Gulf Coast Ecosystem Restoration Science, Observation, Monitoring, and Technology Program

NOAA RESTORE Act Science Program

Draft Science Plan

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Executive Summary

In 2012, the U.S. Congress passed the "Resources and Ecosystem Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act" (Public Law 112-141, Sect. F; "RESTORE Act"). The RESTORE Act transfers 80% of all administrative and civil penalties paid by responsible parties in connection with the Deepwater Horizon incident to a Gulf Coast Restoration Trust Fund. The RESTORE Act also established several programs funded by the Trust Fund to aid in the ecological and economic recovery of the Gulf Coast states. Under Section 1604 of the RESTORE Act, the National Oceanic and Atmospheric Administration (NOAA) was directed to establish a Gulf Coast Ecosystem Restoration Science, Observation, Monitoring, and Technology Program (NOAA RESTORE Act Science Program). This plan lays out the pathway for the program.

NOAA's vision for the RESTORE Act Science Program is long-term sustainability of the Gulf of Mexico ecosystem and the communities that depend on it. The program's mission, as directed in the RESTORE Act, is to initiate and sustain an integrative, holistic understanding of the Gulf of Mexico ecosystem and support, to the maximum extent practicable, restoration efforts and the long-term sustainability of the ecosystem.

For this plan, the program has defined the Gulf of Mexico as the Gulf of Mexico Large Marine Ecosystem (LME), with an emphasis on marine and estuarine environments. The Gulf of Mexico LME includes waters that extend beyond U.S. State and Federal waters (i.e., international waters). NOAA envisions that its science investments will evolve over time and will adapt to changes in knowledge and technologies.

The NOAA RESTORE Act Science Program is an opportunity to help integrate science efforts across the Gulf ecosystem into a unified program capable of addressing science-based management questions on the connectivity of the entire Gulf of Mexico ecosystem and advance overall understanding as an integrated system. The content of this plan highlights long-term priorities, initial areas of investment for the program and the process by which they were determined, and the anticipated sequencing of investments.

The following long-term priorities for implementing the program were drawn from prior science and research needs assessments for the Gulf of Mexico and from input the program received from stakeholders during engagement sessions.

- Increase comprehensive understanding of Gulf ecosystem services, resilience, and vulnerabilities of coupled social and ecological systems.
- Construct management-ready and accessible ecosystem models for the Gulf of Mexico.

- Improve forecasting, analysis, and modeling of climate change and weather effects on the sustainability and resiliency of Gulf ecosystems.
- Increase comprehensive understanding of watershed, sediment, and nutrient flows and impacts on coastal ecology and habitats.
- Increase comprehensive understanding of living coastal and marine resources, food web dynamics, habitat utilization, protected area, and carbon flow.
- Analyze new and existing social and environmental data to develop long-term trend and variability information on the status and health of ecosystems, including humans.
- Develop, identify, and validate system-wide indicators of Gulf Coast environmental and socioeconomic conditions.
- Obtain information and develop decision support tools needed to monitor and adaptively manage habitat, Living Marine Resources, and wildlife.
- Network and integrate existing and planned data/information from Gulf monitoring programs.
- Develop and implement advanced engineering, physical, chemical, biological, and socioeconomic technologies to improve monitoring.

In establishing these long-term science priorities, NOAA reviewed the numerous science and research needs assessments documented for the Gulf of Mexico over the past several years and conducted over 100 meetings to seek input from stakeholders, including representatives from the Gulf States Marine Fisheries Commission, Gulf of Mexico Fishery Management Council, universities, federal agencies, and non-governmental organizations. This plan will be refined over time and will be based on new knowledge and greater understanding generated by activities sponsored under the full scope of the program or in response to any additional resolutions under the Clean Water Act that resulted from of the Deepwater Horizon event (i.e., additional funding for the program).

Section I: Background

1.   RESTORE Act Section 1604

In 2012, Congress passed the "Resources and Ecosystem Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act" (Pub. L. 112-141, RESTORE Act). The RESTORE Act specifies that 80% of administrative and civil penalties paid by responsible parties in connection with the *Deepwater Horizon* incident be deposited into the Gulf Coast Restoration Trust Fund. The RESTORE Act also establishes several programs, which will be funded by the Trust Fund, to aid in the ecological and economic recovery of the Gulf and its coastal states. Under section 1604 of the RESTORE Act, the National Oceanic and Atmospheric Administration (NOAA), in consultation with the U.S. Fish and Wildlife Service (USFWS), is directed to establish a Gulf Coast Ecosystem Restoration Science, Observation, Monitoring, and Technology Program. This program will be funded by 2.5% of the funds deposited into the Trust Fund plus 25% of the Trust Fund's accrued interest. Refer to Appendix II for a complete graphical presentation of the funding structure for Deepwater Horizon Gulf restoration initiatives. The explicit purpose of this new program is "to carry out research, observation, and monitoring to support, to the maximum extent practicable, the long-term sustainability of the ecosystem, fish stocks, fish habitat, and the recreational, commercial, and charter-fishing industry in the Gulf of Mexico." (Section 1604(b)(1)).

Section 1604 also includes the following specific instructions regarding the Program:

- NOAA and USFWS must consult with the Gulf of Mexico Fishery Management Council (GMFMC) and the Gulf States Marine Fisheries Commission (GSMFC) in carrying out the Program. [Section 1604(b)(4)]
- Annually funds "may be expended for marine and estuarine research; marine and estuarine ecosystem monitoring and ocean observation; data collection and stock assessments; and pilot programs for fishery independent data; and reduction of exploitation of spawning aggregations." [Section 1604(b)(2)].
- In distributing funds for research, "priority shall be given to integrated, long-term projects that build on, or are coordinated with, related research activities and address current or anticipated marine ecosystem, fishery, or wildlife management information needs." [Section 1604(b)(4)(d)]
- Administrative expenses cannot exceed 3 percent of the funds provided to the Program. [Section 1604(g)(1)].
- Unless agreed to by a grant recipient, the funds cannot support existing or planned research led by NOAA. [Section 1604 (g)(2)(A)]
- Funds cannot be used to implement existing or initiate new regulations promulgated or proposed by NOAA. [Section 1604(g)(2)(B)]

- These agencies shall seek to avoid duplication with other research and monitoring activities. [Section 1604(e)]
- NOAA and USFWS shall develop a plan for the coordination of projects and activities with existing Federal and State science and technology programs. [Section 1604(f)].

Based on the provisions of Section 1604 of the RESTORE Act, NOAA and USFWS have drafted this plan to guide the initial and long-term development and implementation of this section of the Act. In keeping with the explicit purpose of the Act, the plan provides guidance for those seeking funding to focus their research proposals on science that will lead to achieving the program's purpose.

2.   Program and Plan Purpose

The purpose of the NOAA RESTORE Act Science Program is to achieve an integrative, holistic understanding of the Gulf of Mexico ecosystem, as well as to support (to the maximum extent practicable) restoration efforts and the long-term sustainability of the ecosystem, including fisheries, wildlife, habitats, fishing industries, coastal communities and their economies.

The program's emphasis is on conducting science and synthesizing observations and monitoring to provide useful information that improves understanding of the Gulf of Mexico ecosystem. This will lead to more informed management decisions, science-based restoration projects, and ecosystem sustainability, including human communities. NOAA's administration of the program will focus on areas where NOAA has unique capacity and potential for leading significant research with lasting benefits to promote the health of this ecosystem.

This plan lays out the path forward for the program: It outlines key topics for research and development, as well as a progression of science activities that will advance the knowledge, understanding, and capabilities necessary for building and employing holistic understanding of the ecosystem and its response to significant stressors. Given that the amount of funds to be made available has yet to be defined, NOAA envisions that its science investments will evolve over time, adapting to changing information and knowledge. This plan will be refined based on new knowledge and greater understanding of the full scope of the program, pending any additional resolutions under the Clean Water Act (i.e., additional funding for the program) as a result of the Deepwater Horizon event. The content of this plan highlights the initial areas of investment for the program and the process by which those areas were determined. Additionally, it provides information on how the program will be implemented and the partners with which the program will leverage future opportunities.

The RESTORE Act Science Program represents an opportunity and capacity to help coordinate the diverse science efforts across the Gulf into something that will advance overall

understanding, management and sustainability of the Gulf of Mexico as an integrated ecosystem.

3.   Program Vision, Mission, and Outcomes

NOAA's vision for the RESTORE Act Science Program is for long-term sustainability of the Gulf of Mexico ecosystem and the communities that depend on it. The mission statement of the program is to:

> 'Initiate and sustain an integrative, holistic understanding of the Gulf of Mexico ecosystem and support, to the maximum extent practicable, restoration efforts and the long-term sustainability of the ecosystem, including its fish stocks, fishing industries, habitat, and wildlife through ecosystem research, observation, monitoring, and technology development.'

Desired outcomes of the NOAA RESTORE Act Science Program follow:

- The Gulf of Mexico Ecosystem is understood in an integrative, holistic manner.
- Restoration activities are guided by this ecosystem understanding.
- Management of the Gulf of Mexico ecosystem is guided by this ecosystem understanding.
- Long-term sustainability of the Gulf of Mexico ecosystem is achieved, supporting the communities and economies that depend on this ecosystem.

Numerous documents were developed in recent years that identified science needs for the Gulf of Mexico. Many of these documents were produced with extensive stakeholder input and in consultation with resource managers throughout the Gulf States. The overarching goal for this program was developed on the basis of these documents to ensure that high priority and recurring needs were captured, and were in accordance with the RESTORE Act, Section 1604, which created the RESTORE Act Science Program:

> *Support the science necessary for better understanding and management of the Gulf of Mexico ecosystem, specifically:*
>
> - *healthy, diverse, sustainable, and resilient estuarine, coastal and marine habitats;*
> - *healthy, diverse, sustainable, and resilient coastal and marine resources , including wildlife and fisheries; and*
> - *resilient and adaptive coastal communities.*

Research categories are broadly articulated in the RESTORE Act. To ensure that this research program addresses known regional priorities and expends funding judiciously, ten critical

science priorities have been identified to guide investment. The science priorities described below are drawn from, and include explicit reference to, these earlier science needs documents and the requirements of the RESTORE Act. The plan will be executed via sponsoring scientific investigations to advance each of the science priorities; program execution and administration are outlined in Section III. Anticipated products of these investigations, direct outputs, and broader outcomes will enhance the foundation of reliable, accessible, sound science for management needs in sustaining healthy Gulf ecosystems.

4.   **Program Scope**

NOAA's RESTORE Act Science Program provides the basis for both natural and social sciences to inform decision-makers to manage the complex Gulf ecosystem *in integrative and holistic fashion*. NOAA will continue to engage its partners in connecting and improving accessibility of relevant observations and monitoring information, related analyses and modeling components, and serve as a science resource for restoration activities. Multidisciplinary work will leverage related complementary efforts, e.g., in human health effects and impacts. The research, monitoring, assessment, and programs eligible for amounts made available under the program shall include all marine, estuarine, aquaculture, and fish species in State and Federal waters of the Gulf of Mexico.

5.   **Geographic Scope**

Because the Gulf of Mexico ecosystem was not defined in the RESTORE Act for the purposes of the NOAA RESTORE Act Science Program, the program has defined the Gulf of Mexico as the Gulf of Mexico Large Marine Ecosystem (LME), with an emphasis on marine and estuarine environments. Large Marine Ecosystems have natural boundaries based on four ecological criteria: bathymetry, hydrography, productivity, and trophically related populations. In general, they are relatively large regions of coastal waters, are 200,000 km^2 or greater, and extend from river basins and estuaries to the seaward boundary of continental shelves and the outer margins of coastal currents. The Gulf of Mexico LME includes waters that extend beyond the U.S. State and Federal waters (i.e., international waters). The program will support research conducted in the Gulf of Mexico LME, deep waters of the Gulf beyond the continental shelf, and on processes that impact the Gulf of Mexico LME in a direct, significant, and quantifiable way.

Gulf of Mexico LME
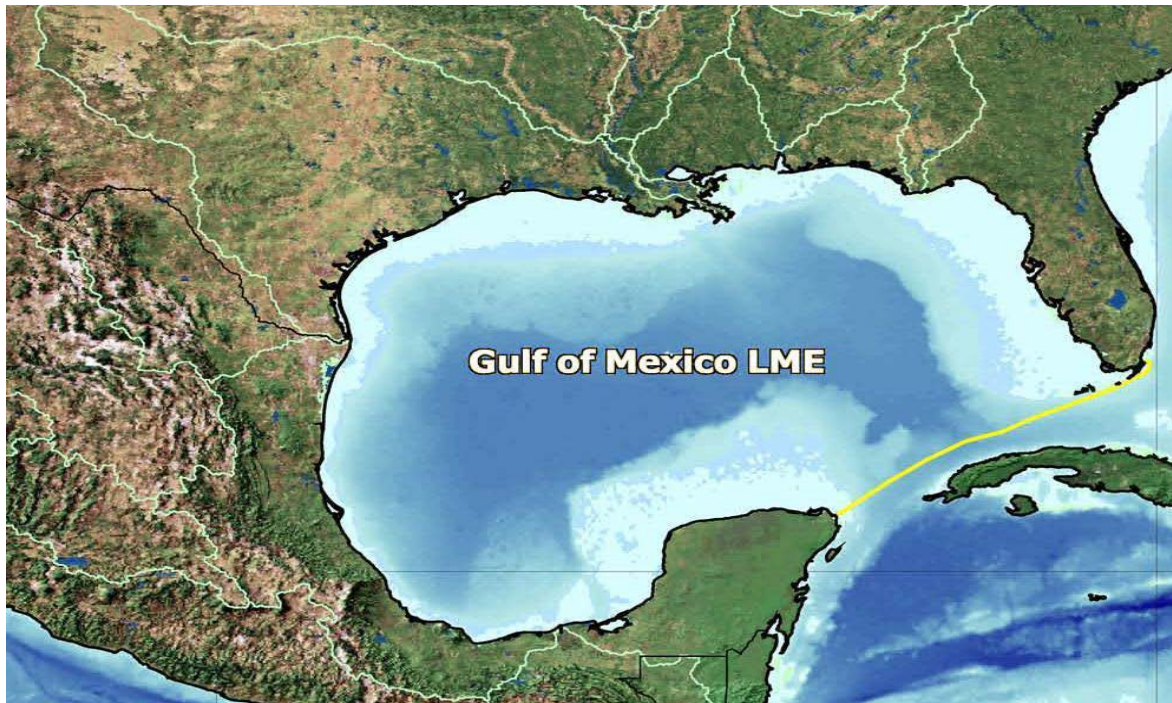
6.   Research Scope

Focusing the scope of activities supported by this program will help ensure that the research, observations, science, and technology are responsive to the guiding legislation; are coordinated with related RESTORE-sponsored science; complement and leverage existing and future science efforts; and address, in an integrated and holistic manner, the critical knowledge needed for Gulf of Mexico ecosystem restoration and management. The priorities do not define specific science needs that would be provided in phased requests for proposed scientific investigations, but will encompass a suite of scientific objectives. Investigations supporting these objectives, taken together, will meet the desired outcome of improved holistic understanding and management of the Gulf of Mexico ecosystem.

