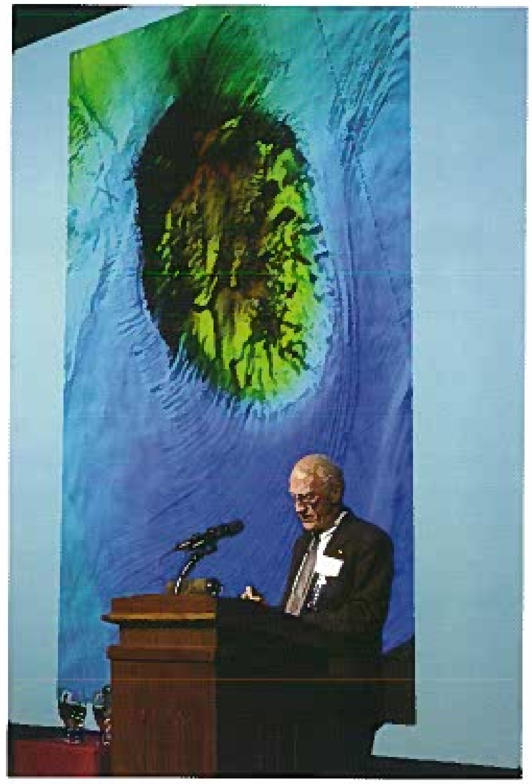


DR. JAMES COLEMAN is a Boyd Professor for the Coastal Studies Institute of Louisiana State University and Agricultural and Mechanical College. Dr. Coleman is a former chairman of the Marine Board and presently a member of the Ocean Studies Board of the National Academy of Sciences. He is a member of the National Academy of Engineering and Russian Academy of Natural Sciences. His research interests include coastal and marine processes and coastal management. He has received the Kapitsa Medal of Honor for his contributions to the field of petroleum sciences and presently serves on the U.S. Commission on Ocean Policy.

The Department of Oceanography was established at Texas A&M University on January 8, 1949. During this 52-year period of its existence, departmental scientists have made significant scientific contributions to our understanding of the Gulf of Mexico's continental margins. The early research of the department concentrated on oyster mortality, collection of oceanographic data, and marine pipeline problems. These early studies were funded by the Office on Naval Research, United Gas Pipeline Company, and a consortium of oil companies.

The first major research contribution was made by W. Armstrong Price in 1951. His article, *"Building of the Gulf of Mexico"* was the first systematic attempt to establish the major physiographic elements of the Gulf of Mexico shoreline and offshore provinces. In this article, he developed three modes of origin, the first such attempt to develop a history of development of the basin. Dr. Armstrong followed this research with a seminal paper on *"Dynamic Environments: Reconnaissance mapping, geologic, and geomorphic elements of the Continental Shelf of the Gulf of Mexico"* in 1954. He utilized the research of other A&M scientists such as Charles Bretschneider, Warren Thompson, and several others. He based the shoreline geomorphic provinces on wave energy regimes, being one of the first such attempts at using process-form interactions in classifying shorelines. In my opinion, this single paper added more to our knowledge of the Gulf Basin than any previous work and has stood the test of time.

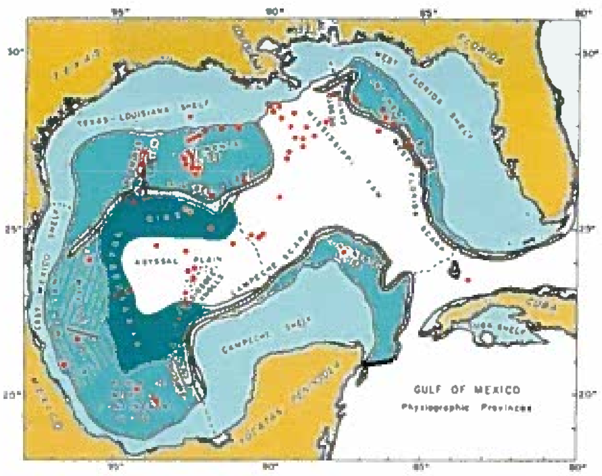
In 1954, Dr. Price published another paper, *"Environment and formation of the Chenier Plain,"* a contribution by the Texas A&M Foundation. In this paper, he elaborated on Richard Russell's earlier paper. Dr. Russell described the geomorphology, while Dr. Price described the geologic formation of this province.

In 1954, publication of Bulletin 89, *Gulf of Mexico: Its Origin, Waters, and Marine Life"* by the Fish and Wildlife Service of the U.S. Department of the Interior, Fish and Wildlife Service contributed significantly to our understanding of the Gulf Basin. Two papers in this volume were contributions by Texas A&M scientists. Dr. Dale Leipper described the physical oceanography of the Gulf of Mexico (one of the first major attempts to summarize the physical oceanography of this basin) and Dr. Price described, in detail, the shorelines of the entire coast of the Gulf Basin.

In 1958, Dr. Andrew Neumann published a paper *"Configuration and Sediments of Stetson Bank,"* a contribution of the Texas A&M Foundation. This paper was one of the first of numerous later contributions by other A&M scientists to describe the sediments that cap the numerous salt dome banks that are found in the Gulf of Mexico Province.

In the 1960s, significant contributions on the marine geology of the continental margins of the Gulf of Mexico were made by A&M scientists. In several papers by Drs. Antoine, Bryant, and Jones, the structural framework and origin of the continental shelf, slope, and scarp were described. These contributions were the first to describe the salt ridges in the western Gulf of Mexico and the Florida Escarpment in the eastern Gulf of Mexico. In 1968, Dr. Bryant published a paper, *"Stability and Geotechnical Characteristics of Marine Sediments, Gulf of Mexico"*, one of the first papers to describe the geotechnical properties of the continental slope, Mississippi Fan, and Abyssal Plain. Dr. Arnold Bouma, in 1968, continued this sediment research on the marine sediments of the Gulf of Mexico in a paper entitled, *"Distribution of Minor Sedimentary Structures in Gulf of Mexico Sediments"*.

In the 1970's Drs. Bouma, Bryant, and Antoine published a paper on the origin and configuration of Alaminos Canyon. This was the first of many later publications that described the numerous canyons that cut the continental margins of the Gulf of Mexico. These papers documented the association of the canyons with salt structures and described the deposition of coarse clastics in the canyon channels. Drs. Rezak and Bryant continued the studies of banks in a paper on *"West Flower Garden Bank"* in 1973. This paper contained a very detailed bathymetry of the bank and described, in detail, the sedimentary facies.

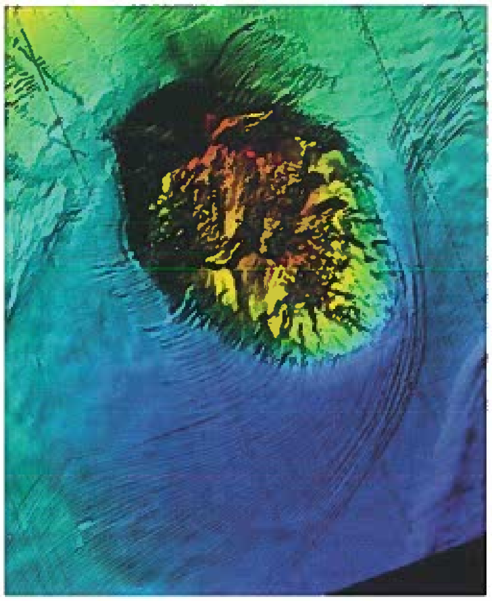


A major contribution by Drs. Geyer, Sweet, Rezak and Bryant in 1973 described the natural hydrocarbon seepage in the Gulf Basin. This was the first systematic scientific study of natural hydrocarbon seepage in the basin.

In the late 1970s and early 1980s, numerous papers by Drs. Prior, Bryant, Garrison, Coleman and others described the subaqueous sediment instability that is present in the Mississippi River delta offshore and on the continental margins of the Gulf Basin. These studies were the first to recognize that marine sediment instabilities can occur on extremely low angle slopes. These studies were responsible for setting the stage for a large number of contributions on subaqueous sediment instability on other continental margins.

In 1983, in preparation for DSDP Leg 96 drilling of the Mississippi Fan, Drs. Prior, Adams, and Coleman published a paper, *"Characteristics of a deep-sea channel on the Middle Mississippi Fan as revealed by high resolution survey"*. This paper contained the first description of a major sinuous channel on a deep-sea fan, described the leveed channel, and documented the presence of bedforms in the channel axis. Leg 96 – Drilling of the Mississippi Fan, was one of the first detailed sedimentologic studies of a deep-sea fan. Several Texas A&M scientists participated in this project. Dr. Bouma described, in detail, the sedimentology of the various sedimentary environments, Drs. Feely and Bryant described the depositional units and growth patterns, Dr. Bryant detailed the geotechnical properties of the sediments, and Drs. Kennicutt and Brooks described the geochemical characteristics of the sediments.

In the mid-1980s, Drs. Sassen, Brooks, and Kennicutt documented the authigenic carbonate buildups associated with hydrocarbon seeps in the Gulf Basin. These studies documented the abundance of carbonates on the continental slope, ascribed the origin of the carbonates to microbial breakdown of hydrocarbons, and associated this process with the initial stages of the formation of caprock on top of the salt domes.



In the 1990s, major contributions by Texas A&M scientists included descriptions of the salt-withdrawal basins, chemosynthetic communities, gas hydrates, brine flow channels, and erosional furrows. Dr. Bryant, with others, defined the various types of intraslope basins and associated the formation of these basins with the withdrawal of salt. Drs. Brooks, MacDonald, Kennicutt, and Sassen associated the major chemosynthetic communities with thermogenic seeps and biogenic accumulations. In 1996, a special publication of the Gulf Coast Association of Geologic Societies – *"Structural Framework of the Northern Gulf of Mexico"* described in detail the major structural provinces in the basin. Major contributions to this publication by Texas A&M scientists included papers by Drs. Watkins, Bryant, Simmons, and Bradshaw.

In the late 1990s, Drs. MacDonald, Sassen and others conducted research on the formation and distribution of gas hydrates. During these cruises, the researchers described the "Ice Worm", polychaetes that live and thrive in methane hydrates.

In the late 1990s, Dr. Bryant and others, continued the studies on the instraslope basins and described a major process of brine flow channels in Vaca Basin. More recently, Dr. Bryant described, in detail, the presence of linear erosional furrows at the base of the continental slope. These furrows, as documented by deep submersible dives, are the result erosion by strong currents. This discovery has major significance to emplacement of deep-water drilling facilities and pipelines.

As documented above, Texas A&M University scientists have been in the forefront of discoveries and research on the continental margins of the Gulf of Mexico basin during the roughly 52-year existence of the Departments of Oceanography and Meteorology. The contributions have formed the basis for additional studies by other academic institutions and scientists working in this complex basin.

Texas A&M University's Contributions to Gulf of Mexico Ecosystem Research

Sammy M. Ray
Marine Biology Department
Texas A&M University at Galveston
Galveston, Texas

The filing of several large lawsuits ($30-$40 million) by Louisiana oystermen against several major oil companies operating in coastal Louisiana for alleged damages to oyster crops served as a catalyst for a dramatic expansion of interest in the scientific study of the Gulf of Mexico. Leading this stimulus was the establishment of Project 9 in early 1947 through the Texas A&M Research Foundation (TAMRF), under the leadership of Dr. A.A. Jakkula, to investigate the cause(s) of unusual oyster mortality. The project mission: Determine the role, if any, of petroleum operations in the excessive oyster mortality and determine the cause(s), if possible, of such high losses. In short order, three other organizations- Gulf Oil Corporation (GULF), Louisiana Wildlife and Fisheries Commission (LWFC) and Freeport Sulphur Company (Freeport) assembled teams to investigate the excessive oyster mortality in coastal waters of Louisiana.

Project 9, sponsored by six major oil companies, mounted by far the largest effort in this investigation. Dr. Sewell H. Hopkins (Head) and Dr. John G. Mackin (Associate Head) led A&M's studies. Scientists and technicians representing a wide range of scientific disciplines (bacteriology, biological techniques, chemistry, ecology and hydrobiology, geology and hydrobiology, oyster biology, parasitology and physiology) from Marine Science institutions from all three North American coasts as well as a few European scientists were involved during the life (February 1, 1947 and May 31, 1950) of Project 9.

By early to mid-1947, all groups launched extensive field and laboratory studies designed to determine the effects of oil production activities on oyster production. After one to two years of study, many investigators began to doubt that "oil production operations" were the cause of all major losses. Some researchers began to focus on biological agents such as predators, parasites and competitors as possible causes of the unusual oyster mortality.

During the later stages of these investigations, the heads of three groups: Dr. Mackin (TAMRF), Dr. H. Malcome Owen (LWFC) and Albert W. Collier(Gulf) began comparing notes of their studies. These investigators concluded that each was looking at the same "undescribed" organism that they suspected was the cause of the abnormal warm-weather oyster mortality in high salinity areas. This collaboration led to the publication in 1950 of the description of this unknown protistan agent as *Dermocystidium marinum* (Dermo) by Mackin, Owen and Collier (Science, 111, 1950). With the publication of this paper, the law suits were either dropped or settled out of court for fractional amounts of the original claims.

In addition to discovering a major disease-causing oyster parasite, the Louisiana oyster investigations generated a strong impetus for the establishment and expansion of Marine Science programs in the Gulf Coast States. Many of the principals in the Louisiana oyster investigations later contributed significantly to Marine Sciences. Undoubtedly, the massive role played by Project 9 in these investigations sparked administrators of the Agricultural and Mechanical College of Texas (now Texas A&M University) at College Station, Texas, to establish a Department of Oceanography. This important step took place in 1949 under the leadership of Dr. Dale F. Leipper with three other faculty members. As a result of this action, A&M became the leader in studying various aspects of the Gulf of Mexico ecosystem.

SAMMY M. RAY is Professor Emeritus in the Marine Biology Department at Texas A&M University at Galveston. Dr. Ray received a Bachelor of Science in Zoology from Louisiana State University in 1942 and a master's and PhD in Biology from Rice University in 1952 and 1954, respectively. The recipient of numerous honors in his long career, Dr. Ray most recently was inducted into the Texas Science Hall of Fame.

With the termination of Project 9, TAMRF's Project 23 was inaugurated on June 1, 1950 to continue oyster disease studies and to maintain a Marine Laboratory at Grand Isle, Louisiana. The A&M Marine Laboratory was established on the campus of the University of Texas Medical Branch in Galveston, Texas by Dr. Mackin in 1952. Later (1956) Dr. Leipper aquired building 311 (WWII surplus) at Fort Crockett as a shore based facility for R/V HIDALGO and its replacement R/V ALAMINOS, contract research and teachers summer institutes. In 1961, A&M entered a new area of marine activity by establishing the Texas Maritime Academy under the direction of Captain Bennett M. Dodson. The Maritime Academy, which initially occupied the east wing of building 311, is the only Gulf Coast institution devoted to the training of cadets for the U.S. Merchant Marine Service.

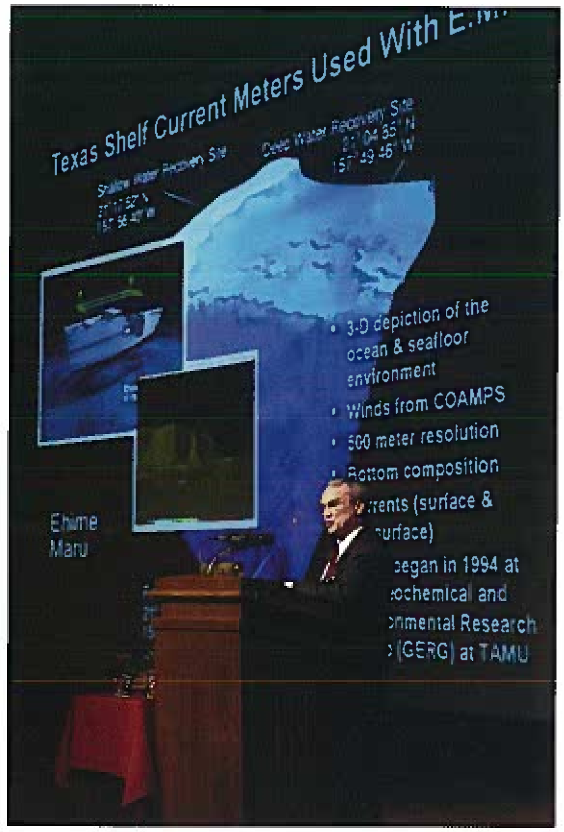
In 1963, Sammy M. Ray was named director of the Marine Laboratory. At this time the future of the Marine Laboratory appeared rather bleak because of its limited use and poor financial support. A concerted effort was made to broaden the use of this coastal facility by other academic departments on the College Station campus as well as other academic institutions that desired access to a sea-side facility for research and instruction in Marine Sciences. The outlook for the Marine Laboratory greatly improved with granting of permission in 1964 to offer formal courses for resident credit in cooperation with various departments at College Station. This action, strongly supported by Dean Frank Hubert (College of Arts and Sciences) changed the Laboratory from more of a summer field station to a year-around academic institution. The course offerings and student research programs continued to expand as main campus departments (primarily Biology and Wildlife and Fisheries Sciences) increase their participation. A second favorable development for the Marine Laboratory was the establishment of the College of Geosciences in 1965. With this change the Laboratory Director attained greater administrative flexibility since he reported directly to Dean Horace Byers, the first Dean of Geosciences. A third major boost in the laboratory's programs occurred in 1968 when A&M was named a Sea Grant College under the direction of Dr. John C. Calhoun. Many of the Laboratories' ongoing research projects meshed well with the National Sea Grant goals.

Texas A&M made a major move in 1971 to expand its role in Marine Sciences by combining the Texas Maritime Academy and the Marine Laboratory to form the Moody College of Marine Sciences and Maritime Resources under the leadership of Dr. William H. Clayton. This institution now known as Texas A&M University at Galveston (TAMUG) focuses on programs (both undergraduate and graduate) with a distinct marine flavor. Although Fort Crockett (two buildings) is still utilized by faculty and graduate students, the Galveston campus has undergone a tremendous expansion of facilities on Pelican Island. Also, the Oceanography Department maintains a shore-based facility and docks on Pelican Island to support the R/V GYRE.

In the intervening period of more than 50 years between the initiation of Project 9 (1947) and the present (2002), Texas A&M University has played a major role in academic instruction and research to increase our understanding of the Gulf of Mexico ecosystem.

Texas A&M University's Pioneering Discoveries – Physical Oceanography of the Gulf of Mexico

Dr. Don L. Durham
Technical Deputy Director Commander
Naval Meteorology and Oceanography Command



Texas A&M University's oceanography department's origin in 1949 is rooted in multidisciplinary considerations of oceanography and coastal engineering. Early research studies focused on degradation of oyster beds, hydrographic surveys in the Gulf of Mexico and engineering efforts in assessing gas/oil pipelines to offshore drilling platforms. The oceanography department at Texas A&M University (TAMU) has prospered and grown from five original billets with two occupied by professors with specialties in meteorology, physical oceanography and ocean engineering to more than 80 faculty, scientists and professional staff today with multidisciplinary expertise covering all facets of oceanography. In addition, significant contributions in oceanography with particular emphasis on the Gulf of Mexico (GOM) have been funded over the years by the Office of Naval Research (ONR), National Science Foundation (NSF), Mineral Management Service (MMS), and numerous other federal, state and private organizations.

Studies of the physical oceanography in the Gulf of Mexico have included numerous hydrographic surveys aboard various TAMU oceanographic research vessels, direct and remotely sensed instrumented collection efforts, as well as theoretical and numerical model studies of tides, storm surges and general circulation of the GOM. Extensive surveys and analyses have been conducted on the loop current and its dynamics including the generation of anticyclonic rings and their migration into the western gulf, tides and tidal currents, air-sea interaction including upwelling induced by various phenomenon such as hurricanes and other extreme weather events, deep water current regimes, longshore currents along the SE Texas coast and Yucatan shelf, variability over a broad spectrum of mixing lengths and wind waves and storm surges in several harbors and coastal areas. Results of these studies have made significant contributions to the knowledge base of oceanography in general and the GOM in particular with results of many of these studies applicable to similar phenomena in other regions of the global oceans.

TAMU physical oceanography graduates have made significant contributions in academic, administrative and scientific positions in nearly all major federal science and technology funding agencies including associated laboratories, most major oceanographic universities, numerous industries, several private and/or non-profit organizations, as well as military organizations, particularly the U.S. Navy. The U.S. Navy operational oceanography community has benefited greatly from physical

DR. DONALD L. DURHAM is the United States Navy's senior civilian manager and top scientific advisor for meteorology, oceanography and hydrography, overseeing an operational support organization at more than 50 locations worldwide. He received a M.S. and a Ph.D. in Physical Oceanography from Texas A&M University in 1972. Dr. Durham has led a broad range of research and operational programs for the Department of Defense with more than 50 professional papers and technical reports.

oceanographic studies of the GOM. Current Navy operational numerical models of dynamic oceanographic circulation, storm surges, tides and waves can be tied directly to or are associated with research of TAMU professors and/or their graduates. In addition, the Naval Oceanographic Office (NAVOCEANO) is currently employing numerous advanced instruments, which were developed at TAMU, in their routine military surveys around the globe. Recent efforts by NAVOCEANO in raising the Japanese Fishery Research Vessel, Ehime Maru, used TAMU buoy arrays of current meters with real time communications to assist with the monitoring of the currents throughout the water column offshore Honolulu, Hawaii.

National interest in coastal ocean observations and a recent surge in homeland security are focusing our nation's attention on the coastal marine environment. The U.S. Navy, National Oceanic and Atmospheric Administration, Coast Guard and Army Corp of Engineers are defining their specific and collaborative security roles in homeland defense with particular attention to potential threats to priority harbors and ports by mines and water-borne dispersion of hazardous materials. TAMU is well positioned to continue making outstanding contributions in coastal and regional physical oceanography with sustained multidisciplinary efforts in U.S. coastal regimes – TAMU oceanography department's beginnings nearly 50 years ago.

Texas Sea Grant/Extension and the Shrimping Industry (Three Decades of Interaction)

Gary Graham
Professor and Marine Fisheries Specialist

The idea to mirror the traditional Land Grant research and educational program for marine resources was conceptualized in the early 1960s by Athelstans Spilhaus in a keynote presentation to the American Fisheries Society. During its early formulation, Professor Spilhaus visualized Sea Grant as "county agents in hip boots" who provided an efficient and effective approach to the conduct of educational outreach activities in the coastal communities. His vision was captured in the Sea Grant College and Program Act of 1966.

Texas A&M University took the early lead in the new Sea Grant initiative securing funding under the program and then in 1971 reached designation as one of the first Sea Grant Colleges. In that role, the University embodies the three elements of Sea Grant, namely applied research, outreach and education. In support of this and similar initiatives, marine extension agents and specialists now abound throughout the coastal United States in hip boots (and shrimping boots). Dr. Spilhaus' concept is now a success story.

My presentation will focus upon educational efforts that have been conducted between the Texas Sea Grant College Program and the shrimping industry over the past three decades. It should be noted that the shrimp industry is not the only group that benefits from the activities of the Sea Grant Program. Numerous clientele groups such as youth coastal residents, recreational fishermen and marina operators to name a few, are served by the Texas Sea Grant program. The experiences that I wish to share today from my 30-year career will show the integration of educational efforts in support of the Texas shrimping industry. These were conducted in my role as Fisheries Specialist for the Texas Marine Advisory Service (MAS), which is a cooperative effort of the Texas Sea Grant College Program and Texas Cooperative Extension. My focus on the Texas shrimp industry is appropriate because traditionally shrimp has been the nation's most valuable seafood harvest and Texas has traditionally led all states in the value of shrimp landed at its docks.

GARY L. GRAHAM has been actively involved with fisheries extension for the commercial and recreational sectors for the past 32 years. A number of his projects have focused on fisheries development, trawl gear efficiency and conservation engineering, and plotting fishing obstructions in the Western Gulf. He serves on a number of fisheries management advisory committees and is the Regional Coordinator for the Gulf & South Atlantic Fisheries Foundation. He is a National 4-H Fishing Instructor.

Establishing a Bond of Trust

My initial years posed challenges to establishing educational programs with the commercial shrimping industry. Basically, the concept of educational programming in the industry was looked upon by commercial fishermen with suspicion. In addition, many of the previous dealings between the public sector and the fisherman were through regulatory agencies and therefore the initial perception that we were game wardens required immediate resolution.

One of the first successful programs that was undertaken by the Sea Grant Program was to initiate an inventory of bottom obstructions. Known commonly as the "hang book" program, shrimp boat captains were contacted and their confidential records for locations of problematic underwater objects on which they had damaged or lost gear was requested. This information, in the form of loran coordinates (the primary positioning technology available) was consolidated into a publication, which is still being updated and made available to fishermen today. This atlas covers an area from Brazos Santiago Pass, adjacent to the Mexican border, to the Mouth of the Mississippi River. The location of more than 12,000 obstructions or hangs are recorded. Conducting this project required personal contact with fishermen aboard hundreds of vessels, so, through the "hang book effort", many new friendships were established. These new contacts and the success of this project paved the way for numerous and diverse educational efforts within MAS.

The Magnuson Act and Beyond

The decade of the1970s was an interesting period for Gulf of Mexico shrimp fishermen. One catalyst for this dynamic period was the passage and implementation of the Fishery Conservation and Management Act of 1976 later named for its primary Congressional authors. The new regulatory regime created by this legislative action initiated an era of challenge for the gulf shrimp fisheries. Unlike many U.S. fisheries that initially benefited from the legislation that excluded foreign fishing operations from U.S. waters, the gulf shrimp fishery was negatively impacted. As other coastal states followed the movement to exclusive jurisdiction over coastal waters, traditional shrimping grounds utilized by U.S. Flag vessels off the coast of Mexico in the Bay of Campeche and Contoy were no longer available. Many U.S. shrimp vessels were also displaced from foreign waters in Central and South America. While some U.S. shrimp vessels were sold to foreign investors, many were forced to return to what was becoming crowded U.S. waters. The increased fishing pressure realized from this displacement of the U.S. distant water fleet back to U.S. waters exacerbated many of the festering issues that have now become significant conflicts within fishery management.

Furthermore, concern for overexploitation of the shrimp resources from displaced vessels resulted in requests from industry members to investigate other potential fishing opportunities. In addition, the removal of foreign fishing vessels from U.S. waters created a period of euphoric speculation in fishery development. The resulting federal focus on the development of under-utilized species resulted in tax incentives, loan guarantees and applied research to build fishing capacity and identify harvestable stocks. The government also supported the creation of fishery development foundations in support of the commercial fishing industry seeking fulfillment of the dream envisioned by the federal extension of jurisdiction offshore 200 miles. In support of these initiatives, the applied research, extension and education functions of Sea Grant directed extensive effort to underdeveloped species and new fishing technologies. In some cases, it is paradoxical to reflect upon some of the efforts, such as the development of commercial fishing for shark, swordfish, and various reef fish. Many of these fisheries are now among those facing significant management challenges as research attempts to contribute a better understanding of the inter-relationship of stocks and species.

Redirection into Fishery Conservation

The 1980s represented a period of new and contentious fishery educational challenges. In the early portion of the decade, concern for the conservation of marine sea turtles became a significant issue in the Gulf of Mexico shrimp fishery. With visibility of the issue heightened by an international conference on the conservation of sea turtles hosted at the U.S. Department of State, initiatives were soon begun on finding a technical solution to reduce the incidental capture of sea turtles by shrimp trawlers. While the federal government through its National Marine Fisheries Service attempted to design a modification to shrimp trawls that would protect sea turtles and be acceptable to the shrimp industry, it soon became obvious such acceptance was not to be realized easily. In recognition of the growing pressures for the shrimping industry to adopt trawl adaptations known as turtle excluder devices (TEDs) in trawls and knowing the power of the Endangered Species Act in regulating impacts on threaten or endangered species, the Marine Advisory Service spent hundreds of days at sea demonstrating and evaluating the government developed TED to industry members. It soon became obvious that the weight and size of the device, along with concerns for shrimp losses, would make it a hard sell to the shrimping business. In the midst of this growing conflict, the strength of the Sea Grant Extension education program was apparent as it took on the role of a facilitator in developing industry ideas to improve and supplement the development of TEDs. The success of these efforts are documented in the lineage of the shrimp trawl gear that is being used today and serves to assuage some of the concerns that had existed regarding TEDs. The result of this and other efforts to save the Gulf of Mexico sea turtles is further reflected in the significant increase in the population of nesting females over the past several years.

The 1990s brought a redirection of focus away from sea turtles and toward non-targeted species (bycatch) harvested in shrimp trawls. Here again, Sea Grant with its extension education efforts was able to enter into this arena through a cooperative effort with the Texas Shrimp Association, a trade association for the Texas shrimp industry. The result was a study to document and quantify species harvested in shrimp trawls. This early work yielded a comprehensive data base regarding bycatch characterization. The effort continued for approximately 5 years and was expanded regionally through cooperative efforts with the Gulf and South Atlantic Fisheries Foundation, Inc. With this data available, since 1994 a cooperative effort has been made with the shrimping industry to develop a new gear technology known as bycatch reduction devices (BRDs). It is significant to note that the two BRDs federally certified to meet the mandate for industry use were a result of this cooperative effort between Sea Grant and the shrimp industry.

Also during this period, efforts to expand the potential for *in situ* investigation of TED and BRD technology was initiated through cooperative work with the University of Georgia Marine Extension and the Texas Sea Grant Program. Under this program high-technology underwater cameras were shown to be an effective method in which to view actively fished trawling gear in the clear waters off South Texas. Not only does this allow gear to be observed during harvest of commercial quantities of shrimp, but also provides video footage that can be viewed by fishermen throughout the Southeast. This opportunity has provided a tremendous resource for disseminating educational information and technology transfer throughout the Gulf and South Atlantic Region. It should be noted that workshops and personal assistance with TEDs and BRDS have been provided on a regional level from North Carolina to Texas.

Other successful educational endeavors have been achieved as a result of university efforts. A decade ago research was directed toward the evaluation of high tinsel strength "super fibers" in the construction of shrimp trawls. Although this high-tech material is much more expensive than traditional nylon netting, it has now been adopted by more than 500 vessels in the Southeast Region of the U.S. Because of its smaller diameter and greater strength, vessels are experiencing more than a 15 percent fuel savings from its use - more than enough to compensate for the higher purchase price. Here again, the Sea Grant Extension education efforts continue to be in the forefront for technology transfer efforts to the shrimp fishery.

Not Just on the Water

While most of the activities in my career have focused on shrimp harvesting technology, it should be noted that not all successful educational programs in support of the shrimp industry are done at sea. Today, a Sea Grant Seafood and Economics Specialist has developed a unique program that accumulates financial data from the shrimp fishing industry and prepares evaluations that measure economic performance of shrimping vessels. As a result of a comprehensive database provided by vessel owners, a business or financial institution can compare the financial viability of different operations as well as conduct an in-depth economic evaluation of the offshore shrimp fishery.

Contributions relative to quality control and food safety have also been an important role provided by the Sea Grant Program-Marine Advisory Service. Specialists within the program have been successful in developing proper handling procedures for shrimp - both at the vessel level and in processing plants. New efforts have yielded important guidelines in maintaining seafood at the retail level as well. The Sea Grant Program serves as the lead component in training and certification of seafood industry members in Hazard Analysis and Critical Control Point (HACCP) Certification.

A final example of a non-harvest related extension education effort by the Texas Sea Grant Program is in fishing vessel safety training. While the training is available through a safety consultant, the Sea Grant Marine Business Specialist within the MAS continues to administratively manage this initiative to educate fishing vessel crews in survival and safety considerations while on board a fishing vessels.

Not Just Adults

Perhaps one of the largest long term contributions made by Sea Grant to the shrimping industry relates to the youth education. Throughout the history of our program, much emphasis has been directed toward providing youth with understanding and appreciation for the marine and estuarine environment. MAS agents and specialists have developed a number of youth programs along the coast. The shrimping industry relies on the productivity of our marine habitat to provide an abundant catch. While most of the youth in this state will not be directly involved in the shrimp fishery, they will either directly or indirectly undertake the responsibility of maintaining healthy estuaries and marine habitats. The success of this effort, to a great degree, will reflect the future viability of the shrimp industry as well as all living marine resources.

Conclusion

In summary, Texas A&M University was established by the Morrill Act of 1862 and from that foundation created a world-recognized identity in agricultural research, extension and education. In capitalizing on the opportunities provided in the Sea Grant College and Program Act of 1966 the University has established its legacy in the coastal and marine environs as well.

Thank you for your attention.

Texas A&M University and Mexico Cooperation in Gulf of Mexico Research

Artemio Gallegos-Garcìa
Investigador Asociado
Laboratorio de Ocenaografia Fisica
Instituto de Ciencias del Mar y Limnologia
Universidad Nacional AutÛnoma de Mexico

Presentation Summary

The Gulf of Mexico is a common heritage that modulates our weather and climate and provides basic resources. Thus marine observations, forecasts, and other products and services dealing with the Gulf of Mexico's marine and coastal environment, are strategic consequential elements for the sustainable development of the Region. Much is to be gained by sharing information about this major marginal sea under our care. Only a sustainable Gulf of Mexico will hold our nations together. Certainly, 45 years of Texas A&M and Mexico cooperation in Gulf of Mexico research, and the call to this Symposium confirms that our oceanographic communities concur with such a platform.

ARTEMIO GALLEGOS-GARCÍA earned his Ph. D. in Physical Oceanography from Texas A&M University in 1980. He has held a research and faculty position at the Institute of Marine Science and Limnology of the Universidad Nacional Autúnoma de México since 1980. His research and teaching interests focus on ocean dynamics and climate.

