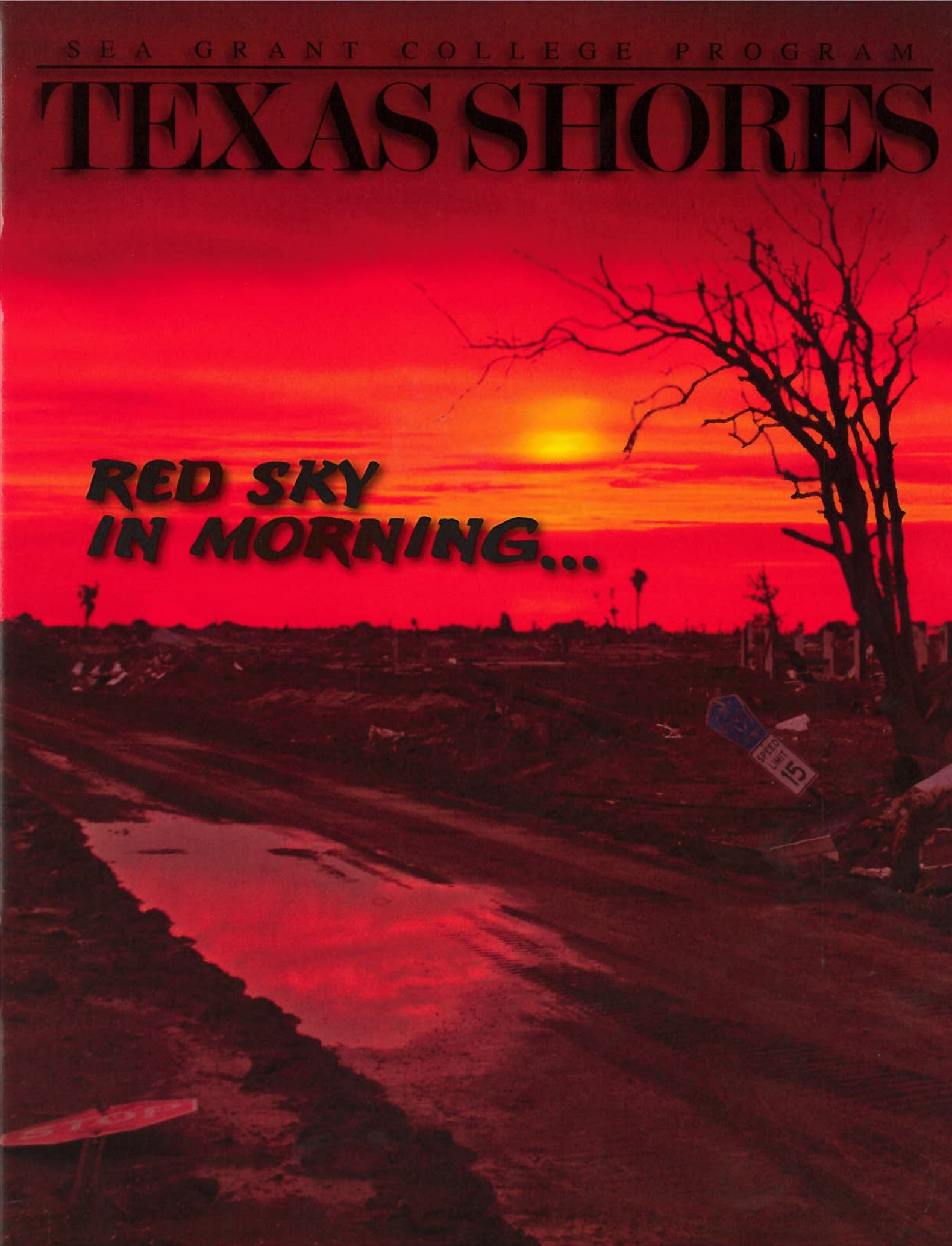
SEA GRANT COLLEGE PROGRAM

TEXAS SHORES



TEXAS SHORES: sea notes

Stickney new interim head of oceanography

Dr. Robert Stickney, director of the Texas Sea Grant College Program, has been serving since Sept. 1, 2006, as interim head of the Department of Oceanography at Texas A&M University.

Dr. Björn Kjerfve, dean of the College of Geosciences, appointed Stickney to the position in August while the search for a permanent department head continues.

"I am delighted that Dr. Stickney was willing to accept my offer to lead the Department of Oceanography as the interim head for the near future," Kjerfve says. "Bob is such a natural-born leader, instills confidence, and with his vast administrative experience, the department is in very good hands."

Dr. Robert Stickney

Stickney has been director of Texas Sea Grant since 1996 and joined the faculty of the Department of Oceanography in the same year.

"As a professor in the Department of Oceanography as well as being director of Texas Sea Grant, I feel an obligation to assist the department in any way possible," Stickney said when the appointment was announced. "So, while the interim job of department head will require a considerable amount of time and effort, I look forward to the challenge.

"A search is under way for a permanent head, which I hope will be successfully concluded in the near future. In the meantime, my excellent staff at Sea Grant can be depended upon to go the extra mile to assist me as a I take on added responsibilities."

Stickney also has been an affiliate professor since 1996 in TAMU's Department of Wildlife and Fisheries Sciences, where he was a faculty member in 1975-83.

He previously served as director of the School of Fisheries at the University of Washington and of the Fisheries Research Laboratory in the Department of Zoology at Southern Illinois University, in addition to being a full professor at both institutions. He holds a Ph.D. in oceanography from Florida State University and bachelor's and master's degrees in zoology from the University of Nebraska and the University of Missouri, respectively.

Stickney is a charter member of the U.S. Chapter and past president of the World Aquaculture Society, a fellow of the American Institute of Fisheries Research Biologists, a Certified Fisheries Scientist of the American Fisheries Society, and a member of the National Geographic Society and Sigma Xi.

— Cindie Powell

Floating Classroom director receives Lyondell Environmental Award, assists British marine mammal research team

MATAGORDA — Willie Younger, Extension Marine Education Specialist with the Marine Advisory Service of the Texas Sea Grant College Program, was selected from a field of educators from across the nation to receive the Lyondell Environmental Award.

As part of the award, which was made possible by a partnership between the Earthwatch Institute and Lyondell Chemical Company, Younger and the other recipients, six classroom teachers from around the country, traveled to England last July to assist a research project on Start Bay near Dartmouth that is studying how grey seals there react to steadily increasing encounters with humans.

"Lyondell provided me this once-in-a-lifetime opportunity to be part of an important study that can contribute to the sustainability of both Earth's natural resources and mankind's well-being," says Younger, who is the director of Texas A&M University's Floating Classroom Program.

The partnership between the Earthwatch Institute and Lyondell Chemical Co. is designed to help expand the understanding and appreciation of the environmental, economic, historical and cultural dimensions of planet Earth. Participant travel and other costs of the award are funded by Lyondell. Participating educators are encouraged to share what they learn, observe and experience during their expedition with those they teach, whether in a classroom or in a field study experience like Younger leads. As the director of the Texas A&M Floating Classroom Program, a cooperative statewide education venture of Texas Cooperative Extension and the Texas Sea Grant College Program, Younger can share the information he learned with thousands of students and hundreds of teachers.

Willie Younger

"Although we do not have seals along the Gulf Coast of the U.S., we do have a number of species of coastal and marine animals with the potential to be unintentionally harmed by the way we conduct our encounters with them, whether the meeting of man and animal is by design or by accident," Younger says.

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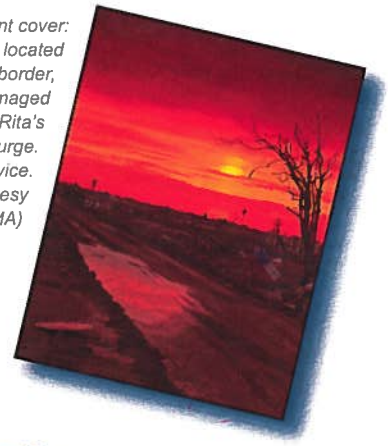

Front cover: Holly Beach, La., located near the Texas border, was heavily damaged by Hurricane Rita's tidal surge. Service. (Photo courtesy FEMA)

Dr. Steven DiMarco, associate professor of oceanography at Texas A&M University

Back cover: Kayaking at sunset - kayak fisherman wading out to deeper water near San Luis Pass, May 2006. (Photo by Bill Harvey, county extension agent)

TEXAS SHORES is published quarterly by the Texas Sea Grant College Program in an effort to promote a better understanding of the Texas marine environment. Sea Grant is a partnership of university, government and industry focusing on marine research, education and outreach. Nationally, Sea Grant began in 1966 with the passage of the Sea Grant Program and College Act. Patterned after the Land Grant Act of the 1860s, the Sea Grant concept is a broad-based scientific effort to better the world for all those living in and out of the sea.

In 1968, Texas A&M University received the distinction of being named among the nation's first six institutional award recipients. Three years later the school was designated a Sea Grant College. The university has a rich heritage of oceanography research dating back to 1949 when the program began. In addition, there is an ongoing program to get marine information to the public.

Sea Grant is a matching funds program. The Texas Sea Grant College Program itself is made possible through an institutional award from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, as well as appropriations from the Texas Legislature and local governments.

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HARD LESSONS

by **Jim Hiney**

Photo courtesy U.S. Coast Guard (USCG)

Barely one month after Hurricane Katrina devastated New Orleans and coastal Mississippi and Alabama, and one day after Hurricane Rita pummeled east Texas, Terrie Looney and her family returned to their Chambers County, Texas, home near Winnie fully expecting to be added to the 2005 hurricane season's home-loss statistics.

Along their three-hour trip from Livingston, where they rode out the storm, they passed myriad fallen trees and mangled buildings — particularly metal structures missing roofs.

"I was expecting to find nothing," says Looney, Texas Sea Grant Extension's marine agent for Chambers and Jefferson counties. "We left fully prepared to come home to nothing. Before we left, I knelt down to pray in the driveway to the Lord and said, 'You gave this to us. If you want it, you'll take it away but I know you'll lead us and keep us safe.'"

The family turned into the driveway of their 8-acre property and found trees down and other evidence of Rita's wrath, but their home was still intact.

"My husband and I burst out laughing because it was a tremendous blessing," she remembers. "We lost other things — the roof on the barn, we had fences down and debris was blown all over the place — but we had our house."

The Looneys were among the lucky ones.

A record 28 storms grew strong enough to be named during a season that began June 1, 2005, and stretched into early January 2006, five weeks beyond the traditional Nov. 30 end of the season.

Of the 28 named storms, 15 became hurricanes (another record) and seven of these grew to be major storms (one shy of the record set in 1950). A major storm is one that reaches Category 3 or higher on the Saffir-Simpson Hurricane Scale.

A record five of the seven major hurricanes grew to become Category 4 storms and a record four reached Category 5 intensity — the highest possible, with sustained winds in excess of 155 miles per hour.

Five of the storms (Hurricanes Dennis, Katrina, Rita, Stan and Wilma) were deemed so devastating to life and property that their names were retired from the list of potential storm names. Retiring five names from a single hurricane season is … you guessed it … a record.

In total, the tropical storms of 2005 caused more than $100 billion in damage to the United States and were blamed for more than 2,280 deaths. The season's most famous storm, Hurricane Katrina, was responsible for the vast majority of the destruction — credited with causing about $80 billion in damage along the Gulf Coast and killing more than 1,300 people.

The Saffir-Simpson Hurricane Scale

The Saffir-Simpson Hurricane Scale — developed in 1969 by civil engineer Herbert Saffir and Bob Simpson, who was head of the U.S. National Hurricane Center at the time — is a 1-5 rating system for classifying Western Hemisphere hurricanes by their highest sustained wind speeds.

The scale is used primarily to predict the amount of damage and flooding a hurricane will cause when it makes landfall. A storm is deemed a tropical depression when its winds are between 0 mph and 38 mph. It is upgraded to a tropical storm and given a name when sustained wind speeds are between 39 mph and 73 mph. Once a tropical cyclone's highest sustained winds pass 74 mph, the storm becomes a hurricane and is rated by the Saffir-Simpson Hurricane Scale using the following categories:

- **Category 1** — Wind speeds between 74-95 mph, storm surge of 4-5 feet expected (storm surge values are dependent on the slope of the continental shelf in the landfall region).
- **Category 2** — Wind speeds between 96-110 mph, storm surge of 6-8 feet expected.
- **Category 3** — Wind speeds between 111-130 mph, storm surge of 9-12 feet expected.
- **Category 4** — Wind speeds between 131-155 mph, storm surge of 13-18 feet expected.
- **Category 5** — Wind speeds over 155 mph, storm surge greater than 18 feet expected.

The much-anticipated and feared 2006 Atlantic Hurricane Season proved milder than first expected thanks to the reoccurrence of El Niño — a periodic phenomenon that disrupts normal ocean-atmosphere interactions and affects weather all over the planet. El Niño usually causes increased wind shear in the tropical regions of the Atlantic where most hurricanes are born. Wind shear interferes with the transfer of heat energy from evaporating ocean waters to the storm, or more simply, cuts the fuel supply to the engine.

The 2006 season had nine named storms and five hurricanes, two of them major. None of the storms hit the nation's Atlantic coast — only the 11th time this has occurred since 1945.

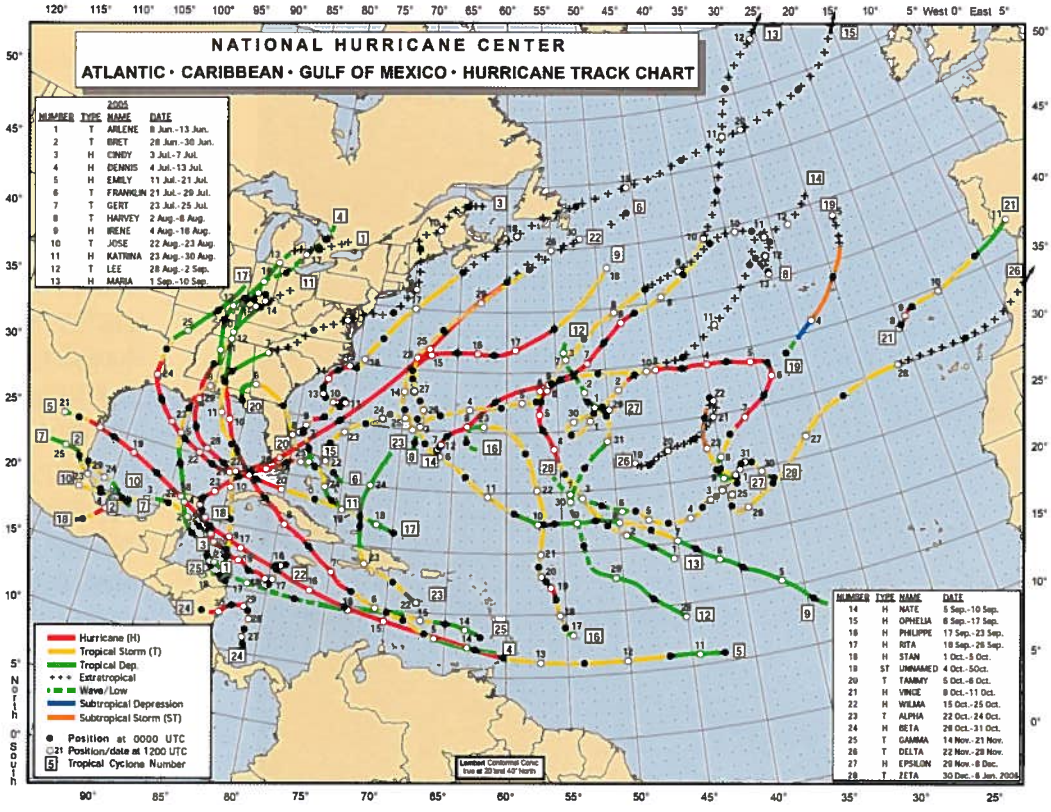
Forecasters with the National Hurricane Center (NHC) originally predicted in May 2006 that there could be 13 to 16 named storms, with eight to 10 of those becoming hurricanes. Of these, four to six were predicted to become major storms.

