A Strategy for a Healthy Gulf of Mexico:

Resilience through Ecosystem Restoration

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The Gulf of Mexico (Gulf) is vital to our Nation and our economy, providing valuable energy resources, abundant seafood, extraordinary beaches and recreational activities, and a rich cultural heritage. Even before the *Deepwater Horizon* (DWH) oil spill of 2010, the health and function of the Gulf ecosystems and economies have suffered from decades of significant human and natural stressors. The Gulf has experienced chronic loss of critical wetland habitats, erosion of barrier islands, imperiled fisheries, water quality degradation, impacts from invasive species, and substantial coastal land loss due to natural forces, the alteration of hydrology, and impacts from other human activities. In addition, the Gulf Coast region has endured repeated natural catastrophes, including major hurricanes such as Katrina, Rita, Gustav, and Ike. The National Oceanic and Atmospheric Administration (NOAA) has a responsibility, driven by the agency's stewardship mandates, to help ensure the nation, including the Gulf, has a strong foundation of resilient ecosystems that sustain thriving marine and coastal resources, communities, and economies.

Facing the impacts of a rapidly changing environment, the nation must consider alternate approaches to increase our resilience to these threats and seek innovative ways to improve the condition and resilience of coastal habitats and the ecological and human communities that rely on them. Fully incorporating the values of functioning habitat into economic considerations in coastal and fisheries management is a fundamental evolution in how we improve resilience of habitats, living resources, and communities in the long term. Improving the science and accuracy in how we value ecosystem services will also further economic analyses and incentives to advance natural or green infrastructure (e.g., living shorelines) and promote consideration and investment in the multiple services provided through habitat restoration and conservation. NOAA will be a strong, on-the-ground leader, partner, and collaborator for these efforts, and provide expertise in science and natural resource management and policy to catalyze action to restore, protect, and sustain a resilient Gulf of Mexico ecosystem.

Any path to a healthy Gulf of Mexico must build on previous and existing opportunities, and rely on the strengths of government, industry, academia and nongovernmental organizations; No one entity has the capacity or capability to accomplish such a broad mission alone. Three recent directives from President Obama capture the need for an ecosystem approach to build a healthy and viable Gulf:

- *Louisiana-Mississippi Roadmap for Restoring Ecosystem Resiliency and Sustainability* (http://www.whitehouse.gov/administration/eop/ceq/initiatives/gulfcoast);
- *R*ecommendations proposed by Secretary of the Navy Ray Mabus in *America's Gulf Coast: A Long Term Recovery Plan after the Deepwater Horizon Oil Spill* (http://www.epa.gov/gmpo/pdf/gulf-recovery-sep-2010.pdf); and
- *The Gulf of Mexico Regional Ecosystem Restoration Strategy*, a joint federal, state, local, tribal, and stakeholder-driven document (http://www.epa.gov/gulfcoasttaskforce/pdfs/GulfCoastReport_Full_12-04_508-1.pdf).

The results provided by these multi-agency efforts provide a foundation for the current funding streams from the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act of 2012 (RESTORE Act), the Gulf Environmental Benefit Fund (GEBF), and the Natural Resource Damage Assessment (NRDA). Other funding opportunities are available through federal, state, academic, and industry partnerships, which provide for unprecedented opportunity in the Gulf to work together to craft a new path toward ecosystem recovery and increased coastal resilience for the region.

Although all related generally by a focus on the Gulf region, these various initiatives operate through differing goals, authorities and mandated processes. Some of these initiatives are still working through these processes, the resolution of which may also require an opportunity for public comment and conclusion of ongoing litigation. In particular, NRDA, the mechanism through which the public will be compensated for injuries to natural resources caused by the *Deepwater Horizon* oil spill, is currently in the process of injury assessment, which will inform the development of corresponding restoration plans. The NRDA-developed injury assessment and proposed restoration plans will be subject to a public process of review and comment and, ultimately, judicial consent and approval. Nothing in this document is intended to contradict or impede the ongoing NRDA or processes that may be going ongoing under other initiatives. Instead, this document identifies general priorities and actions where NOAA seeks to use its collective mandates, science, management and policy expertise to collaborate with our state, federal, academic, industry and NGO partners (regional and national) to help restore the Gulf ecosystem and economy and extend our commitment to a Gulf-wide, ecosystem-scale approach to recovery and restoration.

Resilience Objectives for the Gulf of Mexico

The goal and objectives outlined here cannot be achieved by NOAA alone, but rather will require a robust collaborative effort with our partners to implement an aggressive coordinated science-based approach to restore the impaired Gulf ecosystem and to protect it from further degradation. To realize a healthy, functional ecosystem that sustains resilient and thriving marine and coastal resources, communities and economies in the Gulf of Mexico, NOAA will pursue the four objectives outlined below.