Ecosystem Integrity, Global Change and Biocomplexity

How Do We Meet the Challenges of the Next Decades?

Margaret Leinen
Assistant Director for Geosciences
National Science Foundation

MARGARET LEINEN is the Assistant Director for Geosciences of the National Science Foundation. She is also responsible for the coordination of all environmental research and education across the foundation. She also chairs the interagency committee responsible for coordinating federally funded global change research. Leinen is a paleoceanographer and served as the Dean of the Graduate School of Oceanography, University of Rhode Island before moving to NSF.

The framework you have chosen for discussing A Sustainable Gulf of Mexico — the century between 1950 and 2050 — provides a wonderful perspective on our evolving view of the Gulf and other important ecosystems with time. The themes you have highlighted, Ecosystem Integrity and Global Change are related. At the National Science Foundation we are trying to underscore the complicated connections between such perspectives and to provide opportunities for scientists to study the Biocomplexity of the Environment. Biocomplexity refers to the interconnectedness of physical and biological systems in the environment, and their great potential for non-linear behavior.

Environmental or ecosystem integrity refers to its functional soundness of environmental systems, from local to planetary scales. Important to consider not only current functionality, but also a system's ability to deal with outside stress, and its capacity to develop, regenerate and evolve. Given this, how might we think about our challenge? In the middle of the 20th Century, our view of ecosystem integrity generally focused on the abundance and condition of individual organisms. Most scientists studied organisms, not ecosystems. And those that did study ecosystems generally looked at the relationships between organisms, not the relationships between organisms and their dynamic, changing environments. To ensure a sustainable Gulf of Mexico in 2050 we will need to be more holistic. The complex interactions of the Gulf physical and ecological systems will need to be understood in light of decadal ocean cycles or oscillations, changes in dynamics of fish populations due to fishing, oxygenation changes due to organic carbon and nitrogen runoff and a host of other factors. Although we talk about problems in this larger framework now, it is very difficult to execute research that reaches across the temporal and spatial scales necessary for such understanding. Our observing systems, other than satellites are rudimentary at the scale of Galveston Bay, no less the entire Gulf.

In 1950 if global change was discussed, it was discussed in geologic terms—glacial to interglacial cycles, for example—or in terms of decadal scale variability such as the drought cycles that seemed to occur at approximately 30-year intervals in the Midwest. At present we understand that global change, both natural and anthropogenic, is a major force at work, shaping our environment, but it is very difficult for us to determine the relationships between and among natural variability and anthropogenic changes; and, within anthropogenic changes, those that may be forced by changes in greenhouse gases, and those that may be forced by other global scale changes such as land use change. The key to future understanding of these forces as well as understanding how to use or live with large environmental systems like the Gulf sustainably, lies in our ability to first observe processes at the spatial and temporal scales appropriate for the process, and second, to develop the capability to model those processes based on first principles rather than parameterizations.

There is great potential for ecosystems and for the environment to have strong chaotic or non-linear dynamics, but we are still struggling to understand whether this renders such systems totally unpredictable or whether there are organizing principles that will allow us to model non-linear systems to achieve predictability or at least the projection of likely scenarios. This challenge, too, requires observing systems that are capable of operating over time scales long enough to observe the response of the environment to internal dynamics as well as external forcing. And this challenge, too, requires the capacity to develop large, complex models that easily assimilate data.

Humans cast a long shadow of impact on the environment. It is clear that it is large and that understanding the social, economic, and behavioral forces that contribute to our impact on the environment will play an accelerating role in the future. It is a sterile exercise to project the future condition of the Gulf based solely on the interaction of physical and non-human biological systems: we may know the role of turbulence in keeping polluted or nutrient-laden sediment suspended in rivers in exquisite detail. But if we ignore the social and economic factors forcing the increasing human control of the flow, we will fail to project the potential for increasing low- or no-oxygen areas of the Gulf reasonably.

If there are consistent messages coming from this backward and forward look, it is that we must move from the decades where we studied what we **could**, to a future in which we study what we **should**. We must demand and develop the capability for observing the environment at the spatial and temporal scales appropriate to our problems. We now need to develop the capability of sampling processes *in situ* at appropriate spatial scales, whether *in situ* is below the surface of the waters of the Gulf, or in the terrestrial ecosystems on shore. Further, we need to develop the capacity to sample processes over decades to understand the complex relationships between natural and human forcing and environmental response. We need to demand sensors and instrumentation that can be deployed in both terrestrial and marine environments reliably for long periods of time.

The National Science Foundation is focusing on the development of such observing systems on many fronts. For example, in addition to partnering with agencies to develop a near-surface ocean observing capability, NSF is also developing the capability for ocean scientists to study the coastal zone through networked coastal observatories, and to study processes at the scale of an entire lithospheric plate through plate-scale networked observing systems. On land, our National Ecological Observatory Network targets the development of networked capabilities that will bind and extend existing long-term ecological research capabilities to study the changes in entire ecosystems.

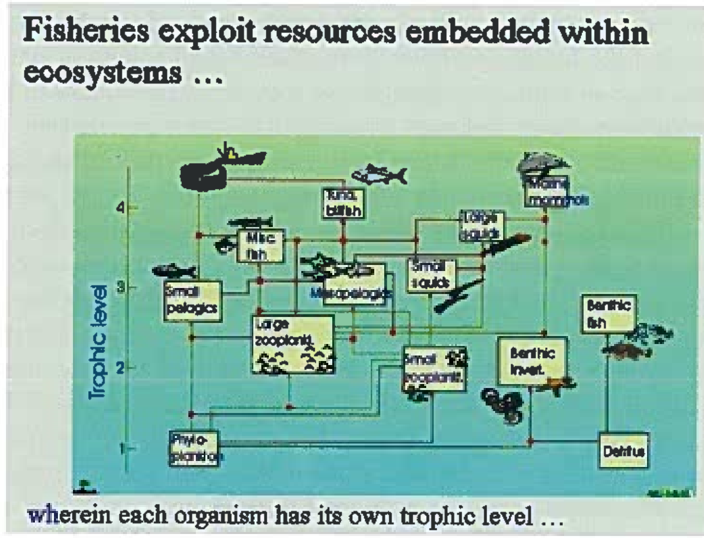
The common element enabling this transition to the capacity to study what we should is the cyberinfrastructure made possible by both wired and wireless communication and computation networks. At NSF we know that every discipline needs the capacity to network vast arrays of sensors, to store the data from these sensors, to retrieve **information** from those enormous repositories of data, and to visualize that data in ways that let the finest of microprocessors, the human brain, synthesize and formulate hypotheses. We have begun the development of large-scale grid computing backbones that will allow all disciplines to build the capacity to manipulate this fire hose of data.

We will need new paradigms for integrating spatial imagery with data— powerful new conceptual tools that will allow us to merge the maps, photos and other spatial imagery with data on outfalls, nutrients, the hydrologic cycle and so forth. We need to have tools that free us from digitizing old imagery, making the links between time series of imagery, and merging it seamlessly with historical and current digital data streams—effortlessly.

I do not believe our community has demanded enough. The complex issues surrounding man and the environment are great intellectual challenges – worthy of much greater investment by one of the greatest nations on earth, worthy of study by the greatest scientific minds. I see our challenge at NSF to join with you in making that case, in developing those capabilities, that will allow you to understand the Gulf and solve problems that will lead to its sustainability into the next century and beyond.

Sustainable Ecosystems

Dr. Daniel Pauly
Professor
University of British Columbia



Fisheries date back to the Stone Age, but still represent one of the key uses of the World Ocean. The sector's long history of absent sustainability was aggravated by industrial fishing vessels being added, from the end of the 19th century on, to the smaller crafts and fixed gear then and now still used to exploit coastal fish populations.

Landings increased massively, especially after the Second World War. Then, a series of massive fisheries collapses occurred in various parts of the word, many involving seemingly well-studied fish populations. In the late 1980s, these collapses ceased to be compensated for by the 'opening up' of new fisheries, and global catches began to slowly decline from a peak of about 85 million metric tons. About 20 to 30 million metric tons of fish caught as bycatch, and subsequently discarded may be added to this, resulting in a global catch (= landings + discarded) of around 110 million tons in the waning years the late 20th century.

Marine fisheries provide about 20 percent of the world protein supply. For large parts of the world population, particularly in East and Southeast Asia, and in Africa, fish is by far the most important source of animal protein. From the early 1950s to the mid 1980s, capture fisheries landings and aquaculture production have grown faster than global human population, leading to a substantial increase in fish supply per person. This trend reversed in the late 1980s, and it is only the large reported increase in aquaculture production that has prevented a more rapid decline of fish supply per person. In the west, this trend is masked by imports, the bulk of it from developing countries.

Over the past fifty years, world fisheries have seen drastic changes, due to technological developments, the emergence of the new Law of the Sea, the collapse of the Eastern Bloc distant-water fisheries and the globalization of much of the fishing industry and of the markets for marine products; thus more than 75 percent of all fish consumed globally originates from the Exclusive Economic Zone of other, exporting countries (this contrast with less than 5 percent for e.g. rice, another key food commodity).

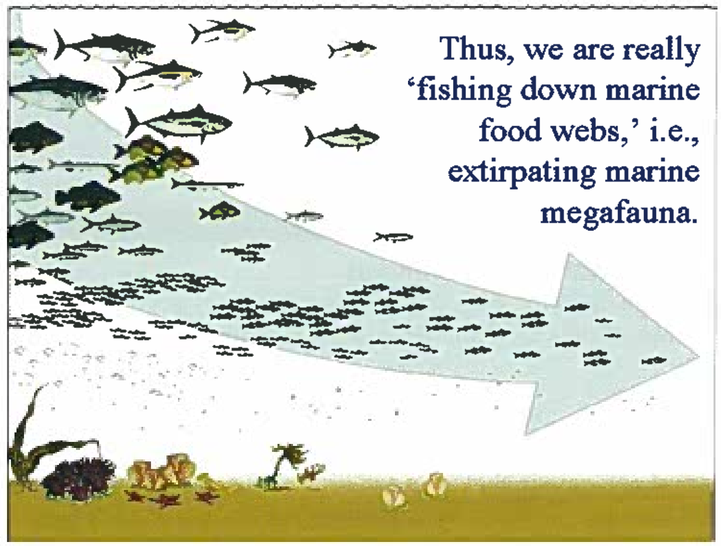
Of all human impacts on marine ecosystems, fisheries are now the most destructive. Indeed, it is only the expansion of fishing capacity which has so far masked their impact. The recently demonstrated decline of global catch, in spite of ever increasing fishing effort, has now unmasked the industry's serial depletion and extirpation of resource populations, and the concomitant habitat destruction.

The populations of much sought after 'top predators,' especially bottom fishes such as cod, groupers, hake and sole are in a particularly deplorable state. As a consequence, the fisheries have turned to prey fish and invertebrates, leading to a process now known as 'fishing down marine food webs.

DR. DANIEL PAULY was born in Paris and educated in Switzerland and Germany. He received a Master's of Science and a PhD in Fisheries Biology at the University of Kiel. During a 23-year career, he has been with the International Center for Living Aquatic Resources Management (ICLARM) in Manila, the University of the Philippines, the Institut für Meereskunde and the Fisheries Centre at the University of British Columbia while continuing as ICLARM's principal science adviser until December 1997 and science adviser of its FishBase project until 2000. Dr. Pauly has been principal investigator of the *Sea Around Us* project at the Fisheries Centre since 1999, studying the impact of fisheries on the world's marine ecosystems. In 2001, he was awarded both the *Murray Newman Award* for Excellence in Marine Conservation Research, sponsored by the Vancouver Aquarium, and the *Oscar E. Sette Award* of the Marine Fisheries Section, American Fisheries Society.

Ironically, it is concern about stagnation and decrease in landings about 100 years ago which gave birth to fisheries science, whose task was to provide advice for a better management of the fisheries based on scientific insights in the dynamics of the fish stocks, then well perceived as part of integrated ecosystems. However, the aspects of fishery science that became most important were those devoted to making fishing operations more effective, notably by improving location and catching methods. This service, now involving space age technologies, has led to an immense fishing pressure being applied to all fish populations, throughout all of their range, leaving none of the refuges that earlier protected parts of these populations, and hence the fisheries from themselves.

Traditional fisheries management measures (e.g., restriction on gear, mesh size, or composition of landings) have mostly failed, or aggravated these and related problems (e.g., by encouraging misreporting and discarding of by-catch). Alternative approaches, such as network of marine reserves, which have a great potential for rehabilitating fisheries, will fail, as well, if the key problems of fisheries are not addressed, notably the build up of excess fishing capacity, much of it driven by government subsidies (i.e., taxpayers' money) and indeed, of excessive expectations from fisheries, by both governments and the consuming public.



America's Ocean — A Surrogate for Distant Seas

Vice Admiral Paul G. Gaffney II
President, National Defense University
Member of the U.S. Commission on Ocean Policy

Paul Gaffney II is a vice admiral and president of the National Defense University. He was the chief of Naval Research and director of the Test and Evaluation and Technology Requirements in the Office of the Chief of Naval Operations. Gaffney is a member of the U.S. Commission on Ocean Policy.

If one integrates over a few days the location of all the world's electronic emissions – and one can do that from satellites these days – one will see a pretty good outline of the world's coastlines. What's the point? Electronic emissions can be directly correlated with important economic operations and important population centers. Sure one will see signals grouped around Chicago, Munich, Moscow, and Beijing. But, this mapping exercise shows that most people and their most important activities are "bundled" near coastlines.

From a broad National security perspective that revelation leads a nation to invest in a global, agile maritime defense capability to protect shores and guarantee commerce.

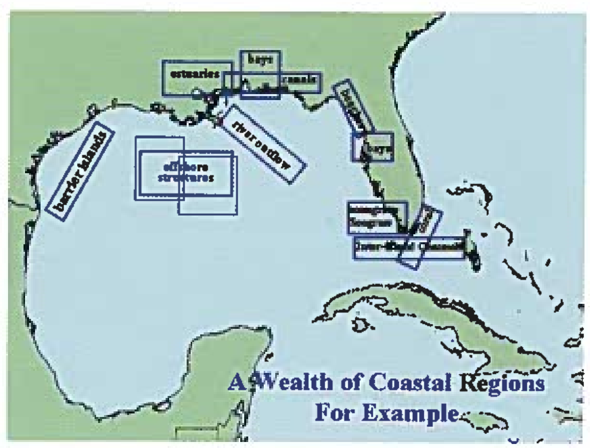
The U.S. strategy has always been to prevent the spread of conflict to our shores. We deter and win offshore. Terrorism challenges that strategy, but holding terrorist-supporting states accountable, again, moves the game offshore.

Clearly, while our Nation deliberately plans for military engagement in several discrete areas of the world, it is impossible to predict the exact locale where U.S. might need to engage next.

In almost all military contingencies over the past five decades, expeditionary Navy, Marine and naval special operations forces have been called upon.

As those forces approach a foreign shore they need to understand its ocean dynamics, hydrography, local weather phenomena, tidal variation, marine flora and fauna, and so forthÖbecause they want the environment to enhance operations not detract from them.

The Navy's ocean survey fleet – a robust, modern and globally ranging fleet – cannot do comprehensive surveys everywhere, and are not permitted to do close-in coastal surveys in many areas. So how does America prepare its forward Sailors and Marines?



One way is to do comprehensive survey, data collection, remote sensing correlation, and modeling of diverse environments at home and try to identify "rules of thumb" that will help us characterize key oceanic behaviors that can affect naval operation safety and effectiveness in areas with which we have no experience or little knowledge. Gain skill in surrogate environments here, transfer that knowledge quickly to distant ocean areas which we have been unable to comprehensively understand beforehand.

America's Sea – the Gulf of Mexico — is a perfect surrogate laboratory. It contains many coastal environmental types, it is close to Navy, academic, and state ocean centers of excellence and is the home for several Federal ocean programs, it's easy and cheap to reach. And, there is an opportunity in the Gulf for many Federal, State, and private ocean programs to leverage one another.

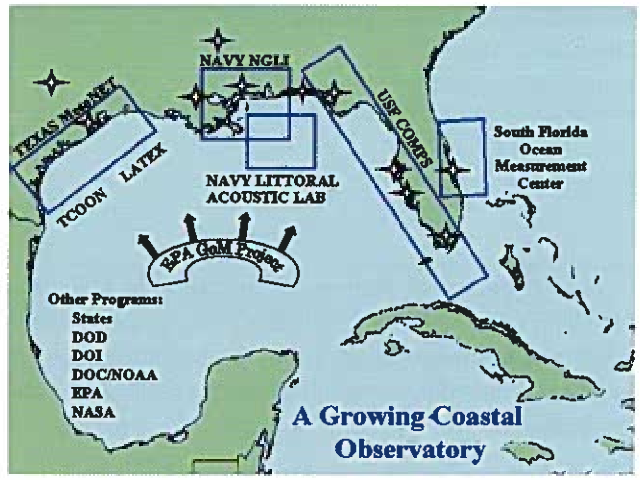
This same logic can be transferred to the Gulf of Maine, Buzz-a-Gansett, the Georgia Bight, Onslow Bay, the Gulf of Alaska, and the Neptune Project area – and it should.

But, I have favored the Gulf as a top priority. Especially when one includes the offshore energy industry as a partner.

The Gulf (and other nearby U.S. "owned" basins) is an ideal surrogate for the Navy and Marine Corps. It is likewise a key locale from which to launch a U.S. global ocean observing system: reachable, affordable, talent rich, oceanographically diverse, and multi-agency interesting.

A U.S. led global ocean observing system is a responsible capability to support. I would create it first at home, and then move outward. I would start with some of our large basins and bays first. At the top of my list would be a basin that can help address distant National security needs as a *surrogate laboratory.

There are others which are also important. But, among those at the very top must be the American Sea – the Gulf of Mexico.



The Global Ocean Observing System: Adequacy of Coastal Observations

Thomas C. Malone
Horn Point Laboratory
University of Maryland Center for Environmental Science

The Program of Action for Sustainable Development (*Agenda 21*, 1992 UNCED) calls for the establishment of a global ocean observing system that will enable effective management and sustainable utilization of the marine environment and its natural resources. Effective and sustainable use of the marine environment and its living resources depends on the capability to repeatedly assess and anticipate changes in the status of coastal ecosystems and living resources on national to global scales. GOOS is an effort to respond to this mandate by developing an international framework for coordinating, enhancing and supplementing existing monitoring and research programs to provide the data and information required for more timely detection and prediction of changes in the state of coastal ecosystems and the resources they support. Successful implementation of the observing system will increase the value to society of research and monitoring in marine and estuarine ecosystems, in part by providing the data required to routinely and periodically assess the status of marine and estuarine ecosystems.

This paper addresses two related topics. The first is the challenging and difficult task of producing scientifically credible quantitative assessments of the status, condition or health of coastal marine and estuarine ecosystems (ecosystem assessments) on regional to global scales. The second is the design of an observing system that will provide the data required to produce such assessments in a routine and timely fashion.

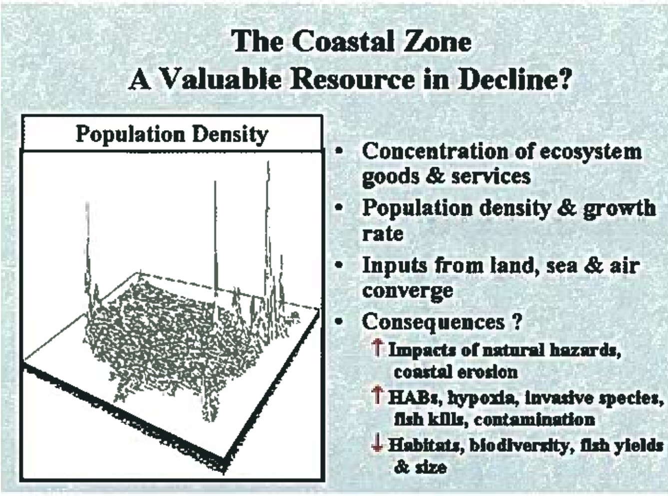
Coastal eutrophication, harmful algal events, habitat loss, declines in living marine resources, and other changes in coastal ecosystems have led to international conventions and initiatives that are intended to enable improvements in environmental protection, resource management, and conservation. Achieving the goals of these agreements requires accurate, quantitative, and periodic assessments of the status of coastal marine ecosystems and living resources on national to global scales, and efforts to provide such assessments increased dramatically during the 1990s. The recently released Pilot Analysis of Global Ecosystems and the soon to be released State of the Nation's Ecosystems are used here to illustrate the need to link such analyses to sustained observing systems that provide rapid access to the required data and information.

The results of these analyses deliver a clear message:

> If assessments of the status of coastal ecosystems and resources are to be quantitative and comprehensive, and if they are to be repeated in a timely fashion for decision makers and the public at regular intervals, major improvements are needed in the kinds, quality and quantity of data collected and in the efficiency with which data are disseminated, managed, and analyzed.

These and other analyses reveal fundamental problems in current and past research and monitoring programs that make comprehensive, quantitative, timely and routine

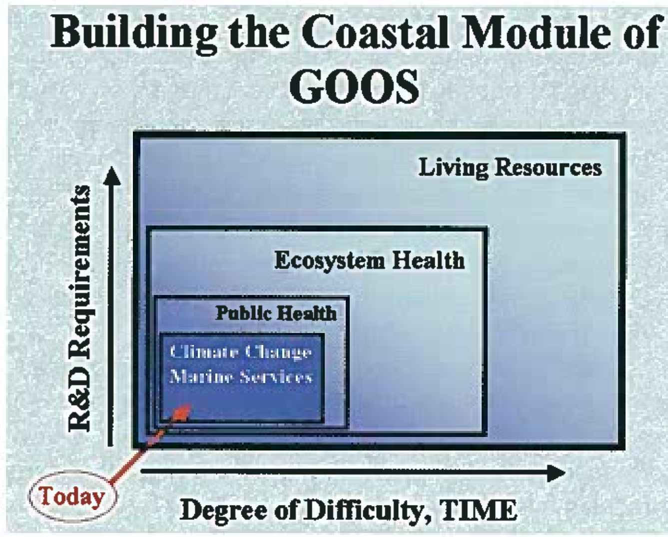
DR. TOM MALONE received his B.A. in zoology from Colorado College, M.S. in oceanography from the University of Hawaii and Ph.D. in oceanography from Stanford University. He has published more that 60 technical papers in peer reviewed journals and books on coastal oceanography, plankton dynamics and eutrophication. Prof. Malone served as the Director of the Horn Point Laboratory of the University of Maryland Center for Environmental Science for the past 10 years; is Past-President of the American Society of Limnology and Oceanography; and has served on numerous committees and panels for the U.S. National Academy of Science. He chaired the Coastal GOOS Panel for the IOC and currently serves as the co-Chair of the Coastal Ocean Observations Panel (responsible for formulating design and implementation plans for the coastal module of GOOS) and the U.S. GOOS Steering Committee. Prof. Malone recently received the Louis T. Benezet award from Colorado College for excellence in research and contributions that have improved people's lives.



assessments of coastal ecosystem status virtually impossible. The most important problems that require immediate attention are as follows:

1. Undersampling (insufficient resolution in time and space to make a statistically meaningful calculation), especially in the southern hemisphere;
2. Lack of spatially and temporally synoptic observations of key physical, chemical and biological variables;
3. Lack of standards or comparable protocols for measurements and data exchange;
4. Unefficient data management systems that do not provide rapid access to diverse data from disparate sources;
5. Kack of operational models for assimilating and analysing data with acceptable speed and skill.

The coastal module of GOOS is being designed to address these problems, and one of the more important uses or products that the coastal module will make possible are scientifically credible, quantitative, routine and periodic assessments of the status of coastal ecosystems on local, regional and global scales.

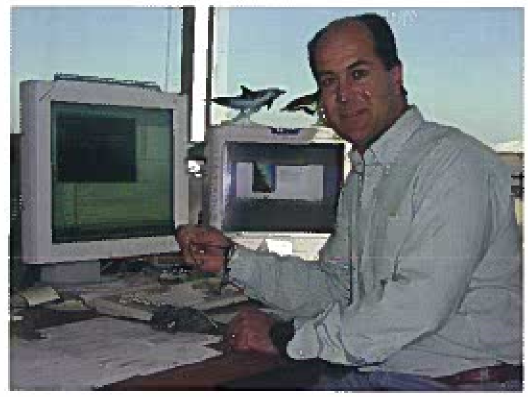


Climate Effects on the Gulf of Mexico Ecosystem

Frank Muller-Karger
College of Marine Science
University of South Florida

Climate and Change

The American Heritage Dictionary (2000) defines climate as "The meteorological conditions, including temperature, precipitation, and wind, that characteristically prevail in a particular region." This is different from weather, which refers to the state of the atmosphere at a particular place during a short period of time, typically less than a few days. Most definitions of climate don't consider the ocean, and they don't attribute climate to specific causes. Within scientific circles, however, the meaning of climate is growing to include the variability of weather, the atmosphere, the hydrosphere, lithosphere, biosphere, and such extraterrestrial factors as the sun (Encyclopaedia Britannica, 2000).



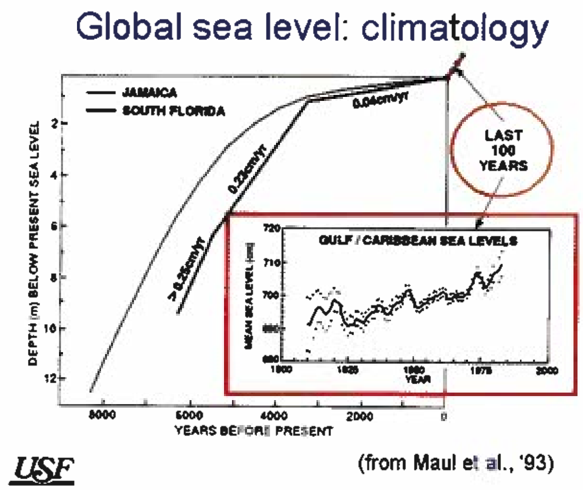
DR. FRANK MULLER-KARGER is on the faculty of the College of Marine Science at the University of South Florida. Dr. Muller-Karger's primary interests are science education and oceanographic research of coastal zones, continental margins, and the contributions of the marine environment to the global carbon cycle. His research utilizes observational time series, satellite data and other new technologies to measure large-scale oceanographic phenomena. He is of Puerto Rican, Venezuelan and German descent and speaks fluent Spanish. Dr. Muller-Karger is a member of the U.S. Commission on Ocean Policy.

The period of time over which we assess climate can range from one month to many millions of years, and usage may commonly refer to a person's own experience and span a period of between 10 and 30 years. Most of us have at some point made a comment on how weather has changed from what was expected at a particular time of the year; this is an example of awareness of climate and how common it is to detect changes in climate. Over the last 12,000 years alone, the average annual temperature of the Earth's atmosphere has changed from less than 12°C (<54°F) at the end of the last ice age, to over 14°C (>57°F) over much of the last 10,000 years. Indeed, global temperatures reached near 14.5°C (~58.5°F) between about five to six thousand years ago (the "Holocene Maximum") and then decreased significantly to reach minima of approximately 13.5°C (56°F) in the past 1,000 years. The first of these minima occurred around the year 1,400 and the second around 1650, defining what is known as a "Little Ice Age". Temperatures have been climbing since then, and since 1940 they have persistently averaged over 15°C (59°F) with a few cooler exceptions in the 1960s and 1970s (Maul, 1993; IPCC, 2001). In the history of the Earth there are long periods with relatively stable air temperatures, such as during the middle of the Holocene between four and six thousand years ago, when temperatures remained relatively constant. More commonly, however, climate tends to drift toward cooler or warmer conditions over shorter periods.

At present, climate seems to be changing. Over the last 100 years, and particularly over the past 25 years, we have obtained more accurate measurements of the temperature of the ocean and of land via more direct means such as reliable thermometers. Combining the few reliable long-term measurements available from around the globe, the National Oceanic and Atmospheric Administration (NOAA) estimates that the average combined land and ocean annual temperature over the period 1880-2000 was 13.9°C (57°F), with the annually averaged land temperature being 8.5°C (47.3°F) and the sea surface temperature being 16.1°C (61°F). For the year 2001, land temperatures were estimated to be 0.74°C (1.33°F) above this average, while ocean temperatures were 0.43°C (0.77°F) higher. Air temperatures at ground level over the last century have increased at an average rate of about 0.6 C, and there is some evidence that in the last 25 years the increase has been somewhat faster (estimated at about 2.0°C/century). The higher average oceanic temperatures seen in the past few years are at least partially attributed to the strong El Niño-Southern Oscillation (ENSO) event of 1997-1998.

The changes in the temperature of the atmosphere are accompanied by changes in glacial extent, rainfall, and river discharge, among many other environmental parameters. These in turn have a direct impact on the ocean's physical properties, such as salinity and sea surface temperature. Variability in these properties affects the ocean's circulation, which is largely driven by the wind and by regional changes in salinity and temperature. Further, changes in the amount of water tied up in land-based glaciers and in the volume occupied by the ocean as water changes temperature have an impact on sea level.

Global sea level rose very rapidly at the end of the last glaciation, as glaciers and the polar ice sheets melted at their fringes. On average around the globe, sea level is estimated to have risen at rates exceeding 2.5 mm/year between about 8,000 and 6,000 years before present. These rates steadily decreased to less than 2.0 mm/year through about 4,000 years ago and stabilized at less than 0.4 mm/year through the late 1800s. Global sea level rise has accelerated again within the last 100 years, during which it has averaged about 1 to 2 mm/year.



The question of whether the trends of increasing sea level and oceanic temperature are sustained or not drives much of today's marine scientific research. These studies base projections on extrapolations from trends of increasing temperature and sea level over the past 25-100 years, and consider that anthropogenic greenhouse gases such as carbon dioxide and methane that accumulate in the atmosphere are at least in part responsible for a positive trend in these parameters. These studies, however, are hampered by the lack of past and present observation networks that permit an assessment of how different regions of the global ocean respond to change. The observations would be of particular relevance along the coasts of all continents, but there are precious few time series of oceanographic observations in the global ocean. Clearly, the historical dearth of oceanic data leaves us with only crude tools to assess historical changes in oceanic meteorology, sea level, ocean temperature, and key biological and chemical parameters. At present we have a great opportunity to build a robust system that will allow future generations to help assess climate change.

Based on incomplete evidence, atmospheric temperatures have been projected to change between 1.5 and 4°C (3 to 7°F) over the next century (see synthesis study by the IPCC, 2001). A more recent study shows that the rate of growth of greenhouse gas emissions has slowed since its peak in 1980, due in part to international cooperation that led to reduced chlorofluorocarbon use, slower growth of methane, and a steady rate of carbon dioxide emissions (Hansen and Sato, 2002). If fossil fuel use continues at today's reduced rates for the next 50 years, and if growth of methane and air pollution (for example, production of soot) is halted, Hansen and Sato (2002) estimate that the warming in 50 years will be about 0.7°C (1.3°F), and may be less than half the warming in the "business-as-usual" scenarios of the IPCC (Hansen and Sato, 2002).

Combined, the physical factors that reflect climate such as changes in temperature, sea level, and precipitation have profound effects on biological processes in the ocean and along coastal zones. It would be a mistake at this stage to make concrete predictions or to draw conclusions on how some of these changes are affecting ecological systems along the coast and the interior of the Gulf of Mexico, since these predictions would be based on incomplete information. Any premature conclusions will taint the way we look at how we design an observing system, and how we analyze data. It is important that we develop a robust observing system to help monitor these environments. A few problems in the Gulf are becoming apparent, and many of these are described by Twilley et al. (2001) and in Maul et al. (1993). The text below provides only a superficial treatment of these problems and intends only to highlight some of the issues that seem most apparent.

Effects on coastal environments in the Gulf of Mexico

The warming of the globe over the past 100 years has not been uniform. Some areas, including parts of the southeastern U.S., have cooled or show no apparent change. Others show greater warming. Similarly, on a global scale there is little evidence of sustained trends in climate variability or in extremes. However, on regional scales, there is clear evidence of changes in variability or extremes. The changes observed at any one location confound the effect of natural, human-induced changes in climate. And along the coasts of the globe, the rapid development of coastal and submerged lands for human use has led to obvious substantive changes.

Recent synthesis studies attempt to provide insight into how climate has changed around the periphery of the Gulf of Mexico. The synthesis efforts show how little information is available on the interior of the Gulf of Mexico. Basically, we have no mechanism to assess how the oceanography of the Gulf of Mexico has changed, and we have only the most basic tools to assess changes along the coast.

Twilley et al. (2001) found publications that suggest trends of sea surface temperature warming along the coasts of the Gulf with cooling in offshore waters. Maul et al. (2001) examined seawater temperature records at tide gauges around the USA and found a mixed record of warming at some locations, cooling at others, and no evidence of a north-south gradient in trends along the seaboard of the USA. Within the Gulf of Mexico, Maul et al. (2001) observed no change in temperature at Key West, one of their most "oceanic" sites (mean of 0 °C/100 years with a standard error of ±0.3 °C/100 years based on observations between 1926 and 1994). They found a slight decrease in temperature at Galveston (mean of –0.1°C/100 years with a standard error of ±0.5 °C/100 years, between 1921 and 1992). Maul et al. (2001) point out the difficulties in assessing trends, given significant changes in the methodology for measuring sea surface temperature at the tide gauge stations (seawater is now measured automatically at the intake of the tide gauge stilling system, rather than by bucket).