But as the 2006 Hurricane Season progressed with little tropical storm activity, forecasters revised their estimates, predicting 12 to 15 named storms with seven to nine becoming hurricanes — three to four of these becoming major storms.

Ironically, the forecaster's revised 2006 prediction was almost identical to the 2005 pre-season forecast that fell terribly short of reality.

The long-term annual average is 11 named storms and six hurricanes, with two becoming major storms.

NHC forecasters say warmer waters, more moisture in the air and other conditions in the Atlantic Ocean have led to increased tropical storm activity that could continue for another decade.



This 2005 Atlantic hurricane map shows the season's frantic activity.

Graphic courtesy National Huricane Center

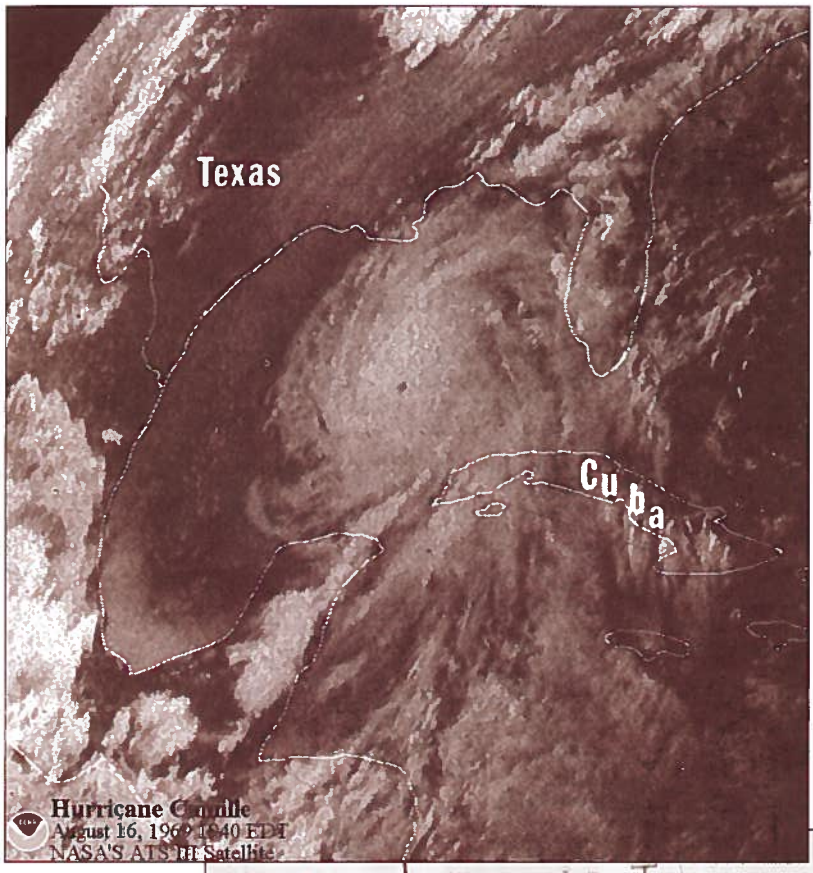
Jill Hasling, president of Weather Research Center, Inc., in Houston, believes major hurricane activity will be just a bit higher than the NHC prediction for the next few years.

"From 2001 to 2011, you have a chance on average of five Category 3 or Category 4 hurricanes over the oil leases in the Gulf of Mexico," she told about 125 participants at the 30th annual International Marine/Offshore Industry Outlook Conference, hosted by the Texas Sea Grant College Program in Houston in April 2006.

Hasling came to her conclusion after studying storm activity dating back to 1851. She grouped the storms by 30-year time spans and noticed an interesting decadal trend. The majority of storm activity alternated between the Gulf of Mexico and the U.S. East Coast on 10-year cycles.

Hurricanes Katrina and Rita combined to destroy 115 offshore oil platforms, damage 50 more and shut down about one-third of the nation's refining capacity.

Photo courtesy USCG



(Top), Hurricane Camille takes aim at Louisiana and Mississippi in August 1969. (Bottom) Hurricane damage in the Corpus Christi area following Hurricane Celia in August 1970.

Photos courtesy National Oceanic and Atmospheric Administration (NOAA)

"Major hurricane activity in the Gulf of Mexico should decrease from 2011 to 2021 because the storms will go up along the East Coast," she said. "There will be a few in the Gulf of Mexico, but not as many — an average of two per year."

Hasling is at a loss to explain the trend, but she quickly dismisses the idea that global warming is responsible for the cycle, last year's record season or hurricane formation in general.

"If the number of tropical storms is related to global warming, how did we have 19 storms that we know of in 1887 and 21 storms in 1933?" Hasling asks. "We did not have satellites in those years, so there were probably more storms at these times.

"We don't have much data on storms until the 1940s, so we don't know if earlier storms were as intense or more intense than the ones we're getting today," she says.

Hurricanes are one type of tropical cyclone. Tropical cyclones are defined as storm systems with closed circulation around a center of low pressure, fueled by the heat released when moist air rises and condenses.

Tropical cyclones occur throughout the world, although atmospheric conditions make them rare in the southern Atlantic Ocean. In the Pacific Ocean region they are referred to as typhoons, and they are generally more powerful than hurricanes — the name given to tropical cyclones in the North Atlantic Ocean. In the Indian Ocean, these storms are called tropical cyclones, or just cyclones. Australians, in their inimitable style, refer to a tropical cyclone as a "willy-willy."

Several of 2005's record storms baffled scientists by defying some accepted norms of hurricane behavior. According to the National Hurricane Center's final reports on these storms, Hurricane Vince formed farther northeast in the Atlantic than any other tropical cyclone on record, and then unexpectedly reached hurricane strength over waters considered too cold to support a hurricane. Hurricane Wilma became one of the fastest-intensifying hurricanes on record, and later strengthened unexpectedly in the face of strong wind shear. Tropical Storm Delta, Hurricane Epsilon and Tropical Storm

Zeta all formed over cold Atlantic waters of the late-season eastern Atlantic, much like Hurricane Vince (though at lower latitudes). All three persisted in the face of heavy wind shear, and Epsilon managed to reach hurricane strength over waters well below the temperatures previously thought necessary for hurricane formation. Epsilon became the longest-lasting December hurricane, while Zeta became the longest-lasting storm in January.

Hurricanes evoked fear long before Katrina and Rita. Fifteen-year-old Alexander Hamilton, destined to be aide-de-camp to Gen. George Washington before becoming the nation's first Secretary of the Treasury, was living in the town of Christiansted, St. Croix, when the great hurricane of August 31, 1772, struck the Caribbean island. He described the terrifying chaos, including what appears to be the eye of the storm passing over the island, to his father in a letter dated Sept. 6, 1772:

Honored Sir,

I take up my pen, just to give you an imperfect account of one of the most dreadful hurricanes that memory or any records whatever can trace, which happened here on the 31st ultimo at night. It began about dusk, at north, and raged very violently till ten o'clock. Then ensued a sudden and unexpected interval which lasted about an hour. Meanwhile the wind was shifting round to the south west point, from whence it returned with redoubled fury and continued till nearly three in the morning. Good God! what horror and destruction — it's impossible for me to describe — or you to form any idea of it. It seemed as if a total dissolution of nature was taking place. The roaring of the sea and wind — fiery meteors flying about in the air — the prodigious glare of almost perpetual lightning — the crash of falling houses — and the ear-piercing shrieks of the distressed were sufficient to strike astonishment into angels. A great part of the buildings throughout the island are leveled to the ground — almost all the rest very much shattered — several persons killed and numbers utterly ruined — whole families wandering about the streets, unknowing where to find a place of shelter — the sick exposed to the keenness of water and air — without a bed to lie upon — or a dry covering to their bodies — and our harbors entirely bare. In a word, misery, in its most hideous shapes, spread over the whole face of the country ....

Dangerously important

With the memory of Hurricane Katrina fresh in their minds, more than three million people living along the Gulf coast fled their homes as Hurricane Rita bore down on Texas and Louisiana, making it the largest evacuation due to a tropical storm system in the nation's history

The evacuation came a little more than a year after Hurricane Ivan, dubbed "Ivan the Terrible," ripped through the Caribbean islands of Grenada, Jamaica and Grand Cayman before making landfall near Gulf Shores, Ala. At its peak, Ivan was a Category 5 storm. It was a strong Category 3 storm when it arrived at the Alabama coast.

Ivan is credited with causing about $15 billion in damage and killing about 125 people during the then-record setting 2004 Hurricane Season.

A total of eight tropical cyclones reached at least tropical storm strength in August 2004, breaking the previous record of seven set in 1933 and 1995. Taken together, the 2004 and 2005 hurricane seasons must be proof that some factor, like global warming, is changing tropical weather patterns, right?

Tidal surge from the 1900 storm nearly leveled Galveston Island.

Photo courtesy of NOAA

"It may seem an unusual cycle to most folks because we have come out of a couple of decades of relatively inactive hurricane seasons in the 1970s and 1980s," Dr. Naomi Surgi, Advanced Hurricane Project leader with the National Weather Service's Environmental Modeling Center, told *Texas Shores* magazine a year before Katrina and Rita's devastating landfalls. "But if you go back to the 1940s, 50s and 60s, those were decades of very active seasons. The 1990s were back to being very active again, and such with the current decade as well, so we may be in the middle of a couple of decades with a lot of activity."

During the 1940s and 1950s, Florida was hit by 15 hurricanes. From 1970 to 1989, only four hurricanes hit the state.

Florida pays for its highly desirable sunshine and moderate climate by lying in the middle of a path favored by hurricanes. Between 1900 and 1996, Florida was struck by more hurricanes — 57 of the 158 storms that made landfall in the United States — than any other state. Of the 158 storms, 64 were Category 3 or higher, and 24 of those hit Florida.

Texas was second on the list, registering hits by 36 storms, 15 of those major.

Since 1900, Atlantic hurricanes have cut a swath of destruction across the Western Hemisphere, causing billions of dollars in damage and more than 71,000 deaths, according to figures published by the National Oceanic and Atmospheric Administration (NOAA).

These monster storms batter coastlines, destroy buildings, cause massive flooding and generally tear up the landscape with their incredible power, which NOAA scientists say can equal the energy of 10,000 nuclear bombs during the life of just one storm.

Despite the size and power of hurricanes (and in an amazing show of hubris), people devise schemes every year for diverting or destroying the storms. Many of the plans have been suggested to NOAA officials repeatedly and include:

- seeding the storms with silver iodide,
- placing a substance on the ocean surface to prevent evaporation,
- cooling the surface waters with icebergs or deep ocean water, and
- using nuclear weapons to blow the storms apart.

Many of the ideas focus on weakening a storm's eye wall, the circular boundary around the hurricane's eye featuring the highest surface winds, causing the storm to become disorganized and eventually break apart.

It is worth looking at a few of the ideas because they tell us a couple of things about humans: We fail to appreciate the size and power of tropical cyclones and our ecoblivion prevents us from considering the effect these plans could have on marine ecosystems.

For a couple of decades, NOAA carried out Project Stormfury, an attempt to weaken hurricanes by dropping silver iodide into the rain bands of storms. Silver iodide has been used for years to try to coax rain out of clouds in drought-parched areas of the world. When used on a hurricane, the theory was that silver iodide would help the thunderstorms in the rain bands to grow at the expense of the eye wall.

In practice the cloud seeding did not work or, if it did work, the results were so insignificant that they could not be seen or measured.

Researchers did some work trying to develop a liquid that could be spread over the ocean surface and prevent evaporation. Again, this is an interesting idea

Galveston residents stand among the ruins of homes in 1900.

Photo courtesy of NOAA

theoretically because it would rob the hurricane of the massive amounts of water it needs to fuel itself.

The idea died when no one could find a substance that would stay together in the rough seas of a tropical cyclone.

Since hurricanes run on heat drawn from warm water, the common sense thing to do is cool the ocean around a storm and take its fuel (although the 2005 storms that developed in cooler water appear to contradict this theory). Ideas along this line proposed towing icebergs from the arctic zone or pumping cold water from the ocean's depths to its surface.

Without going into too much detail, the idea fails on scale alone. By NOAA's calculations, people would have to cool about 24,000 square miles of ocean during any given 24-hour period to cover every potential track a storm might take, and that does not take into account the lead time needed to find the icebergs and tow them into place.

The pumping plan is an even larger undertaking. To make it work, humans would have to pre-position sufficient numbers of pumps in a grid comprising all possible storm tracks. For the mainland United States alone (from Cape Hatteras, N.C., to Brownsville) the grid would have to cover 528,000 square miles.

Now consider what the plan would mean to the marine ecosystem. Suddenly cooling the surface of the ocean would most likely kill much of the sea life in the affected area.

By far the most outlandish proposal, and one of the most frequently submitted to NOAA by some of the more eccentric members of the general public, calls for using a nuclear warhead to simply blow a hurricane apart. Forget for a moment that the plan calls for using a weapon of mass destruction. The main difficulty with using any explosive to modify hurricanes is the amount of energy required. Hurricanes already release enough energy per hour to supply the world's electrical needs for the same period of time.

A view of New Orleans from a U.S. Coast Guard helicopter after Hurricane Katrina.

Photo courtesy USCG

One nuclear warhead might not even cause a hurricane to flinch, let alone disappear. On top of that, the fallout would spread quickly along with the trade winds and contaminate large areas of land and ocean, causing untold environmental damage.

Hurricanes are bad enough without being radioactive, too.

Having the ability to control hurricanes would lead to the inevitable ethical question: Should we control hurricanes?

"We need hurricanes, that's what takes the heat from the tropics to the north," says Hasling. "We need them to make our north livable and they break droughts."

For instance, Hurricane Camille averted drought conditions and ended water deficits along much of its path in August 1969.

Tropical regions would be unbearably hot if hurricanes (and other natural mechanisms) did not redistribute heat to cooler climates. The storms' surges and winds also stir up the waters in coastal estuaries, which are important nursery grounds for many species of sea life.

There is no doubt that Atlantic storms are becoming more financially destructive.

Fourteen of the 15 most damaging storms to hit the United States have occurred since 1990. The cause of the devastation was manmade, but not necessarily due to global warming.

America's coasts have experienced increasing population growth — and the inevitable development that follows — since the last decade of increased hurricane activity in the 1960s.

