5. Restoring Natural Resources

What Is in This Chapter?

This chapter describes how the Trustees plan to restore the natural resources and associated services injured by the *Deepwater Horizon* oil spill. This document is programmatic—as a whole, this Draft PDARP/PEIS provides long-term direction and guidance for restoring injured resources and services and lays out the Trustees' preferred alternative for restoration. It does not list or select individual restoration projects. Following the publication of this plan, Trustee Implementation Groups will develop and issue for public review subsequent restoration plans that propose, evaluate, and ultimately select specific restoration projects for implementation. That subsequent planning process is described in Chapter 7, Governance, including a description of how the Trustees will ensure future plans are consistent with the restoration goals, objectives, and approaches described in this document.

This chapter is organized as follows.

- **Bridging Injury to Restoration (Section 5.1):** How are the wide-ranging injuries described in Chapter 4, Injury to Natural Resources, tied to the Trustees' preferred alternative for restoration, which is an ecosystem-level approach?
- **Overarching Trustee Restoration Planning Approach, OPA Requirements (Section 5.2):** What is the Trustees' overall approach to restoration planning?
- **Trustee Programmatic Goals, Purpose, and Need (Section 5.3):** What are the Trustees' overarching goals, purpose, and need for restoration?
- **Approach to Developing and Evaluating Alternatives (Section 5.4):** What is the Trustees' process for developing restoration alternatives (a required step under the OPA and NEPA statutes that guide Trustee action), and what are the restoration planning alternatives that the Trustees developed?
- **Alternative A: Comprehensive Integrated Ecosystem Restoration (Preferred Alternative) (Section 5.5):** What is the Trustees' preferred alternative of comprehensive integrated ecosystem restoration and what are the restoration types that together form a comprehensive, integrated approach to restoration?
- **Other Alternatives (Sections 5.6, 5.7, and 5.7.2):** What are the other three restoration planning alternatives the Trustees considered?
- **Comparative OPA Evaluation of Action Alternatives (Section 5.9):** How do the two action alternatives compare and why did the Trustees select comprehensive integrated ecosystem restoration as their preferred alternative?
- **Summary of Preferred Alternative and Funding Allocations (Section 5.10)**: How can the preferred alternative be summarized? Under the preferred alternative, what is the funding allocation to each restoration type in defined restoration areas? What is the restoration potential for the funding? What is the process for subsequent restoration planning?

- **References (Section 5.11):** What literature is cited in this chapter?
- **Scoping Report (Appendix 5.A):** What comments did the Trustees receive from the public that helped them begin to develop restoration approaches?
- **Early Restoration (Appendix 5.B):** What projects were or are being done as part of Early Restoration?
- **Restoration Screening Overview (Appendix 5.C):** How did the Trustees use information from public comments and Early Restoration to develop restoration approaches?
- **Restoration Approaches and OPA Evaluation (Appendix 5.D):** What restoration approaches did the Trustees develop, and what are the implementation and OPA considerations?
- **Monitoring and Adaptive Management Framework (Appendix 5.E):** What elements of monitoring, assessment, and science support ensure the Trustees' goals and objectives are fully realized over years of implementing a restoration plan?

5.1 Bridging Injury to Restoration

The injuries caused by the *Deepwater Horizon* spill cannot be fully described at the level of a single species, a single habitat type, or even a single region. The ecological scope of this incident was unprecedented, with oiling occurring in the deep ocean a mile below the surface, in offshore habitats, as well as nearshore and shoreline habitats hundreds of miles from the wellhead. The injuries affected such a wide array of linked resources over such an enormous area that the effects of the *Deepwater Horizon* spill must be described as constituting an ecosystem-level injury. Just as the injuries cannot be understood in isolation, restoration efforts must also be considered and implemented from a broader perspective. Consequently, the Trustees' preferred restoration alternative was similarly developed using an ecosystem-level approach, informed by reasonable scientific inferences based on the information collected for representative habitats and resources. This approach resulted in the comprehensive, integrated, ecosystem restoration portfolio (referred to as the integrated restoration portfolio) identified as the preferred alternative in this chapter.

The integrated restoration portfolio addresses the diverse suite of injuries that occurred at both regional and local scales. The Trustees have considered key ecological factors such as linkages (interactions between the interdependent network of habitats and organisms [from microbes, to plants, to animals]), as well as factors such as resiliency and sustainability (e.g., Folke et al. 2004; NOAA 2011). The preferred alternative allocates restoration funds across restoration types, making investments regionwide, the open ocean, and throughout all five Gulf states to restore coastal and nearshore[1] habitats, improve water quality in priority watersheds, protect and restore living coastal and marine resources, and enhance recreational use opportunities. By making investments across resource groupings and supporting habitats, the Trustees will maximize the likelihood of appropriately compensating the public for all the resources and services injured by the spill.

What Is a Restoration Portfolio?

A **portfolio** approach to restoration involves distributing restoration "investments" across a range of different restoration types and locations. This is similar to the idea of a financial investment portfolio in which financial assets are diversified in order to maximize returns and reduce risks. Portfolio theory has a long history in financial management, but also has been used in natural resource management to balance ecological benefits against risks (e.g., Halpern et al. 2011; Hoekstra 2012).

This investment of funds particularly focuses on restoring Louisiana coastal marshes as an essential element of the preferred alternative. Given both the extensive impacts to Louisiana marsh habitats and species and the critical role that these habitats across the Gulf of Mexico play for many injured resources and for the overall productivity of the Gulf (Gosselink & Pendleton 1984), coastal and nearshore habitat restoration is the most appropriate and practicable mechanism for restoring the ecosystem-level linkages disrupted by this spill. As ecologically significant as these coastal and nearshore habitats are, however, aspects of this vast and diverse injury will require additional restoration,

[1] For purposes of this document, the Trustees use the terms coastal and nearshore as appropriate for each resource; therefore, the terms are not specifically defined.

especially to those resources that spend some or all of their lives in the open waters of the Gulf of Mexico. Therefore, this plan also calls for restoration, focused on specific resource groups and recreational use opportunities, which will directly support the recovery of these vital resources.

The integrated restoration portfolio includes assignment of funds to monitoring, adaptive management, oversight, and comprehensive planning. In addition to being a guiding approach to implementing this plan, adaptive management (Thom et al. 2005) will be used to address currently unknown conditions that may be uncovered in the future. In this way, the Trustees provide for flexible, science-based decision-making to ensure that the integrated restoration portfolio provides long-term benefits to the natural resources and services injured by the spill.

This chapter provides an overview of the Trustees' methodical decision process, including an evaluation of alternatives, which resulted in this preferred alternative. This process incorporated input from the public and support from natural resource science experts to identify the types of restoration that will best contribute to making the environment and public whole from all the natural resource damages caused by the *Deepwater Horizon* oil spill. The Trustees' overall restoration planning process takes into account the scope of the spill, the context of NRDA restoration planning within the Gulf of Mexico, and the OPA requirements and criteria for restoration planning and implementation that guide the Trustees' actions.

5.2 Overarching Trustee Restoration Planning Approach, OPA Requirements

5.2.1 OPA Requirements and Criteria for Restoration Planning

NRDA restoration planning under OPA is a process that includes evaluating injuries to natural resources and natural resource services and using that information to determine the types and extent of restoration needed to address the injuries. OPA charges trustee agencies to identify and implement actions appropriate to restore, replace, or acquire natural resources or services equivalent to those injured by oil spills to the condition that resources would have been in if the incident had not occurred (33 USC § 2706(b)).

As defined under the OPA regulations for NRDA (15 CFR § 990.30), natural resource services refer to the functions performed by a natural resource for the benefit of another natural resource (ecological services) and/or the public. Natural resource services describe all the ways that resources provide benefits to each other, through ecological linkages among habitats and organisms and among organisms themselves. Examples of natural resource services include (but are not limited to) nutrient cycling, water purification, pollination, food production for other species, and habitat provision (Millennium Ecosystem Assessment 2005). Recreational use services include (but are not limited to) recreational activities such as wildlife viewing, fishing, boating, nature photography, education, swimming, and hiking. The healthy functioning of natural resources supports these and other services (de Groot et al. 2002). For the purposes of this document, the term "natural resource services" includes ecological and human use services.

Restoration activities under OPA are intended to return injured natural resources and services to

Restoration Terms Defined

Restoration: Any action that restores, rehabilitates, replaces, or acquires the equivalent of the injured natural resources and services.

Baseline: The condition of the natural resources and services that would have existed had the incident not occurred.

Primary Restoration: Any action, including natural recovery, that returns injured natural resources and services to baseline.

Compensatory Restoration: Any action taken to compensate the public for interim losses of natural resources and services from the date of incident until recovery.

Natural Resource Services: The functions performed by a natural resource for the benefit of another natural resource and/or the public.

(See 15 CFR § 990.30.)

Early Restoration: For *Deepwater Horizon*, restoration projects funded under the Framework Agreement between the Trustees and BP, allowing projects proposed by the Trustees to move forward in advance of reaching full resolution of the case.

Emergency Restoration: Actions taken before an assessment is complete to minimize continuing injury or prevent additional injury.

(See 15 CFR § 990.26.)

their baseline condition (primary restoration) and to compensate the public for interim losses from the time of the incident until the resources and services recover to baseline conditions (compensatory restoration) (15 CFR § 990.10). To meet these goals, the restoration activities need to produce benefits that are related, or have a nexus (connection), to natural resource injuries and service losses resulting from the spill. To meet the NRDA regulations, trustees must identify a reasonable range of restoration alternatives, evaluate and select the preferred alternative(s), and develop a Draft and Final Restoration Plan.

In addition to developing restoration measures that will address the injuries to natural resources and lost natural resource services, the OPA regulations provide for alternative methods for determining the value of lost natural resources. Early in this NRDA process, NOAA initiated a total value study, which is one such alternative method. However, because the Trustees have concluded that the natural resource injuries and service losses in this case can be addressed by the preferred restoration alternative described in this Draft PDARP/PEIS, the Trustees have not completed that total value study and are not relying on it. Draft materials describing the methods and preliminary results of the total value study are nonetheless included in the Administrative Record.

5.2.2 Scope and Programmatic Context of Restoration Planning

Restoration planning for large marine oil spills has been conducted in the past (e.g., Exxon Valdez Oil Spill Trustee Council 1994; NOAA et al. 2014), but the duration, longevity, and pervasive impact of the *Deepwater Horizon* oil spill on resources throughout the northern Gulf of Mexico calls for a restoration effort of unprecedented magnitude. The extensive injuries to multiple habitats, species, ecological functions, and geographic regions clearly establish the need for comprehensive restoration planning on a landscape and ecosystem scale that recognizes and strengthens existing connectivity between habitats, resources, and services in the Gulf of Mexico. A comprehensive restoration plan must consider this ecosystem context in deciding how best to restore for the vast array of resources and services injured by this spill.

To fulfill the OPA mandate, the Trustees have pursued an iterative and phased restoration planning process, which has enabled the Trustees to adapt their restoration planning as more information became available. This phased planning process will continue after the issuance of this document. The Trustees began their restoration planning soon after the spill and initiated a public scoping effort in early 2011 to identify issues of public concern. With sufficient information about restoration opportunities and initial information about assessed and likely injuries, the Trustees embarked in 2011 on Early Restoration planning to accelerate the restoration process. Throughout, natural resource experts have also been working on programmatic restoration planning to identify the approaches and techniques that would be most appropriate for benefiting injured habitats, resources, and services. Figure 5.2-1 provides a general overview of the phased restoration planning process.

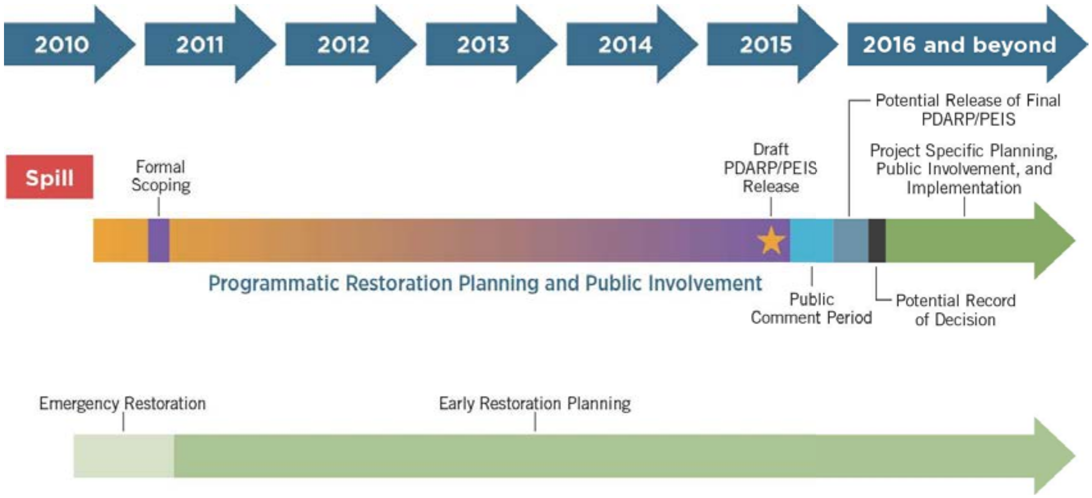

Figure 5.2-1. Generalized timeline illustrating phased restoration planning process. Restoration implementation (not shown on this timeline) will continue beyond the timeline for the restoration planning process.

Given the scope and magnitude of restoration remaining to be conducted, the Trustees are undertaking this next step of restoration planning at a program level. The Trustees are releasing this Draft PDARP/PEIS to clearly set before the public a nested framework of programmatic goals, restoration types, and restoration approaches that will guide and direct the subsequent phases of restoration (Figure 5.2-2). Those subsequent phases of restoration will identify, evaluate, and select specific restoration projects for implementation that are consistent with the restoration framework laid out by this Draft PDARP/PEIS.

Figure 5.2-2. An example of the Trustees' nested framework of restoration goals, restoration types, and restoration approaches. Restoration goals are presented in Section 5.3; restoration types are presented in Section 5.5; restoration approaches are presented in Appendix 5.D.

5.2.3 Primary and Compensatory Restoration

To develop restoration alternatives, the Trustees must consider both primary and compensatory restoration options (15 CFR § 990.53). Active primary restoration actions work to directly restore injured natural resources and services to baseline on an accelerated time frame (15 CFR § 990.53). An example of active primary restoration is the Trustees' Emergency Restoration project to restore submerged aquatic vegetation (SAV) beds damaged by propeller scarring and other response vessel impacts (Chapter 1, Section 1.4.3.1). This project directly restored the injured SAV in the location of that project to baseline conditions faster than would have occurred under a natural recovery scenario.

In contrast, compensatory restoration actions are intended to compensate the public for the loss of natural resources and services during the “interim” time period between the start of injury and the eventual recovery of the resource or service (15 CFR § 990.53). For example, many beaches were closed to public access during the *Deepwater Horizon* spill and the associated cleanup and response actions. The re-opening of clean beaches represented the recovery to baseline of the recreational use services provided by sandy beaches. However, under OPA, the public is still entitled to compensation for the loss of recreational uses during the time period when the beaches were closed. Because the beaches have been re-opened, the Trustees do not need to undertake primary restoration for this injury. Instead, the Trustees will identify compensatory restoration options that will provide the public with additional recreational use services, typically in locations near to where the injury occurred.

As described in Chapter 4, some injured resources have suffered permanent injury (e.g., eroded marsh shorelines) and some others will take decades to recover (e.g., sea turtles, mesophotic reef, and deep benthic communities). For these resources, actions taken to restore the resources to baseline conditions can be considered both primary and compensatory restoration, depending on the amount, type, and location of the restoration being conducted.

Whether the time period of injury was short or long, all injured resources suffered some level of interim loss during the time period between the start of injury and recovery. Compensatory restoration is therefore an important part of this restoration plan. Typically, in planning for compensatory restoration, Trustees look for restoration opportunities that can benefit natural resources and services by addressing existing stressors to resources. Some examples of these stressors that the Trustees will seek to address through this restoration plan include direct impacts to living coastal and marine resources caused by trawling activities, marine debris, and invasive species, as well as habitat degradation caused by coastal development, subsidence, sea level rise, unintended boating and recreational use impacts, reduced sediment supply, and pollution (e.g., Gulf Coast Ecosystem Restoration Task Force 2011). Addressing these problems that are harming the natural resources and services affected by the spill provides a means to compensate the public for the interim losses these resources and services experienced.

5.3 Trustee Programmatic Goals, Purpose, and Need

5.3.1 Programmatic Trustee Goals

The Trustees' goals for *Deepwater Horizon* NRDA restoration planning are specific to addressing injury and align with the overarching goals previously identified by the Gulf Coast Ecosystem Restoration Task Force (GCERTF 2011).[2] Thus, at the highest level, the Trustees' guiding principle is to provide a comprehensive restoration plan that restores the range of habitats, resources, and services injured by the spill by allocating restoration funds using an integrated restoration portfolio across restoration types and locations to meet the following goals:

- Restore and Conserve Habitat.
- Restore Water Quality.
- Replenish and Protect Living Coastal and Marine Resources.
- Provide and Enhance Recreational Opportunities.
- Provide for Monitoring, Adaptive Management, and Administrative Oversight to Support Restoration Implementation.

These goals work both independently and together to achieve necessary benefits to injured resources and services. The goal of restoring and conserving habitats recognizes that wetlands, barrier islands, and SAV beds are highly productive and serve as important nursery and foraging habitat for many living coastal and marine resources such as birds, turtles, marine mammals, finfish, shellfish, and invertebrates (e.g., O'Connell et al. 2005). These actions could also be used to restore for lost human uses and to complement approaches to restore water quality. The goal of restoring water quality recognizes the intricate linkages between improving water quality and the health and resilience of coastal and marine habitats and resources (e.g., Bricker et al. 2008). Furthermore, the quality of Gulf Coast water is closely linked to human activities (e.g., development, industry, and agriculture) within watershed (or basin) boundaries. The goal to replenish and protect living coastal and marine resources acknowledges that resources such as fish, sea turtles, and deep coral communities make up an interconnected Gulf food web. They provide many important ecosystem services such as contributing to a resilient, biologically diverse, and productive system better capable of rebounding from natural events and pressures as well

[2] President Barack Obama established the Gulf Coast Ecosystem Restoration Task Force on October 5, 2010 "to coordinate the long-term conservation and restoration of America's Gulf Coast" (GCERTF 2011).The Task Force reviewed the long-standing challenges facing Gulf Coast ecosystems that existed before the *Deepwater Horizon* oil spill and identified four overarching goals that would facilitate the long-term vitality of the Gulf Coast:

- Restore and conserve habitat.
- Restore water quality.
- Replenish and protect living coastal and marine resources.
- Enhance community resilience.

The Task Force also noted that implementation of ecosystem restoration efforts on a large scale depends on a robust scientific foundation and the use of an effective adaptive management framework (GCERTF 2011).

as anthropogenic events and pressures (Adger et al. 2005). The goal of providing and enhancing recreational opportunities acknowledges all the myriad ways that the human community interacts with the natural environment, from fishing to sunbathing to bird watching and countless other recreational activities. Therefore, this goal seeks to improve on those experiences through maintaining healthy coastal and marine habitats and resources, increasing the public access to these coastal resources, and enhancing the quality of these recreational activities. The Trustees include monitoring and adaptive management as one of their goals to provide for a flexible, science-based approach to ensuring that the restoration portfolio being implemented over several decades provides long-term benefits to the resources and services injured by the spill in the effective and efficient manner envisioned in this programmatic plan.

Consistent with these programmatic goals, the Trustees also developed goals for each restoration type, as described in the discussion of Alternative A (Sections 5.5.2 through 5.5.14). These more specific goals will help to guide restoration planning and future project selection for each restoration type. Subsequent restoration plans will be consistent with one or more of the restoration type goals when identifying and selecting restoration projects for that specific restoration type. The Trustees intend to assess progress on all restoration type goals and will strive for all goals to be addressed over time through implementation of multiple restoration projects. To that end, the Trustees will also consider certain factors in evaluating restoration types and approaches, such as the following:

- Key ecological factors such as connectivity, size, and distance between projects, as well as factors such as resiliency and sustainability.
- The potential impact or synergy of other Gulf restoration activities on NRDA restoration planning.
- The inclusion of innovative approaches to restoring resources and services.
- The need to follow an adaptive approach to restoration through iterative planning, implementation, and monitoring to optimize restoration results.

5.3.2 NEPA Statement of Purpose and Need

To meet the purpose of restoring extensive and complex injuries to natural resources and services resulting from this spill, the Trustees identified a need for a comprehensive restoration plan consistent with OPA and able to restore these injured natural resources and services. The Trustees' overarching goals and planning objectives, above, align with this purpose and need. At this programmatic level, the Trustees therefore propose to identify and select a comprehensive restoration plan linked to injury to guide and direct subsequent development and selection of specific restoration projects. Consistent with the comprehensive restoration plan that is ultimately selected, the Trustees will undertake subsequent restoration planning and project implementation to provide primary and compensatory restoration of habitats, species, and services.

5.4 Approach to Developing and Evaluating Alternatives

From the early days of the spill, the Trustees recognized the need for an ecosystem-level perspective in determining the restoration required to address the magnitude and diversity of injuries. According to the NRDA regulations under OPA, trustees are responsible for identifying a reasonable range of restoration alternatives (15 CFR § 990.53(2)) that can be evaluated according to the OPA evaluation standards (15 CFR § 990.54). The alternatives must be designed so that, as a package of one or more actions, each restoration alternative would make the environment and the public whole (15 CFR § 990.53(2)). NEPA also directs agencies to rigorously explore and objectively evaluate all reasonable alternatives (40 CFR § 1502.14(a)). NEPA calls for agencies to "use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment" (40 CFR § 1500.2 (e)). This section describes the Trustees' process for developing and evaluating restoration alternatives that meet the Trustees' identified need for a comprehensive restoration plan, linked to injury, that will guide and direct subsequent development and selection of specific restoration actions.

5.4.1 Initiating Public Involvement in the NRDA

Public input is an integral part of OPA and is important to ensuring that the Trustees consider relevant information and concerns of the public. A Notice of Intent to Conduct Restoration Planning for the *Deepwater Horizon* Oil Spill (NOI) was published in the Federal Register on October 1, 2010, and announced publicly by the Trustees (DOI 2010). Pursuant to 15 CFR § 990.44, the NOI announced that the Trustees determined to proceed with restoration planning to fully evaluate, assess, quantify, and develop plans for restoring, replacing, or acquiring the equivalent of natural resources injured and losses resulting from the spill. The Trustees also established websites to provide the public with information about injury and restoration processes,[3] and the Trustees have received hundreds of proposals (available on cited webpages) since publication of the NOI in 2010. The Trustees have reviewed all these proposals and used these submittals in the development of restoration approaches, as described further below.

[3] The Trustees established the following websites:

- NOAA, Gulf Spill Restoration, available at http://*www.gulfspillrestoration.noaa.gov/*.
- DOI, *Deepwater Horizon* Oil Spill Response, available at *http://www.fws.gov/home/dhoilspill/*.
- Texas Parks and Wildlife Department, *Deepwater Horizon* Oil Spill, available at *http://www.tpwd.state.tx.us/landwater/water/environconcerns/damage_assessment/deep_water_horizon.phtml/*.
- Louisiana, *Deepwater Horizon* Oil Spill Natural Resource Damage Assessment, available at *http://losco-dwh.com/*.
- Mississippi Department of Environmental Quality, Natural Resource Damage Assessment, available at *http://www.restore.ms/*.
- Alabama Department of Conservation and Natural Resources, NRDA Projects, available at *http://www.alabamacoastalrestoration.org*.
- Florida Department of Environmental Protection, *Deepwater Horizon* Oil Spill Response and Restoration, available at *www.deepwaterhorizonflorida.com*.

5.4.2 Scoping for Restoration and for a PEIS

The Trustees initiated a 90-day formal scoping and public comment period for this Draft PDARP/PEIS in February 2011. Scoping was conducted in accordance with OPA (15 CFR § 990.14(d)), NEPA (40 CFR § 1501.7) and state authorities. The Trustees issued an NOI to begin restoration scoping and prepare a Gulf Spill Restoration Planning PEIS. That NOI requested public input to identify and evaluate a range of restoration types that could be used to fully compensate the public for the environmental and recreational use damages caused by the spill, as well as to develop procedures for the selection and implementation of restoration projects that will compensate the public for the natural resource damages caused by the spill. As part of the scoping process, the Trustees hosted public meetings across all the Gulf states during spring 2011. The NOI initiating scoping for the DARP and supporting PEIS can be viewed at: *http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2011/02/PEIS-NOI_signed.pdf*.

Scoping comments received from the public included identification of the need for restoration in the following categories: land acquisition and conservation; marsh restoration; hydrologic restoration (e.g., diversions and culverts); beach, barrier island, and/or dune restoration; SAV; shellfish; marine mammals and sea turtles; birds and terrestrial wildlife; offshore resources (including corals and excluding other resources already listed); invasive species removal; and human use of natural resources. Scoping comments also were received related to socioeconomics; restoration implementation approaches and issues (e.g., use of local advisory groups and local labor resources); long-term monitoring and evaluation (related to restoration); and a general category established to capture comments not related to any other category. A more detailed scoping summary report is available as Appendix 5.A, Scoping Report. The restoration ideas identified during scoping served as the foundation for the development of restoration approaches that were considered in the screening process.

5.4.3 Early Restoration

The scoping process was followed by the engagement of the Trustees in several phases of Early Restoration planning and implementation. Early Restoration was in addition to the Emergency Restoration projects that the Trustees implemented (Chapter 1, Section 1.4.3.1). Early Restoration allowed the Trustees to move forward with implementing restoration projects in advance of reaching full resolution of the case. As described in Chapter 1, on April 20, 2011, the Trustees and BP agreed that BP would provide up to $1 billion toward Early Restoration projects, under the terms of a Framework Agreement,[4] as a preliminary step toward the restoration of injured natural resources and services caused by the spill. The Framework Agreement provided an opportunity for progress towards on-the-ground restoration while the Trustees continued with assessment and restoration planning activities. Early Restoration projects partially addressed injuries to nearshore resources, birds, fish, sea turtles, and recreational uses through coastal habitats restoration, resource-specific restoration, and education and infrastructure projects. That work serves as a foundation for restoration in the future. This Draft PDARP/PEIS presents the full restoration needed, taking into account those projects already planned or completed under Early Restoration, to compensate for all injuries to natural resources and services.

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[4] The Framework Agreement can be found at *http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2011/05/framework-for-early-restoration-04212011.pdf*. Accessed July 7, 2015.

To date, 64 projects with a total cost of approximately $832 million have been selected through the first four phases of Early Restoration planning (DWH Trustees 2012a, 2012b, 2014, 2015). In Phase I, the Trustees selected eight projects that included two oyster projects, two marsh projects, a nearshore artificial reef project, two dune projects, and a boat ramp enhancement project. In Phase II, the Trustees selected two projects to address injuries to the nesting habitat of beach-nesting birds and nesting loggerhead sea turtles that resulted from response activities to the spill. The Trustees selected a Final Programmatic Early Restoration Plan and Programmatic Environmental Impact Statement (FERP/PEIS) for implementation in October 2014 to describe the program for identifying, selecting, implementing, and overseeing Early Restoration projects for Phase III and subsequent phases of Early Restoration. The Trustees selected 44 Phase III Early Restoration projects, including barrier island, dune, living shoreline, oyster, seagrass, and recreational use projects. In Phase IV, the Trustees selected 10 additional projects including recreational use, bird, sea turtle, fish, seagrass, and living shoreline projects. Appendix 5.B, Early Restoration, Table 5.B-1, identifies the project, Early Restoration phase (Phases I, II, III, and IV), geographic area (state- or Gulf-wide), and restoration type with which the project is associated..[5] An agreement in principle with BP has been reached on an additional potential $45.4M for a Phase V plan, which would represent the final phase of Early Restoration.

Throughout Early Restoration public involvement has been very important. Formal scoping was conducted as part of Phase III PEIS development to identify the concerns of the affected public, state and federal agencies, and Indian tribes; involve the public in the decision-making process; facilitate efficient Early Restoration planning and environmental review; define the issues and alternatives that will be examined in detail; and save time by ensuring that draft documents adequately address relevant issues. In addition to the public scoping for Phase III, the Trustees held public meetings during public review periods for each of the four Early Restoration plans/NEPA analyses released to date. These public meetings helped ensure public input into the restoration planning process. Although these Early Restoration processes are not formally a part of scoping for this Draft PDARP/PEIS, this continued and evolving public input was incorporated into the restoration planning for this Draft PDARP. Phase III Early Restoration scoping particularly re-emphasized the public's interest in a complete description of the injuries to resources and services caused by the spill and the corresponding public request for the Trustees to prepare a comprehensive restoration plan responsive to the full suite of injuries. As described in the FERP/PEIS, the Trustees committed to preparing a comprehensive restoration plan to address all injured resources and services. This Draft PDARP/PEIS is that plan, and it builds on Early Restoration progress made by the Trustees, but is intentionally separate from the FERP/PEIS to set the path forward for fully compensating the public for the magnitude and extent of injuries resulting from the 2010 *Deepwater Horizon* spill.

5.4.4 Screening to Identify Restoration Approaches

The purpose of the screening process was to identify and compile a diverse set of restoration approaches to carry forward for consideration in developing restoration types and planning alternatives. The Trustees took three steps in the screening process: 1) identification of restoration ideas and options,

[5] To view an interactive map of Early Restoration projects in the Gulf states approved by the *Deepwater Horizon* NRDA Trustees go to *http://www.restoration.noaa.gov/dwh/storymap/.*

2) organization of restoration ideas and options into restoration approaches, and 3) initial evaluation of restoration approaches for suitability under the NRDA. Consistent with OPA (15 CFR § 990.53 (a)(2)), the screening process evaluated the feasibility and applicability of restoration options in restoring for injured natural resources.

To develop the restoration approaches for consideration, the Trustees relied on a variety of information sources to identify restoration ideas and options. These information sources included public scoping comments (described in Section 5.4.3, Early Restoration), regional restoration planning documents (including plans developed by co-Trustees, nongovernmental organizations, academia, and other sources), ideas submitted in a project submittal database, Trustees' agency and resource-specific restoration expertise, and restoration categories evaluated and reviewed by the public as part of *Deepwater Horizon* Early Restoration planning (described in Section 5.4.3, Early Restoration). This screening process is further described in Appendix 5.C, Restoration Screening Overview.

Restoration Approaches

The restoration approaches organize restoration ideas from multiple different sources in ways that are meaningful for an evaluation under both OPA and NEPA. The restoration approaches describe options for implementation, and some include techniques to provide examples for specific methods. The restoration approaches are not necessarily intended to stand alone. They may be used in combinations to develop projects that maximize benefits for injured resources.

5.4.5 Developing Restoration Types Based on Injury

The Trustees identified the set of restoration types that make up Alternatives A and B based on their understanding of 1) the injuries that resulted from the *Deepwater Horizon* spill and 2) the ecosystem setting of the northern Gulf of Mexico, including linkages between habitats and resources. Since the restoration types define the range of actions needed to fully restore for this spill, any comprehensive restoration plan selected by the Trustees at this time must include all these restoration types.

Restoration types are nested within the following four programmatic restoration goals (see Figure 5.4-1):

- Under the goal of Restore and Conserve Habitat, the Trustees identified two restoration types: 1) Wetlands, Coastal and Nearshore Habitats and 2) Habitat Projects on Federally Managed Lands. These restoration types will benefit injured coastal and nearshore habitats as well as many injured species of fish and invertebrates in the water column, marine mammals, and birds, by providing food, shelter, breeding, and nursery habitat.
- Under the goal of Restore Water Quality, the Trustees identified two restoration types: 1) Nutrient Reduction and 2) Water Quality (a more general restoration type designed to address broader water quality degradation). The Trustees included these restoration types because they recognized that water quality improvements benefit recreational uses as well as contribute to the overall health and resiliency of coastal ecosystems.

