Strategy for Restoring the Gulf of Mexico

Recommendations to the Gulf Coast Ecosystem Restoration Task Force

Audubon

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COVER PHOTO: Young oysters are examined growing on artificial reefs at an oyster restoration site at Alabama Port.

This document presents a strategy that maps the road to recovery for a healthy and resilient Gulf of Mexico.* This Strategy identifies four priorities for protection and restoration of the Gulf of Mexico with goals and outcomes supporting each priority. Several supporting activities are also identified that will create enabling conditions for a successful restoration program. These priorities and activities are intended to contribute to the protection and restoration of the Gulf after the Deepwater Horizon Oil Spill, while addressing the more systemic problems that are the result of decades of environmental decline. This Strategy integrates the vast knowledge of the numerous institutions and individuals that have been conserving and restoring the Gulf for more than 40 years.

Restoring the Gulf of Mexico for People and Nature

The Gulf of Mexico is ecologically and economically one of the most productive bodies of water on earth (Beck et al. 2000, Tunnell 2009). It provides the nation with valuable energy resources, abundant seafood, beautiful beaches, productive coastal wetlands, and a rich cultural heritage (Yoskowitz et al. 2010). But the Gulf has been mistreated for decades, as can be seen in degraded habitats, poor water quality, stressed fisheries, and altered coastal freshwater inflows (NOAA 2008, GOMA 2009).

St. Joseph Peninsula, Florida. © Jeff Ripple

This history of diminished ecological capacity in the Gulf has direct impacts on human communities. A weak, unhealthy Gulf ecosystem increases the vulnerability of human communities to a multitude of hazards. We call this reduced 'resilience,' or the reduced ability of biophysical and socioeconomic systems to adapt to and recover from change. In recent years, diminished coastal habitat has magnified hurricane impacts on remaining habitats, wildlife, and Gulf residents, and in 2010 the world's largest unintentional marine oil spill occurred here.

The coastal communities dotting the Gulf shoreline know well the threats that rising seas and habitat loss pose to their safety and livelihoods. All told, over half of the Gulf of Mexico's coastal habitats, roughly 4 million acres, have vanished—barrier islands, coastal marshes, mangroves and other coastal forests, seagrass beds and oyster reefs. For generations these habitats not only supported robust fisheries-based economies, but they also intercepted the surge created by strong storms, lessening their impact on human settlements. With sea levels rising and storms becoming more intense, the existence and health of these coastal habitats is more critical now than ever before. Unless society embraces a bold new restoration vision—one that restores habitats at an ecosystem scale—the future of the Gulf Coast is tenuous.

With public awareness of the Gulf of Mexico's economic and environmental value at an all-time high, now is the time for cohesive action to protect and restore this national treasure for future generations. The Gulf Coast Ecosystem Restoration Task Force has been established to address the damage caused by the Deepwater Horizon Oil Spill and begin planning for a more resilient Gulf Coast ecosystem. Development and implementation of a Gulf Coast Ecosystem Restoration Strategy ("Strategy") is the first step in this process. Our organizations offer these recommendations in the spirit of assisting the Task Force in the difficult job of coming up with a comprehensive strategy to restore the Gulf.

* The authors of this report recognize that the Gulf of Mexico system functions as a whole and activities in all countries are important, but, because the scope of work of the Gulf Coast Ecosystem Task Force is the northern Gulf, this report is limited to recommendations for the northern Gulf. In this report, "Gulf of Mexico" and "northern Gulf of Mexico" are often used interchangeably.

Background on the Strategy

Vision for a Healthy Gulf of Mexico

In developing the 'Strategy for Restoring the Gulf,' the authors of this document first envisioned what a healthy Gulf of Mexico would look like. Doing so allowed for focusing the strategy and setting measurable goals that inform progress toward recovery. The following is a proposed vision statement for a healthy Gulf of Mexico.

A healthy Gulf of Mexico ecosystem supports:

- sustainable populations of the full suite of native biodiversity;
- productive habitats that characterize a healthy Gulf, such as wetlands, coastal forests, mangroves, oyster reefs, seagrass beds, coral reefs, offshore banks and deep-water reefs, and other deep-water habitats, including deep-water corals, sponges and cold-seep communities, that benefit both the economy and local cultures;
- sustainable, healthy populations of commercially and recreationally important species;
- ample access to places and resources that provide for public benefit, including clean waters that are swimmable and beaches that sustain vibrant tourism-based economies in balance with nature;
- connectivity with coastal rivers and adequate freshwater inflows to maintain productive bays, estuaries and Gulf communities;
- healthy coastal habitats that are resilient to impacts from development, storms, and climate change, and;
- thriving cities, towns, and neighborhoods where citizens appreciate the full range of goods and services provided by a healthy Gulf ecosystem and are good stewards of nature.

Guiding Principles

Scientists and conservationists agree that an overarching goal of this Strategy should be restoration of the Gulf of Mexico ecosystem to a healthy and productive status, which maintains a full complement of biodiversity and sustains appropriate human uses. Development of the Strategy must be aligned with the reality that the Gulf knows no political boundaries. Indeed, it is one interconnected system from the barrier islands to the coral reefs and from the inner reaches of coastal marshes to the abyssal plain deep in the central Gulf.

Hence, the Gulf Coast Ecosystem Restoration Strategy should be Gulf-wide in scope and be based upon a clear synthesis of a functioning and productive Gulf ecosystem. While the Strategy should provide an overarching

Fisherman in late afternoon surf in Galveston, Texas. © Ron Wooten

framework to address injured natural resources and lost ecological services due to the Deepwater Horizon Oil Spill, the Strategy should also address more systemic problems, such as the on-going loss of coastal wetlands and formation of the hypoxic zone at the mouth of the Mississippi River, both of which are the result of decades of environmental degradation. Restoration and recovery of some resources, such as migratory birds and fishes, may require actions beyond United States' boundaries.

In light of the breadth and depth of past and ongoing degradation of the Gulf ecosystem, the authors of this report believe the Gulf Coast Ecosystem Restoration Strategy should recommend and support restoration action at the greatest scale practicable. Available funds for restoration should not be divided up among many small, isolated projects that will not, even when aggregated, address the scale of the problem.

We also stress the urgency of undertaking comprehensive Gulf-wide restoration. Although we support a robust investment in science to increase our collective understanding of Gulf processes, to assess the status of particular Gulf resources, to document possible longer term damage from the Deepwater Horizon Spill, and to monitor the effectiveness of restoration activities, we do not believe restoration should be delayed until we have perfect baseline data or complete knowledge of spill impacts. The decline of the Gulf ecosystem must be arrested; we know enough to take appropriate action in the near term. The monitoring and assessment can and should take place simultaneously.

To accomplish restoration at scale and with lasting impact will require cooperation and coordination across many boundaries, both geographic and organizational. Traditional lines of authority, jurisdiction and responsibility have limited the more holistic approach to Gulf-wide, ecosystem-based conservation required by this Strategy. Federal and state agencies should work together toward this common vision with perhaps unprecedented sharing of data, resources and responsibilities.

Understanding Ecosystem Drivers and Threats

Understanding the drivers and threats to the Gulf of Mexico ecosystem is critically important to the development and design of the Strategy. Varying kinds of drivers and threats from physical, chemical, geological, and biological/ecological, as well as socio-economic sources should all be considered, since any of them can have an influence on the success (or failure) of restoration efforts.