With the availability of reliable long-term temperature records (> 25 years) at high temporal resolution (daily to seasonal), several cyclic or at least recurring processes have been detected in the Gulf of Mexico and adjacent Atlantic Ocean. The best known is related to the ENSO, which has its origins in the tropical Pacific. Other large-scale processes that affect the Atlantic Ocean have been called the North-Atlantic Oscillation (NAO), the Tropical Atlantic Variability (TAV), and the Arctic Oscillation (AO). It is becoming more evident that ENSO largely controls the storm tracks over Florida, but it appears that the NAO and the AO also play a role in whether storm tracks will tend to pull cold air well southward or not. NOAA analysts believe that during strong La Niñas, the predominant northern storm track would be more likely to pull cold air down into Florida, but above or below normal temperatures in the source region probably depend on other factors. The general lack of storminess over Florida during strong La Niñas would mean more sunshine and less rain, and above normal "average" seasonal temperatures, but a greater chance of cold spells. The NAO and AO are not as well understood as ENSO and are much less predictable. According to NOAA, this is an example of a "tangled system" and the interplay between ENSO and a strong phase of the NAO would be difficult to foretell. Some researchers have predicted an increase in the frequency of intense hurricanes in the next 25 years (see references in Twilley et al., 2001), but the historical global meteorological record is still too short to help make sound inferences about the connection between ENSO or other periodic phenomena and hurricane intensity or frequency in the Gulf of Mexico.

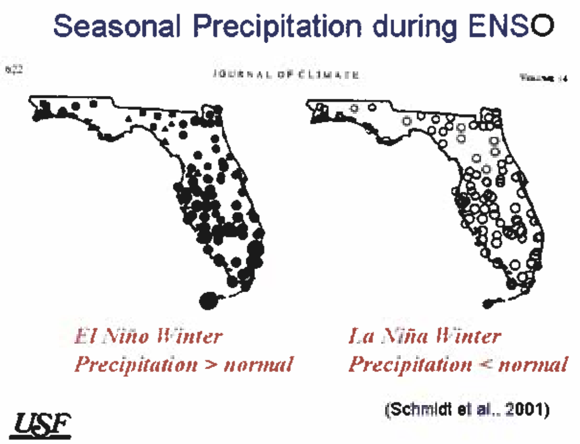
Key West, a site of tectonic stability, shows an average sea level rise of 2.2 mm/year (Hanson and Maul, 1993). However, Twilley et al. (2001) point out that sea level rise along areas of the Gulf coast is more dramatic than the global average due to local geological processes. A regional maximum of 10 mm/year is centered in the northwestern Gulf of Mexico immediately west of the Mississippi Delta (Hanson and Maul, 1993). This is an area of coastal subsidence (sinking land). To the southwest, the coasts of Texas show sea level rise in the range of 2 to 8 mm/year. In contrast, regional minima (-3 mm/year occur in the southwestern Gulf, where there is diastrophism (active upward distortion of the land). The records available show that the average rate of sea level rise for the Gulf coast accelerated around 1930, and a projected average increase of sea level for the 21st century of is about 0.5 meters. Estimates range widely, however, because local geological effects need to be considered to understand the net effect of global changes in sea level along the coast.

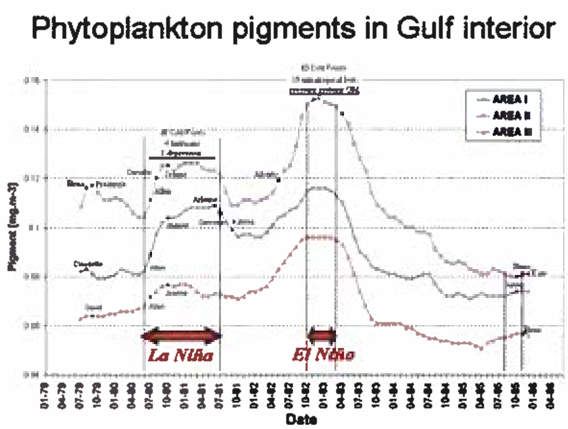
At Key West, sea level seems to be unrelated to local air temperature, barometric pressure, precipitation and records of coral growth. However, sea level is significantly lower than normal during the year preceding an ENSO event, and higher than normal during the event itself (Hanson and Maul, 1993). Such behavior has not been confirmed at other sites along the Gulf coast.

The impact of sea level rise on coastal ecosystems is varied and complex. Of concern is increasing rates of erosion of beaches, but these processes are strongly modified by human interventions including construction of jetties, piers, pipelines, etc., as well as beach renourishment projects.

An important factor that affects the coasts and shelf environments of the Gulf of Mexico is riverine discharge. The Rio Grande is dammed at a couple of locations (Amistad Reservoir and Falcon Lake), and thus is not a good choice for monitoring changes in climate. The Mississippi's discharge record at Vicksburg, Mississippi, shows no significant trend in average discharge with time since 1929, and there is large variability in total average discharge observed from year to year. Rainfall over the Mississippi valley has not shown a significant trend in the last 90 years either, and there is a good relationship between rainfall and discharge. Thus, the Mississippi's discharge may be a valuable index for the effects of climate (Muller-Karger, 1993).

While there is at this time no apparent trend in the discharge rate of the Mississippi River, at least two major factors have led to large changes in the Mississippi River delta and surrounding areas. The Mississippi Delta is a feature that has changed radically over geologic times because of climate change (Coleman, 1988) and sedimentation patterns, but now these natural processes have been radically changed. The completion of the Old River control structure in 1963 led to about 30% of the Mississippi's discharge to be diverted to the Atchafalaya River. This has changed the natural rates and patterns of sediment delivery to delta lands. As a result, the modern delta is starved of sediments and erosion and flooding have become serious problems in the region. Also, over the last 100 years, nitrate concentrations in the Mississippi River have increased significantly as a result of increased use of fertilizers within the Mississipi's drainage basin (Walsh, 1988; Turner and Rabalais, 1991). In the last 30 years, nitrate concentrations in the river have increased three- to five fold, from about 35 micro-mol/kg (~0.5 mg/l) around 1960 to over 178 micro-mol/kg (~2.5 mg/l) in the late 1990's. Non-point source leaching of pollutants from farmlands and cities contributes over 90% of the nitrogen and phosphorus nutrients being washed into the Mississippi River. The most apparent effect of this increase in nutrient load is very high primary productivity near the delta in the





spring, with subsequent decomposition of this material forming an anoxic zone that can cover in excess of 18,000 km². This area has been called "The Dead Zone" because its formation leads to the asphyxiation of aquatic life off the Mississippi Delta (Turner and Rabalais, 1991). For additional information on this phenomenon and its social and economic impacts please refer to the EPA assessments developed by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force during the fall of 1997 (see http://www.nos.noaa.gov/products/pubs_hypox.html#Topic3 and http://wwwrcolka.cr.usgs.gov/midconherb/hypoxia.html). At present there are attempts to develop ideas for mitigation schemes, some of which include restoring or building wetlands and riparian buffer zones along waterways. These would serve as filters to clean Mississippi River water may be allowed to flow over the wetlands. Clearly, any such scheme will lead to additional landscape and ecological changes in the delta region.

The Mississippi is a clear example of how human-induced change can completely overwhelm any decade- to century-scale coastal processes that respond to climate change.

Over northern Florida, rainfall and river discharge during winter and spring of ENSO years is higher than normal (Sun and Furbish, 1997). The increased discharge delivered to the northeastern Gulf of Mexico in spring 1998 may be expected to lead to higher than normal nutrient availability and blooming of phytoplankton along the coast (Gilbes et al., 1996).

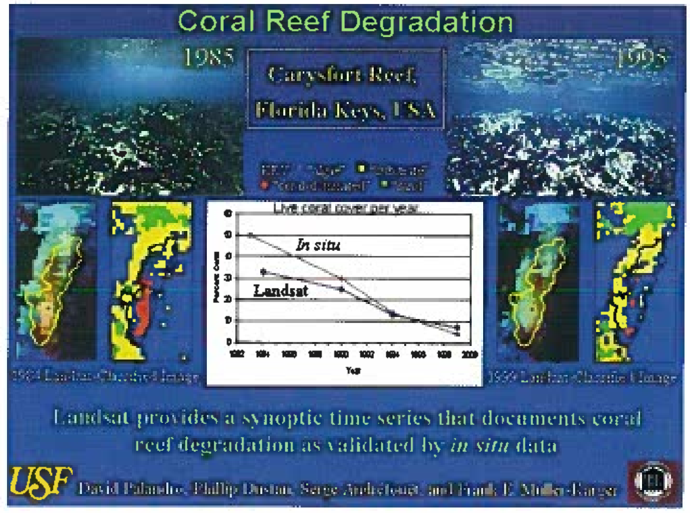
All the these changes can have important impacts on key coastal ecosystems, such as estuaries, lagoons, and bays and specifically on coral reefs (Milliman, 1993), mangrove forests (Snedaker, 1993), and sea grass beds (Vicente et al., 1993). Further, increased nutrient discharge into the coastal zone may be one of the factors that can lead to increased frequency in the occurrence of red tides.

Effects on offshore environments of the Gulf of Mexico

In the interior of the Gulf of Mexico away from the continental margin there is a serious dearth of biological data collected in a coherent and systematic way prior to about 1980. This hampers any attempt to assess effects of climate change on ecosystems over longer historical periods. A few studies allow us to make inferences on what could happen under certain climate change scenarios, however. Also of use are charts depicting the distribution of major ecological domains (Gable, 1993), but these charts need to be redrafted frequently to help understand where change is taking place.

The Gulf of Mexico exhibits some of the largest and persistent coastal upwelling regimes of the subtropical western North Atlantic. One of these is located over the Bank of Campeche, along the northern and western coasts of the Yucatan Peninsula. This area supports a very large industrial fishing fleet, and any reduction in the flow of water through Yucatan Straight forced by major changes in the circulation of the North Atlantic are likely to influence the strength and timing of this upwelling, and therefore the biological productivity of this region.

The largest upwelling phenomenon, however, takes place seasonally in the region called the northeastern Gulf of Mexico (NEGOM) along the shelf break of the West Florida Shelf (Yang and Weisberg, 1999; Muller-Karger, 2000). A cold water tongue extends southward along the West Florida Shelf starting usually around November, and persists through February-March. The origin of this large upwelling



tongue appears to be massive movement of water along the shelf break forced by density gradients set up by the temperature difference between waters in the interior of the Gulf and waters on the shelf. Very little is known about the ecological importance of this feature, but it occurs every year and serves as a mechanism to disperse river-derived water along the West Florida Shelf break. It is associated with higher concentrations of phytoplankton and colored dissolved organic carbon (Gilbes et al., 1996).

More than 1,000 species of finfish inhabit the waters of the Gulf of Mexico. Although only a small fraction are considered economically important, in 1998 finfish represented a substantial commercial resource valued at more than 145 million dollars. Global change can have varying impacts on fish habitat, and fisheries pressures can contribute to this by removal of predators, prey, and competitors. Similarly, any change in the temperature gradient in the Gulf may lead to a change in the processes that lead to the seasonal upwelling, and a major change in the patterns of productivity within the Gulf.

Melo et al. (2000) used time series of phytoplankton pigment concentration estimates derived from the Coastal Zone Color Scanner (CZCS) satellite sensor and historical Sea Surface Temperature (SST) records (Reynolds and Marsico, 1993 and COADS, 1998) to examine variability over approximately one decade. There appears to be a 4 - 5 month lag in Sea Surface Temperature and ENSO events (Enfield and Mayer, 1996) for the Caribbean and Gulf of Mexico basins. Melo et al (2000) found that during the ENSO of 1982–1983, positive anomalies were observed in the pigment concentration in the Gulf of Mexico during winter months. This was associated with intense mixing of the water column by higher frequency and stronger winds associated with cold fronts. ENSO 1982–1983 therefore had a fertilizing effect on the region. Over this period, cold fronts reached the region with almost twice the frequency of previous years, and more low-pressure systems formed in the Gulf of Mexico and traveled farther to the south than normal, causing high winds in our study areas. Another positive anomaly was observed in 1980–1981, a non-ENSO period that featured higher hurricane and extra-tropical low-pressure activity.

Other issues of ecological concern in the northern Gulf of Mexico relate to marine mammals. Large numbers of whales and manatees live in the region. Sensitive species include bottlenose dolphins, right whales, sperm whales, manatees, and several other important species of mammals. There are concerns that these animals may be increasingly threatened by toxicants, recreational boating, shipping, offshore drilling exploration and exploitation operations, and military tests (see, for example, Petzet, 1999). While the impacts are not directly related to what may be considered climate change, they are short-circuited by direct impact from human activities. It is important that the requirements of these animals be considered in designing systemic solutions for protection of the Gulf ecosystem.

Conclusions

Assessing the effects of climate change and developing predictive tools will require the deployment of a well-designed and robust observation network within the marine environment, and substantial investments in the skills needed to interpret these data. This observing system needs to include a variety of technologies to observe biological and chemical parameters across ecosystems ranging from coastal reef to the deep water where pelagic fish communities and whales live, in addition to basic physical parameters.

Clearly, humans deeply influence their surroundings and the impact of development of coastal communities and marine industries, as well as development in areas far inland, have large impacts on the marine environment. At present, nearly two thirds of coastal waters are affected negatively by human population growth, leading to severe issues of ecosystem health. We have the opportunity to "design" the fate of ecosystems if we develop policies that are based on solid scientific principles and if all stakeholders work together to uphold these policies. We are an integral part of global change, and minimizing our impact on these ecosystems will require a new paradigm of working with resource managers, policy makers, industry, scientists, educators, and the general public. We need to establish partnerships between these groups to ensure that we proceed with growth in a manner that is consistent with preserving the health of our own society and culture, and ensure sustainable use of natural living resources for the enjoyment of our children and future generations.

Acknowledgment

The manuscript benefited from input and discussions with John J. Walsh (College of Marine Science, University of South Florida).

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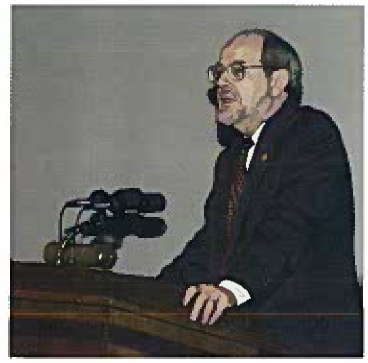
U.S. Commission on Ocean Policy Site Visit at Texas A&M University

Dr. Ronald Douglas
Executive Vice President and Provost
Texas A&M University

Ladies and gentlemen, distinguished visitors:

I am pleased and honored to welcome the members of the United States Ocean Commission to Texas A&M University and to this conference on a Sustainable Gulf of Mexico. We are proud to host the Commission for its important task of receiving testimony and public comment about regional ocean issues of national significance. The Commissioners will hear from speakers who will provide a Texas perspective on resource development, the sustainable environment, coastal management and security, and other ocean-related topics of national importance. The speakers represent interests from the oil and gas industry, academic research, and local and state government, notably the Texas General Land Office. These distinguished speakers will no doubt bring forward important issues for consideration and recommendations that will contribute to national policy.



Dr.Ronald Douglas

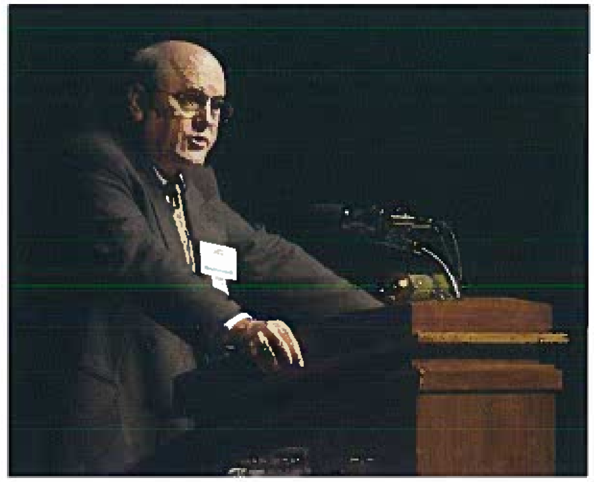
Following the speakers' presentations, there will be an opportunity for comments from the public.

Once again, let me express my warmest welcome to Texas A&M. We are honored that the Commission is able to visit our campus, and we look forward to a productive discussion.

I am pleased to introduce Commissioner James Coleman, Boyd Professor for the Coastal Studies Institute of Louisiana State University, also a member of the Ocean Studies Board and the National Academy of Engineering, who will moderate the proceedings.

The U.S. Commission on Ocean Policy

New Biological Discoveries in the Gulf of Mexico



James P. Ray
Manager, Environmental Sciences
Shell Global Solutions U.S.
Houston, TX 77082

Good afternoon. It is my pleasure today to appear before this panel of the new United States Commission on Ocean Policy. In my brief comments, I hope to convey the importance of the biological sciences in the continued quest to better understand our oceans; to focus on the importance of biology in better managing our resources; and in continuing to develop our offshore energy resources.

My name is Jim Ray. I am the Manager of Environmental Sciences with Shell Global Solutions U.S., located at Westhollow Technology Center in Houston, Texas. By training, I am a biological oceanographer who proudly graduated from this very institution over a quarter of a century ago. I still maintain my ties to the Oceanography Department and currently serve as a member of their Oceanographic Advisory Council.

As a representative of the industrial user community, I would like to focus on the importance that the biological sciences play in our proper management of the oceans. Over the past 10 years, the petroleum industry has rapidly moved off the continental shelf and down the continental slope into deepwater. As they did so, they were moving into an oceanographic realm where less information was available.

In the U.S., there are a variety of different environmental laws, regulations, and government agencies that define what may or may not be done offshore. The requirements to seek and utilize new data from the far offshore regions have led to numerous new and exciting discoveries over this past decade. Biology is at the heart of these new discoveries because a key thrust of the regulatory requirements is to understand and properly manage the living resources.

The use of deep diving submersibles, remote operated vehicles, autonomous underwater vehicles, fixed cameras, and towed video systems, have revealed a variety of new species, and more insight into the life cycles and behaviors of many organisms. Most deepwater drilling operations have remote operated vehicles with cameras for guiding their underwater maintenance work. In the course of doing their business, the industry has observed a variety of deepwater fish and invertebrates. We have seen surface species, such as sharks and swordfish, at great depths. We have also seen many new species that have never been identified.

The industry has found significant hydrocarbon reserves on the continental slope of the Gulf of Mexico. Early development started on the upper slope and continues to move deeper. Recently. a well was drilled on the abyssal plain at a water depth of more than 9,000 feet.

There are a number of commonly held beliefs about the deep sea environment: for example, it is dark and cold with a flat, featureless mud bottom; the bottom currents are low, and although there are a variety of strange looking fish and bottom dwellers, there are not many of them. I think today you will hear that most of these "assumptions" are not always true.

In fact, the geomorphology of the seafloor can be very complex. Deepwater currents at 6,000 feet have been measured in excess of 2 knots. Although the abundance of

JAMES P. RAY is the Manager of Environmental Sciences for Shell Global Solutions U.S., located at Westhollow Technology Center in Houston, Texas. Dr. Ray is a biological oceanographer by training, having received his degree from Texas A&M in 1974. Since that time, he has served as an environmental advisor for Shell Oil Company. Dr. Ray's career has primarily focused on issues related to the effects of oil and gas operations on offshore environments, including studies ranging from the acoustical impacts of offshore activities on bowhead whales in the Arctic to the impacts of oil spills on coral reefs and mangroves in the tropics. A major portion of Dr. Ray's career has focused on the fate and effects of pollutants in the marine environment. He chaired the American Petroleum Institute's Production Effluent Guidelines Task Force, which was the focal point for most of the drilling fluids and produced water research. He currently chairs the Offshore Operator's Committee Environmental Sciences Subcommittee, which oversees environmental issues and research for the Gulf of Mexico. Dr. Ray also served on the Minerals Management Service Scientific Advisory Committee and the National Research Council's Ocean Studies Board.

individual species is low, the deep sea might be one of the most diverse environments on earth.

Over the past decade, we have made numerous discoveries and expanded our knowledge on a range of species that live in our offshore waters. It is Important to realize that even though we have a focus on the "deepwater" environment, we are really considering the entire water column. not just the seafloor six thousand feet below.

For example, it used to be thought that we had a limited number of marine mammals in the Gulf of Mexico. Thanks to ongoing National Marine Fisheries Service and Minerals Management Service studies, we have now identified 29 species of marine mammals. A majority of these are far offshore in deepwater. We also know that we have a population of over 600 sperm whales, which tend to migrate east and west along the 3,000-foot bathymetric contour. This is along the same corridor where many of the deepwater platforms are located. Studies are currently ongoing to determine acoustic effects on the whales and their behavior. The sperm whales have been known to stay submerged for up to two hours and dive to depths between 5,000 and 10,000 feet. We have also learned from satellite tracking that they can transit along the coast to the west, as far as the Bay of Campeche in Mexico. Most importantly, the sperm whales are also an endangered species.

Using research submersibles and remote operated vehicles, unique new deepwater communities have been discovered around natural brine pools and hydrocarbon seeps along the continental slope. These communities are unique because instead of being linked to, and depending on, photosynthetically derived organic carbon as a food source, they derive their energy from carbon compounds created by bacteria which get their energy by oxidizing sulphide and methane compounds which emanate from the natural seeps and brine pools.

These chemosynthetic communities have low diversity but a high abundance of organisms that are specially adapted for living in extreme environments. Because of the symbiotic relationship with bacteria that can process and extract energy from sulphides and methane, the various tube worms, clams, and other animals can thrive in a relatively nutrient poor environment.

The tube worms are very unique and are characterized by having no mouth, gut, or anus. They assimilate their nutrients from the environment and the symbiotic bacteria that are deriving energy from the seeps. Some of these worm tubes can be ten feet tall and the life span has been estimated to range from 170 to 250 years old. The industry is now required to conduct geohazard surveys prior to drilling activities in order to identify potential habitat suitable for these chemosynthetic communities.

In 1997, a new species of marine polychaete worm was discovered in 1,500 feet of water. Where they found it was quite unusual. During their dive, Drs. Mac Donald and Fisher observed a boulder sized outcrop of frozen methane gas, more commonly known as gas hydrate. Upon closer examination, the entire underside of the outcrop was covered by network of small burrows filled with pink colored polychaete worms. Studies are currently underway to learn more about the worm's life history, reproduction, and relationship to the gas hydrates. For example, are they deriving their nutrition symbiotically from methane utilizing bacteria?

In the past several years, a number of surveys have discovered sunken ships in the deep Gulf of Mexico. Because we know exactly how long they have been on the seafloor, they provide ideal habitats for studying the colonization of deepwater species to hard bottom substrates. Future studies hope to reveal new information on the species present in the deep sea, their reproductive dispersal mechanisms, and their recruitment and growth rates.

We know little about the open ocean segment of the life cycles of the five species of threatened and endangered species of marine turtles that live in the Gulf of Mexico. Observation programs and satellite tracking programs are allowing us to slowly unravel the mysteries.

The large blue fin tuna, whose populations have been dwindling, are thought to use the eastern and central gulf as one of their primary spawning areas. New satellite tracking tags are being used to learn more about their distribution.

So why are these discoveries important for the future? The first answer is simple. Scientists need the information to better understand the marine ecosystems.

The second answer is more complex. As man's activities continue to impinge on our marine habitats, there is an ever growing need to have adequate scientific information so that our activities and resources can be properly managed. This applies to a range of activities, from commercial and sports fishing, to the search for and development of offshore energy resources.

There are numerous resource agencies with the mandate for acquiring this information and managing the resources. It starts with the National Environmental Policy Act of 1969, better known as NEPA. Starting with this broad federal mandate on the environment, a number of other federal agencies are involved in managing our offshore environment. The Minerals Management Service leases offshore lands and has the responsibility for monitoring future impacts under their mandate in the Outer Continental Shelf Lands Act. The National Marine Fisheries Service is responsible for commercial fisheries, and managing endangered species such as marine mammals and sea turtles. The Environmental Protection Agency regulates any discharges to the marine environment.

In order for these various agencies to meet their mandates and to properly manage our offshore environment, there will be a long term, ongoing need to acquire biological information on the marine environment. It will be crucial to understand our fisheries issues for long term sustainability, and it is required to support our on going development of offshore energy.

I would like to close with two key points. First, what is needed for the future? The bottom line, which I am sure you will hear many times while on this commission, is "more money!!!" Our nation needs to make a long term commitment to support the needed scientific investigations. Without an adequate commitment, timely and long term progress will be impeded.

Unfortunately, the cost of science is directly proportional to water depth. In simple terms, the deeper the water, the more it costs. The ships are larger, the equipment is bigger and more expensive, the technologies required are more sophisticated, and it takes longer to complete tasks.

Cooperation between academia, the government, and industry can help reduce some of these costs, but it has to be a team effort. We need to insure that oceanographic institutes have adequate funding to maintain quality staffs and to attract bright new students who will be the scientists of the future. There will also be a need to support new and better equipped ships as platforms for conducting the next generation of deepwater oceanography.

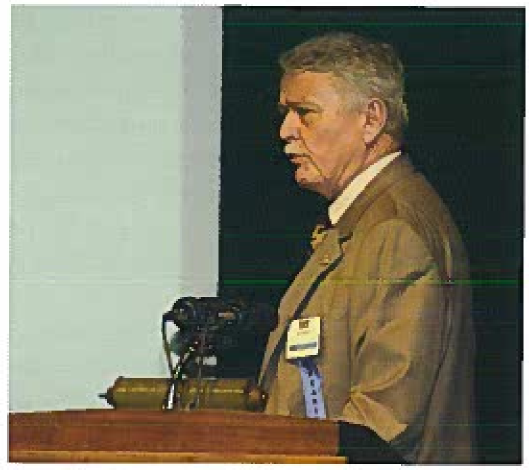
Secondly, as we look to the future, a focused, national energy program is needed. Within the confines of such a program, there should be a national imperative that the various government agencies with ocean mandates **work cooperatively** to support the long-term energy mission.

This includes a government commitment to provide adequate funds to each of the agencies involved. At the present time, only the Minerals Management Service tries to move forward on energy developments, while at the same time balancing their environmental responsibilities. The same sense of urgency and mission are not evident in the other government agencies. If everyone was pulling in the same direction, the nation would have a timelier and more secure offshore energy program and a better managed environmental program. We do not need to create a new Super Agency. We need to adjust the focus of our existing agency missions, revise the budget structure, and work together to gather the needed oceanographic information.

Thank you for this opportunity to address the Commission. We wish you success in assisting the government develop new ocean policy for the coming years.

Gulf of Mexico Components of an Ocean Observing System

Worth D. Nowlin, Jr.
Texas A&M University and U.S. Naval Oceanographic Office



Modules. The Global Ocean Observing System (GOOS) is being designed in two modules: (1) a *global module* designed to monitor, predict, and understand marine surface conditions and climate variability; and(2) a *coastal module* designed to sustain healthy marine ecosystems, ensure human health, promote safe and efficient marine transportation, enhance national security, and predict and mitigate against coastal hazards.

User Driven. A key tenet of GOOS is that it must be planned to *provide data and products needed by users*. An essential initial step is the assessment of user needs, which may differ by region.

Regional Systems. Therefore, a natural organizational mode is into regional ocean observing systems. It now seems clear that the coastal module of GOOS will be implemented as a *federation of regional observing systems*. These must be integrated among one another and with the global module of GOOS. We seek sharing of data and products to produce an integrated, sustained U.S. ocean observing system.

Types of Observations. Some *"backbone" observations* will be needed by most, if not all, regional systems (e.g., surface winds, sea level, temperature, currents, or surface waves). Other types of observations will be *specific* to regional systems (e.g., observatiions to monitor/predict hypoxia).

Funding for Regional Systems. Within the U.S. coastal zone (extending from the estuaries to the boundaries of our EEZ) it is expected that the federal government will support a considerable portion of the needed backbone observations. However, many of the specific observations needed by distinct regional systems must be financed by entities within the region, including industry, non-governmental organizations (NGOs), and state, regional, and local government agencies.

U.S. Regional Ocean Observing Systems are Under Development. Regional systems already under development along our nation's coasts include: the Gulf of Maine Ocean Observing System (GoMOOS), and the Gulf (of Alaska) Environmental Monitoring and Prediction System (GEM).

Vision Statement

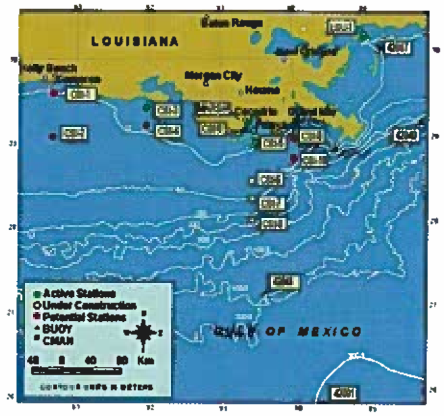
We seek to establish a sustained observing system for the Gulf of Mexico to provide observations and products needed by users in this region for the purposes of

- Monitoring and predicting effects of climate variability,
- Sustaining healthy marine ecosystems,
- Ensuring human health,
- Promoting safe and efficient marine transportation,
- Enhancing national security, and
- Predicting and mitigating against coastal hazards.

We envision sharing of data, models, and products via the internet for the common benefit of all participants, including industry, NGOs, academia, and federal, state, regional and local government agencies. It is understood that this Gulf of Mexico observing system will be integrated with other regional coastal ocean observing systems, in particular to create an integrated and sustained U.S. component of the ocean observing system. Collaboration with other nations bordering the Gulf of Mexico is to be actively sought in developing this system.

We recognize that the system will require sustained financial support from a combination of government, private, and non-governmental organizations. That will be possible only if the system is built and remains responsive to the needs of these organizations and to the public. Thus, the system will be subject to continuing oversight by representatives of such organizations and of the public.

WAVCIS - Wave-Current Surge Information System For Coastal Louisiana



Building Blocks

Data Management. Some 25 academic, federal and state governmental, and private partners have met and agreed to share real time and delayed mode physical data from the Gulf of Mexico and its estuaries. As part of a NOPP-funded effort, we have some funds to assist with this sharing, and we plan to entrain collectors of non-physical data into the system. The U.S. Naval Oceanographic Office has established a public-access server active 24x7 to facilitate the exchange of such data.

Observational Elements. In addition, to federally-supported *in situ* operational observations in the Gulf of Mexico, there are numerous observations funded by state and local governmental agencies. Some are operated by those agencies; others are operated by academic initiations. The private sector also supports in situ observations in the Gulf; access to such data may be negotiated. Observations made from satellites are supported by governments of the U.S. and other nations. Much of the value-added processing is carried out in academic laboratories.

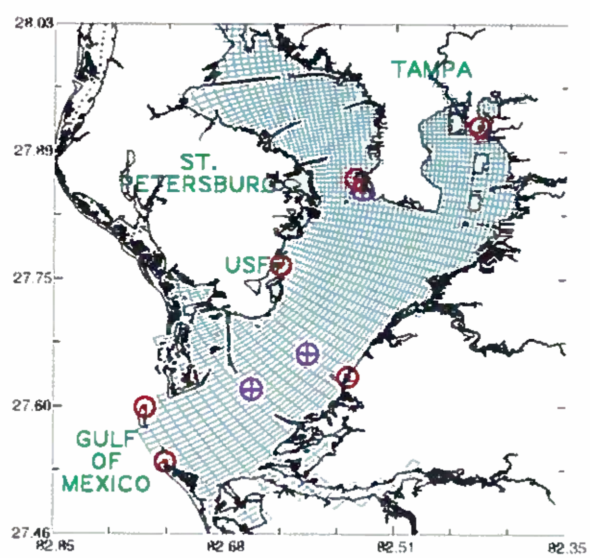
Models. A wide variety of models are available to analyze and forecast currents and other oceanographic conditions in this region. Some are operational, notably those to support the Physical Oceanographic Real-Time Systems in Tampa Bay and Houston-Galveston Bay, to support spill monitoring over the Texas-Louisiana continental shelves, to predict currents in Texas estuaries, to support the needs of offshore petroleum producers, and to support U.S. Navy missions.

Approach to Design and Implementation

The objectives of the Gulf of Mexico ocean observing system are to:

- Complete inventory of existing operational and product-producing components for the Gulf of Mexico; entrain those responsible into the design process;
- Determine needs of regional users;
- Establish a Gulf of Mexico GOOS Users' Forum;
- Establish data and information management system;
- Implement sharing of model code and output;
- Compare/validate models;
- Prepare initial design with priorities for implementation;
- Augment existing observations and products to begin implementation of the initial design; and
- Evaluate, complete, improve, and refine the system.

Tampa Bay Circulation Model domain



External Requirements

To successfully establish a federation of sustained, integrated regional coastal ocean observing systems for the U.S., there are several key requirements. Among the most important are the following:

(i) **Recognizing the need for a system and the roles of partners**. The federal governmental must recognize the need for a sustained, integrated ocean observing system and, importantly, agree on the respective roles of federal government, state and local governments, academia, and the private sector in this system. These roles have been carefully considered by many planners during the past decade and stated in various documents, but they have not been recognized in governmental policy, without which agreement on the roles of partners in the development of the system will be difficult to problematical.

(ii) **Implementing the "backbone" observations.** Agreement must be reached on the *"backbone"* observations and services that the federal government will provide. Implementation will require strong coordination of the activities of various federal agencies having mandated responsibilities for products and services based on these observations. NOPP may be able to effect this coordination, but not without stronger individual agency backing than is received at present.

(iii) **Providing a permanent source of support.** Federal legislation is needed to provide a permanent source of funding to develop the system. Such support must be available to state and local governments, perhaps with the requirement of matching funds, for the planning, implementation, and maintenance of a federation of regional coastal ocean observing systems covering the EEZ and estuaries of our nation.

Texas General Land Office

Spencer Reid
Senior Deputy Commissioner
Texas General Land Office

Thank you for the opportunity to address the commission today. There are three programs at the General Land Office (GLO) that have issues to call to your attention: Resource Management, Oil Spill and the Energy Division.