1) Support Science to Inform Decision-Making and Investments

All of the restoration efforts and the entire region will benefit from collaborative work toward a science-based approach focused on the overall long-term health, prosperity and resilience of the Gulf Coast region. NOAA is well-positioned to ensure science informs decision-making throughout the many forums and venues where critical choices will be made supporting restoration and long-term sustainability. As a science-based agency, NOAA brings its expertise and experience to bear in planning and implementing the foundational research, modeling, monitoring, and decision-support tools, to ensure a healthy, functional Gulf ecosystem in the face of scientific uncertainty. NOAA is also implementing the RESTORE Act Science Program, which supports an integrated and holistic understanding of the Gulf of Mexico ecosystem.

NOAA will coordinate with federal agencies, the Gulf's RESTORE Centers of Excellence, the Gulf States themselves, and other restoration groups to integrate robust science into restoration decision-making processes.

2) Improve Coastal Community Resilience

From oil spills to hurricanes, NOAA provides unique science and services in support of resilient coastal communities. Resilience is the capacity of human and natural/physical systems both to "bounce forward" by recovering quickly after a disaster or other hazardous event, and adapting over time in ways that minimize vulnerability. Gulf Coast communities face many challenges related to balancing growth, mitigating risks from existing coastal hazards, adapting to climate change, and protecting natural infrastructure (i.e., wetlands, barrier islands, living shorelines, etc.), all of which affect resilience. Building resilience is an economic imperative for the Gulf region – individuals, businesses, communities, and ecosystems that protect and support them all need to be more resilient in order to sustain and grow the region's economic prosperity. The likelihood of robust funding for restoration, recovery, and science

programs in the wake of the *Deepwater Horizon* oil spill present a unique opportunity for NOAA to provide national leadership and strategic assistance to help Gulf Coast communities become more resilient.

NOAA will work with communities to improve community understanding, consideration and adaptation to coastal hazards and climate risks, vulnerabilities and potential impacts, including efforts to develop standards for and indicators of community resilience. Further, NOAA will improve community understanding of the benefits of natural and nature-based infrastructure, and support implementation as a complement to or in place of built infrastructure, to enhance resilience to coastal hazards.

3) Restore and Conserve Key Habitats

Habitat throughout the Gulf of Mexico has been and continues to be in a state of deterioration and decline. Gulf-wide, coastal wetlands are being lost at alarming rates as a result of sea level rise, land development, channelization, storms, erosion, hydrologic modifications, and impacts from invasive species climate change. Along with habitat, we are losing the natural infrastructure that sustains resilient and thriving marine and coastal resources, communities, and economies. The Gulf of Mexico has a broad array of coastal and marine habitats that include coastal wetlands, submerged aquatic vegetation, coral reefs, ridges and shelves, barrier islands, as well as upland and riparian habitats. This priority is not directed towards specific species, but focuses on the conservation and restoration of entire habitats, which will ultimately benefit all species and the ecosystem services they provide.

To address this priority NOAA will leverage its existing habitat-directed and place-based programs to generate partnerships with federal, state, tribal, and local governments, non-governmental organizations, and private landowners. Efforts will include wetland and barrier island restoration through debris removal, sediment management, re-vegetation, hydrology improvements; land acquisition, the management and prevention of potential invasive species. Such efforts will provide long-term protection of key habitats, improve regulatory programs, deliver tools and data to coastal planners, and address management needs and capacity of special places through NOAA's coastal programs.

4) Restore and Sustain Living Coastal and Marine Resources

The Gulf is inhabited by many economic and ecological importance species, including rare, threatened, or endangered species as well as those that are valued for their role in commercial or recreational fisheries, the diversity and resilience of the Gulf, or their importance to local economies and quality of life. Such species may include fish, marine mammals, sea turtles, sea birds, as well as those within coral reefs, mesophotic, or deep benthic communities. These organisms are the principal components of an interconnected ecological web that influences the structure and function of the Gulf. Environmental stressors originating from humans (e.g., overfishing, pollution, habitat loss, and invasive species) and natural phenomena (e.g., climate change, hurricanes, and harmful algal blooms) have substantial impacts on these species. In addition, the *Deepwater Horizon* oil spill added significant acute and chronic stress to living marine resources and their habitats. While it is important to dedicate restoration activities broadly across habitats upon which these resources rely, it is equally important to develop species or community-specific restoration actions to directly support the recovery of these valuable and unique resources. The NRDA evaluation and corresponding public review process is still ongoing, but it is conceivable that habitat restoration may be sufficient to address many species losses and inhibition of their functionality as a result of oil exposure. For others, it may be necessary to implement actions to reduce mortality and promote healthy populations in order to complement habitat restoration activities.