"I feel Hurricane Katrina was a watershed event for us — pun fully intended," says Dr. John Jacob, Coastal Communities Development Specialist with the Texas Sea Grant Extension Program. "There is a question of failure up and down the line. Short-term planning — emergency planning — went to hell. What about long-term planning? What about building in vulnerable areas? Were the right decisions made? Obviously they weren't.

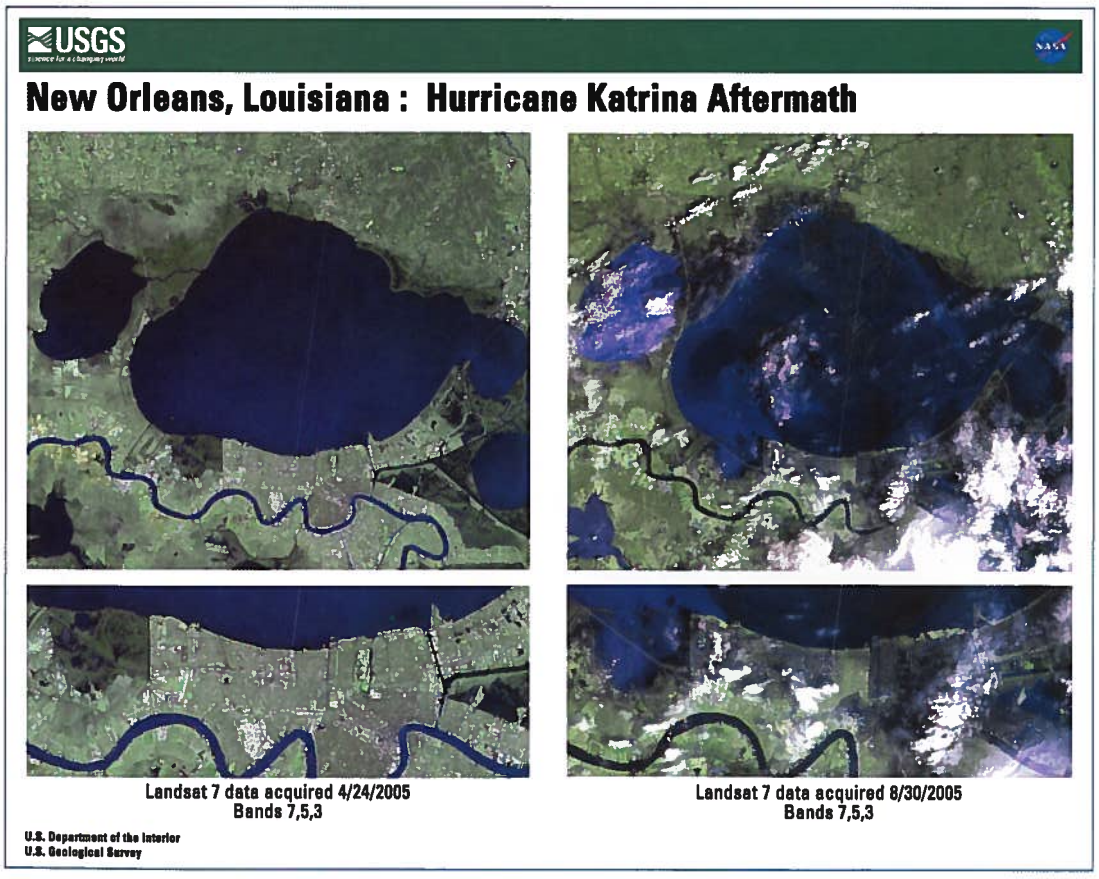
"What about over here in Houston? Have we made the right decisions? We are putting thousands of new homes in low-lying Galveston County. What is that going to do for emergency planning? That should be on our minds," he exhorts. "To me this says that it's time for us to stop pussyfooting around and start talking more seriously about land use planning. We have always been afraid to talk about it. We've always said that is not part of our culture and we shouldn't be involved in it because it's just not Texas. Well, that is garbage. We're going to have to stand up now and say this is a public responsibility."

Regulators have already dabbled in land use planning by limiting some development in flood plains. The logical extension is to question whether people should be allowed to build in other vulnerable low-lying areas or to destroy other valuable ecological areas that are critical to our future.

"Land use planning is not anti-free market," Jacob contends. "It's the community asking, 'What are the bounds of that market?'"

For instance, New Orleans' French Quarter did not suffer as much damage as the rest of the city because it was built about three feet above sea level, as opposed to the rest of the city, which was built below sea level. Most of the structures in the French Quarter were built before the levee system was put in place — during a time when periodic flooding was part of the Mississippi River's life cycle. Many of the buildings are masonry structures, and the district itself is built in a pedestrian friendly manner that encourages resiliency, says Jacob.

Masonry houses are expensive, but if they are built in areas that encourage walking over driving,



Satellite photos show the extent of flooding around the New Orleans area caused by Hurricane Katrina.

Photo courtesy U.S. Geological Survey

people can re-direct their transportation costs into building sturdier homes, says Jacob, exhibiting his predilection for "smart growth" development.

Smart growth champions town-centered development reminiscent of the way communities were built before automobiles became the transportation mode of choice. It favors dense population centers, like the 15,000 people per square mile French Quarter, designed to provide for most of the residents' needs, versus the typical suburban subdivision, which has 3,000 to 4,000 people per square mile.

"The real message from Katrina is it's time to speak out more forcefully," Jacob contends. "Those of us in this field, the holders of the knowledge, can't be passive. We are the responsible ones. If we don't take action, what is the next generation going to say to us? We can't twist people's arms, they are going to do what they're going to do, but we had better try to get the word out."

USCG crew searches for survivors following Hurricane Katrina.

Photo courtesy USCG

Run from the water - hide from the wind

Dr. Sammy Ray traveled from Galveston to Huntsville one Saturday morning this past summer to pick up his grandchildren for a visit. The trip brought back a lot of memories.

"I relived the evacuation," says Ray, professor emeritus of marine biology at Texas A&M-Galveston and one of the millions who fled the Houston-Galveston area in advance of Hurricane Rita. "I followed the same route that I'd used in September (2005). This Saturday morning it took me a little under two hours to travel as far as it took me two days to do during the Rita evacuation."

Ray and his wife, Charlotte, eventually made it to their daughter's home in Grand Prairie well after Rita made landfall. The normally five-hour trip took 77 hours and took a health toll on the Rays, who are both in their 80s.

"I came down with gout and kidney stones," says Ray in a painful tone. "I never had it happen at the same time before. My problem was I didn't drink water because I didn't have a place to get rid of it without stopping in the middle of the road. My wife is so modest, she didn't want people to know we were pouring pee out of a can onto the road."

Emergency managers involved in hurricane planning have a simple mantra: Run from the water, hide from the wind. Simply put, evacuate if you live in an area predicted to flood from storm surge, but stay put and batten down the hatches if you are threatened only by wind and rain. This message got lost in the panic as Hurricane Rita bore down on the Texas coast.

Call it the "Katrina Effect."

Upwards of one million people whose homes were not in flood-prone areas fled because of the destruction they saw Katrina inflict on Louisiana, Mississippi and Alabama. Ray also blames Houston Mayor Bill White, whose calls for voluntary evacuation "spooked people who lived on the west side of Houston and the Sugar Land area who had no reason to worry about the storm surge."

"They all got on the damn highway at the same time," he fumes.

At the time, it looked like the Houston-Galveston area would take either a direct hit or a powerful glancing blow from the one-time Category 5 storm and the fourth most intense Atlantic hurricane in history. White was not the only government leader urging evacuation. Harris County Judge Robert Eckels and Texas Gov. Rick Perry also advised people living in the storm's projected path to get out of its way.

Before Rita, Ray had long ago sworn off evacuating from tropical cyclones. Hurricane Allen's early projected path threatened Galveston in August 1980. Allen was the second most intense Atlantic Hurricane on record when it rumbled through the Gulf of Mexico.

Hurricane Rita devastated Holly Beach, La.
Photo by Tom MacKenzie, courtesy U.S. Fish & Wildlife Service.

Ray decided to leave the island, but not without a large number of the oysters he and a colleague were using in their research. "We had made arrangements to store (the oysters) in College Station, so we loaded up my truck and my wife's car and left at midnight," Ray recalls. "The storm turned and hit near the Rio Grande, so I decided in my mind that I was not running anymore."

Hurricane Rita changed his mind.

"When I saw the predicted track for Rita, I saw we would be in the dirty quarter of the storm," says Ray, referring to the right side of a tropical cyclone — where the forward motion of the storm combines with its counter clockwise-spin to produce the highest winds. "I knew that if the storm stayed on track to hit Port Lavaca and Point Comfort, it was just going to tear the hell out of Galveston. I told my wife, 'If that storm hits where they say it will, I don't expect to find a damn thing here when we return and I'm resigned to that. Let's get our butts off this island.'"

Ray spent Tuesday night, Sept. 20, 2005, preparing his lab for the storm, which was predicted to make landfall near Matagorda Bay the following Saturday. He wanted to evacuate his wife by 8 a.m. the following day, but Charlotte had just gotten out of the hospital and it took the pair five hours longer to get their things together and go.

They left at about 1 p.m. and by the time they got to the causeway leading from the island to Interstate Highway 45 on the mainland at Texas City, Ray knew they were in trouble.

"I sort of get the picture that things aren't going to be too good when we cross the causeway and there were military trucks stopped in the right hand lane of the causeway going north," he remembers. "We got word that the tollways were free, so when I got up to about Beltway 8, where you could take off to take the tollway, I said, 'You know, if the tollway is free, there will be lots of people taking it, so I'm not going that way.'"

Ten hours later and still on I-45, the Rays had made it as far as the Greenspoint exit in far north Houston. Ray pulled off the highway and up to a convenience store. He was low on fuel and had yet to use the restroom.

"Up to now, I had two times in my life I did not want to relieve myself — both were in combat. Now I've got a third time. People think there are certain things that are not to be talked about, but relieving yourself in combat is a difficult thing to do," says Ray. "You've got to go, but I always had this vision of my head being caught in someone's crosshairs while I'm squatting in a field, so I kept my rest stops to a minimum."

The store's owner told Ray he had little fuel left, but Ray was welcome to it after the owner filled up his own vehicle when the store closed at 2 a.m. At 5 a.m., the store finally closed. The Rays filled up their car and got back onto the evacuee-choked highway.

By late Thursday evening, the Rays had traveled a little more than 15 miles before pulling off the road just north of The Woodlands to get a little sleep.

"I didn't realize how slowly we were moving," says a still surprised Ray. "I told my wife that I believed the odometer was broken because it wasn't turning very fast. One of problems was people were traveling in caravans and once someone would let one car in, there were many behind it that would force their way in. Also, people were using the shoulders as lanes but would get blocked from time to time by stalled vehicles. I've never seen such discourtesy in my entire life."

Earlier in the day, state officials had instituted a contra-flow plan that opened both northbound and southbound lanes on I-45, Interstate Highway 10 and U.S. Highway 290 to northbound only traffic. Contra-flow began miles behind and too late to help the Rays.

The couple managed to catch two or three hours sleep as Thursday night melded into Friday morning. Ray awakened to growing pain from gout and kidney stones.

"I told my wife that if we didn't get off the road by Friday night, I didn't think I was going to make it," he says.

The Ray's son offered his parents the first glimmer of hope during their long ordeal. He had a friend who owned a ranch near the city of Buffalo, located just off I-45 about 50 miles north of Huntsville. If the Rays could make it to Huntsville, the friend would meet them and take them to his home.

Sammy and Charlotte reached Huntsville at about 2 p.m. and hooked up with their son's friend, who brought a fresh supply of gasoline, around 4 p.m. About two hours later, the Rays arrived in Buffalo. They had traveled about 180 miles in 53 hours.

"At that point I was in terrible pain from the gout and the kidney stones," says Ray.

He characterizes his Friday night sleep as "restful." Ray was able to take sodium bicarbonate, more commonly known as baking soda, the next morning and its alkaline nature began to dissolve the uric acid responsible for his gout and kidney stones.

Hurricane Rita approaching the Texas-Louisiana border.

Photo courtesy National Aeronautics and Space Administration

"My daughter-in-law and her mother came down to pick us up on Saturday because my wife was also in bad shape and neither of us could drive safely," says Ray. "We finally got to Grand Prairie at about 6 p.m."

Adding insult to injury, Hurricane Rita shifted well east of her originally predicted landfall, coming ashore at the Texas-Louisiana border and sparing Galveston much damage.

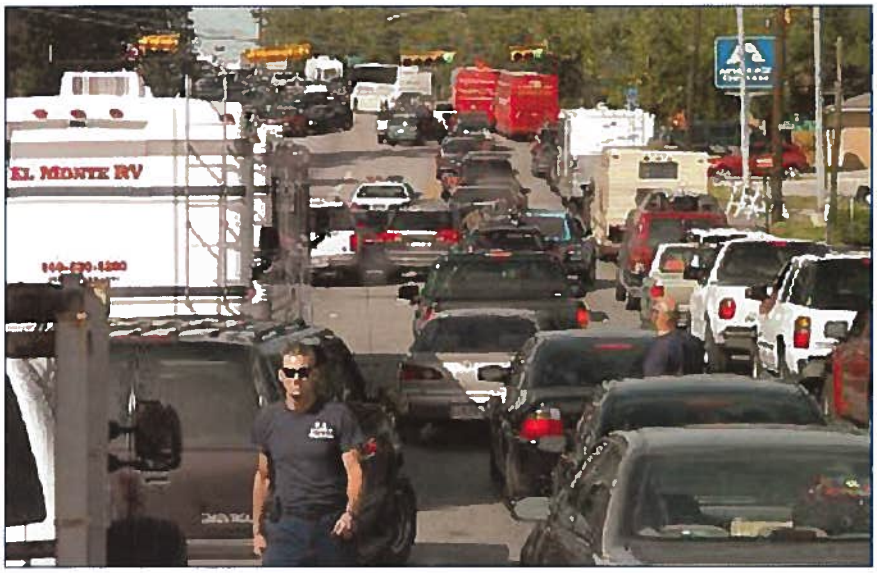
"I was worried about a tree in my yard that I thought would fall on my house," he says in a peevish tone. "I called a neighbor of mine and found he was back in his house. He said everything was fine. Our power was off for such a short time that some ice cubes I had in a tray never melted.

"If I had known what the storm was doing, we would have stayed at the convenience store in Houston because the guy would have let us and we would have had a bathroom," Ray continues, before reconsidering the situation. "Well, I guess I could not have turned around because contra-flow had started."

Ray says the evacuation taught him a valuable lesson. When the next storm threatens Galveston, "I'm going to be ready to go. I'm going on 88 years old, I can't take another evacuation like that, although my wife and I are probably tougher than most people our age. I'm going to get the hell out of here two or three days earlier than they tell me I have to be out. I don't give a damn about the lab or anything. I'm not going through that experience again."

Texas' leaders do not want people going through a similar evacuation, either. They were a bit red-faced that, after performing so well in caring for Hurricane Katrina's evacuees, they did not have an adequate plan to help Texans brace for Hurricane Rita.

In the weeks following Katrina, state and local leaders lauded Houston's leaders for quickly and efficiently finding food and shelter for thousands of the storm's evacuees. As Rita bore down on the Texas coast, the state's emergency managers discovered there was effectively no plan for contra-flow lanes out of the Houston-



Hurricane Rita evacuees clog Huntsville.

