Slide 1

Hello, my name is Michael Carron. I am the Co-Director of the Northern Gulf Institute. My office is located at NASA's Stennis Space Center and I am a research professor at Mississippi State University. The Northern Gulf Institute is a consortium of Mississippi State University, Louisiana State University, Florida State University, University of Southern Mississippi, and Dauphin Island Sea Lab.

Welcome to a lecture on Marine Ecosystems. In this lecture I will give you an overview of Marine Ecosystems and discuss how we go about assessing their health.

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Let's start out by defining a couple of terms. Often the terms "habitat" and "ecosystem" are used incorrectly as synonyms. A "habitat" is a Place where an organism or a biological population normally lives or occurs or is most likely to be found. As school teachers you appreciate the habitat of a head louse. It is usually, the scalp of a young student. Many animals and plants are limited to a very specific range of environmental conditions. The human head louse must have human blood to survive and therefore is limited to the human head. Other organisms can live in a wide range of conditions and are therefore found in many different places.

An Ecosystem includes all living organisms (biotic factors) in an area as well as its physical environment (abiotic factors) functioning together as a unit. An ecosystem can be much larger, in space, than a particular habitat. For example, the oyster generally prefers to live in shallow brackish coastal seas and bays, but receives nutrients from fresh water rivers (without oysters) and is preyed on by oyster drills, a type of mollusk, that prefers to live in more salty water. When we have a period of drought the saltiness (salinity) of the coastal waters increases and allows the oyster drills to expand their habitat onto the oyster beds (reefs).

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Since there are few natural boundaries in the ocean we can consider all of the oceans as one large interconnected ecosystem. In fact we could even consider the earth and its atmosphere as the master ecosystem. Water slowly moves from one ocean basin to the other and the atmosphere carries pollutants from one region of the earth to another. For example, mercury spilled in the Pacific ocean will eventually end up in fish in the Atlantic ocean. This may take a very long time, but it will happen. In contrast, mercury from industrial smoke stacks fairly quickly moves around the Earth.

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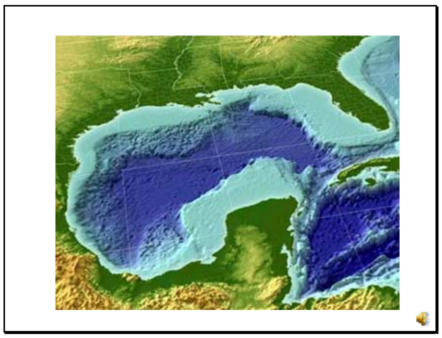

It is almost impossible to understand the complexities of the global ecosystem. Scientists have devised a system to break up the world into fairly large “bite-sized” pieces. For the oceans they have split the world into what they call Large Marine Ecosystems. In scientific jargon they say, “LME.” The whole west coast of the US is one. This is because the North Pacific and California currents flow from the north to the south and make the ocean waters off of the west coast have similar properties..

Another example is the Gulf of Mexico. The Gulf of Mexico is a semi-enclosed ocean basin pretty much surrounded by the US, East Coast of Mexico, and Cuba.

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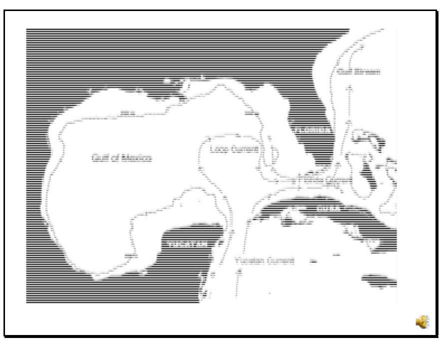

The main ocean currents that affects the Gulf of Mexico are the Yucatan and Loop Current which are part of the Gulf Stream system. The currents brings very warm water from the Caribbean Sea into the Gulf of Mexico through the Yucatan Strait between Mexico’s Yucatan Peninsula and Cuba. Both of these currents ultimately flow to the east between the US and Cuba and then up the east coast of Florida and to the west of the Bahamas. The extremely warm water of these currents are one of the causes for the intensification and, sometimes, spawning of Gulf of Mexico Hurricanes.