The objectives are listed by their established priority:

- Increase comprehensive understanding of Gulf ecosystem services, resilience, and vulnerabilities of coupled social and ecological systems.
- Construct management-ready and accessible ecosystem models for the Gulf of Mexico.
- Improve forecasting, analysis, and modeling of climate change and weather effects on the sustainability and resiliency of Gulf ecosystems.
- Increase comprehensive understanding of watershed, sediment, and nutrient flows and impacts on coastal ecology and habitats.

- Increase comprehensive understanding of coastal and marine resources, food web dynamics, habitat utilization, protected areas and carbon flow.
- Analyze new and existing social and environmental data to develop long-term trend and variability information on the status and health of ecosystems, including humans.
- Develop, identify, and validate system-wide indicators of Gulf Coast environmental and socioeconomic conditions.
- Obtain information and develop decision support tools needed to monitor and adaptively manage habitats, Living Marine Resources, and wildlife.
- Network and integrate existing and planned data/information from Gulf monitoring programs.
- Develop and implement advanced engineering, physical, chemical, biological, and socioeconomic technologies to improve monitoring.

7.   Engagement Summary

To be successful, the NOAA RESTORE Act Science Program must harness the expertise of the research community that works in the Gulf of Mexico and link the community to the region's pressing science needs. An engagement process is required that connects researchers, resource managers, and resource users and utilizes the input of their collective knowledge to facilitate the progress and direction of the program. NOAA, in collaboration with the USFWS, has and will continue to actively engage stakeholders including representatives from the GSMFC, the GMFMC, universities, RESTORE Act Centers of Excellence (once selected), Federal agencies, and nongovernmental organizations. These interactions shaped the program's science plan framework and, subsequently, this plan and the science priorities included within it.

Because this plan grew out of the program's science plan framework, it was strengthened by the input gathered and assimilated during framework construction. That input was received through a series of virtual engagement sessions (hosted by the program in August and September of 2013) from an engagement session held in conjunction with the Gulf of Mexico Alliance All-hands Meeting in June 2013, and from input sent directly to the program. Specific to this plan, feedback from a series of presentations on the program offered at conferences and workshops throughout the beginning of 2014 and input from an engagement session at the Gulf of Mexico Oil Spill and Ecosystem Science Conference in January 2014 have shaped its development. With the release of this draft version of the science plan, a formal comment period combined with additional virtual engagement sessions focused on gathering specific input on the plan will provide stakeholders with an opportunity to respond to specific details. They will then be able to offer constructive suggestions on how to ensure that it responds to the research and management needs of the Gulf of Mexico.

In general, the engagement approach taken has been to continuously seek to raise awareness of the program and to solicit input through several different avenues. In addition to one-on-one meetings and seminars with stakeholders, the program needs a continued presence at ocean and coastal science and resource management conferences and at workshops within the Gulf of Mexico region and nationally. At these venues, the program presents updates and, when possible, hosts structured engagement sessions. The program has held virtual engagement sessions in the past and will continue to use this approach in the future as well. The program maintains a website (http://restoreactscienceprogram.noaa.gov/) where the latest information on the program is available and stakeholders can sign up to receive alerts and announcements about the program. Finally, stakeholders can always submit input to the program at noaarestorescience@noaa.gov.

One goal of this engagement process is to ensure that activities supported by the NOAA RESTORE Act Science Program complement the research and monitoring activities supported by other organizations in the Gulf of Mexico region including the Centers of Excellence established by the RESTORE Act, the Gulf Coast Ecosystem Restoration Council, and Gulf States. In addition, the program is engaging with other research programs that stemmed from the Deepwater Horizon oil spill, such as the Gulf Research Program at the National Academy of Science, the Gulf of Mexico Research Initiative, and the National Fish and Wildlife Foundation's (NFWF) Gulf Environmental Benefit Fund. NOAA is also actively engaging and coordinating with government and nongovernment research programs that were active in the region before the Deepwater Horizon oil spill.

8.   Rationale for Priorities

Early in the development of the NOAA RESTORE Act Science Program, NOAA learned from discussions with stakeholders and from other science and restoration initiatives focused on the Gulf of Mexico region that it would be valuable to support work on a set of short-term priorities to be completed within 3 years. The rationale was that it would allow the research community to compete for funding for short-term projects whose results would guide the future direction of this program as well as the other science and restoration initiatives planned or underway (Appendix II).

Therefore, NOAA proposed the following short-term priorities, vetted them in engagement sessions with stakeholders, and used them to form the basis of the initial federal funding opportunity to be released by the program:

- Comprehensive inventory and assessment (i.e., strengths/weaknesses) of ongoing ecosystem modeling efforts (conceptual and quantitative);

- Identification of currently available health/condition indicators of Gulf of Mexico ecosystem components, including humans, followed by comparative analysis of strengths and weaknesses and design/testing of additional indicators; and
- Assessment of monitoring and observation needs and development of recommendations to build from existing assets to establish a Gulf wide monitoring and observation network.

It is expected that many of the projects that support these short-term priorities will establish or further support the acquisition of baseline data and information that describes the current state of science and knowledge of the Gulf of Mexico. Products, such as needs assessments, synthesis documents, inventories, and gap analyses, are intended to provide a foundation for long-term science activities and the development of practical ecosystem management tools to facilitate science-based decisions.

The long-term priorities detailed in Section II of this plan represent the focus for the science program for the next 5 to 10 years and possibly beyond. These long-term priorities will form the basis for subsequent federal funding opportunities to be issued by the program. The leadership of the program will determine the order in which these long-term priorities will be addressed and, in making their decisions, will consider advice and information gathered from the following areas:

- stakeholders;
- the topics being addressed by funding opportunities announced by other science initiatives in the region;
- new research results; and
- amount of funding available to the program.

Within the federal government, the Executive Oversight Board (EOB) for the program will review federal funding opportunities proposed by the program and the RESTORE Science Program Advisory Working Group (RSPAWG) of NOAA's Science Advisory Board will continue to provide strategic advice on science priorities. Refer to Section III, Program Structure and Administration, for more information on the EOB and RSPAWG.

The NOAA RESTORE Act Science Program anticipates updating this plan and its long-term priorities every 5 years. However, it may update the plan more frequently or add supplementary material following future significant events in the Gulf of Mexico region. Such events could include subsequent natural or technological disasters or significant findings from research in the region that compel the program to consider new research directions.

9.   Priorities Development

Long-term priorities for implementation of the program were drawn from prior science and research needs assessments for the Gulf of Mexico and from input the program received while engaging with stakeholders. In establishing these long-term science priorities, NOAA reviewed numerous science and research needs assessments documented for the Gulf of Mexico over the past several years and conducted over 100 meetings to gather input from stakeholders. Participants included representatives from the GSMFC, GMFMC, universities, federal agencies, and nongovernment organizations. We looked for commonalities between assessments and stakeholder input to identify priorities; then cross-checked what was assembled through additional discussions with resource managers and researchers.

Priorities for the long-term implementation of this program were further refined based on consideration of the following relevant criteria:

- What are the management and restoration science needs?
- How will the research priority support management science needs?
- How will the research priority help achieve the program's stated goals?
- Is the priority duplicated within other science programs in the Gulf of Mexico?
- Will the priority fill knowledge gaps in the scientific knowledge about the Gulf of Mexico, leading to a more holistic understanding of the ecosystem?
- Is the priority within the scope of this program?

Primary consideration was given to priorities that support the science needs of the management community. Providing the science necessary for resource managers to make sound management decisions is foundational to this program to fulfill its mission. In addition to providing the science necessary to improve management and restoration decisions of today, the research carried out through this program will contribute to a more comprehensive understanding and better management of the ecosystem in the future.

Section II. Research Priorities

Ten long-term research priorities were identified through the process described above. For each, the following discussion includes the management needs that drive the priority, related outcomes, and anticipated outputs. A list of example activities is also included. Note that the priorities below are not listed in order of importance or programmatic priority; they transition from activities tied to holistic understanding to model development to assessment of ecosystem status and dynamics to observational and monitoring support. Activities listed for each priority are examples of the types of activities that could be undertaken and are not intended to represent an exhaustive list. Collectively, research conducted in support of the ten priorities, and the resulting outputs, will be the underpinning for integrated ecosystem assessments and improved resource management.

Increase comprehensive understanding of Gulf ecosystem services, resilience, and vulnerabilities of coupled social and ecological systems.

Ecosystem Services, the contributions that ecosystems provide that support, sustain, and enrich human life, have long been recognized by scientists and communities, though perhaps the term "ecosystem service" was not used. In a 2005 publication by the National Academy of Sciences (NAS), it was noted that "Despite growing recognition of the importance … they are often taken for granted and overlooked in environmental decision-making." This disregard for ecosystem services was reiterated by Santos and Yoskowitz (2012) by the release of a website specifically designed for distribution and sharing of information on ecosystem services, "Although ecosystem services are critical to human well-being, cases in which they have been applied to real policies and decisions are rare. For society to make informed decisions about a sustainable use of the environment, a link from the quantification of ES [ecosystem services] to society's needs is necessary."

It is well documented that the structural and functional characteristics of ecosystems brings about the services (Anton et al. 2011) that humans have come to depend on for food and water (provisioning services), regulation of disturbances (regulating services), habitat for wildlife (supporting services), and aesthetics (cultural services). However, incorporation into ecosystem management policy remains inadequate.

Managers need a better understanding of the ecosystem services provided by the Gulf of Mexico ecosystem. *Millennium Ecosystem Assessment: Research Needs* (Carpenter et al. 2006) identified numerous needs to improve ecosystem management. The following are particularly relevant for the Gulf of Mexico:

(iv) systematic information on stocks, flows, and economic values of many ecosystem services (e.g., freshwater fisheries, natural hazard regulation, groundwater, and pollination); (v) knowledge of trends in human reliance on ecosystem services, particularly services without market values (e.g., domestic fuel wood and fodder); (vi) systematic local and regional assessments of the value of ecosystem services; and (vii) connections between data on human systems and ecosystems.

Coastal communities are increasingly vulnerable to coastal disasters such as hurricanes, sea level rise, inundation, and subsidence. A communities' resilience is impacted by the ability to plan and mitigate for loss of natural systems that, when present, could abate damages from these disasters. Documentation of natural systems, and the services they provide, is necessary to understand how these systems could improve a communities' ability to withstand disasters. Managers need methodologies to record services provided by natural systems, appraise quality and quantity of those services, and assign values (including non-monetary values) to those services; including how interactions with humans can impact those services. Having such knowledge will help inform community planners so that strategic decisions can be made to reduce vulnerability and improve resiliency.

Once ecosystem services are identified and methodologies for assessing quality and quantify are established, the issue still remains for how managers go about integrating consideration of ecosystem services into the decision-making process. Over the past decade or so, many researchers have attempted to tackle this obstacle by developing "frameworks" that would guide integration of these services into decision making. Yoskowitz et al. (2013) released a proposed framework that was developed based on existing work and their application using expertise gained about ecosystem services in the Gulf of Mexico. This publication also provides a good overview of other frameworks for considering ecosystems services in the decision making process (Yoskowitz et al. 2013). However, while this framework and other frameworks do exist, application by resources managers is not occurring. The process needs to be disseminated and tested, and other processes may need to be developed as well.

Management Needs:

- Knowledge of the ecosystem services provided in the Gulf of Mexico.
- Understanding of mechanisms by which natural biodiversity produces or contributes to production and delivery of key ecosystem services.
- Methodologies to assess quality and quantity of and assign values to ecosystem services.
- Processes for integrating ecosystem services into management decision-making.

Outcomes:

- Gulf of Mexico resource managers understand the linkages among habitats, ecosystem services, and human well-being.
- Environmental management policies and decision-making processes in the Gulf of Mexico LME include consideration of ecosystem services.
- Gulf of Mexico resource managers are able to consider ecosystem services when making conservation decisions.

Outputs:

- Comprehensive inventory of Gulf of Mexico habitats and the ecosystem services each provides.
- Quality and quantity assessment of Gulf of Mexico habitats.
- Rating system to define the quality of ecosystem services.
- Report on the socioeconomic and cultural linkages with ecological processes, including identification and measurement, if possible, of cultural ecosystem services, in the Gulf of Mexico.
- Process for incorporating consideration of ecosystem services in resource management decisions.
- Tools for assigning values to ecosystem services in the Gulf of Mexico.

Examples of Key Activities:

- Determine how the connections among Gulf habitats influence the quality and quantity of ecosystem services currently provided.
- Analyze socioeconomic and cultural linkages with ecological processes in the Gulf of Mexico.
- Develop approaches and tools for assigning values to ecosystem services in the Gulf of Mexico.
- Increase understanding of importance of specific and aggregate ecosystem services to human health and well-being.