Photo courtesy USCG

"Our goal is to learn from the lessons that Hurricane Rita taught us and make Texans safer in future mass evacuations."

Gov. Rick Perry

Galveston area and inadequate plans for providing fuel to fleeing motorists. When contra-flow finally began a day after leaders called for mandatory and voluntary evacuations, it came too late to ease the gridlock.

Shortly after Rita struck and in the face of mounting criticism over the evacuation, Gov. Rick Perry appointed a task force to examine hurricane evacuation, transportation and logistics issues. The task force held public hearings around the evacuation zone and took comments from the public, local officials, emergency responders and people who, like the Rays, experienced the horrors of the evacuation first hand.

The task force issued its findings and recommendations in a report released Feb. 14, 2006. A month later, Perry signed an executive order implementing all of the task force's recommendations except those requiring legislation — like one that would give the governor the authority to order evacuations in catastrophic events that impact more than one jurisdiction.

"Our goal is to learn from the lessons that Hurricane Rita taught us and make Texans safer in future mass evacuations," Perry said in March, when the executive order was issued. "These directives focus on saving lives and reducing the vulnerability of Texans — particularly those least able to fend for themselves."

Both the task force report and the executive order focused on five key areas: command, control and communications; evacuation of people with special needs; traffic flow; fuel availability; and public awareness.

"To improve command, control and communications, I have directed mayors and county judges in each the state's 24 councils of government to establish a regional command structure and appoint an incident commander to lead each region's efforts to prepare for disasters and execute a response like a mass evacuation," Perry said.

The Texas Department of Public Safety will be responsible for command, control and communications for evacuations that involve multiple regions.

After discussions with the state, the 13 counties comprising the Houston-Galveston Council of Governments chose to form the Multi-Agency Coordinating Center (MACC). The MACC functions as a support system for the counties, locating and coordinating resources throughout the region during an emergency.

Under the executive order, the governor's Division of Emergency Management (DEM) was charged with developing a statewide evacuation and shelter plan and overseeing the development of local and regional plans. The DEM will also lead a yearly statewide evacuation exercise.

The first live exercise was held in May 2006 and was hailed as a success by Perry's office.

"In the exercise, we practiced a lengthened preparation timeline," said Rachael Novier, Perry's spokeswoman at the time. "In the past, the state used what we call an H-72 planning sequence (a planning sequence of 72 hours before tropical storm force winds hit), and in the exercise we practiced a 120-hour planning sequence. The lengthened planning sequence allows the state to put all the pieces in place to support local communities and execute a

more efficient and safe evacuation. The sequence provides advanced planning for things like ensuring fuel supplies in the evacuating area and the evacuation routes and working with our private sector partners to begin distributing commodities. The exercise further strengthened our private sector partnerships. Working together side-by-side during the exercise was invaluable and will help us work as one team during a crisis.

"The images on the news from Hurricane Katrina were fresh in people's minds. That deadly storm made us really think through every decision carefully and imprinted in everyone's mind that these storms are devastating and that lives will be lost if state and local officials do not take swift action to help protect citizens.

"Since the report and executive order were issued, we have made a lot of improvements and issued a new and improved state hurricane evacuation and sheltering plan," said Novier.

The basics of the state's new hurricane response plan, broken down by the five focus areas, are:

Command, control and communications

"The big issue for any disaster is communication," says Harris County Judge Robert Eckels. "We learned in Katrina that we did not know what was coming our way. We had to constantly adapt and change to what was facing the Houston region from New Orleans. When Rita came, we did a much better job of letting people know at the end of the line what we were sending out, whether we were sending buses or airplanes with evacuees to Arkansas, Dallas or wherever. We did not do as good of a job along the route, so all of a sudden there were between 2,000 and 5,000 people stuck in Polk County and the county judge there did not know they were coming and had to adapt very quickly. So the big issue will be communications along the routes, both between officials and then between officials and the public trying to get a message out of what people need to do and whether they need to evacuate or not and what conditions they may face along the route."

Perry's executive order also called for creation of eight regional response teams — each comprising 42 highly trained emergency responders representing police, firefighters and emergency medical services — to support multi-jurisdictional evacuations and to be among the first people who move into hurricane-ravaged areas to set up emergency management operations.

Evacuating people with special needs

"We have a very broad approach to defining Texans with special needs," said Novier. "Anyone who needs assistance during evacuation could qualify as having special needs. That could be someone who simply does not have transportation, someone with a medical or physical disability that leaves them to need assistance or those who are elderly and will require extra help during an evacuation."

The state has created a transportation

USCG Petty Officer Chuck Hunt signals that his team can load two more Hurricane Katrina victims. The team was working in the Algiers Point neighborhood of New Orleans.

Photo courtesy USCG

assistance registry as a way for emergency management officials to take basic information about Texans with special needs and arrange rides for them. Texans can reach the registry through the state's 211 telephone hotline, which was created as part of a national initiative to provide information on local health and human services programs.

"Any coastal Texan who has a special transportation need during an evacuation can call 211 and register," Novier explained. "We've trained operators to take basic information that is kept in a secure registry. The information includes a person's name, location, if a pet will also be evacuated and any special medical information that will help us match the person with the proper form of transportation. We've had thousands of people sign up already and it is a great resource both for individual Texans or someone calling in on behalf of a group."

The state has contracted for 1,100 buses to help evacuate special needs Texans if needed. Officials have also secured evacuation aircraft and worked with the federal government to ensure that trains are available to transport Texans away from the coast. Each train will be able to carry about 1,600 special needs Texans, said Novier, adding, "We're lining up a host of transportation modes and gathering a clear sense of special needs evacuees and how to best deploy these evacuation modes."

Getting special needs Texans out of harm's way is only half the battle. They must go somewhere for shelter. Perry's staff developed a new strategy called the "host city concept."

Under the plan, coastal cities are working with inland cities to provide special needs shelters. For example, the city of Galveston has worked with the city of Austin, identifying shelters for Galveston's evacuees. San Antonio is working with Corpus Christi's leaders to become their host city, and Houston is negotiating with several north Texas communities to provide shelters.

"It's very important that a special needs evacuee gets on a bus or other state-provided transportation knowing where they are headed," Novier stressed. "They will wear a bracelet that will allow their loved ones to know when they arrive at a shelter, so we won't have those situations like we saw with Hurricane Katrina, when people had difficulty reaching their family members and reconnecting after a mass evacuation."

I-45 North in Houston became a veritable parking lot as people fled Hurricane Rita.

Photo courtesy Federal Emergency Management Agency

Traffic flow

Of all of the images from Hurricane Rita, some of the most lasting are the miles-long parking lots that were the major highways out of the Houston-Galveston area. About 60 people died along the packed highways and thousands more were stranded after running out of fuel. Of the dead, 23 were nursing home residents who perished when their evacuation bus caught fire on I-45 just south of Dallas.

Novier was in the State Operations Center — Texas' emergency command and control headquarters in Austin — as Rita approached the state's coast and made

landfall. She readily admits that many people who ultimately were not affected by the storm fled their homes needlessly, although they did not know it at the time.

Eckels adds that predicting a hurricane's landfall "is an inexact science. The challenge we face is when to make the call for the evacuation. In New Orleans, with Katrina, they waited too late to make the call. It was pretty apparent to us where that storm was going and they waited too long to make the call.

Galveston Strand area after the 1900 storm. Photo courtesy of NOAA

"With Rita, we had a high probability of a strike somewhere in the area of Freeport southward, which would have put a worst case scenario track into the Houston area and Galveston Bay," he continues. "I think we made the right call at the time. The storm moved 70 miles, which is not a long distance, but it made a huge difference on the impact that the storm had on the Houston area."

Because of the storm's wobbling nature, "It caused an evacuation of an area from Corpus Christi all the way to Beaumont. Some of those evacuation routes conflicted with each other, and that led to severe congestions into all of the areas," notes Eckels. "I think the governor has done a better job of planning for his emergency management operations and the Texas Department of transportation for evacuating a broader swath of the Texas coast so that you avoid some of the conflicts of people trying to leave from Matagorda County and Houston and running into each other at State Highway 71 and I-10."

The governor's office took much heat for delaying opening of contra-flow lanes a day after the evacuation was ordered. Truth is that the state did not have a contra-flow plan in place as Rita neared and TxDOT was forced to improvise, making it the first time in history the state had implemented a contra-flow plan.

In less than a year, emergency managers put together detailed evacuation plans, including contra-flow contingencies, for most of the major highways leading out of the Houston-Galveston, Corpus Christi and Rio Grande Valley regions.

The Texas Department of Public Safety has been given the authority to employ contra-flow in any given area, based on an approaching storm's strength and projected landfall, but it will not be used for every hurricane. Contra-flow will most likely be implemented when Category 4 or Category 5 storms threaten the coast.

DPS will implement contra-flow before mandatory evacuations are ordered.

The new contra-flow plans are very detailed — down to the number of DPS troopers, TxDOT workers or other emergency responders who will be placed at access points along the contra-flowed highways.

Each highway has designated beginning and ending points for contra-flow traffic. The major highways involved include:

- I-45 (Houston) — Begins just north of Hwy. 242, between The Woodlands and Conroe, and ends at Hwy. 287 near Ennis.
- I-10 (Houston) — Begins east of FM 359 in Brookshire and ends at Loop 1604 in San Antonio.
- US-59 (Houston) — Begins south of Kingwood Drive in Kingwood and ends in Nacogdoches.
- US-290 (Houston) — Begins at FM 1960 and ends at FM 1948 just west of Burton. Evacuees can turn north onto Texas 6 at Hempstead and continue to the Bryan-College Station and Waco areas, or they can continue west on US 290 and take refuge in Brenham or Austin.
- I-37 (Corpus Christi) — Begins just north of the Nueces River, at Hwy. 77, and ends at FM 3006 near Pleasanton.
- US 281 (Rio Grande Valley) — Begins at FM 755 near Encino and continues north, ending at US 285 in Falfurrias.

Katrina

Category 5 hurricane (SSHS)

Fatalities: ≥1,836 total

Damages: $84 billion

Formed on August 23, 2005

Dissipated on August 31, 2005

Highest winds: 175 mph

Lowest pressure: 902 mbar (hPa; 26.65 inHg)

Areas affected: Bahamas, South Florida, Cuba, Louisiana (especially Greater New Orleans), Mississippi, Alabama, Florida Panhandle, most of eastern North America

Homes destroyed in Gulfport, Miss. Photo courtesy NOAA

Flooding isolated New Orleans.

Photo courtesy USCG

As the levees failed, most of New Orleans was under water.

Photo courtesy U.S. Navy

Rita

Category 5 hurricane (SSHS)

Fatalities: 7 direct, 113 indirect

Damages: $11.68 billion

Formed on September 17, 2005

Dissipated on September 26, 2005

Highest winds: 180 mph

Lowest pressure: 895 mbar (hPa; 26.44 inHg)

Areas affected: Bahamas, Florida, Cuba, Yucatán Peninsula, Louisiana, Texas, Mississippi, Arkansas

Blue tarps cover many of the homes in Lake Charles.

Photo courtesy FEMA

Downed power lines and fallen utility poles on Lake Street in Lake Charles.

Photo by Rick Goad, courtesy Hurricane Digital Memory Bank

Forests were toppled in Silsbee.

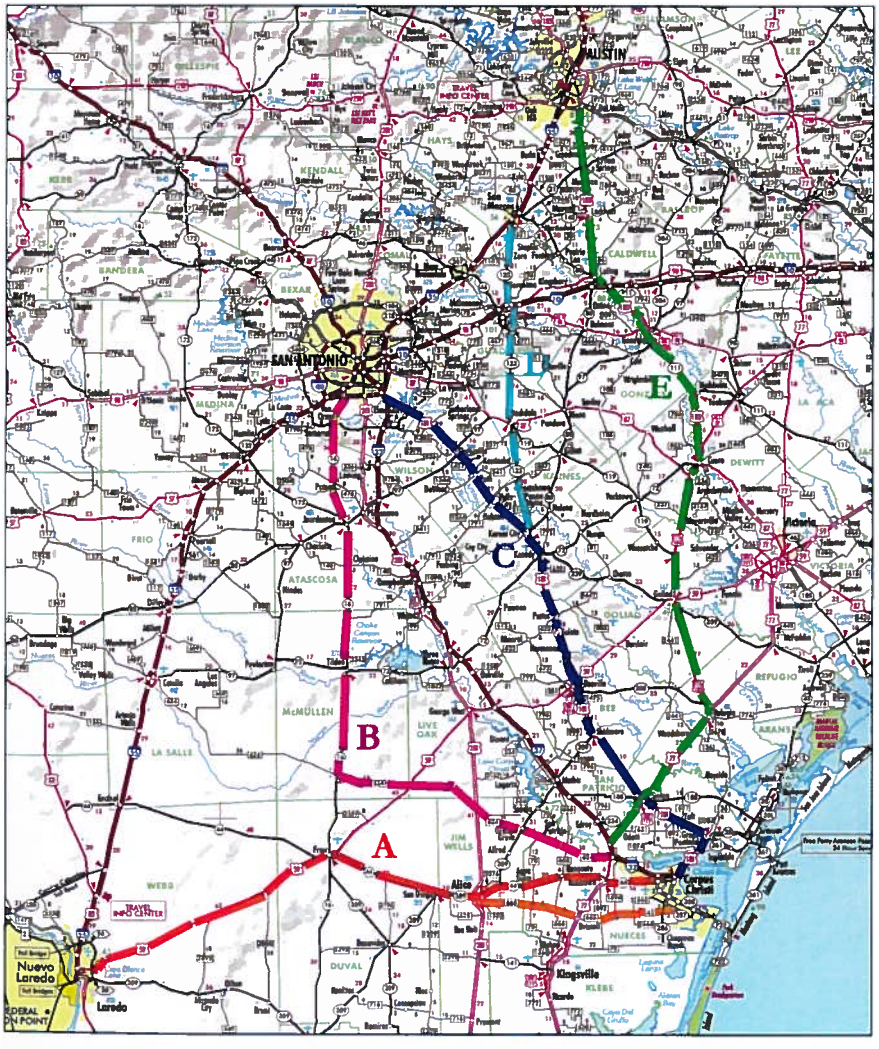
Photo courtesy U.S. Air Force

The evacuation plans also call for creation of comfort stops along the evacuation routes. The stops, set up at existing state rest stops and in other areas as deemed necessary, will provide basic assistance and water to evacuees whose vehicles become disabled or who are simply in need of rest and water.

"This is recognizing that you can't clear up traffic in Houston on any given Tuesday afternoon, so during an evacuation you can still expect heavy congestion, but we want to move the traffic as quickly as possible and also provide comfort stations along the evacuation routes at existing rest stops or at stops set up as needed," said Novier. "These comfort stations will provide basic assistance and water to evacuees should their vehicles become disabled or they need to stop and rest."

Hurricane evacuation routes out of Corpus Christi.

Graphic courtesy City of Corpus Christi



Fuel availability

The Texas Department of Transportation (TxDOT) is working with the Texas Oil and Gas Association and the Texas Petroleum Marketers and Convenience Store Association to ensure that fuel will be available to the greatest extent possible in the event of another emergency evacuation along the Texas Gulf Coast.