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When trying to assess the health of a Large Marine Ecosystem, scientists try to understand the things that strongly influence the ecosystem. We call these “drivers and pressures.” This cartoon, prepared by the National Coastal Data Development Center is an attempt to represent some of the main ones. A little later we will discuss most of these.

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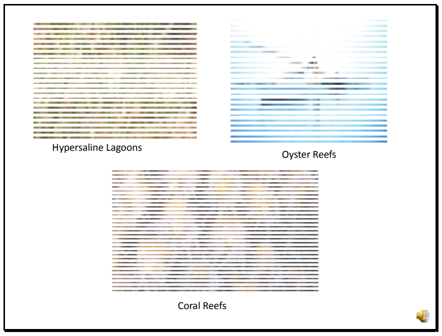

Even Large Marine Ecosystems are so complex that it is almost impossible for a oceanographer or even a team of scientists to study everything about them. Another way to study them is to divide a LME into bite-sized pieces by looking at specific geographical types. For example, we may study coral reefs and other tropical ecosystems. Or coastal estuaries and salt marshes. One could even break these down into smaller pieces such as lagoons (the Mississippi Sound for example), seagrass beds or even the intertidal systems of a particular beach. Even though each of these ecosystems belong to a larger system, most of the drivers and stressors are fairly local and can be reasonably studied by a typical research team.

Marine ecosystems have some unique qualities that set them apart from other aquatic ecosystems, such as those we might find in lakes. The most important quality of marine ecosystems is the significant presence of dissolved compounds, particularly salts. The primary ones being Sodium and Chlorine. On average the oceans have about 35 grams of salt per thousand grams of water. Scientists call this ratio, salinity. Coastal ecosystems often have lower salinity because of fresh water runoff from rivers, streams, and storm drains. There are some cases where there are bays with little fresh water inflow and high evaporation. In these cases the salinity becomes higher than the ocean and we call these hypersaline ecosystems. A major example of this is the Mediterranean Sea, but that’s a story for another time and another lecture. We find these hypersaline ecosystems along the Texas coast.

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Marine ecosystems are vital to the health of the Earth Ecosystem. Coastal ecosystems account for about 1/3rd of all marine biological productivity, and estuarine ecosystems (salt marshes, sea grasses, mangrove forests, etc.) are some of the most productive regions on the planet. The diversity and productivity of marine ecosystems are vital for human survival and well-being. These habitats provide us with a rich source of food and income, animal feed, food additives and, even, cosmetics. Mangrove forests, coastal marshes, and reefs provide protection to coastlines by reducing wave action and preventing erosion. Salt marshes and estuaries often accumulate sediment building land. Coastal vegetation filters runoff removing toxic materials and excess nutrients. An extensive salt march can completely detoxify human sewage in certain scenarios.

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Human activities, such as over fishing, coastal development, pollution and the introduction of exotic species have caused significant damage to many coastal ecosystems. For the next few minutes I would like to discuss some of the specifics of The Gulf of Mexico and then I will follow with an overview of how we are going about assessing its health.

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One way I like to look at the Gulf of Mexico's coastal ecosystems is to divide the Gulf into three zones based on some general observations. Of course there are always exceptions to generalizations, but for the little time we have here I think this works.

The first zone would be what one generally finds along Florida's west coast. This zone generally has sandy bottoms, clear water, and lots of fresh water input. The fresh water flowing into the bays creates what we normally call Estuarine Circulation with the fresh (and therefore less dense) water flowing out of the bay in the surface layer and salty (more dense) water flowing into the bay near the bottom. Of course, this is just the average flow because during strong tides the water is flowing either in or out of the bay. But the net flow is in near the bottom and out near the surface. In the West Florida zone we also have underwater reefs that provide a vital habitat for an extremely diverse population of plants and animals.