Major natural drivers in the Gulf of Mexico include the Loop Current, freshwater inflows (most notably the Mississippi River drainage), hurricanes/tropical storms, and ecological buffers and filters. These are all large scale drivers that effect large areas of the Gulf. Smaller scale currents, river drainages, and storms also have effects in more localized areas of the Gulf. Anthropogenic drivers often couple with natural drivers to compound threats and affects.

- **Loop Current**—source water and biologic connectivity enters from the Caribbean Sea into the Gulf of Mexico; trash and pollutants also follow this major current system.
- **Freshwater inflow**—freshwater, nutrients and sediments enter the Gulf via a number of drainages, bays estuaries, and rivers. These freshwater inflows provide nutrients to the Gulf system, and the freshwater/saltwater mix provides habitat conditions necessary for wintering waterfowl, reproductive nurseries for many marine species, and the brackish-water conditions needed for species such as oysters. There are negative effects as well with the massive Mississippi drainage providing an over-abundance of nutrients that has created a "dead zone" in the Gulf; as well as reduced sediments due to levying and damming that has starved Louisiana coastal marshes.
- **Hurricanes/tropical storms**—these large storms impact coastal natural resources and also damage or destroy the human built environment.
- **Ecological buffers and filters**—the Gulf's wetlands, oyster reefs, barrier islands and mangrove forests provide important buffers in the Gulf ecosystems, filtering nutrients, and providing unique habitats for many coastal species.

It was clear even before the Deepwater Horizon incident that the Gulf was in decline and that its future ability to sustain healthy fish and wildlife populations, economies and cultures is in question. Many threats at multiple scales have exerted a cumulative negative impact upon the Gulf (Kumpf et al. 1999). In some cases, the linkage between those factors and sources of stress is known, and in other cases, that linkage remains complex and elusive. Below is a list of threats to the Gulf of Mexico ecosystem, as well as some comments on direct effects on natural systems and resources.

- **Agricultural**—can cause problems with water quality and quantity, and habitat fragmentation and conversion.
- **Changes in freshwater inflow/discharge** (amount/rate/timing/channelization) into estuaries around the Gulf—Affects turbidity and salinity regimes and thus reproduction and recruitment of many estuarine-dependent species such as crabs, shrimp, fish and bivalves, and survival and recruitment of many habitats including seagrass, salt marsh/wetlands, and oyster reefs.
- **Channelization and dredging for navigation**—disrupts water flow; sediment disposal can cause sedimentation of natural habitats; constructing levees along rivers also affects sediment dispersion; affects deltaic (marsh) communities, their well-being, growth, and preservation; also sediment management programs not fully effective.
- **Coastal development and industrial development/expansion**—causes habitat loss due to land conversion from natural to human-built environment; reduces biodiversity, connectivity and resilience; increases habitat fragmentation and stormwater run-off.
- **Damaging fishing techniques**—habitat destruction, unintentional catches, and wasted by-catch.
- **Endocrine disruptors, pesticides, and other forms of pollution**—have their largest effect in estuaries and nearshore, primarily affecting early life history stages.
- **Engineered shoreline structures**—disrupts long-shore sediment flow, causes erosion elsewhere.
- **Global climate change**—affects intensity and duration of cold fronts, storm intensities, ranges and reproductive periods, and success of species, precipitation patterns and resulting freshwater inflows.
- **Harmful algal blooms**—can cause massive fish/invertebrate kills; often interact with increased nutrient discharge.
- **Invasive species**—includes non-native or invasive wetland and marine organisms as well as native species occurring outside of their natural range or in excess of historic abundance due to anthropogenic activities; food web disruption, displacement of native species.
- **Nutrient discharge into rivers and outflows into estuaries and the Gulf**—affects well-being of estuaries; generates oxygen minimum-zone and dead (or hypoxic, low oxygen) zones, both in estuaries and offshore.

Algae bloom © NOAA

Agricultural fertilizer © Thirteen of Clubs/Flickr creative commons

Coastal development © Gerry Ellis

- **Ocean acidification**—general decrease in ocean water pH due to elevated atmospheric carbon dioxide levels; another corollary of global climate change; will affect larval and adult survival; will affect sound transmission in water, hence sensory capabilities of many species.
- **Oil and gas exploration and development**—affects land use, causes environmental degradation in ways both direct (e.g., pollutants) and indirect (e.g., canals accelerating coastal erosion); offshore releases of oil can affect coastal lands and marine environments well beyond geography of source.
- **Overfishing**—affects food webs and trophic cascades; many non-target species are affected; biodiversity reduced.
- **Sea level rise**—another aspect of global climate change; impacts enhanced by groundwater and petroleum product extraction causing subsidence.
- **Treated and untreated sewage discharge**—untreated discharges cause water quality problems and diseases. Sewage treatment does not degrade many of the chemicals and drugs placed in waste water, e.g., prescription drugs, caffeine, and other chemicals that may have already passed through humans; can have unintended consequences on marine life.

Use of the Strategy

Restoration activities and projects that result from this Strategy should have demonstrable environmental and societal benefits and have clear, measurable, and feasible endpoints. Long-term monitoring and measurement should be a key element of restoring the Gulf of Mexico, and a Gulf of Mexico Ecosystem Scorecard is suggested as a relevant, and now widely used tool for judging the progress of implemented restoration projects. Sustaining a sound Gulf economy depends on a healthy Gulf ecosystem, and it is very important to coordinate and link state projects so that the sum of all projects advances progress towards a desired future condition in the Gulf.

The successful implementation of this Strategy or any other plan that targets recovery, resiliency, and long-term sustainability will depend on a strong recognition of the natural and socio-economic diversity of the Gulf. Long-term success will most likely be achieved when local, community-based approaches emerge from the regions and when local, regional and national efforts are all aligned and all parties are accountable for achieving the goals. Inter- and intra-agency approaches that break through traditional organizational and political silos are necessary to ensure the most comprehensive planning and implementation.

Development and implementation of restoration plans should be coordinated with external, independent peer review as an integral part of the planning and evaluation processes. This peer review should be periodically conducted by an interdisciplinary panel of scientists and practitioners—professionals who have no financial or professional stake in the decisions made.

The Strategy for Restoring the Gulf of Mexico

Focus of the Strategy—It is clear that achieving a healthy Gulf of Mexico will require a combination of well-defined goals and measurable outcomes, strong investment in scientific monitoring and adaptive management, and bold action with increased accountability.

The Strategy for Restoring the Gulf of Mexico focuses on:

- defining **essential priorities** to address threats and move toward a healthy Gulf,
- developing measurable **goals** using the best science available,
- identifying important **supporting activities**, and
- using a comprehensive approach that includes wildlife, people, and the places they live.

A NOTE ON OUTCOMES: This document attempts to identify specific, quantitative restoration outcomes in order to set clear, measurable goals. These numbers are derived from a consideration of the scale and magnitude of the habitats, species, and functions that have been lost from the Gulf over the last several decades. Thus, the outcomes represent an approach to restoration at a scale that will make a difference in the recovery of the Gulf.