Officials have done some sophisticated modeling to determine how to best rush additional fuel supplies into evacuation areas as the storm approaches so "the people who are evacuating can fill up their tanks before they go," said Novier.

The models will also help emergency managers shift fuel supplies to the evacuation routes, thus ensuring that gas stations along these routes will be open and ready to serve evacuees.

During the hurricane season, TxDOT will display messages along coastal highways on dynamic message signs advising coastal residents to keep their gas tanks full. These types of messages have traditionally proven to be a valuable tool to inform the public about traffic safety and hurricane preparedness issues.

"We hope to provide an effective reminder to coastal residents about the need to be cautious during hurricane season and to watch their fuel gauges," says Zane Webb, TxDOT's director of maintenance. "This will be a critical part of our state's overall plan to improve the availability of fuel during an emergency. Any emergency evacuation can only be successful if drivers start out with a full tank of fuel."

Emergency managers recommend that coastal residents fill their automobile fuel tanks when they get to half empty during hurricane season and keep their tanks close to full when a storm enters the Gulf. Should fuel supplies become low along evacuation routes, TxDOT will post signs indicating the next available fuel locations.

"The Texas fuel and petroleum market-

ing industry is committed to making sure that fuel is available during any emergency evacuation to the greatest extent possible," says Wade Upton, State Fuel Coordinator. "However, the most important first step a citizen can take is to purchase fuel for their evacuation vehicle early and keep their tank topped off should a storm threaten their area. The greatest fuel storage capacity on the Gulf Coast is the sum of the individual vehicle fuel tanks of our residents. Our hope is that our coastal residents will pay particularly close attention to these messages being displayed by TxDOT on area highways."

The state is also turning to the private sector for expertise in strategically staging supplies so they are quickly available both before and after a hurricane makes landfall.

"We have partnered with retailers like Wal-Mart, HEB, Brookshire Brothers, Home Depot and Valero to provide commodities to shelters and communities in need," said Novier. "These companies are fully integrated into the State Operations Center."

The State Operations Center is Texas' emergency response command post. It is housed in a reinforced concrete bunker embedded in bedrock three stories below ground level at the Texas Department of Public Safety Headquarters in north central Austin.

The facility was originally built in 1964, at the height of the Cold War, when federal regulations required state command and control facilities to be hardened against blast and fallout from a nuclear attack. The facility was expanded from 12,000 square feet to 22,000 square feet in 1991.

"We've learned that the private sector has an ability to deliver essential aid even under extremely adverse conditions," she continued. "The private sector can provide basic food, water, ice, fuel and medicines quickly. Too often, the government or the public sector tries to re-invent the wheel, and these are companies that have tried and true distribution systems and a real dedication to public service."

Public awareness

To increase public awareness, Gov. Perry directed the Public Utility Commission of Texas to work with utility companies serving evacuation-prone areas to include hurricane preparedness and evacuation-related public awareness information in monthly billing statements prior to and during the hurricane season each year.

Even with the improved hurricane response plan, "people must understand we are still not going to be able to move one million or two million people out of the eastern region of the state in the normal four-hour drive time to Dallas," Eckels says matter-of-factly. "It might take them 10 hours to 20 hours to get there, but if they are prepared for it, they can survive it much more effectively than if they are not prepared for the trip."

"We know that evacuations are not like driving home from work," added Novier. "They are going to throw curveballs based upon the storm and unique challenges will present themselves, but we've taken these steps to make the process as orderly, smooth and safe as possible."

Surviving the storm

Terrie Looney and her family did not need to discuss the pros and cons of evacuating their residence as Hurricane Rita approached. When you live in a mobile home, the decision is easy: get out.

Evacuation is only half the battle when it comes to surviving a hurricane. The other half is returning home and enduring the aftermath, which can include weeks without power, fresh water from the tap or other common utilities.

Gas is a precious commodity during hurricane season.

Sea Grant file photo

The Looneys — Terrie, husband Larry and daughters Katherine, 15, Casey, 10 and Vicky, who was almost 2 — were better prepared than most families to deal with Hurricane Rita. As marine agent in Chambers and Jefferson counties, Looney practiced what she taught others and had a family hurricane preparedness plan in place. The plan, plus some intuition, gave her a five-day jump on Rita's landfall.

A New Orleans marina after Hurricane Katrina.
Photo courtesy NOAA

On Monday, Sept. 19, 2005, Rita was a tropical storm churning in the waters between the Bahamas and Cuba. The National Hurricane Center's five-day track predicted the storm would make landfall in the Freeport area, west of Galveston Bay, but the cone of possible landfall sites stretched from the Mississippi-Louisiana border to Mexico.

"The Beaumont area was on high alert because the hurricane's cone was so large," remembers Looney. "Monday morning, when I saw the radar images, something told me the storm was going to head for Beaumont. Even the Saturday before the storm, the county's emergency management personnel were telling people to pay attention and get supplies together. We still had a lot of Katrina evacuees in our area, so they strained our resources. Then we started getting evacuees from the lower coast coming to the Beaumont area."

Voluntary evacuation began Tuesday, Sept. 20, and emergency management staff called for evacuating special needs residents on Wednesday. Mandatory evacuation began Thursday, Sept. 22.

"We started seeing a tremendous amount of traffic beginning on Tuesday (from the Houston area). People thought they were safe, but the storm's track continued to move eastward as the people moved up the coast," says Looney. "We already had our fuel and other supplies together. We topped our cars off Wednesday night. Larry got the next to the last tank of gas at the station in Winnie."

The Looneys stocked up on food, water, medical supplies, feed for their animals and other essential supplies, like plenty of diapers for Vicky.

Traffic on I-10 was bumper-to-bumper in front of the Looneys' home by Thursday, as the family finished securing their home, barn and other property. "We watched it take five hours for a vehicle to move less than a half mile," Looney recalls. "We started hearing reports of no food or fuel available along the evacuation route. We had people coming from the Houston area and there were many Louisiana residents who drove toward Beaumont before taking routes to north Texas."

Ironically, the evacuees were moving into harm's way. As Rita neared the Texas coast, she veered increasingly eastward and eventually came ashore at the Texas-Louisiana border.

By the time the Looneys left Friday morning, Sept. 23, "There was not a single vehicle on the highway," says Looney. "It was weird. We drove out and found I-10 empty, and it has never been empty. Even at 2 a.m. there are usually cars going by."

The family packed some belongings, two horses, five dogs, four cats, 32 goats, two weeks' worth of food for the family and several days' worth of food for the animals into its two pickup trucks and two livestock trailers and headed north on back roads at about 9 a.m. They did not encounter much traffic of any kind until they reached State Highway 105 in north Beaumont, and then it was "only three or four cars," Looney says.

The Looneys turned onto westbound SH 105, following the hurricane evacuation route that took them to U.S. Highway 59. They traveled north on U.S. 59 until they hit heavy traffic in Livingston at about 1 p.m.

"People were on the side of the road lined up for gas, and officials were trying to route people around the city of Livingston," Looney remembers. "We decided to stop in Livingston because there was no fuel and we were probably not going to get any more fuel for awhile. We had already decided we'd stop when we got down to half a tank of gas so we would have half a tank to get back home."

She telephoned the Polk County Cooperative Extension Office for advice on where she could shelter her family and her animals. The animals could take refuge in a local livestock arena, Looney was told.

A secretary in the Cooperative Extension Office invited the Looneys to stay with her and her husband in their home on the shore of Lake Livingston.

"She offered to take in my children and my husband," Looney says with a tone of grateful awe in her voice. "Here I am going to this woman's home and I don't even know her last name."

Hurricane Rita arrived in Livingston at about 4 a.m. Saturday morning, Sept. 24, with wind gusts of more than 100 miles per hour.

"I could hear the wind start howling then," says Looney. "Watching out the window you could see there were probably 4-foot to 5-foot seas coming across that lake. The waves were going over the bulkhead and splashing into this woman's house."

Rita's winds battered Livingston past noon. Powerful waves damaged the Lake Livingston dam to the extent that officials were forced into an emergency release of water to reduce pressure on the structure.

Rita dumped 3 to 4 inches of rain in the Livingston area before the storm moved out on Saturday evening, and by mid-morning on Sunday the Looneys were back on the road and heading home. They picked a fortunate time to return — before emergency management officials set up roadblocks to prevent people from returning to the coast.

"If we had waited another day, we probably could not have gotten home," says Looney.

Shortly after noon, the family turned into their driveway to find that the trees and brush on their property had provided good defense to Rita's winds. Their mobile home was intact and the few trees that were down had fallen away from the trailer. A neighbor just down the road did not fare as well. His mobile home, on a tree-less lot, was blown off its foundation.

The Looneys had their home back, but post-Rita life was far from normal. There was no electricity for 11 days. The community well distributed water via an electric pump, so there was no running water for five days — until a generator could be attached to the pump.

"The situation put us back about 100 years," says Looney. "People who were used to camping and cooking out had a less stressful time of it than people who had no camping experience."

Making things worse, temperatures soared into the mid- to upper-90s daily. As fate would have it, the Looneys' generator broke a week before the evacuation and could not be easily repaired, and they were not able to buy a new one before the storm hit.

No generator meant no electricity to run an air conditioner.

"We watched it take five hours for a vehicle to move less than a half mile."

Terrie Looney

USCG makes a roof-top rescue in New Orleans.

Photo courtesy USCG

"Without that generator, we would have really been in trouble," she admits. "I can't imagine the suffering of people trapped for days with no shade or water following Hurricane Katrina."

Terrie Looney

"It reached 95-plus degrees and there was no wind. Every person in our family was drinking more than a gallon of water each day," says Looney, who had stored about 40 gallons of drinking water in containers before the storm. "We would go outside for a little while and try to clear debris, but our clothes would get soaking wet from sweat. We'd have to go back in the house and just lay there, trying to stay cool.

"At night it was just as bad because there was no wind," she continues. "It's one thing to work during the day and be able to come inside and cool off at night, but what we found was our house acted like an oven. Without air conditioning, it got hot during the day and it held heat at night."

The Looneys were particularly worried about the heat affecting their youngest daughter. They eased Vicky's misery by placing her on the porch in a bucket filled with water from a rainwater catchment. She played and cooled off under the watchful eyes of her parents.

The Looneys also found some comfort soaking in their bathtubs. Anticipating that there would be no running water when they returned, Looney filled the bathtubs before the family left so they would have water to flush the toilets.

Other than the unrelenting heat, Vicky seemed not to notice anything different about her post-Rita life, "except that mom and dad were both home," says Looney.

"My 10-year-old, once she understood we were safe and we would not have air conditioning, was fine," she continues. "My 15-year-old had the hardest time because she was very concerned about the lack of her normal facilities — she could not take normal showers and the computer was down. It was tremendously upsetting to her because all of her communication that she is used to — that her world is built around — was gone. She was at a total loss, almost to the point of panic."

The two older girls were able to temporarily escape their new austere lifestyle by accompanying their grandmother in her motor home on a trip to the far northeast Texas town of Winnsboro.

One of Looney's supervisors provided the family a measure of relief two days after they returned home. Ralph Rayburn, head of the Texas Sea Grant Extension program, drove from his College Station office to deliver a generator and some fuel to the Looneys on Tuesday, Sept. 27.

"The generator allowed us to set up a small window air conditioning unit and a fan, which made it bearable at night," says Looney.

The generator was not capable of meeting all of the family's electrical needs, but it did allow them to alternately run their television, radio and refrigerator in addition to the air conditioner and fan.

"We stayed pretty close to the radio because it was our major source of information," says Looney. "We had one station that was able to stay on air and it had set times for news conferences, so that's when we would tune in.

"Without that generator, we would have really been in trouble," she admits. "I can't imagine the suffering of people trapped for days with no shade or water following Hurricane Katrina."

The generator's fuel supply was sufficient to last until Thursday, when a gas station in nearby Winnie returned power to its pumps using a generator.

"We had to wait in line and then pay cash for fuel," Looney remembers. "Most gas stations required cash because their credit card machines didn't work without

electricity. I bought $130 worth of gasoline."

The generator consumed about 10 gallons of fuel daily during intermittent use, and at $3 per gallon, "The fuel, even if you can get it, becomes a financial problem," Looney says. "Cash was a big deal. I belong to a little credit union and when the mandatory evacuation was called, the credit union shut down. That was on a Thursday. My direct deposits did not go in because the computer systems and everything else shut down. ATMs were completely wiped out from people trying to get their money. I talked with a bank teller after the fact and she said they were afraid they were going to run out of money because people were coming in and wiping out their accounts.

"I had gotten some cash on Monday (Sept. 19) while I was in town, but it was not enough. I had gotten $300 with the thought that payday was coming, but the loss of electricity meant the banks were down and my paycheck couldn't come through."

The family sustained itself using a centuries old cooking method with a somewhat modern twist. They initially cooked outside over an open fire, emptying their freezer and "cooking anything we could wrap in foil," Looney says. "We laughed that we were on the Atkins diet because it was all of the meat you could eat."

An open fire carried with it the danger of burning food or, worse, burning a child. Looney solved the problem by making a solar oven out of an ice chest and a pane of glass. A solar oven, or solar cooker as some people call it, is exactly what the name implies — a device that uses the sun's power to cook food. Solar cookers come in several different forms — Looney's was a type of solar box cooker.

A Swiss aristocrat and physicist built the first documented solar cooker in the late 1760s. Typically, solar box cookers do not generate temperatures much above 300 degrees Fahrenheit. Solar cooking in general is considered a slow-cooking method.

"I used the solar oven to cook biscuits, roasts and vegetables. I even tried a cake and yeast bread," she says. "I could leave the oven to do its job without worrying about the food burning or a child getting near it because there was no open flame. The food turned out pretty good. A solar oven is not something that will cook breakfast fast — it might take two hours for biscuits, but you could have them for lunch."

Looney did not have a formal role in the emergency management plans for either Chambers or Jefferson County, so she spent her first few days back home trying to get her family settled. She and about 10 neighbors in their community of about 30 homes began patrolling the area, taking care of animals and property.

When she was finally able to venture out on the Thursday after the storm, she heard of a distribution center that had been set up at the local volunteer fire department. She went there and began helping distribute food and water.

Looney also helped distribute brochures on food safety, how to clean out flood-damaged refrigerators, handling water-damaged documents and how to battle mold in the home.

In Rita's wake, officials in both counties have asked Looney to take a more active role in future emergency management situations, particularly when it comes to hurricanes and flooding.

Part of her duties will involve water quality testing, which concerned her in the days following Rita.

"My big concern for the general public was sanitation," she says. "My family knew how to put some bleach in the water, wash things and keep our hands clean, but other people were not aware

Motor vessels Sea Wolf and Sea Falcon were washed onto the road in Empire, La., after Hurricane Katrina ripped through the area Aug. 29, 2005.

Photo courtesy USCG

that hygiene becomes very much an issue in a situation like that.

"There were many water wells that were possibly contaminated and the Texas Commission on Environmental Quality brought in a lot of test kits, but no one knew what to do with them. As a marine agent, I can do water quality testing and help distribute the kits."

She will also aid in the counties' emergency plans for dealing with livestock and other animals impacted by storms.