Construct management-ready and accessible ecosystem models for the Gulf of Mexico.

Modeling is an important tool for developing a holistic understanding of the Gulf of Mexico LME. A robust and rigorous modeling approach grounded in observations and an experimentally derived understanding of the components and processes in the ecosystem can

clarify connections between these components and processes. Such an approach can also identify gaps in our understanding to be targeted for future observational and experimental work. A modeling approach can be particularly useful in simulating an observational network and making informed decisions about where to place new observational assets. Once a model or a suite of models are robust enough, they can be used to inform management decisions and, in the best-case scenario, accurately predict the changes that will result from a given management action and/or change in environmental conditions.

To arrive at this end goal of model development, a forum for bringing ecosystem model developers and users together would be helpful. Testbeds, such as those often developed by NOAA (www.testbeds.noaa.gov) for meteorological applications, have been used to transition new capabilities from research to application. In doing so, scientists were brought together from the research and development communities with such operational end-users as forecasters and decision-makers; the purpose was to test whether or not advanced capabilities are reliable and useful for forecasting and decision-making.

In addition to improvements in models focused on specific processes (e.g., hypoxia) or areas of the Gulf of Mexico LME (e.g., oyster recruitment in a specific estuary), an initiative to regionally integrate these models is also needed to develop a more comprehensive understanding of how the entire Gulf of Mexico LME functions. These more comprehensive system-wide models would aid the management community when it comes to making decisions about species with broad ranges or complex and diverse life cycles and begin to consider and account for the full geographic extent of decisions.

Management Needs:

- Models that can quantify and track sources, fate, and transport of abiotic and biotic components within the ecosystem (Walker et al. 2012, Sempier 2009, Gulf of Mexico Alliance 2009).
- Integration of socioeconomic drivers and outcomes into ecological models to create more accurate representations of the linkages between social and ecological systems.
- Regional integration of models to produce a more comprehensive understanding of how the entire Gulf of Mexico LME functions (National Marine Fisheries Service 2013).
- A forum for ecosystem modelers and resource managers to evaluate and refine ecosystem models.
- Data dissemination tools that translate model output into information ready to use in a timeframe consistent with management needs (Walker et al. 2012).

Outcomes:

- Gulf of Mexico resource, environment, industry, and public health managers have confidence in the outputs and utility of Gulf of Mexico ecosystem models.
- Gulf of Mexico resource managers have tools or a forum where modeling results are presented in a usable format and in a suitable timeframe to inform management decisions.
- Resource management practices and policies in the Gulf of Mexico LME consider and incorporate ecosystem modeling, including socioeconomic components.
- Ecosystem models underpin adaptive management and integrated ecosystem assessment in the Gulf of Mexico LME.
- A community of ecosystem modelers aware of each other's work and interested in integrating their models to develop more comprehensive system-wide models for the Gulf of Mexico LME.

Outputs:

- A suite of ecosystem models that collectively clarify the connections between and among components and processes in the Gulf of Mexico LME.
- A suite of ecosystem models that have the capacity to accurately predict changes in the Gulf of Mexico LME in response to environmental change and management action.
- Modeling tools that translate ecosystem model outputs into ready-to-use information received in timeframes consistent with management needs.
- An ecosystem modeling testbed or similar forum where ecosystem modelers and resource managers can test and evaluate models.
- System-wide models for the Gulf of Mexico LME that incorporate individual models targeting different components and processes in areas of the Gulf of Mexico ecosystem.

Examples of Key Activities:

- Expand and refine existing monitoring and observation systems to track nutrient pollution to the Gulf and its ecosystem impacts (e.g., hypoxia, harmful algal blooms), in support of scenario forecast models aimed at providing information for nutrient reduction management strategies.
- Incorporate in a holistic fashion the multiple pathways by which nutrient and other pollutants impact the Gulf of Mexico LME, including humans.
- Synthesize new and existing data and advancements in understanding ecosystem processes to improve ecosystem modeling, especially for the prediction of ecosystem change in the Gulf of Mexico LME.
- Model and predict the effects of major environmental events, both natural and human driven (e.g., floods, spills, hurricanes, and fire).

- Model resource stability and sustainability and include interactions between and among fisheries, habitat, threatened and endangered species, ecosystem processes, and stressors to assist with making ecosystem-based management decisions.
- Model connectivity patterns for management of conservation areas in the Gulf of Mexico.
- Use objective modeling techniques, including observing system simulation experiments, to evaluate optimal deployment of ecosystem monitoring and observing assets.
- Model health and sustainability of marine mammals, sea turtles, and other protected Living Marine Resource (LMR) populations.
- Model resource management practices and policies in the Gulf of Mexico, including socioeconomic components, and their impact (pressure) on resources.

Improve forecasting, analysis, and modeling of climate change and weather effects on the sustainability and resiliency of Gulf ecosystems.

In the Gulf, billions of dollars will likely be spent to construct restoration projects over the next two decades. Key needs of trustee state and federal agencies include determining the types of information that should be incorporated into the design of large-scale restoration projects proposed for the Gulf to ensure long-term project sustainability in the face of anticipated climate-driven changes and extreme weather. The impacts of climate change (e.g., sea level rise, salinity changes, landscape changes, temperature increases) or extreme events such as hurricanes have not yet been routinely incorporated into restoration planning, because of the limited availability of scientific predictive guidance directly applicable to the design and adaptive management of restoration projects.

Further, little is known about how project sponsors should develop and implement strategies for monitoring and observing projects to effectively assess the impacts of climate change and extreme events on specific types of restoration projects and overall on restoration programs across the large-scale ecosystem. Despite existing, robust observation and monitoring activities in the Gulf of Mexico focused on water levels, land subsidence, habitat change, and salinity among others, little is known about the parameters and instrumentation necessary to measure climate change and extreme events as they relate to Gulf restoration projects (Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative [GCPO LCC] 2013, Walker et al. 2012).

Management Needs:

- Knowledge of how to best incorporate scientific understanding of the anticipated impacts of climate change and extreme events on the performance

of restoration projects in the Gulf of Mexico (GCPO LCC 2013).

- Knowledge of methods and instrumentation necessary to 1) measure the impacts of climate change and extreme events on restoration projects, and 2) support dedicated adaptive management (Walker et al. 2012).
- A better understanding of how to develop an observation and monitoring strategy will be important for trustee agencies to develop adaptive management plans for projects and programs as climate change and extreme events alter physical and biological conditions (Walker et al. 2012).

Outcomes:

- Gulf of Mexico trustee agencies and project sponsors understand the potential impacts of climate change and extreme events on various types of restoration projects.
- Observation and monitoring practices in the Gulf of Mexico include instrumentation and methods to effectively measure impacts of climate change and extreme events.
- Restoration projects in the Gulf of Mexico are adaptively managed and effectively sustained in the face of these impacts.

Outputs:

- Recommendation for a Gulf implementation strategy for monitoring and observing restoration projects to better detect the impacts of climate change and extreme events.
- Guidance tools for predicting impacts of climate change and high-impact weather on restoration and recovery activities.

Examples of Key Activities:

- Determine the observation and monitoring requirements for effective assessment of climate change and extreme event impacts on various types of restoration projects common for the Gulf (National Ocean Service 2011)
- Investigate how climate and climate change (i.e., changes in ocean acidity, temperature, precipitation patterns, sea-level rise, etc.) shape the structure and function of the ecosystem and the connection between its living resources and communities (GCPO LCC 2013, National Ocean Service 2011).
- Conduct research to forecast direct and indirect effects of climate change on indicator, particularly significant, or susceptible species (GCPO LCC 2013, Walker et al. 2012).
- Analyze, model, and predict the effects of major environmental events in the

future, both natural and human driven (floods, spills, nutrients, hurricanes, fire, etc.) (Walker et al. 2012).

- Develop sound approach for downscaling (GCPO LCC 2013, National Ocean Service 2011) global and regional climate models and projections to provide guidance for local and regional predictions.
- Develop and apply dynamically coupled Earth System (atmospheric, hydrodynamic, oceans) and ecological models to forecast the impacts of sea-level rise and storm inundation (GCPO LCC 2013, National Ocean Service 2011).
- Incorporate climate-related effects and thresholds into ecosystem modeling platforms.
- Integrate downscaled climate models with existing and improved hydrologic modeling platforms focused on forecasting freshwater and sediment delivery to coastal systems (GCPO LCC 2013, National Ocean Service 2011).
- Assess the ability of key coastal habitats (e.g., marshes, barrier islands) to adapt to sea-level rise and climate change to inform and guide restoration priorities (Sempier et al. 2009).

Increase comprehensive understanding of watershed, sediment, and nutrient flows and impacts on coastal ecology and habitats.

Water, suspended sediments, and nutrients transported from watersheds to the coastal zone by rivers are critical to many natural processes that create and nourish habitats and living resources. However, human activities have greatly altered these transport processes. Along the Gulf of Mexico, most of the rivers carry elevated levels of nutrients that fuel algal blooms, result in hypoxia, block light to underwater grasses, and smother critical habitats. Many rivers and coastal areas also contribute contaminants to the northern Gulf of Mexico.

The magnitude and timing of freshwater inputs determine where certain organisms (e.g., oysters) can grow and reproduce. Much of the sediment transported by the Mississippi River that formerly nourished coastal marshes is now captured upstream by the many dams in the river. The levees along the lower river block remaining suspended sediments from reaching the marshes where they would normally raise elevations to keep pace with subsidence and rising sea levels. However, since these sediments are being captured by the levees, many of the marshes are starved of sediments necessary to maintain themselves and prevent conversion to open water. The combination of freshwater inputs that causes density stratification, as well as nutrients that fuel massive algal blooms each spring, results in the largest hypoxic zone in North America.

Management of Gulf ecosystem impacts from altered flows, excessive nutrients, and increased/ reduced suspended sediments has been fragmentary and often ineffective, which leads to

continued degradation of habitats. Impacts include direct threats to people (e.g. vulnerability to storm surges) and threats to the living resources and habitats that sustain the economic vitality of this region. Many believe that we are nearing "tipping point" levels of degradation in some of the Gulf's habitats and living resources; beyond that point, the ecosystem could suffer catastrophic impacts that would be extremely difficult, if not impossible, to reverse.

Traditional management of freshwater flows, nutrients, and suspended sediments treats these constituents and their impacts as isolated and disconnected entities, and can lead to unintended consequences as by-products of these strategies. For example, nutrient load reduction is the sole focus of efforts to reduce the northern Gulf's large hypoxic zone. Similarly, sediment is the primary focus of efforts to divert Mississippi River waters to adjacent marshes. Since these diverted waters now contain high concentrations of nutrients, unintended consequences to the marshes are appearing such as less robust and resilient marsh grass growth. Furthermore, the reestablishment of freshwater flows in some areas is dramatically altering habitats and abundance of economically important resources.

The quantity and quality of freshwater flowing into the Gulf of Mexico significantly influences coastal and marine habitats and life in the Gulf. Upstream agricultural, residential, industrial, and commercial water usage and discharges are intertwined with reservoir and dam management practices. Understanding the connection between upstream land-use practices, hydrologic modifications, dam and reservoir management, and variability in downstream freshwater flows is needed to address this issue (Walker et al. 2012, U.S. Fish and Wildlife Service 2013).

Development, pollutants (including oil and dispersants), nutrient enrichment, ocean acidity, invasive species, sea-level rise, hurricanes, floods, and other chronic, acute, lethal, and sublethal stressors can significantly impact the ability of natural systems and species to maintain cohesion and sustainable populations. These and other stressors shape the structure and function of human and ecological communities and the connection between and among the living resources and the environment in which they live. Understanding these connections on the shore, at the surface, in progressively deep water, and between the surface and the various water depths is vital to developing effective management schemes. All of these interactions are impacted by stressors on the system and understanding the impacts should help to guide management decisions that result in habitat, population, and community resiliency in the Gulf (Petersen et al. 2011, Walker et al. 2012, Murawski and Hogarth 2013, U.S. Fish and Wildlife Service 2013).

Management Needs:

- Holistic ecosystem approaches to the management of freshwater flows, nutrients, and suspended sediments.
- Comprehensive ecosystem goals for restoration and accompanying management approaches that consider the range of benefits and consequences of alternative management scenarios.
- Tools to forecast outcomes of restoration actions with the confidence sufficient to drive the large expenditures needed to reach restoration goals.

Outcomes:

- The scientific basis and compelling societal benefits to drive holistic ecosystem approaches to management with respect to sediment, nutrient, and water flows, as well as their impact on coastal ecosystems.
- Ecosystem structure and function are maintained at desired levels and is highly resilient to changes in nutrient, sediment, and water discharge under different natural and anthropogenic scenarios.
- Adaptive management of the Gulf's ecosystem and its associated habitats and living resources positioned to move from reactive to proactive mode. This move will be based on available, reliable, and sustainable management toolset capabilities for comprehensive synthesis, observations, and modeling of impacts of sediment, nutrient and water flows.

Outputs:

- Operational ecosystem-based scenario forecast models and tools to inform management goal-setting for establishing and revising Best Management Practices (BMPs) for nutrient, sediment, and freshwater loads most effective for the Gulf's ecosystem conservation and restoration.
- Document that articulates societally supported and science-based quantitative ecosystem restoration goals.
- Recommendations for operational monitoring and observation programs with sufficient detection and analytical capabilities to adequately support data acquisition and process studies needed for scenario forecast model development.

Examples of Key Activities

- Develop holistic understanding of the relationship among nutrients, sediments, and freshwater inputs and their effects on ecosystem structure and function under a range of scales of variability, both natural and anthropogenic.