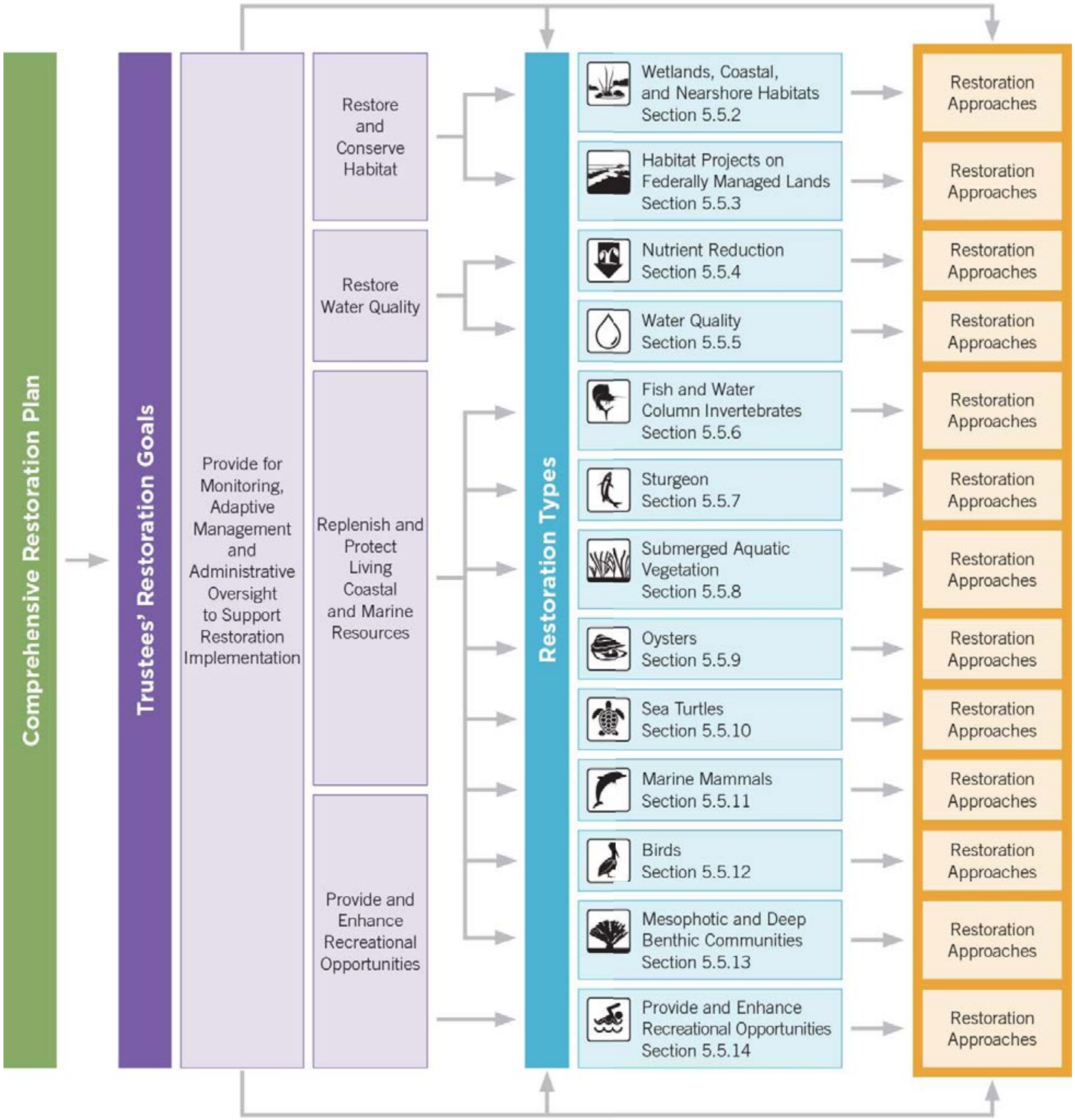


Figure 5.4-1. The Trustees' comprehensive restoration plan showing the goals and their related restoration type(s) connecting to restoration approaches, with monitoring, adaptive management, and administrative oversight planned throughout all restoration types.

- Under the goal of Replenish and Protect Living Coastal and Marine Resources, the Trustees identified eight different resource-focused restoration types, each of which is intended to benefit species and life stages that have specific restoration needs or weaker linkages with nearshore habitats.
- Under the goal of Provide and Enhance Recreational Opportunities, the Trustees identified a single restoration type (Provide and Enhance Recreational Opportunities) to directly benefit lost recreational uses of the Gulf of Mexico's natural resources and habitats due to the *Deepwater Horizon* spill.

Nested within the programmatic goals described in Section 5.3.1, Programmatic Trustee Goals, each restoration type (see Sections 5.5.2 through 5.5.14) includes specific restoration goals and the strategy to achieve those specific goals, which includes identifying a set of restoration approaches. In addition, the Trustees' fifth goal, Provide for Monitoring, Adaptive Management, and Administrative Oversight to Support Restoration Implementation, supports each restoration type and informs overall decision-making within the Trustees' adaptive management framework. The Trustees will ensure that subsequent plans and selected projects continue to support the goals of the restoration type and contribute to the programmatic Trustee goals and objectives.

5.4.6 The Trustees' Alternatives

Using all the information developed through the efforts outlined above, the Trustees developed a reasonable range of alternatives. The restoration types and restoration approaches are building blocks for comprehensive restoration plan alternatives, which also must meet the Trustees' programmatic goals, described above. These alternatives reflect different approaches to comprehensive restoration planning, and each is defined by an overarching restoration planning philosophy and rationale. The alternatives developed and evaluated in this Draft PDARP/PEIS are as follows:

- Alternative A (described in Section 5.5) is an integrated restoration portfolio that emphasizes the broad ecosystem benefits that can be realized through coastal habitat restoration in combination with resource-specific restoration in the ecologically interconnected northern Gulf of Mexico ecosystem. The Trustees have identified Alternative A as their preferred alternative.
- Alternative B (described in Section 5.6) is a resource-specific restoration portfolio that emphasizes close, well-defined relationships between injured resources and the restoration types. Restoration focuses on restoring as directly as practical for assessed injuries.
- Alternative C (described in Section 5.7) defers restoration plan development at this time, in favor of continued injury assessment. A comprehensive restoration plan would be proposed when greater scientific understanding of the injury determination is achieved.
- Alternative D (described in Section 5.8) is the natural recovery/no-action alternative, which the Trustees are required to evaluate under OPA and NEPA. Under this alternative, Early Restoration would be the only restoration implemented; no additional restoration under NRDA would be done by Trustees to accelerate the recovery of injured natural resources or to compensate for lost services.

In simple terms, Alternatives A and B (two of the action alternatives) can be thought of as different investment strategies for achieving the Trustees' programmatic restoration goals described in Section 5.3.1, Programmatic Trustee Goals. Both of these alternatives are composed of a portfolio of restoration types that are closely tied to the different categories of injury described in Chapter 4, Injury to Natural Resources. The alternatives differ in their emphasis on coastal habitat restoration and ecological interconnectivity compared to their emphasis on living coastal and marine resources (see Section 5.9, Comparative OPA Evaluation of Action Alternatives). Alternative C is a different investment strategy, with an emphasis on continued assessment prior to developing a comprehensive restoration plan. Restoration types for Alternative C are not described because they would be developed at the time a comprehensive restoration plan is proposed under that alternative. Restoration is not described for the natural recovery/no-action Alternative D. The comprehensive restoration plan ultimately selected by the Trustees will include monitoring, assessment, and science support in an adaptive management framework, as well as administrative oversight and management. These science and management plan elements ensure the Trustees' goals and objectives are fully realized over years of implementing a restoration plan; they are described in Sections 5.5.15 (Monitoring and Adaptive Management) and in Appendix 5.E (Monitoring and Adaptive Management Framework). Additional information on administrative oversight and adaptive management is also provided in Chapter 7, Governance.

5.4.7 Evaluation of Alternatives Under OPA

Once the reasonable range of restoration alternatives is developed, the OPA regulations (15 CFR § 990.54) provide minimum criteria to be used by trustees to evaluate those alternatives. The trustees must evaluate and select the proposed restoration alternatives, and eventually actual restoration projects, based on these OPA evaluation standards:

- The cost to carry out the alternative.
- The extent to which each alternative is expected to meet the Trustees' goals and objectives in returning the injured natural resources and services to baseline and/or compensating for interim losses.
- The likelihood of success of each alternative.
- The extent to which each alternative will prevent future injury as a result of the incident and avoid collateral injury as a result of implementing the alternative.
- The extent to which each alternative benefits more than one natural resource and/or service.
- The effect of each alternative on public health and safety.

Additionally the OPA regulations (15 CFR § 990.54) allow the trustees to establish additional incident-specific evaluation and selection criteria for alternatives and restoration projects. For this incident, the Trustees have determined that the action alternatives and subsequent restoration plans and projects must also be consistent with the goals outlined in Section 5.3.1, Programmatic Trustee Goals, and with the restoration types described in Section 5.5, Alternative A: Comprehensive Integrated Ecosystem Restoration (Preferred Alternative).

5.4.8 Evaluation of Alternatives Under NEPA

The NEPA process is intended to help federal agencies make decisions that appropriately consider environmental consequences of actions that may affect the environment (40 CFR § 1500.1(c)). To comply with NEPA, the Trustees are cooperating agencies for the PEIS, which is integrated with the PDARP. The alternatives evaluated for OPA purposes are consistent with the NEPA statement of purpose and need (Section 5.3.2, NEPA Statement of Purpose and Need). As required by NEPA, a no-action alternative is also evaluated. The PEIS component of this document evaluates the direct, indirect, and cumulative environmental consequences of the alternatives. The Trustees' evaluation of alternatives under OPA and identification of a preferred alternative is informed by this NEPA analysis. The NEPA analysis is presented in detail in Chapter 6, Environmental Consequences and Compliance with Other Laws.

5.5 Alternative A: Comprehensive Integrated Ecosystem Restoration (Preferred Alternative)

5.5.1 Restoration Philosophy and Rationale

Alternative A establishes a comprehensive, integrated ecosystem restoration plan (referred to as the integrated restoration portfolio) based on the programmatic Trustee goals to Restore and Conserve Habitat, Restore Water Quality, Replenish and Protect Living Coastal and Marine Resources, Provide and Enhance Recreational Opportunities, and Provide for Monitoring, Adaptive Management, and Administrative Oversight to Support Restoration Implementation. Alternative A comprises restoration types that, as an integrated portfolio, address the Trustees' goals by maximizing the potential synergies among the restoration types and approaches. The comprehensive, integrated ecosystem plan will implement a range of approaches to address 1) assessed injuries to natural resources and services, including lost recreational use, and 2) inferred injuries to ecosystem components and services. This plan includes a substantive focus on northern Gulf of Mexico coastal habitats to restore resource-to-habitat and habitat-to-habitat linkages in the northern Gulf of Mexico system. Inferred injuries are addressed by maximizing the benefits achieved through restoration of coastal and nearshore habitats. This focus on coastal habitats is complemented by additional restoration that addresses specific injuries or aspects of injuries not fully addressed by coastal habitat restoration to ensure that the full range of injuries caused by this spill is addressed. The Trustees will implement monitoring, assessment, and scientific support activities to evaluate the response to restoration and to better inform ongoing restoration and management decisions within an adaptive management framework. The Trustees will also factor in contingencies to address future unknown conditions, given the unprecedented scale of restoration required and the number of years that it will take to implement this plan.

> **Ecosystem Linkages**
>
> - A persistent or recurring process or attribute that connects different ecosystems in some manner.
> - Such linkages are integral, even defining, components of aquatic ecosystem structure and function.
>
> Lamberti et al. (2010)

The following sections describe each of the restoration types that make up this alternative. The sections are structured similarly and each include the specific goals for that restoration type; the strategy for implementing the restoration type, including the restoration approaches that could be implemented; implementation considerations; and monitoring, including both project-level and resource-level monitoring considerations as applicable. The restoration approaches, including more specific implementation considerations and OPA considerations, are further described in Appendix 5.D, Restoration Approaches and OPA Evaluation.

As discussed in Section 5.3.1, Programmatic Trustee Goals, a single project implemented under a restoration type may only address one or a subset of the goals described for that restoration type. Over time, however, the portfolio of restoration projects that will be implemented under a restoration type is intended to address all the goals set out for that restoration type. It is also possible that a single restoration project (especially larger or more complex projects with multiple components) may pertain to multiple restoration types and address multiple restoration goals across types. The integrated

ecosystem restoration philosophy of Alternative A is intended, in part, to promote restoration projects that benefit multiple habitats and resources.

5.5.2 Restoration Type: Wetlands, Coastal, and Nearshore Habitats

> This restoration type addresses the overall goal of **Restore and Conserve Habitat**

The coastal and nearshore environment of the northern Gulf of Mexico encompasses a vast, biologically diverse collection of interrelated habitat complexes that stretch from Texas to Florida. These habitats provide food, shelter, breeding, and nursery habitat for many ecologically and economically important animals, including fish, shrimp, shellfish, birds, sea turtles, marine mammals, and terrestrial mammals (Chesney et al. 2000; Deegan 1993; Griffin & Griffin 2003; Minello et al. 2003; O'Connell et al. 2005; Zimmerman et al. 2000). Each of the habitats that would benefit from this restoration type provides a distinct set of resources needed to support animals in the coastal environment. These habitats are linked together within a broader coastal and nearshore ecosystem through the movement of water, sediments, energy, and nutrients (Deegan 1993; Nelson et al. 2013). These habitats are also linked together through the movement of animals that use multiple habitats during their life cycle to grow and reproduce (Beck et al. 2001; Beck et al. 2003; Gillanders et al. 2003; Heck Jr. et al. 2008; Minello et al. 2003). In addition, coastal and nearshore habitats have important connections to the resources of the open ocean of the Gulf of Mexico (Beck et al. 2001; Deegan 1993; Koenig & Coleman 1998; Nelson et al. 2011), with a large number of marine- and estuarine-dependent species either directly using nearshore habitats as juveniles or preying on organisms that use the nearshore habitats.

The *Deepwater Horizon* spill and associated response actions caused a suite of injuries to nearshore and shoreline resources, which include estuarine coastal wetland complexes, sand beaches, and the services they provide. These injuries occurred at the species, community, and habitat level and affected a wide variety of ecosystem components over an area extending along many hundreds of miles of the northern Gulf of Mexico coastline. In addition, other fish and aquatic invertebrates such as crustaceans and planktonic plants and animals were exposed to oil in the water column (see the text box below that summarizes key aspects of the injury assessment that informed restoration planning). All these resources depend directly or indirectly on the productivity of wetlands, coastal, and nearshore habitats through ecological and physical relationships such as foodweb dynamics, organism movements, nutrient and sediment transport and cycling, and other fundamental ecosystem processes. Therefore, the Trustees determined it was most appropriate to develop an integrated restoration portfolio, taking into account the important linkages among habitat types and between habitats and injured resources.

Key Aspects of the Injury That Informed Restoration Planning

Estuarine Coastal Wetland Complexes

- Injury occurred over hundreds of miles of coastline in the northern Gulf of Mexico, within multiple interconnected shoreline habitats, affecting diverse species that use these coastal habitats for some or all of their life cycle.
- Injuries were extensive and pervasive, including impacts to marsh vegetation, such as

decreases in plant cover and aboveground biomass. Animals that live in the marsh (e.g., sediment-dwelling invertebrates, snails, insects, shrimp, fish, and oysters) were also injured. For example, substantial decreases in secondary production (50 percent to 90 percent decline) would be expected for periwinkles, brown and white shrimp, and southern flounder in areas adjacent to shorelines that experienced heavy, persistent oiling, compared to shoreline areas that had no observed oil.

- Physical impacts included an increase in the rates of marsh-edge habitat erosion.
- Effects were greatest in the mainland salt marshes of Louisiana. However, effects were also evident in other regions, including marsh in Alabama and Mississippi, and for other vegetation types, such as intermediate marsh in the Mississippi River delta and mangroves.
- The marsh edge, which serves as a critical transition between the emergent marsh vegetation and open water habitat, suffered the most acute injuries. However, vegetation and soils on the marsh platform behind the edge were also oiled and injured as the marsh platform flooded with the tide. The impacts to the marsh platform further exposed animals that use this habitat for refuge and forage.

Sand Beaches Habitat

- Over 600 miles (965 kilometers) of sand beach and dune habitat along shorelines and barrier islands across the northern Gulf of Mexico were injured as a result of a combination of the direct effects of oil and ancillary adverse impacts of response activities undertaken to clean up the oil. Injuries included reduced abundance of crabs, amphipods, insects, and other macrofauna that live in the sand and wrack (decomposing vegetation that serves as habitat and food source for many beach organisms), impacts to beach mice, as well as a disruption of bird and sea turtle nesting habitat.

Fish and Invertebrates

- A vast volume of open water across the northern Gulf of Mexico was exposed to *Deepwater Horizon* oil, injuring water column resources. The surface slick alone covered a cumulative area of at least 43,300 square miles (112,000 square kilometers) across 113 days in 2010. The estimated average daily volume of contaminated water under surface oil slicks was 57 billion cubic meters. As a comparison, this volume is approximately 40 times the average daily discharge of the Mississippi River at New Orleans.
- Water-column resources injured by the spill include species from all levels in the food-chain, from bacteria to estuarine-dependent species, such as red drum, shrimp, and sea trout, to large predatory fish, such as bluefin tuna, that migrate from the Gulf of Mexico into the Atlantic and as far as the Mediterranean Sea.
- The Trustees estimate that 2 to 5 trillion larval fish and 37 to 68 trillion invertebrates were killed in the surface waters and between 86 million and 26 billion fish larvae and between 10 million and 7 billion planktonic invertebrates in deeper waters. Of these totals, 0.4 to 1 billion larval fish and 2 to 6 trillion invertebrates were killed in estuarine surface waters. The larval

loss likely translated into millions to billions of fish that would have reached a year old. Larval fish that were killed but would not have survived to age 1 are also a significant loss; they are an energy source for other components of the ecosystem.

Birds

- At least 93 species of birds, including both resident and migratory species, across all five Gulf Coast states, were exposed to *Deepwater Horizon* oil in multiple northern Gulf of Mexico habitats, including open water, islands, beaches, bays, and marshes. Laboratory studies showed that exposure to *Deepwater Horizon* oil leads to injuries, including feather damage, abnormal blood attributes, organ damage, and death.
- Trustee scientists quantified that between 51,600 and 84,500 birds died as a result of the *Deepwater Horizon* oil spill, although significant mortality occurred that was unquantified. Further, of those quantified dead birds, the breeding-age adults would have produced an estimated additional 4,600 to 17,900 fledglings. Due to a number of factors that likely led to underestimation of mortality, true mortality is likely closer to the upper ranges than the lower. The magnitude of the injury and the number of species affected makes the *Deepwater Horizon* spill an unprecedented human-caused injury to birds of the region.

See Chapter 4 (Sections 4.4 through 4.9) for a more detailed description of these injuries and the Trustees' injury assessment.

The ecological value of restoring multiple coastal habitats is enhanced when a restored habitat is situated within an appropriate matrix of other ecologically connected coastal habitats (Baillie et al. 2015; Boström et al. 2011; Heck Jr. et al. 2008; Hitt et al. 2011; Irlandi & Crawford 1997; Meynecke et al. 2008; Micheli & Peterson 1999; Mumby 2006). Sediment, nutrients, and food resources move between and through these connected estuarine habitat areas out to the continental shelf, connecting the productivity of marsh to production of fish and shellfish in the Gulf of Mexico (Beck et al. 2003; Boesch & Turner 1984; Deegan 1993; Deegan et al. 2000; Orth & van Montfrans 1990; Roth et al. 2008; Thomas et al. 1990; Zimmerman et al. 2000). White shrimp, for example, begin their life cycle off the continental shelf in the Gulf of Mexico and may move through all of the salinity zones in the estuary as they grow from tiny "post-larvae" to large juveniles (Deegan 1993; Minello & Zimmerman 1991; Zimmerman et al. 2000). Thus, this restoration type includes opportunities to restore a combination of nearshore and coastal habitats that collectively contribute to productivity in the Gulf of Mexico and can benefit a large variety of injured species and ecological functions. This restoration type is the foundation for the preferred alternative because of the multiple benefits that can be derived through habitat projects.

5.5.2.1 Goals of the Restoration Type

For injuries to coastal habitats and resources that use these habitats (e.g., fish, invertebrates, and birds) in the northern Gulf of Mexico, the restoration goals are as follows:

- Restore a variety of interspersed and ecologically connected coastal habitats in each of the five Gulf states to maintain ecosystem diversity, with particular focus on maximizing ecological functions for the range of resources injured by the spill, such as oysters, estuarine-dependent fish species, birds, marine mammals, and nearshore benthic communities.

- Restore for injuries to habitats in the geographic areas where the injuries occurred, while considering approaches that provide resiliency and sustainability.

- While acknowledging the existing distribution of habitats throughout the Gulf of Mexico, restore habitats in appropriate combinations for any given geographic area, considering design factors, such as connectivity, size, and distance between projects, to address injuries to the associated living coastal and marine resources and restore the ecological functions provided by those habitats.

5.5.2.2 Strategy to Achieve Goals

This restoration type includes restoration that will benefit the major coastal and nearshore habitats and associated services of the Gulf of Mexico, including wetlands, oyster reefs, submerged aquatic vegetation, barrier, coastal and riverine islands, dunes, and sand beaches; the resources that depend on these habitats; and the ecological functions and services that these habitats provide. This restoration type is the centerpiece of the Trustees' restoration plan because restoration of these habitats at a large scale can provide benefits across the northern Gulf of Mexico ecosystem that suffered injuries from the spill and associated response activities. Opportunities to restore these habitats and benefit associated resources and services are located throughout the Gulf of Mexico. Restoration will be implemented to maximize habitat benefits and may not correspond to specific areas that were directly oiled.

In planning coastal habitat restoration, the Trustees recognize that there are systemic issues that adversely affect habitats in the Gulf of Mexico, which provide opportunities for coastal habitat restoration to compensate for injuries resulting from the *Deepwater Horizon* incident. Habitat loss and degradation are extensive along the Gulf Coast and are related to numerous stressors, including storms, relative sea level rise, oil and gas activities, engineering of the Mississippi River, and other anthropogenic impacts (e.g., bulkheads and residential development) and coastal subsidence (Anderson et al. 2014; Dahl & Stedman 2013; Handley et al. 2007; Ko & Day 2004; Kolker et al. 2011; Lowe & Peterson 2014; Morton & Barras 2011; White & Morton 1997). Wetland loss, in particular, is an ongoing concern in coastal Louisiana (Barras et al. 2008; Couvillion et al. 2011), and this region also sustained the most shoreline oiling associated with the *Deepwater Horizon* incident. This habitat loss through the conversion of vegetated and structured coastal and nearshore habitats to open water affects the species that depend on those habitats, as well as the recreational opportunities that the habitats provide.

The Trustees will undertake restoration in all five Gulf states to provide benefits across the interconnected northern Gulf of Mexico ecosystem and are placing particular emphasis on coastal and nearshore habitat restoration in the historic Mississippi River delta plain in Louisiana. This region received the majority of the oiling in coastal habitats in the Gulf and included virtually all of the areas subject to heavy persistent oil. Coastal and nearshore habitat in Louisiana includes a diversity of habitat types, including herbaceous marsh of different salinities, mangroves, chenier ridges, SAV, and oyster reefs. The gradual elevation gain from coast to uplands in the historic Mississippi River delta plain region results in a large, connected marsh zone that spans a range of salinities, from salt and brackish marsh along the estuarine shoreline, to intermediate and freshwater marsh further inland from the coast (Gosselink & Pendleton 1984; Sasser et al. 2014). This diverse combination of habitats supports a vast array of resources injured by the spill. Concentrating restoration in Louisiana, while also providing for

habitat restoration in all five states, ensures that the Trustees are meeting the objective of restoring for the range of habitats, resources, and services injured by the spill.

The Trustees will seek to implement coastal and nearshore habitat restoration in ways that achieve multiple ecosystem benefits. Coastal and nearshore habitats integrate and form a continuum within the nearshore ecosystem and contribute to an integrated, connected food web (Baillie et al. 2015; Boesch & Turner 1984; Boström et al. 2011; Deegan 1993; Deegan et al. 2000; Nelson et al. 2011; Nelson et al. 2013). This critical role was disrupted by injuries to these habitats and their associated resources; therefore, this restoration approach will seek to implement projects across the Gulf that address multiple ecosystem benefits through habitat restoration. By identifying opportunities to restore multiple habitats within one project, or to implement multiple projects within a given area, the Trustees believe that recovery of injured ecosystem functions may be accelerated and a more integrated restoration of the nearshore ecosystem and its service flows can be achieved.

Although this restoration type will restore all types of coastal habitats, it emphasizes restoration of wetland complexes. Coastal wetlands provide a wide range of ecological functions and services, including providing important habitat for fish and wildlife species, improving water quality, stabilizing shorelines, reducing storm surge risk, and capturing and storing carbon in organic soils (Armentano & Menges 1986; Costanza et al. 2014; Moody & Aronson 2007; Woodward & Wui 2001; Zimmerman et al. 2000). Coastal wetlands provide important habitat for fish, benthic communities, birds, and terrestrial wildlife (Nagelkerken et al. 2008; Peterson & Turner 1994; Robertson & Duke 1987). They help stabilize substrates and reduce coastal erosion (Gedan et al. 2011). Wetland restoration provides important nursery areas for the production of larval fishes and crustaceans, resulting in increased production of ecologically, recreationally, and commercially important fish species (Minello & Webb Jr. 1997; Peterson & Turner 1994). Numerous marsh birds and wading birds benefit from the invertebrate production stimulated by coastal wetland productivity (Greenberg et al. 2006). Another benefit of coastal wetland systems is their ability to mitigate storm risk, providing protection to nearby infrastructure and coastal communities (Costanza et al. 2014; Costanza et al. 2008). This benefit is particularly effective for low-energy storm events. Improved wetlands could also provide ancillary benefits to human users through increased opportunities for recreational activities (Zedler & Leach 1998).

Considering the scale of impacts from the oil spill, the Trustees also understand the importance of emphasizing the need to increase resiliency and sustainability of this highly productive Gulf ecosystem through restoration. Diversions of Mississippi River water into adjacent wetlands have a high probability of providing these types of large-scale benefits for the long-term sustainability of deltaic wetlands systems. Controlled river diversions are gated structures that allow for release of river water and associated nutrients and sediments into adjacent deltaic wetland areas at prescribed times and rates (Allison & Meselhe 2010). This release schedule allows water movement to be controlled, maximizing desired ecological benefits and reducing possible undesired impacts such as shoaling in shipping and anchorage areas, flooding in low-lying surrounding land, and storm surge. If correctly designed, sited, and operated, diversions will help restore injured wetlands and resources by reducing widespread loss of existing wetlands through 1) reintroducing nutrients and freshwater into salt-stressed, nutrient-starved ecosystems and 2) increasing sediment deposition to partially offset relative sea level rise and help build new habitats (Andrus 2007; Day et al. 2012; DeLaune et al. 2003; DeLaune et al. 2013; Kemp

et al. 2014; Kolker et al. 2012; Lane et al. 2006; Wang et al. 2014). Smaller-scale diversions can also be used to achieve site-specific benefits, rather than the regional benefits associated with larger scale diversions, by restoring the natural deposits and landforms associated with deltaic distributary channels (Boyer et al. 1997; Cahoon et al. 2011; Roberts 1997).

Diversions are a long-term strategy to address regional land loss, and as a restoration approach diversions also provide potential benefits that are intended to complement the benefits of other wetland restoration approaches. Diversions will also be implemented on a scale that can influence multiple habitats and resources (Day et al. 2007; Falcini et al. 2012; Kemp et al. 2014). More broadly, such actions will help recover wetlands injured or lost due to the *Deepwater Horizon* spill by reducing future losses of existing wetlands or creating new wetlands (Day et al. 2007; Paola et al. 2011; Wang et al. 2014). This restoration type will help maintain the Louisiana coastal landscape and its ability to overcome other environmental stressors by stabilizing wetland substrates; reducing coastal wetland loss rates; increasing habitat for freshwater fish, birds, and benthic communities; and reducing storm risks, thus providing protection to nearby infrastructure (Barbier et al. 2013; Day et al. 2012; Day Jr. et al. 2009; DeLaune et al. 2013; Falcini et al. 2012; Roberts et al. 2015; Rosen & Xu 2013).

In addition to wetland restoration, restoration of beaches, dunes, islands, and barrier headlands will also be an important part of this restoration type. Barrier and coastal island and headland restoration and creation have broad ecological and socioeconomic benefits because of the many resources that barrier shorelines sustain. Barrier shorelines are unique habitats that represent a significant component of complex and productive coastal ecosystems. In the Gulf of Mexico, many of the barrier and coastal islands provide important habitat for threatened and endangered species and species of concern (e.g., piping plover, least tern, black skimmer, American oystercatcher, and brown pelican). Long-term beneficial effects to finfish, shellfish, and other invertebrates include enhancing the quantity and quality of adjacent shallow-water, soft-bottom habitats that serve as nurseries and foraging areas. A larger beach area also improves food and nutrient exchange with aquatic habitats and provides important resting or loafing areas for birds. Back-barrier marshes can provide foraging and refuge habitat for fish, shellfish, and birds. Additionally, reducing erosion and storm surges could benefit oyster populations and seagrass beds by reducing excessive sedimentation in nearshore waters (Wilber & Clarke 2001). Beach and dune restoration has the potential to reduce the effects of future storm surges on nearshore wetlands and associated brackish-water resources, particularly where existing dunes have been damaged by prior hurricanes. Dune restoration will benefit endangered beach mice in their federally designated critical habitats in Florida and Alabama and will help maintain suitable habitat for sea turtle and bird nesting in the face of losses to sea level rise and development along the coasts.

Wetland, beach, dune, and island restoration will be complemented by restoration of other habitats including oyster reefs and SAV. Restoring across a range of coastal habitats will help maximize the benefits to resources and services that were affected by the spill. Therefore, within this restoration type, multiple restoration approaches are included: “Create, restore, and enhance coastal wetlands”; “Restore and preserve Mississippi-Atchafalaya River processes”; “Restore oyster reef habitat”; “Create, restore, and enhance barrier and coastal islands and headlands”; “Restore and enhance dunes and beaches”; “Restore and enhance submerged aquatic vegetation”; and “Protect and conserve marine,

coastal, estuarine, and riparian habitats" (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation).

> **Restoration Approaches**
>
> - Create, restore, and enhance coastal wetlands
> - Restore and preserve Mississippi-Atchafalaya River processes
> - Restore oyster reef habitat
> - Create, restore, and enhance barrier and coastal islands and headlands
> - Restore and enhance dunes and beaches
> - Restore and enhance submerged aquatic vegetation
> - Protect and conserve marine, coastal, estuarine, and riparian habitats

Because of the importance of coastal and nearshore habitats to the overall health and resiliency of the Gulf of Mexico, the Trustees initiated habitat restoration under the early restoration framework, targeting several different coastal and nearshore habitat types (Appendix 5.B, Early Restoration). Phase I of Early Restoration included marsh creation projects in Louisiana and Alabama, oyster cultch projects in Louisiana and Mississippi, and dune restoration in Alabama and Florida. Phase III of Early Restoration included additional habitat projects, including barrier island and back-barrier marsh creation in Louisiana, which also benefits brown pelicans, skimmers, terns and gulls; oyster cultch projects in Alabama and Florida; "living shoreline" projects that included construction of oyster reefs and vegetation planting in Mississippi, Alabama, and Florida; beach/dune restoration projects in Alabama and Florida; and seagrass recovery in Florida. Phase IV of Early Restoration also included habitat projects, such as living shoreline projects in Alabama and Mississippi, coastal island restoration in Texas to create nesting habitat for wading birds, and additional seagrass recovery in Florida. These Early Restoration projects provide an important foundation for additional habitat restoration. This restoration type will build on that foundation to implement coastal habitat restoration at a landscape scale that will be needed to compensate for injuries to specific coastal and nearshore habitats, injuries to the resources and services those habitats support, and the broader ecosystem-wide injuries caused by the incident.