Looking back, Looney says she learned much from her first encounter with a hurricane.

"You enjoy things that you used to take for granted," she says. "The little shower we rigged up with the bucket of water from off the roof was a tremendous luxury. We had been used to camping and my husband had lived in a place on the river without electricity, so we were in good shape. But there were people who were at a tremendous loss because they did not know how to do things like make what we call 'Buffalo burgers,' made from hamburger, onions and potatoes baked on the fire in a foil pouch.

Grand Isle, La., after Hurricane Katrina.

Photo courtesy NOAA

"I also did not realize the emotional toll an event like this takes on people," she continues. "My house was intact, but we still lost other things. My mother had four trees through her roof, my brothers and sisters had homes that were significantly damaged. There is an emotional toll, there is a grieving that goes on for this loss and it takes a while to recover. There is also shell shock, especially with the children. Now, when an ordinary thunderstorm comes up, everyone is hypersensitive — even the animals. When it thunders, my dogs try to get into the house as fast as they can because they've been through this trauma and it stays with them."

For the most part, the Looneys' family hurricane plan served them well, although there are a couple of things Looney has or will change before the next storm. She will make larger stashes of food, water and first aid supplies. Looney has already switched her accounts to a bank that has offices statewide, making it easier for her to get money if the family is displaced — and they will leave again.

"We probably will not take the cats because they do not travel well," she laughs now. "Those are difficult decisions you have to make. Traveling with them is probably more hazardous than leaving them."

Predicting the unpredictable

Most Galveston residents paid little attention to the rain, building wind and encroaching tide on the morning of Saturday, Sept. 8, 1900, despite learning four days earlier that a hurricane had struck Cuba before moving into the Gulf of Mexico. Even the hurricane warning flags raised the previous day above the local office of the U.S. Weather Bureau were largely ignored.

A short article in the Sept. 8 edition of *The Galveston Daily News* reported storm damage in Mississippi and Louisiana, and noted very little other information was available because telegraph wires in the two states were down. But another article in the same edition reported what weather bureau forecasters in Washington, D.C., believed: The storm had begun a long turn, or recurve, that would send it toward Florida and the Mid-Atlantic states.

By the time Galveston residents realized the truth, the bridges between the island and the mainland were down. An estimated 8,000 people died in the winds — reported to be 135 miles per hour — and flooding of the Category 4 storm. They were victims of a fledgling hurricane forecasting system as much as they were victims of their own naiveté.

"In that day and time, forecasters did not think hurricanes came to Texas," says the Weather Research Center's Hasling. "Even though Indianola had been destroyed by a hurricane (in 1886), they thought it was a freak storm."

Before the advent of reconnaissance aircraft (mid-1940s) and the satellite era (early 1960s), hurricane reports relied on first-person accounts from ships at sea or coastal observers. The nation's coasts were sparsely populated in part because of the threat of hurricanes, and ships at sea often had no way of communicating with officials ashore, so they could not report their observations until they put into port.

In one notable instance, the British sloop of war *HMS Racer* encountered a powerful hurricane in the

western Caribbean Sea, near Jamaica, in late September 1837. The storm carried the ship along with it for four days, dismasting the vessel before releasing it near the Yucatan Peninsula.

From that moment on, the hurricane was dubbed "Racer's Storm."

Thought to be a Category 4 or Category 5, Racer's Storm became the first recorded hurricane to strike both the Gulf and Atlantic coasts of the United States, and it inflicted heavy damage on Brownsville and Galveston.

As late as the early 1970s, hurricane forecasting was a hit-or-miss proposition. The National Hurricane Center's best guess for a storm's path three days before landfall had an average error of 380 miles — meaning a storm predicted to hit Houston could come ashore anywhere between Gulfport, Miss., and northern Mexico.

Such a large potential strike zone made it difficult for emergency managers to know what areas of the coast most needed evacuation.

Hurricane forecasting has made great strides in the past three decades, mirroring advancements in computer technology. Hasling characterizes computing as "the biggest boon to meteorology."

"We can run global numerical weather prediction models and more quickly. It used to be models would take more than a day to run. Now we can run models in three to six hours. Forecasters are now putting out five-day hurricane tracks. Before, they were only putting out three-day tracks. Their five-day track is as good as their three-day track was five years ago," says Hasling, whose organization is a non-profit weather research and educational center. "We've not only improved forecasting, but we've started predicting storm tracks further out. It gives people a false impression that the National Hurricane Center is wrong, but they are giving you the error if you look at the cone of the path, not just the center of the eye."

Hurricane Rita's seemingly dramatic course change was within the NHC's five-day track for the storm, says Hasling. The track originally predicted the storm would make landfall near Port Lavaca, but the cone of potential impact sites comprised a 10 percent course deviation on either side of the hurricane's path, which covered most of Texas' and part of Louisiana's coasts.

The NHC currently evaluates data from about 12 different computer models when predicting a storm's path. The models use a variety of information from surface and satellite observations about the large-scale atmospheric features, like upper-level high pressure systems and wind currents, that steer hurricanes, but these models do not always agree.

"Some models may have a storm headed for the Bay of Campeche while other models have the same storm headed for Miami," says Hasling. "The NHC takes all of the information, gets a consensus of the models and develops the official track. The models have gotten better as computing capacity increases, and we are getting more information from satellites than we did in the past."

Conversely, meteorologists' ability to predict a storm's intensity has improved little in 30 years. Scientists do not fully understand some of the factors that influence a hurricane's strength, like the effect of humidity and the rate at which a storm pulls heat energy from the ocean.

One of the nation's premier hurricane forecasters, Dr. William Gray, believes the El Niño conditions credited with making the 2006 hurricane season milder than predicted will dissipate before the 2007 season begins.

He is again forecasting above average hurricane activity, with 14 named storms and three of these growing into major hurricanes. Gray, head of the Tropical Meteorology Project at Colorado State University's Department of Atmospheric Science, believes at least one of the major storms will strike the United States packing sustained winds of 111 mph or more.

Looney knows that another hurricane may come her way one day, be it this year or any year. As certain as she is that she will evacuate her family, she is just a sure they will return home again … and again and again.

"I like the coast. I enjoy the environment here," says Looney. "Everybody has a potential disaster wherever they live. My husband grew up in Oklahoma, where they spent many nights in tornado cellars. People in California live with earthquakes and mudslides. The idea of tornadoes and earthquakes scares me to death. I'll pick hurricanes over tornadoes any day. At least I see my disaster coming and I can get out of the way."

The Return of the Dead (Zone)

by **Cindie Powell**

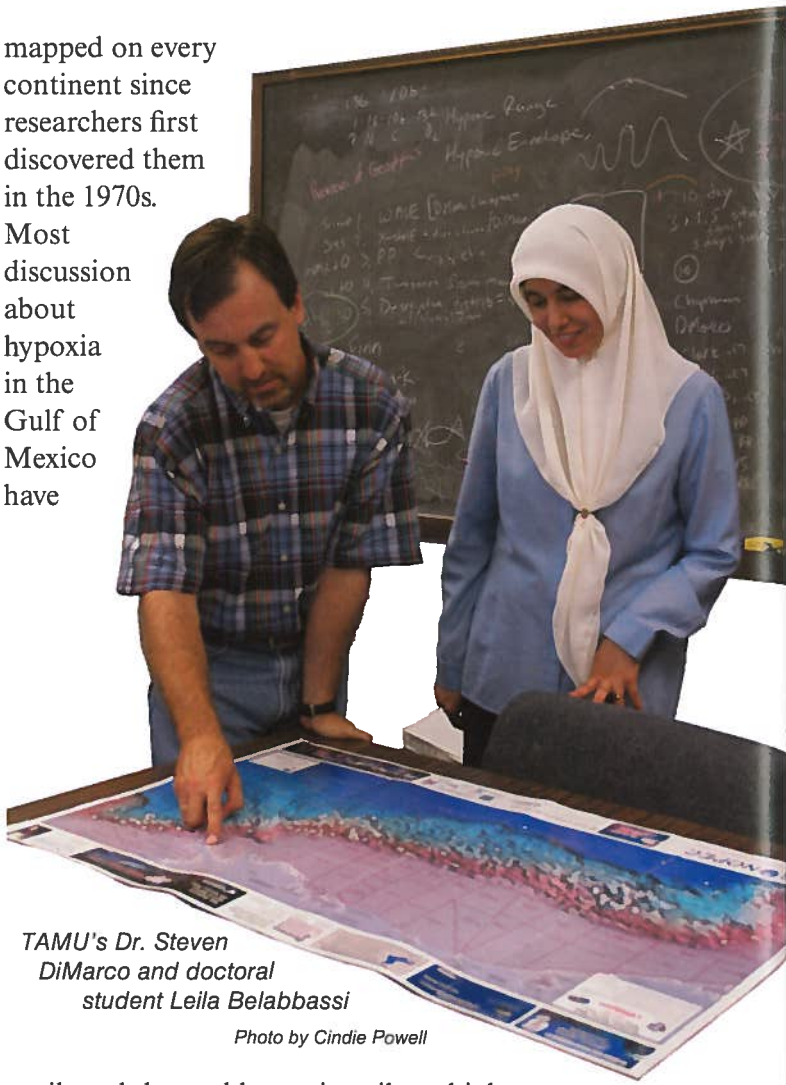
A Texas Sea Grant-funded study of previously collected data has shed new light on links between processes in the northern Gulf of Mexico and the annual formation of the "dead zone" off the coast of Louisiana — and is being used as the foundation for additional studies that could one day provide an early indication of the onset of its formation there and elsewhere in the Gulf.

The dead zone is a region of low concentrations of dissolved oxygen, or hypoxia, that forms every summer on the continental shelf — the gently sloping nearshore extension of the coastal plain — off of Louisiana, extending in some years as far west as Texas. It is characterized by low levels of oxygen near the bottom that will not support commercially important species of fish, shrimp and crabs. Since mapping first began in 1985 its size has averaged 13,000 square kilometers or 5,000 square miles — larger than the Rio Grande Valley of Texas, or slightly smaller than the state of Connecticut. In July 2006, the dead zone was measured at 17,280 square kilometers or 6,662 square miles — smaller than the largest recorded size of 8,500 square miles in 2002, but also much larger than the average prior to 2006, which was 4,800 square miles.

"The hypoxic layer, at least in the region we're looking at, is literally only two meters deep — man-height — and divers can see it when they go down," says Dr. Steven DiMarco, associate professor of oceanography at Texas A&M University, who has studied the Louisiana dead zone. "They tell me they hit the river turbidity first, and that layer usually has really strong currents as it's being blown around by the winds. As soon as you get under that it's calm and clean until you're within a couple of meters of the bottom. Then you see this cloud of very opaque water; in some places it's like fluid mud, you sink into it up to your armpits.

"That's where our sensors go in — we see the turbidity go up and the light transmission go to zero, and the oxygen values just drop."

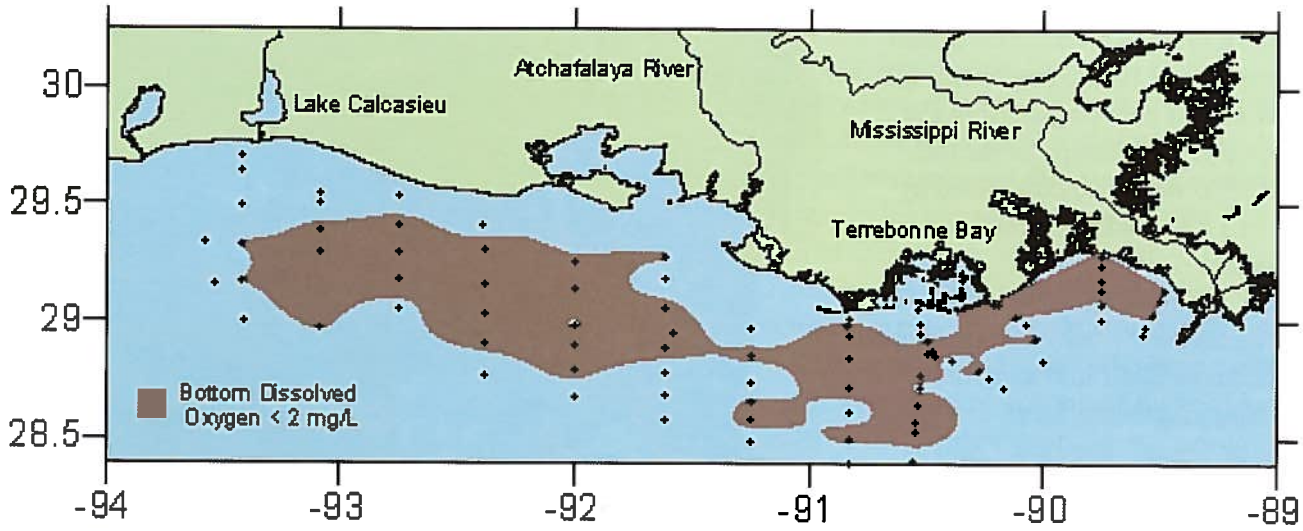
Worldwide, about 150 dead zones have been mapped on every continent since researchers first discovered them in the 1970s. Most discussion about hypoxia in the Gulf of Mexico have attributed the problem primarily to high rates of external nutrient loading from the Mississippi and Atchafalaya rivers, especially nitrogen from agricultural fertilizers from as far away as the Midwest, leading to pressure to decrease fertilizer use throughout the Mississippi River watershed. The Mississippi River alone drains 40 percent of the land area of the United States and accounts for almost 90 percent of the freshwater inflow to the Gulf of Mexico.

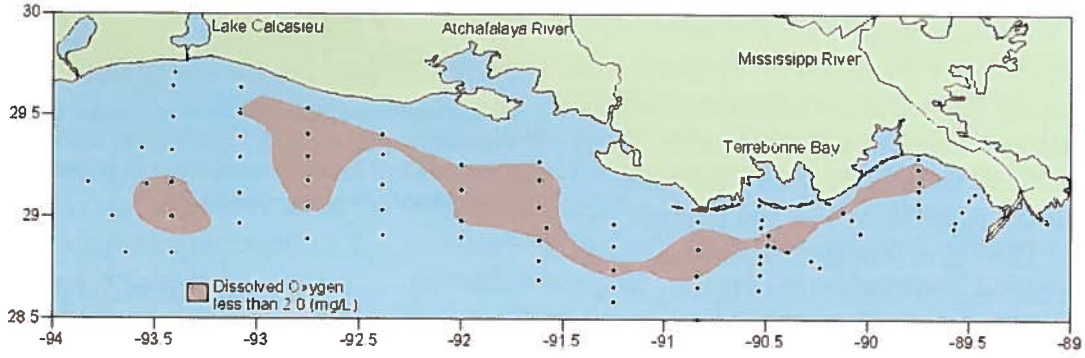


TAMU's Dr. Steven DiMarco and doctoral student Leila Belabbassi

Photo by Cindie Powell

The Louisiana dead zone may begin in spring and last through the summer, when the increased temperatures and decreased storm-pattern mixing





Shaded area indicates size and expanse of bottom water hypoxia in mid-July 2006 (pictured at top) and in mid-July 2005 (pictured at right).