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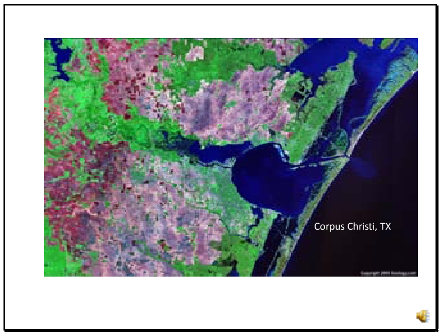

The second Gulf of Mexico ecosystem zone would be the Texas coast. This zone is generally dominated by sandy bottoms, clear water, very little fresh water runoff, and hyper saline bays and lagoons. The lagoons tend to have very fine sediments because of the low energy environment behind the islands. A diver can easily stir up the sediments. During hurricanes the lagoonal sediments are stirred up and often deposited on land.

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The Texas coast is prime location for sea turtles to lay their eggs. This is a photo of park rangers assisting baby sea turtles make it to the water without being harassed by humans and predatory birds like sea gulls.

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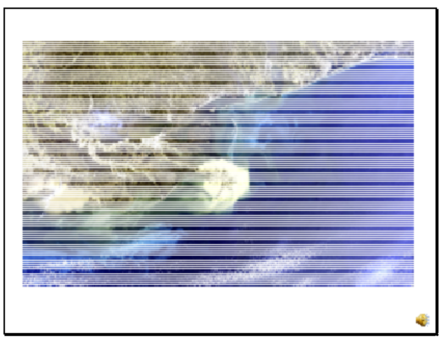

The third zone is the Northern Gulf of Mexico. This zone covers most of the Louisiana, Mississippi, Alabama, and western Florida Panhandle coastal areas. It is generally characterized by muddy bottoms, major fresh water input (for example, from the Mississippi and Mobile rivers) , brackish lagoons and bays and water with lots of sediment and nutrients. The nation's major oyster and shrimp fisheries are found here. And as we will see in a little while, this ecosystem becomes huge when looked at critically.

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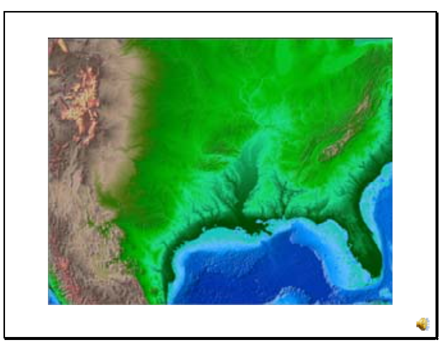

I've already mentioned that the Gulf of Mexico is bordered by Five US states. These, five Mexican states and Cuba make up the coastal part of the Northern GOM ecosystem. But by taking a different view of the Northern Gulf of Mexico Ecosystem we see that it really is made up of an additional 27 states in the US alone. This is the study area that the Northern Gulf Institute has as its primary focus.

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I've taken a different view of the northern Gulf of Mexico ecosystem. We see that it really is made up of an additional 27 states in the U.S. alone. This is the study area that the Northern Gulf Institute has for its primary focus.

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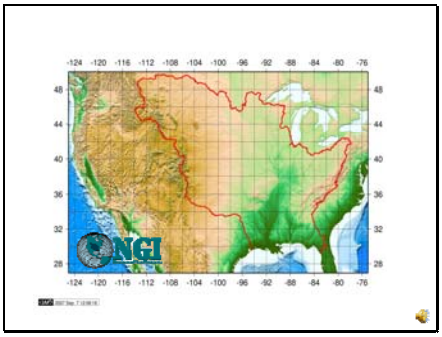

I like to point out that almost everything that happens to the rivers in the area on this map outlined in red which covers about half of the United States…everything East of the Rocky Mountains and west of the Appalachian and Allegheny Mountains…ultimately impacts the health of the Northern Gulf of Mexico. Even a small part of Canada drains into the Gulf.