5.5.2.3 Planning and Implementation Considerations

These restoration approaches have been used extensively in the past throughout the northern Gulf of Mexico (Louisiana CWCRTF 2006, 2010, 2012) (see Figure 5.5-1), and several are included in Early Restoration plans. Thus, the Trustees will benefit from lessons learned from past projects to improve success for future projects. For those projects where there is less experience, the Trustees will rely on robust monitoring and adaptive management to address critical uncertainties and maximize restoration benefits (Hijuelos & Hemmerling 2015; Steyer & Llewellyn 2000; Steyer et al. 2003; Teal et al. 2012).

The heterogeneous habitat distribution across the Gulf of Mexico will be a major consideration for the Trustees as they determine the best combinations of, and balance between, habitats to target to achieve the goals set out for this nearshore ecosystem restoration. This existing habitat distribution is likely to be one of several factors considered by the Trustees in determining the best combinations of habitats that will achieve the objective of providing ecological functions for the range of targeted resources. These combinations could be achieved through integrated projects or by siting projects targeting one habitat near other existing projects or natural habitats to provide greater ecosystem benefits. The Trustees also intend to consider projects being implemented through other funding streams (e.g., RESTORE and the Gulf Environmental Benefit Fund [GEBF]) in order to identify

opportunities for restoring habitat complexes by expanding on habitat restoration conducted through these other funding sources.

Source: *Top: Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) Task Force. Middle left: Florida Department of Environmental Protection. Middle right: Jud Kenworthy. Bottom left: CWPPRA Task Force. Bottom right: CWPPRA Task Force.*

Figure 5.5-1. A wide variety of coastal habitat restoration projects have been successfully implemented in the northern Gulf of Mexico. Top: CWPPRA Barataria Barrier Island Complex project (BA-38), Plaquemines Parish, Louisiana. Middle left: Pensacola Bay oyster reef restoration, Santa Rosa County, Florida, NOAA Restoration Center, Community-based Restoration Program. Middle right: scientist monitoring a seagrass restoration site. Bottom left: CWPPRA Whiskey Island back-barrier marsh creation (TE-50), Terrebonne Parish, Louisiana. Bottom right: CWPPRA Bayou Dupont sediment delivery system project, Jefferson and Plaquemines Parishes, Louisiana (BA-39).

This restoration type is intended to achieve large-scale benefits. To do that, restoration prioritization and design will attempt to maximize benefits, as appropriate. For example, enhancement of coastal wetlands for juvenile shrimp, crabs, oysters, and some fishes could be accomplished by incorporating open water and marsh edge into the marsh complex (Baltz et al. 1993; Minello et al. 2008; Minello & Rozas 2002; Neahr et al. 2010; Rozas & Minello 2015; Zimmerman et al. 2000). Maximizing benefits

could also be accomplished by implementing habitat complexes through combining multiple restoration approaches, such as incorporating construction of nearshore oyster reefs or living shorelines into the design of marsh creation projects (Baillie et al. 2015; Boström et al. 2011; Dorenbosch et al. 2004; Grabowski et al. 2005; Hitt et al. 2011; Hosack et al. 2006; Irlandi & Crawford 1997; Micheli & Peterson 1999).

Given the large amount of habitat restoration that will be part of this plan, there will, by design, be impacts to the current system. These impacts will vary by restoration approach and will depend on the amount of restoration conducted. Implementing such a large scope of complex projects will require a thorough engineering and scientific evaluation, consultations and permitting, and stakeholder engagement processes. There will also necessarily be some cumulative impacts that will need to be tracked. One impact is the large amount of sediment that will be required to conduct this substantial amount of restoration. The Trustees will need to consider developing a sediment management plan as part of subsequent planning that identifies known sediment sources and prioritizes their use both geographically and over time (Khalil & Finkl 2009, 2011). Another impact is that the Trustees might make a purposeful effort to transition from one habitat type (e.g., shallow soft bottom) to another (e.g., emergent wetlands). Although such activities may be designed to return the system to its former state prior to habitat degradation, the Trustees will need to consider the potential impacts of these transitions both individually and cumulatively over the course of implementing projects.

For example, some large-scale projects, such as river diversions, have the potential to alter the ecosystem of the basin receiving the water and sediment (Das et al. 2012; Day Jr. et al. 2009; Lane et al. 2007). The river diversions considered under this restoration type would differ substantially from the salinity control structures that currently exist along the lower Mississippi River in that they would be designed specifically to maximize sediment delivery to existing marshes and shallow open water areas. Because no examples currently exist in the environment for the type of diversions considered in this restoration plan, there is uncertainty concerning the exact impacts that may occur, and additional studies will be needed to address these issues. However, the existing salinity control structures do provide some insights into potential impacts that will need to be evaluated. Potential impacts include changes in soil stability (Allison & Meselhe 2010; Kenney et al. 2013; Teal et al. 2012), changes in dredging requirements for navigation channels (Allison & Meselhe 2010), and salinity shifts within the receiving estuary that may affect the distribution of some estuarine-dependent fish species (Adamack et al. 2012; de Mutsert & Cowan Jr. 2012; Rose et al. 2014; Rozas & Minello 2011; Rozas et al. 2005), sustainability of local oyster populations (Soniat et al. 2013), and available BSE marine mammal habitat and/or the health of BSE marine mammals (LaBrecque et al. 2015; Miller 2003; Miller & Baltz 2009; Waring et al. 2015). To aid in better understanding the effects of sediment diversions, the state of Louisiana, through its Coastal Protection and Restoration Authority, is conducting a robust set of studies and analyses on proposed sediment diversion projects. Utilizing the best tools and information available, the studies are analyzing the effects of proposed river diversions within and outside of the Mississippi River. The studies and analyses will evaluate potential changes in wetland area, habitat, fisheries and communities.

The decades of experience that the Trustees have in implementing coastal habitat restoration provide a high degree of certainty in project outcomes; however, implementation at such a large scale, and with

this particular focus on ecosystem benefits, will require an additional level of consideration in project design, implementation, and performance evaluation. The variety of restoration approaches that could be implemented under this restoration type each have unique implementation considerations, which are further described in Appendix 5.D, Restoration Approaches and OPA Evaluation. In addition to specific implementation considerations, the Trustees also recognize the need to incorporate robust monitoring, analysis, and science support to inform future restoration planning, address critical uncertainties, and maximize restoration benefits.

5.5.2.4 Monitoring

Based on previous restoration experience over the past two decades in the Gulf of Mexico (Louisiana CWCRTF 2006, 2010, 2012), performance monitoring for many of the restoration approaches may be sufficient at the scale of the individual project to evaluate restoration outcomes and determine the need for any corrective actions. However, for some approaches that are more complex, or that could be combined to form sufficiently large assemblages of projects, monitoring might need to expand beyond the footprint of each individual project (Hijuelos & Hemmerling 2015; Steyer & Llewellyn 2000; Steyer et al. 2003). In most cases, data collection, including engineering evaluations, will also be needed during the project planning stage to inform project design and resolve any site-specific uncertainties related to project implementation.

Performance monitoring for most individual wetland, coastal, and nearshore habitat restoration projects will be based on widely accepted monitoring protocols. The Trustees have developed monitoring frameworks through their work on Early Restoration for restoration approaches applicable to a range of coastal and nearshore habitats, including wetlands, oyster reefs, SAV, and beaches and barrier islands (see Appendix 5.E, Monitoring and Adaptive Management Framework). These frameworks include measurements of the habitat structure (e.g., elevation), development of the vegetative community (e.g., percent cover of marsh vegetation and species composition), and faunal utilization (e.g., by beach mice, birds, and fish). Due to the large amount of wetland, coastal, and nearshore habitat restoration that will be performed under this restoration type, the Trustees may choose to monitor a smaller set of core parameters on all projects, with more intensive and expanded validation monitoring conducted on a subset of projects to better characterize ecological function and inform the design and implementation of future coastal habitat restoration projects.

Some restoration approaches, such as Mississippi River diversions, are more complex and will require larger scale monitoring, evaluation, and adaptive management to support all phases of the restoration process (Hijuelos & Hemmerling 2015; Peyronnin et al. 2013; Steyer et al. 2003; Teal et al. 2012). This approach will allow the Trustees to proceed with implementation of these very important and more complex restoration types, while minimizing unintended consequences through the adaptive management process. Due to the size and inherent complexity of these projects, planning and performance monitoring for Mississippi River diversions should include modeling and monitoring at a scale appropriate to evaluate changes in receiving estuaries (e.g., sedimentation and shoaling rates, vegetation change, salinity, nutrient loads, and the distribution of estuarine fauna).

In addition to the project monitoring described above, the Trustees may conduct monitoring and scientific support for restoration of endangered beach mice in Florida and Alabama. This enhanced data collection will be used to inform the planning, implementation, and evaluation of dune restoration

projects intending to benefit beach mice. In addition to providing important information to inform restoration planning for this restoration plan, the enhanced data may inform population assessments, conservation management, and recovery activities for these protected species and help ensure restoration projects taking place on beaches and barrier islands avoid impacts to this protected resource.

5.5.3 Restoration Type: Habitat Projects on Federally Managed Lands

This restoration type addresses the overall goal of **Restore and Conserve Habitat**

Because of the importance of coastal habitats to the health and vitality of our nation's natural and economic resources, some of the Gulf's unique habitats are federal trust resources located in areas such as national parks and seashores and national wildlife refuges. Federal agencies act as trustees for the lands managed by those agencies. Starting with the designation of Pelican Island as the first National Wildlife Refuge in 1903, the federal government has set aside lands in the Gulf of Mexico region to preserve and protect these habitats and the wildlife that depend on them from encroachment by and destruction from human uses. Although some of the habitats on these lands may also occur at other locations, these lands were carefully selected by the U.S. Congress to be conserved as a whole. These lands typically serve as a foundation of a natural resource conservation system on which other local efforts are built. These habitats are critical to the survival of wildlife populations and are home to many federally protected, threatened, and endangered species.

The *Deepwater Horizon* oil spill injured lands managed by federal agencies throughout the Gulf (see text box below that summarizes key aspects of the injury assessment that informed restoration planning). Therefore, the Trustees place particular emphasis on restoration for federally managed lands in addition to the habitat restoration that will be implemented under the Wetlands, Coastal, and Nearshore Habitat restoration type. Restoration on federally managed lands will consider the diversity of habitats that occur on these lands, including coastal wetlands, marsh, oysters, SAV, sand beaches, and dunes.

Key Aspects of the Injury That Informed Restoration Planning

Federally Managed Lands

- Examples of federally managed resources injured by the *Deepwater Horizon* oil spill and response efforts include, but are not limited to, St. Vincent National Wildlife Refuge in Florida, Bon Secour National Wildlife Refuge in Alabama, Bureau of Land Management (BLM) Fort Morgan Area in Alabama, Gulf Islands National Seashore in Florida and Mississippi, Grand Bay National Wildlife Refuge in Mississippi and Alabama, Jean Lafitte National Historical Park and Preserve in Louisiana, Delta National Wildlife Refuge in Louisiana, Breton National Wildlife Refuge in Louisiana, Big Branch Marsh National Wildlife Refuge in Louisiana, and McFaddin National Wildlife Refuge in Texas.

Vegetated Shoreline Habitat

- Injury occurred over hundreds of miles of coastline in the northern Gulf of Mexico, including at least 21 miles (34 kilometers) of federally protected and managed lands, within multiple

interconnected shoreline habitats, affecting diverse species that use these coastal habitats for some or all of their life cycle.

- Injuries were extensive and pervasive, including impacts to marsh vegetation, such as decreases in plant cover and aboveground biomass. Animals that live in the marsh, including sediment-dwelling invertebrates, snails, insects, shrimp, fish, and oysters, were injured. For example, substantial decreases in secondary production (50 percent to-90 percent decline) would be expected for periwinkles, brown and white shrimp, and southern flounder in areas adjacent to shorelines that experienced heavy persistent oiling, compared to shoreline areas that had no observed oil.

- Effects were greatest in Louisiana. However, effects were also evident in other regions, including marshes in Alabama and Mississippi, and for other vegetation types, such as *Phragmites* in the Louisiana delta and mangroves.

- The marsh edge, which serves as a critical transition between the emergent marsh vegetation and open water habitat, suffered the most acute injuries. However, vegetation and soils on the marsh platform behind the edge were also oiled and injured as the marsh platform flooded with the tide. The impacts to the marsh platform further affected animals that use this habitat for refuge and forage.

Sand Beach and Dune Habitat

- Over 600 miles (965 kilometers) of sand beach and dune habitat across the northern Gulf of Mexico were exposed to *Deepwater Horizon* oil, of which 436 miles (702 kilometers) of sand beach habitat along shorelines and barrier islands were injured as a result of a combination of the direct effects of oil and ancillary adverse impacts of response activities undertaken to clean up the oil. This included at least 173 miles (278 kilometers) of federally protected and managed lands. Injuries included reduced abundance of crabs, amphipods, insects, and other macrofauna that live in the sand and wrack (decomposing vegetation that serves as habitat and food source for many beach organisms), impacts to beach mice, as well as a disruption of bird and sea turtle nesting habitat.

Submerged Aquatic Vegetation

- SAV in the federally managed Jean Lafitte National Historical Park and Preserve, Louisiana, was injured as a result of the freshwater releases. Increased amounts of freshwater from the Davis Pond Diversion release reduced salinity, resulting in reductions in SAV species diversity and percent cover. Along the Lake Cataouatche Shoreline in the Park, the Trustees documented an 83 percent loss of SAV cover between March 2010 and November 2012.

See Chapter 4 (Section 4.6, Nearshore Marine Ecosystem) for a more detailed description of these injuries and the Trustees' injury assessment.

5.5.3.1 Goals of the Restoration Type

For injuries to habitats on lands managed by federal agencies resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Restore federally managed habitats that were affected by the oil spill and response actions through an integrated portfolio of restoration approaches across a variety of habitats.
- Restore for injuries to federally managed lands by targeting restoration on federal lands where the injuries occurred, while considering approaches that provide resiliency and sustainability.
- Ensure consistency with land management plans for each designated federal land and its purpose by identifying actions that account for the ecological needs of these habitats.

5.5.3.2 Strategy to Achieve Goals

This restoration type will focus on the many habitats that were injured on lands managed by federal agencies. This type of restoration will be accomplished through habitat restoration that addresses the priority habitats of each federal property as prescribed by existing land management plans. Habitat restoration will be prioritized for the particular properties where those injuries occurred. Where restoration cannot be implemented on the specific injured property, the Trustees will look to other federally managed lands in the Gulf of Mexico including but not limited to Shell Keys National Wildlife Refuge in Louisiana and St. Marks National Wildlife Refuge in Florida. This restoration type will work to address those key restoration needs on federal lands in all five states.

The focus of this restoration type will be habitat restoration, which could include restoration of wetlands, dunes and beaches, oyster reefs, SAV, and barrier islands. Some habitats on lands managed by federal agencies are threatened due to rising sea levels, coastal erosion, and increased visitor traffic. Restoration can help address these threats and align with the existing management priorities on federal lands. For example, although public visitation is encouraged on lands managed by federal agencies, the Trustees would pursue projects that help minimize the impacts created by visitation. These projects might include dune walkovers, signs and interpretive materials, controlled parking and routes of access, and similar means to ensure visitors minimize their impacts on the habitat.

Restoration Approaches

- Create, restore, and enhance coastal wetlands
- Restore oyster reef habitat
- Create, restore, and enhance barrier and coastal islands and headlands
- Restore and enhance dunes and beaches
- Restore and enhance submerged aquatic vegetation
- Protect and conserve marine, coastal, estuarine, and riparian habitats
- Promote environmental stewardship, education, and outreach

The Trustees will implement a combination of restoration approaches in the terrestrial and marine environment. The restoration approaches under this restoration type include "Create, restore, and enhance coastal wetlands"; "Restore oyster reef habitat"; "Create, restore, and enhance barrier and coastal islands and headlands"; "Restore and enhance dunes and beaches"; "Restore and enhance submerged aquatic vegetation"; "Protect and conserve marine, coastal, estuarine, and riparian habitats"; and "Promote environmental stewardship, education, and outreach" (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation). The Trustees initiated restoration on federally managed lands through Early Restoration (Appendix 5.B, Early Restoration). In Phase I, the Trustees implemented a dune restoration project on Bureau of Land Management (BLM) and U.S. Fish and Wildlife Service (USFWS) lands in Alabama to restore primary

dune habitat that was injured from response efforts. In Phase IV, the Trustees selected a seagrass recovery project to restore seagrass injured from boats during spill response on National Park Service (NPS) lands in Florida. Although these Early Restoration projects will address some of the injury to habitat on federally managed lands, they will not fully address the injury to these habitats. Additional and strategically targeted habitat restoration for lands managed by federal agencies is required to address remaining injury to this resource.

5.5.3.3 Planning and Implementation Considerations

This restoration type will focus restoration on federally managed lands. As responsible managers of these lands, federal agencies have a public process and a plan that communicates a vision. Appropriate land uses for each land managed by a federal agency may guide the type of restoration that is appropriate for each property. Not all restoration approaches will be appropriate for all lands, and the Trustees will need to respect the vision for each property when developing restoration projects. Because of the variety of restoration approaches, the Trustees discuss specific considerations for each restoration approach in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.3.4 Monitoring

Performance monitoring will be conducted to track restoration approaches and determine if projects, individually and together, are meeting restoration objectives. Performance monitoring will also assist, where feasible, in determining the need for corrective actions and adaptive management. Performance monitoring approaches for habitat projects on lands managed by federal agencies will vary with the goals of the restoration approach. Monitoring for this restoration type will be similar to the monitoring approaches described for the Wetlands, Coastal, and Nearshore Habitat restoration type (See Section 5.5.2.4, Monitoring).

5.5.4 Restoration Type: Nutrient Reduction (Nonpoint Source)

> This restoration type addresses the overall goal of **Restore Water Quality**

Nutrient pollution adversely impacts water quality and poses a significant threat to localized watersheds across the entire Gulf Coast. Excessive nutrient enrichment, or eutrophication, of Gulf coast estuaries and their watersheds is a chronic threat that can lead to hypoxia, harmful algal blooms, habitat losses, and fish kills. There are many existing local, state, regional, and federal programs across the Gulf that are working to address nutrient pollution, including the eight National Estuary Programs across the Gulf Coast, the Gulf of Mexico Alliance, EPA's Gulf of Mexico program, USDA's Gulf of Mexico Initiative, and the Gulf Coast Ecosystem Restoration Council. Building on these existing efforts, nutrient reductions can enhance overall ecosystem health by benefitting the estuaries that are integral habitat providing food, shelter, and nursery grounds for many of the Gulf's ecologically and economically important species (e.g., fish). The *Deepwater Horizon* incident resulted in impacts to ecological connectivity throughout nearshore habitats (see text box below that summarizes key aspects of the injury assessment that informed restoration planning). To restore these ecological linkages, the integrated restoration portfolio needs to include a portfolio of water quality and habitat restoration approaches that can provide large-scale benefits and address chronic threats to the Gulf ecosystem. Reducing nutrient loading is part of the portfolio that will mitigate the chronic and pervasive ecosystem threats incurred by eutrophic Gulf Coast waters.

Key Aspects of the Injury That Informed Restoration Planning

- The ecological linkages of these habitats and communities and their connectivity to the larger Gulf of Mexico ecosystem can result in cascading impacts, influencing the overall health and productivity of the Gulf of Mexico ecosystem.

See Chapter 4 (Section 4.6, Nearshore Marine Ecosystem) for a more detailed description of these injuries and the Trustees' injury assessment.

5.5.4.1 Goals of the Restoration Type

To contribute to overall health and resiliency of the coastal environment and resources, restoration goals are as follows:

- Reduce nutrient loadings to Gulf Coast estuaries, habitats, and resources that are threatened by chronic eutrophication, hypoxia, or harmful algal blooms or that suffer habitat losses associated with water quality degradation.
- Where appropriate, co-locate nutrient load reduction projects with other restoration projects to enhance ecological services provided by other restoration approaches.
- Enhance ecosystem services of existing and restored Gulf Coast habitats.

5.5.4.2 Strategy to Achieve Goals

This restoration type will use a suite of conservation practices to reduce nutrient loadings, depending on the watershed and site characteristics. Agriculture and its associated land use practices (e.g., application of fertilizer and concentrated animal farm operations) are a principal source of elevated nutrient loads along the Gulf Coast. Furthermore, agriculture is a dominant land use throughout all Gulf Coast states contributing 78, 29, 38, 28, and 27 percent of land use within Texas, Louisiana, Mississippi, Alabama, and Florida, respectively (USDA 2015a, 2015b, 2015c, 2015d, 2015e). A variety of conservation practices could be implemented to reduce nutrient concentrations and sediments from agricultural lands along the Gulf Coast. Although a principle source of nutrient pollution, agriculture is not the sole source of nutrient pollution in coastal watersheds. Additional restoration techniques such as stormwater management practices, forestry management practices, creation and enhancement of wetlands, hydrologic restoration, and coastal and riparian conservation could also be used to mitigate nutrient pollution. All, or a combination, of these practices could be implemented in coordination with the land owners and local, state, and federal agencies to reduce nutrient loadings and chronic water quality degradation affecting coastal streams, habitats, and estuarine and marine resources.

Restoration Approaches

- Reduce nutrient loads to coastal watersheds
- Reduce pollution and hydrologic degradation to coastal watersheds
- Create, restore, and enhance coastal wetlands
- Protect and conserve marine, coastal, estuarine, and riparian habitats

The restoration approaches associated with this restoration type are "Reduce nutrient loads to coastal watersheds"; "Reduce pollution and hydrologic

degradation to coastal watersheds"; "Create, restore, and enhance coastal wetlands"; and "Protect and conserve marine, coastal, estuarine, and riparian habitats" (see Appendix 5.D, Restoration Approaches and OPA Evaluation). Coordinating the implementation of the nutrient reduction approach at a watershed level and considering this approach together with other habitat and resource restoration approaches will help provide ecosystem-scale benefits to the nearshore Gulf Coast. As such, the Trustees will establish watershed selection criteria to inform site and project selection prior to implementing the restoration approach.

5.5.4.3 Planning and Implementation Considerations

This restoration type would require the voluntary cooperation and support of public and private landowners. As such, these activities would be coordinated with appropriate partners including, but not limited to, private landowners and farmers; timber management/logging operations; state agencies; municipal and county governments; and federal agencies such as U.S. Forest Service, U.S. Department of Agriculture's Natural Resources Conservation Service (USDA-NRCS), U.S. Environmental Protection Agency (EPA), and NOAA. For example, USDA-NRCS conservation programs could facilitate coordination with private land owners and farmers to provide technical assistance to farmers and implement conservation practices to improve nutrient and sediment management along the Gulf Coast. Through voluntary conservation programs, farmers could improve nutrient application and management methods as well as soil erosion control practices to decrease the amount of nutrients going into the watershed and ultimately discharging into coastal Gulf waters.

Implementation of these conservation practices in vulnerable watersheds would benefit coastal and marine habitats and resources; however, identifying project-specific sites will require coordination with project partners. In addition, the selection of nutrient management techniques would be coordinated with appropriate local, state, and federal agencies and the private landowner/farmer. The implementation and success of these nutrient management techniques is highly dependent on land owner and farmer cooperation and maintenance. Therefore, the partners must be engaged throughout the process of selecting watersheds, sites, and nutrient management techniques to ensure appropriate implementation and maintenance throughout the lifetime of the project. Appendix 5.D, Restoration Approaches and OPA Evaluation, presents additional considerations for the restoration approach under this restoration type.

5.5.4.4 Monitoring

The restoration approaches that will be implemented under this restoration type have been used along the Gulf Coast and other regions of the United States to reduce pollutant loadings. Examples of water quality improvements from individual projects have been implemented and documented (e.g., agricultural fields where conservation practices have been implemented; USDA & NRCS 2015). Achieving benefits on a watershed scale is a complex process; however, small-scale studies have demonstrated benefits to the receiving waterbody (USDA & NRCS 2015). Linkages between water quality improvements and ecosystem benefits are conceptually understood and have resulted in measureable ecosystem benefits in certain watersheds (Greening & Janicki 2006; Russell & Greening 2013). Quantifying those linkages is challenging given the various nutrient inputs in a watershed (Keeler et al. 2012), but monitoring and adaptive management will be used to address these challenges.

Performance monitoring for nutrient reduction projects will include project-level monitoring of nutrient levels for indicator agricultural fields as well as nutrient monitoring within the receiving stream network and its estuary. In particular, coordinating and expanding science and monitoring to understand nutrient transport and freshwater flow through Gulf coastal watersheds and the relationship between watershed nutrient loadings and the occurrence of Gulf coastal ecosystem threats (i.e., hypoxia, harmful algal blooms, and habitat loss) will be important. This information will inform the adaptive management of watershed restoration efforts, including the identification of additional areas (e.g., subwatersheds) within the watershed to target for further restoration. Where appropriate, monitoring needs may be met by existing water quality monitoring networks (e.g., U.S. Geological Survey National Stream Quality Accounting Network). These existing water quality monitoring networks may be supplemented, as needed, to provide more robust watershed-scale monitoring to support planning, implementation, and evaluation of this restoration type.

5.5.5 Restoration Type: Water Quality (e.g., Stormwater Treatments, Hydrologic Restoration, Reduction of Sedimentation, etc.)

This restoration type addresses the overall goal of **Restore Water Quality**

Pathogens and harmful algal blooms, potentially fueled by eutrophication or alterations to freshwater flows, compromise the health of Gulf Coast habitats and resources as well as their recreational use (i.e., swimming and fishing). Coastal development results in land use changes and hydrologic alterations that change the volume, timing, duration, and quality of freshwater inflow in the form of increased stormwater runoff and hydrologic restrictions. These alterations in freshwater inflows are also correlated to increased flooding, salinity shifts, and discharge of pollutants, including fecal bacteria and pathogens, to nearby coastal water bodies. Combined, these stressors contribute to beach closures, restrictions on shellfish harvesting, and reduced aquatic habitat quality and may even compromise human health (e.g., exposure to pathogenic bacteria, viruses, or biotoxins from harmful algal blooms). Therefore, efforts to address water quality can provide benefits to coastal ecosystems as well as human use.

Key Aspects of the Injury That Informed Restoration Planning

- Impacts from the *Deepwater Horizon* oil spill, including oiled shorelines and closing of areas to recreation, resulted in losses to the public's use of natural resources for outdoor recreation, such as boating, fishing, and beach going. The Trustees estimated nearly 16 million boating, fishing, and other shoreline user days were lost throughout the five affected states, with the losses occurring across multiple years. Total recreational use damages due to the spill are estimated to be $693.2 million with uncertainty ranging from $527.6 million to $858.9 million.[6]

See Chapter 4 (Section 4.10, Lost Recreational Use) for a more detailed description of these injuries and the Trustees' injury assessment.

[6] An approximation of the 95 percent confidence interval for this estimate is derived by adding a point estimate for the Tier 2 subset of total recreational use damages to the upper and lower 95 percent confidence interval of the Tier 1 recreational use damages, recognizing that the statistical uncertainty of the Tier 2 estimates is unknown.

Considering the need for a portfolio of restoration and knowing that Florida had substantial recreational use losses, the Trustees recognize the opportunity for improving water quality in coastal watersheds in Florida to address recreational use losses (see text box above that summarizes key aspects of the injury assessment that informed restoration planning). Mitigating hydrologic and water quality degradation in coastal watersheds along the Florida coast would reduce the occurrence of chronic threats to coastal and nearshore habitats and provide improved recreational use opportunities. Additionally, water quality improvements benefit the overall health and resiliency of the Gulf ecosystem by restoring integral estuarine habitats and the resources that depend on them.

5.5.5.1 Goals of the Restoration Type

To support an integrative, comprehensive ecosystem restoration approach and benefit recreational uses in Florida, restoration goals are as follows:

- Reduce pollutant loadings, including nutrients and pathogens, to priority watersheds along the Florida coast that are threatened by chronic eutrophication, harmful algal blooms, hypoxia, habitat losses, or beach and shellfish closures associated with water quality degradation.
- Mitigate high-volume flows and prevent dramatic shifts in salinity that threaten many coastal habitats and resources along the Gulf Coast.
- Where appropriate, co-locate pollutant reduction projects with other restoration projects to enhance ecological services provided by other restoration approaches

5.5.5.2 Strategy to Achieve Goals

This restoration type will implement a range of approaches to reduce pollutants, nutrients, and pathogens being discharged to coastal watersheds and improve hydrology to enhance ecosystem services and recreational use along the Florida coast. These approaches will be implemented in urban, suburban, and agricultural landscapes within coastal watersheds. Stormwater control measures and agricultural conservation practices will be used to moderate stormwater flows and flooding while also reducing pollutant, nutrient, and pathogen loads to coastal watersheds. Traditional stormwater control practices such as retention and detention ponds, combined with low-impact design practices such as pervious pavements and rain gardens will reduce pollutant discharges and moderate stormwater runoff flow discharge rates and volumes. Erosion control practices, such as living shorelines, vegetated buffers, and unpaved road stabilization, could be used to reduce sedimentation of coastal habitats. Lastly, hydrologic restoration will assist in addressing water quantity issues through moderating high-volume flows and preventing dramatic shifts in salinity that threaten many coastal habitats and resources along the Florida coast (e.g., oyster reefs and harmful algal blooms). Depending on the watershed and site characteristics, all, or a combination, of these practices could be implemented to reduce pollutant loadings and improve hydrology to priority coastal watersheds in Florida that have chronic water quality degradation affecting coastal and nearshore habitats,

Restoration Approaches

- Reduce pollution and hydrologic degradation to coastal watersheds
- Reduce nutrient loads to coastal watersheds
- Create, restore, and enhance coastal wetlands
- Protect and conserve marine, coastal, estuarine, and riparian habitats

resources, and human uses. The restoration approaches associated with this restoration type are "Reduce pollution and hydrologic degradation to coastal watersheds"; "Reduce nutrient loads to coastal watersheds"; "Create, restore, and enhance coastal wetlands"; and "Protect and conserve marine, coastal, estuarine, and riparian habitats" (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation).

5.5.5.3 Planning and Implementation Considerations

Site-level water quality restoration has proven successful throughout the nation (Clausen et al. 2000; Holman-Dodds et al. 2003; Roseen et al. 2009). However, maximizing restoration success will require a coordinated, comprehensive watershed approach. Consequently, watershed selection and prioritization criteria could be established to inform site and project selection prior to implementing the restoration approaches (Schueler & Kitchell 2005). The implementation of these approaches in priority watersheds would help maximize benefits. Designation of priority watersheds and project-specific sites will require coordination with appropriate local, state, and federal authorities. Coordination within watershed boundaries and across other habitat restoration types will maximize benefits to the nearshore Florida coast. Appendix 5.D, Restoration Approaches and OPA Evaluation, describes additional implementation considerations for these restoration approaches.