Essential Priorities

The strategy proposes to focus on achieving tangible results in the following essential priorities:

- Recover Habitat
- Sustain Native Fish and Wildlife Populations
- Restore And Enhance Water Quality And Ensure Freshwater Inflows
- Conserve Special Places On Land And In Water

Recover Habitat

Goal: Restore priority upland, coastal and submerged ocean habitats that sustain biodiversity and ecosystem function and provide essential benefits to humans.

Why is it important? Healthy habitats provide essential supportive, provisioning, and regulating services that sustain human well-being (MEA 2005). Habitats provide the necessary structure for biodiversity to perform important functions that maintain system balance. Interconnectivity among habitats maintains the flow of resources and is essential to the health of the larger environment. Recovery of damaged and degraded habitats can bolster existing ecosystem services, increase resilience within and among habitats, and augment biodiversity. Thoughtful restoration may require shifts in management priorities, and the implementation of ecosystem-based strategies.

Outcomes:

Wetlands

Coastal wetlands are an essential component of a healthy Gulf of Mexico ecosystem. They trap and filter sediment and nutrients, moderate freshwater inflows, provide habitat for millions of resident and migratory wildlife, serve as nursery grounds for fish and shellfish, and help protect coastal communities by buffering storm surges. Wetlands have been documented as being one of the most productive habitats on earth, producing tons of organic matter per acre—as much productivity as a cornfield, providing the basis of a food-web that supports hundreds of wildlife species. According to the Gulf Coast Joint Venture, more than half the coastal wetlands in the lower 48 states lie along the Gulf of Mexico. These wetlands are disappearing at an alarming rate—8.9 square miles per year in Texas, 16.5 square miles per year in Louisiana—as a consequence of saltwater intrusion, channelization, erosion, subsidence, pollution, invasive species, sea level rise, and importantly, residential and commercial development. Unfortunately, over the past several decades, the Gulf has lost over 50 percent of its wetlands. Restoration strategies include acquisition and protection of key areas, restoration of hydrological processes to nourish and rebuild wetlands, creation and maintenance of salt water barriers, invasive species control, revegetation of key areas, pollution control measures, and others.

- **Outcome:** By 2013, develop an inventory (types, locations, status) of Gulf Coast wetlands, identify causes of wetland loss (including but not limited to development, sea level rise, and interference with deltaic processes of sediment deposition) and develop restoration goals and strategies to prevent further wetland loss and to recover and sustain fisheries and other populations of wildlife historically supported by these coastal waters.
- **Outcome:** Restore hydrological processes of Mississippi River to make available 80 percent of the sediment coming down the river to restore 5,000 acres per year to sustainability and create 500 acres of new wetlands per year by 2020.
- **Outcome:** To the maximum extent possible, prevent the loss of additional wetlands to sea level rise by creating buffer zones and otherwise managing coastal areas to enable coastal wetlands to migrate inland.
- **Outcome:** Prevent the loss of additional coastal wetlands to development through strict enforcement of section 404 permitting requirements.

Coastal Forests

As evidenced by hurricanes that have hit the Gulf Coast in recent years, coastal forests are an extremely important component of the coastal landscape for the ecosystem services they provide. Published studies bear this out (Danielsen et al. 2005; Kathiresan and Rajendran 2005; Reid and Whitaker 1976; Raupach and Thom 1981). In addition to protection against storms and surge, coastal forests offer important habitat for myriad wildlife species. The Gulf of Mexico provides critically important habitat for neotropical migratory bird species that utilize Gulf Coast forests as "stop-over" habitat before migrating further inland to nest and reproduce. Coastal forests provide habitat for numerous common and imperiled species, including black bear, and will attenuate climate change impacts through ongoing carbon sequestration.

Wholesale changes in hydrology, subsidence, and human development threaten the viability of these coastal forest systems. For example, while the chenier-plain coastal live oak-hackberry forests have been recognized as important for mitigating storm surge and preventing saltwater intrusion into freshwater ecosystems, many have been cleared and developed for mineral extraction, residential purposes, roads and utility construction. Likewise, dramatic changes in coastal hydrology and the coastal landscape in Louisiana have prevented many bald cypress swamps from naturally regenerating.

Transitional forested communities can play a critical role in supporting productivity, diversity and stability within the adjacent open marsh, as well as supporting their own endemic species. These forested areas are critical "stop-over" habitat for neotropical migrants, and serve to filter surface water entering the coastal systems. Relatively little attention has been directed to these integral habitats as compared to open marsh systems, ultimately with both the forested marsh and the open marsh habitats losing ground.

THE MISSISSIPPI RIVER DELTA

The Mississippi River Delta coastal ecosystem is the 7th largest in the world, reflecting sediment delivery from a watershed that is the 4th largest, encompassing 40 percent of the landmass of the continental US, and providing 65–90 percent of all riverborne freshwater to the U.S. Gulf coast. Most fish and wildlife species of the northern Gulf, particularly those that are commercially or recreationally important, are dependent on estuaries at some point in their life cycle. Sixty percent of the remaining U.S. estuarine wetlands along the Gulf are found within the Deltaic complex. (F. Moretzsohn et al. 2011; Binninger, J. and J. Allen 2010; Couvillion et al. 2011).

Pursuant to the 1928 Flood Control Act, the Corps of Engineers constructed flood control levees, navigation canals, and other works that extend from Cairo, Illinois, to the mouth of the Mississippi River. This program has prevented catastrophic river flooding for nearly a century, yet has starved the Delta of sediments and fresh water, leading to exacerbated wetland loss. Threats from hurricane flooding have become more severe and deep-draft navigation at the mouth of the river has required increased dredging. This system has also shunted inorganic nutrients from the vast agricultural areas of the Mississippi Basin into the Gulf, bypassing natural assimilation of nutrients by wetlands and creating a large anoxic or "dead zone" offshore that extends into Texas waters during summer months. Additionally, the vast supporting network of energy pipelines and canals has cumulatively contributed to saltwater intrusion and wetland loss.

The loss of 30 percent of Deltaic wetlands over the past century—1900 square miles—and ongoing annual loss rates of 16 square miles (Penland, S. and Campbell, T. 2004; Couvillion et al. 2011), has diminished the sustainability of the navigation, flood control and storm protection systems, as well as oil and gas, and transportation infrastructure. This loss is now understood to have acute regional impacts but also threatens nationally important economic and environmental assets.

Unleashing and leveraging the power of the Mississippi River to serve more fully as an engine for restoration should clearly be a part of the Gulf Coast restoration strategy.

Aerial view of wetlands and marshlands that comprise the Mississippi River Delta on the Louisiana Gulf Coast.

- **Outcome:** Restore and protect sufficient coastal forest habitats to provide for protection of human communities and recover and sustain populations of wildlife historically supported by these habitats.
- **Outcome:** Utilize existing programs such as the Forest Legacy Program, the Coastal and Estuarine Land Conservation Program, Forest Stewardship Program, Forest Productivity Program, Forest Land Enhancement Program, Wildlife Habitat Incentives Program, and Coastal Impacts Assistance Program so that management of private forests is optimized to provide wildlife habitat and protection from storms.
- **Outcome:** Restore hydrology of coastal forests to conditions that support regeneration and maintenance of bald cypress swamps.
- **Outcome:** Pursue non-traditional sources of funding for coastal forest protection and restoration such as mitigation banking, carbon banking, and hazard avoidance funding (FEMA).