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Scientists use the word, Watershed, to describe the area of land that drains to a particular point along a stream. Each stream has its own watershed. Topography is the key element affecting this area of land. The boundary of a watershed is defined by the highest elevations surrounding the stream. A drop of water falling outside of the boundary will drain to another watershed.

This map shows the major watersheds that ultimately drain into the Mississippi River. It doesn't matter to the Gulf if something happens in the Missouri River watershed or the Ohio River watershed. Both of these drain into the Mississippi River Watershed which ultimately drains into the Northern GOM.

If a person in, say, South Dakota, drains the oil from his car's crankcase into a storm drain, that oil will ultimately flow down the Missouri River to the upper and lower Mississippi River and out into the Gulf of Mexico…potentially harming oyster beds or killing young sea birds.

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Now that we have had a chance to discuss Marine Ecosystems and the Gulf of Mexico ecosystem, in general, it is probably a good time to begin talking about how we would assess the health of the Northern Gulf of Mexico and what we can do to improve it.

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Remember this figure. It shows one additional piece of information. There is an area south of the Mississippi River Mouth that indicates a relatively new phenomena that has been observed in the GOM. A hypoxic or area of very low oxygen near the bottom that is the result of the high levels of nutrients, especially nitrogen and phosphorus that drains from the Mississippi River Watersheds. The main sources of nitrogen are fertilizers and manure. Quite a bit of phosphorus comes from laundry detergent.

The oversupply of nutrients in the water, called eutrophication, can cause intensive growth of plants and phytoplankton….microscopic plants. When the plants die they sink to the bottom and decompose using up all of the available oxygen.

Other areas of hypoxia have been observed off of Mississippi and Mobile Bay. The Chesapeake bay in Maryland and Virginia also has an extensive nutrient driven dead zone.

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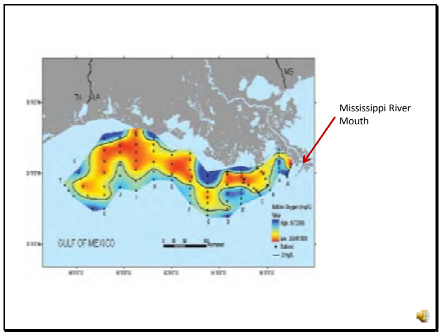

The oversupply of nutrients in the water, called eutrophication, can cause intensive growth of plants and phytoplankton….microscopic plants. When the plants die they sink to the bottom and decompose using up all of the available oxygen. Any animal that depends on the oxygen in the water near the bottom will either leave the area if possible or die.

Since the 1970’s scientists have documented a large area of hypoxia off the coast of Louisiana and Texas. This, so called, “Dead Zone” forms annually in late spring, reaching its greatest extent in midsummer. The largest of these dead zones was 8,500 square miles and formed in the middle of a nationally important commercial and recreational fishing area.

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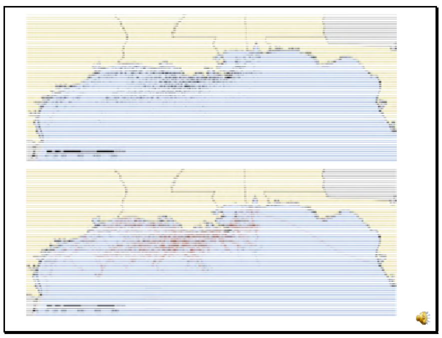

Humans may have more impact on the GOM than on any other LME in the US. 52% of the total Crude Oil and 54% of the Natural Gas production comes from the GOM.

This vital industry keeps America running. It also employs over 100K men and women with total wages of over $12B annually. There are around 20K men and women working in the Gulf of Mexico at any one time.

These two maps show the location of the 4000+ oil and gas platforms in the GOM and the approximately 25,000 miles of pipeline.

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We are fortunate that the potential for an oil spill has been minimized by modern drilling technology. A positive aspect of the platforms is that since the NGOM does not have many natural reefs, the platforms have become a fruitful habitat for many Gulf species and is a favorite place for scuba divers and game fishermen.