- Determine the sources, sinks, and transport pathways between watershed, coastal and deep water environments to develop sediment, nutrient, and carbon budgets for the Gulf ecosystem.
- Determine cause-and-effect relationships among sediment, nutrient loading and freshwater inputs, as well as the distribution and sustainability of estuarine habitats and associated ecosystem services.
- Identify sources of pollution in the Gulf of Mexico, understand the presence and flow of pollutants in the Gulf food web, and develop recommendations to reduce animal and human exposure to these pollutants.
- Determine societally-supported quantitative ecosystem restoration goals.
- Characterize the quality, quantity, and variability of freshwater, sediments, nutrients and pollutants that enter the Gulf of Mexico, including current and historical loads in rivers/tributaries and Gulf receiving waters.
- Quantify and delineate the historical and current hydrologic regimes of watersheds that support key coastal habitats (e.g., bottomlands, swamps, marshes, sea grasses) and potential changes under various future scenarios.
- Develop the capacity to examine the effects that upstream (e.g., reservoir and dam management) and coastal hydrologic modifications (e.g., diversions) have on the delivery of freshwater, nutrients, and sediments to coastal ecosystem structure and function.
- Develop the capacity to determine extant and optimal levels of sediment, nutrients, and water delivery to support sustainable coastal ecosystems and associated habitat and living resources within the context of management-driven goal setting.

Increase comprehensive understanding of living coastal and marine resources, food web dynamics, habitat utilization, protected areas, and carbon flow.

The ecological interplay within and among species, such as resource and mate competition, predator-prey and parasite-host interactions, habitat utilization, larval dispersal, juvenile refugia, and disease transmission, is fundamental to understanding community and ecosystem functioning. At higher levels of biological organization, research into habitat utilization and species movement patterns such as large-scale tagging and tracking programs for sea turtles, seabirds, and marine mammals will help managers understand how these interactions cause populations to expand and contract. At more basic levels, information on the larval movements and early life-history development processes of important fish and invertebrate species in the Gulf of Mexico will help to drive management and restoration options. An even deeper understanding of the processes that drive ecosystems may be obtained by clarifying trophic interactions through such techniques as stable isotope and fatty acid analyses in combination

with diet studies conducted at the finest taxonomic resolution possible (Sempier et al. 2009, Petersen et al. 2011, Walker et al. 2012, National Marine Fisheries Service 2013).

The demographics and movement patterns of living coastal and marine resources between habitats at various life stages is an important determinant of ecosystem health in the Gulf of Mexico. Quantifying and understanding these variables and the relationship among habitats and populations and communities are necessary to achieve a holistic ecosystem-based understanding of resource management outcomes. This understanding could be enhanced by developing and utilizing a comprehensive habitat and living marine and coastal resource database that integrates biogeochemical and oceanographic data (Holling and Gunderson 2002, Gulf of Mexico Fish Council 2008, Sempier et al. 2009, Petersen et al. 2011, Walker et al. 2012, National Marine Fisheries Service 2013).

Fishery Management Councils and Commissions and certain State and Federal Agencies would benefit from several areas:

- spatially explicit, fishery-independent habitat surveys;
- fishery-integrated ecosystem assessments that include habitat-specific vital rates;
- additional fishery surveys within and outside existing programs;
- research to determine impacts of fishery and other human activities on habitats essential for sustaining living coastal and marine resources; and
- more efficient, less destructive, and less wasteful fishing gear.

Additionally, foundational studies are needed that compile existing data to demonstrate changes in status and population dynamics of important species and to explicitly identify data gaps (Gulf of Mexico Fishery Management Council 2008).

One way that the connections among the ecosystem, living coastal and marine resources, and humans can be understood is by tracking the flow of fixed carbon. Quantifying and understanding the flow of fixed carbon between habitats should help in identifying and measuring the connections among habitats, resources, and human and ecological communities. In addition, quantifying the rates of primary production, secondary production, and decomposition in Gulf of Mexico habitats should provide a fuller understanding of the accumulation of biomass and the sequestration of carbon (National Marine Fisheries Service 2013).

The Gulf of Mexico is surrounded by numerous federal marine-protected areas, refuges, and parks, as well as many state and non-governmental areas managed for natural resource protection. These areas are thought to be vital to maintaining a healthy Gulf of Mexico for humans and other living animals and plants. Research is needed to better understand how these protected areas influence the health and resiliency of floral and faunal populations within

their boundaries and in adjacent areas (Petersen et al. 2011, Ocean Conservancy and the Gulf of Mexico University Research Collaborative 2012, U. S. Fish and Wildlife Service 2013).

Management Needs:

- Inventory, review of applicability and utility, and gap analysis of management actions that have been or could be applied to enhance the health and sustainability of Gulf living coastal and marine resources.
- Better understanding of food -web dynamics, larval movements, and ecological interactions within and among species and habitats.
- Better understanding of fish, invertebrate, and wildlife populations in the Gulf and how these populations interact with each other and within habitats to create a healthy marine ecosystem.
- Guidance and decision-support tools for effective ecosystem-based living resources management.
- Better understanding of the factors that control primary production and the sources, fate, and transport of fixed carbon throughout the Gulf ecosystem.
- Better understanding of how and where upstream land uses are affecting coastal and marine habitats and living resources of the Gulf.
- Better understanding of the factors that contribute to and disrupt ecosystem, community, and population resiliency to prioritize habitats and species for conservation and targeted management actions.
- Better understanding of restoration and recovery needs, including monitoring and assessment, to determine best measures for evaluating successes or failures.
- Better understanding of how marine protected areas influence floral and faunal populations within their boundaries and in adjacent areas.

Outcomes:

- Increased knowledge of data gaps and supportable conclusions to help guide future scientific investigations.
- Increased ability to manage and protect those populations and habitats that are crucial to a healthy Gulf ecosystem.
- Increased understanding of how primary production and carbon flow influences productivity of Gulf LMRs.

- Increased understanding of how management actions that influence primary production and carbon flow in one area might affect another.
- Increased understanding of how and where changes in upstream water management actions might benefit or harm Gulf living coastal and marine resources.
- Increased ability to use information about habitat utilization and the movement of species within the Gulf to improve habitat conservation and support restoration.
- Increased ability to predict how natural and human-based stressors will impact the resiliency of human communities and nonhuman habitats, populations, and communities within the Gulf region.
- Increased ability to separate effective and sustainable recovery and restoration actions in the Gulf from those that provide minimal benefit.
- Increased ability to effectively manage marine protected areas and coastal refuges and parks to enhance the health and resiliency of humans and Gulf flora and fauna.

Outputs:

- Critical analysis/assessment of Gulf ecosystem indicators that support sustainable LMRs.
- Data and analysis of food web dynamics, larval movements, and ecological interactions within and among species and habitats.
- Data and analysis of interspecific interactions among Gulf fish, invertebrate, and wildlife populations and their habitats that determine marine ecosystem health.
- Guidance and decision-support tools useful for managers engaged in ecosystem-based fisheries management or planning, conducting, and evaluating restoration/recovery projects targeted toward coastal and LMRs.
- Analysis of factors controlling primary production and fixed carbon movement in the Gulf.
- Data and analysis to describe how and where upstream land use practices and water discharges affect Gulf habitats and living coastal and marine resources.
- Data and analysis of the factors that influence ecosystem, community, and population resiliency.
- Data and analysis of assessment and monitoring associated with restoration and recovery actions.
- Data and analysis to enhance understanding of the effectiveness of marine protected areas and coastal refuges and parks.

Examples of Key Activities:

- Develop and apply tools for understanding how the various trophic levels in the Gulf interact to create a sustainable and resilient ecosystem.

- Develop and apply tools that increase our understanding of the role of habitats in supporting healthy marine ecosystems and populations of fish, invertebrate, wildlife, and indicator or sentinel species.
- Develop guidance approaches and decision-support tools for effective ecosystem-based fisheries management.
- Expand and refine existing fishery population assessments to include habitat-specific vital rates.
- Develop and apply tools that achieve a deeper understanding of the relationship between marine and coastal protected areas and the health and resiliency of humans, fish and wildlife populations, and natural habitats.
- Develop and apply the monitoring and assessment tools necessary to effectively evaluate restoration and recovery actions.
- Understand the factors that influence the creation and movement of carbon through the Gulf ecosystem.

Analyze new and existing social and environmental data to develop long-term trend and variability information on the status and health of ecosystems, including humans.

The ability to conduct truly integrative and synthetic analysis of the Gulf ecosystem depends in large measure upon the ability to construct and analyze high-quality datasets that are temporally and spatially extensive, span perhaps several decades, and cover the entire LME. Careful analysis of such data reveals long-term trends and rates, allows comparative studies, promotes the development and assessment of high-fidelity ecosystem models, and provides context for the establishment of restoration endpoints and baselines.

Traditionally, data collection in the Gulf, as elsewhere, was accomplished through a massive number of largely uncoordinated federal, state, and academic monitoring programs. The present data record was built up over many decades by programs that were designed and carried out for different and largely uncoordinated reasons. Previously, the data record for any given measured parameter was generated using a range of sampling, analytical, and reporting protocols. This methodical heterogeneity provides challenges for building the record for individually measured ecosystem variables; beyond this, a tremendous heterogeneity across the range of different data types is required and should include not only biological data but also supporting chemical, physical, and geologic data. In addition, socioeconomic data will be required to examine the historic and ongoing evolution of ecosystem service provisions.

Assembling these varied datasets into a coherent whole that allows truly long-term and/or regional trend analysis requires a careful and dedicated effort by scientists. In other words, this work is a highly significant step beyond simply identifying individual historical datasets and providing for discovery and access. An analogy can be made with the climate science community: to document the extent, location, and rates of climate change, the community has undertaken the initiative to build and maintain Climate Data Records, which are defined by the National Research Council as "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change" (National Research Council 2004a and 2004b). These records are built, maintained, and curated over the long term by designated (and funded) entities. A similar effort is required to construct Ecosystem Data Records to support Gulf assessment and restoration.

Management Needs:

- A data system that "...fosters data comparability, consistency, standardization across programs, projects, and habitats" (Walker et al. 2012) with an emphasis on reuse of existing data.
- A compilation and synthesis of biological, physical, chemical and socioeconomic data.

Outcomes:

- Researchers and managers have easy access to a spatially and temporally extensive body of quality-assured ecosystem and socioeconomic data that enables a more synthetic, holistic understanding of the Gulf ecosystem.
- Researchers and managers can incorporate socioeconomic data to inform decision processes.

Outputs:

- Quality-controlled, consistently formatted, and spatially and temporally continuous records of key ecosystem and socioeconomic parameters.
- Protocols for collecting additional missing data and for incorporation into decision processes.
- Set of guidelines on best practices about social data collection.

Examples of Key Activities

- Create and maintain long-term, quality-controlled Ecosystem Data Records that highlight historical trends and anomalies in important ecosystem parameters, including the human dimension.

- Implement agreed-upon standards for data documentation, nonproprietary data formats, and transport protocols.

Develop, identify, and validate system-wide indicators of Gulf Coast environmental and socioeconomic conditions.

As resource managers make the move away from single-species management toward a more holistic, integrated approach to management, much discussion has surrounded the indicators that would be necessary to measure and monitor the state of health at an ecosystem level. It is becoming increasingly evident that managers must not only focus on the environmental elements and associated indicators, but also socioeconomic and human well-being (Kelble et al. 2013). This priority area centers around the concept of identifying indicators that will serve as valid proxies for the environmental, socioeconomic, and human well-being elements of the ecosystem and allow for periodic assessments of the state of health.

The Sea Grant publication, *Gulf of Mexico Research Plan* (Sempier et al. 2009), identifies a priority need to "Determine the correct variables to use as indicators of ecosystem health, identify the optimal methods to measure the indicators, and design better-defined indices with more indicators to evaluate the status of ecosystems." This priority was ranked as one of the top five needs. Before routine State of Health assessments for the Gulf of Mexico can be contemplated, a standard set of ecosystem indicators must be established. This standard must determine the minimal set of indicators and the confidence associated with those indicators to truly reflect the health of the ecosystem and its components. Once a standard set of indicators has been established, agreement must be made on how those indicators will be measured. The sampling protocol, frequency, and spatial distribution of these indicators must be defined in the methodology. Without standardized methodology, managers will not be able to rely on ecosystem indicators for the long-term status and trends assessments upon which management decisions will be based.

Ecosystem indicators must reliably reflect not only the ecosystem state of health but also serve as suitable proxies for human well-being. Sempier et al. (2009) identified research topics associated specifically with ecosystem indicators and effective management, accurate, timely and synoptic assessments and the link to human uses of the ecosystem in three of the top ten priorities. Ecosystem indicators can be an effective tool for the management decision-making process if they are correctly vetted, represent the factors of the environment that are most suitable for assessing ecosystem health, and provide a valid proxy to establish a linkage to human well-being.

Management Needs:

- Standard set of ecosystem indicators (including socioeconomic, environmental, and biophysical measures) to reflect ecosystem health.
- Methodology to measure ecosystem indicators.
- Datasets (proper temporal and spatial scales) to design ecosystem indicators.
- Ability to use ecosystem indicators to link ecosystem health to human well-being and to base management decisions on those indicators.

Outcomes:
- Resource managers routinely consider ecosystem indicators in the decision-making process.
- Coastal communities are knowledgeable about State of Health reports and are able to use reports to improve their community's ecosystem health and human well-being.

Outputs:

- Analysis of the utility of ecosystem indicators to effectively represent the state of ecosystem health.
- Analysis of utility of human well-being indicators to effectively represent the state of human community health.
- Standardized set of ecosystem indicators for use in State of Health assessments.
- Guidance manual that defines protocol for use and design of indicators (both ecological and human well-being), including (minimally) best methodology, spatial distribution, and frequency.
- Guidance for managers to incorporate data from indicators into the decision-making process.

Examples of Key Activities:

- Analyze ecosystem indicators to support coastal and marine resources and decisions regarding conservation areas.
- Understand optimal threshold numbers for indicator and particularly important species.
- Coordinate and integrate existing Gulf monitoring efforts to track sentinel species and sites.
- Monitor progress toward achieving ecosystem goals.

Obtain information and develop decision support tools needed to monitor and adaptively manage habitats, Living Marine Resources, and wildlife.