Texas has the third longest shoreline in the U.S., covering 18 coastal counties and including 367 miles of Gulf beaches and 3,300 miles of bay shoreline. Texas has one of the highest erosion rates of any state.

The Resource Management Division

Texas Coastal Management Program

The Texas Coastal Management Program (CMP) is a networked program linking state and federal agencies in the cooperative management of Texas' coastal resources. The Texas CMP incorporates:

- Review of federal and state agency actions for consistency with the CMP goals and policies.
- Grants to local governments, universities, and other qualified entities for projects that protect, restore, or enhance understanding of our coastal resources.
- Permitting assistance to persons planning coastal projects.
- Addressing coastal non-point source pollution to improve the quality and safety of our coastal waters.

Coastal Impact Assistance Program (CIAP)

Texas received a one-time grant of $26.4 million from Congress to offset impacts to coastal natural resources and communities due to offshore oil and gas exploration; $9.2 million was granted directly to the 18 coastal counties and $17.2 million was granted to the state:

- $9.7 million was awarded in June 2001 to 18 projects;
- $6.3 million will be awarded in March 2002 to additional large-scale projects; and
- $1.1 million will be awarded in December 2002 to small-scale projects.

The Texas CIAP plan is available at www.glo.state.tx.us/ coastal/ciap/plan/index.html

Beach Environmental Assessment

Congress has appropriated $400,000 for FY02 to Texas for implementation of the Beaches Environmental Assessment and Coastal Health Act (BEACH Act). Texas' existing Beach Watch program monitors bacterial water quality at 13 of the most popular Gulf beaches in six counties. BEACH Act funding will allow for water quality monitoring at all recreational Gulf and bay beaches.

Natural Resource Damage Assessment

The GLO is one of three state natural resource trustees who are jointly responsible for assessing injuries to natural resources resulting from an unauthorized discharge of oil or hazardous substances and asserting a claim for compensation on behalf of the public.

Coastal Erosion Planning and Response Act

The Texas Legislature appropriated $15 million in Cycle 1 (2000-2001) and $15 million in Cycle 2 (2002-2003) to support erosion response projects and studies. Projects conducted cooperatively with local governments, state and federal agencies, and have a funding match requirement.

In Cycle 1:

- 34 erosion response projects + 3 studies were conducted,
- $15 million state funding leveraged $28 million total project funding, and
- 23 miles of shoreline restored/protected.

In Cycle 2:

- 41 projects + 5 studies will be conducted,
- $15 million state funding will leverage $30 million total project funding, and
- 30+ miles of shoreline will be restored/protected.

Benefit/Cost of Beach Nourishment

Travel and tourism is America's leading industry, employer, producer of new jobs, and earner of foreign exchange. Beaches are the leading factor in travel and tourism, benefiting America's economy and global trade. Beach nourishment is an investment in our coastal economies and a benefit to our national economy. Average cost to nourish a Gulf beach is ~$5 million per mile, however the economic return for dollars spent on developed coastlines exceeds 600 to 1.

Challenges

Additional resources needed to address coastal erosion in Texas:

- Requests for total project funding in CEPRA Cycle 2 (2002-2003) exceeded $111 million, yet only $15 million of state funding was available.
- A monitoring program is needed to evaluate the long-term effectiveness and efficiency of erosion response projects funded through CEPRA.

Further federal funding is needed to build upon the success of the Coastal Impact Assistance Program in addressing the impacts of increasing development and increasing demand on our coastal natural resources, estuaries, and watersheds.

- In June 2001, 129 project proposals were received totaling approximately $135 million.
- For March 2002, 182 project proposals were received totaling approximately $88 million.
- Clear national goals and objectives for the protection and restoration of coastal, estuarine, and ocean resources would help to coordinate the current disparate patchwork of current federal laws.

Oil Spill Prevention and Response

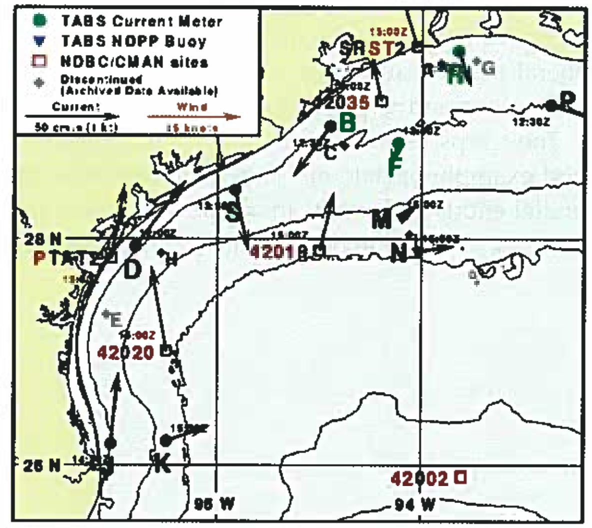
The Oil Spill division has general responsibility for spills of petroleum in the tidewater environments. For the purpose of the presentation today, I will focus on the need for a reliable data collection and monitoring of natural processes.

Our agency recognizes the importance of a real time ocean observing system. The need was driven home for us during the

Mega Borg incident and several other oil spills along the Texas coast during the early 1990's. During these events, scientists from NOAA were unable to generate accurate predictions of where the oil would go. The problem was easily traceable to a lack of timely data about the local currents.

Oil spill trajectory models use wind and currents to predict where oil will go. They are one of the few tools that allow a response effort to get a step ahead of an oil spill. The NOAA weather buoys provide critical wind and sea state information, but they do not provide the currents needed by trajectory modelers.

To fill this gap, GLO and the Geochemical and Environmental Research Group at Texas A&M developed a fleet of current reporting buoys to be anchored off the Texas coast. This network of buoys came to be known as TABS: the Texas Automated Buoy System. TABS now spans the length of the Texas coast from Mexico to Louisiana.



http://tabs.gerg.tamu.edu/tglo

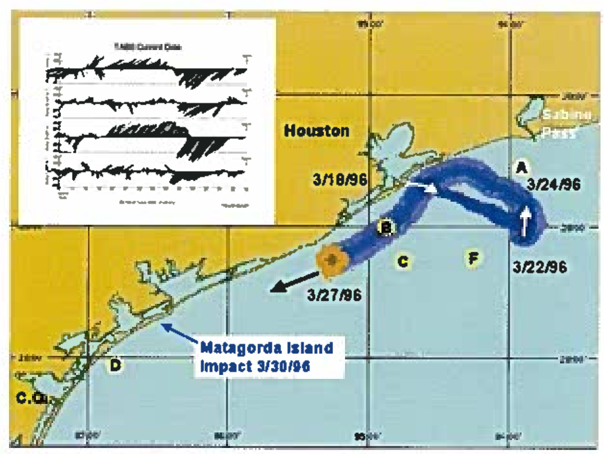
The TABS information is most often used in determining an oil spill's threat of landfall, but has also been used to determine if a spill will remain in the pre-approval area long enough for the use of chemical dispersants. Data has been available on the World Wide Web to the spill response community and the public since 1995. Data is updated every half-hour and is available in either data tables or graphics. The forecast modeling component of TABS provides for automated current forecast out to two (2) days. The forecasts are updated every night and sit ready to be used in the event of a spill.

The success of the TABS approach to ocean observing was recognized recently by the US Navy.

At the Navy's request, the state loaned two (2) TABS buoys to the recovery effort of the Japanese fishing vessel *Ehime Maru* in Hawaiian waters.

The advantage of having the information provided by TABS is best exemplified in the Buffalo Barge 292 spill in 1996. During this event, TABS proved itself on three counts. First, it provided information that the spill would be traveling up-coast once it left Galveston Bay. This points out the importance of real time data, since historical records indicated the currents should be down-coast at this time of year. Second, it provided the information needed to stand down the alert to the Sabine Pass. This saved two days of unnecessary deployment at Sabine Pass, which would have cost a quarter of a million dollars. And finally, it provided the information needed to predict landfall at Matagorda Island 3 days ahead of time. This allowed the movement of response resources to the island ahead of the slick.

Industry also recognizes the need for real time ocean observing systems. I'm pleased to report that a consortium of 16 offshore oil producers and pipeline companies has joined together to fund two (2) buoys in the Flower Garden Banks Marine Sanctuary. This effort provides the offshore community with the ability to predict the movement of spills near the Flower Garden Banks. New sensors measuring salinity and dissolved oxygen are also being tested on TABS buoys to increase their usefulness.



Request

Oil spills do not respect state or national boundaries. Texas has benefited from building its own ocean observing system. We hope that our example will lead to a national effort to provide for a network of coastal observing systems for the United States. A network of observing systems would be a tremendous benefit to all coastal states' efforts to protect coastal resources.

GLO Energy Program

The state owns four million acres in the Gulf and Bays where 6,000 wells have been drilled since 1914. By law, operators are required to properly plug and abandon wells. In 1999, 163 non-compliant wells were identified. This resulted in the GLO project to inspect and plug abandoned wells. At the beginning of the project, each well was ranked based on the potential for a spill, its location, and hazard to navigation. To date, 33 wells have been plugged by the GLO at an average cost: $57,000/well.

By agreement with the Army Corp of Engineers, in 2001 the GLO assumed the permit evaluation process for Oil Field Development General Permits (OFD GP). Seven general permits authorize oilfield-related activities. The GLO receives and reviews applications and responds to the applicant within 30 days.

The Corps retains enforcement. Ten Permits have been issued to date. This is a good example of state and federal cooperation that avoids the time and expense of parallel efforts and results in a superior process for the public.

Thank you for the opportunity to bring these matters to your attention.

The Texas Sea Grant College Program

A.R. "Babe" Schwartz
Attorney and Former State Senator

Mr. Chairman and members of the President's Commission on Ocean Policy, I am A.R. "Babe" Schwartz of Austin, Texas. I am honored to appear before you at my alma mater. When I first carne to this campus as a student, the focus of the university was a military program to wage World War II. After the war, the nation was thrust into the leadership role of the free world and a multitude of new needs to restore the world's resources.

Our democratic society has matured in the past 50 years as it faced the challenges of rapidly expanding world population. In the process, the nation has struggled with the often contravening stimulus to fully utilize natural resources and still provide for future resource availability in a clean environment.

During my 25 years in the Texas Legislature ending in 1981, I was privileged to serve at a time when this state was accepting the challenge to develop its coastal and marine resources while ensuring resource availability for future generations. I was involved in the creation and later chaired the Texas Coastal and Marine Council, which served as a major focus for the state's initiative in these areas. I was also Chairman of the Senate Natural Resources Committee during those years of seemingly perpetual conflicts between users of coastal and marine resources. Whether rivalries were commercial versus recreational fishermen, waterfront property owners versus beach access proponents, or port developers versus habitat preservationist, it was clear that decision makers needed applied research and associated outreach/extension activities to formulate effective regulations and policies. At the height of my involvement with coastal issues, I became acquainted with the Sea Grant College Program and the fact that Texas A&M University had been chartered as one of the initial four universities to be so designated. This mix of coastal interests happily occurred as I began to serve on the Senate Finance Committee, which was to be the principal funding support for the state's share of this program.

When Congress established the Sea Grant College Program Act of 1966, it was intended to apply the successful attributes or the Land Grant College Program to issues of the coastal and marine region. Funding has been a struggle from the start. In spite of limited funding, the Sea Grant initiative has supported researchers at institutions of higher education across the state, and has produced a cadre of extension and outreach professionals that provide the talent and experiences to meet the challenges of sound utilization and conservation of coastal and marine resources.

In Texas, we have seen Sea Grant involved in research in hyperberic physiology, endangered marine species ecology, marine aquaculture, coastal processes, fisheries biology, and ecosystem health to name just a few. In the extension of these applied research efforts to user groups and policy leaders, we have seen development of a major shrimp aquaculture industry in South Texas, cooperative efforts with the Texas shrimp harvesting industry to adapt technical modifications to shrimp trawls that minimize impact to migrating sea turtle populations and coastal marina initiatives to adhere to best management practices and thereby minimize water pollution. Sea Grant Extension initiatives have also been the catalyst behind such successful projects as beach cleanups and sand dune stabilization.

Additional efforts are underway in the area of watershed management, non-point source pollution reduction from residential landscapes, improvements in seafood handling to reduce loss in the retail markets and expanding marine educational opportunities in support of school teachers and youth.

In my years of public service, I have experienced first hand the benefit inherent in resolving natural resource issues by using a non-regulatory group of professionals that can serve as "honest brokers" to both the user groups and policy makers. The Texas Sea Grant College Program has and should continue to play that role.

During the interim of the 76th Texas Legislature, the Senate Natural Resources Committee conducted a study entitled "Opportunities and Challenges Facing the Texas Coastal Region." Finding number four of that study reads as follows:

> "By focusing on the Texas Sea Grant College Program, integrate the assets of the state's higher education resources into the planning, co-ordination and research efforts on coastal challenges and opportunities."

In support of this finding, I participated in a successful legislative effort that placed the Texas Sea Grant College Program on the Coastal Coordination Council as a non-voting member. That body oversees the state's Coastal Management Plan. Under the Council's structure, this places the Sea Grant Program at the table with the state's regulatory agencies having jurisdiction over coastal issues. The addition of Sea Grant to the council will enhance the Council's opportunity to perform extension and outreach efforts as well as identify the resources of the state's higher education system to meet the opportunities and challenges of the coastal region.

I trust that while the Ocean Policy Commission continues its deliberations to establish a clear and constructive national policy in the coastal and marine arena, that it will recognize the successes and substantial additional potential of the Sea Grant College Program. Unfortunately, the structure of Sea Grant is being challenged within the Executive Branch. A reversion of the program to the National Science Foundation is being proposed. In the recently released Presidential Budget, the Office of Management and Budget has recommended moving Sea Grant to the National Science Foundation at a time when Sea Grant's role in and importance to National Oceanic and Atmospheric Administration is becoming increasingly recognized. While NSF was the governmental organization in which Sea Grant was housed during its infancy, it was soon transferred from NSF to the NOAA, where the focus is on applied research intertwined with extension and outreach services. This now would be a difficult fit for the NSF. Practical application of usable research has been the hallmark of the Sea Grant Program. I urge that deliberate consideration of the costs and benefits of any major modification to the current structure and goals of the Sea Grant Program be made before any changes in organizational structure are undertaken. Let's leave Sea Grant with the multiple capacities it has served so well, research, outreach and education.

Thank you for the opportunity to appear before you today. I look forward to responding to any questions on this subject that you have.

The Integrated Ocean Drilling Program (IODP)

Dr. James A. Austin, Jr.
Senior Research Scientist
The University of Texas at Austin, Institute for Geophysics

Members of the commission, ladies and gentlemen, thank you very much for giving me the opportunity to address you today. It is indeed a pleasure to make you aware of ongoing planning by the U.S., Japan and a consortium of other nations for a successor to the current Ocean Drilling Program, whose Science Operator, Texas A&M University, is our host for these proceedings.

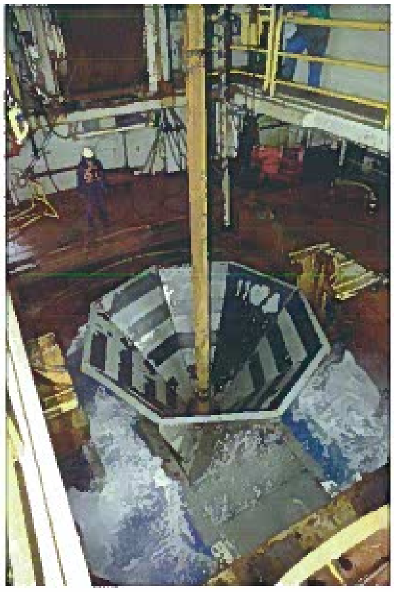
Planning for an Integrated, International, Science-Driven, Multi-Platform Ocean Drilling Program. Where Do We Stand?

- The Integrated Ocean Drilling Program (IODP) is intended to succeed the present Ocean Drilling Program (ODP), a single drilling platform, multi-national scientific effort led by the U.S., on October 1, 2003. ODP has been a leader in ocean exploration since it began in 1985, and cost sharing by international partners has made it an exceptional bargain for the U.S.
- Texas A...M University operates the ODP drilling vessel, the *JOIDES Resolution*, on behalf of the global scientific community, under contract to Joint Oceanographic Institutions, Inc. and the U.S. National Science Foundation (NSF).

IODP

- IODP is the logical successor to an ongoing scientific ocean drilling effort that is now in its fourth decade. The Deep Sea Drilling Project (DSDP) and ODP together represent the longest running and by far the most successful international collaborative Earth sciences effort in human history.
- Most of what we know about the oceans today stems all or in part from the efforts of scientific ocean drilling, including:
  - Collecting information worldwide about long- and short-term climate change, e.g., for comparison with ice records now available from Greenland and the Antarctic. Scientific ocean drilling has shown the relationship between such changes and Earth's orbital parameters over tens of millions of years. The science of "paleoceanography" owes its very existence to scientific ocean drilling.
  - Corroborating the theory of plate tectonics/continental drift, the fundamental linkage between oceanic and continental evolution on Earth, and the key to understanding the range of geologic hazards, including earthquakes, volcanic eruptions, and the generation of tsunamis.
  - Other important contributions include: 1) Assessing the long-term linkage of planetary change with the generation of natural resources, as recorded in the sediment and crustal records of continental margins around the world, including the Gulf of Mexico. 2) Studying sea-level change over the last ~35 million years, to help us predict sea-level changes in the future. Through scientific ocean drilling, we now understand better the linkages between fluctuations in high-latitude glaciations through time and long-term global climate changes.

DR. JAMES AUSTIN uses 2-D and 3-D MCS reflection and refraction data to examine the structure and stratigraphy of passive margins around the world, including the east coast of the U.S. and Canada, the Iberian Peninsula, and most recently along the northern Antarctic Peninsula. He is especially interested in the application of seismic stratigraphic principles to understanding the significance of seismic unconformity in both shallow- and deep-water environments and of the uniformity of seismic facies in carbonate versus clastic depositional provinces. Austin serves the marine geoscience community as a strong proponent of scientific ocean drilling and is currently a member of an international planning committee, IPSC, which will plan the post-2003 program of scientific ocean drilling under the new Integrated Ocean Drilling Program (IODP).



IODP Centerpieces

- Japan will co-lead IODP with the U.S. and possibly a European consortium.
- The Japanese vessel will be a state-of-the art, riser-equipped, dynamically positioned symbol of national leadership in scientific research (see overhead #4), the U.S. vessel will be a suitable replacement for the *JOIDES Resolution* (see overhead #5), and Europe may supply "mission-specific" platforms (see overhead #6) for environments not suitable for either the Japanese or U.S. platforms (e.g., coral reefs, shallow-water portions of continental shelves, high-latitude ice-covered seas like the Arctic).

The Japanese riser vessel "Chikyu" (meaning "The Earth")

- This photo was taken on the date of her launch in Okayama Prefecture, January 18, 2002. Princess Sayako launched *Chikyu*, eloquent testimony to the ship's importance for Japan.
- Outfitting the *Chikyu* for scientific research will take another 2-3 years, followed by 1-2 years of sea trials. She should be available for science in 2006-2007.

Riserless Drilling Vessel (NSF)

- The U.S. has committed itself to replacing or modifying the ODP drilling vessel, *JOIDES Resolution*, as the second†"centerpiece" of IODP.
- An RFP for that activity will be forthcoming from NSF in 2002. The new vessel should be available in 2004-2005.

Arctic Drilling

- The first phase of IODP, in 2004, may involve one or more†"mission-specific" scientific programs. Some of these are already under review.
- The highest ranked of these is a multi-platform (one icebreaker/drillship and two supporting icebreakers) expedition to the Arctic, which may occur in 2004.
- A European consortium may provide this type of capability on a continuing basis to IODP.

IODP Science†– Focus on Processes

- In spite of the continuing influence and excitement of scientific voyages of discovery like the Arctic, international marine science has made a fundamental transition over the past several decades. Scientific ocean drilling has moved from an "age of reconnaissance and exploration" to an increased focus on precise problem definition and hypothesis testing, including a new emphasis on monitoring of active processes as fundamental indicators of how the Earth behaves (including how it responds to anthropogenic influences).
- We have made a start on some of these processes within ODP.
    - Climate change - the study of climate change over various times-scales will continue to be a focus in IODP.
    - Gas hydrates (also known as clathrates, a frozen mixture of water and methane)†– in terms of global volume, gas hydrates dwarf other sources of hydrocarbons (~10,000 gigatons of carbon, perhaps twice that of fossil fuels), but because they are widely dispersed we do not yet know if they are a viable economic resource. And what roles do they play in climate change and in submarine slope stability, e.g., in the generation of tsunamis? The Gulf of Mexico could be a future focus for the study of hydrates, where they are know to occur in abundance, in concert with industry.
    - Deep biosphere - we have made a start in the study of the "deep biosphere"

in ODP, but only a start. We now know that micoorganisms live in marine sediments a kilometer below the seafloor These life forms within marine sediments and oceanic crust may provide vital clues to our own evolution. Furthermore, an emphasis on the investigation of deeply buried life on Earth will in link the international scientific ocean drilling community with other communities, e.g., the space sciences community (because of the ongoing search for extraterrestrial life) and the pharmaceutical industry (because Earth's deep biosphere may provide beneficial drugs and medicines for mankind).

Observatories

- A focus on processes necessitates an emphasis on setting up, maintaining, and revisiting seafloor observatories of all kinds. IODP will form a VITAL part of a global ocean observing system.
- Such an emphasis means that scientific ocean drilling in fact represents at"cascade" of ongoing activities, incorporating pre- and post-drilling functions (e.g., geophysical surveys, downloading data from observatories) as well as coring and sampling by multiple drilling platforms at discrete locations.
- Such activities require a significant investment in infrastructure beyond the drilling platforms themselves: satellites, research vessels, submersibles, shore-based laboratories, core repositories.

IODP Anticipated Support

- The U.S. and Japan are the designatedt"lead agencies" for IODP, each contributing at"centerpiece" drilling platform and associated science costs.
- Europe may become a thirdt"lead agency" by providing the international community witht"mission-specific" drilling technologies as they are required.
- Additional members (e.g., Canada) are already onboard; some others are considering the levels of their commitment.
- The search for new members around the world continues. All of this means that scientific ocean drilling is an outstanding bargain for the U.S.

Industry Liaison Working Group

- Collaboration between the international academic community and industry <u>must</u> play a more central role in IODP than it ever has before. Over the past several decades, scientific ocean drilling has developed technology critical for current deep-water exploration efforts by industry, in basins like the Gulf of Mexico.
- Future collaboration with industry is likely to take many forms: sharing of high-quality geophysical data in areas of industry interest (e.g., the Gulf of Mexico), joint workshops to develop drilling proposals, and industry participation in the international science advisory structure which nurtures and ranks proposals to be drilled by IODP. Both industry and the international scientific community will benefit from this collaboration, in a cost-efficient manner impossible for private industry alone.

Thank you for your attention. If you have any questions, I would be glad to attempt to answer them.

Sustainable Coastal Margins

Ronald C. Baird
National Oceanic and Atmospheric Administration

DR. RONALD BAIRD is the director of the National Sea Grant College Program and the associate director for Ocean Research for the National Oceanic and Atmospheric Administration.

Many scholars and futurists have remarked that environment will be Society's primary socioeconomic concern in the 21st century. Concurrently the central focus and organizing principle in addressing the reconciliation of environment and economics is, I believe, sustainability. While there are a number of definitions of sustainable development, perhaps none completely satisfactory, the concept nonetheless captures in one word much of the philosophical underpinnings that must drive future coastal resource management practice and policy.

Sustainable is defined as support, nourish and prolong. When applied to environments, there are implications for the reconciliation issue that have great significance for coastal stewardship. Sustainability involves consideration of the environment globally and the maintenance of that environment in an acceptable state or condition, however defined. The concept also implies that societal values are part of the definition of acceptable state and that economic development must not only be productive but also benign in the sense of promoting unacceptable environmental states. Finally, and this is critical, sustainability is forever, meaning the time horizon is indefinite.

Turning now to coastal margins, much has been written about the immense economic importance to society of coastal areas and marine environments. Much of the value of such areas derives from their economic utility (e.g., transportation, recreation) and ecological value derived from the high productivity of associated ecosystems. Consequently, coastal areas have experienced unprecedented population growth and economic development, particularly in the last quarter century. With that growth has come a host of human derived impacts on coastal environments that have significantly altered their ecological character or state. The nature and extent of many of those impacts are well documented. For the Gulf of Mexico, these include pollution, hypoxia, habitat loss or modification, over-fishing and exotic species. This list is by no means exhaustive.

The central issue in the sustainability equation, then, is how to balance resource use with conservation so that we ensure human health and maintain prosperity while preserving ecological systems in states that will not preclude or severely reduce their productive use. It also means indefinitely, and, therefore, any successful balancing act must factor in future conditions, both human induced and natural variability such as climate. Since our domain of concern today is coastal marine systems, including estuaries, we are considering environments that are highly dynamic with significant spatial and temporal heterogeniety. They are also environments most subject to prolonged and escalating human disturbance. Consequently, the current state of coastal ecosystems in the U.S. reflects to varying degrees those cumulative anthropogenic impacts. From a management perspective we are already dealing with perturbed systems. The issues then become: is the current environmental state within acceptable limits; can it be maintained; how and at what cost, or, if not, can restoration or mitigation activities restore the system to within a range of acceptable states? If the latter is not politically or economically feasible, can the geographic extent of the degraded system be contained or reduced? That is the management context for sustainable coastal margins into the next century.

Having defined an organizing principle, a management context and geographic domain, the question arises as to what might be the ingredients of effective management practice and public policy in the context of sustainable coastal margins.

First, we need to understand the general nature and complexity of the problems we are facing. Foremost of those is rapid population growth. The sheer magnitude, scale and short time periods involved and their potential impacts are difficult to truly comprehend. A few examples make the point. In the 10 years from 1990 to 2000, according to the U.S. census, the U.S. added 33 million people, well in excess of earlier predictions. Seven coastal states (two Gulf states) accounted for over one half of that growth, while 17 of the 20 most populous states have coastal counties. Many Gulf coastal counties have densities of over 250 people per square mile and many more are expected. One third of Gulf counties over the two decades 1990-2010 are expected to increase by over 30 percent in population.

The associated impacts for the U.S. are equally impressive. In the 1990's, the volume of goods transported by sea increased by 67 percent; wastewater effluents nationwide are now 2.3 trillion gallons per day; for every 10,000 people, the best waste water treatment plant releases over 1/4 ton of particulate organic carbon per day. Over 6.4 trillion tons of sand/year are moved for beaches; from 1973-93 fish landings tripled; there are now more than 10 million saltwater anglers and their 1998 expenditures were about three times the ex-vessel value of domestic commercial fish landings; coastal states in aggregate in 1993 earned over 80 percent of total U.S. tourist revenue. The future then portends greatly increased human activity, and linkages between that activity and adverse environmental impacts are apparent, complex and not always understood. The magnitude, geographic scale and temporal urgency of the problems, however, argues strongly for the timely implementation of sound practical solutions on a sustained basis.

While our current policies have achieved much in environmental protection, adverse impacts continue at significant rates. For instance, the areal extent of the Gulf of Mexico hypoxia zone in summer is approaching the size of the state of Delaware. Better management performance for coastal margins is therefore a necessity in a sustainability context. While the issues are complex and political reform difficult, our institutions of governance are being challenged to react at unprecedented rates.

Management response must be science-based, meaning based on facts and understanding of biological systems. Moreover, science-based management will require holistic approaches in which environmental and economic knowledge are integrated. The point is that the multiplicity of impacts, their rates, linkages and geographic extent will demand approaches where ecosystem function, integrity and productivity are critical considerations along with socioeconomics. Research agendas need be focused on better understanding these processes, improved predictability, and better appreciation of the inter-relationships of scale from global to regional to local. Less well appreciated but no less important is emphasis on management critical and geographically explicit science, mechanisms that more rapidly synthesize and transfer information to decision makers at distributed levels (national to local), and the engagement of our educational system in coastal issues and capacity building. Better and more comprehensive observing systems coupled with a strong research base are essentials. Finally, emphasis on the science and technology of sustainability that reduces man's environmental footprint and promotes protection and mitigation are often less appreciated elements of a comprehensive management agenda. An international dimension must also be included.

Lack of scientific information is not always the major impediment to effective management of coastal resources. Many problems and their causes are known for some time before management action. Environmental management is a politically mediated activity and a diverse array of organizations and the public at large influence both regulatory policy and societal response to management decisions. To work effectively, large scale, regional management approaches must build political consensus and integrate knowledge at unprecedented rates, that is be adaptive and iterative. This country is built on a federalist system that results in a plethora of jurisdictions concerned with coastal margins. Regulatory agencies have tended to be specialized (e.g., fisheries, health), compartmentalized and lacking the mandate to address questions in the holistic manner that future management will demand. This introduces regulatory "drag" on the economy and inertia in responsiveness. We need a new management paradigm, a national coastal agenda that has broader political/legal mandates, that is better coordinated with local/regional authorities and can adopt management approaches that are systematic, integrative, holistic and anticipatory. Public education and environmental literacy need also be policy objectives of a national coastal agenda.

Finally, enlightened public policy rests on a sound foundation in legislation. At present, the essential fish habitat provisions of the sustainable fisheries act is the only legal mandate for marine environments that I am aware of that requires management to explicitly consider environment holistically in the context of exploitable fish stocks. It is the legal framework, not science, that defines acceptable environments. All too often, poorly framed legislation has left policy to the courts or to agency interpretation. The legislative framework from local to federal will largely determine how well we satisfy the sustainability equation for our coastal margins. In the end, our laws are a reflection of societal values.

Sustainability of Marine Resources: Lessons of the Exxon Valdez Oil Spill and Other Alaskan Phenomena

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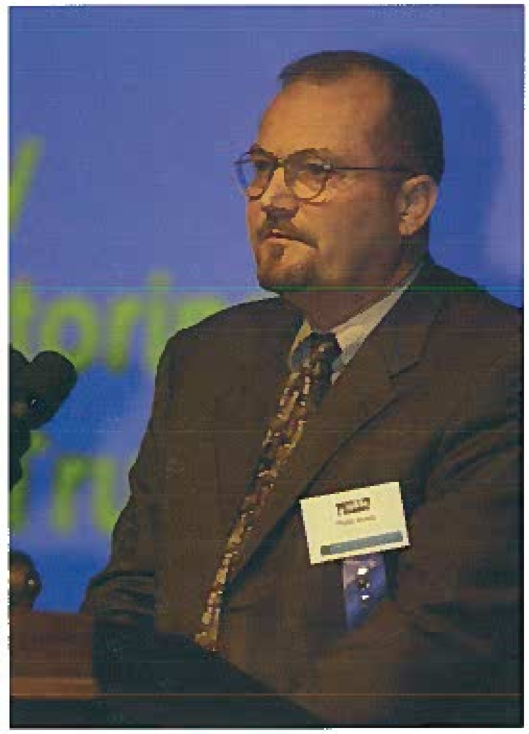
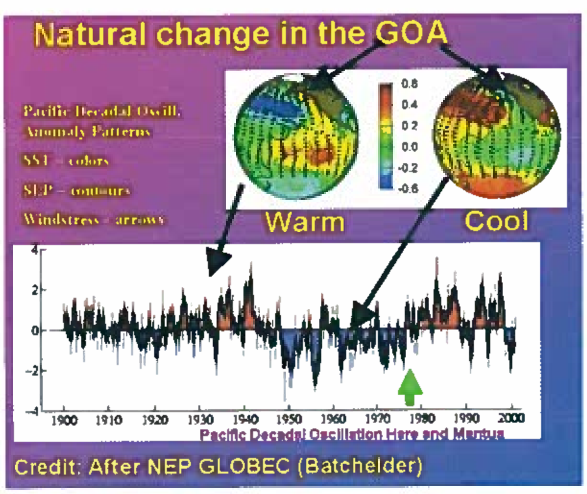


A program rooted in the science of a large-scale ecological disaster is uniquely suited to form the foundation for exploring the present and future of sustainability of marine resources, and for providing advice on a Sustainable Gulf of Mexico. The knowledge and experience gained during almost 12 years of biological and physical studies in the aftermath of the Exxon Valdez oil spill (EVOS) confirmed that a solid historical scientific record is essential to understand the sources of changes in valued natural resources. Experience from the 1989 oil spill is that understanding the sources of change in natural resources is essential to develop and apply prescriptions for sustainable management of marine resources.

Natural forces and human actions combine to shape the sustainability of the fish, shellfish, birds and mammals that are the most obvious indicators of the state of the marine ecosystems. Discerning even the immediate biological effects of large scale human effects, such as a major oil spill, is difficult due to the small size of the majority of the organisms on the first and second trophic levels, and due to the vagaries of tides and weather which play important roles in determining the horizontal and vertical extent of this kind of human impact. It is therefore no surprise that other more subtle human causes of change, such as soil erosion, are difficult to quantify, or even identify without long-term monitoring of the basic physical and biological attributes of the marine environments. Experience in the Gulf of Alaska demonstrates that sustainability requires reliable, relevant long-term monitoring of physical and biological oceanographic properties.