Mangroves

Mangroves dominate large coastal areas in the Gulf below 29°N latitude, and smaller stands of dwarf black mangroves can be found in areas above 29°N in Texas and Louisiana. However, the populations in Texas and Louisiana are occasionally reduced by stress from cold snaps, so are not generally included in management plans. It should be noted, however, that many predictions call for a significant increase in mangrove distribution as a result of elevated global temperatures in the future. Mangroves provide habitat to a wide variety of animals including two endangered species, the Key deer and the West Indian manatee (Spalding et al. 2010).

Mangrove loss in some areas has been significant. For example, in Tampa Bay mangrove area losses were estimated to be 44 percent in the late 1990s (Spalding et al. eds. 1997). Major threats to this habitat include development pressure, altered freshwater and tidal flow regimes, land-based sources of pollution, unsustainable pruning, and climate change (Florida Fish and Wildlife Conservation Commission 2005). Relevant strategies for conserving mangroves in the U.S. include management plans for the Florida Keys National Marine Sanctuary, Everglades National Park, Rookery Bay National Estuarine Research Reserve, Charlotte Harbor National Estuary Program, and the Tampa Bay National Estuary Program.

- **Outcome:** Fund and implement existing management plans.
- **Outcome:** Develop state plans to reduce land-based sources of pollution in Gulf coastal waters by 2015.
- **Outcome:** Reduce habitat loss and fragmentation resulting from conversion of natural or minimally impacted habitats.
- **Outcome:** Develop a plan to restore natural hydrology to impaired mangrove swamps by 2015.
- **Outcome:** Expand public education and law enforcement programs by 25 percent—focused on proper mangrove pruning and trimming in high priority areas by 2015.

Coastal wetland in Mississippi. Erika Nortemann/© 2010 The Nature Conservancy

A brown pelican with chicks, nesting in a mangrove forest rookery in Barataria Bay along the Louisiana Gulf Coast. © 2010 Bridget Besaw

A tricolored Heron hunts for small fish at low tide among the exposed oyster reefs along the Texas Gulf Coast. Erika Nortemann/© 2010 The Nature Conservancy

Oyster Reefs

Globally, oyster reefs are the single most impacted marine habitat (85 percent loss) due to overharvest, disease, sedimentation, pollution, and changing salinities. The Gulf of Mexico supports the only remaining significant wild oyster harvest in the world and has some of the best of the few remaining reefs. These reefs provide high quality habitat for aquatic life, benefit water quality, and protect shorelines. Oyster reefs also act as ecosystem engineers that allow for other plant and animal species to thrive. Even with significant reductions from the historic extent of oyster reefs, the Gulf of Mexico likely represents the last place in the world where large scale oyster reef conservation and sustainable fisheries may be possible now; as such it is of global significance (Beck et al. 2009; Beck et al. 2011).

- **Outcome:** By 2030, restore more than 50 percent of the historical area of oyster reefs Gulf-wide so that there are sufficient recruitment and densities of oysters that enable them to maintain a positive accretion rate (i.e., their growth exceeds local sedimentation rates and keeps pace with relative sea level rise).
- **Outcome:** Oyster reefs should be managed to support a suite of ecosystem services, including sustainable harvest, fish production, water filtration, nitrogen removal, and protection of shorelines and wetlands.
- **Outcome:** Improve protection measures for native oyster reefs by making them a priority for habitat restoration and conservation plans.

An aerial view of prop scar damage on a seagrass bed in Florida.
© Florida Department of Environmental Protection

Kemp's Ridley turtle hatchling on Padre Island along the Texas coast.
Erika Nortemann/© 2010 The Nature Conservancy

Seagrasses

Seagrass in the northern Gulf of Mexico represent more than 50 percent of the total U.S. distribution and is a valuable habitat in the Gulf because it provides a variety of benefits ranging from habitat for commercially, recreationally and ecologically important species to sediment stabilization (reducing turbidity) to providing important forage material for endangered species like the West Indian manatee and sea turtles. It has been estimated that 20 percent to 50 percent of seagrass beds have been lost in the Gulf in the past 50 years (Handley et al. 2007). This habitat is threatened by several factors including poor water quality and direct destruction by boat propellers. In 1992 it was estimated that the northern Gulf historically had 2.5 million acres of seagrass (Duke and Kruczynski 1992).

In 1999, the EPA Gulf of Mexico Program committed to restoring, enhancing, and protecting 20,000 acres of important coastal seagrass habitats within the northern Gulf of Mexico region by the year 2009 (Handley et al. 2007). Handley et al. (2007) estimated that in 2002 there were 1,246,408 acres in 14 of the largest estuaries in the northern Gulf. All 14 estuaries assessed have experienced some declines in seagrass habitat.

There are places in the Gulf where restoration of seagrass beds would be of Gulf and global significance. Big Bend, Florida, for example, and Laguna Madre, Texas, contain some of the largest and least impacted beds in the Gulf (Beck et al. 2000).

- **Outcome:** Develop an inventory (types, locations, status, etc.) to facilitate establishment of seagrass restoration goals.
- **Outcome:** Ensure protection of existing seagrass beds by decreasing new scarring of seagrass beds resulting from boat activity, reducing dredging and improving water quality in bays and estuaries.
- **Outcome:** Given losses of 20 percent to 50 percent of the historic estimate of 2.5 million acres in bays in the Gulf, restore at least 500,000 acres of seagrass by 2030.

Barrier Islands and Beaches

Barrier islands are formations of sand, shell, and gravel that exist along coasts, forming a defense against winds and waves and providing habitat for many species of animals. An undisturbed beach community has a unique faunal and floral composition. The organisms in this habitat are important for the biological functionality and physical stability of natural beach habitats. Activities such as development, beach raking, and vehicle traffic have a direct negative effect on the viability of these communities, thus many species endemic to beaches have experienced dramatic population declines.

Beaches and barrier islands in the Gulf of Mexico provide globally important habitat for a variety of wildlife and are critical to the survival of 13 federally threatened and endangered species. Padre Island, Texas, is 113 miles long and is the world's longest barrier island. The Kemp's Ridley sea turtle, which has long been considered the most endangered sea turtle in the world, is known to nest there. About 80 percent of the threatened loggerhead turtles in the southeastern U.S. nest in only six Florida counties, making this their most important nesting site in the western hemisphere (Erhart et al. 2003). The northern Gulf of Mexico also provides critical breeding, wintering, and migratory habitat for a number of birds with high conservation concern including Wilson's plover, snowy plover, red knot, and least tern. This region is home to about 70 percent of the wintering population of the threatened piping plover (Elliott-Smith et al. 2009).

Things to consider in protecting beaches and barrier islands are the uniqueness of beach communities, potential nesting areas for sea turtles and diamond back terrapins, shorebird foraging and nesting habitat (e.g. plovers, red knots, wading birds), species of tiger beetles, and other interstitial invertebrate organisms that are functionally important to the physical environment. Dune habitat should be included as well, and species like beach mice, kangaroo rats and sea oats should be considered. Beaches are habitat and should be managed as such whenever possible.