Data and graphics provided by Dr. Nancy Rabalais, Louisiana Universities Marine Consortium (LUMCON)

favors its development by creating stratification – instead of mixing in a solution, like lemonade, the water forms into layers, like oil and water. Freshwater inflows park on top of the heavier saltwater of the Gulf, and oxygen from the air at the surface of the water can't move deeper into the water column. Meanwhile, the enrichment of the system with chemical nutrients, or eutrophication, promotes excessive plant growth. Nitrogen and phosphorus from the fertilizers used upstream act like an all-you-can-eat buffet for phytoplankton in the water, and the organisms that aren't used for food by other species die and sink to the bottom, where they decompose and exhaust the water's dissolved oxygen.

A question that has come up in recent years about the dead zone is whether it might be a naturally occurring phenomenon that is exacerbated by the nutrient inflows, or whether other factors — such as temperature, salinity, wind speed, freshwater inflows and currents — that lead to stratification might play a role that is at least as important as the nutrients.

The Texas Sea Grant-sponsored study, led by TAMU distinguished professor of oceanography Dr. Worth Nowlin, was designed to identify these other factors, attempt to quantify their relative importance, and relate them back to the occurrence of hypoxia in the northern Gulf of Mexico.

TAMU student Leila Belabbassi, who has used the work she did on the study as the basis for her doctoral thesis, and her colleagues re-examined data collected in the 1990s over the Texas, Louisiana, Mississippi/Alabama and Florida continental shelves and also examined historical databases for information about background conditions such as winds, currents, heating, river discharge and nutrient loading, local factors such as stratification, and nutrient and light levels as they relate to levels of dissolved oxygen.

"We found that every region has specific kinds of processes that characterize it," Belabbassi says. "Each zone has its specific characteristics."

The researchers used data from two surveys sponsored by the U.S. Department of the Interior's Minerals Management Service. The Louisiana-Texas Shelf Circulation and Transport Processes Study (LATEX-A) includes data collected in the early to mid-1990s by TAMU researchers led by Nowlin. The

The Dead Zone

Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study's (NEGOM-COH) nine cruises from the Mississippi Delta to Tampa in the late 1990s and 2000 were also conducted by scientists in TAMU's Department of Oceanography.

"We wanted to see what the difference is between the regions — why does it happen on the Louisiana Shelf and sometimes on the Mississippi/Alabama Shelf, and not in Florida or Texas?" she says. "And as we assumed, it was the stratification and the organic matter that was consuming oxygen."

River inflows drive the two main players in the formation of a hypoxic zone, nutrient loading and stratification, which Belabbassi found are lacking on the Texas Shelf and the Florida Shelf, which are furthest from the Mississippi River.

"There is not much freshwater coming in, because the other rivers (flowing into the Gulf) have very little discharge, so the water is not very stratified and there is not a lot of organic matter reaching the bottom, thus the oxygen at the bottom is not depleted by the bacteria," she says.

Researchers prepare the mooring marker buoys aboard the R/V Gyre for the hypoxia cruises in 2005. Pictured are, from left, Paul Clark of TAMU's Geochemical and Environmental Research Group (GERG) and Billy Green of Texas A&M University-Galveston.

Photo courtesy Steve DiMarco

Two other zones in the northern Gulf are adjacent to the Mississippi River Delta, the Louisiana Shelf to the west and the Mississippi/Alabama Shelf to the east. The Louisiana Shelf sees the annual appearance of the dead zone, while to the east, the Mississippi/Alabama Shelf might see small, localized areas of low oxygen near the Mississippi Sound and Chandeleur Sound. Belabbassi says she thinks the difference lies in the circulation patterns specific to each shelf. Both have freshwater inflows from the rivers, but off-shelf eddies next to the Mississippi/Alabama shelf transport the Mississippi River water out of the region, reversing over most of the shelf the normal offshore increase in salinity.

The study led Belabbassi to attempt to quantify the importance of stratification in the formation of hypoxic zones. She determined that there is a value for the degree of stratification in the water column — the Brunt-Väisälä Frequency — that is the limit for the formation of a hypoxic zone. This value, from physics, indicates the natural frequency of oscillation for a water parcel displaced without heat transfer from its rest position. The force causing the oscillation is the buoyant force.

"The Brunt-Väisälä Frequency measures the degree of stratification of the water column — how stable the water column is," Belabbassi says. "We found out that if the Brunt-Väisälä Frequency is less than 40 cycles per hour, we don't find any low oxygen because there's still mixing in the water, so that's the limit. There is a very good correlation between the Brunt-Väisälä Frequency and dissolved oxygen at the bottom."

Belabbassi's research led other TAMU researchers to submit proposals for further study. The National Ocean and Atmospheric Administration (NOAA) funded a three-year study from 2003 to 2006, led by DiMarco, to look at how physical processes affect hypoxia and how the respiration rates — the rates at which oxygen is used — change at different locations.

"With the new NOAA funding I was able to take what Leila's been doing to the next level," DiMarco says.

The researchers conducted several seven- to eight-day cruises in the spring and summer of 2004 and 2005, conducting surveys of the dead zone region and setting up and checking stationary moored gauges and equipment.

"Every time we went out we found something new," DiMarco says, indicating that there is still much to learn about hypoxia in the Gulf of Mexico.

In their first cruise in April 2004, the researchers were able to establish a baseline for the area.

"There was no hypoxia, nothing that even resembled hypoxia. It was a fairly low discharge year over the wintertime, there was a lot of mixing going on and there wasn't a lot of freshwater," he says. "We weren't finding hypoxia even though we covered the area from Mississippi almost to the Texas border."

By the next cruise, the hypoxia had appeared.

"It was in a line from the river mouth all the way to Cameron (La.), continuous, unbroken, and there was a lot of freshwater out there — it was about a month after some flooding — so the timing was right, and it was hypoxia as you always see it," he says.

On the third cruise, the hypoxia was fragmented — "It was all broken up into these patches on the order of 25 to 50 km in diameter."

The researchers on the third cruise also made a discovery — a physical process on the continental shelf that had not been described before. Below the surface of the water, they found a wave-like feature that is hypoxic at the trough — the lowest point — and oxygenated at the peak. The distance between peaks measured about 50 km, DiMarco says, and the "wave" height from trough to peak was 10 meters in 20 meters of water, or covering half the water column.

"It's very slow-moving," he says. "In the course of the week that we were there it moved hardly at all, by the instrument resolution that we were looking at."

The researchers speculate that it could be a continental shelf wave, or a meander — the term that applies to the bend in a river on land also applies to curves in water movement below the surface. DiMarco checked with other researchers who have worked in the area previously and none of them had ever encountered the phenomenon.

"We saw similar features in 2005. We're thinking these waves are kind of endemic, which shouldn't be surprising in retrospect — those types of waves occur anytime you have strong stratification."

They followed the wave along the 20-meter isobath — the line on the map connecting points of equal water depth, in this case 20 meters — from south of Terrebonne, La., to just south of Cameron, and found four wavelengths of the wave in that distance.

"Nobody had ever done a line along the 20-meter isobath before, and we just kind of happened onto it as we were doing stations," DiMarco says.

In March they made the first of the 2005 cruises, and found much different conditions from the previous year — about a third of the stations were already showing signs of hypoxia.

"Usually you don't think of hypoxia starting until April or May, and having it in March, while not unheard of, is unusual. We linked that to the flooding in January — there was a big slug of freshwater that came out, the winds weren't all that bad, it was a fairly mild year in terms of storms moving through in the spring, and all the conditions were right for hypoxia."

In May, the conditions were relatively unchanged from the readings they had taken in March. The July cruise, however, had more variety.

"We went out one day after Hurricane Cindy went over Venice (La.), and while we were out, (Hurricane) Dennis formed," DiMarco says. "About 30 hours into the cruise, we got an indication that the storm was building and heading straight for us, so we cut and ran all the way to Sabine."

The researchers stayed in 10-meter-deep

Piers Chapman of Louisiana State University (left) and Willie Flemings of GERG ready the equipment for deployment. Also on deck is Stephen Rodriguez of LUMCON.

Photo courtesy Steve DiMarco

DiMarco, Flemings and Chapman deploy the instrumentation off the stern of the Gyre during a 2004 cruise.

Photo courtesy Steve DiMarco

waters off Sabine, out of the National Hurricane Center's cone of probability, the projected area through which the eye of the storm might pass, until Dennis made landfall in Florida.

"Dennis pushed us way to the west, and we didn't want to give up all that ship time, so we started sampling at the Texas border — and we found hypoxia," DiMarco says. "We did this whole region between Cameron and Sabine, which we hadn't done before as part of our project, and it was hypoxic — in fact it was anoxic, with oxygen levels below detectable levels."

When the cruise returned east to the Atchafalaya, an area where the dead zone typically is located, there was no hypoxia.

"The storms had scrubbed it completely away" by churning up the water and eliminating the stratification, he says.

There were two other surveys of the area soon after the TAMU group's research cruise. NOAA's National Marine Fisheries Service (NMFS) annual SEAMAP (Southeast Monitoring and Assessment Program) survey took place about a week after the TAMU trip and found hypoxia not only south of Sabine in the same location as did DiMarco's group, but also starting to reestablish itself south of the Atchafalaya. A week after that, Dr. Nancy Rabalais of the Louisiana Universities Marine Consortium (LUMCON) conducted her annual survey to map the extent of the dead zone and found hypoxia "essentially over the whole region," DiMarco says.

"In two weeks it had completely reestablished itself after being completely churned up," he says. "It was stinkin' hot out there, so you have the thermal stratification as well as the salinity stratification (from) the freshwater, and there was no wind."

The TAMU researchers conducted their fourth and final survey of the year in August and made their second significant find of the project — an unusual stratification pattern that had not been found anywhere else.

"It was hot and it was calm, and there wasn't a wave in the Gulf of Mexico," he says. "You couldn't ask for better conditions to do a survey. And at one station we found a double minimum of the oxygen."

The water was oxygenated near the surface, then 10 meters below was a hypoxic layer that was full of nutrients and chlorophyll. Two meters below that was another layer of oxygenated water, then at the bottom it was hypoxic again. After testing at the station every half hour for a full 24 hours, the researchers headed into shore, casting for samples every five kilometers.

"That mid-layer stayed robust at 10 meters all the way to shore as the bathymetry came up, until they intersected at the 10-meter isobath. Then we knew that it was a bottom layer."

The upper hypoxic layer, which showed the typical characteristics of a dead zone, was being advected or blown horizontally offshore. Meanwhile, the decay of the organisms in the layer released nutrients, which started a new cycle of phytoplankton bloom, which died and sank, creating the bottom hypoxic layer, a pattern of recirculation DiMarco describes as a flywheel.

He received funding from NOAA for another study that began in August 2006 in partnership with TAMU's Geochemical and Environmental Group (GERG), Texas A&M University-Galveston, Louisiana State University, the Virginia Institute of Marine Science (VIMS) and Canada's Dalhousie University. Researchers on the project from the latter

two entities are specialists in biological and sediment modeling whose expertise will provide additional layers of information to the numerical modeling of the physical processes from DiMarco's earlier project.

"There's still a lot of work to be done finding out about that system. The LATEX program was a physical program, it was designed to look at transport and circulation, so we think we know a lot about the system in terms of the physical processes, but it's getting the concurrent measurements of dissolved oxygen and benthic respiration, all the biological and chemical parameters simultaneously with the physical, that's going to really knock this out of the park."

The new project will emphasize moorings, with equipment mounted on existing Gulf of Mexico buoys, including those in the Texas Automated Buoy System (TABS).

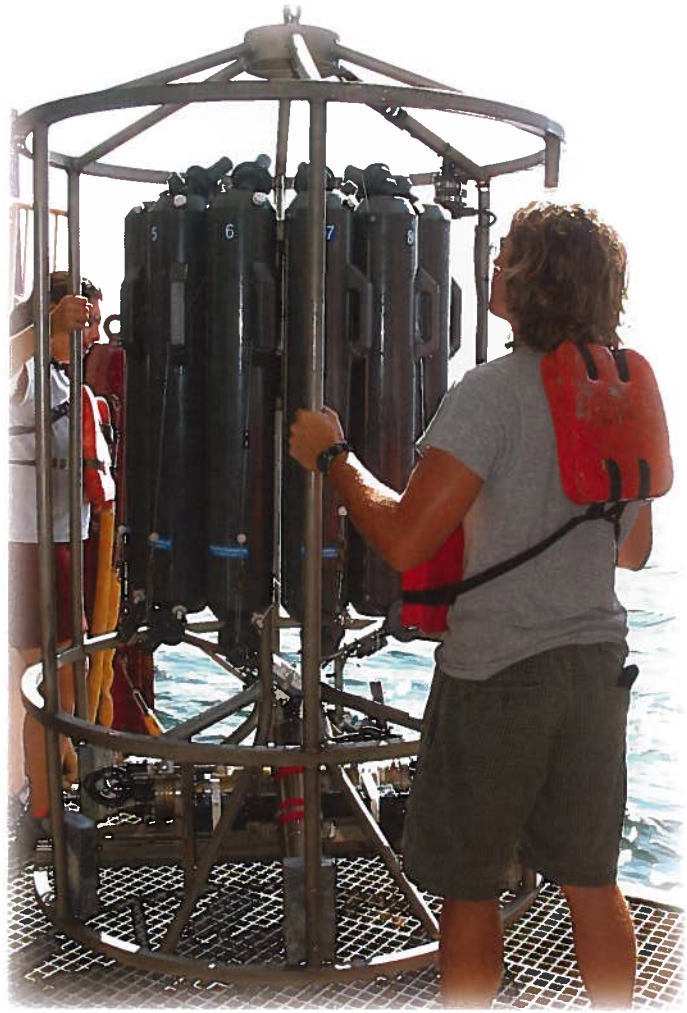
"They'll be real-time reporting, so essentially every hour we'll have profiles of currents, current velocity, and then point measurements — two and three points of dissolved oxygen and dissolved nitrate, temperature and salinity — and at the bottom we'll probably get pH and turbidity as well. It'll be as near to real time as you can make it with cellular phones and satellite phones."

Stratification's role in the formation of hypoxia, which up to now has taken a backseat to nutrient loading, is beginning to be more prominent in discussions of the phenomenon.

DiMarco says that reducing nutrient loading to reduce hypoxia makes sense from a management point of view — "Clearly you had to do something." — but the scientific hypothesis that questions its effectiveness because reducing nitrate would not reduce stratification is also valid.

"The biologists on our team say that the bottom respiration across the Texas-Louisiana Shelf is the same everywhere, and the only thing that changes is the stratification. If the respiration itself isn't remarkable, if it's about what you'd expect in a river system, why did this system go hypoxic? It's because of that intense stratification on the eastern side of the Texas-Louisiana Shelf."

Belabbassi says her research, which focused on the quantitative interrelationships of low salinity river water, vertical stratification and nutrient enrichment at the bottom as factors responsible for the occurrence of hypoxia in the Gulf, shows that there are gaps in



TAMU graduate students Laura Rubiano-Gomez and Keith Dupuis prepare to deploy the CTD/Rosette System, which provides data about conductivity, temperature and water depth or pressure and includes water sample collecting bottles and a dissolved oxygen sensor.

Photo courtesy Steve DiMarco

knowledge that require further study.