5.5.5.4 Monitoring

The restoration approaches that will be used under this restoration type are fairly well-established and has been demonstrated to result in improved water quality at the scale of the individual project (e.g., stormwater control measures; NRC 2008). However, the degree to which these local improvements in water quality contribute to water quality improvement downstream is less certain, as is the best combination and placement of projects within a watershed needed to maximize improvement of water quality in the receiving estuary (Schueler & Kitchell 2005). Performance monitoring for water quality projects will likely include project-level monitoring of the targeted water quality parameters at the input and output locations, broader water quality monitoring within the receiving stream network and its estuary, and measurements of improvement in the quality of human use of the targeted estuaries and adjacent beaches (e.g., reductions in the number of beach and shellfish closures). Monitoring at the scale of the targeted watershed may be needed to inform the adaptive management of watershed restoration efforts, including identifying additional areas (e.g., subwatersheds) within the watershed to target for further restoration.

Monitoring efforts would be directed at improving the understanding of pollutant reductions and their impacts on the human use of coastal areas (Schueler & Kitchell 2005). These efforts would include coordinating and expanding science and monitoring to understand pollutant transport and freshwater flow through Gulf coastal watersheds and the relationship between watershed pollutant loadings and occurrence of Gulf coastal ecosystem threats and human use impacts (i.e., hypoxia, harmful algal blooms, habitat loss, and beach and shellfish closures). Where appropriate, these monitoring needs will be met by existing water quality monitoring networks (e.g., U.S. Geological Survey National Stream Quality Accounting Network and state monitoring programs). These existing water quality monitoring networks may also be supplemented, as needed, to provide more robust watershed-scale monitoring to support planning, implementation, and evaluation of this restoration type.

5.5.6 Restoration Type: Fish and Water Column Invertebrates

> This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

A wide variety of organisms inhabit the water column, including numerous fish species and invertebrates (such as shrimp, crabs, and squid). Many of these species spend their entire life in the water column (e.g., from a planktonic larval stage to an adult nektonic stage), while others may only use the water column for a distinct life stage before settling to benthic habitats. These organisms inhabit all parts of the water column, from estuaries to the deep sea, and play important ecological roles by cycling and transporting nutrients and energy between nearshore and offshore areas and between the surface and the deep sea. They also form (in large part) the marine food web that includes other injured resources, such as birds, sea turtles, and marine mammals.

The northern Gulf of Mexico commercial and recreational finfish fisheries support a billion dollar seafood industry and a substantial recreational fishery (NMFS 2014b). Because of the commercial and recreational importance of fisheries in the Gulf, many of the injured species are managed through federal and state statutes and intergovernmental fishery organizations that work to ensure the sustainability of these populations by incorporating the best available science into decision-making. For example, the Magnuson-Stevens Fishery Conservation and Management Act is the primary law governing marine fisheries management in U.S. federal waters and fosters long-term biological and economic sustainability by preventing overfishing, rebuilding overfished stocks, increasing long-term economic and social benefits, and ensuring a safe and sustainable supply of seafood.

Key Aspects of the Injury That Informed Restoration Planning

- A vast quantity of water across the northern Gulf of Mexico was exposed to *Deepwater Horizon* oil, injuring water column resources. The surface slick alone covered a cumulative area of at least 43,300 square miles (112,000 square kilometers) across 113 days in 2010. The estimated average daily volume of contaminated water under surface oil slicks was 57 billion cubic meters. As a comparison, this volume is approximately 40 times the average daily discharge of the Mississippi River at New Orleans.
- Water-column resources injured by the spill include species from all levels in the food chain, from bacteria, to estuarine-dependent species, such as red drum, shrimp, and sea trout, to large predatory fish (e.g., bluefin tuna) that can migrate from the Gulf of Mexico into the Atlantic and as far as the Mediterranean Sea.
- The Trustees estimate that 2 to 5 trillion larval fish and 37 to 68 trillion invertebrates were killed in the surface waters and between 86 million and 26 billion fish larvae and between 10 million and 7 billion planktonic invertebrates in deeper waters. Of these totals, 0.4 to 1 billion larval fish and 2 to 6 trillion invertebrates were killed in estuarine surface waters. The larval loss likely translated into millions to billions of fish that would have reached a year old. Larval fish that were killed but would not have survived to age 1 are also a significant loss; they are an energy source for other components of the ecosystem.
- The Trustees determined that additional injuries occurred, but these were not quantified.

Examples include adverse effects to fish physiology (e.g., impaired reproduction and reduced growth) and adverse effects to reef fish communities (e.g., reductions in abundance and changes in community composition).

See Chapter 4 (Section 4.4, Water Column) for a more detailed description of these injuries and the Trustees' injury assessment.

The large and continuous release of oil resulted in impacts to many species throughout the water column (see text box above that summarizes key aspects of the injury assessment that informed restoration planning). The restoration will need to address injuries to the species at different life stages and across their geographic range. In accordance with the ecosystem approach to restoration, the Trustees will implement a portfolio of restoration approaches for the water column injury that is three-fold:

1. Coastal and nearshore habitat restoration, discussed and implemented under the Wetlands, Coastal, and Nearshore Habitats restoration type (Section 5.5.2), SAV restoration type (Section 5.5.8) and Oysters restoration type (Section 5.5.9).
2. Offshore habitat restoration, discussed and implemented under the Mesophotic and Deep Benthic Communities restoration type (Section 5.5.13).
3. Mortality reduction, accomplished by addressing known sources of mortality to fish and invertebrates by reducing bycatch and fisheries interactions discussed and implemented under this restoration type (Section 5.5.6).

Implementing this portfolio of restoration approaches provides a robust, comprehensive solution to addressing the range of injured water column species and life stages.

5.5.6.1 Goals of the Restoration Type

To address injuries to fish and invertebrate species from the spill through reducing bycatch and fisheries interactions, the restoration goals are as follows:

- Restore injured fish and invertebrate species across the range of coastal and oceanic zones by reducing direct sources of mortality.
- Increase the health of fisheries by providing fishing communities with methodologies and incentives to reduce impacts to fishery resources.

5.5.6.2 Strategy to Achieve Goals

This restoration type will decrease mortality to fish and invertebrates by reducing bycatch and decreasing directed catch using voluntary and incentivized approaches. Fishing mortality, as either intended target catch or as bycatch, is often the dominant source of non-natural mortality to fish species. Bycatch occurs because fishing methods are imperfect and lack exact selectivity, and it remains one of the most pressing environmental concerns with fishing (Benaka et al. 2012). Bycatch can lead to impacts on natural resources at multiple biological scales, from populations to the ecosystem, and can also lead to adverse economic impacts (Patrick & Benaka 2013). Reducing fishing mortality may provide

an effective, immediate, and practical approach to restoring fish and invertebrates injured by the spill, especially oceanic pelagic species, for which habitat restoration may not be feasible. For example, reducing fishing mortality in the pelagic longline fishery could directly benefit western Atlantic bluefin tuna in the Gulf of Mexico. Reducing mortality in this fishery is particularly important because the northern Gulf of Mexico is a primary spawning ground for bluefin tuna.

Reducing bycatch in international, U.S., and state fisheries is a priority for many management agencies. Therefore, this restoration type consists of restoration approaches in both nearshore and offshore waters in the Gulf of Mexico or outside the Gulf in U.S. or international waters. Reducing bycatch is a management priority because bycatch contributes to overfishing, threatens protected and endangered species, and can close fisheries, which ultimately affects livelihoods and economies. For example, a fishery closure can occur due to exceedance of an incidental take statement established in a Biological Opinion issued under the Endangered Species Act (ESA). There are several ways to reduce bycatch, including temporary reductions in fishing effort, gear conversions, and removing derelict gear (NMFS & NOAA 2011). These approaches may not only reduce bycatch and bycatch mortality but can also improve catch rates and harvesting efficiencies of target species and lead to greater landings and profits. Reducing bycatch can therefore be an efficient way to create value for fisheries while restoring for injured resources.

Restoration Approaches

- Gear conversion and/or removal of derelict fishing gear to reduce impacts of ghost fishing
- Reduce mortality among Highly Migratory Species and other oceanic fishes
- Voluntary reduction in Gulf menhaden harvest
- Incentivize Gulf of Mexico commercial shrimp fishers to increase gear selectivity and environmental stewardship
- Enhance development of bycatch reducing technologies
- Reduce post-release mortality of red snapper and other reef fishes in the Gulf of Mexico recreational fishery using fish descender devices
- Reduce Gulf of Mexico commercial red snapper or other reef fish discards through IFQ allocation subsidy program

The restoration approaches associated with this restoration type include "Gear conversion and/or removal of derelict fishing gear to reduce impacts of ghost fishing," "Reduce mortality among Highly Migratory Species and other oceanic fishes," "Voluntary reduction in Gulf menhaden harvest," "Incentivize Gulf of Mexico commercial shrimp fishers to increase gear selectivity and environmental stewardship," "Enhance development of bycatch reducing technologies," "Reduce post-release mortality of red snapper and other reef fishes in the Gulf of Mexico recreational fishery using fish descender devices," and "Reduce Gulf of Mexico commercial red snapper or other reef fish discards through IFQ[7] allocation subsidy program," (described in Appendix 5.D, Restoration Approaches and OPA Evaluation). This type of restoration was initiated in Phase IV of Early Restoration with the Pelagic Longline Bycatch Reduction Project (PLL Project) (see Appendix 5.B, Early Restoration). The PLL Project aims to reduce bycatch associated with the Gulf pelagic longline fishery through a temporary, voluntary pelagic longline fishing repose and gear exchange.

[7] IFQ = individual fishing quota.

5.5.6.3 Planning and Implementation Considerations

Several of the restoration approaches involve working directly with fishers. Because of the commercial and recreational importance of fisheries in the Gulf, these fisheries are already managed under other regulatory frameworks. Therefore, restoration activities need to consider existing, pending, and proposed regulations and international agreements. Restoration approaches are intended to work in concert with existing regulations to create resource benefits beyond what regulations achieve without creating undue burden on the fishing community. The federal and state regulations can vary by state and the international agreements can vary by country. These differences need to be considered when developing appropriate projects within each fishery and geography. Since restoration activities targeted at fishers in this restoration plan are voluntary, no changes to regulations are necessary to implement these projects.

Several of these restoration approaches involve voluntary gear modifications. Key considerations for each of these approaches include education, outreach, training, and appropriate incentives or compensation. Incentives are designed to compensate fishers for time spent to exchange gear and increase participation in gear exchange programs (Piovano et al. 2012) and are anticipated to vary among potential user groups. Partnerships promoting active outreach and education with stakeholders in both commercial and recreational fisheries are considered critical for maximizing the use and conservation benefit of this technology (Graves et al. 2012). Therefore, outreach efforts would likely include some combination of workshops, displays, and presentations at fishing tournaments, public events, professional conferences, and youth fishing programs; these outreach effort could also include the development of educator outreach "toolkits," brochures, and online publications (Fluech et al. 2012; Podey & Abrams 2012). Another consideration is the availability of gear and ensuring a sufficient supply to meet the need.

All these considerations involve agreements, which would be developed with each participant, specifying the agreed-on restrictions for project participation. For some fisheries there could be other challenges to implementation such as gaining industry buy-in to participate in a voluntary program. The reluctance to participate could be due to concerns related to financial impacts from participation and fear of setting a precedent for future regulations. It will be important to gauge fisher interest through stakeholder outreach and coordination with state agencies, regional management bodies such as the Gulf of Mexico Fishery Management Council and the Gulf States Fishery Management Commission, and international management organizations to develop win-win restoration activities. These types of approaches also require careful consideration of how fishing behavior could be affected. For example, without the same access to red snapper quota, fishers in the eastern Gulf may alter their fishing effort to pursue other species of reef fish, which may impose greater pressure on these fish populations in the northern and western Gulf.

These restoration approaches could be implemented in the Gulf of Mexico or the Atlantic to work with fisheries that could have the most beneficial effect on injured resources. Some of these approaches could also involve working with international fisheries, which would present additional challenges. For example, working with non-U.S. vessels may require coordinating with intergovernmental organizations and working through existing programs to develop workable contracts and establish monitoring requirements to increase the likelihood of restoration success. Other restoration approaches might be

geographically constrained initially in order to identify the best methods and fishing gear before expanding. This type of phased implementation allows for information to be gained during initial implementation, increasing information from scientific partners and allowing for the evolution of gear technology.

Costs associated with a specific gear, incentive structure to ensure participation, and requisite training and outreach are also important considerations. Gear costs can vary widely, which could influence the approaches implemented compared to the potential benefits that could be achieved. For example, the cost of a bycatch reduction device (BRD) can range from $50 to several hundred dollars, while a hopper sorting system can range from tens of thousands of dollars to hundreds of thousands of dollars. Despite the high costs associated with installing a hopper sorting system, long-term use and large-scale adoption of these devices throughout the Gulf are possible. To best meet the desired ecological outcomes with long-term sustainability, the Trustees will need to take note of these important project development considerations. Because of the variety of restoration approaches and target fisheries for reducing bycatch, the Trustees discuss specific considerations for each restoration approach in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.6.4 Monitoring

Restoration approaches within this restoration type will enhance and expand on a variety of existing fishery management efforts to reduce bycatch (NMFS 2011, 2014a). These approaches will be targeted to fisheries that are diverse in their locations, fishing communities, target species, and bycatch levels. Using a robust adaptive management approach will improve the likelihood of restoration success. Adaptive management can address critical scientific uncertainties through monitoring and other targeted scientific support. Monitoring and adaptive management of water column restoration projects will rely heavily on existing and expanded fishery observer programs and other fishery-dependent data, given the connection between this restoration type and existing fishery management efforts.

Performance monitoring will be conducted to track restoration projects and determine if projects, individually and together, are meeting restoration objectives such as reducing bycatch rates, reducing bycatch mortality, and achieving voluntary reductions in catches. Performance monitoring may measure parameters such as participation in and compliance with incentive-based programs, aggregated counts and dispositions of target or bycatch species, measures of fishing effort product grades, and economic and market conditions. Data may be collated and aggregated from existing fishery observer and logbook programs and supplemented as required with additional data collected by additional project-specific observers on vessels participating in voluntary restoration projects. The use of observers and project-specific data collection would be coordinated with appropriate state and federal agencies.

Resource-level monitoring may be required to support planning, implementation, and evaluation of fish and water column restoration. Monitoring and scientific support may be conducted to improve understanding of the status and trends of key water column resources and to better define the effectiveness of bycatch reduction and bycatch mortality reduction approaches for species intended for restoration. In addition to providing information needed to adaptively manage restoration actions, these additional data collection efforts may provide fisheries managers with better information on which to make management decisions, which could provide further benefit to the species targeted for restoration.

Information on the life histories of species targeted for restoration and the structures of the communities in which they live can improve restoration outcomes. A more in-depth understanding of characteristics, such as age structure, growth rates, fecundity, and connectivity, may be important to understanding of the status and trends of key water column resources and would influence restoration project design and evaluation. Enhanced fishery-independent data collection methods, such as increased spatial and temporal effort for fishery-independent surveys and enhanced sampling of information on life history, trophic position, reproductive biology, and habitat associations could improve restoration outcomes. These types of fishery-dependent and fishery-independent information are similar to data required for fisheries management in the Gulf of Mexico (SEDAR 2015). Collected information that increases our understanding of densities of organisms in geography and over time, ecosystem functioning, and trophic relationships can be used to inform restoration project planning, design, and evaluation. Moreover, because densities of water column species can vary significantly across geographies and over time, particularly for large, mobile predators, the ability to accurately assess the impact of restoration would be improved by these additional data.

Although the Trustees have confidence in bycatch and bycatch mortality reduction approaches, the degree to which the effectiveness of bycatch reduction and bycatch mortality reduction approaches are understood varies depending on the context in which they are used (e.g., Diamond et al. 2011). Efforts to characterize the effectiveness of bycatch reduction devices (e.g., gear comparisons and mark-recapture studies) and facilitate a more accurate estimate of discards and fishing effort (e.g., electronic fishery reporting methods and additional observer capacity) can substantially improve the evaluation of restoration outcomes and inform planning of future restoration projects.

5.5.7 Restoration Type: Sturgeon

This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) is a fish that inhabits coastal waters and rivers in the northern Gulf of Mexico from Lake Pontchartrain in Louisiana to the Suwannee River in Florida. After spending the first 2 to 3 years in the river in which it hatched, a Gulf sturgeon becomes anadromous, spending fall and winter in the Gulf and spring and summer in the rivers where it spawns. Gulf sturgeon are listed as threatened under the federal ESA, and critical habitat has been designated (see Figure 5.5-2).

Large numbers of this federally protected species from most Gulf sturgeon river populations were exposed to *Deepwater Horizon* oil, and a substantial number of these fish were affected by this exposure (see text box below that summarizes key aspects of the injury assessment that informed restoration planning). Considering the protected status of Gulf sturgeon, restoration will focus on approaches that are consistent with those identified in the federal Gulf Sturgeon Recovery Plan (FWS & GSMFC 1995). The restoration approaches emphasize spawning habitat and reproductive success.

Source: *USFWS.*

Figure 5.5-2. Designated Critical Habitat and historic range of Gulf sturgeon.

Key Aspects of the Injury That Informed Restoration Planning

- The Trustees conducted a focused assessment of potential injuries to Gulf sturgeon (*Acipenser oxyrinchus desotoi*), because Gulf sturgeon are listed as a threatened species under ESA and inhabit areas exposed to *Deepwater Horizon* oil.
- Between 1,100 and nearly 3,600 Gulf sturgeon were exposed to the *Deepwater Horizon* oil in the nearshore areas of the northern Gulf of Mexico in the fall of 2010. This estimated exposed population represents a substantial proportion of the total populations from six of the eight natal rivers systems. Although a direct kill of Gulf sturgeon from the oil was not observed, the Trustees found evidence of physiological injury, including exposure biomarkers for DNA damage and immunosuppression, to exposed Gulf sturgeon compared with Gulf sturgeon that were not exposed to the oil.

See Chapter 4 (Section 4.6, Nearshore Marine Ecosystem) for a more detailed description of these injuries and the Trustees' injury assessment.

5.5.7.1 Goals of the Restoration Type

To address impacts to sturgeon, restoration goals are as follows:

- Restore and protect Gulf sturgeon through improving access to spawning areas.
- Increase the reproductive success of Gulf sturgeon.

5.5.7.2 Strategy to Achieve Goals

This restoration type will improve conditions and provide access to spawning habitat for Gulf sturgeon in order to improve survival of the Gulf sturgeon's earliest life stages: egg, fry, fingerling, and juvenile. The first two to three years of a Gulf sturgeon's life is spent within the rivers where it was spawned. As older fish, individuals will embark on far-reaching migratory lifestyles. Therefore, in the early years, opportunities are available to affect a great number of individuals in a relatively small area. Year-class strength is established during these stages, and environmental conditions such as water temperature, salinity, flow, turbidity, and other factors affect survival rates (FWS & GSMFC 1995).

Gulf sturgeon spawning habitat has been associated with limestone outcroppings, cobble, gravel, or other hard bottom habitats (Scollan & Parauka 2008). These sites are relatively uncommon features in the rivers where Gulf sturgeon spawn, and Gulf sturgeon make long migrations year after year to the same location to take advantage of this spawning habitat. To effectively restore injured Gulf sturgeon, the Trustees must ensure that they have access to suitable spawning habitat. Gulf sturgeon river populations have been identified in the following rivers (from west to east): Pearl River (on the border of Louisiana and Mississippi), Pascagoula River, Escambia River, Blackwater River, Yellow River, Choctawhatchee River, Apalachicola River, and Suwannee River. For many spawning rivers in the Gulf sturgeon's range, suitable spawning habitat is limited. Restoring the conditions in these rivers will increase the Gulf sturgeon's ability to spawn and reproduce. Therefore, restoration could be implemented in any of these rivers.

The restoration approaches associated with this restoration type are "Restore sturgeon spawning habitat"; "Reduce nutrient loads to coastal watersheds"; and "Protect and conserve marine, coastal, estuarine, and riparian habitats" (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation). This approach is consistent with the Gulf sturgeon recovery plan to ensure that restoration aligns with existing conservation priorities. This restoration type also includes monitoring to address critical uncertainties related to identifying spawning habitat, threats, and options for addressing those threats in targeted rivers. This information is necessary to evaluate and improve Gulf sturgeon reproductive success.

Restoration Approaches

- Restore sturgeon spawning habitat
- Reduce nutrient loads to coastal watersheds
- Protect and conserve marine, coastal, estuarine, and riparian habitats

5.5.7.3 Planning and Implementation Considerations

The Trustees will consider Gulf sturgeon restoration activities in Louisiana, Mississippi, Alabama, and Florida. The Trustees would coordinate and collaborate with local, regional, and/or governmental stakeholders to implement restoration projects. Additional considerations discussed below will be

important in planning restoration projects to achieve the best ecological outcomes and long-term sustainability of project benefits.

In some rivers that have been studied closely, Gulf sturgeon appear to seek habitat conditions that are predictable and measureable (e.g., Sulak & Clugston 1998). However, the Trustees may choose to implement projects on rivers that have not yet been mapped for habitat. These rivers would require a substantial information gathering effort, possibly including spawning locations, before projects can be implemented. It is possible that, after identifying riverine habitat used by Gulf sturgeon, the Trustees determine that no actions are necessary to improve the quality of the habitat, but based on Trustee experience with implementing similar projects, this is unlikely. For example, sediment discharged from agriculture and silviculture activities can cover the clean, hard substrate of the riverbed necessary for productive Gulf sturgeon spawning, thereby reduce spawning success. Identifying these conservation opportunities in targeted watersheds near potential spawning habitat is important for mitigating these environmental threats. Conservation practices on agricultural and forested land can be implemented to reduce sediment and nutrient loading from public and/or private lands. The Trustees would, however, implement this restoration in a step-wise fashion in which they would first ascertain the need for and scope of riverine restoration required at each site before proposing the actual restoration work. Site identification would include targeting river basins where distinct populations were injured and where restoration opportunities exist. Appendix 5.D, Restoration Approaches and OPA Evaluation, describes additional implementation considerations for the restoration approaches.

5.5.7.4 Monitoring

Performance monitoring will be conducted to evaluate the effectiveness of restoration actions conducted under these restoration approaches. Performance monitoring will be designed to determine if projects, individually and collectively, are meeting restoration objectives. Performance monitoring will also assist, where feasible, in determining the need for corrective actions and adaptive management. Although not all projects will share the same project-level objectives, performance monitoring of sturgeon restoration projects will use metrics such as geographical distribution, weight, length, survival, age, and reproductive condition. Depending on the project, additional environmental metrics will also need to be monitored, including contaminant concentrations in environmental media, as well as a variety of water and sediment quality parameters. Although the Trustees intend to strive for consistency in performance-monitoring parameters, frequency, and duration for similar restoration types, flexibility in monitoring design is necessary to account for inherent differences between restoration projects and locations.

Although this approach consists of restoration techniques that are established and that constitute successful methods of enhancing reproduction and survival in Gulf sturgeon, some critical information gaps exist. To maximize project efficiency and success, the Trustees may incrementally address key information needs through monitoring and adaptive management. Potential monitoring and scientific support efforts include mapping suitable spawning habitat, identifying which spawning sites are used, identifying summer holding areas for adults and juveniles, identifying sources of habitat suitability degradation, and estimating abundance trends and instream movements, especially of juveniles.

5.5.8 Restoration Type: Submerged Aquatic Vegetation

> This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

SAV beds serve many important functions within the nearshore environment, including contributing to primary productivity; directly and indirectly serving as the base of nearshore food webs; providing habitat and shelter for many species of fish, invertebrates, sea turtles, and birds; providing direct and indirect ecological connectivity between intertidal nearshore habitats and deeper subtidal habitats; removing nutrients from the water column and oxygenating sediments; and trapping sediments, thereby improving water clarity and stabilizing the sea bottom (Beck et al. 2007; Heck Jr. et al. 2008; Orth et al. 2006) (see Figure 5.5-3).

Key Aspects of the Injury That Informed Restoration Planning

- SAV in the Chandeleur Islands, Louisiana, was injured as a result of oiling. The spatial distribution of seagrasses decreased from 2010 to 2012 along the shallow shelf west of the Chandeleur Islands.
- A total of 112 acres of seagrass beds were identified as persistently lost (defined as loss for two consecutive mapping intervals), and 160 acres were classified as delayed loss (areas where seagrass was present in 2010 and 2011 but lost in 2012).

See Chapter 4 (Section 4.6, Nearshore Marine Ecosystem) for a more detailed description of these injuries and the Trustees' injury assessment.

The SAV beds off the Chandeleur Islands are unique and extremely productive, which exemplifies the important functions of SAV in the nearshore environment (Beck et al. 2007; Handley et al. 2007; Heck Jr. et al. 2008; Poirrier & Handley 2007). The Islands' location serves as a "fly trap," as it the first area of vegetated, shallow water habitat that pelagic juvenile fish and invertebrates come across in the vast Gulf; in this habitat, they are able to escape predation and feed in productive shallows. These seagrasses also provide habitat and food for green sea turtles and support the overwintering of redhead, a type of duck (Michot & Chadwick 1994). The Chandeleur Islands also support important populations of commercial and sport fishes (Fodrie & Heck Jr. 2011; Fodrie et al. 2010). These SAV beds are the only such to have been documented in Louisiana and are the largest and most continuous seagrass beds in the north-central region of the Gulf of Mexico (Handley et al. 2007; Poirrier & Handley 2007).

Source: Dr. Joseph Z. Zieman, University of Virginia, Charlottesville Virginia.

Figure 5.5-3. Underwater SAV meadow of mixed species of seagrass, *Thalassia testudinum* and *Syringodium filiforme,* that grow in the Chandeleur Islands, Louisiana.

SAV restoration is important throughout the Gulf because of the important functions of SAV habitats (Fonseca et al. 1998; Orth et al. 2006). This restoration approach will be implemented under the Wetlands, Coastal and Nearshore Habitat restoration type to achieve broader, more regional benefits of habitat restoration. However, the SAV injury (see text box above that summarizes key aspects of the injury assessment that informed restoration planning) and the unique characteristics of the Chandeleur Islands are factors that make it additionally important to implement restoration specifically in the Chandeleur Islands. This restoration would be in addition to any SAV restoration that may be implemented under the Wetlands Coastal and Nearshore Habitats restoration type.

5.5.8.1 Goals of the Restoration Type

For injuries to SAV resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Restore for injuries to SAV beds in the Chandeleur Islands chain to provide resiliency and sustainability to this unique habitat.
- Restore ecological functions of SAV beds in the Chandeleur Islands by considering these beds as a component of the Islands' integrated habitat complex.

5.5.8.2 Strategy to Achieve Goals

This restoration type will address injury to the SAV beds of the Chandeleur Islands habitat complex, while considering restoration that is needed to restore resiliency to these beds (Thomson et al. 2010). The association of the seagrass beds with the barrier islands is an extraordinary and important biophysical relationship. The islands themselves provide a physical land barrier that buffers wave and

current energy originating in the open waters of the Gulf of Mexico (Thomson et al. 2010). The emergent barrier islands and the shallow shelf are one entire geological unit that has been slowly moving westward into Chandeleur Sound for hundreds of years (Fearnley et al. 2009; Pham et al. 2014; Thomson et al. 2010). The level of protection provided by the islands is also sufficient to allow for the physical conditions (water currents, wave turbulence, and water depth) behind the barrier to support the growth of seagrasses (Fonseca & Bell 1998). In turn, the seagrasses further baffle wave and current energy and promote sediment deposition, while the roots and rhizomes bind and stabilize the shelf substrate. By trapping and stabilizing sediments, the seagrasses help maintain the elevation of the subtidal platform on which the islands are perched (Fonseca 1996). Thus, seagrasses play a critical role in sustaining the back-barrier platform and the foundation the islands need to remain above sea level. Therefore, this restoration type aids in the resiliency and survival of the Chandeleur Islands and, as part of this integrated complex, provides benefits to a wide range of resources including birds and fish (Fodrie & Heck Jr. 2011; Heck Jr. et al. 2008; Michot & Chadwick 1994).

Restoration Approach

- Restore and enhance submerged aquatic vegetation

The restoration approach associated with this restoration type is "Restore and enhance submerged aquatic vegetation" (see Appendix 5.D, Restoration Approaches and OPA Evaluation). The Trustees may choose to implement this restoration approach in combination, or in association, with other restoration approaches, such as "Create, Restore, and Enhance Coastal Wetlands," to increase overall service flows and benefits to other injured resources such as fish and barrier islands. Implementing approaches that emphasize the habitat complex within the Chandeleur Islands will restore the overall ecological function of these injured SAV beds.

5.5.8.3 Planning and Implementation Considerations

Although the Trustees have extensive experience restoring SAV beds, several restoration considerations are unique to designing and implementing SAV restoration in the Chandeleur Islands (e.g., Thomson et al. 2010). The existence of seagrass beds in the Chandeleur Islands is made possible by two critical factors: 1) the presence and persistence of emergent land features (the islands) above sea level that baffle wave and current energy and 2) a sediment source to maintain suitable water depth (2 meters or less) on the leeward platform where SAV grows. The emergent islands and the platform are a coupled geological unit (barrier island system) slowly migrating west into Chandeleur Sound (Fearnley et al. 2009; Pham et al. 2014; Poirrier & Handley 2007; Thomson et al. 2010). The leeward platform is the foundation on which the islands are perched and maintained above sea level. The SAV beds play an important role in this process, functioning as a stabilizing feature on the submerged platform and helping to maintain its elevation (Fonseca 1996).

In planning and conducting SAV restoration activities, areas with suitable water quality conditions for SAV growth would be selected and their water quality maintained (Fonseca et al. 1998; Fonseca et al. 1987). Additionally, existing SAV could be protected, and restoration would take place where SAV has previously existed. Sites should also be selected where the water depth, light, salinity, temperature, and sediment quality is appropriate. In addition, the remote location of the Chandeleur Islands must be considered. Existing infrastructure is limited, with no direct route for vehicles or vessels. Therefore,

materials and labor will have to be shipped from shore to implement any restoration effort. All these factors will influence the cost of restoration.

The Chandeleur Islands are a north-south oriented chain of sand and vegetated islands in the northern Gulf of Mexico east of Louisiana and south of Mississippi. They are also dynamic and subject to weather events and reduced sediment availability (Fearnley et al. 2009; Pham et al. 2014; Poirrier & Handley 2007; Thomson et al. 2010). These conditions can pose challenges for restoration implementation. One of the most important needs is to stabilize movement of sediments in and around the islands. These sediments become mobile and are either eroded away from existing SAV beds due to exposure from high wind and wave energies that result as the beds lose their island protection or are buried when storm events move large quantities of sand onto existing beds. Appendix 5.D, Restoration Approaches and OPA Evaluation, presents additional implementation considerations for the restoration approach.

5.5.8.4 Monitoring

This restoration type includes a restoration approach that is relatively straightforward and well-tested, and for which performance monitoring at the scale of the individual project will be sufficient to evaluate restoration outcomes and determine the need for any corrective actions (Farrer 2010; Fonseca et al. 1998; Fonseca et al. 1987). The Trustees have developed a monitoring framework for SAV restoration through their work on Early Restoration (see Appendix 5.E, Monitoring and Adaptive Management Framework; Farrer 2010). As outlined in the monitoring framework, performance monitoring for SAV restoration may include such parameters as SAV species composition and cover within restored areas, elevation of filled prop scars, and the structural integrity of signage and other protective measures.

The Trustees may choose to collect a standard set of parameters on all projects to facilitate consistent evaluation of projects and for transparency to the public on project performance (Fonseca et al. 1998; Fonseca et al. 1987; Treat & Lewis III Eds. 2006). More intensive and expanded validation monitoring conducted on a subset of projects to better characterize ecological function and address critical uncertainties may also be helpful in evaluating project performance and informing the design and implementation of future SAV restoration projects (Farrer 2010; Fonseca 1994; Fonseca et al. 1996).