- **Outcome:** Increase publicly owned beach property via fee simple and conservation easements for the protection of beach invertebrate communities, associated flora and fauna, and long term public use by 2020.
- **Outcome:** Maintain, re-establish or mitigate anthropogenically disrupted upland and coastal sand source systems to allow barrier islands the ability to maintain their natural sand budget and natural geomorphology by 2020.
- **Outcome:** Have 50 percent of Gulf Coast public beaches follow best management practices for beach maintenance by 2020.

Coral Reefs

The Gulf of Mexico is home to a variety of coral habitats including hard-bottom, patch reefs, deep-sea, offshore mid-water reefs, and shallow water reefs (Tunnell et al. 2007). Shallow water reefs can be found in the U.S. in the Florida Keys National Marine Sanctuary (FKNMS), which includes roughly 6,000 coral reefs between Key Biscayne and Dry Tortugas as well as the only emergent coral reefs in the continental U.S. (Florida Dept of Environmental Protection 2009) Mid-water corals are generally found in waters between 100 to 600 feet deep along the western coast of Florida (US Coral Reef Task Force 2011) and in waters between 60 to 400 feet deep directly south of the Texas, Louisiana, and Alabama border at the edge of the continental shelf (Waddell

and Clarke eds, 2008). The latter area includes a unique ecological feature known as the Flower Garden Banks National Marine Sanctuary (FGBNMS). The banks are composed of coral reef structures that have grown on salt domes, and have the highest coral cover in the western hemisphere, with greater than 50 percent cover (Puglise and Kelty eds. 2007). Deep-sea corals are found distributed throughout the Gulf at depths of 600 feet or greater (NOAA 2008), and are generally slow growing and fragile (CoRIS 2011). In some cases little is known about the biology of these corals and the extent of their distribution. Worldwide, coral reefs are considered biodiversity hotspots, providing habitat, spawning, and nursery ground for a wide variety of animals, including many economically valuable reef fish (US Dept of Commerce 2010). Coral reefs below the southern tip of Florida are also habitat for threatened elkhorn and staghorn corals.

Coral cover in South Florida has dramatically declined over the last 30 years. Some fishing practices have impacted deep-sea, mid-, and shallow-water corals through mechanical damage from gear. Furthermore, overfishing of predators and grazing fish has had negative impacts on Florida's mid- and shallow-water coral. Additional threats to shallow- and mid-water coral reefs in the Gulf include boat groundings and anchoring, coastal development, land-based sources of pollution, and climate change. Relevant strategies for conserving coral reefs in the U.S. include the Florida Keys National Marine Sanctuary Management Plan, Flower Garden Banks National Marine Sanctuary Plan, Dry Tortugas National Park Management Plan, NOAA Coral Reef Ecosystem Research Plan, the National Action Plan to Conserve Coral Reefs, and Florida's Comprehensive Wildlife Conservation Strategy (Waddell and Clarke eds. 2008; Florida Fish and Wildlife Conservation Commission 2005).

- **Outcome:** Fund and implement existing management plans.
- **Outcome:** Complete coral habitat mapping in the Gulf of Mexico using high-resolution bathymetric surveys, to document and track distribution of all coral reefs by 2020.
- **Outcome:** Identify priority areas for expanding current, or create new measures to protect corals in the Gulf by 2015.
- **Outcome:** Finish development of recovery plans for threatened elkhorn and staghorn corals, implement and fund the plans.
- **Outcome:** Develop a research plan and fund scientists to investigate the range and biology of deep-sea corals.

Tending to a crop of staghorn coral in the waters off Key Largo, Florida. © 2009 Tim Calver

Ocean Habitats (including pelagic and deep-water benthic)

Healthy and diverse offshore ocean environments should be sustained as major components of a biologically diverse, productive, and resilient Gulf ecosystem. Existing management plans that can be used to inform this conservation effort include those of the National Marine Sanctuaries in the Gulf of Mexico and federal fishery management plans (identify essential fish habitat, habitat areas of particular concern and minimize the impacts of fishing on essential fish habitat).

- **Outcome:** Using existing information, identify sensitive and outstanding habitats by 2012 and protect from incompatible human uses by 2015. Based on the mapping and monitoring outcome below, protect a matrix of offshore habitats, including sensitive and outstanding habitats, from incompatible human uses by 2025.
- **Outcome:** Document the Gulf-wide distribution, diversity, condition, and management status of offshore habitats in Mexican, Cuban and U.S. waters by 2020. Identify and prioritize sensitive and outstanding habitats by 2020.

Sustain Native Fish and Wildlife Populations

Goal: Sustain healthy populations of fish and other wildlife that contribute to a productive and diverse ecosystem and thriving economy.

Why is it important? The Gulf of Mexico is home to valuable finfish and shellfish species that contribute to a large regional fishing-based economy (Yoskowitz 2008). Therefore, the human communities in the Gulf States are substantially dependent on the productivity of living resources and ecosystems in the region. Over the past several decades some species have been over-fished, and this unsustainable activity has contributed to a decline in the health of the Gulf's resources.

The Gulf is home to more than 15,000 marine species (Felder and Camp 2009) from bacteria to invertebrates to marine mammals. The Gulf supports globally significant populations of many species of migratory birds, colonial nesting birds, commercially important finfish, sharks and marine mammals. This diversity contributes to the stability and resilience of these wildlife species. Significant reductions in populations of fish and wildlife negatively impact on this stability and resilience, and often cause cascading effects throughout ecosystems.

The threatened Gulf sturgeon can live over 60 years and are found in coastal rivers from Louisiana to Florida. In the winter they use bays, estuaries and the open waters of the Gulf. © Paul A. Lang/USFWS

Outcomes:

Fish

The Gulf of Mexico is home to an outstanding collection of marine and coastal fish species, many of them commercially and recreationally important. Unfortunately past management and fishing practices and the reduction and degradation of essential fish habitat has taken a toll on the region's fish populations, impacting coastal communities dependent upon these resources. For example, red snapper spawning abundance has been reduced to less than five percent of historic spawning abundance. The Gulf is also home to several federally protected fish species. In addition, migratory species such as the Alabama shad—a NOAA "species of concern"—were likely a historically important prey species and trophic link between marine and fresh waters before severe population declines in the Gulf of Mexico. In 2000 the American Fisheries Society identified species at risk of extinction in the U.S. and identified the northern Gulf of Mexico as a "hot spot" of at-risk species. Fortunately, it's not too late to reverse this trend. While Gulf fisheries currently support $22 billion in economic activity, future sustainable yields and economic benefits can be much higher if fisheries are restored to and maintained at optimal levels. Several existing management plans can help support this goal: management plans for federally managed fish species developed by the National Marine Fisheries Service and U.S. Fish & Wildlife Service; fishery management plans developed by the Gulf States Marine Fisheries Commission and Gulf states; the Smalltooth Sawfish Recovery Plan; and the Gulf Sturgeon Recovery/Management Plan.

- **Outcome:** Management of Target Populations—All federally managed fish species are managed at optimum yield, overfishing is prevented, and rebuilding of depleted populations is completed within the timelines designated in fishery management plans. All state managed species are managed to achieve optimum yields, end and prevent overfishing, and rebuild depleted populations.