With the mission of understanding causes of change and sustaining human uses of valued natural resources in mind, in March 1999 the Exxon Valdez Oil Spill Trustee Council (Trustee Council) dedicated approximately $120 million for long-term monitoring and research in the northern Gulf of Alaska (GOA). The Gulf of Alaska Monitoring and Research Program fund, GEM, will be fully in place by October 2002 and function as an endowment, with

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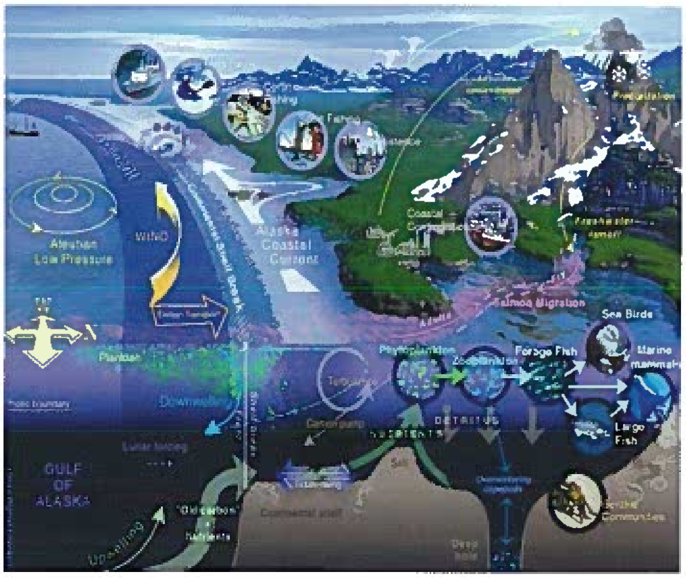


an annual program funded through investment earnings, after allowing for inflation-proofing and modest growth of the corpus. The GEM ideal is that prudent sustainable human uses of the natural resources of the spill area requires increased knowledge of critical ecological information about the northern GOA.

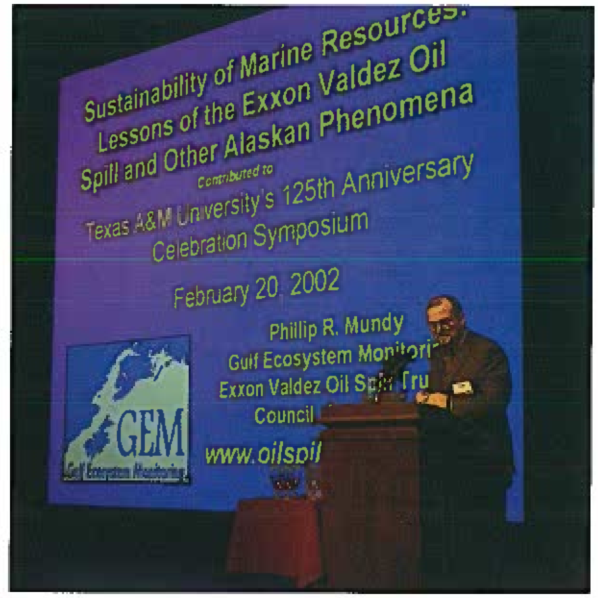
In making the decision to allocate these funds for a long-term program of monitoring and research in support of sustainable management practices, the Trustee Council explicitly recognized that the degree to which recovery from the oil spill has occurred may never be known for the many smaller species about which little information was available at the time of the 1989 spill. The GEM Program recognizes that sustainable management of these resources and services requires substantial ongoing investment to improve understanding of the marine and coastal ecosystems that support the resources, and many of the people, of the spill region.

Another GEM ideal is that improving the quality of physical and biological information available to resource managers should lead to increased ability to sustain the uses of highly valued natural resources, such as commercial fish species. Using the natural resources of the spill area without compromising their health and recovery requires increased knowledge of critical ecological information about the northern GOA. This knowledge can only be provided through a long-term monitoring and research program that will span decades, if not centuries. There are both immediate, short-term needs to complete the understanding of the lingering effects of the oil spill and long-term needs to understand the sources of changes in valued natural resources.

Other Alaskan phenomena have lessons to teach about sustainable use of natural resources. The GEM program is just one of three government-funded endowments in Alaskan waters that promise to free marine science investigations from limitations imposed by the short-term nature of government fiscal years. When combined with GEM, the annual financial returns from the endowments of the North Pacific Research Board, and the Northern Fund should provide $20M annually to marine research in Alaskan waters in perpetuity. The goals of the three programs are consistent, and it is my hope that work to develop a common scientific plan for the three funds will be sufficient to make the funds a common force for providing information to advise sustainable salmon management actions.

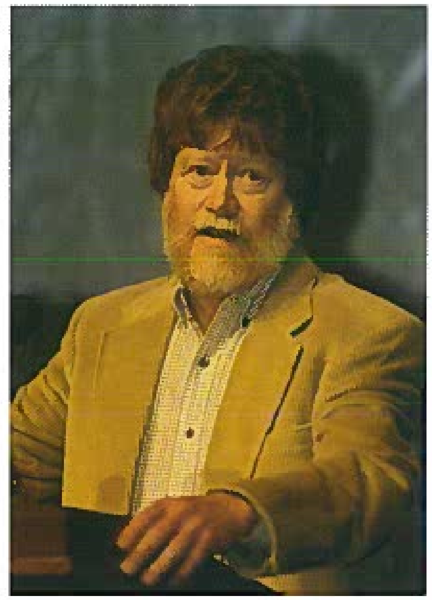
GEM will help provide badly needed information, but the challenge of achieving a common science plan for three separate endowments shows that there remain many institutional and management constraints to providing for sustainability of marine resources on geographic scales large enough to be called "ecosystem-level." Overcoming constraints to ecosystem-based management in both the Gulf of Alaska and the Gulf of Mexico requires finding and developing a common understanding of the principles that are essential to keep natural resources functional and productive, as well as the actions that follow from those principles. While the task of achieving consensus on management principles and attendant actions across the divergent interests of resource-dependent stakeholders, scientists, policy analysts and government decision makers may seem daunting, the fact that it has actually been done in a neighboring collection of ecosystems provides hope that principles and criteria of sustainable natural resource management can be developed for the Gulf of Mexico. The fourth Alaskan phenomenon, the Alaska Sustainable

Salmon Fisheries Policy (SSFP) is a model of how to define ecosystem-based management principles within a complex and often contentious political setting. Under the SSFP the State of Alaska now approaches the regulatory process for its salmon fisheries within an ecosystem-based framework of scientifically accepted principles and supporting criteria. The SSFP incorporates scientific, management and social concepts including biodiversity, the biogeochemical cycle, effective regulation of human actions, the precautionary approach, and community involvement. Understanding the elements of the SSFP and the 3.5-year process that led the Alaska Board of Fisheries to adopt the SSFP on March 23, 2000, should help guide efforts toward ecosystem-based management in the Gulf of Mexico, and anywhere else coastal marine resources are managed.



Industrial Ecology of the GOM Oil Patch

Dr. Robert Gramling
Professor, University of Louisiana



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On the flats at the bottom of this hill there was a tiny farm in January, 1865. A well was being drilled. On January 7, the well began to flow oil, a lot of oil! Men rushed here to drill wells of their own. The farm was sold, divided into lots, and Pithole City appeared by summertime. By September, as many as 15,000 people lived on this hillside. Over 50 hotels had been built, and stores, banks, offices and saloons filled the land half-way down the hill. By the next January, some of the wells had played out, and Pithole began to die. Fires burned much of the town, but people leaving quietly to go to richer oil fields led to the rapid decline of Pithole. After a few years, the land at the foot of this hill once again was only farmland along Pithole Creek. (Sign at the "Historic Museum" Pithole, Pennsylvania 1992).

Pithole was the first oil boomtown, it was far from the last. As short as its 500 day life cycle was, it illustrates several important aspects of the extraction of natural resources. First, extractive activities must locate where the resource is! Because the geological (in the case of oil) factors that distribute a resource may have no relationship to the activities that distribute human populations, this extractive process must frequently rebuild the local physical infrastructure and social environment. Houston is an excellent example of this. Second, ultimately non-renewable (and increasingly, because of our management practices, renewable) resources become exhausted. With Pithole this happened in about a year and a half, With the Gulf of Mexico it is going to take about a century and a half.

The story in the Gulf started with Spindletop 101 years ago. The world's first major petroleum reservoir, Spindletop, was tapped on January 10, 1901, near Beaumont, Texas. The reservoir was huge when compared to previous east coast finds and moved the attention of the fledgling oil industry to Texas and the Gulf coast. Two major future multinational oil companies, Gulf Oil and the Texas Company (later renamed Texaco), were founded as a result of the discovery at Spindletop. The find was named after the hill which lay over it on which spindly pines grew, and which proved to be the limestone cap over a salt dome. This led to the search for other salt domes, which were common along the Gulf coast. With the growth and development of seismic technology the many salt domes that did not rise above the surface began to be located in southern Louisiana, but here the terrain really became a problem.

The Louisiana deltaic plain is a vast, open land laid down by the Mississippi River over millennia as it snaked across southern Louisiana, blending land and water in a succession of channelization, deposition and erosion. It spreads from the Chandeleur Islands off Mississippi westward almost two hundred miles to Vermilion Bay. In places the great wetland plain intermingled with estuaries, extends almost sixty miles inland from the shoreline, with most of it too fragile to support the weight of a traveler let alone a drilling rig.

In the 1920s exploration for oil moved into this environment. Initially exploratory drilling occurred by driving creosote pilings into the marsh bottom and constructing a drilling platform. Machinery was barged to the site and drilling commenced in a similar fashion to that on land. However, this exploratory drilling in the Louisiana coastal wetlands was costly because the platforms were built on unstable silt and the drilling machinery was heavy and produced significant vibrations. As a result hundreds of pilings were required for each platform and the cost of the construction of a platform was quite a gamble, all lost in the event of a dry hole.

In 1933 the Texas Company produced the first mobile, barge mounted, drilling rig. With the drilling machinery mounted above the barge the mobile rig could be towed into place and sunk to rest on the bottom where it provided a stable base for drilling. Once drilling was complete, successfully or unsuccessfully, the barge could be re-floated and moved to a new location. The mobile drilling rig completely revolutionized exploration and production in the marine environment. Over the next several decades mobile rigs grew in size, power (able to drill deeper) and cost. By the early 1950s these huge inland submersibles were over 200 feet in length and 55 feet in width and were capable of drilling wells to 20,000 foot depths. It was usually easier to dig canals through the marsh or shallow estuaries, barge equipment to the site, and supply the whole operation with vessels through the new canals than to prepare the marsh to support the weight of drilling equipment and access roads. Thus, during the 1930s, following the drilling barge and barge-mounted dragline, the extensive networks of canals associated with oil development in coastal Louisiana) was initiated. With almost no permitting practices, private landholders and the state of Louisiana, allowed virtually unlimited access by barge to drill sites in the coastal wetlands and a network of pipeline corridors only exacerbated the problem. By 1970 there were 7,300 kilometers of canals, just in Louisiana, and just South of the GIWW.

As the discovery of new finds moved closer and closer to the coastline, it became evident to some that petroleum reservoirs extended out under the Gulf of Mexico. In 1947 Kerr-McGee oil company brought in the first successful production well 12 miles off the Louisiana coast in 18 feet of water. The success touched off two processes that were to have major implications for the future of petroleum production on public lands; a technological race into deeper and deeper water, and a political battle over who owned the oil under the sea.

Well before Kerr-McGee's success, the states of Louisiana, California, Florida and Texas began to realized the potential for revenue from oil under the sea. In 1936 the Louisiana legislature created the State Mineral Board that was to competitively lease the waters adjacent to the state. In 1941 Florida entered into an agreement with Arnold Oil for exploration of coastal and inland waters.

The issue that came into play was the ownership of subsurface lands. The states of California, Louisiana, and Florida, assumed that they owned the sea bottoms, but there were those in the Federal government that had different ideas. The most vocal advocate for Federal ownership was Secretary of Interior Harold Ickes who, shortly after World War II, convinced Truman to issue a proclamation asserting Federal ownership of sub-surface lands. In addition, Ickes persuaded Truman to initiate a suite against California in the U.S. Supreme Court. In the absence of legal precedent, the State of Louisiana (and Texas which soon followed) continued to lease offshore lands in spite of the Truman Proclamation and the impending suit. By 1950 Louisiana and Texas had leased almost 5 million acres offshore.

The Supreme Court ruled against California in 1947 and ultimately, claims to the Outer Continental Shelf were settled by this and a series of additional decisions by the U.S. Supreme Court, decisions that are known as the "Tidelands Cases." These decisions established the rights of the Federal Government over all of the U.S. offshore lands.

The Tidelands controversy became a major issue in the 1952 Presidential election, with Eisenhower favoring the claims of the states and following Eisenhower's election Congress passed the Submerged Lands Act of 1953 (43 U.S.C. ß 1301-1315), which gave to the states title to the traditional "territorial sea" offshore lands that were within three miles of the shoreline[1]. The second piece of 1953 legislation that ultimately was of much more importance, was the Outer Continental Shelf Lands Act (43 U.S.C. ß 1331-1356), which authorized the Secretary of Interior to lease the "Outer Continental Shelf," (OCS)

[1]Two current exceptions involveTexas and the west coast of Florida, where the Supreme Court later ruled that the states had held title to three marine leagues (approximately 10.4 miles) as sovereign nations before they were admitted to the Union.

lands ("out") beyond state lands for the development of oil, gas, salt and sulphur resources and also to subsequently administer those leases. This act put the Federal Government into a regulatory role with regard to offshore lands.

The technology moved ahead quickly. When Kerr-McGee brought in the first offshore production in 1947, once again the industry relied on tried and true technology. The mobile rigs developed for the Louisiana wetlands, as large as they were, were not appropriate for use offshore. The water was too deep and the barges were subject to being moved by wave action in the open Gulf. So Kerr-McGee used pilings driven into the sea bottom and constructed a platform for drilling. As in the marsh this soon proved to be inadequate for exploration. The construction of platforms in the open Gulf was much more expensive than in the marsh, all sunk cost, lost in the event of a dry hole. This spurred the development of mobile drilling rigs for the open Gulf, the first of which appeared in 1949, and by 1960 all of the types of drilling rigs in use today were off the drawing board and working in the Gulf.

During the next decade and a half the modern system of offshore development emerged as exploratory rigs, production platforms, crew and supply vessels and the use of helicopters became standardized. The structure of industry also changed. The major multinationals, because of their immense capital potential, own (or through the leasing process acquire control of) the potential oil and gas resources in the reservoirs and the refineries required to produce a marketable product. In addition, as the *Exxon Valdez* reminds us, they may own the means of delivering raw materials to the refineries and the distribution system allowing the marketing of finished products from the wholesaler to the station on the corner. What these fully integrated corporations most notably do *not* own are the corporations and equipment that address the various pieces of the process necessary to get the resource in the ground to a point where it is available to be transported to a refinery.

Although the necessary capital for the first offshore operations was only available from the largest oil companies, the concept of equipment leasing (including offshore drilling rigs and support vessels) and independent offshore supply companies (e.g. to supply drilling mud, water, etc.) quickly emerged as offshore operations began to standardize. It is here in this most temporary of situations where the opportunity for the myriad smaller players in the offshore game exists and where much of the expertise in the Gulf infrastructure remains.

Today, there are over 3,000 platforms on the Outer Continental Shelf and an unknown number in the state waters of the Gulf. These platforms are connected to each other and to shore facilities by some 25,000 miles of pipelines on the OCS and again an unknown quantity in state waters. Traditional steel jacketed platforms have been installed in water depths of 1,300 feet, and water depths of a mile and a half are being approached by a new generation (tension leg, guyed tower, floating production storage and offloading installations) of production facilities.

But there is a rub. With only 3 percent of the world's proven oil reserves the United States has lost the ability to be energy independent, at least if that independence is predicated on oil. While the deep Gulf is one of the only remaining areas (along with Alaska's North Slope) with potential for significant discoveries, most of the Gulf is starting to go out of production. The social and economic dislocation will be enormous as exploration and production in the Gulf wind down, but there are some interesting ecological questions too.

Estimates in the central Gulf are that 28 percent of the hard substrate *is* the legs of current production platforms. This raises questions of whether we want to remove these structures as they go out of production, potentially having significant effects on the current distribution of certain ecological regimes. Do we want to topple these structures in place as suggested by Minerals Management Services' "Rigs to Reefs" program? Should we remove them on a controlled schedule? If we leave them out there, toppled or not, some sort of navigational aid will have to be maintained for a very long time. Who will pay for this? What about the 25,000 miles of pipeline, do we really believe in can come out? There has been a serious effect on the Gulf of oil production; there is the potential for serious effects as production ends. At the minimum there are some serious questions we should be asking.

Cetaceans of the Oceanic Gulf of Mexico

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Cetaceans and the Oceanic Habitat

The Gulf of Mexico is a semi-enclosed, partially land-locked, intercontinental sea lying on the western margin of the Atlantic Ocean. It has been called the American Mediterranean Sea and has a total area of about 1.5 million square kilometers. As a large marine ecosystem, it has a unique bathymetry, hydrography and productivity. Cetaceans (whales and dolphins) are upper trophic level predators that play an important role in the pelagic marine ecosystem of the Gulf of Mexico. However, there was little information about the distribution, abundance and ecology of these marine vertebrates in the Gulf until surveys began in 1981. These early studies eventually lead to the Texas A&M University GulfCet I (1992-94) and GulfCet II (1996-99) programs, which were the most extensive surveys of cetaceans ever conducted in the offshore waters of the northern Gulf of Mexico. The objectives of the GulfCet programs were to: 1) estimate the minimum abundances of cetaceans and 2) characterize the distribution and habitat-associations of cetaceans and seabirds in the oceanic northern Gulf, with an emphasis on the continental slope (waters 200-2,000 m deep).

To accomplish these objectives, we used an integrated approach that included visual (aerial and shipboard) and acoustic (shipboard) surveys of the distribution of cetaceans and simultaneous hydrographic measurements. We also used near real-time sea surface altimetry from the TOPEX/POSEIDON and ERS satellites to determine the location of hydrographic features (e.g., cyclonic and anticyclonic eddies) during shipboard surveys.

In addition, we measured zooplankton and micronekton biomass derived from both net and acoustic sampling to indicate the amount of potential food available for higher trophic level foraging by cetaceans and seabirds. We hypothesized that hydrographic features in the study area had different levels of potential prey that influence cetacean distribution. We further hypothesized that these food stocks would be locally concentrated in nutrient-rich areas offshore from the Mississippi River, within cyclonic eddies, and along the high-shear edges of cyclonic eddies.

Nineteen cetacean species were identified in the oceanic northern Gulf of Mexico. Minimum abundance estimates ranged from 86,705 to 94,182 total animals. Pantropical spotted dolphins were the most abundant species with an estimated 46,625 animals, followed by spinner dolphins (11,251) and clymene dolphins (10,093). Estimates for bottlenose dolphins, striped dolphins, melon-headed whales, Atlantic spotted dolphins, Risso's dolphins and short-finned pilot whales ranged from 5,618 to 1,471. Abundances of all other species were less than 1,000. Cetaceans were sighted throughout the study area, but fewer were sighted in the western Gulf.

Cetaceans in the northeastern and oceanic northern Gulf of Mexico were concentrated along the continental slope in or near cyclones and confluence zones. Cyclonic eddies are mesoscale features with locally concentrated zooplankton and micronekton stocks that appear to develop in response to increased nutrient-rich water and primary production in the mixed layer. In the north-central Gulf, an additional factor affecting cetacean distribution may be the narrow continental shelf south of the Mississippi River delta. Low salinity, nutrient-rich water may occur over the continental slope near the mouth of the Mississippi River (MOM) or be entrained within the confluence of a cyclone-anticyclone eddy pair and transported beyond the continental slope. This creates a deep-water environment with locally enhanced primary and secondary productivity and may explain the presence of a resident, breeding population of endangered sperm whales within 50 km of the Mississippi River delta. Overall, the results suggest that the amount of prey for cetaceans may be consistently greater in the cyclone, confluence areas, and south of the MOM, making them preferential areas for foraging. Since cyclones in the northern Gulf are dynamic and usually associated with westward moving cyclone-anticyclone pairs, cetacean distribution will be dynamic. However, with near real-time satellite remote sensing of sea surface altimetry, these features can be tracked and used to predict where pelagic cetaceans may be concentrated. The exceptions are bottlenose dolphins, Atlantic spotted dolphins and possibly Bryde's whale that typically occur on the continental shelf or along the shelf break outside of major influences of eddies. We have little information on the environmental variables that influence the distribution of these three species or their prey because hydrographic surveys have concentrated on deeper waters beyond the continental shelf.

Although cetaceans were commonly observed throughout the northern oceanic Gulf of Mexico during all four seasons, we could not determine whether animals were in transit or resident in the study area for extended periods. It is possible that the oceanic northern Gulf encompasses only a portion of the home range for many of the species observed. Without additional information on daily movement patterns and feeding behavior, significant uncertainties remain in our understanding of cetacean association with mesoscale hydrographic features. The relationships between physical and biological processes are subtle and complex, and factors other than hydrographic features and potential prey abundance may influence the distribution of cetaceans. The seasonal movements of cetaceans may be affected by reproductive and migratory behavior, although we currently have little information on the behavior of pelagic species. The exception is sperm whales south of the MOM, which appear to reside along the lower slope throughout the year. We suggest that this area may be essential habitat for sperm whales in the northern Gulf, although additional information on population structure, seasonal movements and behavior is needed.

The diversity of cetaceans in the study area was comparable to that along the continental slope of the northeastern United States and in the eastern tropical Pacific. However, the overall density of cetaceans in the oceanic northern Gulf of Mexico was lower. The lower densities of cetaceans in the Gulf could be related to more oligotrophic conditions and lower concentrations of prey. The estimated minimum biomass of cetaceans in the oceanic northern Gulf is 24,239 tonnes. Of this biomass, sperm whales represent 43 percent. Together, pantropical spotted dolphins, sperm whales and short-finned pilot whales constitute 72 percent of the estimated cetacean biomass. The minimum food requirement for all cetaceans in the oceanic northern Gulf is an estimated 281,774 tonnes per year, of which pantropical spotted dolphins, sperm whales and short-finned pilot whales consume 61 percent.

Potential Impacts of Oil and Gas Exploration and Production

Eighty-three percent of the crude oil and 99 percent of the gas production in United States federal waters occurs in the Gulf of Mexico, primarily along the Texas-Louisiana continental shelf and slope. In 1997, the Gulf of Mexico produced 4.11×10^8 barrels of crude oil and 5.14×10^{12} cubic feet of natural gas. By 2003, oil production in the Gulf is projected to increase 43 percent, and gas production is projected to decrease by 9 percent. Production from deepwater fields (depth >305 m) will account for about 59 percent of the daily oil production and 27 percent of the daily gas production in the Gulf. The increase in deepwater oil and gas production along the continental slope has resulted from the development of advanced geophysical and drilling technologies. By the early 2000's, exploration wells will be drilled at 3,000-m depths at the very edge of the Exclusive Economic Zone, and production systems will be designed for depths of 1,800 m and greater. In addition to oil and gas exploration and production, this area has considerable commercial shipping traffic that enters the northern Gulf ports. The long-term forecast for petroleum transportation is for the total volume to increase into the next century. The projected number of service-vessel trips for lease sales in the central Gulf alone could exceed 700 trips per day or 260,000 trips annually. The cumulative impact of these human activities on cetaceans in the northern Gulf cannot be predicted with certainty. However, it can be anticipated that cetaceans along the continental slope will encounter increasing oil and gas exploration and production activities that include: surface and subsurface construction; FPSO (Floating Production, Storage and Offloading facilities) activities; waste discharge; service-vessel and aircraft traffic and noise; geophysical surveying; and oil spills. The only way to determine the long-term effects of these activities is through a monitoring program that commences ahead of the widespread implementation of deepwater exploration and production.

Deep Sea Benthos in the Southwestern Gulf of Mexico: Lessons learned on Ecosystem Organization and Complexity

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ELVA G. ESCOBAR-BRIONES has been a Professor with the Institute of Marine Sciences and Limnology (ICML) of the National Autonomous University of Mexico (UNAM) since 1993. She received an undergraduate degree in biology from the Metropolitan Autonomous University (UAM) in 1981, a master's degree in fisheries and ocean sciences in 1984 and her doctorate in biological oceanography in 1987, also from UNAM. Dr. Escobar-Briones' research interests are the biology and ecology of marine benthic communities.

The use of natural habitats, non-renewable resources and components of biological diversity in a way and at a rate that maintains its potential to meet the needs of present and future generations is a major concern of sustainable use. The use that incurs in a decline of all the above generally leads to a simplification of the ecological systems and reduced diversity. Although the deep sea encompasses habitats considered among the last frontiers being used by humans, our long-term observations on the organization and complexity of these ecosystems in the tropics are limited.

Sustainable development requires knowledge based in accurate information. Most of the questions asked for the management of an ecosystem concern the ability to detect changes in the physical, chemical or biological state of the environment, and to distinguish cause from effect. To detect, measure and assess changes in natural ecosystems appropriate indicators of the ecosystem attributes and of the changes must be defined.

The collections of quantitative samples from the deep-sea infauna date back to the 1960's and 1970's, when the Department of Oceanography at Texas A & M University described the deep sea Gulf of Mexico assemblages during the Alaminos expeditions leaded by W. Pequegnat. The Mexican scientific community, through UNAM, initiated studies in the deep sea with some delay due to the high costs and the technical difficulties in funding deep-sea research in the offshore sectors of the Gulf of Mexico.

After 5 years of intensive investigations on infauna taxonomic richness, abundance and standing stock in the Southwestern Gulf of Mexico, it seems worth while to summarize some results and compare them with data from existing information in the Gulf and discuss some aspects of future benthic research. Trying to be consistent with previous work, deep sea in this paper is defined as the depth between the continental margin and the abyssal plain to nearly 3800 m.

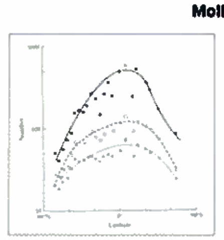
Latitudinal diversity gradients, recognized as a central problem in ecology have shown a pole-ward decrease. A similar general pattern has been recognized with increasing depth. The integrated functioning ecosystem depends, in part of the variety of species or taxonomic groups (phyla, classes, orders) in them, this latter category allows comparisons between habitats and provides an important tool in cases where the systematic of specific groups is poorly known. Previous records for the Gulf of Mexico recognized high diversity to the phylum level. Values were 17, out of 29 described phyla recognized in the marine environment, occurring in the infauna collected from 350 m to 2600 m. Little is know of the patterns of occurrence both in the geographical and bathymetric gradients.

Current results from the Southwestern Gulf of Mexico describe a similar high number of phyla. The diversity attains a minimum value

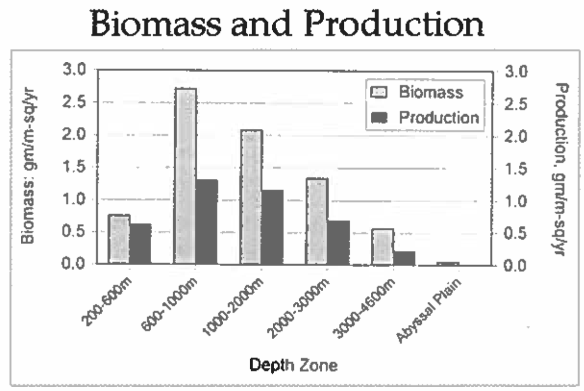
The Conceptual Idea of Deep Sea Diversity

Author	GoM Section	Phyla
Gettleson 1976	Northern	13 to 16

Phylum	No. of Species
Crustacea	113
Annelida	183
Nematoda	72
Mollusca	51



Latitudinal species richness in bivalve mollusks. Points are average number of species (S), genera (G), and families (F). Stehli et al (1969) between 1000 and 2000 m, associated to the minimum oxygen zone. An increase in taxonomic richness has been recorded with increasing depth. The values recorded are similar or higher than values recorded at 500m. Dominant faunal components vary in composition with depth. Extreme large nematodes are present in macrofauna samples their presence may challenge some of the older concepts of indicator faunal groups for the size ranges within the infauna or within depth zones. These higher diversity and variability recorded in the abyssal plain can be attributed to a complex abyssal topography and questions the homogeneity of abyssal bottoms described so far and require of detailed mapping of the abyssal plains.



Demersal fish biomass and annual production calculated from an allometric equation **for faunal depth** zones in the northeast Atlantic Ocean. Haedrich and Merret (1992)

The deep-sea is an ideal place to study the relative importance of spatially and temporally varying processes that determine the community structure. For decades the deep-sea was described as a non-changing habitat. The standing stocks recorded in earlier studies for the Gulf of Mexico show a decrease with depth the average values were about ten times lower than those at equivalent depths in the Atlantic. Ongoing studies in the Southwestern Gulf of Mexico have allowed us to recognize high standing stocks in the abyssal plain that are similar to values recorded in the upper slope on the same Gulf sector. These values are mostly attributed to large numbers of Crustacea that replace nematodes or polychaetes that dominate other depth zones. Earlier studies have described the Gulf of Mexico as a depauperate basin compared to other basins which leaded to expect a low variability in the benthic standing stocks as a response to the impoverished content of organic matter in sediment, mostly supplied from shallower depths. New results have allowed us to recognize high variability of the standing stocks at the local, geographical and regional spatial scales. This variability of standing stocks in the abyssal plain needs to be correlated to processes within the basin as well as to factors within the benthic boundary layer and sediments where other energy sources may be responsible of the patterns observed. The mesh size of sieves used in the earlier studies (420 um) in contrast to the ones currently used (300 or 250 um) should be as well reconsidered.

The tropical ocean remained as a persistenly oligotrophic in contrast to higher latitudes that suggested a persistent depauperate condition of the deep sea in the tropics. Results from 5 year monitoring the deep sea Southwestern Gulf of Mexico allowed us to recognize between year significant changes in standing stocks. These changes are attributed to disturbances generated by temporal discrete events related to physical or external properties of the system (e.g., Winter fronts, Summer hurricanes, ENSO) that enhance export of biogenic carbon to depth. These events create in conjunction with other physical features complex mosaics of organic material in the seafloor responsible for the variability in the deep-sea infauna in the tropics. The data obtained so far opened new questions that need immediate answers to understand the high variability of the tropical deep-sea ocean. Conclusions of a hypothetical character are generated to support a sustainable use of the deep sea Gulf and its resources.

The disposal of waste is a service that the deep-sea Gulf of Mexico provides to the surrounding countries. Other services that are being explored include natural resources (e.g., oil, gas and gas hydrates and deep sea developing fisheries). Whist these resources may benefit the countries in the short term, long-term actions based on knowledge ecosystem structure and function must be considered to base its sustainable use. All this biological deep-sea research done so far acquires an appplied aspect as the three nations become interested in extracting gas, oil and gas hydrates from abyssal bottoms and dispose different waste materials into the deep ocean. To evaluate the effect of these activities with sustainable development additional research in collaboration is urgently needed.

The Gulf of Mexico poses a challenge to scientists, managers and the national economies that involves trying to solve the problems shared by all large scale ecological commons. While being a limited in size, and open access area, the Gulf is threatened by activities that affect the environmental quality (by pollutants), the sustainable natural resource availability (i.e., extraction of gas, oil, developing fisheries) and the biological diversity (e.g. potentially available active compounds of interest to biotechnology). It should be kept in mind that most environmentally destructive practices originate from the misuse of common resource pools. Thus, while there are no easy answers to solving large scale ecological commons problems, there are some clues and usefull strategies to pursue.

Acknowledgements

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Climate Change and the Global Ocean Observing System

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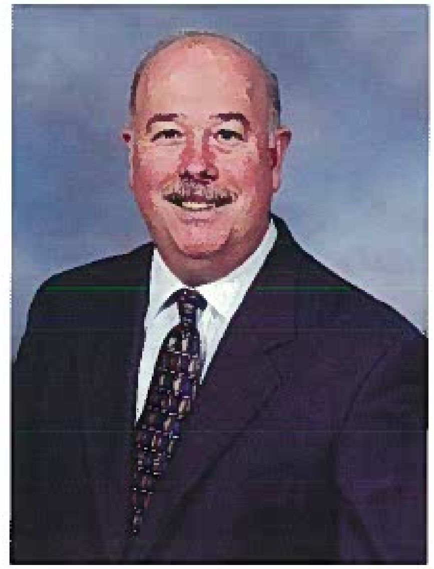
DR. D. JAMES BAKER was trained as a physicist, practiced as an oceanographer, has taught and carried out research at Harvard University and the University of Washington, and has held administrative positions in academia, the non-profit sector and government. Most recently, he was a Presidential appointee as Under Secretary for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration (NOAA) in the U.S. Department of Commerce. He has lectured and published widely in oceanography, climate and the scientific aspects of sustainable development, and authored the book **Planet Earth: The View From Space**, published by Harvard University Press. Before heading NOAA, Dr. Baker was President of Joint Oceanographic Institutions Incorporated (JOI) in Washington, D.C. He has chaired numerous national and international advisory committees on science and management issues, has advised Congress and the executive branch, and has been active in the work of several scientific societies. He co-founded and served as the first President of The Oceanography Society. He is a Fellow of the American Meteorology Society and the American Association for the Advancement of Science.

The Global Ocean Observing System (GOOS), now being implemented, is a sustained, coordinated, and international operational system for gathering and processing data about the ocean and regional seas which will provide accurate description and forecasts of ocean conditions, create long term data sets, and provide a framework for the necessary pre-operational research and development needed for new and improved products and services. In this talk I will show the economic significance of these products and services, briefly go through the history of the development of GOOS, illustrate by example how GOOS will help with understanding and predicting phenomena like El Nino and the North Atlantic Oscillation, and show how GOOS will help nations meet the needs of various international conventions. I will show some detail about the two major design elements of GOOS: the coastal module and the open ocean model with emphasis on how the Argo float program contributes to the overall data set. I will then show examples of operational forecasting by the U.S. Navy and plans for ocean carbon studies. I will conclude with an overview of joint GOOS activities between the World Meteorological Organization and the Intergovernmental Oceanographic Commission and a timetable for implementation.