Resource-level monitoring and scientific support may be needed to inform restoration planning. High resolution aerial photography may be acquired and photo-interpreted to compare with historical imagery to identify areas in potential SAV habitat that have not naturally revegetated following severe storm events (e.g., Hurricane Katrina and Tropical Storm Isaac). Such areas would be targeted for consideration of future restoration actions. This information can be integrated with detailed topography/bathymetry maps and wave energy models to identify environmentally suitable areas for SAV restoration and barrier island stabilization. Concurrently, in-water monitoring of seagrass distribution, species composition, and abundance can be used to verify remote sensing data and identify candidate species and locations for restoration and enhancement.

5.5.9 Restoration Type: Oysters

This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

Oysters are an ecological keystone species that are widely distributed throughout all five Gulf of Mexico states and contribute to the integrity and healthy function of the

Oysters are found on saltmarsh shorelines, on intertidal mudflats, and in shallow waters, including between saltmarshes and seagrass beds. For this restoration type, nearshore refers to oyster reefs that occur in estuarine waters up to 50 meters from shore. Subtidal refers to oyster reefs greater than 50 meters from shore.

nearshore ecosystem. As sessile organisms for the majority of their life, oysters rely on broadcast spawning to generate a regional larval pool that sustains populations across the Gulf. Planktonic, free-swimming oyster larvae are carried by currents and tides across large areas to replenish oyster populations. Healthy, interconnected oyster populations form reefs that provide the hard substrate needed for oyster larvae to settle, grow, and sustain the population. In addition to providing habitat for oysters, oyster reefs 1) serve as habitat for a diversity of marine organisms, from small invertebrates to large recreationally and commercially important species such as stone crab, blue crab, red drum, and black drum; 2) provide structural integrity that reduces shoreline erosion; and 3) improve water quality and help recycle nutrients by filtering large quantities of water (Eastern Oyster Biological Review Team 2007; Peterson et al. 2003; Powers et al. 2009; Wells 1961; Wong et al. 2011).

Although native oyster reefs have declined in many regions, Gulf of Mexico oyster reefs are among the most productive in the world, with subtidal reefs supporting a robust oyster fishery (Beck et al. 2011; VanderKooy 2012). In addition, oyster habitat that fringes saltmarshes is one of the most common habitat couplings along the U.S. Gulf Coast (Geraldi et al. 2009; Grabowski et al. 2005) (see **Error! Reference source not found.**). NRDA studies estimate that 76 percent of salt marsh habitat in the northern Gulf of Mexico had adjacent oyster cover within 50 meters, with the bulk occurring within 3 meters of the marsh edge (Powers et al. 2015). However, fringing oyster habitat is fragile and has natural recovery times that can take decades (Powers et al. 2015).

Source: *Dr. Earl Melancon, Nicholls State University.*

Figure 5.5-4. Fringing oyster reef, Grande Terre Island, Louisiana.

The *Deepwater Horizon* spill severely affected nearshore oysters, subtidal oysters, and oyster recruitment (see text box below that summarizes key aspects of the injury assessment that informed restoration planning). Circulation modeling conducted for the injury assessment demonstrates that nearshore oysters and subtidal oysters form a common regional larval pool and identifies connections between oyster supply and settlement within and among basins (Murray et al. 2015). Nearshore oysters, which are not intensively harvested, also provide an important source of larvae to oysters in deeper waters (Murray et al. 2015; Powers et al. 2015). Therefore, the loss in oyster abundance and cover in the

subtidal and nearshore zones due to the spill would be expected to reduce spawning stock available to repopulate oyster reefs throughout the region (Grabowski et al. 2015; Powers et al. 2015).

This restoration type will emphasize nearshore and subtidal oyster restoration that also addresses the critical ecological process of oyster larvae recruitment. Restoration of recruitment is important because the recruitment failure has delayed or prevented recovery of oysters in spill-affected areas and areas that depend on such oysters as a source of oyster larvae, such as subtidal reefs (Melancon 2010; Powers et al. 2015). According to oyster researcher Earl Melancon (Marshall 2010), nearshore oysters supply larvae to subtidal reefs located within Gulf estuaries and therefore play a critical role in rebuilding oyster populations. This restoration will be in addition to oyster restoration that may be implemented as part of the Coastal, Wetland, and Nearshore restoration type. This additional restoration will ensure that all aspects of the oyster injury are compensated.

Key Aspects of the Injury That Informed Restoration Planning

- Substantial injury to subtidal oysters in the northern Gulf of Mexico occurred as the result of the *Deepwater Horizon* spill and response actions.
- The abundance of subtidal oysters in coastal Louisiana was reduced by summer river water releases conducted as part of response actions to the *Deepwater Horizon* spill. Between 4 and 8.3 billion subtidal oysters (adult equivalents) were lost. This injury is most pronounced in Barataria Bay and Black Bay/Breton Sound.
- Nearshore oyster cover was significantly reduced over a total of 155 miles (250 kilometers) and resulted in the loss of 8.3 million adult-equivalent oysters, due to impacts of response activities and physical fouling by oil. An additional estimated 5.7 million oysters per year (adult equivalents) are unable to settle because of the loss of oyster shell cover. The loss of nearshore oyster cover also contributed to an increase in shoreline erosion rates and wetland loss.
- The injuries to nearshore oysters resulted in a lack of recruitment and recovery throughout the region. As shown by NRDA modeling studies, larvae produced from nearshore oysters settle and grow in subtidal areas to contribute to subtidal oyster populations.
- The long-term sustainability of nearshore and subtidal oysters throughout the north-central Gulf of Mexico has been compromised as a result of the combined effects of reduced spawning stock, larval production, spat settlement, and spat substrate availability caused by the spill.

See Chapter 4 (Section 4.6, Nearshore Marine Ecosystem) for a more detailed description of these injuries and the Trustees' injury assessment.

5.5.9.1 Goals of the Restoration Type

For injuries to oysters resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Restore oyster abundance and spawning stock to support a regional oyster larvae pool sufficient for healthy recruitment levels to subtidal and nearshore oyster reefs.

- Restore resilience to oyster populations that are supported by productive larval source reefs and sufficient substrate in larval sink areas to sustain reefs over time.

- Restore a diversity of oyster reef habitats that provide ecological functions for estuarine-dependent fish species, vegetated shoreline and marsh habitat, and nearshore benthic communities.

Source: Dr. Earl Melancon, Nicholls State University.

Figure 5.5-5. Oyster larvae are transported by currents and tides and settle onto existing oyster shells to grow into "spat." This process is referred to as oyster recruitment. This picture from Barataria Bay, Louisiana, shows 49 live, 1- to 2-month old oyster spat on one shell.

5.5.9.2 Strategy to Achieve Goals

This restoration type will address the range of injuries to oysters, emphasizing projects that address recruitment issues (Figure 5.5-5). Restoration will be implemented in all five Gulf states to provide benefits across the interconnected northern Gulf of Mexico ecosystem. The restoration of oyster reef habitats that were lost or injured across the region would be conducted to restore oyster abundance and the services oyster reefs provide. The lack of oyster recruitment recovery is likely due in large part to the direct loss of nearshore oysters, which would otherwise serve as a regional source of larvae. *Deepwater Horizon* NRDA studies provide the first extensive survey of Gulf nearshore oysters and demonstrate these oysters were more prevalent than previously understood. In addition, nearshore oyster reefs serve as an important source of larvae to subtidal reefs. Therefore, to address the regional impairment of oyster recruitment, restoration of nearshore oyster reefs would be prioritized. Implementing oyster restoration in both nearshore and subtidal areas will help ensure the recovery of the ecological processes and conditions required for both the oysters and associated fish and invertebrates. This restoration will be accomplished by directly restoring reef habitat, enhancing oyster reef productivity, and restoring regional oyster recruitment by increasing oyster spawning stock populations and, subsequently, the regional larval supply.

Restoration Approach

- Restore oyster reef habitat

The restoration approach associated with this restoration type is "Restore oyster reef habitat" (see Appendix 5.D, Restoration Approaches and OPA Evaluation). This restoration approach could also be implemented in combination, or in association, with other restoration approaches under the Coastal Wetlands and Nearshore Habitat restoration type to increase overall service flows and benefits to other injured resources, such as fish and shallow benthic communities. The Trustees initiated oyster restoration under Early Restoration with an emphasis on subtidal reef restoration, providing for oyster restoration projects in Florida, Alabama, Mississippi, and

Louisiana (Appendix 5.B, Early Restoration). Subtidal oyster cultch placement projects in Louisiana, Florida, Alabama, and Mississippi were approved in Phases I and III, and living shoreline projects in Florida, Alabama, and Mississippi were approved for Phases III and IV. Although these Early Restoration projects will restore for some of the injury to oysters and to the services they provide, they will not fully address oyster injury. This restoration type will implement additional and strategically targeted oyster restoration projects designed to restore oyster recruitment and nearshore oyster cover that are required to address remaining oyster injury.

5.5.9.3 Planning and Implementation Considerations

Each Gulf state manages oysters as an important ecological, recreational, and commercial resource. Therefore, the Trustees will need to coordinate and collaborate with stakeholders, including oyster industry associations and state resource managers, to implement this restoration type. Through this coordination, the Trustees can align restoration with and support oyster management priorities while taking into consideration state-specific implementation needs.

Deepwater Horizon NRDA studies show recruitment is low or absent in many areas, indicating that lack of recruits rather than lack of substrate alone is delaying oyster recovery. Therefore, the oyster recruitment failure needs to be addressed to enable oyster populations to recover and reach population levels that are resilient and can once again support abundant benthic and fish communities. Due to high natural variability in larvae production, larval dispersal patterns, and subsequent recruitment, successful oyster restoration will require a phased approach, careful planning of restoration site placement, and monitoring studies to determine the level of restoration achieved in each phase (Geraldi et al. 2013; USACE 2012).

Both habitat suitability and availability of larvae for recruitment will need to be considered when restoration projects are sited. Although under some conditions, oyster larvae may settle locally (within the same reef), many reefs rely on larval transport between reefs for recruitment of new oysters. Therefore an important consideration is to restore oyster reefs in areas that would then serve as sources of larvae to recruitment-limited reefs, incorporating an understanding of larval transport and recruitment trends within proposed restoration areas. In order for larval-source reefs to be most effective, restricting or prohibiting harvest could be considered in certain areas to restore large female oysters and maintain maximum reproductive potential.

Another important consideration is the regional loss of larger, adult oysters that make up the region's spawning population and serve as sources of larvae. Projects to restore spawning stock as well as reefs in key locations would facilitate the restoration of the regional oyster larval pool, self-sustaining oyster populations, and regional oyster abundance and productivity. In areas with low spawning stock or poor recruitment, restoration planning could consider the use of techniques to increase reef productivity by planting hatchery-reared spat on shell. Large-scale use of these techniques may also require enhancement of regional hatchery capacity to produce sufficient oyster larvae for restoration.

Another important consideration in restoration design and siting is to reduce illegal harvest. Illegal harvest in restoration or protected areas has been shown to severely damage oyster populations and can result in a complete loss of the reef (Powers et al. 2009; USACE 2012). The risk of illegal harvest can

be minimized using several approaches, including public outreach, siting in areas where illegal harvest may be less likely, and designing restored reefs in a manner that would reduce or prevent illegal harvest.

Oyster reefs integrate and form a continuum with other habitats within the nearshore ecosystem and food web (Meyer & Townsend 2000). This pivotal role was disrupted by the loss and, to date, the lack of a full recovery of both oyster reefs and oyster populations. Therefore, this restoration approach will seek to implement projects across the Gulf that address multiple ecosystem benefits through oyster reef restoration. The restoration of oyster reef habitat would be part of the portfolio of restoration types and approaches to achieve multiple Trustee programmatic goals. For example, the role of oyster reefs in the nearshore ecosystem is an important consideration for the Wetlands, Coastal, and Nearshore Habitats, Habitat Projects on Federally Managed Lands, and Fish and Water Column Invertebrates restoration types. Therefore the strategies used to restore oyster reef habitat will consider the range of actions needed to restore the linkages between habitats and resources.

By identifying opportunities to restore the multiple ecosystem benefits of oyster reefs, recovery of injured ecosystem functions can be achieved. Appendix 5.D, Restoration Approaches and OPA Evaluation, provides additional implementation considerations for the oyster restoration approach.

5.5.9.4 Monitoring

This restoration type consists of well-established restoration approaches for which performance monitoring at the scale of the individual project will be sufficient to evaluate restoration outcomes and determine the need for any corrective actions. Performance monitoring will be designed to determine if projects, individually and together, are meeting their objectives with respect to the restoration of oyster resources and services. Although project-level objectives will vary, common metrics will be used, where possible, to evaluate and compare the performance success of oyster restoration projects.

The Trustees have developed monitoring frameworks through their work on Early Restoration for oyster reef restoration and oyster cultch placement or enhancement (see Appendix 5.E, Monitoring and Adaptive Management Framework). These frameworks include measurements of oyster reef spatial extent (e.g., oyster cultch area), oyster reef profile, oyster settlement and growth (e.g., oyster density, mortality, and size distribution), and nekton utilization of reefs (e.g., species composition, density, and biomass). The Trustees may choose to collect a standard set of parameters on all projects to facilitate consistent evaluation of projects (Baggett et al. 2014) and for transparency to the public on project performance. More intensive and expanded validation monitoring conducted on a subset of projects to better characterize ecological function and address critical uncertainties may also be helpful in evaluating project performance and informing the design and implementation of future oyster restoration projects (Baggett et al. 2014).

Although oyster restoration is frequently conducted throughout the Gulf of Mexico, the recruitment failure caused by the spill has created a critical uncertainty for restoration project performance and resource recovery. Collection of resource-level monitoring information may allow for adaptive management and inform future restoration decisions. This monitoring and scientific support could include tracking recruitment trends in locations targeted for restoration, identifying oyster larvae source and sink areas, and identifying areas with healthy oyster spawning populations. The information provided by such recruitment studies would support effective adaptive management for project

implementation and inform the selection and design of oyster restoration projects. For more information on monitoring restoration goals related to recruitment and oyster broodstock enhancement, see Coen et al. (2007)_ENREF_34.

5.5.10 Restoration Type: Sea Turtles

> This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

Sea turtles in the Gulf of Mexico are a shared resource, crossing state, federal, and international boundaries and relying on a system of interconnected beach, nearshore, and offshore habitats. All sea turtles are highly migratory and thus have a wide geographic range. Although sea turtles spend the vast majority of their lives in the water, a few significant life events occur on land, particularly adult female nesting, egg incubation, and hatchling emergence and crawl to the water. Sea turtles nest on beaches with suitable conditions throughout the Gulf of Mexico, from Mexico to Florida and have evolved extremely accurate homing and navigational systems that allow adult females to return to nest on the beaches where they were born (Lohmann et al. 1997). In the United States, nesting occurs almost exclusively in Florida (primarily loggerhead and green turtles), Alabama (primarily loggerhead turtles), and Texas (primarily Kemp's ridley turtles), with occasional/rare nesting in Mississippi and Louisiana.

Key Aspects of the Injury That Informed Restoration Planning

- The Trustees determined that four of the five species of sea turtles that inhabit the Gulf of Mexico were injured by the *Deepwater Horizon* oil spill (loggerhead, Kemp's ridley, green, and hawksbill). Leatherbacks were also likely exposed to oil, but injury could not be confirmed. All these species are listed as threatened or endangered under ESA, are long-lived, travel widely, and use a variety of habitats across the Gulf of Mexico and beyond.
- Sea turtles were injured by oil or response activities in the open ocean, nearshore, and shoreline environments, and resulting mortalities spanned multiple life stages. The Trustees estimated that between 4,900 and up to 7,600 large juvenile and adult sea turtles (Kemp's ridleys, loggerheads, and hard-shelled sea turtles not identified to species) and between 56,000 and up to 166,000 small juvenile sea turtles (Kemp's ridleys, green turtles, loggerheads, hawksbills, and hard-shelled sea turtles not identified to species) were killed by the *Deepwater Horizon* oil spill.
- Nearly 35,000 hatchling sea turtles (loggerheads, Kemp's ridleys, and green turtles) were injured by response activities, and thousands more Kemp's ridley and loggerhead hatchlings were lost due to unrealized reproduction of adult sea turtles that were killed by the *Deepwater Horizon* oil spill.
- In addition, the injury assessment included injuries that were determined to have occurred, but were not formally quantified, such as unquantified injuries to leatherback turtles.

See Chapter 4 (Section 4.8, Sea Turtles) for a more detailed description of these injuries and the Trustees' injury assessment.

All sea turtle species inhabiting the Gulf of Mexico are listed as threatened or endangered under ESA. Therefore, recovery plans have been developed and implemented, under Section 4(f) of ESA, to help identify and guide species conservation and recovery. Recovery plans provide a blueprint for recovery of the species and can be used to help inform and guide restoration planning to compensate for sea turtle injuries as a result of the *Deepwater Horizon* spill.

The *Deepwater Horizon* spill affected nesting (including nesting females, eggs, and hatchlings), small juvenile, large juvenile, and adult sea turtles throughout the Gulf of Mexico (see text box above that summarizes key aspects of the injury assessment that informed restoration planning). These species are long-lived, highly migratory, and occupy multiple habitats over the course of their lives. All these factors affect recovery and necessitate a portfolio of restoration approaches that can address all species and life stages that were injured by the spill. This portfolio includes ecological benefits achieved through restoring coastal habitats (as described in Section 5.5.2, Restoration Type: Wetlands, Coastal, and Nearshore Habitats), reducing bycatch and other anthropogenic mortality, restoring nesting habitat, and robust monitoring.

5.5.10.1 Goals of the Restoration Type

For injuries to sea turtles resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Implement an integrated portfolio of restoration approaches to address all injured life stages (hatchling, juvenile, and adult) and species of sea turtles.
- Restore injuries by addressing primary threats to sea turtles in the marine and terrestrial environment such as bycatch in commercial and recreational fisheries, acute environmental changes (e.g., cold water temperatures), loss or degradation of nesting beach habitat (e.g., coastal armoring and artificial lighting) and other anthropogenic threats.
- Restore in the various geographic and temporal areas within the Gulf of Mexico and Atlantic Ocean that are relevant to injured species and life stages.
- Ensure consistency with recovery plans and recovery goals for each of the sea turtle species to support existing conservation efforts.

5.5.10.2 Strategy to Achieve Goals

This restoration type will address the key threats to sea turtles and emphasize activities that are consistent with their recovery plans. Sea turtles face a variety of threats across different life stages and habitats. They spend the vast majority of their lives at sea where they are exposed to anthropogenic activities that threaten their survival. The most significant anthropogenic threat to sea turtle populations in the marine environment is bycatch in fishing gear—principally trawls, pelagic and bottom longlines, gillnets, and hook-and-line gear (NMFS & FWS 2008; NMFS et al. 2011). While on land, sea turtles also face a variety of threats. In particular, coastal development can alter or destroy sea turtle nesting habitat, which can deter or disrupt nesting and can reduce embryo and hatchling survival. Restoration will address all injured species and life stages by targeting key threats, which is consistent with the recovery plans that are in place for sea turtles. Therefore, the Trustees propose that restoration activities will take place in all five Gulf states and in nearshore and offshore waters to provide benefits

for all injured species and life stages. Restoration for sea turtles will focus in the geographies with the greatest potential to benefit the targeted species, which could include work outside the Gulf of Mexico.

Restoration will reduce bycatch and associated mortality through several mechanisms, including enhanced outreach to fishers and enforcement of existing fishery regulations, and through the development and identification of additional conservation strategies. Improved compliance with existing sea turtle bycatch reduction measures (e.g., turtle excluder devices—TEDs [see Figure 5.5-6], longline hook size and bait requirements, and bottom longline time/area closures) can provide long-lasting benefits to the resource that would accrue over time as individual sea turtles survive to mature and reproduce. Developing and implementing new conservation strategies to reduce bycatch of sea turtles in Gulf fisheries can provide additional long-lasting benefits to the resource. This restoration would target adult and older juvenile life stages. Adult and older juvenile sea turtles are extremely valuable to the population as they are either already reproductively active or have a high likelihood of surviving to reproduce (Crouse et al. 1987; Heppell et al. 2005).

Source: *NOAA-NMFS, Southeast Fisheries Science Center.*

Figure 5.5-6. A loggerhead sea turtle escapes from a trawl equipped with a turtle excluder device (TED) during TED testing. TEDs are used to reduce bycatch of sea turtles in trawl nets.

In addition, restoration could include direct response efforts through enhancement of sea turtle stranding response and mortality investigation. This enhancement will result in faster response times for live and dead stranded sea turtles, a significantly enhanced assessment effort of mortality sources, and more rapid management response to unusual stranding events such that mortality sources can be addressed more rapidly and solutions implemented wherever possible.

Restoration will benefit sea turtles by improving nesting habitat to increase successful nesting, successful emergence of hatchlings from the nest, and survival from the nest to the water. As necessary (and consistent with recovery plans), nests would be detected and eggs protected from human impacts and predators to enhance survival of eggs and hatchlings. Artificial light sources would be reduced, which in turn would reduce hatchling disorientation (see Figure 5.5-7). Sea turtle reproduction

completely depends on the availability of appropriate nesting habitat; therefore, preserving the integrity and suitability of nesting beaches and reducing anthropogenic threats are fundamental to supporting the survival of these unique and highly valued species (Witherington 1999).

Source: Sea Turtle Conservancy.

Figure 5.5-7. Successful efforts to reduce artificial beachfront lighting. Left: "before" condition. Right: "after" photo shows lights visible from the beach that were retrofitted and/or replaced.

The restoration approaches associated with this restoration type include "Reduce sea turtle bycatch in commercial fisheries through identification and implementation of conservation measures," "Reduce sea turtle bycatch in commercial fisheries through enhanced training and outreach to the fishing community," "Enhance sea turtle hatchling productivity and restore and conserve nesting beach habitat," "Reduce sea turtle bycatch in recreational fisheries through development and implementation of conservation measures," "Reduce sea turtle bycatch in commercial fisheries through enhanced state enforcement effort to improve compliance with existing requirements," "Increase sea turtle survival through enhanced mortality investigation and early detection of and response to anthropogenic threats and emergency events," "Reduce injury and mortality of sea turtles from vessel strikes," and "Reduce mortality among Highly Migratory Species and other oceanic fishes" (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation).

The Trustees initiated sea turtle restoration through several Early Restoration projects to address identified needs for a variety of species and life stages

Restoration Approaches

- Reduce sea turtle bycatch in commercial fisheries through identification and implementation of conservation measures
- Reduce sea turtle bycatch in commercial fisheries through enhanced training and outreach to the fishing community
- Enhance sea turtle hatchling productivity and restore and conserve nesting beach habitat
- Reduce sea turtle bycatch in recreational fisheries through development and implementation of conservation measures
- Reduce sea turtle bycatch in commercial fisheries through enhanced state enforcement effort to improve compliance with existing requirements
- Increase sea turtle survival through enhanced mortality investigation and early detection of and response to anthropogenic threats and emergency events
- Reduce injury and mortality of sea turtles from vessel strikes
- Reduce mortality among Highly Migratory Species and other oceanic fishes

of sea turtles, consistent with recovery plans for sea turtles in the Gulf of Mexico (Appendix 5.B, Early Restoration). In Phase II, the project Improving Habitat Injured by Spill Response: Restoring the Night Sky was approved to reduce artificial lighting impacts on nesting habitat for loggerhead sea turtles. In Phase IV, the Sea Turtle Early Restoration project was approved and included four components that will be implemented over a 10-year period: 1) Kemp's Ridley Sea Turtle Nest Detection and Enhancement, 2) Enhancement of the Sea Turtle Stranding and Salvage Network and Development of an Emergency Response Program, 3) Gulf of Mexico Shrimp Trawl Bycatch Reduction, and 4) Texas Enhanced Fisheries Bycatch Enforcement. In Phase IV, benefits also accrued to sea turtles from the Pelagic Longline Bycatch Reduction Project. These restoration approaches, along with the restoration conducted under Early Restoration, are expected to fully address all aspects of the sea turtle injury.

5.5.10.3 Planning and Implementation Considerations

The National Marine Fisheries Service (NMFS) and USFWS share federal jurisdiction for the conservation and recovery of sea turtles. In accordance with the 1977 Memorandum of Understanding, USFWS has lead responsibility on the nesting beaches and NMFS has lead responsibility in the marine environment. The Sea Turtle Stranding and Salvage Network (STSSN) operates within the shared jurisdictional responsibility between the two agencies. NMFS has the primary coordination role for the STSSN to ensure that data are collected in a manner sufficient for conservation management, monitoring, and research purposes and to facilitate their use to meet recovery objectives.

Restoration projects will be implemented throughout the Gulf and in nearshore and offshore waters. In addition, restoration could include work outside of the northern Gulf (e.g., nesting beaches in Mexico). Restoration could also include working with U.S. fisheries operating outside the northern Gulf, or international fisheries, to reduce bycatch on a broader geographic scale. This restoration will require careful consideration of recovery plans, existing laws, and international agreements and close collaboration with state and federal conservation managers to ensure restoration success.

The Trustees will need to coordinate and collaborate with stakeholders and state resource coordinators and managers to implement sea turtle restoration. Coordination with private landowners may be needed for implementing restoration projects on nesting beaches. Coordination with fishers will be needed to implement new conservation strategies to reduce sea turtle bycatch. Effective coordination can help ensure that restoration projects address the key threats and conservation needs within a particular geographic area and can also improve consistency across restoration projects and with sea turtle ESA recovery plans.

Although many of the restoration approaches are based on recovery actions identified as part of sea turtle ESA recovery plans, implementation will allow for enhanced or expanded efforts and may require a phased approach. This phased approach would include data collection to inform the best methods and to ensure restoration success, followed by larger-scale implementation of those preferred methods. Some of the data collection efforts could focus on improving our understanding of current threats in the context of status and trends of sea turtle populations in the Gulf of Mexico, which could inform target species and geographies for restoration. The Trustees discuss specific considerations for each restoration approach in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.10.4 Monitoring

Given the protected status of the five sea turtle species in the Gulf of Mexico affected by the spill, the extent of the injury to them, and the scientific data available to support restoration efforts, a robust, adaptive management approach may be needed to ensure that restoration projects are successful in helping these species recover from injuries associated with the spill (see Figure 5.5-8 and Figure 5.5-9. This monitoring and adaptive management includes performance monitoring to track restoration projects and to determine if projects, individually and collectively, are meeting restoration objectives. It also includes additional monitoring and scientific support to address critical information gaps and help inform the temporal and spatial implementation of future restoration projects.

Source: *NOAA.*

Figure 5.5-8. Measuring a loggerhead turtle captured at sea.

Source: NOAA.

Figure 5.5-9. A loggerhead turtle is returned to the sea following capture and attachment of a satellite tag.

Performance monitoring will depend on the restoration project objective. Performance monitoring for bycatch reduction projects may rely on enhancement of fishery observer programs and use of electronic monitoring and surveys and data collection during project implementation. Performance monitoring parameters for these projects could include changes in compliance rates with existing bycatch reduction approaches, number of bycaught sea turtles observed at piers or identified through commercial fisheries observer programs, number of TEDs properly installed, and number of fishers participating in education and outreach programs. For projects aimed at improving sea turtle nesting success, performance monitoring parameters could include number of successful nesting attempts, hatchling emergence success, hatchling survival from nest to the water, and number of nests protected.

Monitoring and scientific support are critical to better understanding where and when restoration approaches are most likely to be successful and may inform restoration planning, implementation, and evaluation. Monitoring and scientific support at the resource level may include additional surveys of sea turtles at-sea during their oceanic and neritic life stages, enhanced shore-based monitoring of sea turtle nesting activities, and enhanced integration of available data, including development of a near real-time geospatial database to integrate all sea turtle data with oceanographic and threat information. Some information currently exists on sea turtle population structure, spatiotemporal distribution, life history parameters, migration patterns, and habitat use during their long oceanic and neritic life stages, but there are temporal and spatial gaps in these data sets (NMFS & FWS 2008; NMFS et al. 2011). A better understanding of the spatiotemporal overlap between the distribution of sea turtles at various life stages and recreational and commercial fishing effort would help maximize the benefits of bycatch reduction projects by identifying areas and fisheries of greatest bycatch concern (NMFS & FWS 2008; NMFS et al. 2011). Additional information on nesting success, hatchling emergence success, and survival from nest to water may also be needed to inform the planning, implementation, and evaluation of projects aimed at reducing nesting threats (NMFS & FWS 2008; NMFS et al. 2011). Information on sea

turtle spatiotemporal distribution, migration patterns, life history parameters, and habitat use is critical for interpreting population trends, improving sea turtle population models, and helping assess progress toward recovery goals. Furthermore, monitoring and scientific support will be important for evaluating the effects of restoration actions on sea turtle recovery from injuries associated with the spill.

To allow the Trustees to perform the analyses needed to adaptively manage sea turtle restoration projects and identify data gaps, sea turtle data (e.g., spatiotemporal distribution, movements, and habitats) must be integrated with oceanographic information, anthropogenic threats, and remotely sensed data in a common location and useable format. A near real-time sea turtle geospatial database would provide updated, accessible information to support restoration decision-making and evaluation of the effects of the entire portfolio of sea turtle restoration projects and would also provide a central repository for information.

5.5.11 Restoration Type: Marine Mammals

This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

Cetaceans in the Gulf of Mexico inhabit a broad range of habitats, from offshore (including continental shelf) to coastal waters and bays, sounds, and estuaries. All marine mammals are federally protected under the Marine Mammal Protection Act (MMPA) of 1972, through which Congress declared marine mammals to be resources of great international significance (aesthetic, recreational, and economic) and so should be protected and measures taken to replenish species or stocks to the greatest extent feasible commensurate with sound policies of resource management. The MMPA's implementing regulations prohibit the hunting, killing, capturing, collecting, or harassment of marine mammals or the attempt of any of these, with limited exceptions. Sperm whales are the only endangered cetacean species that inhabits the Gulf of Mexico and has additional protection under ESA.

Key Aspects of the Injury That Informed Restoration Planning

- The *Deepwater Horizon* oil spill resulted in the contamination of prime marine mammal habitat in the nearshore and offshore waters of the northern Gulf of Mexico. After inhaling, ingesting, aspirating, and potentially absorbing oil components, animals suffered from physical damage and toxic effects to a variety of organs and tissues, including lung disease, adrenal disease, poor body condition, immunosuppression, and a suite of other adverse health effects.

- Animals that succumbed to these adverse health effects contributed to the largest and longest marine mammal unusual mortality event (UME) on record in the northern Gulf of Mexico. The dead, stranded dolphins in the UME included near-term fetuses from failed pregnancies.

- Nearly all of the marine mammals stocks that overlap with the *Deepwater Horizon* oil spill footprint have demonstrable, quantifiable injuries. The remaining stocks were also likely injured, but there is not enough information to make a determination at this time.

- The Barataria Bay and Mississippi Sound bottlenose dolphin stocks were two of the most severely injured populations, with a 52 percent and 62 percent maximum reduction in their population sizes, respectively. Because they are long-lived animals, give birth to only one calf

every few years, and are slow to reach reproductive maturity, it will take many decades for recovery without any active restoration. Smaller percentages of the oceanic stocks were exposed to *Deepwater Horizon* oil. However, they still experienced increased mortality (as high as 17 percent), reproductive failure (as high as 22 percent), and adverse health effects (as high as 18 percent).

- Shelf and oceanic stocks were generally less affected than BSE stocks. Of these stocks, Bryde's whales were the most affected, with 17 percent (confidence interval of 7 percent to 24 percent) excess mortality, 22 percent (confidence interval of 10 percent to 31 percent) excess failed pregnancies, and an 18 percent (confidence interval of 7 percent to 28 percent) higher likelihood of having adverse health effects (MMIQT 2015).

See Chapter 4 (Section 4.9, Marine Mammals) for a more detailed description of these injuries and the Trustees' injury assessment.