NOAA and partners will target species known to be critical ecosystem components, including apex predators as well as lower trophic level species to determine the best options for recovery. For some resources, protection and conservation may be the best option for restoration. Because of the size and magnitude of the spill, and the relative dearth of information available on many of the impacted living coastal and marine resources, advancing scientific knowledge of these resources and their interactions should be considered as a critical component of restoration actions and associated research. NOAA is committed to including this component in the NOAA RESTORE Act Science Program as well as its own ongoing scientific work in the Gulf.

Building on the Strength of NOAA's Cross-Cutting Capabilities

NOAA's investment must consider ecosystem stressors as well as current and future conditions to achieve a healthy and functional ecosystem that sustains resilient and thriving marine and coastal resources, communities, and economies. To effectively address these threats, meet Agency mandates, and make resource management decisions, NOAA will promote habitat protection and restoration in a landscape-scale[1] context. This context includes connective coastal and marine habitats and considers the ecosystem value of those habitats.

NOAA's investments will focus on critical ecological processes, connectivity between habitats and species, and ecosystem services for coastal communities. NOAA will be a strong, on-the-ground leader, partner, and collaborator, providing considerable expertise in science and natural resource management and policy to catalyze action to restore, protect, and sustain the Gulf of Mexico ecosystem. In this regard, we define these various roles in the following manner:

- **Lead** – directly develop and implement restoration actions unique to NOAA trust resources, mandates, jurisdictions, and expertise.
- **Partner/Leverage** – cooperatively implement restoration with existing partnerships, councils, coalitions, and joint jurisdictions.
- **Inform** – conduct, collaborate, and integrate science and technical expertise into restoration decision-making in an ecosystem context.

The ongoing NRDA process will result in its own set of restoration criteria and priorities, but for other Gulf initiatives the time is appropriate for NOAA to develop a strategic plan for engagement. Setting resilience and restoration criteria enable NOAA to select the right tools to get the best outcomes across species, habitats, and ecological services. It also allows NOAA to target science on questions critical to restoring the ecological processes, habitats, species, and services necessary for Gulf ecosystem restoration. With these objectives and potential roles in mind, NOAA has identified and a set of primary stressors which are generally associated with coastal and estuarine/freshwater, nearshore, and bluewater systems to help guide collective efforts to achieve a resilient Gulf of Mexico through ecosystem restoration:

1) Coastal and Estuarine/Freshwater Systems Resilience and Restoration (Partner/Leverage)

Major rivers like the Mississippi River, as well as several other large rivers and many estuaries are found throughout the Gulf of Mexico. The quantity and quality of the fresh water coming from these systems

[1] A landscape contains ecological processes, geographic patterns, and a variety of socio-economic attributes that must be considered in fashioning large-scale conservation strategies. A landscape also encompasses marine areas that may be described by the term "seascape."

significantly impact the coastal physical-chemical characteristics and biological communities of the region. The delta-building processes of these river systems have created a vast landscape of fresh to saline marshes, bottomland hardwood swamps, barrier island chains, and natural ridge systems that house some of the most ecologically diverse estuaries in the world.

Stressors Affecting Coastal and Estuarine/Freshwater Resilience and Restoration (independent of conclusions reached in the ongoing NRDA):

Resource	Stressors
Coastal and estuarine/freshwater species, habitats, and water column	Impacts from *Deepwater Horizon* oil spill, climate change, introduction of non-native species
Protected resources, including sea turtles and mammals	Bycatch, impaired water quality, marine debris, human interaction, habitat degradation, toxic algal blooms, impaired water quality, and introduction of non-native species
Coastal and estuarine/freshwater habitat	Subsidence, erosion, storm impacts, development, hydrologic alteration, climate change, relative sea level rise, disease, invasive species, eutrophication, sea grass bed damage and loss, loss and degradation of shoreline habitats, coastal wetland and barrier island loss, altered freshwater inflows
Oyster reefs	sedimentation, disease, hydrologic alteration, parasites, impaired water quality, toxic algal blooms, and storm impacts

Natural infrastructure (NI) is a primary mechanism for achieving and maintaining coastal resiliency, but its definition and meaning varies from agency to agency. For example, the Environmental Protection Agency typically uses "green infrastructure" as it relates to stormwater management, particularly in cities. The Army Corps of Engineers refers to "nature-based," meaning managed and hybrid infrastructures including living shorelines. In NOAA's efforts to strengthen community resilience, NOAA is promoting the use of natural and nature-based (or hybrid) infrastructure. We define these to include a continuum of approaches and natural or hybrid systems to build or maintain more resilient communities and ecosystems, including a range of options from protected ecosystems (such as salt marshes, mangroves, reefs, seagrass beds, and sand beaches and dunes) to more engineered structures that involve a combination of natural and traditional grey infrastructure (i.e., ecosystem approaches mixed with sea walls, levees, culverts, bulkheads, and other hardened structures).