An Integrated and Sustained Ocean Observing System

David L. Martin, Director
Ocean.US



DAVID L. MARTIN was awarded the Ph.D. in Oceanography from the University of Washington in 1992. His doctoral research dealt with quantitative methods for addressing atmospheric radiance contamination of multispectral remote sensing measurements of the ocean. He has served in a number of senior leadership positions in the national oceanographic community including being the Director of the Operational Oceanography Center at the Naval Oceanographic Office, the Director of the National Ice Center in Suitland, Maryland, the Assistant for Environmental Sciences for the Deputy Undersecretary of Defense for Science and Technology and his present role as Director of Ocean.US, the national office for integrated and sustained ocean observations.

IThe statutory authority for the National Oceanographic Partnership Program (NOPP), with representatives from fourteen (14) Federal agencies, its National Ocean Research Leadership Council (NORLC), and the Ocean Research Advisory Panel (ORAP) is contained in 10 USC 7901 et seq. NOPP is a collaboration among these federal agencies that provides leadership and coordination of National oceanographic research and education. The program goal is to achieve more by agencies working together as a cohesive unit than a single agency, or even a subset of agencies, can accomplish alone. Areas of specific interest include fostering the development of capabilities for ocean observing systems, data assimilation and modeling, and pre-college education. Particular emphasis has recently been given to developing a plan for a U.S. integrated ocean observing system that would meet national needs, while also serving as the U.S. component of a global ocean observing-system.

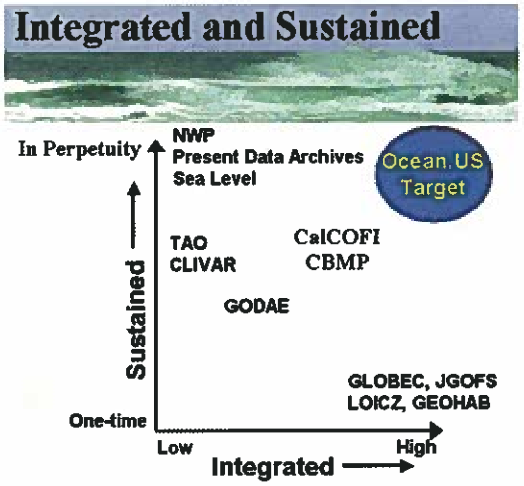
In this regard and in response to a Congressional request for "a plan to achieve a truly integrated ocean observing system", the report "Toward a U.S. Plan for an Integrated, Sustained Ocean Observing System" was prepared by a joint federal/non-federal Task Team (NORLC, 1999a). This led to a set of implementing recommendations in the report "An Integrated Ocean Observing System: A Strategy for Implementing the First Steps of a U.S. Plan" that was delivered in December 1999 (NORLC 1999b). On May 22, 2000, based on the ORAP Report implementation recommendations, the NORLC approved the establishment of an office, Ocean.US, having the charter to develop a national capability for integrating and sustaining ocean observations and predictions. Recent efforts undertaken by Ocean.US have concentrated on the development of an implementation plan for a coastal and open ocean observing system through a major Workshop to be held in the spring of 2002.

The Ocean.US Workshop

Ocean.US, in collaboration with the member agencies of the National Oceanographic Partnership Program and the U.S. Global Ocean Observing System Steering Committee, is hosting a workshop March 10-15, 2002, to develop a strategic design plan for the integrated U.S. Ocean observing system. This formal, national workshop will be the culminating activity leading to an ocean observing system implementation plan.

A critical element in developing an integrated ocean observing system plan that will be specifically addressed at the Ocean.US Workshop is to arrive at a national ocean community consensus on the following:

- What ocean observing systems are needed to meet broad societal and scientific goals,
- What ocean observing systems are available or planned,
- What gaps exist between ocean observation requirements and our present or planned capabilities, and
- What are the resource implications inherent in addressing these gaps in a phased, prioritized manner?



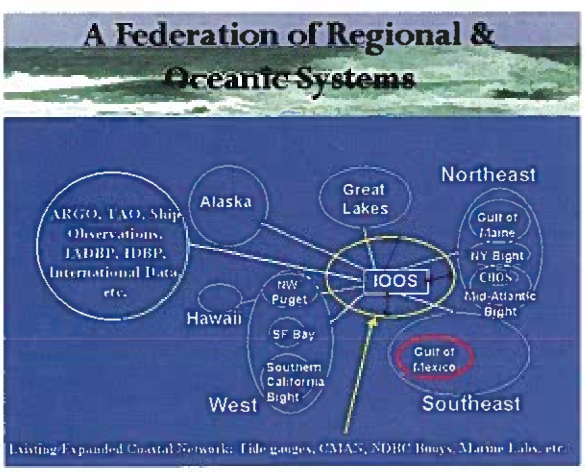
The integrated ocean observing system designed in consonance with this objective process will address societal needs under the seven broad categories of:

- Detecting and forecasting oceanic components of climate variability
- Facilitating safe and efficient marine operations
- Ensuring national security
- Managing resources for sustainable use
- Preserving and restoring healthy marine ecosystems
- Mitigating natural hazards
- Ensuring public health

It is imperative that the external ocean community be directly involved in this process to ensure the resulting consensus reflects the broadest scope of affected users and providers of ocean data and information. Accordingly, great care has been taken to achieve a balance amongst the Ocean.US Workshop participants from across the spectrum of stakeholders in the oceanographic community. This balance necessarily includes representatives of Federal, state and local governments, industry, academia, non-governmental organizations and others concerned about the impact and importance of integrated and sustained ocean observations. Further, the Workshop will have in attendance individuals with the necessary expertise to allow the successful attainment of the Workshop goals. Finally, individuals with understanding of the needs of the many users of data from an integrated ocean observing system have also been identified and will actively participate in this Workshop.

The Workshop will articulate the community consensus on what constitutes the core set of ocean measurements or observations that satisfies the maximum number of goals of the federated system. Based on this consensus, various observing technologies will be examined to determine the optimum methods for measuring various ocean phenomena in terms of:

- What is ready to implement now,
- What should be funded to transition from research to operations, and
- What technological or observational efforts would benefit from focused research efforts?



The combined analyses of integrated observing requirements, and how well they are addressed with existing/planned observing systems, coupled with an analysis of their technological maturity, will allow the development of a phased implementation design plan for an integrated and sustained coastal and ocean observing system. The system will be inherently flexible, to permit the incorporation of new techniques and observational technologies as they evolve to maturity.

The deliverable of the Ocean.US Workshop and follow-on technical review efforts is a prioritized strategic design leading to a phased implementation plan for a national coastal and open ocean observing system for the United States. Following a comment and review period, it is estimated that the final report of this effort will be ready for transmittal by early summer 2002.

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Climate Change Impact on Gulf Coast Resources and Communities

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U.S. Geological Survey, National Wetlands Research Center

DR. VIRGINIA BURKETT is chief of the Forest Ecology Branch at the National Wetlands Research Center of the U.S. Geological Survey, U.S. Department of Interior, where she has worked since 1990. She also serves as an Associate Regional Chief Biologist for the USGS Central Region. She supervises a team of wetland ecologists, forest scientists and landscape modelers who conduct research related to the ecology, management and restoration of forested wetlands. Her expertise includes wetland forest ecology and restoration, coastal wetland ecology, coastal management and wildlife and fisheries management. She started her research career with the Sea Grant Program at Louisiana State University in 1975. Dr. Burkett has served as Director of the Louisiana Coastal Zone Management Program and Assistant Director of the Louisiana Geological Survey and as Deputy Director and, subsequently, as Director and Secretary of the Louisiana Department of Wildlife and Fisheries. She received a B.S. in zoology and an M.S. in botany from Northwestern State University of Louisiana; her doctoral work in forestry was completed at Stephen F. Austin State University in 1996.

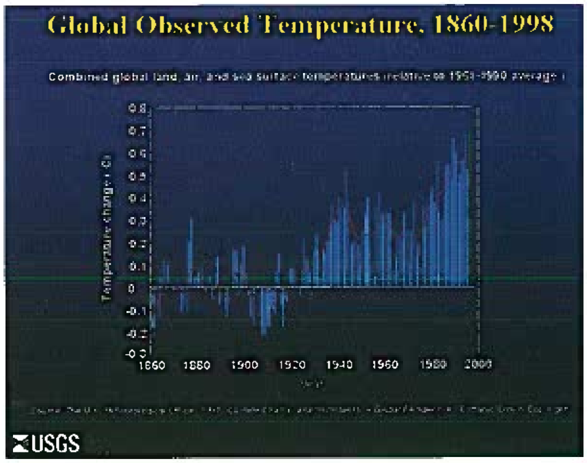
During the 20th century, average temperature increased by approximately 0.6°C and precipitation increased by 5 to 10 percent across most of the United States. In the Gulf Coast states, temperature increases since 1950 have been modest compared with those of other regions. Annual rainfall has generally increased across the northern Gulf of Mexico coast, by as much as 20-30 percent or more in Mississippi and parts of Alabama, Louisiana, and Texas. The timing of rainfall has also changed over the past century, and models suggest that future trends in temperature and rainfall could affect the frequency of both drought and flood events in the northern Gulf of Mexico coastal zone (Burkett et al. 2001).

Climate simulation models (called General Circulation Models or GCMs) used in the "National Assessment of Climate Change Impacts on the United States" (Melillo et al. 2000) suggest that average temperatures in the Gulf Coast states could rise by 1 to 2 C by 2030 and by 3 to 5 C by 2100. The GCMs predict more precipitation in the form of rainfall, more rainfall in the form of heavy downpours, and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Changes in precipitation patterns and evaporation rates will very likely alter soil moisture and runoff, which in turn will influence freshwater inflows and water quality in the coastal zone.

Sea surface temperature in the equatorial Pacific Ocean is predicted to resemble a more steady-state El NiÒo-like condition by 2100 (Timmerman et al. 1999), which should have a dampening effect on hurricanes making landfall in the Gulf coast states, but rainfall associated with both hurricanes and La Niña events may become more intense (Raper 1993, Kerr 1999, Knutson et al. 2001). Increases in hurricane wind strength could also result from future elevated sea surface temperatures over the next 50 to 100 years. One recent model investigation shows that increases in hurricane wind strength of 5 to 10 percent are possible with a sea surface warming of 2.2°C (Knutson et al. 1998).

Increased ocean temperature, most evident in shallow waters, can change the structure and productivity of intertidal ecosystems by directly altering the metabolic rates and phenology of organisms. An analysis of approximately five million ocean temperature profiles taken over the past 55 years by Levitus et al. (2000) indicates that the mean temperature of the oceans between 0 and 300 m increased by 0.31 C during that same period. Although this increase cannot be linked conclusively with global climate change, this increase is in line with land-based global temperature trends. Indirectly, increased ocean temperature can impact intertidal ecosystem productivity by altering water-column stratification, circulation and mixing patterns, nutrient cycling, and many other coastal processes (Scavia et al. In Press).

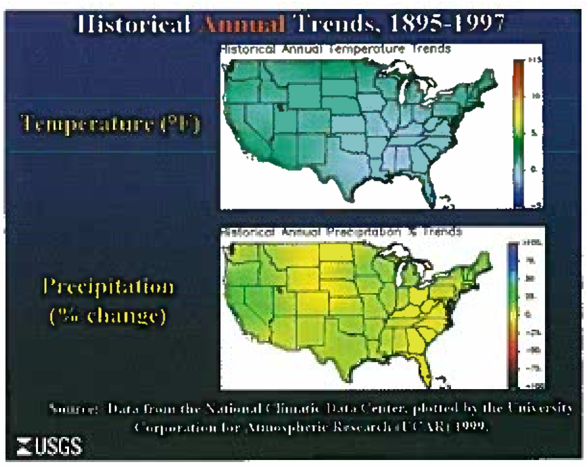
Accelerated sea-level rise is regarded as one of the most costly and most certain consequences of increasing global temperature. Average global sea level rose between 10 and 25 cm during the past 100 years, and this average rate is projected to accelerate 2 to 4-fold over the next 100 years. The mid-range estimate of sea-level rise by 2100 is 0.48 m (IPCC 2001). Sea-level rise will increase tidal flushing in estuaries and storm



surge over coastal landforms. Both average and peak salinity levels will increase in estuaries and adjacent habitats, thereby altering the zonation of vegetation and other biota. Increased storm surge and mean tide levels will also alter the disturbance regime in shallow coastal waters, thereby influencing the composition and productivity of seagrasses and benthic fauna that are vulnerable to changes in sedimentation patterns, current velocity and turbidity. The production of estuarine-dependent fish and shellfish will likely decline in regions where wetlands, seagrasses and other elements of the intertidal food chain are adversely impacted (Burkett 2002).

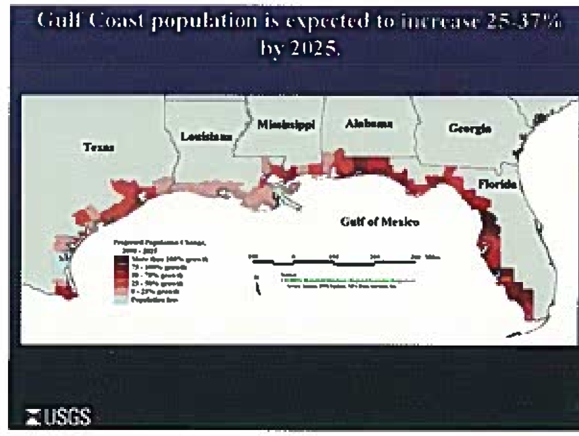
Sea-level rise observed along the U.S. coastline varied between and within coastal regions during the 1900s, but in general the U.S. Gulf of Mexico and South Atlantic coasts (with the exception of Florida) have experienced rates that are significantly greater than that observed on the U.S. Pacific coast (Scavia et al. In Press). Differences in apparent sea-level change at a particular location (referred to as "relative sea-level rise") can be caused by land movements such as isostatic rebound and subsidence. Relative sea-level rise is greatest along the Louisiana coastline where the land surface of the Mississippi River deltaic plain is subsiding (sinking with respect to sea level) as much as 0.25 in/yr (10 mm/yr) due to a combination of natural and human-induced processes. Relative sea-level rise in parts of Texas is also double or more the global average. Sea-level rise alone will increase the vulnerability of coastal communities to storm surge flooding, even if tropical storms do not increase in frequency or intensity.

Sea-level rise will likely continue to have serious impacts on low-lying coastal marshes, particularly in Louisiana where Holocene deltaic sediments are dewatering and compacting at rates that are four times the rate of 20th century global sea-level change. Human development activities can also affect the survival of intertidal systems as sea level rises. Levees, seawalls, roads, and other development can prevent the inland migration of seagrass, beaches, wetlands and other coastal features as sea level rises (Burkett and Kusler 2000).



Changes in precipitation extremes (both droughts and floods) caused by increased temperature and humidity will likely have major effects on the structure and function of coastal ecosystems. Seasonal patterns indicate that projected changes will be greatest in the winter months, but large increases in summer temperature are projected for most of the Gulf Coastal Plain by several GCMs. Both of the principal climate models used in the U.S. National Assessment project declining summer soil moisture across most coastal counties in this region, which suggests changes in vegetation structure due to moisture stress and increased fire frequency (Burkett et al. 2001). Changes in growing season length, photosynthesis and evapotranspiration rates will affect the potential range of many plant species, as well as competition among species. Mild winters since 1970 have already enhanced species such as the invasive, freeze-intolerant Chinese tallow tree (*Sapium sebiferum*) at the expense of native hardwoods in Texas and Louisiana.

Although there is uncertainty inherent in any predictive modeling effort, the models and historical trends presented in the U.S. National Assessment provide a plausible set of climatic and ecological scenarios for the 21st century. The implications of the changes in climate that are simulated by most climate models present serious issues for those responsible for the conservation of coastal resources. One of five key findings of the U.S. National Assessment is that "natural ecosystems appear to be the most vulnerable to the harmful effects of climate change" (Melillo 2000). The rate of ecological change that is likely to occur will not allow for the gradual migration or genetic adaptation of many species, particularly when coupled with habitat fragmentation, invasive species, and other consequences of human development, however, some practical and potentially effective strategies to minimize impacts to coastal ecosystems have emerged. Insights about climate change and its likely impacts should be core tools for coastal resource managers who are engaged in activities such as land acquisition, water resources negotiations, habitat restoration, invasive species control, fisheries and waterfowl management and, in general, planning for the future.



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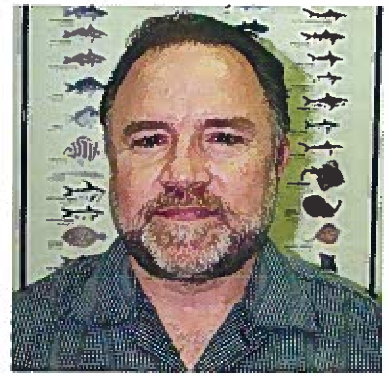
Sustainable Gulf of Mexico Commercial and Recreational Fisheries

Hal R. Osburn
Texas Parks and Wildlife Department

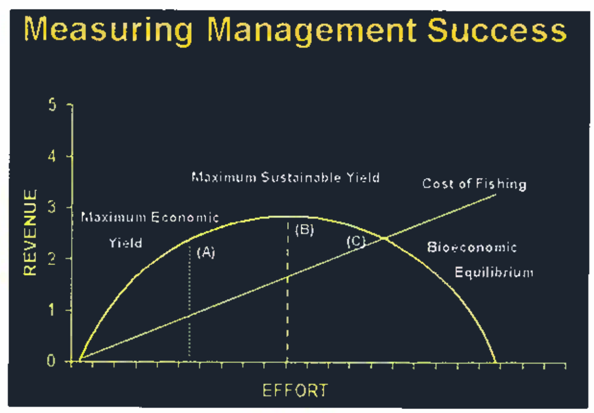


HAL OSBURN has been with the Coastal Fisheries Division of the Texas Parks and Wildlife Department for 26 years as a fisheries scientist and manager and is currently serving as Division Director. He has conducted extensive field research and published numerous scientific publications regarding Texas marine resources and users. He has served as the Governor of Texas' designee on the Gulf of Mexico Fishery Management Council since 1993.

Fisheries sustainability can be defined as a management strategy that meets the present generation's needs without compromising the future generation's options. The Gulf of Mexico offers a tremendously productive and diverse ocean biome with a potential for sustaining numerous commercial and recreational fisheries. The Mississippi River freshwater discharge and the Gulf Loop Current are two of the major geophysical features that help to bring in and distribute enormous nutrient loads that feed a complex marine food web. In the Gulf today, however, that sustainability is challenged, in large part, because of the loss of important habitat and because overcapitalized commercial and recreational fisheries continue to extract excessive harvests. These consumptive demands compete with a growing public need for non-consumptive activities. Fishery managers are confronted with trying to balance allocation of these public resources to create "optimum yield" from a compromised ecosystem.

Management theory suggests that harvesting at maximum economic yield will allow for the greatest profit while still being biologically conservative. However, increasing harvest efficiency, which lowers industry "costs", coupled with increasing demand, which raises industry "revenues", has too often thwarted attempts to maintain stable fishery populations. Fishery management in the Gulf of Mexico finds itself in a transition from an age when fisheries were considered inexhaustible to the time that fisheries will likely be overfished if not stringently regulated.

This transition coincides with the recognition that essential fish habitat and water quality and quantity must be conserved as well. The goal of managers has evolved to one seeking a multi-species ecosystem-based approach with adaptive management of environmentally responsible fisheries. Fulfilling that vision means overcoming serious obstacles, including divided management authority, complex and dynamic environments, poor data sets, legal constraints, competing stakeholders, and difficult law enforcement. The consequence of these problems is that at least one-third of the known stocks are overfished and the status of two-thirds of the Gulf stocks is unknown. Some of the most recreationally and commercially important species, like red snapper, king mackerel, red drum, sharks, grouper, billfish, and shrimp are the subject of intense management scrutiny and allocation battles.



But the problems of Gulf fisheries are not intractable. A host of tools to develop sustainability are available and slowly being applied. Long-term monitoring and observer programs, particularly fishery independent sampling, are being recognized as critical to providing more definitive answers regarding stock status. Collecting more robust social and economic data is gaining importance, including the development of predictive people behavior models to help guide sensitive resource allocation decisions. Market-based management approaches that emphasize limited entry, individual transferable quotas, and license buybacks are being implemented to allow for an orderly downsizing of fishing fleets and an end to the nightmare of derby fisheries. Fishing gear is being modified or even phased out to prevent excessive bycatch and habitat damage. Law enforcement that works on the water, not just on paper, is becoming a reality with the advent of vessel monitoring systems and other state-of-the-art remote sensing technology. That technology, in turn, provides an opportunity for the effective use of marine protected areas as spawning reserves or for conservation of ecologically sensitive habitat. Mitigation and no-net-loss are now mandatory requirements for modifications to our Gulf essential fish habitat. Artificial reefs are being deployed to bolster reef fish communities limited by lack of hard substrate. Even the daunting task of reversing the causes of the enormous hypoxia zone that forms each year in the Gulf is being seriously addressed with multi-state initiatives.

Management tools, however, still need the right people in place to apply them. Bringing stakeholders into the management process, without disrupting the process, remains the ultimate challenge. Too often the path to sustainability has been blocked by legislative and legal obstructions brought on by stakeholders fearful of being disenfranchised. It will take more than just educational forums to dispel the fear factor in fisheries management. Leaders in the commercial and recreational sectors must be found and then empowered to be effective voices of reason to their peers. Building a co-management system, where the users are actually as proactive and conservative as the regulators, is what will most efficiently create sustainable fisheries. Such a system will require flexibility and an adaptive management strategy where trial and error at the local or regional level allows for self-correction. It will also require a recognition that fishery managers are not yet fishery engineers, and that mathematical models, as useful as they are, cannot be the sole dictator of our fishing rules.

The Gulf of Mexico has so many individuals devoted to sustainability, there must be optimism for the future. Yes, on many fishery issues we've fallen flat on our face, but we've picked ourselves up and started over again. A proactive and precautionary approach is taking hold. Stakeholders are seeing the need for change and advocacy groups are finding ways to compromise. Academic institutions have begun focusing on real problems and solutions. Conservation education initiatives are expanding. Regulatory agencies are forming partnerships with all the interest groups. We're learning to fish smarter, not harder.

Trying to correct yesterday's mistakes and prevent tomorrow's is a hallmark of sustainability. In the Gulf of Mexico, we're creating an expectation of sustainability in our coastal communities, and that expectation will encourage the sacrifices needed to make it a reality. Our current commitment to sustainability bodes well for the health of our marine fisheries today and in the year 2050.

Freshwater Inflows: The Key to Sustaining Texas Coastal Ecosystems

Dr. Larry D. McKinney
Senior Director for Aquatic Resources
Texas Parks and Wildlife Department

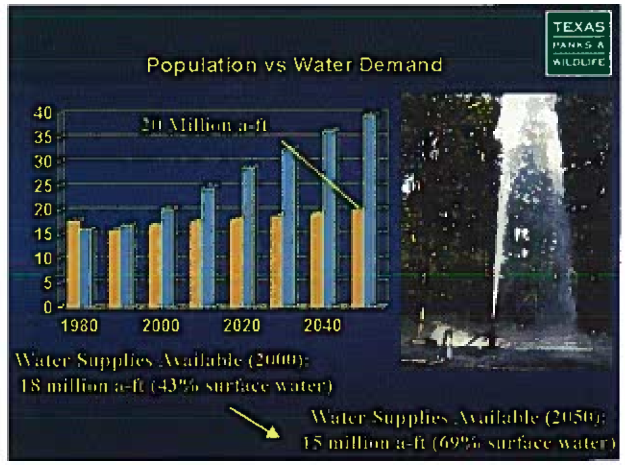
Freshwater inflows create the estuarine conditions that characterize the Texas coastal ecosystem. Development and management of water resources to meet growing municipal, industrial, and agricultural demands are the fundamental resource management issues to resolve in efforts to attain sustainable coastal margins. Habitat loss, deterioration of water quality, and management of fish and wildlife resources are secondary to the issue of water in this regard.

The inflows from 11 major river systems are the key to sustaining the ecological health of Texas estuarine systems. While some 2.6 million acres of coastal habitat may define the visual landscape of these ecosystems, freshwater inflows provide the diverse estuarine gradient that truly defines it. The diversity of conditions – habitats - this gradient creates is the foundation upon which estuarine health and productivity fluctuate. Sabine Lake on the Texas/Louisiana border can experience 13.8 million acre-feet of freshwater annually and grades into the hypersaline Laguna Madre, all within 600 miles of coastline. The quantity and timing of inflows is the bellwether of estuarine productivity. The characteristic species of the estuary: shrimp, crabs, oysters, and a myriad of finfish; respond to the ebb and flow freshwater, as does the basic food chain upon which they depend. Recently completed studies to determine the freshwater inflows necessary to sustain the ecological health of Texas estuaries indicate a need for approximately 18.4 million acre feet-per year delivered in a seasonally adjusted pattern. It is upon these inflows that $2 to $2.5 billion of direct annual economically benefits (recreational and commercial fisheries) and incalculable indirect benefits (waste treatment, ecosystem health, tourism, etc.) rests.

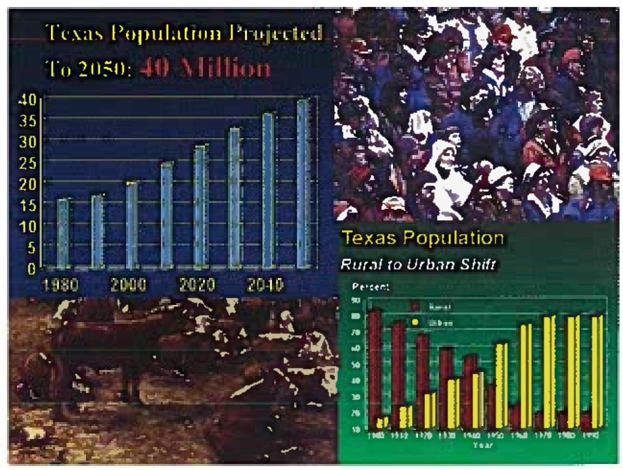
Texas population will double from the present 20 million to almost 40 million in the next 50 years. Existing water supplies will not be sufficient to sustain that growth unless action is taken to better conserve those supplies and supplement them where necessary to meet need. According to the newly adopted State Water Plan, the individual regional water plans that comprise it call for eight new major reservoirs (major defined as more than 5,000 acre-feet of storage capacity) to be added to Texas' existing 214 major reservoirs during the next 50 years. These new major reservoirs would increase surface water availability by 1.2 million acre-feet per year. That is dependable yield, not storage capacity, which in most cases would be considerably greater than firm yield capacity. Our best estimate is a total storage capacity of 3 million-acre feet in those reservoirs – water that might otherwise flow to estuaries. We do not know how much would do so, but the issue is how much is too much? Other pressures are moving to tip the balance further. As groundwater supplies diminish at an accelerating pace, even greater pressure to develop additional surface water will become manifest. The understandable tendency will be, as it historically has been, to ignore the ecological impacts of this daunting challenge and with blinders on – charge forward with all the best intentions.

Dr. Larry D. McKinney is Senior Director for Aquatic Resources for Texas Parks and Wildlife Department. He is responsible for a broad range of natural resource issues including inland and coastal fisheries, assessing and securing freshwater inflows to estuaries, wetland conservation and restoration, endangered species conservation, and other issues related to the ecological health of Texas' aquatic ecosystems. He also administers programs totaling more than $25 million annually, a staff orf 450 and facilities throughout Texas. He has served as Natural Resource Damage Assessment Trustee for TPWD, a governor's appointee to the Gulf of Mexico Regional Marine Research Board, International Coral Reef Initiative and the western panel of the Aquatic Nuisance Species Taskforce. He is a past chair of the Gulf of Mexico Program's Science Advisory Committee and a current member of the Management committee. Dr. McKinney received his PhD from Texas A&M University in 1976.

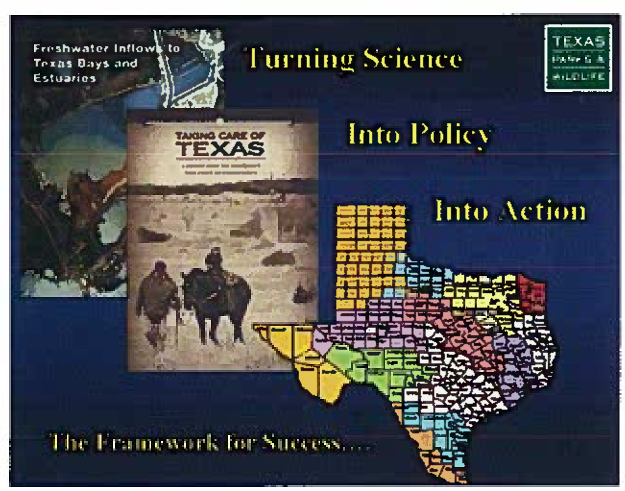
"When these failures in understanding ecological effects are combined with notions of cost-benefit analysis and tradeoffs that justify the demands for water beyond the river limit, the synergistic result may accelerate the destruction of the estuarine system involved," Rozengurt and Hedgpeth (1989).



One of the key problems with water planning in Texas has been that fish and wildlife water needs, water to maintain healthy and productive estuaries in this case, have been ignored or relegated to secondary consideration for so long it is difficult for our decision-makers to think of them in the same terms as they do municipal, agricultural, and industrial needs. That we have been able to ignore those needs attests more to the abundance of that valuable natural resource in the past rather than our careful stewardship of it. Others, both in this country and around the world, have not fared so well as Texas in this regard and the cost of failing to protect the health of their rivers and estuaries is now too high to ignore, but too costly to restore. In Texas, water has been treated much as the pioneer treated the American West: a limitless horizon. It is not. We first learned that lesson in the record drought of the 1950's and responded accordingly. That response, an unprecedented burst of reservoir construction, has helped the state to weather subsequent drought conditions, but will not meet future projections of water demand for anticipated growth in Texas. As we move to solve that future problem we cannot, as in the past, ignore the ecological health of estuaries. The margin of error has shrunk dramatically from the 50's: only 4.9 million-acre feet separates our best estimate of sustainable ecological health and decline. Unless decision-makers recognize and accept this premise our estuaries will not continue to provide the benefits we have come to both expect and depend upon. The evidence is readily available to demonstrate the point.



One of Texas' 15 major rivers, the Rio Grande, has ceased to flow to the sea and the small but productive estuary it supported no longer exists. The river, from its entry into Texas to its almost exit into the Gulf of Mexico, is sad testament to our management failure. International (USA/Mexico) and interstate (Texas/ New Mexico) dispute over water quantities and over-appropriated (Texas) waters has played havoc with hydrology and subsequently ecology. Explosive population growth and resultant decline in water quality has affected both human and ecological health. Invasive exotics like hydrilla and salt cedar choke the life out of the river. The river "ecosystem" exists now only in isolated fragments. Water masters and international commissions charged with its management lack resources and authority to do more than preside over its decline. One hopes it is the worst case and not the future for Texas remaining rivers.



It need not be. Options exist now to balance the needs of all water users: municipal, industrial, agricultural and the environment upon which all depend. It is increasingly complex and will require a more comprehensive and longer-term perspective than may be comfortable for some. The challenge will be to frame the issue in such a way that the consequences of failure to strike this balance are clear and then demonstrate that the best public policy is to address the need for sustainable freshwater inflows directly and inclusively.

A Sustainable Coastal Gulf of Mexico: Research, Technology, and Observations 1950 to 2050

Charge to the Discussion Groups

1. What is the most significant pressures/problems threatening sustainable utilization of the Gulf of Mexico today and over the next fifty years (i.e., overfishing, erosion, hazards, contaminants, mineral extraction, overbuilding, climate change, etc.)?
2. What are the important information and/or knowledge gaps hindering scientifically sound management and preservation of Gulf of Mexico resources (i.e., lack of process studies, interdisciplinary approaches, adequate models, adequate observing systems, etc.)?
3. How can the identified gaps in information and/or knowledge be most effectively addressed (i.e., regional studies, partnerships, integrated studies, centralized databases, more effective teaming, monetary and intellectual resouces, etc.)?

Ecosystem / Biodiversity Perspectives Discussion Group

Robert Brown, Discussion Leader
Ralph Rayburn, Rapporteur

Problems

Members of this discussion group all agreed that the major problem of our coastal margin is human population growth - of the United States and of the world - and particularly along our coasts. Overall population growth places ever increasing demands on all of our natural resources, from fisheries to oil. The increasing population density along our coastal margin leads to commercial development, which degrades the coastal margins and impacts sensitive marshes and estuaries. One of the main overall impacts is on freshwater resources. Sources of competition for our water include agriculture, human consumption, industry, recreational demands and energy needs. Freshwater inflows into the Gulf are decreasing in amount and in quality. Lat year, the Rio Grande did not even reach the Gulf. Some states, like Florida, have little control over their water, in that their watershed is actually found in other states. Others, like Texas, have their watershed within their state boundaries. State water laws vary dramatically, and there is a need for a National Water Plan. There is a Coastal Coordinating Council of the EPA, in which money from the Flood Control Plan is used to buy out people who live in flood planes. Private organizations, like the Nature Conservancy and Conservation International, are purchasing land or development rights to reduce the loss of estuaries and to protect undeveloped land.

Like water, fisheries are a source of conflict along the coastal margin. There are conflicts between commercial and recreational fishers, inshore and off shore fishers, and aquaculture and commercial fisheries. Although freshwater aquaculture and marine mariculture offer means of reducing the pressure on the Gulf fishery, there is concern about the environmental impact of effluents, introduced exotic species, diseases of marine organisms, and use of fish protein in aquaculture feeds. Limited entry programs and fishing license buy-back programs may offer long term solutions for reducing the impact of commercial fishing on the Gulf fishery.