The diverse number of species and geographic range of marine mammals affected by the spill is unprecedented (see text box above that summarizes key aspects of the injury assessment that informed restoration planning; see Figure 5.5-10). These species are long-lived and slow to reproduce and have an important role in the food web as apex predators. All these factors affect the recovery of marine mammals and necessitate a portfolio of restoration approaches that collectively address all stocks, species, and geographies that were injured by the spill. This portfolio includes ecological benefits achieved through habitat restoration (as described in Section 5.5.2, Restoration Type: Wetlands, Coastal, and Nearshore Habitats), addressing direct sources of mortality and morbidity; spatial planning; and robust monitoring of populations, health statuses, and trends.

Source: *NOAA.*

Figure 5.5-10. Sperm whales, bottlenose dolphins, and Bryde's whales in Gulf of Mexico waters: some of the marine mammal species affected by the *Deepwater Horizon* oil spill.

5.5.11.1 Goals of the Restoration Type

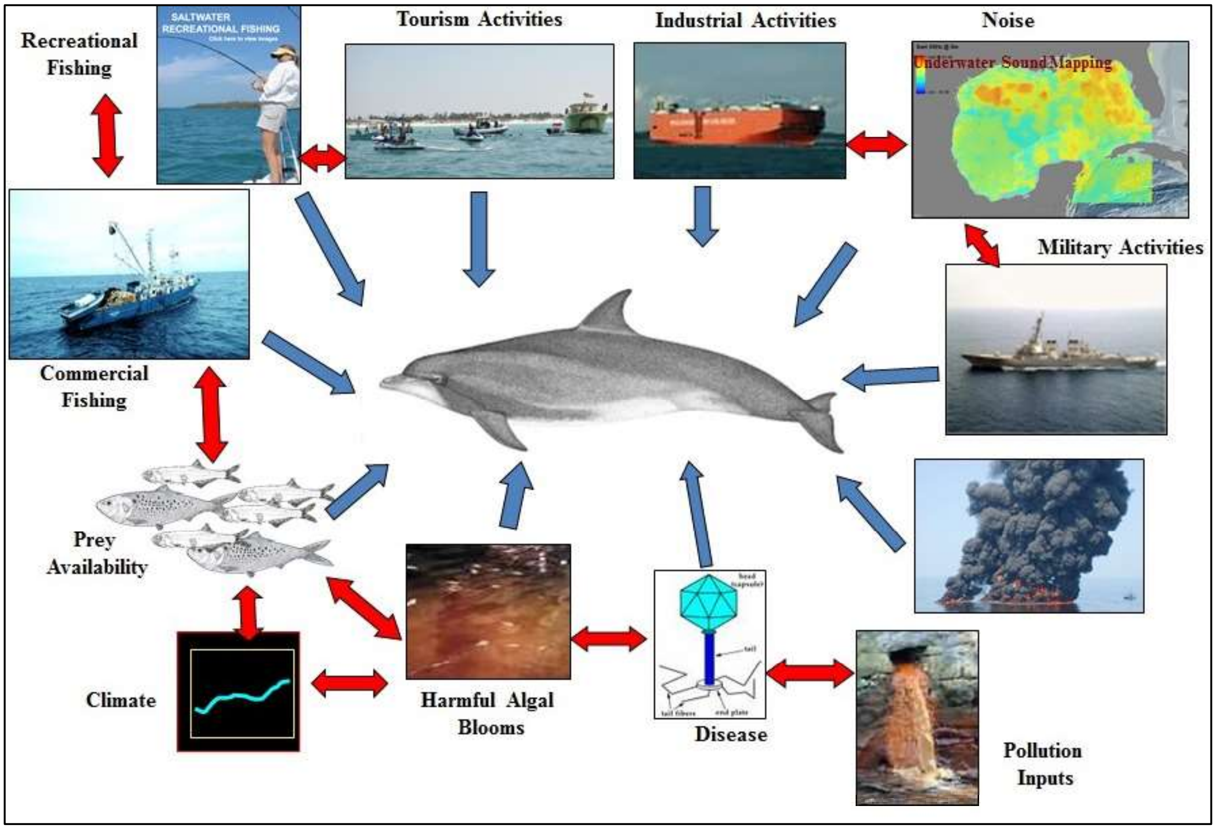
For injuries to marine mammals resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Implement an integrated portfolio of restoration approaches to restore injured BSE, coastal, shelf, and oceanic marine mammals across the diverse habitats and geographic ranges they occupy.

- Identify and implement restoration activities that mitigate key stressors to support resilient populations by collecting and using monitoring information such as population and health assessments and spatiotemporal distribution information.
- Identify and implement actions that will account for ecological needs of the stocks; improve resilience to natural stressors; and address direct human-caused threats such as bycatch in commercial fisheries, vessel collisions, noise, industrial activities, illegal feeding and harassment, and hook-and-line fishery interactions.

5.5.11.2 Strategy to Achieve Goals

This restoration type will address stressors that cause mortality (death) and morbidity (illness that reduces fitness) to marine mammal stocks. Gulf of Mexico cetaceans are subject to many stressors such as pollution, physical hazards resulting from interaction with humans, industrialization, habitat loss and degradation, and fishery bycatch. Considering all the injured stocks of marine mammals throughout their geographic ranges will be important for restoration. For example, restoration could be specifically targeted to ensure recovery of or reduce harm to injured estuarine bottlenose dolphin stocks due to their site-fidelity, smaller stock sizes, and significant injury from the incident. Restoration should also target offshore and shelf species, especially given the endangered status of the sperm whale. Therefore, the Trustees propose that restoration will take place in four Gulf states (Florida, Alabama, Mississippi, and Louisiana) and in coastal and offshore waters to provide benefits for all injured species. In doing so, restoration projects will be focused to support resilient marine mammal populations, reduce further harm or impacts, and complement existing management priorities. To most effectively address the extent of injury to marine mammals across the diverse geographic range they occupy, a combination of several approaches will need to be implemented to provide a portfolio of restoration approaches that collectively will allow populations to recover more quickly or reduce further harm from acute and chronic injuries sustained by the *Deepwater Horizon* incident. This restoration portfolio includes restoration approaches designed to decrease and mitigate interactions with commercial and recreational fishing gear, characterize and reduce impacts from noise, reduce harm from industrial activities, reduce illegal feeding and harassment, and increase understanding of causes of marine mammal illness and death. Thus the portfolio will enable early detection of and intervention in anthropogenic and natural threats, such as disease outbreaks or harmful algal blooms (e.g., Litz et al. 2014) (see Figure 5.5-11). The restoration approaches that address mortality and morbidity are based on existing management activities that are established under the MMPA, ESA and priorities for marine mammal conservation.



Source: *NOAA.*

Figure 5.5-11. Factors affecting marine mammal population health and resiliency in the Gulf of Mexico.

The restoration portfolio for marine mammals will also include robust monitoring and scientific support for an adaptive management approach to restoration planning and implementation. Adaptive management is necessary because of the limited experience implementing restoration for marine mammals at this scale and limited scientific data on impacts for these species. A strong emphasis on data collection and monitoring for marine mammals will inform the public and Trustees on the state of the resource and iteratively drive restoration toward effective projects and subsequent recovery from injuries associated with the *Deepwater Horizon* incident.

The restoration approaches associated with this restoration type include “Reduce commercial fishery bycatch through collaborative partnerships”; “Reduce injury and mortality of bottlenose dolphins from hook and line fishing gear”; “Increase marine mammal survival through better understanding of causes of illness and death and early detection and intervention of anthropogenic and natural threats”; “Measurement of noise to improve knowledge and reduce impacts of anthropogenic noise on marine mammals”; “Reduce injury, harm, and mortality to bottlenose dolphins by reducing illegal feeding and harassment activities”; “Reduce marine mammal takes through enhanced state enforcement related to the Marine Mammal Protection Act”; “Reduce injury and mortality of marine mammals from vessel collisions”; and “Protect and conserve marine, coastal, estuarine, and riparian habitats” (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation).

These restoration approaches are applicable to all estuarine, coastal, and/or oceanic marine mammal stocks, but will be tailored accordingly to address the key needs for each stock and to ensure restoration effectiveness. To complement and inform the restoration approaches, marine mammal experts have identified the following as the overarching monitoring needed to address critical uncertainties in resource data to further inform restoration planning, implementation, and evaluation for adaptive management: 1) population characterization and health assessments, 2) identification and prioritization of stressors on marine mammals, and 3) enhancement and expansion of fishery observer programs and marine mammal stranding networks.

Restoration Approaches

- Reduce commercial fishery bycatch through collaborative partnerships
- Reduce injury and mortality of bottlenose dolphins from hook and line fishing gear
- Increase marine mammal survival through better understanding of causes of illness and death and early detection and intervention of anthropogenic and natural threats
- Measurement of noise to improve knowledge and reduce impacts of anthropogenic noise on marine mammals
- Reduce injury, harm, and mortality to bottlenose dolphins by reducing illegal feeding and harassment activities
- Reduce marine mammal takes through enhanced state enforcement related to the Marine Mammal Protection Act
- Reduce injury and mortality of marine mammals from vessel collisions
- Protect and conserve marine, coastal, estuarine, and riparian habitats

5.5.11.3 Planning and Implementation Considerations

NMFS has jurisdiction over all cetacean species in the Gulf of Mexico. Restoration projects will be implemented for estuarine, coastal, shelf, and offshore species of cetaceans throughout their geographic ranges in the Gulf of Mexico. In addition, work could occur outside of the Gulf such as that needed to reduce noise impacts or vessel collisions to oceanic marine mammals. Any work outside the Gulf would require close collaboration with the international community and other federal managers. This restoration type will target the most important needs in each stock and geographic area to enhance management activities that are already supported, partially supported, or require support and, as part of the approach, an integrated database will be compiled for use for adaptive management. This integrated database will allow greater consistency in the ability to use information collected and better respond to marine mammal threats, supporting restoration needs.

Because scientific data are lacking on many species of cetaceans in the Gulf, restoration implementation will require a phased approach that includes data collection and monitoring. Data collected on marine mammals varies by stock and topic. The current federal resources to support these data collection needs are inconsistent, especially to support the evaluation of impacts of multiple threats and cumulative impacts or the study of stranded marine mammals. Critical needs for identifying priority threats include population monitoring, health assessments, and spatial planning. Furthermore, there are significant gaps in understanding the distribution and abundance of marine mammals in the Gulf. In some cases enough information exists to identify the threat (e.g., bycatch, illegal feeding, noise, or natural stressors), but specific mitigation measure to reduce that threat are less understood. For example, bycatch in fisheries is well-documented as a threat, but mechanisms to reduce threats are less understood. Using a phased approach will enable the data collected to inform restoration decision-making and allow the Trustees to assess the effectiveness of restoration.

The Trustees will need to coordinate and collaborate with state resource managers, other federal agencies, and stakeholders to implement the restoration approaches. This coordination will help identify, develop, and implement effective solutions to maximize marine mammal benefits. Some of the restoration approaches depend on participation and voluntary compliance, which introduce uncertainty to restoration outcomes. Providing incentives, establishing agreements, and providing education and outreach can reduce these uncertainties. In addition, these activities could also benefit from coordination with sea turtle and fish restoration approaches that have similar uncertainties and potential mechanisms for reducing them. Coordination with fish restoration and sea turtle restoration could create efficiencies with education, training, and outside coordination by considering benefits and risks of the activities across all three resources (fish, sea turtles, and marine mammals) collectively rather than singly.

Although the scale of restoration needed is unprecedented, many of the restoration approaches are routinely conducted across the United States as part of existing management activities to help conserve, protect, and recover marine mammals. The Trustees discuss specific considerations for each restoration approach in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.11.4 Monitoring

Given the protected status of marine mammals in the Gulf of Mexico, the extent of their injuries, and the limited scientific data available to inform restoration efforts, robust monitoring and adaptive management is required to ensure restoration is effective at recovering marine mammal stocks from injury. Monitoring and scientific support for adaptive management of restoration approaches would include population and health assessments (see Figure 5.5-12), including live capture-and-release and stranding data, development of spatial planning information management tools (e.g., GIS maps, databases, and statistical models), and identification of stressors and opportunities to inform restoration implementation and adaptive management. This monitoring, analysis, and science support will apply to all injured species in all habitats from estuarine and coastal to shelf and offshore.

Source: *NOAA.*

Figure 5.5-12. Left: conducting live health assessment captures of bottlenose dolphins to monitor population health. Right: using satellite telemetry to assist in better characterizing stock structure.

Specific information from targeted monitoring and scientific support may be required to further Trustee adaptive management and resolve critical data gaps to inform restoration for each injured stock.

Specifically, information is needed to 1) better characterize stock structure; 2) monitor population health; 3) understand and map spatiotemporal distributions of marine mammals; 4) identify, map, and rank the relative influence of anthropogenic stressors by geographic area and stock; and 5) prioritize those stocks in need of additional restoration, adaptive management, or conservation actions using spatial planning tools. Monitoring and scientific support activities may include additional vessel or aerial surveys, live capture-release methods, stranding data, remote biopsy, and/or passive acoustics (see Figure 5.5-13). Although some data sets on the seasonal and spatial occurrence of marine mammals and modeling of habitat preference and spatial distribution are available, much of the available data are outdated and contain significant gaps in space and time that limit their utility (MMC 2011; Vollmer & Rosel 2013; Waring et al. 2015). Updated information with finer spatiotemporal resolution is needed to develop and distribute more accurate spatial planning and decision support tools to further inform restoration, define restoration activities, and monitor the effectiveness of all the restoration activities. Moreover, because animal densities can vary significantly across geographic areas and time, particularly for large mobile predators, the ability to accurately assess the impact of restoration would be improved by these additional data (Waring et al. 2015). There could be efficiencies in developing spatial planning tools by coordinating with other efforts such as sea turtle geospatial planning.

Source: *NOAA.*

Figure 5.5-13. Platforms and approaches for estimating marine mammal population abundance include large vessel surveys for oceanic marine mammal stocks and species, aerial surveys for coastal and shelf stocks and species, and photo-identification studies for estuarine stocks.

Although there are substantial gaps in our understanding, several well-known and documented threats to marine mammals in the Gulf of Mexico exist, including human threats from bycatch in fishing gear, illegal feeding, vessel collisions and noise, as well as natural stressors such as disease outbreaks and harmful algal blooms. Many of the restoration approaches address these threats and are based on established approaches that have been used elsewhere to address similar threats. However, the approaches here will be implemented on a larger scale than ever before and require robust monitoring and adaptive management to ensure the success and tracking of projects, better understand critical data needs, and inform future restoration implementation and outcomes to aid stocks in recovering from their injuries. Monitoring and scientific support for marine mammals may also identify and inform approaches to address interactions between marine mammals and other restoration projects.

Monitoring and adaptive management of some of the marine mammal restoration approaches such as bycatch reduction will rely on data collected from expanded and enhanced marine mammal fishery observer coverage and marine mammal stranding network programs (Byrd et al. 2008; Friedlaender et al. 2001; NMFS & NOAA 2011) (see Figure 5.5-14). The use of these existing programs to support data

collection would be coordinated with appropriate state and federal agencies. The data collected from these programs can inform performance measures and critical uncertainties, including the magnitude of marine mammal bycatch, interaction rates with fishing gear and characterization of these interactions, and stranding causes and rates for BSE bottlenose dolphins, among other parameters. For example, marine mammal stranding data for nearshore stocks are used as an indicator and diagnosis of fishery bycatch in lieu of limited or no fishery observer programs, and enhancing the stranding network's ability to detect and respond to strandings could improve detection of potential changes in the numbers of fishery interactions and where they are occurring (e.g., 79 FR 21701, April 17, 2014; 80 FR 6925, February 9, 2015; Byrd et al. 2014; Byrd et al. 2008; Friedlaender et al. 2001 ; Horstman et al. 2011).

Source: *NOAA.*

Figure 5.5-14. Fishery observer collecting pertinent data; marine mammal stranding data collection.

Performance monitoring will be conducted to track restoration approaches, address uncertainties, inform adaptive management, and determine if projects, individually and together, are meeting restoration goals to restore injured marine mammal stocks and mitigate key stressors to support resilient populations. Performance monitoring and tracking at the scale of the individual project will be used for evaluating and determining the need for any corrective actions to maximize benefits for marine mammals. Performance monitoring may measure parameters such as participation in and compliance with incentive-based programs and state laws, public perception and effectiveness of outreach and education materials, size and response times for stranding programs, stranding rates and locations, indications of fishery interactions on stranded animals, and others. Data may be collated and aggregated from existing and/or enhanced fishery observer programs, state enforcement programs, stranding programs, or project-specific data collection (e.g., social science surveys). The use of enhanced observer coverage and project-specific data collection would be coordinated with appropriate state and federal agencies. Additional monitoring and scientific support beyond individual project performance monitoring may be needed to address uncertainties of the restoration projects, individually and together, and aid in adaptive management at the project and resource level for restoration planning, implementation, and evaluation.

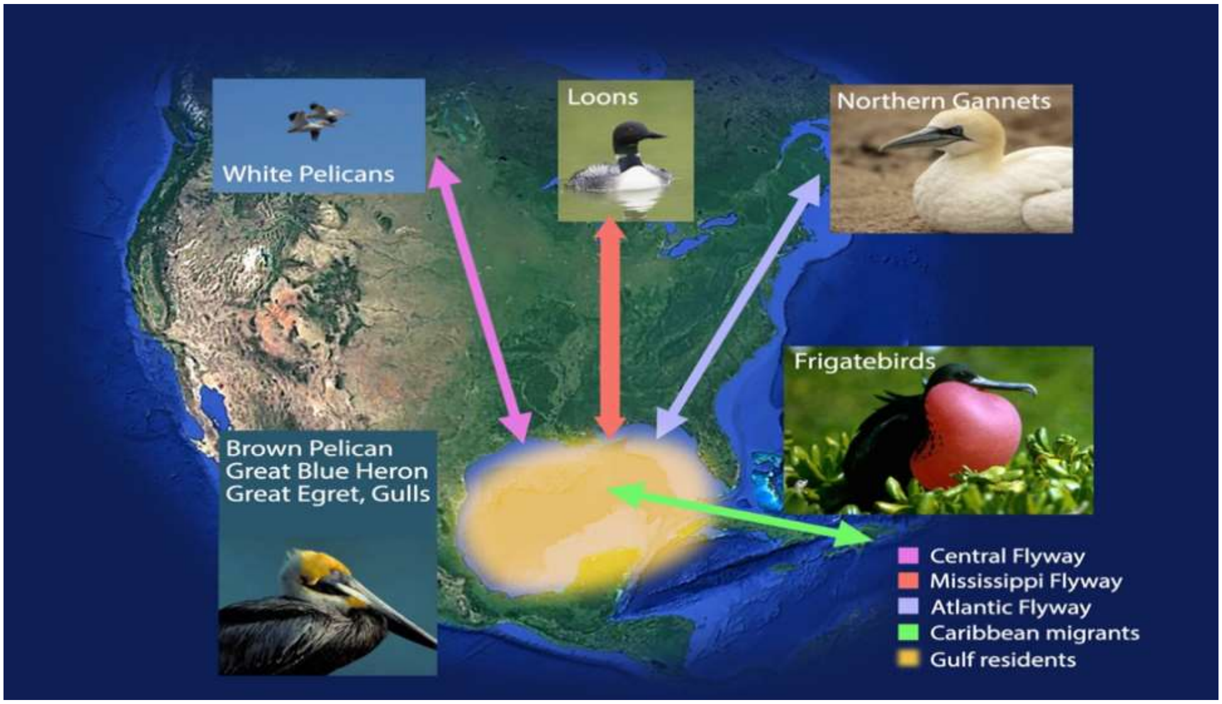
5.5.12 Restoration Type: Birds

This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

The northern Gulf of Mexico consists of a variety of habitats that support a diverse and abundant assemblage of birds.

Over 120 species of birds occur in waters and wetlands of the northern Gulf of Mexico for at least a portion of their lives.

Nearly 300 species use either the coast itself or coastal upland habitats directly adjacent to the Gulf, such as coastal plain and cheniers. Depending on the species, birds use the northern Gulf of Mexico for their entire life cycle, as a breeding ground, as a migratory stopover as they continue farther north or south, or as as a wintering ground following their fall migration. The northern Gulf of Mexico intersects with three of the four major migration flyways in North America, including the central, Mississippi, and Atlantic flyways. The Caribbean represents the closest breeding area of certain bird species affected by the spill, which frequent the Gulf of Mexico to feed (see Figure 5.5-15).



Source: *Kate Sweeney for NOAA; bird photographs by USFWS.*

Figure 5.5-15. Birds that occur in the area of the north Gulf of Mexico affected by the *Deepwater Horizon* oil spill include those that breed in areas farther north and migrate to the Gulf for the nonbreeding period, those that occur in the Gulf year-round, and those that use the Gulf as a migratory stopover. Species listed are examples within each category.

Key Aspects of the Injury That Informed Restoration Planning

- At least 93 species of birds, including both resident and migratory species, across all five Gulf Coast states, were exposed to *Deepwater Horizon* oil in multiple northern Gulf of Mexico habitats, including open water, islands, beaches, bays, and marshes. Laboratory studies showed that exposure to *Deepwater Horizon* oil leads to injuries, including feather damage, abnormal blood attributes, organ damage, and death.
- Trustee scientists quantified that between 51,600 and 84,500 birds died as a result of the

Deepwater Horizon oil spill, although significant mortality occurred that was unquantified. Further, of those quantified dead birds, the breeding-age adults would have produced an estimated 4,600 to 17,900 fledglings. Due to a number of factors that likely led to underestimation of mortality, true mortality is likely closer to the upper ranges than the lower. The magnitude of the injury and the number of species affected makes the *Deepwater Horizon* spill an unprecedented human-caused injury to birds of the region.

See Chapter 4 (Section 4.7, Birds) for a more detailed description of these injuries and the Trustees' injury assessment.

Birds, including those inhabiting the northern Gulf of Mexico, play vital roles in ecosystems, serving as both predators and prey in a large number of food webs. In addition to their vital role in ecosystems and resonance with the general public, birds have significant direct economic contributions. For example, both consumptive (migratory bird hunting) and nonconsumptive (bird watching) activities generate billions of dollars annually in economic activity (FWS 2013).

A vast array of bird species in all five Gulf Coast states were exposed to *Deepwater Horizon* oil in a variety of northern Gulf of Mexico habitats, including open water, islands, dunes and beaches, bays, and marshes (see text box above that summarizes key aspects of the injury assessment that informed restoration planning).

Restoration for birds will need to address the diversity of species injured where restoration would provide the greatest benefits within their geographic ranges. The Trustees will implement a portfolio of restoration approaches that includes coastal habitat restoration being implemented under the Wetlands, Coastal, and Nearshore Habitats restoration type (Section 5.5.2) and additional actions that specifically address opportunities to provide services to injured bird species. Implementing a portfolio of restoration approaches provides a more robust, comprehensive solution to addressing bird injuries.

5.5.12.1 Goals of the Restoration Type

For injuries to birds resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Restore lost birds by facilitating additional production and/or reduced mortality of injured bird species.
- Restore or protect habitats on which injured birds rely.
- Restore injured birds by species where actions would provide the greatest benefits within geographic ranges that include the Gulf of Mexico.

5.5.12.2 Strategy to Achieve Goals

This restoration type will enhance bird reproductive success and survival. Although bird species using the Gulf of Mexico are varied and diverse, many face similar threats to reproduction and survival, including human disturbance, habitat degradation or alteration, high predation rates from introduced and invasive native predators, disease, pollution, and climate change. Others experience additional, unique threats such as becoming fisheries bycatch and collisions with at-sea structures. Mitigating these threats would address injuries to birds resulting from the spill. Restoration that addresses threats to

birds will include addressing habitat loss and alteration, including managing bird predators and detrimental changes to bird habitat vegetative structure. The Trustees would also restore birds injured by the *Deepwater Horizon* oil spill by addressing direct human threats to target bird species.

The large number of individuals, diversity of species, broad geographic range, and specific life history requirements of birds injured necessitates a portfolio of restoration approaches to adequately address injuries. Restoration would therefore take place in areas across the Gulf of Mexico and in non-Gulf areas where injured bird species migrate to and/or breed, potentially including the upper Midwest, Canada, northwest Atlantic, and Caribbean. The restoration approaches for birds include “Restore and conserve bird nesting and foraging habitat”; “Create, restore, and enhance coastal wetlands”; “Restore and enhance dunes and beaches”; “Create, restore, and enhance barrier and coastal islands and headlands”; “Restore and enhance submerged aquatic vegetation”; “Protect and conserve marine, coastal, estuarine, and riparian habitats”; “Establish or re-establish breeding colonies”; and “Preventing incidental bird mortality” (as described in Appendix 5.D, Restoration Approaches and OPA Evaluation).

Restoration Approaches

- Restore and conserve bird nesting and foraging habitat
- Create, restore, and enhance coastal wetlands
- Restore and enhance dunes and beaches
- Create, restore, and enhance barrier and coastal islands and headlands
- Restore and enhance submerged aquatic vegetation
- Protect and conserve marine, coastal, estuarine, and riparian habitats
- Establish or re-establish breeding colonies
- Preventing incidental bird mortality

The Trustees initiated bird restoration under Early Restoration (Appendix 5.B, Early Restoration). In Phase II, projects in Florida, Alabama, and Mississippi enhanced beach nesting habitat. In Phase III, barrier island restoration in Louisiana targeted brown pelican, tern, skimmer, and gull nesting habitat. In Phase IV, projects enhanced and created rookery islands in Texas and enhanced nesting opportunities for fish-eating raptors in Alabama. Although these Early Restoration projects contribute to restoring birds injured by the *Deepwater Horizon* oil spill, they do not fully restore all the birds that were injured. However, building on the work initiated in Early Restoration, this restoration type, in conjunction with habitat restoration conducted for Wetlands, Coastal, and Nearshore Habitat restoration type, will restore birds injured by the *Deepwater Horizon* oil spill.

5.5.12.3 Planning and Implementation Considerations

The restoration approaches are well established for birds. However, considering the broad geographic range over which restoration could occur, the Trustees will need to coordinate and collaborate with local, regional, and/or governmental stakeholders. They will also need to consider the specific bird species and locations to prioritize approaches for implementation. The Trustees will prioritize the restoration of important bird habitats in the Gulf of Mexico upon which many bird species depend for nesting and wintering habitat. Combining restoration approaches will be considered to maximize success. Some of these approaches could also require phased implementation to help ensure site- or species-specific success.

Many of these approaches have been used extensively to increase bird production, health, and survival. Common implementation considerations include the quality of the target habitat and its ability to provide services to birds in the context of local bird population dynamics and needs. Other restoration planning and implementation considerations for the Trustees include long-term protection of restoration investments, coordination with the local community, effects on other resources, engineering and design needs, and the presence of abandoned or current infrastructure within project areas. Because of the variety of restoration approaches, the Trustees discuss specific considerations for each restoration approach in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.12.4 Monitoring

Performance monitoring will be conducted to evaluate the effectiveness of restoration actions conducted under bird restoration approaches. Project monitoring plans would contain information on restoration objectives, performance criteria, specific monitoring parameters, methods to be used to collect data, and expected monitoring timelines. Performance monitoring would be designed to determine if projects, individually and together, are meeting overall restoration objectives. Performance monitoring will also assist in determining the need for corrective actions and adaptive management for specific projects, as well as an overall restoration program.

Where applicable, the Trustees anticipate adopting standardized protocols from existing monitoring programs, such as those endorsed by the Gulf of Mexico Bird Monitoring Working Group, related to bird and habitat restoration. Although not all projects will share the same objectives, bird restoration project monitoring will typically use both qualitative and quantitative performance standards to evaluate results. Performance metrics would help evaluate the results of restoration projects. For example, depending on the nature of a particular project, performance monitoring metrics would include, among others, production of target bird species, efforts to reduce mortality, overall project performance, and local factors potentially affecting success. Additionally, public surveys could be employed before, during, and/or after education and outreach work is conducted to evaluate its effectiveness. Performance monitoring plans for wildlife rehabilitation clinics would incorporate records produced by those clinics on the number and species of birds addressed, disposition prior to and after treatment, and bird collection location(s).

Although local or even regional data sets exist, coordinated and standardized data collection at a scale that is flexible and holistic enough to detect novel ecological threats with respect to management triggers (Hutto & Belote 2013; Lyons et al. 2008; Ogden et al. 2014; Salafsky et al. 2008)would assist with effective restoration of this size. The data collection activities would include additional monitoring and scientific support to address several critical information gaps regarding the effects of restoration activities, including regional metapopulation conditions, movement, and interactions; behaviors of target species given chronic and acute threats; site- and regional-specific recruitment survival rates and drivers; how patterns of dispersal affect recruitment; and the potential for species to shift to alternate nesting habitats in response to habitat loss and/or creation. In addition to providing information needed to adaptively manage restoration actions for birds and their habitats, targeted data collection efforts will provide resource managers with improved technical input for management decisions, which could provide further benefit to the species targeted for restoration.

5.5.13 Restoration Type: Mesophotic and Deep Benthic Communities

This restoration type addresses the overall goal of **Replenish and Protect Living Coastal and Marine Resources**

Mesophotic and deep benthic communities include the hard and soft ground habitat as well as associated fish and invertebrates. Rare corals, fish, crabs, and other small animals and microbes live in habitats on the sea floor and are part of the foundation of life and food webs in the northern Gulf of Mexico. Both hard and soft substrate types support a wide variety of marine life, and many mobile animals move back and forth between the soft and hard bottom habitats. No absolute biological or physical lines separate individual benthic habitats and communities that extend from the depths up across the continental shelf to the shoreline. Rather, as with all ecosystems, what appear to be distinct habitats in fact have transition zones, and many biota move between habitats and/or may thrive at the edges of habitat types (Gittings et al. 1992b; Rezak et al. 1990; Weaver et al. 2002).

Coral can be found on isolated patches of hard bottom substrate and are long-lived and slow growing (Roberts et al. 2006) (see Figure 5.5-16). The benthic coral communities provide food, refuge, and reproductive opportunities for multiple species of fish and invertebrates, which are critical for successful fisheries (Bayer 1954; Brooks et al. 2013; Buhl-Mortensen et al. 2010; Cairns & Bayer 2009; Colin 1974, 1976; CSA and TAMU 2001). Corals may also play a unique role in the reproduction of some fish species (Baillon et al. 2012; Etnoyer and Warrenchuck 2007; Reed 2002) and due to their rarity are important reservoirs of biodiversity in the deep sea (Buhl-Mortensen et al. 2010; Cordes et al. 2008). The seafloor biota plays an essential role in the overall productivity in the deep sea as infaunal organisms consume detritus from the water column (Danovaro et al. 2008). In turn, benthic megafaunal organisms higher in the food chain, such as red crabs, prey on the infauna (Danovaro et al. 2008). Mesophotic reef habitats are important for a variety of fish species of commercial and recreational importance (e.g., snapper, grouper, and amberjack) (Weaver et al. 2002).

Source: *Left: Natural Resource Damage Assessment for Deepwater Horizon, Mesophotic Expedition 2014. NOAA/USGS/FSU/Deep Sea Systems International. Right: Schmidt Ocean Institute and Global Explorer ROV at around 1,050 meters depth.*

Figure 5.5-16. Left: Gorgonian octocoral, *Hypnogorgia pendula*, photographed near 80 meters depth on Alabama Alps Reef in 2014. Right: Purple octocoral colony, *Paramuricea sp.* B3 from Atwater Valley 357 in the Northern Gulf of Mexico.

Soft substrate shelf fishes, including spot, croaker, pinfish, seatrout, and others feed extensively on the mesophotic reefs at night (Gittings et al. 1992a; Rezak et al. 1990; Weaver et al. 2002). Also, a number of deep water mesopelagic fishes feed at night on the reefs (Weaver et al. 2002). Reef and bank areas in the northern Gulf of Mexico are important habitat for these fish species. These areas can also include features on the inner continental shelf, such as drowned barrier islands or reef complexes that are relic depositions, which include hard substrate shell or carbonate fragments (Rezak et al. 1990; Wells et al. 2009).