Gulf of Mexico habitats, from wetlands and barrier islands to the deep ocean, are affected by numerous and diverse processes, including sea level rise, nutrient overloading, extreme weather events, and extraction of living marine and energy-related resources. Evaluating the effects of these processes on habitat and ecosystem function will require timely access to data showing the location and type, as well as both the baseline and current conditions of Gulf of Mexico habitats to more efficiently formulate and execute conservation, restoration and response plans (Petersen et al. 2011, Ocean Conservancy and the Gulf of Mexico University Research Collaborative 2012, Walker et al. 2012). Development of tools used in data collection and analysis should enable researchers and resource managers to: identify habitat type, structure and function; protect habitat from degradation; assess the progress of restoration measures; and monitor habitat health and resiliency under pressure from long-term and episodic stressors (Petersen et al. 2011, Walker et al. 2012).

Baseline habitat information often varies from one location to another based on technologies, expert knowledge, and classification systems. Habitat classification should provide a common language to communicate data and information regarding habitats (McDougall, Janowicz, and Taylor 2007). Complexity and significance of marine resource issues are mounting and the need for additional habitat observations is increasing, particularly with respect to understanding impacts of natural and man-made disasters. Therefore, it is imperative that existing and new data be used to their fullest extent (Federal Geographic Data Committee 2012). Use of a federally recognized classification standard is necessary to accurately inventory, monitor, and assess habitats.

Management Needs:

- A baseline assessment of habitat location, distribution, and condition using existing information that can then be used to direct and prioritize the acquisition of new data and product development.
- The scientific basis to identify and provide metrics for habitat-specific vital rates.
- Modeling tools to help researchers identify the ecosystem components that contribute to resiliency and the environmental and anthropogenic stressors that negatively affect them.
- Monitoring and planning tools to provide information for the design and implementation of commercial and recreational infrastructure.

- Monitoring and planning tools to assess resource use to ensure critical habitats are protected and the resources that they support are sustainable.
- Monitoring and planning tools to support consideration of restoration options.

Outcomes:

- Gulf of Mexico habitats are protected and managed using methods that promote sustainable and resilient ecosystem[s].
- The state of health of Gulf of Mexico habitats is accurately assessed and easily compared with the state of reference sites.
- Gulf of Mexico resource managers can identify healthy vs. at-risk habitats and make informed protection and conservation decisions based on a strong foundation of scientific knowledge.
- Gulf of Mexico resource managers are able to easily monitor the progress of restoration and recovery programs with increased accuracy.
- Faster, more precise responses to future incidents that are potentially threatening to critical habitats.

Output:

- Comprehensive inventory of Gulf of Mexico habitats, ensuring that current formats and classification standards have been applied.
- Listing of prioritized areas for data collection.
- High-resolution maps that identify critical habitats "of great economic significance, ecological sensitivity or rarity" (Ocean Conservancy and the Gulf of Mexico University Research Collaborative 2012).
- Analytical tools able to assess and rank habitat health, identify and predict impacts from stressors, and provide spatial analyses to support marine resource management and marine protection actions.
- Decision support tools.

Examples of Key Activities:

- Complete integration and characterization of available coastal and marine (including deep-ocean) habitat data using standard methods (e.g., Coastal and Marine Ecological Classification Standard, Federal Geographic Data Committee 2012) of remote sensing and full suite of hydrographic methodologies (e.g., high-resolution bathymetry and backscatter).
- Identify gaps in habitat data and develop spatial sampling and mapping protocols to improve habitat identification and monitoring strategies.

- Determination of habitat-specific vital rates

Network and integrate existing and planned data/information from Gulf monitoring programs.

Population assessments, ecosystem, and habitat suitability models are examples of decision support tools that can assist regional resource managers in planning, designing, and implementing a successful management process. These models are most effective when they are built and validated with comprehensive data sets from rigorous integrated monitoring efforts. To achieve holistic ecosystem-based protection and restoration in the Gulf of Mexico, decision support tools must be developed with high quality data from throughout the Gulf. Data comparability, consistency, and standardization across programs, projects, and habitats are crucial, as are improved tools for data dissemination, visualization, and application by resource managers.

Managers require a spatially and temporally comprehensive multimedia monitoring network to determine the condition of important ecosystem components, including the population structure of managed fisheries, wildlife, and protected resources. In addition, associated climatological, biogeochemical, physical oceanographic, and socioeconomic data are critical to fully understand the health and demographics of coastal and marine resources. In the context of Gulf protection and restoration, a comprehensive observation and monitoring network will provide the data foundation necessary to support the development and selection of management and restoration project alternatives.

The constellation of programs (Appendix IV) engaged in monitoring begins with the other components of the RESTORE Act, but extends to other science and restoration initiatives that have emerged from the oil spill including: the Gulf of Mexico Research Initiative ($500M over 10 years), the National Academy of Sciences Gulf Research Program ($500M over 30 years), the Natural Resource Damage Assessment process, and the National Fish and Wildlife Foundation's Gulf Environmental Benefit Fund. The recent initiatives are occurring against the backdrop of existing federal and state research, observing, and monitoring programs operating in the Gulf of Mexico. Conversations with these other programs have begun to form a network to initiate integration of monitoring and observation systems. The role of the NOAA RESTORE Act Science Program in this undertaking will focus on the integration of existing data and expansion of opportunities to incorporate new data as collected from other sources.

Management Needs:

- Assessment and tracking of ecosystem status and trends.
- Data to build and maintain robust decision-support tools for adaptive, ecosystem-based management.

Outcomes:

- Gulf of Mexico resource managers have access to integrated observations and monitoring programs and their data.
- Gulf of Mexico resource managers, modelers, and researchers have access to ecosystem modeling results and access to the supporting data and associated visualization tools.
- Integrated monitoring and observation programs support improved ecosystem modeling and adaptive management.

Outputs:

- Integrated monitoring and observation programs with consistent data base structure.
- Gap analysis to identify missing information (e.g., spatial, temporal, life history, habitat, gear types).
- Incorporation of monitoring programs into adaptive management implementation plans in selected regions.

Examples of Key Activities:

- Coordinate and integrate data from existing recreational and commercial fishery-dependent sampling programs.
- Coordinate and integrate existing Gulf observations and monitoring efforts to promote a monitoring network, including characterization of physical and biogeochemical properties, food web dynamics, habitat, wildlife, and fisheries data collection.
- Identify opportunities to expand and refine existing monitoring and observation systems to support hydrodynamic, biogeochemical, and ecological models that assess and predict the effects of natural and anthropogenic stressors on ecosystem stability and sustainability.

Develop and implement advanced engineering, physical, chemical, biological, and socioeconomic technologies to improve monitoring.

Managers need to have a better understanding of the status of LMR populations in the Gulf of Mexico. New approaches to collecting data are required because of the over-reliance on fishery-dependent data, the large number of moderate-to-small stocks, the complication of managing international transboundary populations and habitat diversity. The development of innovative tools can decrease the costs of observations, mapping and monitoring. For example, more effective quantification of discards will allow managers to fully realize the value of target fisheries without impacting nontarget, overfished or protected species. Investments in innovative fishery monitoring techniques, such as electronic fishing logbooks and video monitoring, can provide a cost-effective means of producing more information.

Experts consistently identify scientific or technological investments and management actions as top priorities (Ocean Conservancy and the Gulf of Mexico University Research Collaborative 2012). Information on genetic characteristics of stocks as well as the migrations of stocks can best be understood by applying state-of-the-art tagging and genetic methodologies. Several investigators suggest that lack of information about movements and stock structure limits our ability to manage transboundary stocks and to effectively implement marine spatial planning. In addition, tagging programs are needed that will improve the accuracy of fisheries' stock assessments by developing improved estimates of natural and fishing mortality rates, according to the Gulf of Mexico Fishery Management Council (2008). Development of large-scale fish genetic and smart tagging programs will allow more accurate estimates of population status and assist in examining population connectivity among Gulf LMRs to better understand species-specific resiliency (Ocean Conservancy and the Gulf of Mexico University Research Collaborative 2012).

Comprehensive characterization of microbial communities is now possible through such molecular- and image-based sensor technologies as advanced automated underwater samplers and submersible flow cytometers, respectively. For example, these technologies have been deployed on buoys and used for real-time detection of harmful algal blooms and their toxins. Deployment of autonomous vehicles (e.g., gliders) increases the spatial and temporal breadth of monitoring capabilities, and can be outfitted with sensors to capture physical, chemical, and biological properties targeting all ecosystem components.

Management Needs:

- Improved quantity and quality of information for assessments of fish, wildlife (e.g., sea turtles, marine mammals, birds), and protected species populations in the Gulf.

- Improved information to understand the connectivity between various portions of the ecosystem from microbes to whales.
- More effectively quantify discards and reduce by-catch of a variety of species during fishing activities.

Outcomes:

- Gulf of Mexico resource managers are provided more precise data that allows accurate and effective implementation of fishery management measures.
- International transboundary populations are managed more effectively.
- Gulf of Mexico resource managers are able to consider an expanded data inventory when making conservation decisions.
- Improved by-catch information.
- Improved stock structure and movement information.
- More comprehensive spatial and temporal monitoring in support of adaptive management of ecosystem restoration activities.
- Expanded and more efficient data collections to support scenario forecast models to inform ecosystem management.
- Increased understanding of all biotic components of the Gulf of Mexico ecosystem, from the level of microbes to large animals.

Outputs:

- Assessment and evaluation (including cost-benefit) of advanced technologies (including, for example, tagging, TEDs, ESPs, flow cytobots, etc.) for enhancing existing monitoring programs to target ecosystem (including LMR) assessments.
- Implementation plan for application of advanced technologies for improved assessment of LMRs.
- Ratings to define the utility of a variety of advanced technologies.
- Complete data on the actual number of vessel interactions with sea turtles and marine mammals.

Examples of Key Activities:

- Improve technology to support large-scale tagging programs to better quantify fishing mortality rates and movements, and to improve estimates of natural mortality.
- Identify or develop and implement advanced technologies (e.g., autonomous vehicles, acoustic, genetic, optical and tagging technologies) to improve understanding of ecosystem structure and function, including assessment of LMRs.
- Develop and provide new and improved by-catch reduction devices and methods.

Summary

Improved knowledge of the ecosystem and it's chemical, physical, biological (including fisheries, wildlife, and humans), and socioeconomic components is essential to manage resources in a holistic, systematic fashion. Information must be made available for managers operating at different geographic scales, with largely diverse demographics, and complex management issues, to make informed decisions and modify their actions as needed to effectively manage ecosystem resources throughout the Gulf of Mexico in an integrated, adaptive manner. Adaptive management requires actions to be modified in relation to their efficacy for restoring or maintaining an ecological system in a desired state or ecological potential (Holling and Gunderson 2002). A key component of adaptive management is a feedback mechanism based on characterizing current ecosystem conditions and measured responses to management actions supplemented with an understanding of the system dynamics and baseline conditions. This information is obtained through rigorous monitoring, modeling, and research combined into integrated assessments and syntheses (Walker et al. 2012). The long-term priorities presented in this plan are intended to provide the knowledge necessary to support management actions, resulting in long-term sustainability of the Gulf of Mexico ecosystem.

Section III. Program Structure and Administration

The NOAA RESTORE Act Science Program is the responsibility of NOAA in collaboration with the USFWS. Within NOAA, the National Ocean Service has responsibility for program planning and implementation, under the supervision of an Executive Oversight Board composed of senior executives representing all NOAA Line Offices and the USFWS. The program will generally use peer-reviewed competitions, using Federal Funding Opportunities and other mechanisms, issued on a regular basis, to request proposals from eligible groups and independent mail and panel reviewers to evaluate proposals. The processes for announcing, awarding and overseeing research investments comport with all applicable federal, DOC and NOAA regulations and guidance for federal assistance. For the RESTORE Act Science Program, additional requirements will be included to comply with the legislation and any applicable Treasury regulations.

1.   Program Management
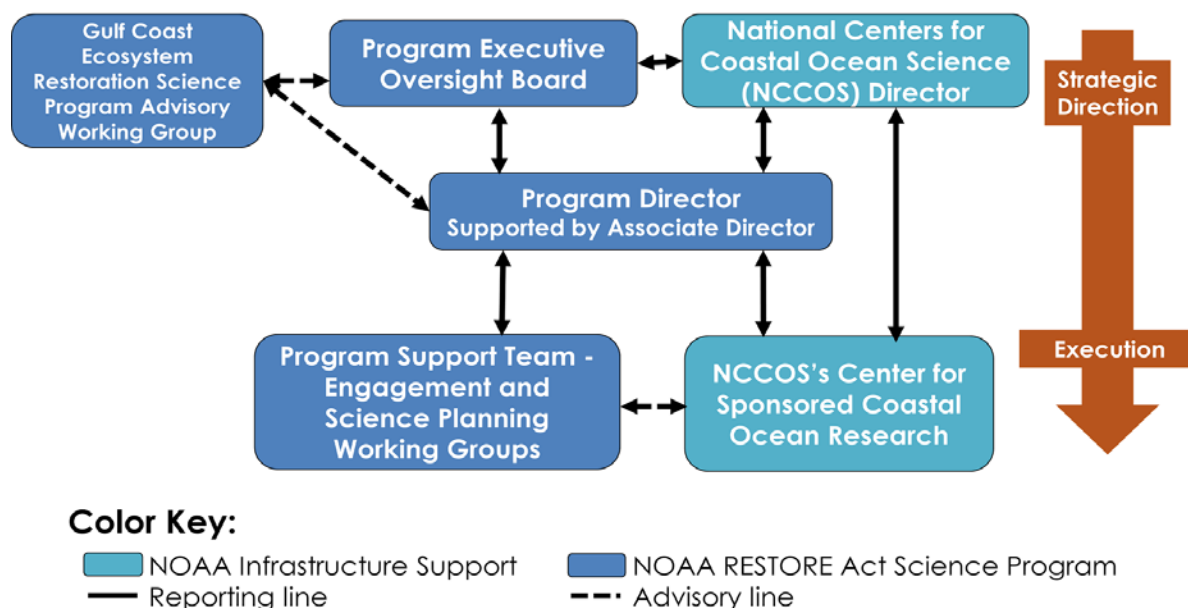
NOAA RESTORE Act Science Program Leadership and Support Team: Led by the RESTORE Act Science Program Director and Associate Director, the Support Team has responsibility to develop short- and long-term goals and priorities for the NOAA RESTORE Act Science Program, in consultation with partners and stakeholders, and for program implementation. The team has representation from the USFWS and from across NOAA. The *Program Director* and *Associate*

Director lead planning, execution, and review of the science, engagement, and program management and serve as primary points of accountability and authority for execution of the program. The *NCCOS Director* provides supervisory leadership and oversight and administrative support to the Gulf-Based Program Director in carrying out program strategies and actions. The *Science Support Team* is responsible for the science planning, coordination, and engagement; provides communication of stakeholders' goals/priorities; maintains needed transparency between federal, state, academic and nongovernmental organizations; and facilitates outreach and engagement.