Other commercial activities along the Gulf Coast have led to additional problems. NAFTA has led to the expansion of the inter-coastal waterway into Mexico and more barge traffic. Increasing marine transportation into the Gulf ports have brought along invasive species, including microorganisms, which could lead to human health problems. Oil exploration has led to some spills, and there is increasing concern about the myriad of underwater pipelines that exist, especially those that are aging. The recent trend of oil exploration in deeper waters is seen as positive, in that the potential impact of a spill on the coast is lessened. Commercial housing and industrial development along the coast has also led to issues of waste disposal.

Gaps in Information

We agreed that there are gaps in information on biodiversity and ecosystem health, but that much of the information might be available if numerous databases could be combined. Up to date and long term databases are needed on land fragmentation along the coastal margin. In order to compare data, standards are needed to identify criteria for measuring the health of ecosystems. New research is needed on bioaccumulation of metals and toxins and the impact of the environment on higher trophic level organisms. The expanding ocean monitoring system needs to be linked to land impacted events. There are numerous groups who are interested in biodiversity and ecosystem health, but research needs to be done on how to 1) educate the general public about the issues and 2) how to motivate them into action. More marine and coastal sanctuaries are need, perhaps through a tax or a licensing requirement on non-consumptive recreational uses, much like those on hunters and fishers.

Addressing Gaps

Partnerships among states, among universities, and between state and federal government will only occur if financial incentives are in place. Initiatives first need to focus on developing public support, through educating children (i.e., Sea Camp), fishers and interest groups (i.e., Sea Grant) and the general public. Although the goal would be a Gulf of Mexico Project encompassing state, federal and private entities to build databases, fill in gaps in data, conduct research and conduct long term monitoring, the initial efforts should be more focused and regional. The recent efforts in Tampa Bay stand as an example of focusing on a single bay system instead of a whole coastline. Galveston Bay or the Laguna Madre might be good systems to start. Private citizens have been shown to be effective in the restoration of the Chesapeake Bay. The public was educated about the problems, citizens became engaged as River Keepers to monitor water quality and ecosystem health, and now three states are working together to preserve the bay.

Universities must respond in a more altruistic manner. Researcher need to share their data and standardize measurement techniques. Universities need to recognize the needs of state and federal agencies for applied research, whereas agencies need to recognize the researcher's needs for cutting edge research for promotion and tenure. Basic and applied science needs to be more integrated, and then presented to the public in a useful form through the Extension Service and Sea Grant programs.

Much could be done through passage of the Conservation And Reinvestment Act (CARA), which would return tax revenues from off-shore oil development to coastal states for restoration, research, and land acquisition. Revising federal and state personal and corporate tax structures, removing federal support of flood insurance programs, and taxing or licensing recreational users would offer additional means of reducing the impact of population growth on the ecosystem health of the coast. With the research derived from collaborating universities and agencies, organizations like the U.S. Army Corps of Engineers could be refocused into major restoration coastal projects, as is occurring now in the Everglades. The key to all of this, however, is understanding the motivation of the general public, in order to educate them to make coastal margin issues their priority.

Sustainability issues for the Gulf of Mexico: The Geoscience Perspective

By David A. Brooks, Discussion Leader
William Bryant, Rapporteur

The Geoscience panel decided to focus its discussion around the mounting pressures on the Gulf coastal environment, which we defined as the land-water region extending from the head of watersheds to the outer continental shelf. It is this region that is increasingly under stress from population increase, overbuilding, susceptibility to hurricanes and flooding, oil and gas exploration and production, overfishing, groundwater depletion, anthropogenic pollution, wetlands losses, rising sea level, and coastal erosion, to name some of the obvious issues. Taken together, these concerns point to the need for "Sound Science in Public Policy," which the panel chose as a leading theme for sustainable development in the coastal region.

We identified three principal areas for discussion and presentation to the larger group, summarized below. We concluded with a specific call for action in the Houston-Galveston "mecosystem" (metropolitan ecosystem), which the group views as a prototype for wider action in the Texas coastal region.

1. Food from the Sea
   - Food Web: imperiled by overfishing at the top and by eutrophication at the bottom. Sound practice requires better understanding of larval recruitment and retention, coupling between bays and offshore waters, impacts of dredging and wetlands loss, and minimization of pollutant stresses.
   - Bycatch: unnecessary destruction of untargeted species during fishing adds top stress to the food web and further endangers some species (e.g. turtles).
   - Education: public understanding of the basic reasons underpinning sound ecosystem management is absolutely necessary to maintain popular and political support.
   - Recruitment: better science basis is necessary for management strategies to conserve, rebuild and maintain healthy fisheries
   - Refuges, Rigs and Reefs: hard-bottom substrates on the Gulf shelf are important to fish stock recovery; fish refuges or marine oases protected from fishing may provide excellent ways to encourage development of stable stocks.
   - Pollution: impacts of oxygen depletion, harmful algal blooms, dispersion of toxics, and their relation to fish diseases and public health
2. The Vulnerable Coast
   - Sensible Development "while there is still time." Texas still has the opportunity to manage development in the coastal region in sensible ways, avoiding some of the negative consequences of overdevelopment that have occurred in other states.
   - Hurricane Preparedness: as population increases, the coastal region is ever more vulnerable to hurricanes, storm surges, and flooding, which require better prediction, forecasting, evaculation planning, wastewater management, and drainage pathways in the built environment.
   - Freshwater: Increasing population in the coastal environment requires better understanding of rainfall patterns and groundwater recharge, redoubled efforts to conserve and husband water resources; updated reservoir planning and management strategies; and sufficient freshwater flow to estuaries and bays to maintain critical ecosystems.
   - Homeland Security: Ports and harbors in Texas account for a large fraction of total U.S. shipping activity. Protection and safety of ports, their offshore approaches, and the infrastructure supporting shipping is critically needed as part of a sound national defense program.
   - Education: Public support for sensible development requires basic understanding of the reasons for actions. To assure sound stewardship for future generations, we must bring fundamental concepts of sustainability science and its relation to public policy into the state-mandated K-12 education curriculum.

3. Energy from the Sea
    - Oil Runs Out? Hydrocarbon resources on land and under the sea are finite and are predicted to diminish in this century. Thus alternatives such as gas hydrates will be needed and the science and technology necessary should be under development now.
    - Until then: deeper water, better technology, greater risks and greater costs are the reality.
    - Seafloor structures: As production moves to deeper water, newly discovered seafloor furrows, ridges, slumps and potential instabilities must be better understood and dealt with
    - Deep and midwater currents in the Gulf can profoundly influence exploration and production operations; the reasons for and prediction of such currents must be priorities
    - A sound national energy policy based on sensible vehicle technology, conservation and good environmental stewardship must be developed and maintained; this requires rebuilding public confidence based on sound understanding.

Sound Science – Good Management for the Houston-Galveston Bay Metropolitan Ecosystem.

- The "mecosystem": land, bay, offshore environment, built infrastructure, dozens of municipalities and regulatory bodies, a burgeoning population, increasing susceptibility to hurricances, surges, flooding, and air pollution
- We propose an integrated and sustained observing, modeling and education system focused on Galveston Bay, its multiple watersheds and the offshore waters of the Gulf shelf.
- Build on existing strengths: TABS, TCOON, PORTS – existing observing systems with state and federal support; the Galveston Bay Estuary Program; the Houston-Galveston Area Council; State agencies with environmental responsibilities; NOAA's responsibilities and current investments in observing and modeling
- Partner with Federal agencies such as the U.S. Geological Survey and the Environmental Protection Agency to expand the Gulf of Mexico Integrated Coastal Program to Galveston Bay, expanding on the Tampa Bay (FL) pilot project
- Develop fully integrated and coupled physical-biogeochemical models for "state of the bay" research, public education and utility forecasting.
- Provide sensible, useful, timely and informative products for news media, schools and managers at local and state level, using the best advantages of the Internet for outreach (e.g. the Rutgers University Project COOL). Envision an oceanic Weather Channel.
- Recognize the importance of and fully implement an integrated science-based public education program aimed at the "K-to-Gray" population.

Social, Economic and Policy Discussion Group Summary

Arnold Vedlitz, Discussion Leader
Robert R. Stickney, Rapporteur

The Social, Economic and Policy group began its discussions with a listing and elaboration of the major policy domains that would drive data gathering and decision-making concerning the Gulf of Mexico. Group members wanted to focus attention on the major policy areas that would be facing local, state, national and international policy-makers and begin to identify the types of data and information that would be needed to help guide policy-makers in making appropriate decisions about these issue areas. The following policy/issue domains were listed as most important:

- Economic development
- Health
- Coastal Hazards
- Pollutants
- Population Growth
- Conflict Resolution
- Culture and Education

The group believed that, once these domains were identified, it was important to determine what kinds of knowledge were needed to inform decision-making about these domains. The first task, as seen by the group, was to identify those who needed the information and then clarify what, specifically, they would need to know to make appropriate decisions. Those needing knowledge would include legislative and regulatory policy-makers, stakeholders and the general public. The types of knowledge they would need ranged from basic scientific and technological information, over time, to social, political and economic aspects of the human environment. The group stressed the need for a multidisciplinary approach to this information and the need to integrate knowledge across scientific fields and issue domains. A coordinated knowledge system needed to be created and successfully communicated.

The lack of successfully communicating appropriate knowledge was seen as a major problem in the current policy-making system. Scientists don't speak with one voice, scientific information is often difficult to translate to lay citizens and decision-makers, disparate scientific elements are seldom coordinated and presented as a comprehensive system, and relevant risks and choices are seldom presented and weighed. The result is that important scientific information, findings that could assist in the decision-making process, is not presented and assimilated well. Decisions are made with or without the inclusion of the scientific/technological component.

The group believed it was essential to better integrate science with policy-making and to discover ways to institutionalize this link. At a minimum, scientists needed to do a better job of systematizing and integrating their findings and in telling their story.

Sustainable Communities Group Summary

Worth Nowlin, Discussion Leader
Tom Malone, Rapporteur

The discussion group on Sustainable Communities first agreed on some general background considerations regarding sustainable, which was taken to mean "meeting the needs of the present without compromising the ability of future generations to meet their needs." Achieving this goal of sustainability requires an interactive process of adaptive management based on principles of integrated coastal management including:

- Ensuring that decisions of all sectors and levels of government are harmonized and consistent with state and national policies; and
- Requiring guidelines for human use based on realistic scenarios for how human activities affect the structure and functions of coastal ecosystems and hence their resilience (to external forcings).

The questions then are whether there can be devised an accepted environmental policy to guide coastal management and development so as to: promote economic development and public safety, ensure environmental stewardship and resolve conflicts.

Specifically, our discussion group agreed that the goal in developing sustainable communities is to sustain the quality of human life in the coastal zone. It was further agreed that this quality is tied closely to the environment, so that the goal implies sustaining the quality of environmental factors of the coastal zone. This is a very long term objective. However, it is determined in very large measures by short-term decisions and actions.

The key policy issues in reaching the correct decisions and actions are:

- Lack of policy to guide decisions and actions;
- Lack of *continuing* attention of policy makers, legislators, and managers. We must have continuing review of policy.
- Conflict between economic impact and plans to maintain quality of life.

To assist in bringing those key policy issues before the public and decision makers and to assist with the resolution of conflicts, the group recommended several general actions. These included:

- Implement a "think tank" mechanism to consider actions needed to attain the objectives.
- Communicate clearly the needs for policy and for continuing review thereof. Education is needed.
- Communicate the areas of potential conflict and ideas for resolution. Education is the key.
- Work to achieve successful local/regional pilot solutions.

In considering the many pressing environmental problems, the group noted that high priority must be given to: sea level rise, water management, waste management, urban sprawl (population increase), habitat loss, energy sources and public health. We selected two broad topics as potential foci to help stimulate action.

1. Public health is endangered by environmental problems. These include prominently water quality, beach quality, harmful algal blooms, and seafood quality.
2. Safe and efficient marine transportation (to accommodate large vessels for growth) may endanger the environment by: dredging, disposal of dredge material, effects of salinity changes, and habitat loss.

Finally, it was the consensus that education is a key. Required is education regarding environmental and economic issues related to sustaining quality of human life in the coastal zone. This must be pursued through K-12 education, in higher education, and through continuing and special education courses. It is important that scientists and engineers work with educators to tailor the message. Both the media and the web should be used to spread that message.

Sustainability — The View from Space

Dr. James Reilly
Astronaut, NASA

Eight and a half minutes after launch, altitude approximately 300 km, velocity approximately 29,000 kph the terminator dividing the night from the day side of the Earth slides below. Your first thought is all the photos you've ever seen are woefully inadequate to the view in front of your eyes. The cobalt blue of the oceans, the entire spectrum of earth tones on the continents and the glistening white of the clouds are like nothing you have ever seen before.

Socrates is quoted as "only when we rise above the Earth can we fully understand the world on which we live". As perhaps the first geologic thinker he must have realized that we needed a larger perspective than what we could obtain on the surface to visualize the structures and processes we seek to understand. It only took us around 2500 years to realize Socrates goal of capturing the "big picture." Over the past 35 years astronauts have returned approximately 300,000 photographs from orbit or on the way to the Moon during 121 US space flights.

The inquisitive nature of the human observer provides a unique capability for acquiring orbital imagery. In a way, this may be considered intelligent remote sensing. The human brain can identify, classify, and organize information rapidly, process that information to designate sites for photographs, and make choices on whether an observed phenomenon is of scientific interest. An example is the use of sunglint in detecting and photographing internal waves, current boundaries, ship wakes, surfactant slicks and island effects on wind and water flow. This has been a unique contribution of astronaut observations to the study of the oceans. As such, crew may act as collaborators in research and take advantage of differing sun angles on a scene, seasonal variations in vegetation, and repeated passes over a region to collect photographic data for analysis back on Earth.

Since being selected for the astronaut program in 1994, **JAMES F. REILLY II** has logged more than 517 hours in space, including three spacewalks. He has flown on two shuttle-Mir missions, with the most recent coming in 2001 when STS-104 delivered and installed the join airlock module to complete the second phase of the International Space Station assembly. Dr. Reilly received his bachelor's, master's and a PhD in geosciences from The University of Texas-Dallas. While in graduate school he participated as a research scientist specializing in stable isotope geochronology as part of a scientific expedition to Marie Byrd Land, West Antarctica. He was an exploration geologist before becoming an astronaut and was activ3ely involved in the application of new imaging technology for industrial applications in deep water engineering projects and biological research.

During a flight, crews will often photograph sites they find interesting or unique. These images may capture an ephemeral event that would otherwise go unnoticed. Oftentimes, these photographs of opportunity are of more scientific interest than are planned observations. A spectacular example is the oblique shot of Rabaul in eruption displaying a dual ash cloud. Other examples include a season-spanning collection of photos of the Bahama Banks used as a primary resource for calculating the areal extents of whiting precipitation events to carbonate platform growth; the development of the Atchafalaya delta, Louisiana, and the Yellow River delta in China.

Sea Ice in the Oyashio Current, Kamchatka Peninsula

Requests for imagery are uplinked to each crew every day in the "morning mail." These requests may be for color photographs of areas where workers in the field seek additional coverage to a site listing of areas of short-term conditions or occurrences or where a time-series of images are desired to monitor geological, meteorological, ecological or oceanographic processes.

To obtain information, images or to request a site for imagery acquisition visit the following sites or make you request through the cited e-mail address. There is no cost for most products.

General information

http://www.spaceflight.nasa.gov

Search for existing photos:

http://eol.jsc.nasa.gov

View photos of cities

http://city.jsc.nasa.gov

Requests for image acquisition:

Earthweb@ems.jsc.nasa.gov

Include justification and any preferences for lenses/equipment

Future Directions in Research, Technology Development and Ocean Observing in the Gulf of Mexico — The University's Role

Dr. David Prior, Moderator
Dean, College of Geosciences
Texas A&M University

The concluding discussion involved two panels, one representing academic institutions in the Gulf of Mexico region and the other representing federal, state and non-governmental organizations.

Gulf of Mexico Academic Institution Members

James McCloy, Texas A&M University at Galveston
Will Schroeder, University of Alabama
Tamara Pease, The University of Texas Marine Science Institute
Wilf Gardner, Texas A&M University
RADM Kenneth Barbor, University of Southern Mississippi
Nick Parker, Texas Coooperative Fish and Wildlife Research Unit, Texas Tech University

Federal and State Agencies and Non-Governmental Organizations

Ronald Baird, National Sea Grant Office, National Oceanic and Atmospheric Administration
Robert Stewart, USGS National Wetlands Research Center
James Rigney, Naval Oceanographic Office
Buzz Martin, Texas General Land Office
Larry McKinney, Texas Parks and Wildlife Department
Roger Zimmerman, National Marine Fisheries Service, Galveston
Dan Beckett, Texas Water Development Board

Panel members were given the following charge —

- How can the wide range of stakeholders in the Gulf of Mexico work together for the greater good?
- What new mechanisms are needed to promote synergy and team building across the academic, private and governmental sectors?
- How can interdisciplinary efforts be supported and encouraged?
- What are the mechanisms to improve communication both of needs and knowledge among the diverse stakeholders with interests in the Gulf?
- Can knowledge and information be more effectively translated into sound policy?
- What is the most important roles that universities can serve in supporting the common goals of sustainability?
- How can the university's role be enhanced and built on?
- What hinders open and collaborative partnering and how can these obstacles be removed?

Panel member responses are summarized in the following table.

McCloy	• Broaden education of our graduate students. Require education outside narrow field; include environmental policy, dispute resolution, GIS. • We need centralized data repositories open to students. • Sea Grant a positive; larger support. • Recruit U.S. graduate students; begin with young
Schroeder	• Undergraduate emphasis on basic sciences first before interdisciplinary and graduate studies. • Offer graduates opportunity for broad programs • Encourage interdisciplinary education • Re-examine our education system
Pease	• Universities to remain involved w/ K-12 and to assist in teaching of teachers • Engage students in policy implications of their field • Outreach to policy makers and media • Commit to open access data system
Tunnell	• History of TAMU-CC development • Synergy of academic-university partnerships
Gardner	• Sustainable development much broader than Oceanography; reaching out is needed • Improve agency-academic communication/partnerships • Maintain the momentum of this conference
Barbor	• Multidisciplinary research • Outreach • Maintain momentum established here • Lay out requirements for new GoM research vessel
Parker	• The watershed controls many activities of the coastal zone • Consider that public supports quality environment • Outreach is a function of the University • Land use planning essential to preserve native habitat and water supply • Train students broadly
Baird	• Agencies and universities must be jointly engaged for environmental stewardship; Sea Grand does engage universities in such stewardship. This role should be expanded. • Seeking solutions to reducing man's environmental footprint. • Universities should take role of technical/scientific development for IOOS. Observing systems should include social measured (population, distributions, etc.) • Need for regional partnerships to develop observing systems and stewardship.
Stewart	• Such fora should be used to focus and broaden our capability to meet the issues of coastal environmental stewardships. • Rely on universities for science. • Universities offer birthplace of new policy • Consider the negative outlooks as opportunities.
Rigney	• Intersections of interest between NAVO and universities: • Benefit from regional GoM observing system • Homeland security requires essential elements of a U.S. coastal observing system. • Interest in new observing technologies • Education of operational oceanographers • How much data is enough to produce a useful products for decision makers
Martin	• We will have greater capabilities in IOOS in Gulf. How dense should observing system grid be? • How will data be packaged? Decisions as to products must be obtained from users. • Use observatories as way to demonstrate to public the value of such observations. • Scientists should work with K-12 educators to inject science and observing system information into the system. • Is GoM sustainability of high priority to University administrators?

McKinney	• Public awareness of objectives is powerful tool • Must link activities in watersheds and coastal margins to requirements of the observing system • Link applied with basic research.
Zimmerman	• Areas of success: • Involve public in activities such as marine mammals and sea turtle stranding networks • Direct involvements with fishing industry and Sea Grant in fish/turtle excluders. • Marsh restoration • Sea turtle research – public tours for school children (education) • Universities should step up their roles in outreach – purveying information to public, policy makers, etc. • Agencies/Universities need to break down business barriers to form partnerships

Texas A&M University Student Poster Session

Abstracts of Posters

Sulfur Geochemistry of Thermogenic Gas Hydrate and Associated Sediment from the Texas-Louisiana Continental Slope

Dwight K. Gledhill and John W. Morse. Department of Oceanography, Texas A&M University, College Station.

Abstract. Thermogenic gas hydrate and associated sediment were recovered from the northern Gulf of Mexico to investigate the interactions between hydrate and sedimentary sulfides. Steep dissolved sulfide concentration gradients were observed both above and below gas hydrate indicating diffusion of sulfide from the surrounding pore-fluid into the gas hydrate. These gradients suggest an incorporation rate of ~1 mmol H_2S/yr-cm^2 assuming molecular diffusion. Despite extensive sulfate reduction (>95%) at the site, the mole fraction of H_2S within the hydrate is too low (~0.3%) to significantly influence its stability. The lower than expected sulfide content of this hydrate is related to the abundance of reactive iron (pyrite iron + HCl extractable iron averages 256 ± 66 mmol/g) that has allowed for elevated TRS concentrations (271 ± 50 mmole/g). These iron-rich sediments are thus capable of sequestering much of the generated sulfide in the form of solid phase iron sulfides thereby making it unavailable for incorporation by gas hydrate. The presence of hydrate did not significantly impact the relative abundance of TRS, however TRS proximal to the hydrate was depleted in ^{34}S by ~10%. relative to TRS remote to the hydrate. The precise mechanism responsible for this relative depletion is not clear, but may prove an important geochemical indicator of sediments in which gas hydrate is, or has been, present. Studies at other sites will be necessary to confirm the generality of these observations.

Spatial Influence of Cold Seeps on the Benthos in the Northern Gulf of Mexico

Clifton Nunnally. Department of Oceanography, Texas A&M University, College Station.

Abstract. The amount of the benthos that is enriched by carbon derived from cold seeps in the Gulf of Mexico is unknown for macrofaunal populations. Seep and non-seep sites have been evaluated for abundance, species diversity and Sediment Community Oxygen Consumption (SCOC) to determine structural and functional differences between macrofaunal communities. By using sediment cores and in-situ sediment incubations these differences have been determined for seep and non-seep sites in the Northern Gulf of Mexico. Simple hypotheses predict greater abundance, less diversity and greater total SCOC (lower respiration per body mass unit) to be found at seep sites. The same hypotheses predict lower abundance, greater diversity and lower total SCOC (greater respiration per body mass unit) away from cold seeps. Increased population at cold seeps is a result of greater available carbon in the sediments. Decreased diversity at seeps is a result of competition for these abundant resources, which is strong enough at seeps to force other taxa out of the local community.

Relevance to "A Sustainable Gulf of Mexico": As deepwater oil production moves out onto the continental slope in the Gulf of Mexico deepwater benthic communities will be encroached upon more regularly. If the scientific and industrial communities are intent on protecting cold seeps, the effective extent of these "oases of the deep" must be finitely determined. Since many seeps in the Northern Gulf of Mexico are also home to marine gas clathrates, cold seeps will also be impinged upon in the future as further areas of offshore energy resources.

Organoarsenicals: The Missing Arsenic Sink

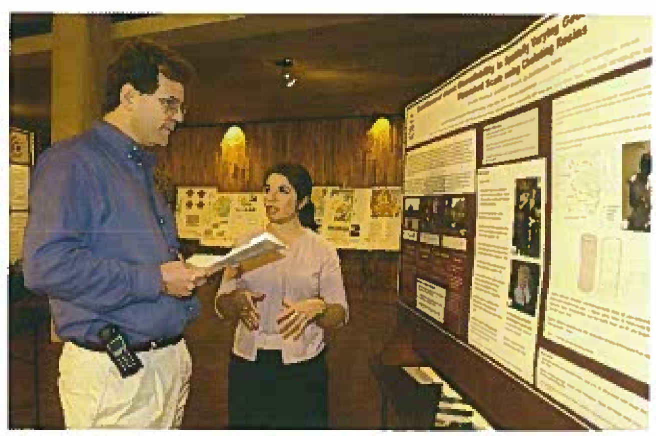
Melissa Roberts and Bruce E. Herbert. Geology and Geophysics, Texas A&M University, College Station; Patrick Louchouran. Physical and Life Sciences/Conrad Blucher Institute for Surveying and Science, Texas A&M University-Corpus Christi, Corpus Christi.

Abstract. Elevated concentrations of arsenic and other uranium (U)-associated elements have been observed in surface and ground waters of the Nueces and San Antonio River watersheds (Texas) that drain the Catahoula formation (a major formation of the Gulf Coast Uranium Province). Intensive U mining from the 1960's to the 1980's has resulted in a diverse series of ground water impacts, including artificial groundwater mounds under reclaimed U mines. Surface ponds and wetlands downstream of these mounds are fed by groundwater seeps containing significant concentrations of arsenic.

It is generally assumed that arsenic fate and transport is controlled by the reactivity of the inorganic species and local redox conditions. We hypothesize that production of organoarsenicals by algae in phosphate-limited, surficial waters and subsequent incorporation into organic matter through microbial decomposition is an important missing component of arsenic cycling in these systems. This set of processes may serve as a significant arsenic sequestration mechanism in the surface and ground waters of South Texas and as a natural attenuation mechanism of arsenic contamination.

Contaminated water and sediments were collected from a stock pond and a downstream wetland. Algae obtained from the pond were cultivated under N:P ratios of 20 to 100, conditions which are inclusive of natural environments as well as extremely phosphorus-limited environments. Arsenic concentrations up to 10 mg/L were applied to each set of cultures. After four weeks of growth, the algae were harvested, washed, digested, and analyzed for total arsenic content using stripping voltarnmetry. Undigested algae samples were extracted using Soxhlet extraction and microwave assisted extraction to quantify organoarsenical species. Organoarsenical compounds in sediments were also extracted and quantified using carbohydrate and humic extraction methods and stripping voltarnmetry.

Quantification of Arsenic Bioavailability in Wetland and Ground Water Environments at the Watershed Scale Using Chelating Resins



Graciela E. Lake and Bruce E. Herbert. Geology and Geophysics, Texas A&M University, College Station. Patrick Louchouran. Physical and Life Sciences/Conrad Blucher Institute for Surveying and Science, Texas A&M University—Corpus Christi, Corpus Christi.

Abstract. Elevated levels of arsenic and other U-associated elements have been observed in surface and ground waters of the Nueces and San Antonio River watersheds, Texas. These watersheds drain the Catahoula formation that includes the Gulf Coast Uranium Province that is enriched in trace elements, including arsenic (As), vanadium (V), and uranium (U). These elements have been released from the U province through natural geochemical weathering over geologic time scales and intensive U mining from the 1960's to the 1980's.

Mining activities have potentially impacted groundwater quality through Infiltration and lateral migration of mineral-rich plumes generated by rainfall infiltration and leaching of ore pads and spoil piles, recharge from contaminated rivers and streams, and infiltration from mine pits. Potential toxicity of arsenic in different geologic environments is dependent on the total concentration and bioavailability of arsenic. It is important to identify those geologic environments that sequester contaminants because these systems retard contaminant transport through the watershed, limit toxicity, and act as long-term sources for the contaminant.

The objective of this project is to quantify the bioavailability of arsenic in different geologic environments at the watershed scale using chelating resins as infinite sinks. Stripping voltarnmetry and Inductively Coupled Plasma Mass Spectrometer (ICP-MS) was used to quantify total arsenic, arsenic (111), and arsenic (V) sorbed by a pre-treated chelating resin. This laboratory technique was applied to loaded chelating resins exposed to field environments to quantify the bioavailability of total arsenic, arsenic(III), and arsenic(V) over time. Such information has been identified as a critical need for protecting the agricultural and aquacultural resources, and the ecological quality of the Nueces Estuary system, designated an Estuary of National Significance by the U.S. Congress via the Water Quality Act in 1987.

A GIS Survey of Arsenic and other Trace Metals in Groundwater Resources of Texas

Lai Man Lee and Bruce E. Herbert. Geology and Geophysics, Texas A&M University, College Station.

Abstract. Water quality issues have increasingly become more prevalent in local and federal politics. Most recent of which was the decision to lower the drinking water standard for arsenic from 50 ppb to 10 ppb by the EPA. Previous studies have focused on small or watershed-scale arsenic concentrations and almost entirely only on arsenic, ignoring possible connections between arsenic and other trace metals.

Comprehensive surveys of water quality are scarce and in between. State and federal agencies offer valuable sources of data that span time and space. This study has produced the most comprehensive water quality database for the state of Texas. Data from the Texas Water Development Board (TWDB) and the National Uranium Resource Evaluation (NURE) were collected into a GIS database. Specific attentions were placed on arsenic and other trace metals in ground water.

Geology, soils, land use and vegetation base maps were used to investigate controls on trace metal concentrations in groundwater. Statistical analyses of the data revealed a strong correlation between arsenic and other oxyanions including vanadium, selenium and molybdenum. These results are suggestive of a geologic source for the concentrations of trace metals in groundwater. Implications and conclusions from this study are that arsenic and other trace metals can be regionally controlled by geology. Additionally, inconsistent monitoring of private wells may underestimate the amount of trace metals in groundwater resources as well as the health risks to private well users.

Deep Sea Seasonality of Benthic Macrofauna in the Northern Gulf Of Mexico

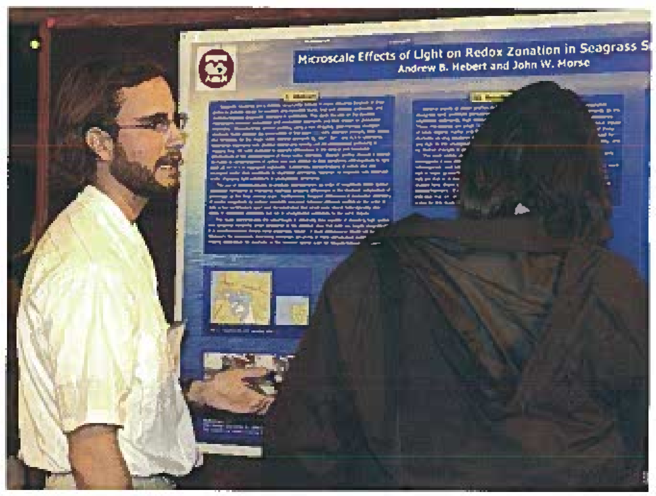
C.L. Gudeman, G.F. Hubbard, and G.T. Rowe. Texas A&M University, College Station.

Abstract. Prior to 1970, it was assumed that there was no connection between surface productivity and deep-sea benthic productivity. More recently, seasonality has been observed in deep-sea environments, but the effects of annual variations on the resident biota remains either obscure or controversial. It has been observed that polychaete density can vary between two time periods across a broad depth interval of the continental slope

of the northern Gulf of Mexico (Hubbard, 1995). This temporal difference has been used to construct a numerical simulation that estimates variations in the amount of organic matter (POC) that is incorporated into the food chain over a typical seasonal cycle (Figure 1). Various studies have demonstrated that the total POC flux tends to vary in time and decline with increasing water depth. This study will demonstrate that benthic macrofaunal density and biomass along the Northern Gulf of Mexico Continental Slope varies with time and geography, and is linked to fluctuations of primary productivity. This allows the growth rates in the model to be adjusted accordingly over the same depth interval to the predicted temporal variation in POC delivery to the sea floor.

Human-Generated Refuse in the Deep Gulf Of Mexico

Human generated refuse and particulate natural refuse (organic) were a frequent occurrence in trawls throughout the Northern Gulf of Mexico along the continental slope during the summer of 2000. Macroalgae, seagrass, and terrestrial plants, which are ingested by deep-sea epifaunal deposit-feeders, may serve as an important contribution to the detrital food chain in the deep-sea (Wolff 1979, 1980; Pawson 1982). Scraps of wood, bark, macrophyte and fruit serve as both habitat and nourishment to marine organisms. Mollusks convert cellulose to fecal pellets, which are ingested by cletritus feeders (Knudsen 1961; Turner 1973). Wood is frequently encountered (Rowe and Staresinic 1979) in deep-sea trawl samples. To date, human refuse has not been quantified systematically in deep-sea samples. This study will depict the qualitative distributions of human generated refuse and organic refuse recovered from the otter trawls.



Microscale Effects of Light on Redox Zonation in Seagrass Sediments

Andrew B. Hebert. Department of Oceanography. Texas A&M University, College Station

Abstract. Seagrass meadows are a primary structuring feature in many estuaries because of their ability to provide refuge for resident and transient fauna, trap and stabilize sediments, and mediate/regulate diagenetic reactions in sediments. This study focuses on the dynamic interactions between seagrasses and associated sediments and their impact on porewater chemistry. Microelectrode vertical profiling using a non-stripping, gold-mercury amalgam electrode made possible the observation of fine-scale (<1 mm) chemical changes, both spatial and temporal, for the major redox reactive elements O^2, Mn^{2+}, Fe^{2+}, and H_2S in sediments. Sediments vegetated with Zostera marina and nearby (<1 m) unvegetated sediments in Yaquina Bay, OR were analyzed to quantify differences in the vertical and horizontal distributions of the concentrations of these redox elements. Overall, profiles showed a distinct decrease in concentrations of sulfide and iron relative to dark conditions with exposure to light (200 mE/m^2/s). Conversely, concentrations of sulfide and iron increased under dark conditions.

The use of microelectrodes to produce approximately an order of magnitude better spatial resolution revealed differences in the chemical composition of porewater at this finer vertical scale. Furthermore, frequent differences in porewater chemistry of similar magnitude to vertical variability occurred between different profiles on the order of only a few centimeters apart and demonstrated that small-scale lateral heterogeneity also exists.