- **Outcome:** Management of at-risk populations—Identify at-risk marine and coastal species and develop restoration plans by 2015. Restore the smalltooth sawfish population consistent with the federal recovery plan pursuant to the Endangered Species Act. Reduce fishery by-catch including fishing interactions with protected species. Restore Gulf sturgeon consistent with the Gulf Sturgeon Recovery and Management

Plan, including conserving and restoring habitat, reducing incidental mortality, and minimizing dredging impacts on Gulf sturgeon habitats.

- **Outcome:** Population Health Assessment—By 2015, double the number of formal assessments for managed fish species annually. By 2020, double the number of managed species with formal assessments. Identify management metrics for unmanaged, incidentally caught fish species by 2020. Develop a data-poor species management framework by 2012.
- **Outcome:** Future of Fisheries Management—By 2020, ensure U.S. fishery policy better accounts for ecological interactions in decision-making.
- **Outcome:** Conservation and Restoration of Migratory Fish Species—By 2020, improve migratory fish populations by stabilizing at least 25 percent of unpaved roads and riverbanks at sites impairing riverine spawning habitat. By 2020, develop a conservation action plan for providing longitudinal connectivity at every dam or in-stream barrier impeding migratory fish access to essential riverine habitat. By 2020, determine the impact of recreational and commercial fisheries and by-catch of Alabama shad, Gulf sturgeon, and other migratory fishes.

Birds

The Gulf of Mexico is important for 395 migratory, breeding, wintering, and resident bird species (National Biological Information Infrastructure). Specifically, the Gulf Coast provides critical breeding, stopover, or wintering habitat for 34 species of shorebirds, five of which are Highly Imperiled, including the snowy plover, Threatened piping plover, and possibly extinct Eskimo curlew. Another 13 species are of High Concern (Brown et al. 2001). There are an additional 36 waterbirds with high regional conservation priority, and 17 of these, including American oystercatcher and sanderling, are of continental concern (Hunter et al. 2006). Gulf of Mexico wetlands have been identified as critical for migratory waterfowl and support globally important populations of rapidly declining species like redhead, northern pintail, and lesser scaup. The resident mottled duck relies upon these wetlands as well, in addition to upland prairies and associated grasslands (U.S. Fish and Wildlife Service 1986, Abraham et al. 2007).

In the northern Gulf of Mexico, National Audubon Society has identified 71 Important Bird Areas (IBA) with a total area the size of Maryland and Connecticut combined. Many of these IBAs support globally important populations of birds, including waterfowl, pelagic birds, pelicans, wading birds, birds of prey, rails, plovers, shorebirds, gulls, terns, and sparrows. Beach-nesting birds and marsh birds, in particular, are already in decline in the Gulf, and other species will be at increasing risk due to threats such as climate change. Many of the species meet the criteria as birds of conservation concern and appear on a number of watch lists.

There is a critical need to increase monitoring of all coastal waterbirds and restoration of imperiled habitats on which they depend. Birds are a relatively well-studied group, and regional population declines in some species are well documented. Even in species experiencing population increases since banning DDT and similar organochlorines (e.g. brown pelican; Butcher et al. 2007), nest sites are limited, making them vulnerable to catastrophic events like hurricanes and oil spills. Unfortunately, efforts to restore coastal habitats have been


Whooping crane. © Kendal Larson


Roseate spoonbill. © Bill Stripling


Brown pelican. © Bill Stripling


Surveying waterbirds © Gerry Ellis

too localized and small scale to have significant impacts on population growth. Capacity is lacking to detect population changes for all species of conservation concern. It is critical to support and establish standardized regional monitoring for all species, especially for those of conservation concern, and to restore and create sufficient habitat to support stable populations at a level that reduces extinction risk.

- **Outcome:** Protect and restore critical bird habitats. Restoring natural hydrologic processes will renourish and reestablish productive marshes, stabilize and restore barrier islands, and provide additional breeding, wintering, foraging, and migratory stopover habitat to compensate for historic habitat loss. The National Audubon Society has identified 71 Important Bird Areas along the Gulf coastal as focal areas for conservation.
- **Outcome:** Develop and implement standardized regional monitoring protocols and integrate into a centralized, publicly accessible database to monitor coastal bird populations at scale by 2015. Science-based monitoring and conservation will follow recommendations from regional and national recovery plans, including the North American Waterfowl Management Plan, Southeast U.S. Regional Waterbird Plan, U.S. Shorebird Conservation Plan, and Endangered Species Plans.
- **Outcome:** Identify and protect critical habitat for threatened and endangered species, such as least tern and piping plover, whose habitats are at greatest risk of development, by acquiring appropriate and available lands by 2030, with the goal of reducing probability of extinction in 100 years to <1 percent.
- **Outcome:** Stabilize and recover populations of declining and vulnerable species, including threatened and endangered species, marsh- and beach-nesting birds, and other conservation priority species, to healthy levels by 2030. Assess population size of declining species and possible need for listing under Endangered Species Act for candidate species, like Wilson's plover; ensure listing where appropriate by 2020.
- **Outcome:** Identify and protect colonially nesting and beach-nesting bird sites, which include at-risk species like reddish egret, brown pelican, black skimmer, and snowy plover, from human and nuisance animal disturbance through stewardship, public education programs, and science-based monitoring at critical sites (IBAs) by 2020.
- **Outcome:** Maintain stable populations of birds, assessed through effective monitoring.

Dolphins in Galveston, Texas. © Ron Wooten

Florida manatee. © Ethan Daniels

Marine Mammals

The Gulf of Mexico is home to a variety of marine mammals including two species protected under the Endangered Species Act, sperm whales and the West Indian manatee, and 20 of which are managed pursuant to the Marine Mammal Protection Act. These species include: Bryde's whale, Cuvier's beaked whale, Blainville's beaked whale, Gervais' beaked whale, bottlenose dolphin (including 38 distinct stocks), Atlantic spotted dolphin, Pantropical spotted dolphin, striped dolphin, spinner dolphin, rough toothed dolphin, Clymene dolphin, Fraser's

dolphin, killer whale, False killer whale, pygmy killer whale, dwarf sperm whale, pygmy sperm whale, melon-headed whale, Risso's dolphin and pilot whale (short-finned) (Wursig et al 2000). For the majority of these species, there are insufficient data to determine stock structure, abundance, distribution, trends, health status or vital rates (survival and reproduction); obtaining this information requires coordinated and cooperative efforts at the state, federal and international level.

- **Outcome:** For ESA-listed species (sperm whale and manatee), restore populations to a level at which the probability of extinction in the next 100 years is less than 1 percent, consistent with federal recovery plans, by 2025. This includes acquiring additional information on population size and trends in abundance; protecting designated critical habitat; minimizing anthropogenic threats that may result in serious injury or mortality; and implementing measures to monitor recovery over the long-term (until 2025).
- **Outcome:** For non ESA-listed marine mammals, ensure populations are at or above optimum sustainable population levels by 2025. This includes acquiring additional information on stock structure, population size, spatial distribution, and movement patterns; minimizing anthropogenic threats that may result in serious injury or mortality; and implementing measures to monitor trends in abundance.