- ***Natural Infrastructure***: Natural infrastructure refers to healthy ecosystems (i.e., those that conserve natural ecosystem values and functions), including forests, wetlands, floodplains, dune systems, barrier islands and reefs that provide multiple benefits to communities, such as storm protection through wave attenuation or flood storage capacity and enhanced water services and security.
- **Nature-based or hybrid infrastructure***:* Nature-based infrastructure refers to engineered systems where natural features are combined with more hard or structural engineering approaches to create a hybrid system. One example is living shorelines, which is an approach that uses plants, sand, and limited use of rock to provide shoreline protection and maintain valuable habitat.

From a public communications perspective, it is recognized that the term "natural infrastructure" can generally be used to encompass all types of infrastructure where ecosystems or habitats are used, including

protected, managed and hybrid systems that are applied along the coasts. Our federal, state and local partners, as well as the private and non-governmental sectors, are looking to NOAA for our expertise in linking science-based information to community well-being. This strategy will be used to meet this need by focusing NOAA's relevant capabilities to strengthen three fronts—advancing understanding of NI benefits, tradeoffs and services, enabling communities and partners to adopt resilient approaches, and building capacity on the ground. The strategy also will demonstrate the greater value of NOAA when we harness and coordinate efforts, and will be used to share and pursue resources through a collective approach toward building NOAA's capacity to address NI.

2) Nearshore Resilience and Restoration (Partner/Leverage; Inform)

Many species depend on healthy nearshore habitats, including threatened and endangered sea turtles, dolphins, manatees, reef fish, and many juvenile marine fish species. This highlights the need to address scientific gaps to improve species management. The nearshore areas provide a range of ecosystem services important to people including recreation, tourism, and commercial and recreational fisheries that supports the Gulf of Mexico economy.

Stressors Affecting Nearshore Resilience and Restoration (independent of conclusions reached in the ongoing NRDA):

Resource	Stressors
Marine species, habitats, and water column	impacts from Deepwater Horizon oil spill, climate change and introduced non-native species
Protected resources, including sea turtles and mammals	bycatch, marine debris, human interaction, impacts to migratory routes, habitat degradation, toxic algal blooms, impaired water quality, introduction of non-native species, and scientific gaps to improve protection
Marine fisheries	fishing pressure and associated trophic interactions, bycatch, habitat degradation and loss, interactions with invasive species, restricted fish passage, impaired water quality, toxic algal blooms, impaired water quality, and climate change
Nearshore habitat	nutrient-driven eutrophication, hypoxia, toxic algal blooms, invasive species, heavy metals, declining water quality affecting priority habitats and species, hydrologic alterations, subsidence, and climate change

3) Bluewater Resilience and Restoration (Lead)

The Gulf of Mexico Basin is characterized by a section of the large central abyssal plain and a steep continental slope extending from the broad continental shelf. Important bathymetric and morphological features affecting the distribution and abundance of marine species include seafloor relief (e.g., shelf edges and canyons), water temperature, ocean currents (e.g., the Loop Current), and cyclonic and anti-cyclonic eddies. Protected species such as marine mammals and sea turtles are often found near oceanographic features such as areas of mixing and upwelling near the shelf edge, sargassum mats, oceanic fronts, currents, and cyclonic eddies where many species find feeding opportunities. Many pelagic species also

migrate seasonally or inhabit large home ranges as part of their life histories. For example, the western Atlantic bluefin tuna range widely in the Atlantic Ocean, but return to Gulf of Mexico waters as one of only two known spawning grounds. Gag Grouper live in estuaries during their juvenile stage; however, they move into the offshore Gulf of Mexico during the adult stage. Further, NOAA's place-based management strategies in marine protected areas strengthen species and habitat connections in the Gulf ecosystem. For example, a network of functional habitats can support ecological linkages such as biodiversity and recruitment after disturbance. These examples demonstrate the importance of healthy, interconnected marine habitats to restore a productive functional Gulf ecosystem.