"Most studies of the processes responsible for hypoxia begin with nutrient loading, especially nitrate, as a major causal factor, but other factors, such as vertical stratification and adequate light levels for photosynthesis, are essential local conditions for hypoxia to occur.

"There is a need for better understanding of how interactions among biological, chemical and physical processes affect dissolved oxygen levels over the inner shelf," she says, adding that knowing the relative contributions to hypoxia from natural and man-made effects is especially important.

"These contributions must be quantified to develop effective management guidelines for minimizing the impact of human activities," she says, which could also lead to ways to provide early indications of the onset of hypoxia.

TEXAS SHORES: sea notes

continued from inside cover

Broussard retires, Texas Shores has new designer

COLLEGE STATION — *Texas Shores* has a new designer for this issue of the magazine as Texas Sea Grant bids farewell to Amy Broussard, associate director of Texas Sea Grant and director of the Marine Information Service, who retired in May after 27 years with the program.

"Amy's vision and leadership shaped Texas Sea Grant's communications program," says Dr. Robert Stickney, director of Texas Sea Grant. "Amy was the consummate professional and made *Texas Shores* the highly respected magazine that it is today. She also developed innovative designs for the many other forms of media that we produce in an effort to provide the public and the scientific community with information on marine and coastal topics."

Broussard was instrumental in developing *Texas Shores* into an award-winning, news-oriented publication, including serving as its designer. She also was the primary designer and editor for many other publications done for Texas Sea Grant and in partnership with outside agencies and organizations. Broussard won more than 35 local, state and national communications awards while at Sea Grant, either by herself or as part of a team, and during her tenure, the MIS staff received nearly 80 awards for print and video communication.

Jim Hiney, editor of *Texas Shores*, has been appointed communications coordinator and has taken on many of Broussard's administrative duties.

"Beyond the Texas program, the national Sea Grant network will miss Amy's leadership and sage advice," Hiney says. "Her impact on the network is evidenced by the trust it placed in her to address major issues. Communicators from other programs often sought her insights on complicated projects and top administrators frequently chose her to develop and produce publications aimed at a national audience. She also recently served on a three-member task force charged with evaluating Sea Grant communications. The task force's final report included recommendations that will fundamentally change for the better the way Sea Grant communicates with its stakeholders."

New Communications Specialist Tanya Baker, who started at Texas Sea Grant in May, is now the lead designer on the communications team.

Baker comes to Sea Grant from the *Galveston Daily News/Texas City Sun*, where she had worked since 1993 in a variety of roles, including as a graphic artist, in print production and as a system assistant. She also served a short tour in the U.S. Navy in 1983-84; is the co-author of a children's book, *Harvey the Hiccuping Hippopotamus*, published by Barron's Educational Series; and since 1999 has participated as assistant to the group leader in short educational trips each March to Europe through EF Educational Tours, designing flyers and documents and being the group's designated photographer/videographer.

"Texas Sea Grant is extremely fortunate to add a person of Tanya's outstanding ability and versatility to the Marine Information Service staff," Hiney says. "She has already suggested several design changes for *Texas Shores* that will make it more visually appealing, and these changes will most likely be incorporated into the magazine's design in the coming year.

"Tanya will be responsible for designing and producing most of our publications, which will allow Assistant Editor Cindie Powell to contribute more reporting to Texas Shores in the future. Cindie's award-winning writing will most certainly make the magazine a more valuable resource for our readers."

— *Cindie Powell*

Clean Marina participation reaches 100

COLLEGE STATION — Participation in the Clean Texas Marina Program has reached the 100 mark for the first time.

Twenty-eight percent of the state's 356 inland and coastal marinas are demonstrating their commitment to keeping Texas waterways clean by participating, with 59 certified as Clean Texas Marinas and another 41 pledging to do their part to keep Texas waterways free of harmful chemicals, excess nutrients and debris as they prepare for certification. The participants include municipal and privately owned marinas.

"Clean water enhances the quality of boaters' experience on Texas waterways, and marinas are keenly aware that many coastal and inland waters are seriously impacted by water pollution," says Dewayne Hollin, marine business management specialist at the Texas Sea Grant College Program and director of the Clean Texas Marina Program.

"Working together through the Clean Texas Marina Program, we can find solutions to these environmental concerns. Environmental protection is part of the cost of doing business, and clean water means good business for marina owners and operators."

The Clean Texas Marina Program is a co-sponsor of the 2006 Texas Marina Facilities and Services Directory, a comprehensive guide to the state's marinas.

"This Marine Directory shows all services and facilities available on a statewide basis, both on inland lakes and coastal waters," Hollin says.

The directory is based on data Hollin collects in his annual survey of Texas marinas. Since the information was first collected in 1986, the number of marinas in Texas has risen by 15 percent, from 309 to 356. During that time, the number of coastal marinas has actually decreased from 125 to 104, or 16 percent, while the number of inland marinas has more than made up for the deficit, increasing from 184 to 252, or 37 percent.

The number of marinas offering pump out services, which has increased significantly since 1986, decreased by 12 since last year. Hollin noted that, while the long-term increase might be attributable to regulations in Texas, which prohibit boaters from discharging anything into public water within three miles of shore, "without the proper service, pump out stations are difficult to maintain, and they are not used very often in some places."

The directory, which is co-sponsored by the Texas Commission on Environmental Quality, Texas Sea Grant College Program and Texas Parks and Wildlife Department, is available free of charge for single copies for the first time this year because of the additional funding.

For more information or to request a copy, contact Hollin at (409) 845-3857 or dhollin@ neo.tamu.edu.

— *Cindie Powell*

TEXAS SHORES: sea notes

Longtime TAMU training vessel to become reef

Photo courtesy TAMUG Communications Office

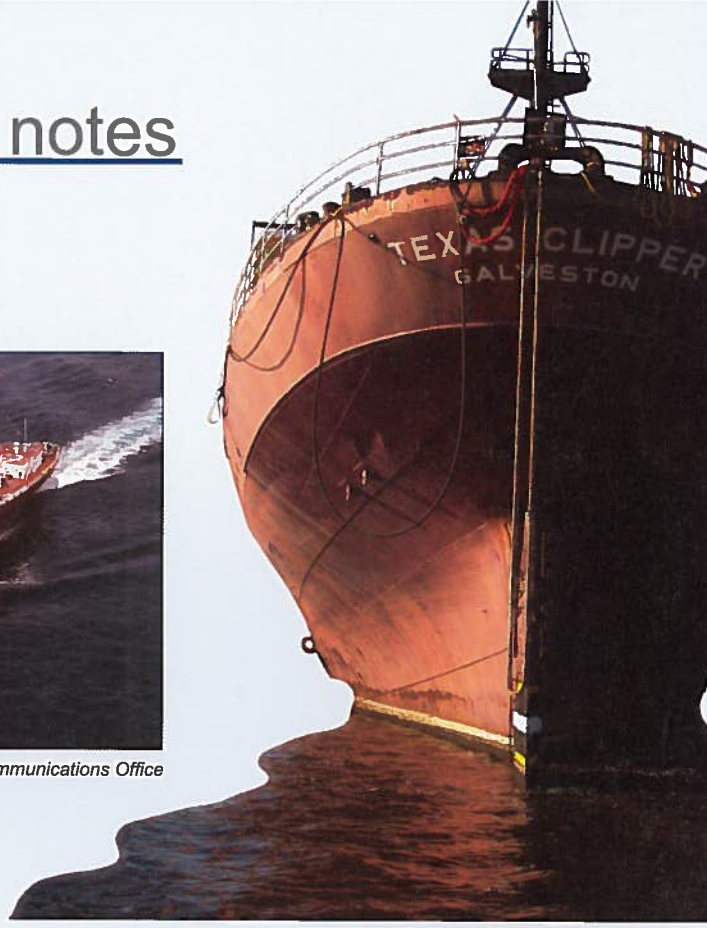


Photo courtesy TPWD Bob Murphy

BEAUMONT, Texas — The Texas Parks and Wildlife Department (TPWD) has completed contractual negotiations for the *U.S.T.S. Texas Clipper*, which served as the Texas A&M University Maritime Academy's training vessel for three decades, to become the first major addition to the department's Ships-to-Reefs program in more than 30 years.

The 473-foot *Clipper* will be sunk 17 nautical miles off the southern coast of Texas, near South Padre Island on or near April 1, 2007, to become an artificial reef.

The department's Texas Artificial Reef Program has worked for more than 10 years with the U.S. Maritime Administration (MARAD) to secure title to the *Clipper*, originally commissioned in 1944 as a troop transport ship. It later served as a cruise liner before becoming Texas A&M's training vessel in 1965. The university decommissioned the ship in 1996.

Photo courtesy TPWD Bob Murphy

The *Clipper* was towed from dock in Beaumont to a shipyard in Brownsville last fall for cleaning, removal of all hazardous materials and final preparations to make the ship safe for divers once she becomes a reef.

The TPWD Ships-to-Reefs program uses the sinking of large obsolete ships to create artificial reefs, adding a unique dimension to the Texas Artificial Reef Program. Ships-to-Reefs efforts began in the mid 1970s through the efforts of the Texas Coastal and Marine Council with the reefing of 12 Liberty Ships at six sites along the Texas coast.

For more information about Ships-to-Reefs or the Texas Artificial Reef Program, go to http://www.tpwd.state.tx.us/artificialreef.

— Texas Parks and Wildlife Department

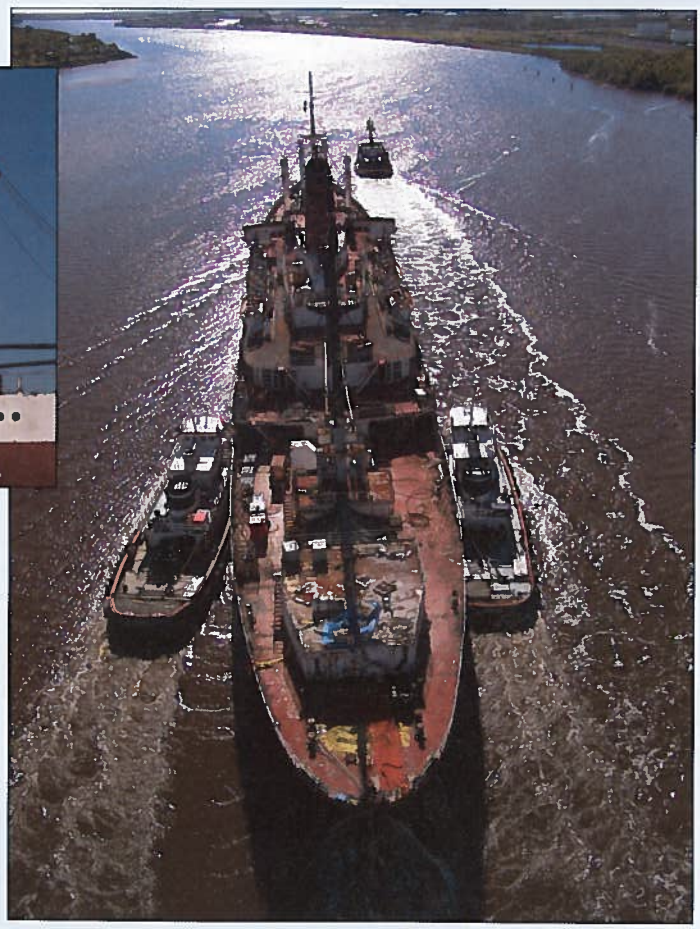


Photo courtesy TPWD Bob Murphy

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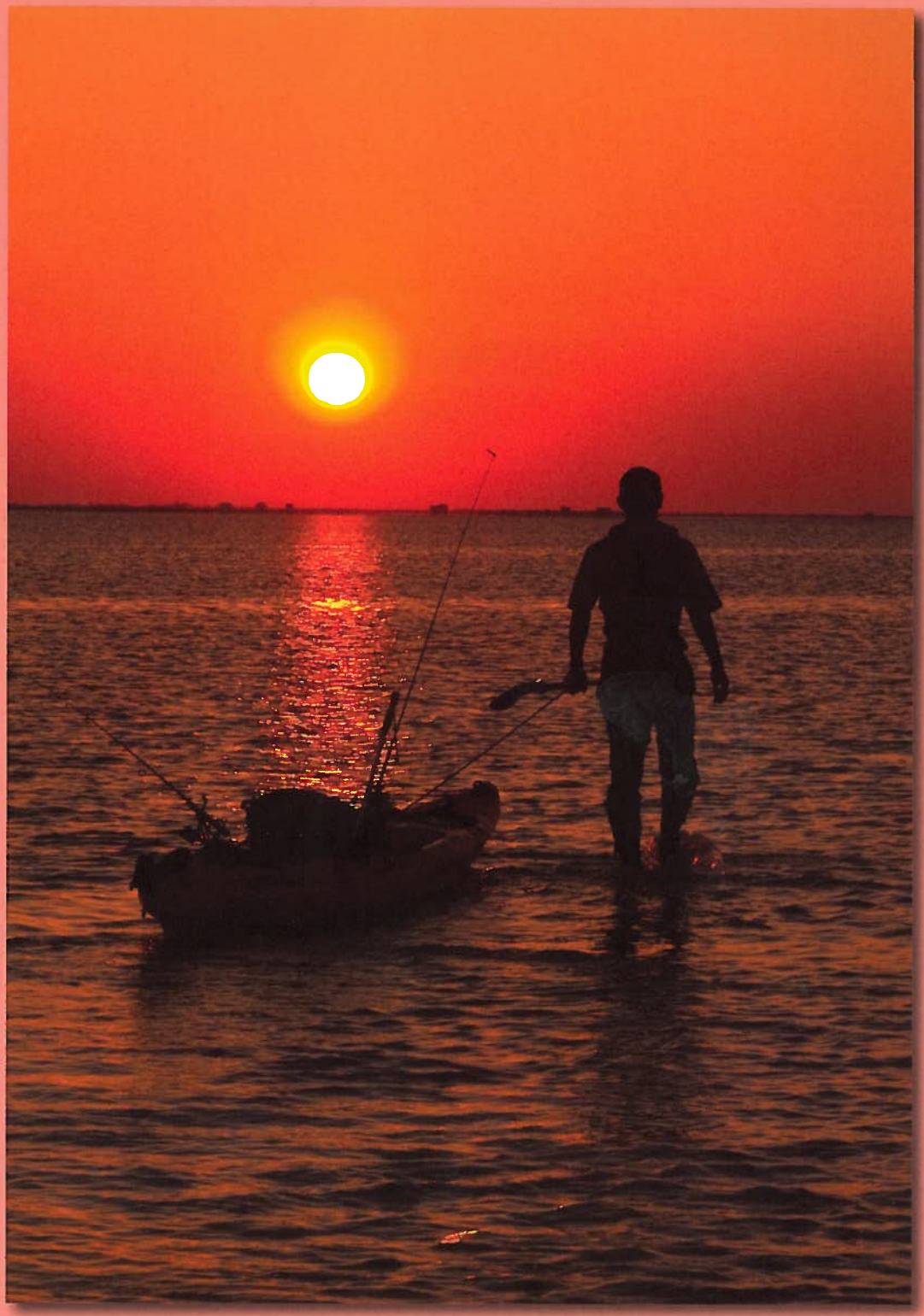

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