Sea Turtles and Terrapins

The five species of sea turtles found in the Gulf of Mexico are protected by the Endangered Species Act as threatened or endangered species and include Kemp's Ridleys, loggerheads, leatherbacks, greens and hawksbills. These sea turtles migrate to within and outside the Gulf from nesting beaches to foraging grounds (Girard et al. 2009). Threats to all species include loss and alteration of nesting and foraging habitat, interactions with fishing, encounters with dredging equipment, and marine pollution. The current status of loggerheads and Ridleys, the majority of which spend their lives in the Gulf, are of special concern. Sea turtles are long-lived species which require many years to mature (12-35 years). Recovering these populations is complicated by a lack of information on growth rates and survival at different life stages and the need to safeguard both terrestrial and marine turtle habitat.

- **Outcome:** Consistent with federal recovery plans, restore green, hawksbill, leatherback, loggerhead, and Kemp's Ridley sea turtle populations to levels that support removal from the federal list of endangered and threatened wildlife.
- **Outcome:** In turtle nesting areas, reduce artificial beachfront lighting, which confuses the sea-finding ability of hatchlings emerging from their nests, by 50 percent by 2020.
- **Outcome:** In turtle nesting areas, reduce mammalian predation of nests to less than 10 percent by 2020.
- **Outcome:** Eliminate vehicular driving on major sea turtle nesting beaches during nesting season.
- **Outcome:** Arrest nesting declines for the four loggerhead recovery units in U.S. waters and ensure the annual rate of increase over a 50-year generation is 1-3 percent or greater.
- **Outcome:** Consistent with the Kemp's Ridley turtle federal recovery plan, achieve 10,000 nesting females in a season by 2015 and on average 40,000 nesting females per season over a six-year period by 2038.
- **Outcome:** Categorize all beach armoring and shoreline stabilization on sea turtle nesting beaches and develop and implement a strategy to ensure that an adequate number remain available for nesting; maintain at least 1,000 miles of loggerhead nesting beaches and adjacent uplands within public or private conservation lands for sea turtles.
- **Outcome:** Reduce sea turtle mortalities cause by interactions with fisheries in the Gulf of Mexico.

Four of seven subspecies of the diamondback terrapin can be found in the Gulf of Mexico. The species is under pressure from a variety of sources including drowning in commercial crab traps and loss of suitable nesting habitat. Terrapin drowning deaths have been well documented throughout their range. Excluder devices have been tested in several states along the Atlantic Coast and have led to some states adopting excluder regulations

Kemp's Ridley hatchlings. Erika Nortemann/© 2010 The Nature Conservancy

of one type or another. For example, the Mississippi Department of Marine Resources (DMR) has introduced excluders to local fishermen by including them on crab traps that DMR distributed after Hurricane Katrina. In addition to drowning deaths, lack of nesting habitat is likely to be the greatest limiting factor on the species. Purchase of appropriate nesting habitat will provide Louisiana protection. Terrapin nesting areas are not always sandy beaches and terrapins have been documented nesting in a variety of habitats.

- **Outcome:** Protect terrapin habitat by minimizing anthropogenic disruption of habitat and by acquiring appropriate and available lands from willing sellers.
- **Outcome:** Reduce by-catch drowning in crab traps through implementation of a terrapin excluder device program. Encourage compatible fishing practices and proper disposal of derelict crab traps.

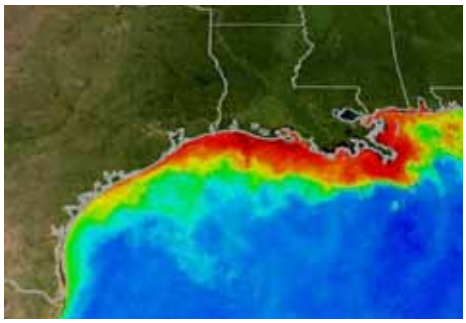
Restore Water Quality and Hydrologic Function

Goal: Improve water quality in coastal, near-shore, and offshore waters and ensure sufficient freshwater inflows into coastal waters and sediment deposition into coastal wetlands to maintain healthy, productive habitat for fish and wildlife.

Why is it important? Freshwater flow is critical to healthy coastal ecosystems. In the Gulf of Mexico, the existence and health of many estuaries is directly linked with riverine processes that deliver fresh water, sediment, and nutrients to coastal waters to moderate salinity, build and sustain floodplain habitats, and support coastal fisheries. Without this connection, the effects of saltwater intrusion and subsidence seriously threaten wetland habitat. The quality of the water flowing into the Gulf is likewise important. At present, a hypoxic zone covering 6,000 to 8,000 square miles develops in the Gulf each summer just off the Mississippi River Delta. This "dead zone" arises from a combination of agriculture-driven nutrient loading upstream and levee-induced funneling of water, sediment, and nutrients into the deep waters of the Gulf of Mexico (Rabalais and Turner 1996). Without these alterations, a good amount of these nutrients would be distributed (along with water and sediment) into the Mississippi Delta wetlands. The "dead zone," disappearing wetlands, and imperiled estuaries all demonstrate the importance of managing rivers, streams, floodplains and watersheds (both coastal and upstream) to re-establish healthy freshwater inflow processes and ensure the beneficial delivery of sediments and nutrients to coastal systems. These corrections are particularly important in light of the fact that the population of this region is expected to double in the next 40 years.

- **Outcome:** Review, revise, and implement the Environmental Protection Agency's Hypoxia Action Plan to dramatically reduce the size and harmful impact of the "dead zone" in the Gulf of Mexico.
- **Outcome:** Meet water quality standards for pathogens and nutrients, using Total Maximum Daily Loads (TMDLs) established for bay systems all along the Gulf Coast to reduce hypoxic zones and harmful algal blooms.

- **Outcome:** Guided by a scientifically sound flow regime established for each bay and estuary system along the Gulf Coast, ensure the delivery of freshwater inflows sufficient to maintain healthy populations of ecologically and economically important species characteristic of each bay, and sufficient to maintain estuaries as functional ecosystems.
- **Outcome:** In Louisiana, improve the management of existing freshwater diversion structures to increase their ability to build and sustain wetlands.
- **Outcome:** In Louisiana, construct and operate a series of large-scale diversions of freshwater and sediment from the Mississippi River capable of building and sustaining Delta wetlands. (See section on Wetlands.)
- **Outcome:** In Louisiana, improve water management in the Atchafalaya River to improve water quality, benefit coastal forest and wetland habitats, and reduce Gulf hypoxia.



"Dead zone" in the Gulf. © NASA

Conserve special places on land and in water

Goal: Conserve a network of special landscapes and seascapes in the Gulf to reverse the trend of habitat loss and to serve as special examples of Gulf habitats and cultural values associated with the Gulf's communities. Increase area-based conservation and public access to special places through adequate policy.

Why is it important? Connectivity is a process of ecological linkage resulting from geographical movement of individuals of a population from one habitat site to another during any life stage. In conserving marine biodiversity in the Gulf of Mexico, connectivity helps maintain a network of functional seascapes that support a healthy flow of benefits to biodiversity (e.g. marine aggregations in nursery areas and feeding grounds), and to human communities (e.g. regulating biological interactions that lead to healthy fish stocks). Connectivity represents an ecological insurance policy providing populations with resilience to substantial disturbances, whether they are natural or anthropogenic.