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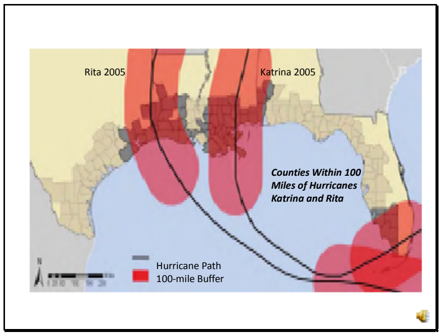

So far we have discussed the Oil and Gas industry and nutrient input to the Northern Gulf of Mexico.

Can you think of other things that might put stress on the Gulf…some are man-made and others are natural?

Hurricanes are an important part of the Gulf of Mexico ecosystem. In 2005 Hurricanes Katrina and Rita caused major disruption of humans and industry in the areas shown on this figure. In 2008 Hurricanes Gustav and Ike did major damage to the Texas coast. While there is probably nothing we can do to prevent hurricanes in the near future, residents and local governments of coastal states and counties in the GOM and along the East Coast must plan and build resilient cities.

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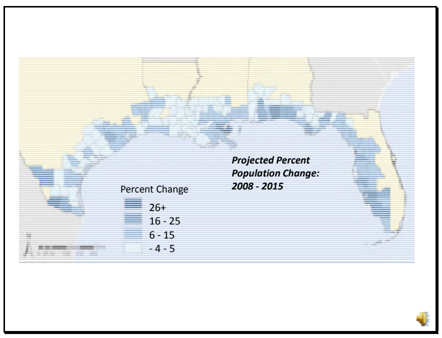

Projected population growth along the Gulf Coast, as it is along all of our coasts, is expected to rise significantly over the next 10 years. This figure shows the projected growth between 2008 and 2015.

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Sea level change in any particular area is a combination of eustatic sea level change and isostatic sea level change. Eustatic SLC is that caused by global changes in the sea surface height caused by the addition of water to the seas and changes of temperature of the sea water. Isostatic sea level changes caused by either sinking or rising of the land local land mass. Most of the Gulf of Mexico coast line, particularly in Louisiana is sinking. This sinking added to the slow rise in eustatic sea level of the oceans means that we can expect a meter or more of relative sea level rise over the next century. This map shows the areas (Red and Yellow) that will be greatly impacted by this with increased coastal erosion and loss of critical habitat, especially coastal marshes and mangrove forests. In some cases roads and critical infrastructure will be threatened.

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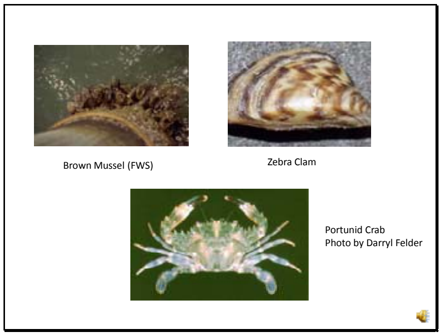

In addition to the potential stressors we've just discussed there has also been a marked increase in invasive species in the GOM and other LME of the US. Invasive species often replace native species, destroy coral reefs or clog up estuaries. Invasive species are often introduces in the ballast water of ships, on boat hulls, from aquaculture escapes, aquaria releases and, even, past government introductions.

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One of our jobs as scientists concerned about marine ecosystems is to devise ways of assessing if a particular ecosystem is healthy. It is impossible to measure everything all the time so what we are looking for are a series of so-called "canaries in the coal mine." These are biological indicators that the ecosystem is healthy or unhealthy. Before there were devices to measure the amount of toxic gases in a coal mine miners kept canaries in cages. Canaries are very sensitive to methane and carbon monoxide and would stop singing if the levels of these gases rose above normal. We can measure many of the characteristics of a marine ecosystem, but we can't be all places at all times and it is very expensive to keep ships and boats at sea. We are searching for a group of biological indicators that will warn us if there is a shift in the ecosystem's health. It would even be better if we could find indicators that could be measured remotely, say, from space.