The *Deepwater Horizon* oil spill severely affected mesophotic and deep benthic communities (see text box below that summarizes key aspects of the injury assessment that informed restoration planning). Because deep water and mesophotic corals are long-lived (hundreds of years) and slow growing (Roberts et al. 2006), recovery from impact is slow. Restoration for these resources is complicated by several factors, including a limited understanding of key biological functions, limited experience with restoration at depth or with these species, and remote locations that limit accessibility (Van Dover et al. 2013). Therefore, restoration for these resources will include phased implementation to allow for data collection to address critical uncertainties and adaptive decision-making. Restoration for these resources is also important for the associated resources, including many injured fish species and plankton communities, that will also benefit from this restoration. This restoration is also important for the deep-sea ecosystem, which has important functions including nutrient recycling throughout the offshore Gulf of Mexico.

Key Aspects of the Injury That Informed Restoration Planning

- The Trustees documented a footprint of over 2,000 square kilometers of injury to benthic habitat surrounding the wellhead, within zones of varying impact. In the three inner zones (approximately 1,000 square kilometers), injuries included oil toxicity to organisms, smothering of organisms with drilling muds, reductions in the diversity of sediment-dwelling animals, and mortality and other health impacts to corals. Within the outermost zone (approximately 1,200 square kilometers), the chemical quality of the seafloor habitat was adversely affected by contamination and the food chain was fouled.
- Significant losses to resident corals and fish occurred across approximately 10 square kilometers of mesophotic reef habitat on the continental shelf edge. A larger area, between 8,500 and 45,000 square kilometers, of potential exposure extends beyond and between the areas where the Trustees have quantified injury. Many pelagic resources, such as grouper, use both reef top and surrounding habitats for feeding.

See Chapter 4 (Section 4.5, Benthic Resources) for a more detailed description of these injuries and the Trustees' injury assessment.

5.5.13.1 Goals of the Restoration Type

For injuries to mesophotic and deep benthic communities resulting from the *Deepwater Horizon* oil spill, restoration goals are as follows:

- Restore mesophotic and deep benthic invertebrate and fish abundance and biomass for injured species, focusing on high-density mesophotic and deep water coral sites and other priority hard-ground areas to provide a continuum of healthy habitats from the coast to offshore.
- Actively manage valuable mesophotic and deep-sea communities to protect against multiple threats and provide a framework for monitoring, education, and outreach.
- Improve understanding of mesophotic and deep-sea communities to inform better management and ensure resiliency.

5.5.13.2 Strategy to Achieve Goals

Restoration will provide spatially explicit management[8] to reduce risk of injury to sensitive mesophotic and deep benthic areas. Using management, including protective measures, to reduce local stressors on offshore benthic communities will help maintain ecological integrity and may increase ecosystem resilience (Mumby & Harborne 2010; Selig & Bruno 2010). Despite the depth of these resources, human activities and environmental perturbations threaten the health and resiliency of these communities. These potential threats include oil and gas (CSA 2006; Hourigan et al. 2007), fishing pressure (Kaiser et al. 2000; McCauley et al. 2010; Morgan & Chuenpagdee 2003; Reed et al. 2007), recreational activities (e.g., diving and boating) (Puglise et al. 2009), marine debris (Bauer et al. 2008; Chiappone et al. 2005; Fisher et al. 2014), invasive species, and climate change. Identifying management actions to address these threats can help prevent future injury to mesophotic and deep benthic communities. In addition, considering the slow natural growth rate, low recruitment, and long life of these corals (especially the deep benthic corals), creation of interim habitat and active transplantation of corals would be helpful to accelerate an otherwise protracted natural recovery (Brooke et al. 2006). The general approach would be to strategically place hard substrate in ideal locations and conditions for coral colonization and coral transplant survival. Coral fragments would then be attached to the hard substrate. In the mesophotic zone, the hard substrate could be 3-dimensional structures that would serve as interim habitat and protection for small, plankton-eating reef fish that were also injured during the spill. Many factors influence habitat selection; however, increased structural complexity may positively correlate with species abundance and diversity, although fish diversity results are variable. (Lingo & Szedlmayer 2006; Wells et al. 2009). Restoration that targets high-value reef sites can provide benefits to the reef and associated fish and invertebrate communities.

The restoration approaches associated with this restoration type are "Coral transplantation and placement of hard ground substrate" and "Protect and manage mesophotic and deep benthic coral communities" (see Appendix 5.D, Restoration Approaches and OPA Evaluation). These approaches may be implemented in combination with one another. Moreover, this restoration type requires robust resource-level monitoring and adaptive

Restoration Approaches

- Coral transplantation and placement of hard ground substrate
- Protect and manage mesophotic and deep benthic coral communities

[8] Spatially explicit management refers to management actions at predefined and limited geographic locations within the Gulf of Mexico.

management to address critical uncertainties such as deep water and mesophotic community characteristics, foodweb dynamics, and habitat distribution.

5.5.13.3 Planning and Implementation Considerations

Restoration for mesophotic and deep benthic communities is novel, with few examples of restoration activities at these depths. A phased approach to restoration can inform restoration implementation and maximize benefits of restoration. Results from small-scale design studies in earlier phases would ultimately be used to design larger-scale implementation. Mesophotic and deep benthic coral community characterization (including genetic studies), improved understanding of foodweb dynamics and trophic connectivity, and mapping of existing deep-sea coral sites can better inform restoration efforts. In other examples of hard substrate placement and coral transplantation at these depths, researchers generally recommended that this type of restoration occur alongside protection (Brooke et al. 2006).

Restoration that prevents future injuries to natural resources from known threats can often have more certain outcomes and can be more cost-effective compared to projects that create new resources (Chapman and Julius 2005). Spatially based management provides a framework for addressing key threats to mesophotic and deep benthic communities. Marine protected areas (MPAs) can restrict oil and gas activities, limit types of fishing gear, restrict anchoring, provide education and outreach, and monitor resources and activities depending on the mechanism used to establish the MPA. Using protective measures and management to reduce threats to mesophotic and deep water communities will help maintain ecological integrity and potentially increase ecosystem resilience (Mumby & Harborne 2010; Selig & Bruno 2010). To implement these types of management actions, the Trustees will need to coordinate with multiple stakeholders through the advisory group and public review processes that are a part of establishing protections. Additional implementation considerations are included in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.13.4 Monitoring

Deep benthic and mesophotic communities are recognized for their unique habitat contributions; however, the full suite of ecosystem services provided by these benthic communities and habitats is largely unknown (Fisher et al. 2014), and very few examples of restoration in these systems exist (Van Dover et al. 2013). The restoration approaches for deep benthic and mesophotic communities are novel, but the Trustees are confident that robust monitoring and adaptive management will improve the likelihood of restoration success by addressing critical scientific uncertainties.

Performance monitoring will be conducted to track restoration projects and determine if projects, individually and together, are meeting restoration objectives to restore, protect, and/or improve deep benthic and mesophotic communities. Although project-level objectives will vary, the parameters monitored to assess project performance and/or identify the need for corrective actions may include spatial distribution of benthic habitats, coral community metrics (condition, species composition, and size distribution), benthic community metrics and species composition, fish habitat use, community metrics, and species composition, among other parameters.

Monitoring and scientific support are also needed to improve understanding of 1) fundamental community characteristics; 2) relevant trophic structures and linkages and foodweb dynamics; and 3)

habitat distribution to support the sound design, implementation, and evaluation of restoration projects for mesophotic and deep benthic communities (Cairns & Bayer 2009; Cordes et al. 2008; Fisher et al. 2014; Quattrini et al. 2014; Van Dover et al. 2013). Information on the life histories of species targeted for restoration and the structures of the communities in which they live can improve restoration outcomes. A more in-depth understanding of characteristics such as age structure, growth rates, fecundity, and connectivity will be important for restoration project design and evaluation (Van Dover et al. 2013). In addition, information on foodweb dynamics and trophic structure can help advance our understanding of the potential impacts of food web changes on the structure and function of deep benthic and mesophotic communities. When paired with ongoing project monitoring, this information could be used to further optimize restoration and management actions for targeted resources and improve the characterization of restoration benefits.

5.5.14 Restoration Type: Provide and Enhance Recreational Opportunities

This restoration type addresses the overall goal of **Provide and Enhance Recreational Opportunities**

Gulf of Mexico coastal communities have a deep connection to the natural ecosystem and the benefits it provides. This relationship is exemplified through the diverse regional cultures connected to the natural resources, employment generated from the use of natural resources and tourism opportunities, and recreation that depends on a healthy and productive ecosystem (NOAA 2011). From fishing to sunbathing to bird watching and countless other recreational activities, people depend on Gulf Coast waters and nearshore environments for valuable recreational, cultural, and ecological resources and services. Tourism and recreation are large contributors to the Gulf of Mexico economy.

From the beginning of the spill, recreational use of the Gulf of Mexico's natural resources and habitats were compromised (see text box below that summarizes key aspects of the injury assessment that informed restoration planning).

Key Aspects of the Lost Recreational Use Injury

- Impacts from the *Deepwater Horizon* oil spill, including oiled shorelines and closing of areas to recreation, resulted in losses to the public's use of natural resources for outdoor recreation, such as boating, fishing, and beach going.
- Spill impacts on shoreline activities in the northern Gulf of Mexico started in May 2010 and continued through November 2011.
- Recreational losses due to the spill affected the states of Texas, Louisiana, Mississippi, Alabama, and Florida. Residents throughout the continental United States were included as part of the affected public.
- The Trustees conducted a number of studies to measure the lost recreational value to the public due to the spill. The Trustees estimated that almost 17 million boating, fishing, and other shoreline activity user days were lost throughout the five affected states, with the losses occurring across multiple years. Total recreational use damages due to the spill are estimated to be $693.2 million with uncertainty ranging from $527.6 million and $858.9 million. See

Chapter 4 (Section 4.10, Lost Recreational Use) for a more detailed description of these injuries and the Trustees' injury assessment.

Because these recreational activities depend on healthy natural resources, restoration will include a portfolio of habitat, fisheries-based, recreational infrastructure, and education and outreach approaches to address all types of recreation that were affected. Promoting public engagement in restoration across the restoration types will also be important. This restoration type will be in addition to restoration under the Coastal, Wetlands, and Nearshore Habitat and Water Quality restoration types in order to emphasize education and access to improve recreational opportunities.

5.5.14.1 Goals of Restoration Type

For lost recreational use resulting from the *Deepwater Horizon* oil spill, the restoration goals are as follows:

- Increase recreational opportunities such as fishing, beach going, camping, and boating with a combination of ecological restoration and creation of infrastructure, access, and use opportunities.
- Use education and outreach to promote engagement in restoration and stewardship of natural resources, which could include education programs, social media, and print materials.

5.5.14.2 Strategy to Achieve Goals

This restoration type provides recreational opportunities through infrastructure, access, and education. However, given the important link between healthy natural resources and recreational activities, restoring habitats and improving water quality will also provide human use benefits (see **Error! Reference source not found.**). Improving recreational use of natural resources requires maintaining healthy coastal and marine habitats and resources and increasing the public access to these coastal resources. Recreational opportunities could be improved by acquiring land along the coast, building improved or new infrastructure, and implementing improved navigation for on-water recreation. Education and outreach are paramount to the development of this conservation ethic for natural resources. Encouraging better community and environmental stewardship of Gulf resources contributes to the restoration and conservation of natural resources. Compensating for human use losses by improving the connection between the communities and natural resources through education and cultural appreciation will ultimately strengthen environmental stewardship of resources in the Gulf of Mexico. Restoration actions to enhance the recreational experiences and actions to draw new participants to Gulf recreational activities would compensate for the lost human uses that occurred as a result of the spill. Educational activities would provide additional recreational opportunities that improve the connectedness of the public to the environment. These opportunities will enhance the community's stewardship of coastal Gulf resources that were injured and therefore prevented from being used during the *Deepwater Horizon* oil spill and response activities.

Restoration Approaches

- Enhance public access to natural resources for recreational use
- Enhance recreational experiences
- Promote environmental stewardship, education, and outreach
- Create, restore, and enhance coastal wetlands
- Restore oyster reef habitat
- Create, restore, and enhance barrier and coastal islands and headlands
- Restore and enhance dunes and beaches
- Restore and enhance submerged aquatic vegetation
- Protect and conserve marine, coastal, estuarine, and riparian habitats

The restoration approaches associated with this restoration type are “Enhance public access to natural resources for recreational use”; “Enhance recreational experiences”; “Promote environmental stewardship, education, and outreach”; "Create, restore, and enhance coastal wetlands"; "Restore oyster reef habitat"; "Create, restore, and enhance barrier and coastal islands and headlands"; "Restore and enhance dunes and beaches"; "Restore and enhance submerged aquatic vegetation"; and “Protect and conserve marine, coastal, estuarine, and riparian habitats” (see Appendix 5.D, Restoration Approaches and OPA Evaluation). Habitat and water quality restoration approaches will complement projects that focus on recreational use. These approaches can be implemented either individually or in combinations to increase the overall service flows and benefits to other resources. The Trustees initiated recreational use restoration under the Early Restoration framework with an emphasis on infrastructure and improving fishing access (Appendix 5.B, Early Restoration). In Phase I, Florida implemented a boat ramp project. In Phase III, additional infrastructure, hatchery enhancement, beach enhancement, and artificial reef projects were implemented in Florida, Alabama, Mississippi, Louisiana, and Texas. In Phase IV, additional projects were implemented in Alabama and Mississippi. In Phase V, an agreement in principle has been reached for land acquisition (including recreational infrastructure improvements) in Florida. Although these early restoration projects will restore for some of the lost recreational use, they will not fully address recreational use injury. Therefore, this restoration type will implement additional recreational use projects in Louisiana, Alabama, Mississippi, and Florida.

5.5.14.3 Planning and Implementation Considerations

The restoration approaches for this restoration type are commonly used throughout the Gulf. Project planning and implementation will consider priorities identified in each state. In addition, specific project design must consider the potential impacts to natural resources and include BMPs and other mitigation measures to avoid adversely affecting sensitive natural resources. Construction or enhancement of recreational infrastructure is a broad restoration approach that was extensively used in Early Restoration to compensate for lost recreational use.

These restoration approaches could also be implemented to complement other restoration types such as Wetlands, Coastal, and Nearshore Habitats; Habitat Projects on Federally Managed Lands; and Water Quality (e.g., Stormwater Treatments, Hydrologic Restoration, Reduction of Sedimentation) in order to provide both ecological and recreational use benefits. For example, projects could be selected based on their ability to protect wetlands and other significant coastal habitats or create connections between protected areas that either are used for recreational purposes or are under direct threat of development but are better served as areas for the community to experience natural resources.

Implementation considerations for education and outreach include building on successful public awareness efforts and encouraging hands-on learning experiences with environmental education using novel and interactive educational materials. An example of a successful approach is the Gulf of Mexico Alliance (GOMA), which has made environmental education one of their six priority issue areas in the Gulf to increase regional collaboration in hopes of enhancing the ecological and economic health of the Gulf of Mexico (Gulf of Mexico Alliance 2009). They have formed the Gulf of Mexico Alliance Environmental Education Network to facilitate information sharing at multiple levels, transfer successes among members, and maximize the impact of limited educational resources. These types of examples could be built upon for this restoration plan. Additional implementation considerations are included in Appendix 5.D, Restoration Approaches and OPA Evaluation.

5.5.14.4 Monitoring

For this restoration type, performance monitoring includes construction or implementation monitoring and monitoring of recreational use. Construction or implementation monitoring ensures the recreational use restoration project was implemented according to the project design. For example, a project that builds a boat ramp should include contracting language that includes a post-construction survey to ensure the boat ramp was built to design specifications. After construction, the Trustees may monitor use of the recreational infrastructure or recreational property by employing routine, systematic user counts or user surveys.

5.5.15 Monitoring and Adaptive Management

Sections 5.5.2 through 5.5.14 described each of the restoration types included in Alternative A: Comprehensive Integrated Ecosystem Restoration, including an overview of monitoring for each restoration type. Restoration in this plan occurs within individual restoration types. However, the Trustees recognize these restoration types influence one another and exist within a matrix of restoration and science efforts and programs across the Gulf of Mexico. This section presents an overview of monitoring and adaptive management considering the multiple levels of this plan from individual projects to multiple restoration types. This section includes a discussion of project-specific monitoring, monitoring at the level of the restoration type, and monitoring and adaptive management for the restoration plan.

5.5.15.1 Approach to Monitoring and Adaptive Management

According to the OPA regulations (15 CFR § 990.55), a draft restoration plan includes "a description of monitoring for documenting restoration effectiveness, including performance criteria that will be used to determine the success of restoration or need for interim corrective action." Given the unprecedented temporal, spatial, and funding scales associated with this restoration plan, the Trustees recognize the need for a robust monitoring and adaptive management framework to support restoration. To increase the likelihood of successful restoration, the Trustees will conduct monitoring and evaluation of restoration outcomes, which can provide feedback to inform decision-making for current projects and refine the selection, design, and implementation of future restoration actions (LoSchiavo et al. 2013; Pastorok et al. 1997; Steyer & Llewellyn 2000; Thom 2000; Williams 2011; Williams et al. 2007) (see Appendix 5.E, for a full description of the Trustees' monitoring and adaptive management framework). This monitoring and adaptive management framework may be more robust for elements of the

restoration plan with higher degrees of uncertainty or where large amounts of restoration are planned within a given geographic area and/or for the benefit of a particular resource.

Figure 5.5-17 shows an overview of the monitoring and adaptive management process interpreted for this restoration plan. The steps of this iterative process include injury assessment, restoration planning (including the development of monitoring and adaptive management plans), implementation of the initial restoration plan, monitoring of restoration actions, evaluation of restoration effectiveness, feedback of information to restoration planning and implementation, refinements to restoration implementation, and reporting on restoration progress towards meeting restoration goals and objectives. The adaptive management feedback loop, including monitoring, evaluation, feedback, and implementation, provides the Trustees with the opportunity to adjust restoration actions, as needed, based on monitoring and evaluation of restoration outcomes (Williams 2011; Williams et al. 2007). This feedback loop will not necessarily be needed in all instances. Projects that meet their success criteria, as determined during the evaluation step, may not need to use the adaptive management feedback loop. In other cases, multiple iterations of the feedback loop may be intentionally incorporated into project implementation. For example, a new restoration technique may be implemented first on a small scale to test design options and resolve any uncertainties through multiple iterations of the feedback loop, prior to implementing the project on a larger scale.

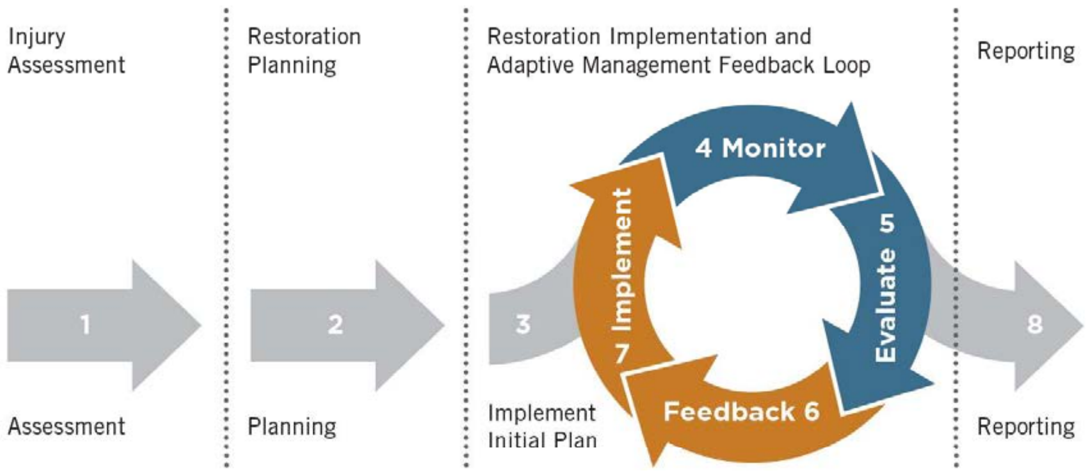


Figure 5.5-17. The monitoring and adaptive management process interpreted to this restoration plan, including a feedback loop represented by orange and blue arrows. This process includes four overarching phases: injury assessment, restoration planning, restoration implementation, and reporting. An adaptive management feedback loop of monitoring (Arrow #4), evaluation (Arrow #5), feedback (Arrow #6), and adjustment of restoration actions (Arrow #7) is included within the restoration implementation phase. Orange arrows represent steps of the feedback loop related to decision-making and governance (see Chapter 7), while blue arrows represent steps related to the collection and analysis of information. This adaptive management process may be applied at the project, resource, and cross-resource levels, as appropriate. For a more detailed description, see Appendix 5.E, Section E.2. Adaptive Management.

The restoration types and approaches identified in this plan vary by location, complexity, and scale. Concurrently, the associated uncertainty and the science needed to support restoration may also vary. The Trustees expect higher uncertainty to be associated with increasing approach novelty, larger restoration scales (e.g., number and area of projects), limited scientific understanding of target

resources, increasing influence of socioeconomic factors, and longer time scales of restoration implementation (LoSchiavo et al. 2013; Simenstad et al. 2006; Steyer & Llewellyn 2000; Williams & Brown 2012) (Figure 5.5-18). These greater uncertainties could drive a greater need to use the adaptive management feedback loop for some elements of the restoration plan.

Figure 5.5-18. The degree of monitoring and adaptive management needed at the project and resource-levels depends on several factors, including the status of scientific understanding of key species, habitats, or ecosystem dynamics; the novelty of a given technique or approach; the scale at which restoration is implemented; the influence of socioeconomic factors; and the time scale over which restoration will be implemented. For further detail, see Appendix 5.E, Section E.2, Adaptive Management.

5.5.15.2 Monitoring and Adaptive Management for Restoration Types

As a foundational piece to the adaptive management framework, monitoring, modeling, analysis, and other scientific support may be conducted to inform restoration planning, implementation and evaluation at multiple scales (Lyons et al. 2008; Roni 2005; Thayer et al. 2003; Thom 2000). As outlined above, monitoring informs restoration planning and implementation for each restoration type (Sections 5.5.2 through 5.5.14 above), and may include both project-specific monitoring as well as monitoring at the level of the restoration type as needed to address uncertainties. The Trustees will perform monitoring and analysis for all restoration projects implemented under this plan, as per the OPA regulations, to evaluate whether projects are meeting their objectives and to inform the need for corrective actions. Additional monitoring and scientific support at the project level may be conducted to

support project design, location, and implementation; identify environmental factors that may influence project success; support project compliance; and better understand ecological functions and benefits.

The Trustees may choose to collect a standard set of performance monitoring parameters on all projects of the same restoration type to facilitate consistent project evaluation and to provide transparency to the public on project performance. However, flexibility in monitoring design will also be necessary to account for inherent differences between restoration projects and locations. For some restoration types, the Trustees may also choose to conduct more intensive and expanded validation monitoring on a subset of projects to better characterize ecological functions and service flows and inform the design and implementation of future restoration projects. For many projects, data collection may also be needed during the project planning stage to inform project design and resolve any uncertainties related to project implementation (e.g., engineering evaluations to resolve site-specific uncertainties related to project implementation for habitat restoration projects).

The Trustees may also perform targeted resource level monitoring and scientific support activities for those restoration types with substantial gaps in scientific understanding that limit restoration planning, implementation, evaluation, and/or understanding of resource recovery status. In particular, gaps in scientific understanding exist for certain aspects of many of the Gulf of Mexico living coastal and marine resources targeted by this restoration plan (fish, oysters, sea turtles, marine mammals, birds, and mesophotic and deep benthic communities), as noted in Sections 5.5.6 through 5.5.13 above. Scientific activities to address these uncertainties could include better characterization of the status and trends and spatiotemporal distributions of injured resources and habitats targeted by this restoration plan to improve the Trustees' ability to target restoration activities and track resource recovery.

5.5.15.3 Monitoring and Adaptive Management for the Restoration Plan

Recognizing the unprecedented amount, type, and geographic scope of this restoration plan, the Trustees will fund monitoring and adaptive management to support the restoration plan as appropriate, in addition to the activities associated with implementation of restoration for each restoration type. This work could include resolving key uncertainties that limit restoration planning, informing and evaluating restoration outcomes across multiple projects and restoration types, and providing a common public portal to access monitoring data and other important information related to restoration activities conducted under this restoration plan.

Uncertainties inherently exist with an undertaking of restoration on the scope and scale outlined above. Therefore, identifying and resolving key uncertainties that limit restoration planning and implementation across all or a subset of restoration types is important to reduce associated risks, and when possible, should be accomplished in an efficient and coordinated manner. Where individual restoration types have particularly large scientific information gaps, these funds may also be used to selectively supplement scientific activities conducted under the allocations for each restoration type. In addition, the Trustees would dedicate monitoring and adaptive management funds to develop and maintain the capacity to review all monitoring results collected for projects and restoration types to detect any unanticipated results that may signal the existence of currently unknown conditions that could influence overall restoration outcomes and/or the recovery of injured resources. Beyond data generated directly as a result of activities associated with this restoration plan, the Trustees will also

develop the capacity to maintain awareness of other scientific and monitoring activities that are ongoing in the Gulf of Mexico. This will both further assist with the detection of any irregularities that could signal the existence of currently unknown conditions and ensure that the Trustees closely follow new scientific research findings relevant to their restoration activities.

To the extent possible, the Trustees may aggregate and analyze monitoring results across all projects within the same restoration type to evaluate overall restoration outcomes. The development of minimum monitoring standards, including core metrics and monitoring methods, would facilitate the aggregation of monitoring results and evaluation of restoration benefits within each of the restoration types. The Trustees may also support the development and maintenance of regional-scale environmental monitoring networks to support restoration planning, implementation, and evaluation for geographic areas where a large number of restoration projects are concentrated. Monitoring information for all restoration types will be synthesized to document progress toward meeting restoration goals and objectives. This synthesis will provide the feedback needed for adaptive management of restoration and may inform planning and implementation of the restoration program outlined in the PDARP.

Finally, the Trustees will establish and maintain the infrastructure needed to manage restoration monitoring information and report on restoration outcomes to the public. This will include development of a common public portal where monitoring data, research results, project information, and reports related to all activities undertaken through this restoration plan are made available in a single location. To this end, the Trustees may identify minimum data standards, QA/QC procedures, and data sharing protocols as needed to connect data management platforms to allow access through the common public portal. Per OPA requirements, the Trustees will report on progress towards meeting restoration goals and objectives for individual restoration projects. They will also synthesize progress toward meeting restoration goals outlined in this PDARP. The Trustees will strive for consistency in the development of all monitoring plans and reports to further enhance transparency to the public. To the extent possible, all information will be provided to the public via the common public portal as it becomes available.

5.6 Alternative B: Resource-Specific Restoration

Section 5.5 presented in detail each of the restoration types that make up Alternative A: Comprehensive Integrated Ecosystem Restoration, together with the monitoring and adaptive management that would be implemented as part of Alternative A. This section presents Alternative B: Resource-Specific Restoration, focusing on the philosophy and rationale for this alternative. Because Alternative B comprises the same restoration types as Alternative A, the description of Alternative B does not repeat the information for each restoration type just presented in Section 5.5.

5.6.1 Restoration Philosophy and Rationale

Alternative B establishes a resource-specific restoration plan based on the programmatic Trustee goals. Alternative B seeks to maximize benefits to individual resources and human uses based on close, well-defined relationships between injured resources and outcomes of restoration actions.

Alternative B comprises the same restoration types as those described in Alternative A. However, there are important distinctions in how the Trustees could implement restoration under the two alternatives. Alternative A (Comprehensive Integrated Ecosystem Restoration) and Alternative B (Resource-specific Restoration) represent two different restoration philosophies and would result in two different investment strategies for the available settlement funds. Alternative A has a primary focus on implementing restoration actions that provide the benefit of ecosystem linkages and the ability to compensate for inferred or unquantified injuries as well as the connectivity among resources, habitats, and human uses. This means that there is an emphasis on coastal habitat restoration in Alternative A. Although ancillary benefits may be provided for ecosystem linkages under Alternative B, these are not a primary consideration for this alternative. Therefore, coastal habitat restoration is a component but not the focus of Alternative B.

Based on the different emphases, it follows that the investment strategies for the settlement funds would differ between the two alternatives. Consistent with the integrated restoration portfolio, Alternative A provides substantially more funding than would Alternative B for the goal of Restore and Conserve Habitat (see Section 5.10.2 for Alternative A allocations) and correspondingly less funding for the goal of Replenish and Protect Living Coastal and Marine Resources. Note that Alternatives A and B would both support the monitoring, adaptive management, and administrative oversight needs (including adaptive management for unknown conditions) described in Alternative A. If Alternative B were to become the preferred alternative, the allocation of funding to restoration goals would be different from that under Alternative A, and Section 5.10, Summary of Preferred Alternative and Funding Allocations, would be revised.

5.6.2 OPA Evaluation

A comparative OPA evaluation of Alternatives A, B, and C is presented in Section 5.9.

5.7 Alternative C: Continue Injury Assessment and Defer Comprehensive Restoration Planning

This section presents Alternative C: Continue Injury Assessment and Defer Comprehensive Restoration Planning, focusing on the philosophy and rationale for this alternative.

5.7.1 Restoration Philosophy and Rationale

Alternative C defers development of a comprehensive restoration plan until greater scientific understanding of the injury determination is achieved. This alternative could include the restoration types identified for Alternatives A and B, which are described in Section 5.5, Alternative A: Comprehensive Integrated Ecosystem Restoration (Preferred Alternative), but also could include refinements to those restoration types or a change in focus across the restoration types. Although approved Early Restoration projects would continue, no further NRDA restoration would be conducted until the additional injury assessment is completed and a corresponding restoration plan developed. If Alternative C were to become the preferred alternative, the allocation of funding to restoration would be substantially less than that under Alternative A because injury assessment costs would reduce the total amount available for restoration.

5.7.2 OPA Evaluation

A comparative OPA evaluation of Alternatives A, B, and C is presented in Section 5.9.

5.8 Alternative D: Natural Recovery/No Action

This section presents Alternative D: Natural Recovery/No Action, focusing on the philosophy and rationale for this alternative as well as the OPA evaluation.

5.8.1 Restoration Philosophy and Rationale

The OPA regulations require that "Trustees must consider a natural recovery alternative in which no human intervention would be taken to directly restore injured natural resources and services to baseline" (40 CFR § 990.53(b)(2)). NEPA also requires consideration of a "no-action" alternative. Under this alternative, Early Restoration would be the only restoration implemented under this NRDA; no additional restoration would be done by Trustees to accelerate the recovery of injured natural resources or to compensate for lost services.

5.8.2 OPA Evaluation

Under the no-action alternative, the Trustees would not prepare a restoration plan nor implement future restoration projects under NRDA, other than those already approved through the Early Restoration process. The Trustees would allow natural recovery processes to occur, which could result in one of four outcomes for injured resources: 1) gradual recovery, 2) partial recovery, 3) no recovery, or 4) further deterioration. Although injured resources could presumably recover to at or near baseline conditions under this scenario, recovery would take much longer compared to a scenario in which restoration actions were undertaken. For example, the majority of SAV resources in the Chandeleur Islands are likely to recover within two to 10 years. However, for marine mammals, recovery could take decades. For some deep water corals, recovery could take centuries. Additionally, the interim losses of natural resources would not be compensated under a "no-action" alternative. If Trustees selected this alternative, the public would not be compensated for the substantial losses in natural resources and services caused by the *Deepwater Horizon* oil spill. OPA establishes Trustee authority to seek compensation for such interim losses, which would continue during the extended recovery periods associated with this alternative. Given that technically feasible restoration approaches are available to compensate for interim natural resource and service losses, the Trustees reject the no-action alternative and a comparative evaluation of this alternative under OPA is not presented.