Internal oversight: The program's *Executive Oversight Board* (EOB) oversees development and implementation of the program, providing strategic and programmatic guidance to the Program Support Team and approval of the Science and Engagement Plans developed by the team. The Board provides oversight to NOAA's National Ocean Service (NOS), which has been designated by NOAA as the executing body of the program, and the Program Director, in the administration of the funds available under the program. The Board will also collaborate with the RESTORE Act Council, science advisory bodies that may be established pursuant to the Act, and other entities as deemed appropriate by NOAA or the Department of Commerce.

Development of Funding Opportunities: Grant solicitations will be developed by a team of NOAA employees, led by the Program Director, who will consider the region's needs for research and development within the program's scope. The team will develop recommendations for solicitation topics by attempting to reach consensus. If the team can't reach consensus, the Director's supervisor will choose the solicitation topics. The Director's NOAA supervisor and the program's Executive Oversight Board will review the recommended topics to ensure that they appropriately address the community's needs and do not favor the Director's home institution.

Recommendations for proposals to fund will be developed by a team that does not include the director. If the director's home institution has no proposal in the recommended list, he could make selections of proposals to fund from the recommended list. If the director's home institution has a proposal in the recommended list, then he would be recused from the decision, which would then be made by the director's NOAA supervisor. Further, if the program has multiple topics in a solicitation and a list of recommended proposals to fund for each topic, the director would be recused from topics where his home institution has a proposal on the recommended list.

External guidance: The Gulf RSPAWG, established under NOAA's Science Advisory Board, provides independent guidance and review of the program. The RSPAWG will focus on the broad research, monitoring, and management components of the NOAA RESTORE Act Science

Program, advising NOAA's Science Advisory Board on capabilities and conditions of the program. The RSPAWG will also provide a mechanism for formal coordination among the multiple organizations that conduct restoration and ecosystem science in the Gulf of Mexico (including RESTORE-related science, as required by Section 1604). In addition to the RSPAWG, the program will periodically conduct an independent, external review of the program to assess its effectiveness. While still in the concept stage, it is envisioned that such an independent review would be conducted on a regular basis, such as initially after the first 3 years of the NOAA RESTORE Act Science Program and then every 4-5 years.

2. Consultation and Coordination

Pub. L. 112-141 Section 1604(b)(1) of the RESTORE Act specifies that NOAA shall consult with the Director of the USFWS, and coordinate (Section 1604(f)) with "other existing Federal and State science and technology programs in the States of Alabama, Florida, Louisiana, Mississippi, and Texas, as well as between the Centers of Excellence." Section 1604(b)(4) of the Act also requires that NOAA consult with the GMFMC and GSMFC "in carrying out the program." Although such a provision is not included in the guidance to the Centers of Excellence under Section 1605, or in the criminal settlement agreements, such as those funding the science programs for the National Academy of Sciences, these and other groups also have acknowledged the need for coordination.

During implementation of the NOAA RESTORE Act Science Program, NOAA will work to ensure that the program is addressing Gulf of Mexico ecosystem priorities and that the work addressed is well-coordinated with other science activities in the region. NOAA already works with most of these partners and stakeholders in various capacities and looks forward to continuing the dialog as related to this program. NOAA is currently collaborating with the groups who either have received or will be receiving funds as a result of the Deepwater Horizon event to support restoration and science. These discussions serve as fora to consider priorities and help reduce duplication of effort.

3. Program Parameters

Eligible Activities

Refer to Section I, 1: RESTORE Act Section 1604 for legislative language regarding eligible activities. In addition, the Act also instructs NOAA as follows:

- Species included – The research, monitoring, assessment, and programs eligible for amounts made available under the program shall include all marine, estuarine,

aquaculture, and fish species in State and Federal waters of the Gulf of Mexico.

- Research Priorities – In distributing funding under this subsection, priority shall be given to integrated, long-term projects that 1) build on, or are coordinated with, related research activities; and 2) address current or anticipated marine ecosystem, fishery, or wildlife information needs.

Program Duration

Recognizing that resolution of all administrative and civil penalties may be protracted, initial investments from the NOAA RESTORE Act Science Program (using penalties generated by the Transocean settlement) will be expended over a period of 7-10 years. However, the program is envisioned to have an operating timeline of approximately 20 years (assuming allocation to the NOAA RESTORE Act Science Program from the Trust Fund can be managed separately from other components of the Trust Fund). This timeline assumes a future resolution of civil penalties as a result of on-going litigation.

Project Duration

In keeping with the research priorities identified in the Act, priority shall be given to integrated projects. "Integrated" projects are defined as cross-disciplinary and may link observations/monitoring, modeling, and field/laboratory research. Proposals for projects supporting the long-term priorities would be supported for up to 3 years in duration, with potential for renewal based on merit review of the follow-on proposal and performance over the period of prior funding. Shorter-term awards may be required to support program execution or initial short-term investments.

4. Eligibility for Funding Opportunities

- Eligible applicants are institutions of higher education; other nonprofits; state, local, and Indian Tribal Governments; commercial organizations; and U.S. Territories that possess the statutory authority to accept funding for this type of research.
- Federal agencies that possess the statutory authority to accept funding for this type of research may apply.
- Foreign researchers may apply for subawards through an eligible US entity.
- Principal investigators(PIs) are not required to be employed by an eligible entity that is based in one of the five Gulf of Mexico States (Florida, Alabama, Mississippi, Louisiana, Texas); however, PIs that are not from Gulf of Mexico-based eligible entities are encouraged to collaborate with partners from a Gulf of Mexico-based eligible entity.

- The NOAA RESTORE Act Science Program funding opportunities will not be used to hire and fund the salaries of any permanent Federal employees, but may fund travel, equipment, supplies, and contractual personnel costs associated with the proposed work.

Funding Restrictions:

The Act stipulates activities that are not eligible under this program. The funds provided may not be used:

- for any existing or planned research led by NOAA, unless agreed to in writing by the grant recipient;
- to implement existing regulations or initiate new regulations promulgated or proposed by the NOAA; or
- to develop or approve a new limited access privilege program for any fishery under the jurisdiction of the South Atlantic, Mid-Atlantic, New England, or Gulf of Mexico Fishery Management Councils.

With respect to the first bullet, if the research being proposed is –

- substantially part of work that is currently tracked in NOAA Line Office Annual Operating Plans (AOPs), any grant or other funding mechanism documentation, or other budgetary or program management documents (using appropriated funds);
- substantially part of work that has been proposed in a NOAA budget formulation program change summary (regardless of success) or other budget formulation documents at the NOAA Line Office level since July 2012 (using appropriated funds);
- substantially duplicative of efforts *implemented* by NOAA, i.e., conducted by NOAA federal scientists or contract scientists on behalf of NOAA (using appropriated funds);

then research being proposed is not eligible for funding under the RESTORE Act Science Program. Final determination of the eligibility of the proposed research will be made by the program.

Funding Mechanisms:

The NOAA RESTORE Act Science Program will likely rely most heavily on grants and/or cooperative agreements as the funding mechanism. However, the program will allow for a mix of funding approaches that provide the flexibility needed to do the work required and involve appropriate institutions.

Partnerships:

Recognizing the inherent complexity of the Gulf of Mexico ecosystem and the diversity of disciplines and expertise that will be required to advance current understanding and support long-term sustainability of the ecosystem, preference will be given to collaborative efforts.

5.   Scientific Integrity

To ensure scientific integrity, the NOAA RESTORE Act Science Program will comply with the NOAA <u>Administrative Order (NAO) on Scientific Integrity</u> (NAO 202-735D). Independent reviews will be performed by scientific peers, not affiliated with institutions that propose projects, to avoid conflicts of interest in the selection of funded research, and in compliance with the NOAA <u>Policy on Conflicts of Interest for Peer Review</u>.

The program will apply the rigorous, competitive, peer-review process established by NOAA's Center for Sponsored Coastal Ocean Research (CSCOR) to select research projects that will be funded by grants or cooperative agreements. This review process is extensive and well-documented to make it as transparent as possible to applicants. In most instances, the program will utilize both mail reviews (to provide comments on individual proposals) and panel reviews (to look at the suite of proposals). The requirement for quality science will be carried through the entire project from concept to final products by including peer-review at all critical levels, seeking the advice of external experts, and initiating regular reviews of the programs.

6.   Data and Information Sharing

There is a need for a comprehensive mechanism to preserve, discover and access data and information resulting from research activities funded through this program to maximize return on the investment made by the Government and various agencies by allowing multiple uses of the data while minimizing duplication of effort. Eligible applicants awarded funding under the NOAA Restore Act Science Program will be required to comply with the Administration's policy for Public Access to Research Results (PARR) and NOAA's Administrative Order (NAO) 212-15, Management of Environmental Data and Information, which states that environmental data are to be managed based upon a lifecycle that includes developing and following a data management plan. The goal of the Data Management plan is to ensure that data are properly collected, documented, made accessible, and preserved for future use in a NOAA Data Center or other long term archive facility. Environmental data and information collected and/or created under an awarded grant/cooperative agreement will be made visible, accessible and independently understandable to users in near real time where appropriate and within two

years after the data are collected or created. Data should also comply with federal standards. The data will have undergone quality assurance/quality control using community-accepted standards, protocols etc. and will be accessible to the public free of charge or at minimal cost that is no more than the cost of distribution to the user, except where limited by law, regulation, policy or by security requirements. Appendix VI provides a partial listing of federal data policies and regulations that are to be adhered to. The grantees are obligated to meet these requirements to ensure the preparation of their data for registry, discoverability and accessibility through the appropriate national data center(s).

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Appendix I. Glossary

A

Abiotic

A nonliving (physical or chemical) component of the environment.[1]

Adaptive management

1. A management process involving step-wise evolution of a flexible management system in response to feedback information actively collected to check or test its performance (in biological, social, and economic terms). It may involve deliberate intervention to test the system's response.

2. The process of improving management effectiveness by learning from the results of carefully designed decisions or experiments. [1]

B

Best Management Practices (BMPs)

Acceptable methods or techniques found to be the most effective, practical, and environmentally responsible means of achieving an objective, such as to protect water quality or minimize pollution.

Biotic

Pertaining to the living components of their environment. [1]

Bloom

A sudden increase in the abundance of alga or phytoplankton resulting in a contiguous mass of highly concentrated phytoplankton in the water column. [1]

By-catch

Fish other than the primary target species that are caught incidental to the harvest of the primary species. By-catch may be retained or discarded. Discards may occur for regulatory or economic reasons. [1]

C

Carbon flow

The energy that flows through an ecosystem in the form of carbon-based molecular reactions that involve the abiotic and biotic (producers, consumers and decomposers) species in an

environment.

Clean Water Act

The Clean Water Act establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis for the CWA was the Federal Water Pollution Control Act, which was reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with these amendments in 1972.

Code of Federal Regulations

A codification of the regulations published in the Federal Register by the executive departments and agencies of the Federal government. The Code is divided into 50 titles that represent broad areas subject to Federal regulation. Title 50 contains wildlife and fisheries regulations. [1]

D

Decision support tools

Tools used to support a decision-making process (for example, Sea Level Rise viewers, scenario models, etc.).

Downscaling climate models

A method by which regional or global scale information is used to generate information about more local scale conditions.

E

Ecosystem indicators

Types of data that are used to detect and track changes in the ecological condition of an area.

Ecosystem Services

Ecosystem services are the benefits people obtain from ecosystems. These benefits include provisioning services, such as food and water; regulating services, such as flood and disease control; cultural services, such as spiritual and cultural benefits; and supporting services, such as nutrient cycling and filtration (e.g., via oyster reefs or vegetation), that maintain the conditions for life on Earth.[1]

Endangered species

A species as defined in the Endangered Species Act, that is in danger of extinction through a significant portion of its range. A species classified as threatened is likely to become an endangered species. [1]

Endangered Species Act

The Endangered Species Act statute was enacted in 1973 to conserve species and ecosystems. Under its auspices, species that face possible extinction are listed as threatened or endangered, or as candidate species for such listings. When such a listing is made, recovery and conservation plans are drawn up to ensure the protection of the species and its habitat.[1]

Environmental Sampling Processor (ESP)

The ESP is a tool developed by the Monterey Bay Aquarium Research Institute, which collects and analyzes water samples underwater (in situ).

F

Federal trust species

Pursuant to 16 USCS § 3772 (1), [Title 16. Conservation; Chapter 57B. Partners for Fish and Wildlife], the term Federal trust species means "migratory birds, threatened species, endangered species, interjurisdictional fish, marine mammals, and other species of concern."