This study highlights the advantages in using data capable of such higher spatial and temporal variability when compared to the classical view that both are largely insignificant in a one-dimensional steady-state diagenetic model. A multi-dimensional model will be necessary for accurately describing processes occurring in sediments hosting seagrasses at the relevant spatial scale for biogeochemical processes.

Long-term Land Development Patterns and Flooding: The Sustainability of a Coastal Metropolis

Buren B. DeFee 11 and George Rogers. Department of Landscape Architecture and Urban Planning, Texas A&M University, College Station.

Abstract. The creation of hardscape and redistribution of soil during land development changes the quantity and direction of waterflow throughout the landscape. Land development often occurs without the guidance of a region-wide plan and without concern over how the landscape changes will affect those who are downstream. While many studies have chosen to model these changes and attempt to predict future water flow, the present paper takes a different approach.

This study focuses on long-term landscape changes and how those changes affected the flow of water in one sub-watershed located in Harris County, Texas. Instead of identifying small, localized changes, a broad approach looks at large areas over long periods of time. Covering a timespan of over 70 years, the preliminary data demonstrates how the addition of hardscape has changed the stream flow rates out of the watershed. Not only was average flow increased, but more importantly, the maximum flows and the frequency with which those maximum flows occurred also increased.

This study is an example of how uncontrolled suburban encroachment into rural areas can change the character of a watershed, increasing both the frequency and intensity of flooding both within the watershed and downstream. It represents a first attempt to examine issues of particular importance to the development of sustainable coastal margins. By analyzing these data in both spatial and temporal dimensions simultaneously, we anticipate to be able to test hypotheses concerning human contribution to natural hazards and hence sustainability.

Biogeochemistry of the Deep Gulf of Mexico

Melanie J. Beazley, Karen S. Sell, and Andy B. Hebert. Department of Oceanography, Texas A&M University, College Station.

Abstract. The deep Gulf of Mexico is currently being studied to identify benthic composition and structure by the Deep Gulf of Mexico Benthic Ecology (DGoMB) program sponsored by the Minerals Management Services (MMS). The objective of the DGoMB program is to determine the relationships between the biological communities and the geochernical processes of the benthos. The ongoing program has completed two of the three slated cruises. The initial cruise in the Summer of 2000 included 43 survey stations, in which only a limited range of analyses occurred. On the second cruise of Summer 2001 stations were divided into "survey" (4) and "process" (7) sites, where more comprehensive analyses were preformed at the process sites. A variety of biological and geochemical sampling techniques were incorporated on the cruises, including, but not limited to, bottom trawls, boxcores, water column profiles, current profiles, and community structures. This presentation will focus on the geochernical aspects of the DGoMB survey. We will concentrate only on the geochernical results and their implications, which consist of sediment solid phase and pore water properfies. At the survey stations, five replicate boxcores were taken for geochernical analyses of the top two centimeters, including trace metals, organics, and geochernical properties. At the process stations, additional (20 cm) cores were taken for sulfate reduction, pore water squeezing and microelectrode profiling. Approximately a third of the survey sites exhibited >4% sulfate reduction, with a few sites showing very extensive sulfate reduction. Unlike most sulfidic sediments, there were no accompanying elevated concentrations of other bioreactive components such as nutrients, dissolved organic carbon and organic carbon. Electrode profiles at the process sites show oxygen penetration depths ranging from close to the water-sediment interface to 10 cm depths. Sulfide concentrations were low (<5 mm) to non-detectable. Manganese (II) was detected at only one site and iron (II) was not detected at any of the

sites. Trace metal concentrations, determined by Dr. Bob Presley, were similar to those generally found in the Gulf of Mexico. However, the strong barium enrichments of up to almost a factor of ten in a few samples are possibly due to the presence of oil residues from drilling activities. Polynuclear aromatic hydrocarbons (PAH), determined by Dr. Terry Wade, at offshore sites were low, however four of the near-shore sites had higher concentrations accompanied by high barium concentrations indicating oil drilling activity.

Deep Sea Studies in Collaboration with the Oil and Gas Industry: Biodiversity Studies Using Remote Operated Vehicles (ROV's)

A.W. Ammons, C.C. Nunnally, M.P. Ziegler, and G.T. Rowe. Department of Oceanography, Texas A&M University, College Station.

Abstract. The offshore oil and gas industry has increasingly focused attention into progressively deeper waters away from shore to supply its energy needs. Consequently, within the Gulf of Mexico, exploration and production are moving from the continental shelf to the deeper continental slope. From a biological perspective, slope habitats are very dynamic ecosystems, though poorly studied. Even though the number of organisms that reside here is typically low, the species diversity is high, indeed among the highest known anywhere. High biodiversity in such a barren environment cannot easily be explained; nor can the effects of anthropogenic influences.

The oil and gas industry is in the unique position of maintaining offshore operations using versatile, professionally operated remotely operated vehicles (ROV's) at drill sites. These platforms, with little to no modification, have the capability to carry out a wide range of research initiatives within slope habitats, while leaving regular drilling operations unaffected. In collaboration with scientists from Texas A&M University, preliminary data from British Petroleum ROV's operating offshore, aboard production rigs and large drill ships, are aiding in our understanding of slope ecology. It is hoped that such a joint venture between industry and academia will prove fruitful, and foster a better understanding of the deep sea.

The Role of Small Scale Habitat Heterogeneity on Macrobenthic Diversity in the Deep Northern Gulf of Mexico

A.W. Ammons, G.S. Boland, G.F. Hubbard, and G.T. Rowe. Department of Oceanography, Texas A&M University, College Station.

Abstract. Many areas of the seafloor are pockmarked with numerous mounds, burrows, and other structural features created through bioturbation by megafauna such as crabs, echinoids, and fishes. On the small scale, these features may create sufficient spatial heterogeneity to account for much of the high diversity found in the macrobenthos. Using photographic data from past studies in the deep northern Gulf of Mexico, various small-scale features are identified. Grades of spatial heterogeneity are assigned, and macrobenthic boxcores taken in these areas are ranked according to variation in abundance and diversity between study sites. Preliminary findings show some evidence of positive correlation between diversity and habitat heterogeneity.

Deepwater Starfish (Asteroidea) of the Northern Gulf of Mexico: Abundance and Distribution of Dominant Species 1950-2000. Trends from the Past and Present

Ammons, A.W., and G.T. Rowe. Department of Oceanography, Texas A&M University, College Station.

Abstract. Long-term (decadal or more) population studies of cleepwater marine organisms are uncommon due to logistical expense and lack of coordination with earlier surveys. The essentially pristine environmental condition of cleepwater habitats however, makes them ideal

platforms for monitoring regional and even global changes, either natural or human-generated. From a biological perspective, such changes might be seen or even predicted by monitoring the population structure of certain conspicuous organisms commonly encountered in the deep sea.

The distribution of dominant starfish taxa occurring on the continental slope of the northern Gulf of Mexico is reported. Trawl data compiled from various oceanographic cruises over a fifty-year period (1950-2000) are used to show changes in abundance and geographic distribution over time.

Planktonic Trophodynarnics in Estuarine Dilution Bioassays

S.E. Lumsden, J.L. Pinckney, and A. Burd. Department of Oceanography, Texas A&M University, College Station.

Abstract. Dilution bioassays form an experimental approach that has been a reliable and frequently used technique for estimating in situ microzooplankton grazing rates and phytoplankton community growth rates in open ocean ecosystems. This technique creates a range of grazing pressures by reducing the encounter rate between predators (zooplankton) and their prey (phytoplankton) via dilution of natural seawater with filtered seawater. However, while the picophytoplanktonic size structure of the open ocean permits the assumption of only one predator: prey trophic link between protozoans and picophytoplankton, this is not the case in estuarine ecosystems. Estuarine zooplankton and phytoplankton communities include many diverse species and size classes contained in a small volume of water. A single dilution bioassay bottle may enclose a complex food web with multiple trophic levels. These multiple pelagic trophic levels and the rapid interactions between them may result in what appear to be anomalous conclusions regarding phytoplankton growth and zooplankton grazing rates. Our findings suggest that the zooplankton community structure found in a sub-tropical estuary such as Galveston Bay, Texas, and possibly similar estuaries, result in fundamentally different responses in dilution bioassays.

Acoustic Backscatter Measured Near-Bottom in the Northeastern Gulf of Mexico from a Bottom-Moored 300kHz ADCP

Laurie R. Sindlinger, Steven F. DiMarco, and Douglas C. Biggs. Department of Oceanography, Texas A&M University, College Station.

Abstract. In the second field year of the Deep Gulf of Mexico Benthos (DGoMB) project, four deployments of a near-bottom-moored ADCP were made allowing us to look for possible scattering due to near-bottom swimmers in the deep Gulf. The water depths in which the ADCP was recording were 755m, 935m, 1,823m, and 2,740m. For each deployment, the downward-looking ADCP was moored 35m off the bottom and data were logged every 15 minutes by 2m depth bins. There are a total of 12 usable depth bins (from 35-6=29m off bottom to 35-28=7m off bottom). Mean near-bottom backscatter intensity was higher in shallower water depths. The highest intensities and the most variability were seen where water depth was 755m, and the lowest intensity and variability were seen where water depth was 2,740m. There was also a higher more structured current speed at the shallowest deployment site. For each deployment, between-bin correlation coefficients were calculated for each of the 12 depth bins investigated in this study. Correlation values decreased for each deployment as the vertical separation between bins increased. There was no apparent phase change seen in the data collected during the four deployments to indicate diel vertical migration of scavengers or zooplankton. Data from among the four deployments is being compared to moored data from near-surface time series. In summer 2002, we plan to return to two of these deployment sites

or to comparable sites and open a baited trap near-bottom and midway through the ADCP deployment period. We plan to open the trap using timed burnwires and look for any associated changes in backscatter intensity.

Comparison of Metal Concentrations in the Blood and Carapace of Wild Kemp's Ridley Sea Turtles *(Lepidochelys kempii)* along the Texas/ Louisiana Coast

Hui-Chen Wang[1], André M. Landry, Jr.[1] and Gary A. Gill[2]. [1]Wildlife and Fisheries Sciences, Texas A&M University, College Station and [2]Oceanography, Texas A&M University, Galveston

Abstract. Nearly 2,800 sea turtles have stranded along the Texas/Louisiana coast since 1994, with the endangered Kemp's ridley accounting for over one-third of this total. Necropsies of stranded carcasses have yielded little insight as to possible cause(s) of death in these turtles. One possible cause, especially in these states where a vast petrochemical industry uses coastal waters frequented by sea turtles for operational purposes, is exposure to and uptake of marine pollutants such as heavy metals. The relationship between sea turtle health and their trophic environment in terms of heavy metal uptake is poorly understood. Research described herein quantifies and compares heavy metal concentrations in the blood and carapace tissue of Kemp's ridleys; captured in entanglement netting operations along the upper Texas and Louisiana coasts during May-August 2000 and 2001. Graphite furnace atomic absorption spectrophotometer (GFAAS) and cold vapor atomic fluorescence were used in the quantitative analysis of 7 heavy metals. Results of this research are compared with those of other studies on heavy metal uptake in blood and carapace tissue of Kemp's ridleys and other sea turtle species. The utility of non-invasive sampling methods for determining heavy metal concentration in endangered sea turtles also is evaluated.

A GIS Approach to Assessing the Relationship Between Kemp's ridley Sea Turtles and Blue Crabs

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Abstract. The blue crab *(Callinectes sapidus)*, a preferred prey of the Kemp's ridley sea turtle *(Lepidochelys kempfi)*, has experienced recent population declines along the Texas coast. Concerns have arisen as to the impact of these declines on Kemp's ridley use of Texas waters as feeding and development grounds. This study employs GIS technology to examine the relationship between Kemp's ridley and blue crab abundance in shallow Gulf waters near Sabine Pass, Texas, an index habitat for the latter species, during 1993-2000. Seasonal occurrence and abundance (expressed as catch-per-unit-effort, CPUE) of Kemp's ridleys were assessed via monthly entanglement netting operations. Similar statistics were generated for blue crabs captured in otter trawls towed adjacent to netting sites. Elevated ridley CPUEs occurred concurrently with highly variable fluctuations in annual blue crab abundance from 1993-1997. Regression analysis of these catch statistics yields no strong logarithmic correlation between Kemp's ridley and blue crab abundance (r^2=0.07). During these years, other factors including density dependent variables related to nesting success and a possible 2-3 year cyclic pattern in recruitment to benthic habitat may have influenced ridley aggregation on developmental feeding grounds. Peak ridley and blue crab abundances in 1997 were followed by concurrent reductions in CPUE of both populations during 1998-2000. These trends yielded a strong logarithmic correlation between ridley and blue crab abundance from 1997-2000 (r^2=0.85). The greater abundance of ridleys and blue crab on the west side of Sabine Pass (p = 0.01, a = 0.05) may be attributed to water vortices created by long shore currents and prevailing southerly winds at this site. Sediment deposition in this entrained water mass produces soft, muddy substrates characteristic of prime blue crab foraging grounds. Factors possibly influencing the decline in blue crab abundance, such as changes in salinity due to

prolonged drought conditions, and their impact on Kemp's ridley dynamics are also assessed. Mean annual salinity levels failed to differ significantly across sampling sites (p = 0.62, a = 0.05), nor correlate statistically with Kemp's ridley and blue crab abundances (ridleys: r^2=0.01, crabs: r^2=0.40). The influence of salinity on ridley or blue crab abundance may be masked by the annual analysis conducted in this study. In order to better understand and manage this endangered species, it is recommended that future research assess how overharvesting of blue crab, nesting beach dynamics, and shrimping activity/bycatch influence Kemp's ridley aggregation to developmental feeding grounds.

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What Is LOER?

The Laboratory for Oceanographic and Environmental Research (LOER; http:Hloer.tamug.tamu.edu) was organized in 1989 at the Fort Crockett Campus of Texas A & M University in Galveston as a research facility associated with the Department of Marine Sciences (TAMUG) and the Department of Oceanography (TAMU). The laboratory is headed by Dr. Peter H. Santschi. Other faculty participants in LOER include Ernie Estes, Gary Gill, Ayal Anis, Tom Ravens, Tim Dellapenna, and Larry Griffin. Numerous research scientists, postdoctoral investigators, graduate and undergraduate students, and staff interested in marine and aquatic environmental research have used LOER facilities. Currently, 8 Ph.D. and 12 M.S. students who received graduate degrees at Texas A&M University have carried out their research work using LOER facilities.

Mission Statement.

The mission of LOER is to provide state of the art common access analytical facilities and support for coordinated research efforts in oceanographic and environmental research

Facilities and Equipment Available at LOER. LOER has state-of-the-art analytical instrumentation and field sampling equipment for determination of major, minor, and trace constituents and radionuclides in sediment, water, suspended particulates, and biological samples

Research Budget and Publications. With a 0.5 - 1 $M/yr budget from government agencies and industry, graduate students and faculty have more than 150 publications in peer-reviewed journals, most with graduate students as first or co-authors.

Research Areas. Relationship between the biogeochernical cycling of trace elements (e.g., Hg, Ag, Pb, Cd, Zn, Cu, Co, Ni, I, etc.) metalloids, radionuclides (e.g., Th, U, Pb, Po, Ra, Be, Cs, and Pu), with organic carbon species (e.g., DOC, POC, carbohydrates, and acid polysaccharides) in natural waters. Investigations into colloidal macromolecular organic matter in mediating the transport, fate, mobility, bioavailibility and speciation of metals and metalloids in aquatic environments, including meteoric, surface and ground waters. Atmospheric transport processes and fluxes of trace elements and radionuclides into coastal waters. Sediment-water exchange processes in coastal marine environments. Particle dynamics in water and in sediments; Sediment transport and erosion processes; Geochronology of coastal sediments. Development of low level analytical techniques for chemical and phase speciation of trace elements and metalloids in natural waters.

Characterization of the Plankton in a Coastal Wetland Cut Off from Freshwater Flow

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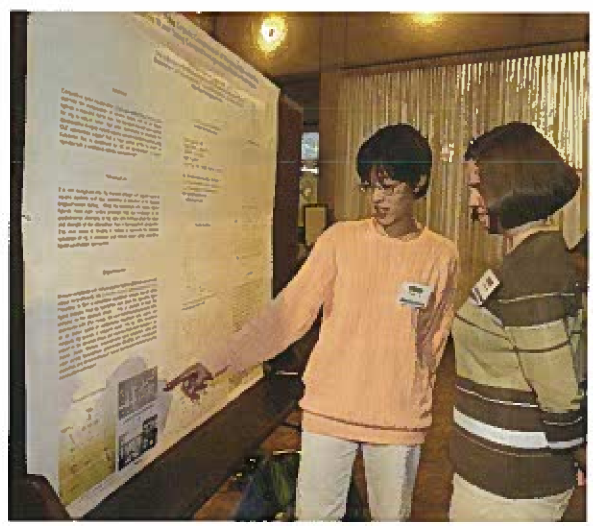
Abstract. Coastal wetlands along the Texas Gulf Coast are critical ecosystems ecologically and economically. Wetland acreage continues to be lost, however, due to freshwater diversion for industrial, municipal, and agricultural use. Freshwater inundation into the upper Nueces Delta, northwest of Corpus Christi, Texas, has been greatly reduced due to dam construction within the Nueces River Basin. Three sampling trips were conducted (30 May, 6 June, and 13 June 2001) to asses how wetland desiccation in the summer, magnified by freshwater diversion, affects the plankton community. Salinities were 190ppt, 220ppt, and 300ppt, respectively, and mid-day water temperatures ranged from 35 C to 39 C. Average gross water column primary productivity, measured using a traditional light-dark bottle method at five stations, was 0.268 g-C m^{-2} day^{-1} on 30 May and undetectable on 6 June and 13 June. Chlorophyll *a* concentrations and standing biovolume also decreased notably after the first sampling trip. Inorganic nutrients generally showed a non-conservative increase in concentration suggesting a source from the dying phytoplankton. The phytoplankton community composition, initially dominated by *Nitzschia longissima* (a large diatom) and coccoid green algae, gave way to a community dominated by coccoid green algae, Synura, cryptomonads, and filamentous cyanobacteria. Zooplankton concentrations, comprised mainly of the protozoa, showed a drastic decrease following 30 May, and bacteria concentrations increased throughout the sampling. Higher trophic levels including fish and invertebrates were virtually absent from this system and a large juvenile fish kill occurred after 30 May. These results indicate a collapse in phytoplankton primary productivity after a critical salinity was reached. This collapse and the extreme hypersaline conditions appear to have negatively affected higher trophic levels. Management schemes of diverted freshwater must consider wetland health in addition to industrial and municipal needs.

Determination of the Organic Complexation of Mercury in Galveston Bay Estuarine Water Using Competitive Ligand Equilibration Techniques



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Abstract. It is well recognized that Hg interacts strongly with organic matter in aquatic systems and that this interaction is important in its aqueous biogeochemical cycling. While Hg-organic ligand interactions have been widely predicted from our knowledge of the environmental chemistry of Hg, very little is known about the nature and strength of the interactions from a thermodynamic perspective. Competitive ligand equilibration (CLE) approaches have been used to estimate the complexation of several metals with natural organic ligands in seawater, but to date, this approach has not been reported for Hg. Here, we report initial results to determine the complexation of Hg by natural organic ligands in estuarine water using CLE approaches. The CLE approach for determining Hg speciation in natural waters is complicated by the fact that Hg-natural organic ligand complex(es) readily extract (> 75%) into non-polar solvents. To apply the CLE approach, a competitive ligand must compete with the natural organic ligand(s) such that a portion of the naturally extractable Hg remains in aqueous solution rather than be extracted into the non-polar solvent. This approach is opposite that of most CLE approaches, where the competitive metal-ligand complex extracts into the solvent and the natural metalligand complex remains in aqueous solution. A ligand which appears to meet these criteria is 1, 2 dimercaptopropanol (BAL). We are currently developing a solvent extraction procedure using BAL as the added ligand and extraction with CCl_4 to isolate the natural organic complexes of Hg from the Hg bound to the competitive ligand. Mercury measurements are conducted using cold vapor atomic fluorescence spectrometry. Mercury - natural organic ligand complexation capacity and natural ligand concentrations are determined using linearization techniques applied to Hg titrations of the natural water sample combined with

equilibrium modeling of the inorganic solution speciation of Hg. Initial results suggest that a major portion of the Hg present in Galveston Bay estuary is complexed by a very small concentration of natural ligand with a conditional stability constant > 10^{25}.

A Sensitive Determination of Iodide Species in Fresh or Saline Matrixes Using High Performance Chromotography and UV/ Visible Detection

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Abstract. Recent studies employ the isotopic ratio of $^{129}I/^{127}I$ as a tracer for seawaters. The possible use of this iodine ratio as a tracer in fresh and estuarine waters as well as the extension of its use to provide a new tool for the geochronometry of organic matter requires a thorough characterization of iodine speciation.

Iodide is determined directly using a new method combining anion exchange chromatography and an ultraviolet visibility detector. Iodate and the total of organic iodine species are determined as iodide with minimal sample preparation. The method has been successfully applied to determine iodide, iodate as the difference of total iodide and iodide after reduction of the sample, and organo-iodine as iodide after organic decomposition and reduction. The detection limit is 0.4 ppb with less than 5% relative standard deviation. Analytical accuracy was tested (1) against certified reference material SRM 1549, powdered milk (NIST), (2) through the method of standard additions, and (3) compared to values of environmental waters measured independently by ICP-MS. The method has been successfully applied to measure the concentrations of iodide species in rainwater, fresh surface and ground water, estuarine water of different salinities, and sea water samples. The organic decomposition technique was tested against known solution concentrations of L-thyroxine, SRM 1549 milk, and iodinated humic and fulvic materials yielding recoveries of greater than 90%.

This technique is one of the few methods sensitive enough to accurately quantify stable iodine species in nanomolar concentrations across the range of matrices in environmental waters. Radioactive ^{129}I will be measured separately for the different iodine species, after special processing, by Accelerator Mass Spectrometry.

Temporal and Spatial Variability in Blenny (Perciformes: Labrisomidea and Blenniidae) Assemblages on Texas Jetties

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Abstract. Texas jetties serve as surrogate rocky shore environments and artificial reefs to structure-dependent organisms. Prior to jetty construction 120 years ago, structured, hardbottom habitats and associated cryptic fish species were effectively absent from the northwestern Gulf of Mexico coast. Fishes in the Families Labrisomidae and Blenniidae represent marine ichthyofauna whose distributional range across the northwest Gulf may have been influenced by jetty construction. Blennies' sedentary, cryptic nature and their recent colonization of Texas jetties render them excellent indicators of environmental stress and candidates upon which to model population dynamics of invasive marine species. These fishes also may be used to evaluate the functional equivalency of artificial habitats to their natural counterparts. Research described herein characterized population dynamics of blenny assemblages along the Texas coast and developed working hypotheses

as to their origin. Blennies were dipnetted from jetty habitats at Galveston, Port Aransas, and South Padre Island, Texas monthly during May 2000 through August 2001. Four blenniid species (*Hypleurochilus geminatus, Hypsoblennius hentz, Hypsoblennius ionthas,* and *Scartella cristata*) and one labrisomid (*Labrisomus nuchipinnis*) contributed to spatially distinct assemblages differing significantly in species composition, diversity and evenness across sampling sites. S. *cristata* dominated assemblages at Port Aransas and South Padre Island, and shared this status with *H. geminatus* at Galveston. *L. nuchipinnis* was not captured at Galveston while *H. geminatus* occurred sporadically south of Port Aransas. *Hypsoblennius spp.* appeared to be rare on Texas jetties. Shannon Weiner species diversity index for blennid assemblages was significantly higher at Galveston than that at Port Aransas ($p=0.003$, $a=0.05$) and South Padre Island ($p=0.004$, $a=0.05$). S. *cristata* in the Galveston population were significantly larger ($P<0.001$, $a=0.05$) than conspecifics from Port Aransas and South Padre Island. Patterns of blenny distribution and ecology on the Texas coast may result from different origins for labrisomid and blenniid populations. S. *cristata* and *L. nuchipinnis* are tropical/subtropical species whose Texas populations likely originated from the southern Gulf of Mexico. The more temperate *H. geminatus* may have colonized Texas jetties from the eastern Gulf. *Hypsoblennius hentz* and *H. ionthas* are estuarine oyster reef species that may have established permanent populations gulfward of bays. Declines in blennid diversity from Galveston to the lower Texas coast may result from S. *cristata's* inability to compete in the more temperate and less structurally complex habitat at Galveston. The disparity in mean size of S. *cristata* across sites is probably due to the smaller sample size or fewer recruits being captured on Galveston jetties, S. *cristata's* subtropical nature may have lessened its recruitment potential to more temperate Galveston waters. Long term assessment of community structure is prerequisite to determining the origins and future development of blenny assemblages on Texas jetties.

Role of Natural Organic Matter in Governing the Bioavailability of Potentially Toxic Metals of Estuarine Bivalves

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Abstract. Colloidal organic matter (COM) makes up a large portion of the bulk dissolved organic matter (DOM) in marine environments. Marine colloids are important in the biogeochemical cycling of trace elements in the ocean due to high complexation capacities. These colloid bound trace elements can then become available to organisms through numerous pathways. This study assesses the bioavailability and uptake of metals by bivalves as a function of the quality and quantity of natural DOM. We report results from short-term uptake experiments that used radioactive metals bound to colloidal organic matter. Separate experiments also used C-14 labeled colloidal organic matter. The types of natural organic matter were varied in order to examine if the quality of the organic matter affects uptake and removal by the bivalves. Other experiments have been carried out to determine the lowest size of colloids oyster can remove from the water by filter-feeding. In such an experiment, colored polystyrene latex particles of various sizes were added to oysters in beakers. Initial results indicated that particles as small as 0.025 mm (25nm) particles were efficiently removed from the seawater as pseudofeces, with removal residence (1/e) times ranging from 4-10 hours, depending on oyster.

Sources of Alluvium in a Coastal Plain Stream Based on Radionuclide Signatures from the ^{238}U and ^{232}Th Decay Series: Hillslope to Channel Coupling and the Effects of Human Agency

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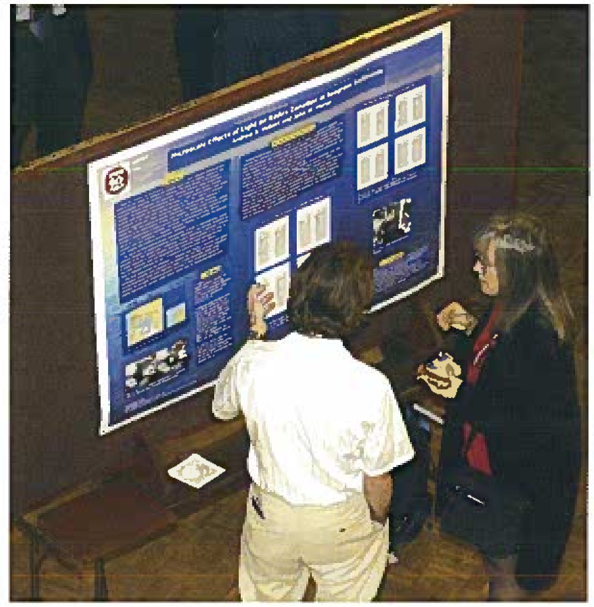
Abstract. Alluvial sources and their change over time or distance, are fundamental questions

in hydrology and geology, often critical in identifying impacts of human and natural perturbations of fluvial systems. A-horizons of upland interfluves and subsoils, sources of alluvium in the lower Loco Bayou basin, Texas, were distinguished using the isotope ratios $^{226}Ra/^{232}Th$, $^{226}Ra/^{230}Th$ and $^{230}Th/^{232}Th$. Fractionation of Ra/Th isotope ratios were also observed in upland soil profiles with Radium isotopes relatively enriched in surface soils, likely due to uptake by vascular plants, and Thorium isotopes relatively enriched at depth, likely due to slightly increased solubility in association with organic acids at the surface, followed by downward migration in solution driven by gravity. Event based alluvial sampling was completed at three stations during flood and bankfull stages. Channel alluvium indicates dominance of subsurface sources during flood (32% - 100%, over•H8km channel length) and bankfull stages (8% - 74%, over•H12km channel length), with importance of subsoils as sources of alluvium increasing downstream. Surprisingly, in light of the study basins geomorphic setting, these results indicate strong coupling between hillslope and channel processes. This relationship is most likely a reflection of land use change from forested to agricultural, concentrated in lower Loco Bayou. The geochemical properties, long half-lives, and isotopic fractionation of radionuclides from ^{238}U and ^{232}Th decay series during pedogenic and fluvial processes in humid climates suggest that the methods reported here are applicable to a wide variety of fluvial systems.



Land Development in Coastal Texas: 1950 to 2050—Implications for a Sustainable Coastal Region

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Abstract. This research project aims at understanding the land development dynamics in the coastal region of the Gulf of Mexico, with a focus on the southern Texas. The approach adopted is to study the land development patterns of the region in the last 50 years and then to simulate the development trends in the next 50 years in various scenarios of economic development and/or natural events (e.g. disasters, ecological changes, etc.). By modeling the changes in land cover and land use in the region, the research examines the impacts of the changes on the regional ecosystem and natural resources, and analyzes the influence of regional development policies. Two key elements of the research methodology are Cellular Automata modeling and Scenario Building. Cellular Automata is an agent-based modeling technique that has been increasingly applied to simulate complex and dynamic systems such as a city or a region. Scenario Building is a qualitative model designed to deal with the uncertainty of the future in a structured manner. Combining Cellular Automata modeling and Scenario Building allows the computational modeling of land use changes to be built on a sound theoretical ground. The research would use remotely sensed data such as satellite images and aerial photographs as well as the conventional data such as the U.S. Census. The research effort is towards identifying desirable policies and strategies to achieve sustainable development in the coastal region.

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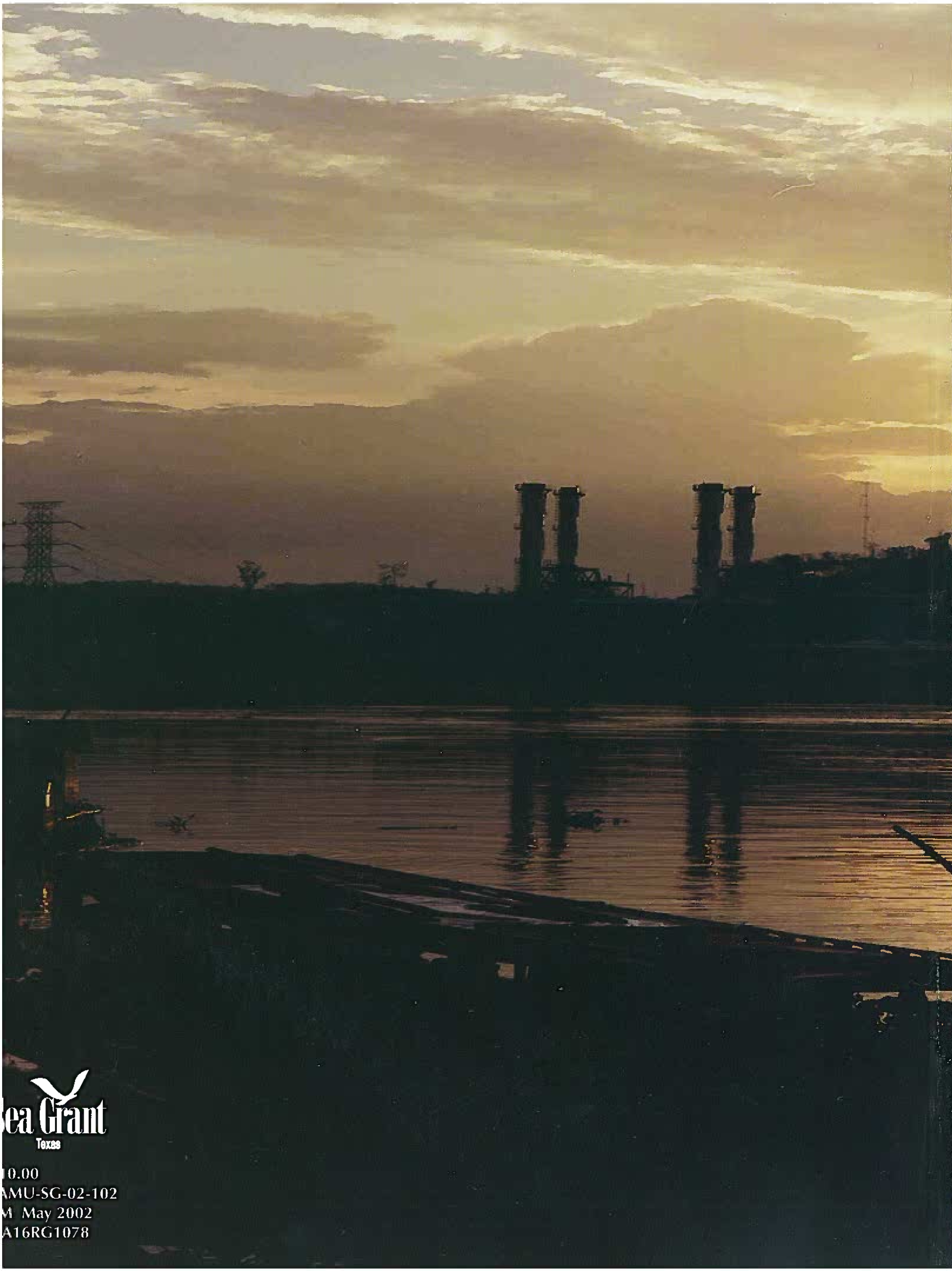

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