Stressors Affecting Bluewater Resilience and Restoration (Independent of conclusions reached in the ongoing NRDA):

Resource	Stressors
Marine species, habitats, and water column	years of oil drilling, impacts from Deepwater Horizon oil spill, climate change, introduction of non-native species
Protected resources, including sea turtles and mammals	bycatch, marine debris, human interaction, habitat degradation, introduction of non-native species
Marine fisheries	fishing pressure, bycatch, habitat degradation and loss, impaired water quality, toxic algal blooms, interactions with invasive species, and climate change
Coral, mesophotic reefs, and deep benthic habitats	direct disturbance, impaired water quality, climate change, and scientific gaps to improve species protection
Marine microbes	community ecology and roles in degradation of oil

Foundational Principles of the Strategy

***Invest in Foundational Science**:* Investment in reliable and authoritative foundational science will support decision-making by providing actionable information. A strong foundation of natural and social science improves knowledge of status and trends to better identify and understand potential shifting resource and ecosystem conditions and their impacts on society, and also provides the basis for evaluation of restoration and recovery projects.

***Incorporate the Value of Ecosystem Goods and Services into Decision Making**:* Beyond the benefits that they provide for fish and wildlife, healthy coastal and marine habitats provide many benefits to society — often referred to as "ecosystem services". This includes services such as storm protection, pollution removal, climate regulation, nutrient cycling, and many aesthetic, cultural, and recreational values, as well as tourism and jobs. Fully incorporating the values of functioning habitat, green infrastructure, and blue carbon into economic considerations in coastal and fisheries management would be a fundamental evolution in how we improve resilience of habitats, living resources, and communities in the long term. Improving the science and accuracy in how we value ecosystem services will also further economic analyses and incentives to advance green infrastructure and will promote consideration and investment in the multiple services provided through habitat restoration and conservation.

Adaptive management: Successful restoration depends on routine and systematic evaluation and monitoring of information and results, and then altering science and management approaches accordingly to achieve the desired ecosystem conditions. Other factors also influence decisions to alter the existing

approach, such as socioeconomic considerations, stakeholder participation, conflict resolution, legal and policy barriers, and internal agency challenges. Adaptive management is an approach to managing natural resources that emphasizes learning from the implementation of initiatives and processes. For adaptive management to be effective, a strong climate of trust among partners is essential.

Sustained Observing and Monitoring: A comprehensive environmental monitoring network for habitat and water quality is a foundational element necessary to make scientifically sound decisions regarding the health and viability of the Gulf of Mexico ecosystem. Relevant information is required for managers operating at different geographic scales to make informed decisions to effectively manage ecosystem resources across the Gulf of Mexico. In the context of Gulf protection and restoration, an environmental monitoring and socio-economic network should provide the information necessary to support the development, selection, and application of successful management and restoration project alternatives, and inform adaptive management decisions at the local, state, and regional levels. A collaborative organizational structure is needed that will incorporate all restoration partners. One possible mechanism to develop an effective network would be through development of a monitoring Community of Practice (CoP). The CoP could provide opportunities to: share lessons- learned, best practices, and resources; collect high-quality data and maintain consistency and compatibility in data used to help assess restoration success reducing duplication of efforts and monitoring costs.

***Data Management/Informatics*:** An array of federal, state, local, academic, and non-governmental agencies are involved in efforts to better understand the Gulf, and with those efforts come demands for spatial and non-spatial data products and tools to support restoration planning and adaptive management. The RESTORE Act, the NOAA-administered RESTORE Act Science Program, and the State Centers of Excellence, will generate volumes of environmental data, information, products, and services. In research funded by NRDA and the National Fish and Wildlife Foundation (NFWF), this data has already begun to be generated and collected. There is a need for a comprehensive approach to preserve, discover, and serve these data publically to maximize the investment by allowing multiple uses of the data while minimizing duplication of effort. Progress toward meeting this need can be made by using current standards of practice for data description and web services, and through implementation of the Public Access to Research Results (PARR) initiative. Data visualization and access can then be integrated across the numerous entities involved in activities to restore the Gulf of Mexico ecosystem.

Conclusion

Through this strategy NOAA seeks to craft a path toward ecosystem recovery and increased coastal resilience for the Gulf region. Recognizing the Gulf Coast region as vital to our Nation and our economy, NOAA and our partners have a unique opportunity to coordinate ecosystem restoration to benefit coastal communities and economies. NOAA will do this by pursuing activities in accordance with this strategy; partner with the Gulf States and partners and work with other Federal agencies to achieve a holistic and comprehensive approach to restore a healthy and resilient Gulf ecosystem.