In the Gulf, near-shore coastal (e.g. bays and estuaries) and offshore oceanic habitats (e.g. reefs and banks) constitute 'stepping stones,' representing ecological nodes that are connected via passive and active movements throughout the Gulf and Caribbean (Ritchie and Keller 2008). In addition to planktonic organisms, some highly migratory species demonstrate active movement throughout the Gulf and Wider Caribbean following connectivity paths that include local and regional post-settlement movement and larger migrations that can span long distances. Good examples of such are whale sharks movements along the Northern Gulf, the Yucatan Straight and the Mesoamerican Barrier Reef in the Caribbean (Hueter et al. 2009); and sea turtles, movements between foraging grounds and nesting beaches from the U.S., Mexico and Cuba (Girard et al. 2009).

Decades of significant development and degradation of the Gulf's coastal areas have led to large-scale loss of habitats and their associated species and services. Conservation efforts should focus on key sites and areas, as well as functional networks of protected areas (Ritchie and Keller 2008) defined by stakeholders and informed by science to sustain social, economic and environmental values.

The Gulf region has a vast maritime heritage that is a vital economic engine for the nation, supplying trillions of dollars to the economy of the United States. These special cultural and maritime sites should be protected so that their cultural and ecological "sense of place" is maintained.

- **Outcome:** Form and empower local and regional partnerships to promote sustainable management of coastal landscapes, seascapes, and cultural areas for conservation and public access.

- **Outcome:** Using the best available science and an open and transparent stakeholder process, identify key marine aggregations and stepping stone areas that are connected in the Gulf that need additional conservation efforts. Conserve 30 percent of these key areas by 2020. These areas support critical processes and provide essential benefits to biodiversity and human communities.
- **Outcome:** Identify key marine aggregations and stepping stone areas in Mexican and Cuban waters, together with stakeholders and partners from these two countries, and promote and support their conservation by 2015.
- **Outcome:** Support and develop an international network of coastal and marine managed areas in the Gulf of Mexico, with different levels of protection, that in total provide essential benefits to biodiversity and human communities by 2030.

Oyster tonging at Grand Bay National Wildlife Refuge. © Lynda Richardson

Fishing off the Texas coast. Erika Nortemann/© 2010 The Nature Conservancy

Supporting Activities

Develop an Environmental Report Card and Long-term Monitoring Plan

Objective: To assure that there are scientifically sound measures to monitor and report the progress of restoration projects and to report on the health of the Gulf of Mexico.

Why is it important? Monitoring and reporting the outcomes of restoration projects and meeting long-term ecosystem goals for the Gulf of Mexico are critical tools for informing policy makers and the public. Transparency in planning, restoration, monitoring, and reporting keeps all parties informed about large investments in ecosystem processes and services. Since monitoring all aspects of an ecosystem is impractical, even impossible, certain ecological indicators can be monitored that represent the entire system. Leading Gulf of Mexico scientists should select these indicators, and all of them should have strong scientific data to support their long-term analysis and utilization. The Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi has initiated the development of just such a Gulf of Mexico report card framework (McKinney et al. 2011).

Strengthen Science-Based Adaptive Management

Objective: Support science-based adaptive management through the establishment of a long-term and stable research and monitoring program. Use monitoring and science results to evaluate the effectiveness of restoration activities and make adjustments to future plans and priorities based on the results.

Why is it important? We must continually look at the results the Strategy is achieving and make whatever adjustments are necessary to ensure that Gulf restoration makes good progress and improves results over time. This will require setting measurable goals, ensuring sufficient monitoring programs are in place, and developing processes where the monitoring results are fed back into future decision-making. This will promote accountability and ensure that we are getting the best results for the Gulf that we can with the resources available to implement the Strategy.

Incorporate the Impacts of Climate Change into Restoration Planning, Design and Implementation

Objective: Incorporate impacts from climate change into planning, design and implementation, and promote the use of ecosystems' infrastructure for natural and human communities to adapt to the threats posed by climate change.

Why is it important? Climate change will continue to exert a growing influence on the Gulf of Mexico. Changes such as sea level rise, ocean acidification, warming waters, more intense storms, altered precipitation patterns, and other climate-related impacts will need to be taken into account both in the development of the Strategy and the implementation of projects. Promoting resilience of natural systems will need to be an important part of this consideration because healthy ecosystems benefit humans and other natural systems by regulating the disturbances created by climate-related hazards. Functional ecosystems can enhance the resilience of communities living in the coastal areas by reducing the vulnerability of the threats posed by storms, sea level rise and other climate-related impacts. Promoting the resilience of natural systems will help promote the resilience of human communities along the Gulf coast. To promote resilience, local decision-makers are in need of high resolution topographic information and accurate models so they can easily visualize and assess the vulnerability of communities, habitats, and infrastructure. Decision-makers also need decision support tools so they can fully account for costs and benefits to thoughtfully make tradeoffs between policy options.

Develop A Restoration Economy

Objective: Ensure that there is a local infrastructure in place to support restoration activities.

Why is it important? The Gulf Coast region is potentially facing a major opportunity to create a restoration economy that could inextricably link economic development, such as job creation and technological innovation, to restoration activities. Much work needs to be done to prepare the region for a large influx of restoration funding such as identifying and determining how to meet the potential need for labor, materials, and technologies to support restoration activities on a large scale. By supporting economic development and job development on the front end, we can ensure that we have the infrastructure ready to support large-scale restoration and the restoration dollars that flow into the Gulf are putting people in the region to work.

Boat People SOS and other members of the 100-1000: Restore Coastal Alabama coalition are partnering to employ out-of-work members of the local Southeast Asian fishing community to help construct materials for oyster reef restoration in Mobile Bay. © 2010 Andrew Kornylak

Develop Market-based Solutions to Help Protect the Value of Nature

Objective: Investigate and develop market-based solutions to incorporate the value of ecosystem services the Gulf of Mexico provides.

Why is it important? Ecosystem services are the benefits that humans obtain from natural infrastructure. In the Gulf, people benefit from abundant fisheries, coastal wetlands that increase protection from storm surge, and clean beaches that provide recreational opportunities, just to name a few. Due to the lack of economic markets for most of these services, they are usually not adequately taken into account in the decision-making process, which can result in the unaccounted for degradation of the services natural systems provide. Market-based approaches (e.g. carbon sequestration) may provide innovative solutions to adequately capture the values that nature provides to society. The Strategy should include a component where market-based solutions are investigated, developed and incorporated where appropriate in relevant decision-making processes related to Gulf natural resources

Paddling in Aransas Pass, Texas. Erika Nortemann/© 2010 The Nature Conservancy

Promote Citizen Science and Stewardship through Expanding Environmental Education and Outreach

Objective: Foster environmental education and outreach needed to increase the number of citizens participating in science and stewardship initiatives.

Why is it important? People value what they know. Education programs that help people understand linkages between nature and their own well-being engage citizens in appreciating and stewarding their environment. Likewise, when citizens acquire specific expertise through data collection—a process known as citizen science—they are more likely to develop a strong stewardship ethic toward nature. The value of citizen science is to facilitate the collection of reliable data across extensive geographic areas as a critical component of understanding anthropogenic effects on wildlife and habitats.

Engaging citizens in stewardship through habitat restoration, wildlife and habitat monitoring, trail maintenance, and beach clean-ups will also create relationships between communities and their environment, enhancing an appreciation of natural communities. Existing programs that engage citizens in stewardship utilizing partnerships between state and federal agencies, universities, non-profits, and community organizations form the basis for ongoing citizen science, which should be expanded to address current and future conservation needs.

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