Fish stock

The living resources in the community or population from which catches are taken in a fishery. Use of the term "fish stock" usually implies that the particular population is more or less isolated from other stocks of the same species and hence are self-sustaining. In a particular fishery, the fish stock may be one or several species of fish but here is also intended to include commercial invertebrates and plants. [1]

Fisheries dependent

A regional fisheries management body established by the Magnuson-Stevens Act to manage fishery resources in eight designated regions of the United States. [1]

Fisheries independent

Characteristic of information (e.g., stock abundance index) or an activity (e.g., research vessel survey) obtained or undertaken independently of the activity of the fishing sector. Intended to avoid the biases inherent to fishery-related data. (see Fishery-Dependent) [1]

Fixed Carbon

The inorganic carbon that is converted to organic carbon by living organisms

Food Webs

The complex predator-prey and consumer-resource relationships between all consumers and producers in an ecosystem.

G

Gap analysis

As used in this plan, a tool to determine where there is a lack of information/data necessary for sound management; also may be used to determine whether a particular process is meeting established objectives. For example, does a fisheries-independent monitoring program collect adequate data to conduct an acceptable stock assessment?

Gulf of Mexico Fisheries Management Council

A regional fisheries management body established by the Magnuson-Stevens Act to manage fishery resources in The Gulf of Mexico region of the United States.

Gulf States Marine Fisheries Commission

The Gulf States Marine Fisheries Commission was established by an act of Congress (P.L. 81-66) in 1949 as a compact of the five Gulf States. Its charge is: *to promote better utilization of the fisheries, marine, shell and anadromous, of the seaboard of the Gulf of Mexico, by the development of a joint program for the promotion and protection of such fisheries and the prevention of the physical waste of the fisheries from any cause.*[3]

H

Habitat

1. The environment in which the fish live, including everything that surrounds and affects its life, e.g., water quality, bottom, vegetation, associated species (including food supplies).

2. The locality, site, and particular type of local environment occupied by an organism. [1]

Habitat utilization

Habitats that a species or assemblages of species prefer or seem utilize in preference to other habitats.

Harmful Algal Bloom

Blooms of algae fueled by nutrient pollution that produce toxic or harmful effects on people, fishes, shellfish, marine mammals and birds.

Holistic

Concerned with the entire system not just the parts

Hypoxia

Conditions when oxygen concentrations fall below the level necessary to sustain most animal

life.

I

Indicators

1. A variable, pointer, or index. Its fluctuation reveals the variations in key elements of a system. The position and trend of the indicator in relation to reference points or values indicate the present state and dynamics of the system. Indicators provide a bridge between objectives and action.
2. Signals of processes, inputs, outputs, effects, results, outcomes, impacts, etc., that enable such phenomena to be judged or measured. Both qualitative and quantitative indicators are needed for management learning, policy review, monitoring, and evaluation.
3. In biology, an organism, species, or community whose characteristics show the presence of specific environmental conditions, good or bad. [1]

Invasive species

An introduced species that out-competes native species for space and resources. [1]

J

Juvenile Refugia

That part of a fish's or an animal's habitat where the young develop and grow and that is protected from predators; also known as nursery areas.

L

Landscape changes

A change in an area of land with distinct geographical characteristics that alters the structure and function of the ecology.

Large Marine Ecosystems (LME)

A geographic area of an ocean that has distinct bathymetry, hydrography, productivity, and trophically dependent populations. [1]

Life history

A history of the changes through which an organism passes in its development from the primary stage to its natural death.[4]

Living Marine Resources

Living organisms found in the marine environment. Generally thought of as those organisms

that depend on the marine environment and that are also of concern or importance to humans.

M

Management ready

Tools and information that have been reviewed and vetted and are considered ready for use by managers in their decision making.

Marine Mammals

Warm-blooded animals that live in marine waters and breathe air directly. These mammals include porpoises, dolphins, whales, manatees, seals, and sea lions[1].

Marine Mammal Protection Act (MMPA)

The MMPA prohibits the harvest or harassment of marine mammals, although permits for incidental take of marine mammals during commercial fishing may be issued subject to regulation.[1]

Meta analyses

A quantitative statistical analysis of several separate but similar experiments or studies to test the pooled data for statistical significance.[5]

N

National Academy of Sciences (NAS)

A private nonprofit, self-perpetuating society of scientists. The NAS was granted a charter by Congress in 1863 that requires it to advise the Federal Government on scientific and technical matters.[1]

O

Ocean Acidification

The increase in acidity of the ocean due to the introduction of carbon dioxide into the ocean and the subsequent production of carbonic acid.

Ontogeny

The developmental history of an organism, typically from fertilization of the egg to the mature organism.

P

Pit Tags

Passive integrated transponder (Pit) tags placed internally in an animal to provide long-term, unique alphanumeric identification for that animal when the tag is scanned by a device that emits a low-frequency radio signal. Tags generally consist of a chip, capacitor, and antenna coil encased in glass.

Primary production

Assimilation (gross) or accumulation (net) of energy and nutrients by green plants and by organisms that use inorganic compounds as food.[1]

Protected Species

Refers to any species which is protected by either the ESA or the MMPA, and which is under the jurisdiction of the NMFS and/or the USFWS. Includes all threatened, endangered, and candidate species, as well as all cetaceans and pinnipeds, excluding walruses.[1]

R

Resilience

Capacity of a natural system (fisheries community or ecosystem) to recover from heavy disturbance such as intensive fishing,[1] storm events, acute and chronic pollution events, and sea-level rise.

Restoration

The process of returning a damaged ecosystem to a less degraded state.

S

Secondary production

Generally the biomass produced by organisms using organic carbon. Note: In some cases secondary production refers only to the biomass produced by organisms that eat plants (herbivores), and tertiary production refers to that produced by carnivores.

Sentinel species

Organisms used to warn of environmental change. Typically, these organisms are particularly susceptible to certain environment changes and therefore may provide early warning of environmental changes or threats.

Socioeconomic

Pertaining to the combination or interaction of social and economic factors. Involves such topics as distributional issues, labor market structure, social and opportunity costs, community dynamics, and decision-making processes. [1]

Stock

A part of a fish population that usually has a particular migration pattern or specific spawning grounds and is subject to a distinct fishery. A fish stock may be treated as a total or a spawning stock. Total stock refers to both juveniles and adults, either in numbers or by weight, and spawning stock refers to the numbers or weight of individuals that are old enough to reproduce. [1]

Stock structure

1. The spatial organization of a species in terms of the genetic structure of the species across geographic space (e.g., a species of large pelagic fish (tunas) may be composed of three separate stocks in the North Atlantic, South Atlantic, and Pacific c Ocean).
2. The structure of a particular stock, in terms of its size or age composition or in terms of its species composition (for a multispecies stock). [1]

Sublethal stressors

Factors that cause damage or trauma but do not kill organisms outright.

Submersible flow cytometer

An underwater flow cytometer used for counting and classifying cells by passing cells in a liquid stream through a light source and typically uses either impedance or optical systems.

Sustainability

1. Ability to persist in the long-term. Often used as "short hand" for sustainable development.
2. Characteristic of resources that are managed so that the natural capital stock is non-declining through time, while production opportunities are maintained for the future. [1]

T

Threatened species

As defined by the ESA, any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Transboundary stocks

A group of commercially exploitable organisms, distributed over, or migrating across, the maritime boundary between two or more national jurisdictions, or the maritime boundary of a

national jurisdiction and the adjacent high seas, whose exploitation can only be managed effectively by cooperation between the States concerned. [6]

Trophic interactions

Interactions between groups of organisms eating resources from a similar level in the energy cycle[1]
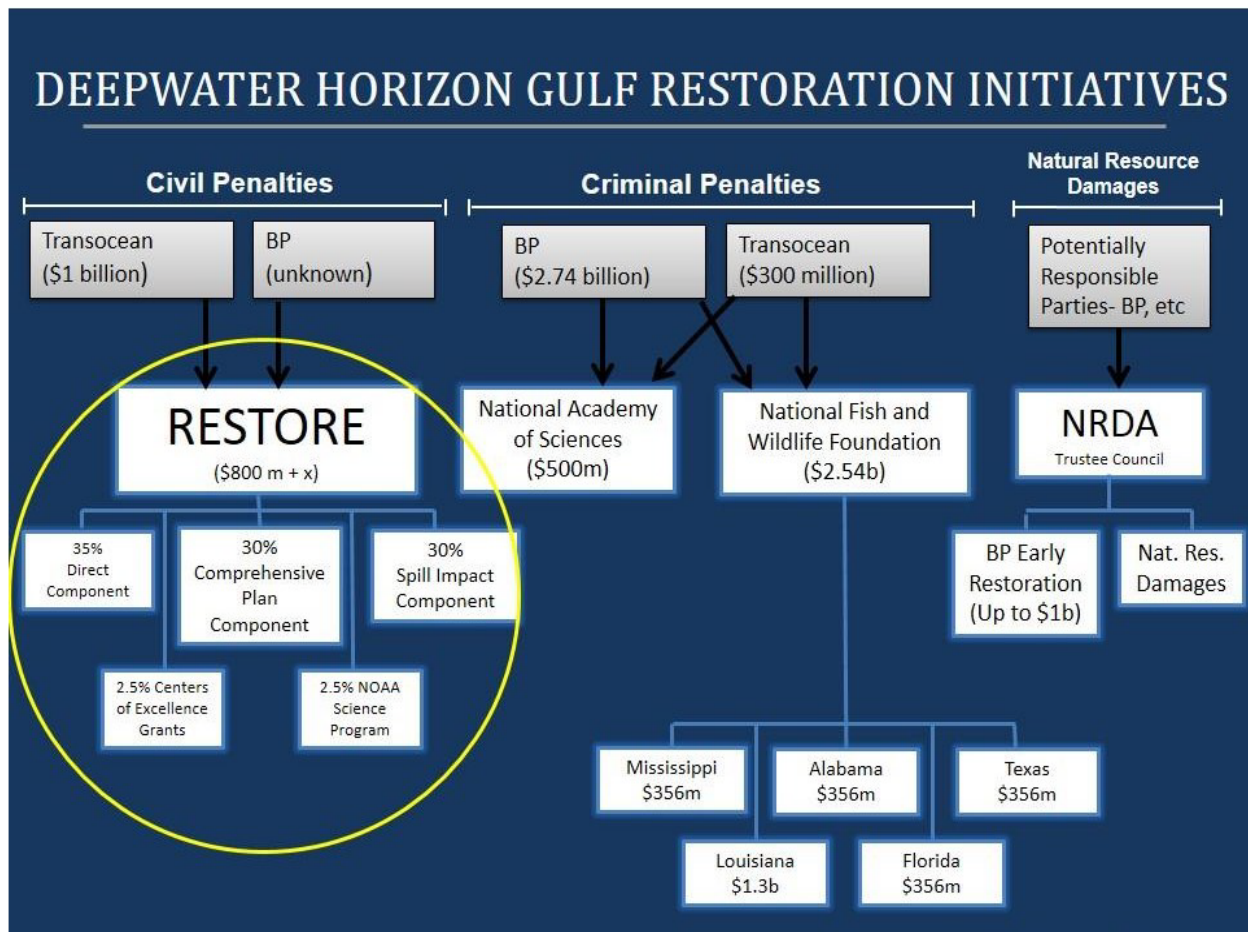
W

Wildlife

Living things, especially mammals and birds that are not domesticated.

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Appendix II. Deepwater Horizon Gulf Restoration Initiatives

DEEPWATER HORIZON GULF RESTORATION INITIATIVES

Civil Penalties

Transocean ($1 billion)

BP (unknown)

Criminal Penalties

BP ($2.74 billion)

Transocean ($300 million)

Natural Resource Damages

Potentially Responsible Parties- BP, etc

RESTORE ($800 m + x)

National Academy of Sciences ($500m)

National Fish and Wildlife Foundation ($2.54b)

NRDA Trustee Council

35% Direct Component

30% Comprehensive Plan Component

30% Spill Impact Component

2.5% Centers of Excellence Grants

2.5% NOAA Science Program

BP Early Restoration (Up to $1b)

Nat. Res. Damages

Mississippi $356m

Alabama $356m

Texas $356m

Louisiana $1.3b

Florida $356m

Appendix III. Overview of Existing/Anticipated Gulf Programs

Several other groups have or are anticipated to receive funding as a result of the Deepwater Horizon oil spill. NOAA believes it is imperative that all recipients of settlement funds derived from the spill money coordinate science activities to maximize the benefit to the environment and people of the Gulf of Mexico. These recipients include, but are not limited to:

- The National Fish and Wildlife Foundation received $2.5 billion from the Transocean and BP settlements with the U.S. Department of Justice. These funds are specifically focused on ecosystem restoration, including barrier island construction, in the Gulf States.   Half of the funds are specifically dedicated to barrier island and river diversion projects in Louisiana.
- The National Academy of Sciences received $500 million from the Transocean (January 2013) and BP (November 2012) settlements with the U.S. Department of Justice. These funds are to be used for human health and environmental protection, including oil spill prevention and response, in the Gulf over a 30-year period.
- The North American Wetlands Conservation Fund received $100 million from the BP criminal settlement (November 2012) to be used for wetlands restoration, conservation, and projects benefitting migratory birds.
- Gulf of Mexico Research Initiative is receiving $500 million from BP over 10 years to fund an independent research program designed to study the impact of the oil spill and its associated response on the environment and public health in the Gulf of Mexico.
- The Deepwater Horizon Natural Resources Damage Assessment (conducted under the Oil Pollution Act of 1990) Board of Trustees are mandated to restore, rehabilitate, replace, or acquire the equivalent of the injured natural resources with the goal of restoring injured resources and services to baseline (pre-spill) conditions, and to compensate the public for interim losses that occur during the time it takes those resources to recover.