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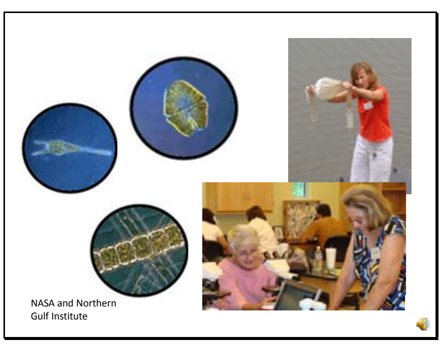

Some of the biological indicators we use include:
Phytoplankton – These microscopic plants are indicators of water quality, specifically nutrients (e.g., nitrogen and phosphorus). The National Oceanographic and Atmospheric Administration has a volunteer phytoplankton monitoring program in all coastal states. The Northern Gulf Institute supports the GOM network. The Mississippi network, pictured here, recently identified harmful algae which precipitated a temporary closure of a commercial oyster bed.

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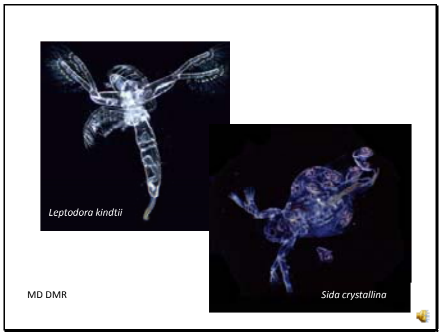

Zooplankton – microscopic marine animals are sensitive to changes in water quality (e.g., toxic pollution, excess nutrients, and low oxygen) and are useful for future fisheries health assessment as they serve as a food source for animals higher up in the food chain
Benthic or bottom animals – also susceptible to stresses associated with toxic pollution, excess nutrients, and low oxygen

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In certain areas where water is clear enough for sunlight to penetrate to enough depth plants grow on the bottom. We call these Subaquatic Vegetation or SAVs. By tracking the changes in the SAV beds we can get an estimate of changes in suspended sediment, nutrients, salinity and photosynthesis. These beds can be measured remotely from Satellites and aircraft.

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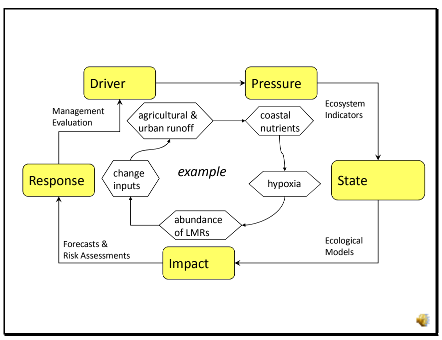

State and Federal agencies track commercial and game fish harvests and take samples of the flesh to determine levels of mercury, other heavy metals, pesticides, and other harmful materials. The total harvest of these species also are an indicator of the health of the ecosystem.

Scientists use the information from all these things we have discussed in an attempt to model the system. The general model that has been developed is called the DPSIR which stands for Driver Pressure State Impact and Response. The example here is concerned with the “dead zones” that I discussed earlier. The state that we find troubling is the hypoxia. By studying the system we have learned that the cause or “driver” is agricultural and urban runoff which puts pressure on the level of coastal nutrients. The result is hypoxia or lack of oxygen. The Impact of this is a decrease in the living marine resources or LMRs of the region. The management response will be to lower the input of nutrients into the water shed. This will mean having states with large agricultural production in the Mississippi River Watershed to use Best Practices when preparing their Corn, wheat and soybean fields. We are actively assessing the state of the important processes in the Gulf of Mexico Ecosystems. From each of these we hope to be able to recommend an appropriate management response that will result in the ecosystems remaining (or becoming) healthy so that future generations will be able to enjoy the benefits of our conservation efforts.

Thank you for your attention. I hope to be able to chat with all of your on-line in the near future.