Appendix IV. Programs in the Gulf of Mexico that Support Ecosystem Research, Restoration, and Restoration Science

Entity	Themes/Priorities/Eligible Activities	Amount of Funding	Timeframe	Geographic Scope
NOAA RESTORE Act Science Program	• marine and estuarine research; • marine and estuarine ecosystem monitoring and • ocean observation; • data collection and stock assessments; • pilot programs for— 1. fishery-independent data; 2. reduction of exploitation of spawning aggregations; and • cooperative research.	2.5% of the Gulf Coast Restoration Trust Fund plus 25% of any accrued interest ($20M based on Clean Water Act penalty settlements as of August 2014)	RESTORE Act does not specify an ending date for the program, but the program will end when the Gulf Coast Restoration Trust Fund is fully expended and all Clean Water Act liabilities by responsible parties have been resolved.	Gulf of Mexico Large Marine Ecosystem
National Academy of Sciences Gulf Research Program	• Foster innovative improvements to prevention, safety technologies, safety culture, and environmental protection systems associated with offshore oil and gas development; • Improve understanding of the links between environmental conditions and human health to strengthen the resilience of Gulf communities and ecosystems to environmental stressors; • Advance understanding of the Gulf of Mexico region as a dynamic system with complex, interconnecting human and environmental systems, functions, and processes to inform the protection and restoration of ecosystem services in the Gulf of Mexico.	$500M	2013-2043 or 2018-2048 The funds accumulate over 5 years (2013-2018) and must be disbursed within 30 years.	
RESTORE Act Centers of Excellence	Each center of excellence shall focus on science, technology, and monitoring in at least one of the following disciplines: • Coastal and deltaic sustainability, restoration and protection, including solutions and technology that allow citizens to live in a safe and sustainable manner in a	2.5% of the Gulf Coast Restoration Trust Fund plus 25% of any accrued interest ($20M based on Clean Water Act penalty settlements as of	TBD[1]	TBD[2]

	coastal delta in the Gulf Coast Region. • Coastal fisheries and wildlife ecosystem research and monitoring in the Gulf Coast Region. • Offshore energy development, including research and technology to improve the sustainable and safe development of energy resources in the Gulf of Mexico. • Sustainable and resilient growth, economic and commercial development in the Gulf Coast Region. • Comprehensive observation, monitoring, and mapping of the Gulf of Mexico.	August 2014)		
<u>Gulf of Mexico Research Initiative</u>	• Physical distribution, dispersion, and dilution of petroleum (oil and gas), its constituents, and associated contaminants (e.g., dispersants) under the action of physical oceanographic processes, air–sea interactions, and tropical storms. • Chemical evolution and biological degradation of the petroleum/dispersant systems and subsequent interaction with coastal, open ocean, and deepwater ecosystems. • Environmental effects of the petroleum/dispersant system on the sea floor, water column, coastal waters, beach sediments, wetlands, marshes, and organisms; and the science of ecosystem recovery. • Technology developments for improved response, mitigation, detection, characterization, and remediation associated with oil spills and gas releases. • Impact of oil spills on public health including behavioral, socioeconomic, environmental risk assessment, community capacity and other population health considerations and issues.	$500M	10 years (2010-2020)	
National Fish and Wildlife	Fund projects benefiting the natural resources of the Gulf Coast that were	$2.544 B $1.272 billion for	5 years (2013-2018)	Reasonable proximity to

Foundation Gulf Benefit Fund	impacted by the spill, specifically, support projects that remedy harm to natural resources (habitats, species) where there has been injury to, or destruction of, loss of, or loss of use of those resources resulting from the oil spill.	barrier island and river diversion projects in Louisiana. $356 million each for natural resource projects in Alabama, Florida, and Mississippi. $203 million for similar projects in Texas.		where the impacts occurred.
National Resource Damage Assessment (NRDA)	Restoration projects that compensate for loss of or loss of use of resources (both living and non-living) damaged by the Deepwater Horizon event.	$1 billion early restoration; final damage assessment TBD.	TBD	Coastal counties and parishes of the five Gulf States.
RESTORE Act – State Allocation (a.k.a. Bucket 1)	• Restoration and protection of the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, and coastal wetlands of the Gulf Coast region. • Mitigation of damage to fish, wildlife, and natural resources. • Implementation of a federally approved marine, coastal, or comprehensive conservation management plan, including fisheries monitoring. • Workforce development and job creation. • Improvements to or on State parks located in coastal areas affected by the Deepwater Horizon oil spill. • Infrastructure projects benefitting the economy or ecological resources, including port infrastructure. • Coastal flood protection and related infrastructure. • Planning assistance. • Administrative costs of complying with this subsection. • ACTIVITIES TO PROMOTE TOURISM AND SEAFOOD IN THE GULF COAST REGION.—Amounts provided to the Gulf Coast States under this subsection may be used to carry out 1 or more of the following activities: 1. Promotion of tourism in the Gulf	35% of the Gulf Coast Restoration Trust Fund equally divided among the Gulf States ($280M based on Clean Water Act penalty settlements as of August 2014)	TBD[1]	Gulf States

	Coast Region, including recreational fishing. 2. Promotion of the consumption of seafood harvested from the Gulf Coast Region.			
RESTORE Act - Gulf Coast Ecosystem Restoration Council (a.k.a. Bucket 2)	The Council will select and fund projects and programs that restore and protect the natural resources, ecosystems, water quality, fisheries, marine and wildlife habitats, beaches, and coastal wetlands of the Gulf Coast region.	30% of the Gulf Coast Restoration Trust Fund equally divided among the Gulf States ($240M based on Clean Water Act penalty settlements as of August 2014)	TBD[1]	Gulf States
RESTORE Act (Bucket 3)	State expenditure plans (SEP) must meet the statutory requirements of the RESTORE Act, including: (1) All projects, programs and activities included in the SEP are eligible activities as defined by the RESTORE Act; (2) all projects, programs and activities included in the SEP contribute to the overall economic and ecological recovery of the Gulf Coast; (3) the SEP takes the Council's Comprehensive Plan into consideration and is consistent with the goals and objectives of the Comprehensive Plan; (4) no more than 25 percent of the allotted funds are used for infrastructure projects unless the SEP contains certain certifications from the Gulf Coast State submitting the SEP. The funds the Council disburses to the Gulf Coast States upon approval of a SEP will be in the form of grants.	30% of the Gulf Coast Restoration Trust Fund will be disbursed to the five Gulf Coast States or their administrative agents based on an allocation formula established by the Council by regulation based on criteria in the RESTORE Act. The RESTORE Act establishes a statutory minimum under which each of the five Gulf Coast States is guaranteed five% of the funds made available in a fiscal year under this component.	TBD[1]	Coastal counties and parishes of the five Gulf States.
EPA Gulf of Mexico Program	The mission of the program is to facilitate collaborative actions to protect, maintain, and restore the health and productivity of the Gulf of Mexico in ways consistent with the economic well-being of the Region.	Congressional appropriations.	Established program with indefinite duration.	Gulf States, adjacent watersheds, and neighboring countries (i.e., Mexico) that influence the Gulf of Mexico.

| NMFS Southeast Fisheries Science Center	The Center conducts multi-disciplinary research programs to provide management information to support national and regional programs of NOAA's National Marine Fisheries Service.	Congressional appropriations.	Established program with indefinite duration.	Gulf of Mexico Large Marine Ecosystem and adjacent watersheds.

[1]Duration of programs established under the RESTORE Act is dependent on the total amount of funds deposited in the Gulf Coast Restoration Trust Fund.

[2]The Centers of Excellence established under the RESTORE Act have not been named. Geographic scope will be determined once those entities have been selected.
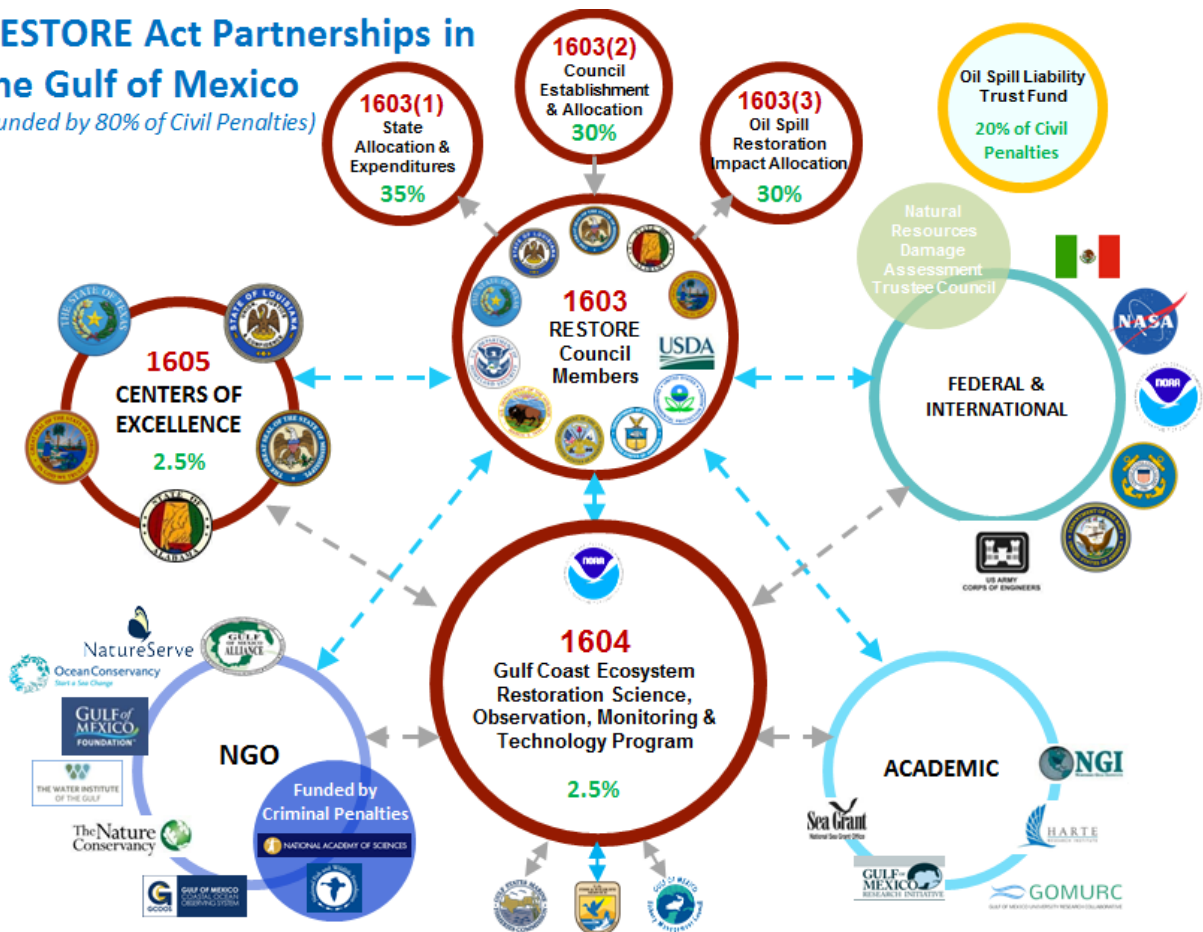
Appendix VI. Federal Data Management Policies

• White House "Open Data Policy" (OMB M-13-13) of May 9, 2013 which supports the related Executive Order of May 9, 2013 (Making Open and Machine Readable the New Default for Government Information). This policy requires federal agencies to collect or create information in a way that supports downstream information processing and dissemination activities. This includes using machine readable and open formats, data standards, and common core and extensible metadata for all new information creation and collection efforts. This policy also requires agencies to catalog their data assets and to publish public data listings.   The NOAA Data Catalog (data.noaa.gov) is NOAA's primary implementation of the Open Data Policy.

• White House policy on "**Increasing Access to the Results of Federally Funded Scientific Research**"

• OMB Circular A-130 which states "The open and efficient exchange of scientific and technical government information, subject to applicable national security controls and the proprietary rights of others, fosters excellence in scientific research and effective use of Federal research and development funds. The nation can benefit from government information disseminated both by Federal agencies and by diverse nonfederal parties, including State and local government agencies, educational and other not-for-profit institutions, and for-profit organizations."

• OMB Circular A-16 which "promotes the coordinated development, use, sharing, and dissemination of surveying, mapping, and related spatial data."

• NOAA Administrative Order 212-101 which implements OMB guidance by issuing NOAA policy that "Environmental data will be visible, accessible and independently understandable to users, except where limited by law, regulation, policy (such as those applicable to personally identifiable information or protected critical infrastructure information or proprietary trade information) or by security requirements."

• NOAA Administrative Order 215-12 which further implements OMB guidance requiring that "Environmental data will be visible, accessible and independently understandable to users..."

• NOAA Environmental Data Management Framework that states: "Accurate, timely, and comprehensive observations of the Earth and its surrounding space are critical to support government decisions and policies, scientific research, and the economic, environmental, and public health of the United States. Earth observations are typically produced for one specific purpose -- sometimes at great cost -- but are often useful for other purposes as well. It is important that these observations be managed and preserved such that all potential users can find, evaluate, understand, and utilize these data."

Appendix VII. Acronyms and Abbreviations

ACRONYM	ABBREVIATION
AOP	Annual Operating Plan
BMP	Best Management Practice
CSCOR	Center for Sponsored Coastal Ocean Research
DOC	Department of Commerce
EDR	Ecosystem Data Record
ESP	Environmental Sample Processor
GAME	Geospatial Assessment of Marine Ecosystems
GCOOS	Gulf of Mexico Coastal Ocean Observing System
GMFMC	Gulf of Mexico Fishery Management Council
GOMA	Gulf of Mexico Alliance
GRIDc	Gulf of Mexico Research Initiative and Data Center
GSMFC	Gulf States Marine Fisheries Commission
IOOS	Integrated Ocean Observing System
LME	Large Marine Ecosystem
LMR	Living Marine Resource
NAO	NOAA Administrative Order
NAS	National Academy of Sciences
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OA/OC	Quality Assurance/Quality Control
PI	Principal Investigator
RESTORE Act	Resources and Ecosystems Sustainability, Tourist Opportunity, and Revived Economies of the Gulf States Act of 2012
RSPAWG	RESTORE Science Program Advisory Working Group
TED	Turtle Excluder Device
USFWS	U.S. Fish and Wildlife Service