5.9 Comparative OPA Evaluation of Action Alternatives

The OPA evaluation standards (Section 5.4.7, Evaluation of Alternatives Under OPA) are used to compare the action alternatives (Alternatives A, B, and C). This comparative evaluation is supported by the consideration of the environmental consequences of the alternatives, which are presented in Chapter 6, Environmental Consequences and Compliance with Other Laws. The section below first evaluates Alternative C and describes why deferring restoration plan development is not preferred. A more detailed evaluation comparing Alternatives A and B is presented, and, based on this evaluation, the Trustees identify the preferred alternative.

As described in Chapter 1, the Trustees are, in part, evaluating a programmatic decision regarding how natural resource damage settlement funds in the amount of $8.1 billion (plus up to $700 million for adaptive management for unknown conditions) would be used for restoration to address the natural resource injuries described in this document. Each action alternative emphasizes a different comprehensive restoration planning philosophy. These programmatic alternatives are evaluated and compared below. Based on these OPA evaluations and the Trustees' finding that Alternative A best meets the Trustees' goals, Section 5.10 further develops and describes the specific funding allocations for that preferred alternative.

5.9.1 Alternative C

Alternative C describes continuing assessment, evaluation, and modeling of injuries to increase the certainty of the injury assessment prior to conducting restoration planning. This alternative is a reasonable option for the Trustees because it would address scientific uncertainties associated with the assessment, and a restoration plan to compensate for injuries would be proposed in the future. However, the Trustees must consider whether continued assessment is preferable to developing a comprehensive restoration plan at this time.

Deferring restoration action and continuing assessment would increase scientific certainty regarding the injury quantification for some of example species and would enable more precise restoration scaling for these directly measured resources. However, continued assessment has some disadvantages including the following:

- Further study would incur higher assessment costs.
- Continued assessment would cause substantial delays in restoration implementation beyond Early Restoration, which would lead to further losses in natural resources and their services.
- Further study may not substantially change the understanding of the nature or extent of certain injuries regardless of the length of time or amount of funding devoted to further study. This is due to the inherent difficulties in studying many oceanic systems and the time that has already passed since the spill. Although further study might be able to provide more certainty to the injury quantification, the Trustees do not expect that the increased degree of certainty would change the Trustees' restoration approach.

Given the reduction in funds available for restoration and the delay in implementing restoration, Alternative C would not be as successful as Alternative A or B in meeting the Trustees' goals for returning the injured natural resources and services to baseline and/or compensating for interim losses. In addition, due to the magnitude and nature of the *Deepwater Horizon* incident, the assessment and evaluation of all potentially injured natural resources in all oiled locations would remain scientifically and financially implausible. The Trustees find that the goals of this Draft PDARP/PEIS can be met without fully resolving all uncertainty. The Trustees conclude that the best path forward is to initiate comprehensive restoration now rather than delay it in an effort to better quantify the injury. Based on this evaluation, the Trustees do not prefer Alternative C.

5.9.2 Alternatives A and B

The Trustees next compared Alternatives A and B. Both action alternatives are composed of a restoration portfolio that 1) meets the four programmatic goals of benefiting habitat, water quality, living coastal and marine resources, and recreational use; 2) includes the restoration types identified based on injury; and 3) distributes that restoration across the five states, federal lands, and nearshore and offshore waters. Additionally, the Trustees' action alternatives meet the fifth goal by including monitoring, adaptive management, and adaptive management for unknown conditions. The Trustees would also factor in contingencies to address future unknown conditions, given the unprecedented scale of restoration required and the number of years that it will take to implement this plan. However, the Trustees' restoration planning under Alternatives A and B differ in their emphasis on coastal habitat restoration and ecological interconnectivity compared to their emphasis on living coastal and marine resources.

Alternative A will employ an ecosystem approach toward implementing the integrated restoration portfolio with the intent of enhancing the connectivity and productivity of habitats and resources, which will help sustain restoration gains over the long term. The recognition of the key role of coastal habitats in the interconnected Gulf of Mexico ecosystem helps ensure that multiple resources will benefit from restoration and that reasonably inferred but unquantified injuries are likely to be addressed. To achieve the desired portfolio of restoration approaches, the emphasis on coastal habitat restoration will be complemented by additional restoration for living coastal and marine resources and recreational uses to ensure that all injured resources are fully compensated. This combination of implementing restoration across resource types and emphasizing coastal habitat restoration plus robust monitoring and adaptive management creates a restoration portfolio that ensures that the Trustees will maximize the likelihood of providing long-term benefits to all resources and services injured by the spill.

Alternative B would implement more direct, resource-specific restoration, shifting the restoration emphasis from the goal Restore and Conserve Habitats to the goal Replenish and Protect Living Coastal and Marine Resources. However, since Alternative B emphasizes living coastal and marine resources and correspondingly reduces the emphasis on coastal habitat restoration, the Trustees are less certain that Alternative B would successfully restore for the reasonably inferred but unquantified injuries described in Chapter 4. The strong, but indirect, ecological linkages between habitats and species injured by the spill would be ancillary, rather than primary, benefits under Alternative B. Figure 5.9-1 provides a depiction of Alternative A and Alternative B.

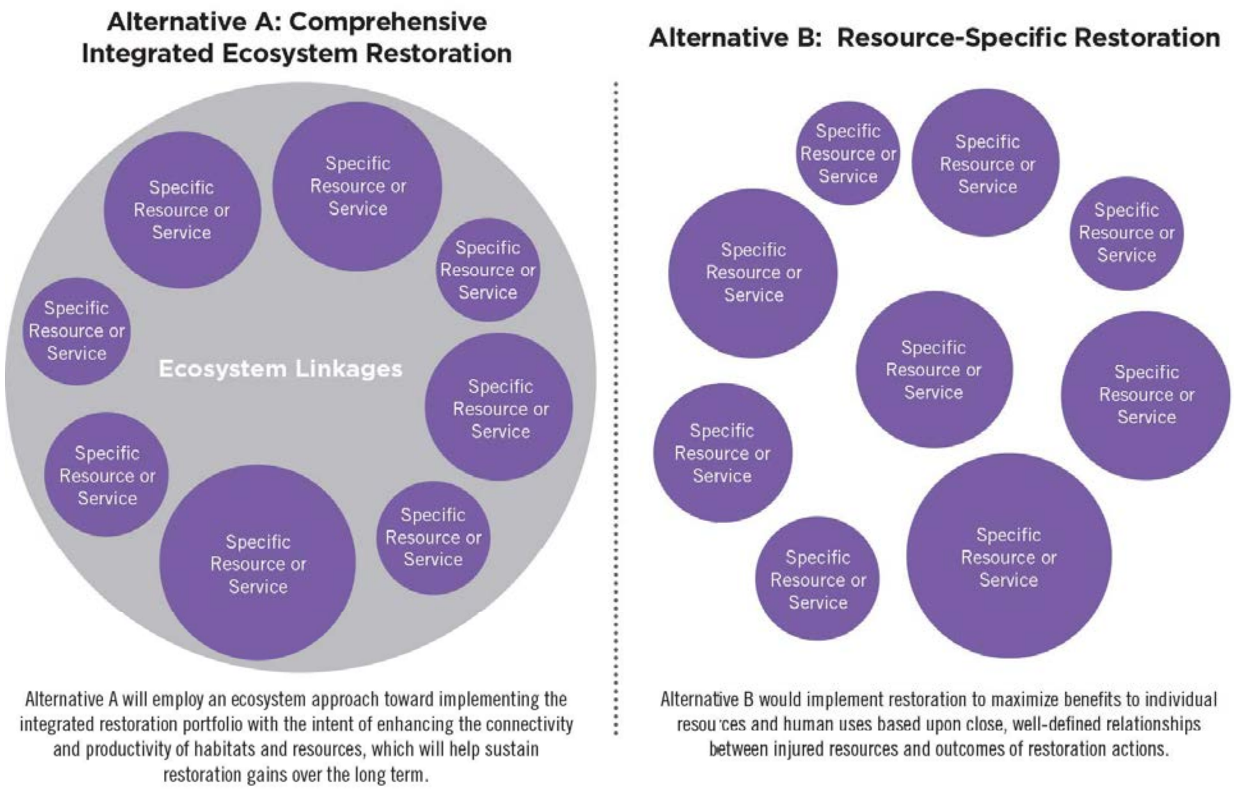


Figure 5.9-1. Depiction of the comprehensive integrated ecosystem restoration approach of Alternative A and the resource-specific restoration approach of Alternative B.

The Trustees find that Alternatives A and B are both consistent with the Trustees' programmatic goals. Table 5.9-1 provides a comparative analysis of Alternatives A and B using a subset of the OPA Evaluation Standards at 40 CFR 990.54 (a)-(f) that are most meaningfully differentiated at this programmatic level.

This evaluation provides sufficient information for the Trustees to determine that Alternative A is preferred, as it best meets the Trustees' goals and purpose and need for restoration.

Table 5.9-1. Comparative analysis of Alternatives A and B using the OPA evaluation standards.

OPA Evaluation Standard (990.54)	Alternative A: Integrated Ecosystem Approach	Alternative B: Resource- Specific Approach
The cost to carry out the alternative	Costs will be more effectively developed and compared in subsequent project-specific restoration plans and are thus not discussed here.	
The extent to which each alternative is expected to meet the Trustees' goals and objectives in returning the injured natural resources and services to baseline and/or compensating for interim losses	Meets all the Trustees' programmatic goals by establishing a restoration portfolio that includes restoration for habitats, water quality, living coastal and marine resources, and recreational use to compensate for all injuries. This alternative best achieves the Trustees' goals and objectives through emphasis on restoring highly productive coastal habitats, which provide food and shelter for a wide array of resources affected by the spill. This alternative explicitly recognizes the importance of coastal habitats to the physical and biological interconnectivity of the Gulf ecosystem and is more likely than Alternative B to address both documented and reasonably inferred but unquantified injuries.	Meets all the Trustees' programmatic goals by establishing a restoration portfolio that includes restoration for habitats, water quality, living coastal and marine resources, and recreational use to compensate for all injuries. This alternative emphasizes direct restoration to compensate for assessed injuries. This alternative will fully compensate for injuries, but is less certain than Alternative A in addressing reasonably inferred but unquantified injuries.
The likelihood of success of each alternative	The Alternatives draw from the same set of restoration types and restoration approaches. Many identified restoration approaches are well established and have a high likelihood of success. Section 5.5, Alternative A: Comprehensive Integrated Ecosystem Restoration (Preferred Alternative), notes where novel approaches are identified and that key uncertainties associated with restoration success will be evaluated thoroughly at the project-specific level. Both alternatives incorporate monitoring, assessment, and science support to ensure that needed corrective actions are taken and that a science-based decision-making framework is in place to increase the overall likelihood of success.	
The extent to which each alternative will prevent future injury as a result of the incident, and avoid collateral injury as a result of implementing the alternative	The potential for preventing future injury and for avoiding collateral injury depends on the specific projects and project locations proposed in subsequent restoration plans; this issue is thus not discussed further here.	
The extent to which each alternative benefits more than one natural resource and/or service	Due to the nature and extent of the injury, the alternatives must address multiple natural resources and services. This alternative includes a substantial amount of restoration for coastal habitats to ensure broader ecosystem benefits (e.g., food, shelter, and spawning areas) to multiple injured resources. This alternative also emphasizes restoring habitats in combination with one another to achieve multiple, and potentially synergistic, benefits and considers restoration approaches that can produce large-scale benefits across multiple resources to support resiliency and sustainability.	Due to the nature and extent of the injury, the alternatives must address multiple natural resources and services. This alternative does not offer the same assurances that substantial restoration will be undertaken for coastal habitats. Therefore, the broader ecosystem benefits would be ancillary. This alternative also does not emphasize habitats in combinations or using restoration approaches that can have large-scale benefits across multiple resources.
The effect of each alternative on public health and safety	Effects on public health and safety are most effectively evaluated at the project-specific level. Thus, this criterion was not used to compare alternatives in this plan.	

5.10 Summary of Preferred Alternative and Funding Allocations

Based on the identification of the integrated ecosystem approach to restoration as the preferred alternative, this section provides additional rationale for the Trustees' preference for this alternative, describes the funding and funding allocation needed to implement the preferred alternative, provides an initial sense of the scale of implementation that would be possible with the available funding, and briefly discusses subsequent restoration planning. Should another alternative become preferred as a result of public comment or additional information, the funding allocations presented below will be updated to reflect that preferred alternative.

5.10.1 Summary of Preferred Alternative

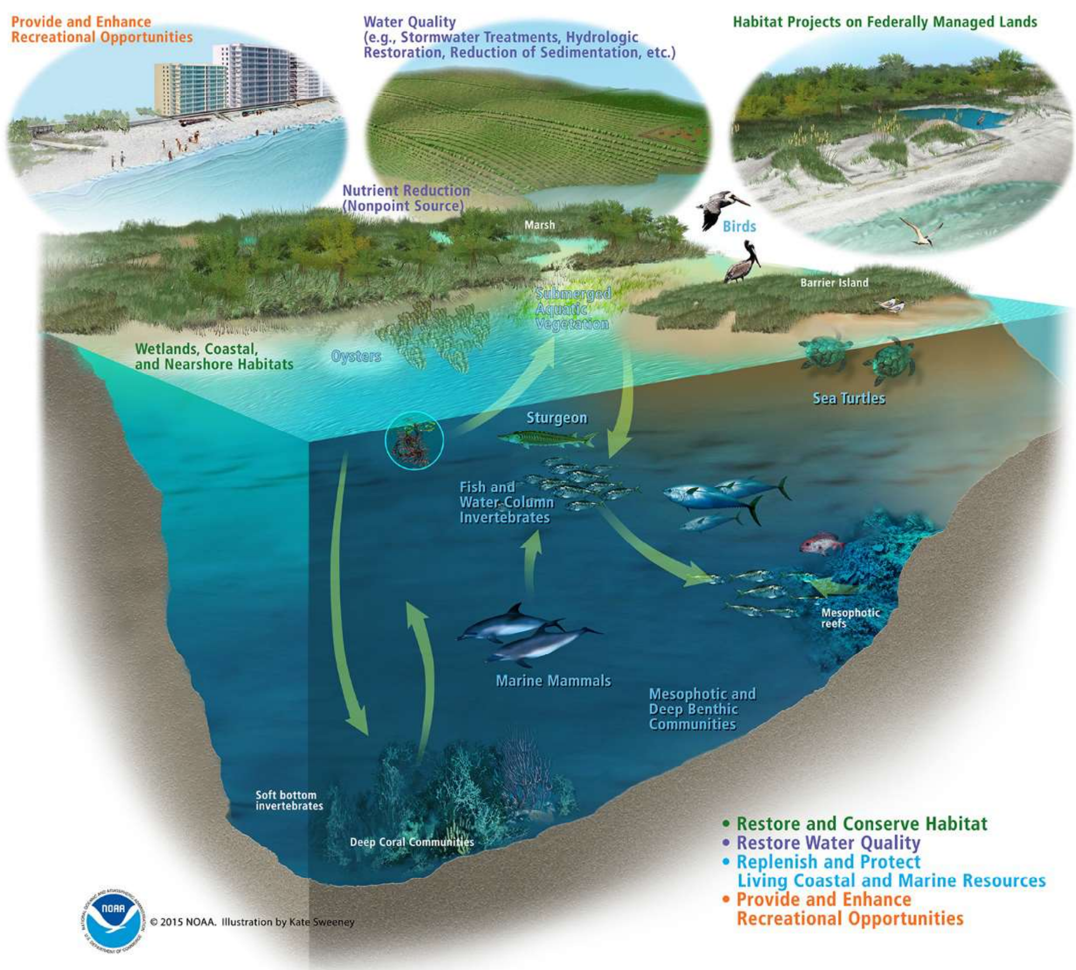
The preferred alternative, outlined in Section 5.5, Alternative A: Comprehensive Integrated Ecosystem Restoration (Preferred Alternative) meets the five programmatic restoration goals by implementing restoration types within a monitoring and adaptive management framework that restore, protect, or enhance habitats, resources, and services within an integrated restoration portfolio. These restoration types work both independently and together to achieve necessary benefits to injured resources and services at the ecosystem level (Figure 5.10-1). Resources and habitats in the Gulf of Mexico are connected through the movement of organisms between habitats and the transport of nutrients, sediments, and other organic matter from inland areas to the coast and between coastal and offshore ecosystem and surface and deep waters (see Chapter 3, Ecosystem Setting).

Shoreline and nearshore habitats, including wetlands, dunes, SAV, and oyster beds, provide important nursery and foraging habitat for many species of injured birds, turtles, marine mammals, finfish, shellfish, and invertebrates (O'Connell et al. 2005; Würsig et al. 2000). These shoreline and nearshore habitats often have high rates of productivity. They are also important contributors to

The Components of the Preferred Restoration Portfolio

- Focus on coastal and nearshore habitat restoration, including improving water quality in priority watersheds.
- Implement restoration at a broad, regional level to ensure that key linkages are restored.
- Emphasize restoration in areas known to have been injured by the spill.
- Consider key ecological factors such as connectivity, size, and distance between projects, as well as factors such as resiliency and sustainability.
- Consider the potential impact or synergy of other Gulf restoration activities on NRDA restoration planning.
- Invest in resource-specific restoration projects as part of the integrated restoration portfolio to ensure that species, life stages, and/or services not fully addressed by coastal and nearshore restoration will be addressed.
- Ensure compensation for lost human use by investing in projects that enhance recreational experiences and work in concert with ecological restoration.
- Follow an adaptive approach to restoration through iterative planning, implementation, and monitoring to optimize restoration results that shift over time in response to scientific data.

productivity in the shallow continental shelf water column through movement of detritus offshore, driven by tides and major currents, and through migration of animals to offshore locations to become a part of the offshore food web (EPA 1999). For example, many species of fish, invertebrates, and crustaceans inhabit marsh habitat as juveniles, but then migrate away from the marsh as they mature, ultimately becoming important food sources for other animals that live offshore (Boesch & Turner 1984). These are critical processes that influence the structure and function of the Gulf of Mexico ecosystem and the services provided to the human community. Because of these scientifically demonstrated physical and biological linkages between nearshore habitats and many of the resources injured by the spill, restoration of these nearshore habitats is a critical underpinning of the Trustees' preferred alternative.



Source: *Kate Sweeney for NOAA.*

Figure 5.10-1. Restoration types described in Section 5.5 that restore, protect, or enhance habitats, resources, and services within an integrated restoration portfolio. The restoration types work both independently and together to achieve necessary benefits to injured resources and services at the ecosystem level.

As part of the ecosystem approach to the restoration portfolio, the Trustees also will conduct restoration to improve water quality in localized watersheds to provide further ecological benefits. For

example, reductions of excessive nutrient inputs would likely reduce the extent and occurrence of low dissolved oxygen, harmful algal blooms, and large aquatic mortality events (commonly referred to as “fish kills”) (EPA 1999). In addition, water quality improvements could benefit beach going, swimming, and recreational fishing experiences in localized watersheds.

Although it is important to dedicate restoration activities broadly across the habitats on which injured resources rely, it is equally important to develop species-specific restoration actions to directly support the recovery of fragile and unique resources, many of which are managed under other authorities. Targeted restoration for key species and resources, such as fish (e.g., bluefin tuna and gulf sturgeon), birds, sea turtles, beach mice, marine mammals, and mesophotic and deep benthic communities, will ensure that species and life stages that have specific restoration needs or that have weaker linkages with nearshore habitats are also restored.

As part of this integrated restoration portfolio, loss of human use as a result of actual and perceived negative impacts on the Gulf region caused by this spill will also be addressed. Coastal communities of the Gulf of Mexico have a deep connection to the natural ecosystem and the benefits it provides (NOAA 2011). Considering this important link between healthy natural resources and recreational activities, restoring habitats and improving water quality will provide human use benefits. However, it is also important to include specific restoration actions that directly provide and enhance recreational opportunities through improving access or increasing educational opportunities.

The Trustees conclude that this combination of efforts will work synergistically to restore for the full range of assessed injuries caused by this spill. By conducting restoration for both targeted species in the vast Gulf of Mexico food web and the habitats on which they rely, ecological linkages such as habitat-community-species interactions, predator-prey relationships, nutrient transfer and cycling, and organism migration and behavior may also feasibly be restored. The ecosystem approach to the restoration portfolio also includes a commitment to monitoring and adaptive management that accommodates the dynamics of ecosystems and new knowledge on how they respond, as well as to continuous oversight and rigorous planning. Adaptive management will also be used to address currently unknown injuries that may be uncovered in the future. In this manner, the Trustees provide for a flexible, science-based approach to ensuring that the restoration portfolio provides long-term benefits to the resources and services injured by the spill in the manner envisioned in this programmatic plan.

5.10.2 Funding Allocations

The Trustees have determined that natural resource damage settlement funds in the amount of $8.1 billion (plus up to $700 million for adaptive management for unknown conditions) is appropriate and sufficient to address injuries caused by this spill. To address the diverse suite of injuries that occurred at both regional and local scales, the Trustees’ preferred alternative allocates these funds to restoration types based on the understanding of injury and the capacity of each programmatic goal and restoration type to restore for injuries. Additionally, the Trustees allocate restoration funds geographically based on their understanding and evaluation of exposure and injury to natural resources and services, as well as their evaluation of where restoration spending for the various restoration types will be most beneficial within the ecosystem-level restoration portfolio. These geographic restoration areas include Regionwide, Open Ocean, and the five Gulf states (Alabama, Florida, Louisiana, Mississippi, and Texas).

By allocating restoration funds across resources, supporting habitats, and geographic areas, the Trustees will maximize the likelihood of providing long-term benefits to those resources and services injured by the spill.

Table 5.10-1 shows the Trustees' allocations by goal and restoration type (rows) and restoration area (columns). This table also highlights where investments have already been made through the Trustees' Early Restoration efforts. The rationale for the remaining allocation of funds by programmatic goal and restoration type, after subtraction of Early Restoration investments, is outlined below.

- **Goal: Restore and Conserve Habitat.** The Trustees allocate the greatest amount of funds to the goal of Restore and Conserve Habitat, given the critical role that coastal and nearshore habitats play in the overall productivity of the Gulf of Mexico.
    - **Restoration Type—Wetlands, Coastal, and Nearshore Habitats.**

        - The Trustees allocate funds throughout all five Gulf state restoration areas to restore coastal and nearshore habitats—such as wetlands, oysters, SAV, beaches, dunes, islands, and barrier headlands—either individually or in combination with one another. The Trustees make this allocation as part of the strategy to develop a diversified portfolio that supports Gulf-wide recovery of injured resources that rely on habitats.
        - Geographically, the wetland habitats of coastal Louisiana will be a primary area of focus. The Trustees focus on the wetland habitats in this area because the area experienced among the heaviest and most persistent oiling and also because these wetlands support very high primary and secondary production that contributes to the overall health of the northern Gulf of Mexico ecosystem. Coastal Louisiana contains a diversity of habitat types, including herbaceous marsh of different salinities, mangroves, chenier ridges,

Geographic Restoration Areas

The Trustees have allocated funds across seven restoration areas, representing geographies where restoration will occur. They are:

- "Regionwide," consisting of categories of restoration activities that will benefit resources that range throughout the Gulf. It also contains funding for Gulf-wide needs such as monitoring, research, oversight, and planning.
- "Open Ocean," consisting of restoration actions for resources primarily in the Open Ocean restoration area.
- "Restoration in Alabama," consisting of restoration activities within the geographic jurisdiction of the state of Alabama.
- "Restoration in Florida," consisting of restoration activities within the geographic jurisdiction of the state of Florida.
- "Restoration in Louisiana," consisting of restoration activities within the geographic jurisdiction of the state of Louisiana.
- "Restoration in Mississippi," consisting of restoration activities within the geographic jurisdiction of the state of Mississippi.
- "Restoration in Texas," consisting of restoration activities within the geographic jurisdiction of the state of Texas.

intertidal oysters, barrier islands, and barrier headlands. The habitats in eastern Louisiana are especially diverse because of the influence of the Mississippi River, which provides for the gradual elevation gain from coast to uplands. This topography results in a large, connected marsh zone across a range of salinities, from barrier islands and saline marsh at the coastal edge, to brackish and freshwater marsh away from the coast (Gosselink & Pendleton 1984). Restoration throughout this coastal habitat area provides the Trustees with an opportunity to provide benefits to the extensive and diverse resources that rely on the productivity of the diverse and vast marshes and other nearshore habitats connected to the Mississippi River delta.

- **Restoration Type—Habitat Projects on Federally Managed Lands.** The Trustees allocate funds to the Florida, Alabama, Mississippi, and Louisiana restoration areas to address injuries that occurred on specific federally managed lands. Restoration in these diverse lands will include a portfolio of approaches that support a wide array of plants, fish, birds, beach mice, and other wildlife, including but not limited to coastal wetlands, marsh, SAV, sand beaches, and dunes.

- **Goal: Restore Water Quality.** The Trustees allocate funds to improve water quality in coastal watersheds as part of the strategy to address ecosystem-level injuries as well as specific aspects of lost recreational use.

  - **Restoration Type—Nutrient Reduction (nonpoint source)**. The Trustees allocate funds to this restoration type throughout all five Gulf state restoration areas to address excessive nutrient loading into coastal watersheds, which in turn will reduce threats such as hypoxia, harmful algal blooms, and habitat losses, thereby compensating for injuries to multiple resources and broken ecosystem-level linkages.

  - **Restoration Type—Water Quality (e.g., Stormwater Treatments, Hydrologic Restoration, Reduction of Sedimentation, etc.).** The Trustees allocate additional funds to the Florida restoration area to address water quality degradation that will not only compensate for injured resources and broken ecosystem-level linkages, but also recreational losses caused by the spill. Focusing this effort within the state of Florida will address specific water quality issues that adversely affect the overall health and quality of this state's beaches, bays, and nearshore habitats that have high recreational value.

- **Goal: Replenish and Protect Living Coastal and Marine Resources.** The Trustees allocate funding to resource-specific restoration actions as part of the integrated restoration portfolio to ensure that species, life-stages, and/or services not fully addressed by coastal and nearshore restoration will be addressed.

  - **Restoration Type—Fish and Water Column Invertebrates**. The Trustees allocate funds to address direct sources of mortality to fish and water column invertebrates. The Trustees make all this allocation to the Open Ocean resource area because of the need to address specific species and life stages that may not sufficiently benefit from coastal and nearshore habitat restoration.

- **Restoration Type—Sturgeon**. The Trustees allocate funds to address the specific recovery needs of this protected species. The funds are allocated to the Open Ocean restoration area and will target approaches focused on sturgeon recovery in priority rivers.

- **Restoration Type—Sea Turtles**. The Trustees allocate funds across all seven geographically defined restoration areas, with particular emphasis on the Open Ocean and Regionwide restoration areas, because of the diversity of species and life stages that were injured. The Trustees may use funds allocated to the Regionwide and Open Ocean restoration areas for restoration outside of the Gulf of Mexico as ecologically appropriate, and these funds may be used for resource-level planning, prioritization, implementation, and monitoring for resource recovery, among others.

- **Restoration Type—SAV**. The Trustees allocate funds to the Louisiana restoration area for restoring the Chandeleur Islands SAV beds to ensure that restoration can be targeted to the unique SAV ecosystem that was affected in this area.

- **Restoration Type—Marine Mammals**. The Trustees allocate funds across Florida, Alabama, Mississippi, Louisiana, Open Ocean, and Regionwide restoration areas, with particular emphasis on the Louisiana, Open Ocean, and Regionwide restoration areas. The Trustees place the majority of funds for marine mammals in these three restoration areas to reflect the diversity of species injured and the geographic distribution of the injury. The Trustees may additionally use funds in the Regionwide and Open Ocean restoration areas for restoration outside of the Gulf of Mexico as ecologically appropriate, and these funds may be used for resource-level planning, prioritization, implementation, and monitoring for resource recovery, among others.

- **Restoration Type—Birds**. The Trustees allocate funds for birds across all seven geographically defined restoration areas because of the diverse array of species and geographic areas that these species inhabit. The Trustees may additionally use funds in the Regionwide and Open Ocean restoration areas for restoration outside coastal Gulf of Mexico habitats, and these funds may be used for resource-level planning, prioritization, implementation, and monitoring for resource recovery, among others.

- **Restoration Type—Mesophotic Reefs and Deep Benthic Habitats.** The Trustees allocate substantial funds for this restoration type, all allocated to the Open Ocean restoration area. This allocation reflects the Trustees' conclusions about the large injury to these rare and long-lived resources, as well as an understanding of the expense of working in these remote regions of the Gulf of Mexico.

- **Restoration Type—Oysters**. The Trustees allocate funds to specifically address unique aspects of injury to oysters that may not be fully addressed by restoration conducted within the goal of Restore and Conserve Habitat. Funds are distributed across all five state restoration areas, as well as the Regionwide restoration area, to address not only injuries to specific oyster beds, but also to address the broader recruitment failure

and ecological functions that need to be restored. Regionwide restoration area funds also may be used for resource-level planning, prioritization, implementation, and monitoring for resource recovery, among others.

- **Goal: Provide and Enhance Recreational Opportunities.** The Trustees allocate funds to restore aspects of lost recreational opportunities not fully addressed by restoration conducted under the other four restoration goals.
    - **Restoration Type—Provide and Enhance Recreational Opportunities.** The Trustees allocate funds to the Florida, Alabama, Mississippi, and Louisiana restoration areas to address specific components of recreational use injuries. These funds are in addition to any recreational use benefits that may be derived from the ecological restoration projects being implemented within the other restoration types.
- **Goal: Provide for Monitoring, Adaptive Management and Administrative Oversight.** The Trustees allocate funds to provide for monitoring, adaptive management, and administrative oversight, recognizing that implementation of this restoration plan will occur over many years.
    - **Monitoring and Adaptive Management.** The Trustees allocate funds to the broader monitoring and adaptive management activities of the restoration plan, which are in addition to funds allocated within each restoration type. Recognizing that the restoration plan outlined in this Draft PDARP/PEIS is unprecedented in amount, type, and geographic scope, the Trustees allocate funds for monitoring and adaptive management to all restoration areas. However, the Trustees allocate the largest funds to the Open Ocean and Louisiana restoration areas, commensurate with the locations of the largest restoration fund allocations. The Trustees also allocate significant funds to the Regionwide restoration area to support such activities as the development and maintenance of a web-based public portal to access monitoring data and other important information related to restoration activities conducted under this restoration plan.
    - **Administrative Oversight and Comprehensive Planning.** The Trustees allocate funds across all seven geographically defined restoration areas, emphasizing the Regionwide, Open Ocean, and Louisiana restoration areas, commensurate with areas of greatest restoration fund allocations. The Trustees make this allocation because implementing this plan will require significant administrative oversight and will especially benefit from comprehensive planning to guide restoration project selection and adaptive management.
    - **Adaptive Management Natural Resource Damage Payment for Unknown Conditions.** The Trustees also set aside funds to address currently unknown conditions that may be uncovered in the future. The Trustees make this allocation because conditions will change over the course of the decades it will take to fully implement the restoration outlined in this plan, and setting aside funds to address future unknown conditions reduces the risk of proceeding with restoration in the face of those uncertainties.

Table 5.10-1. Settlement of NRD claims; NRD final allocation ($ dollars).

Major Restoration Categories	Unknown Conditions	Regionwide	Open Ocean	Alabama	Florida	Louisiana	Mississippi	Texas	Total Restoration Funding*
1. Restore and Conserve Habitat									
Wetlands, Coastal, and Nearshore Habitats				**65,000,000**	**5,000,000**	**4,009,062,700**	**55,500,000**	**100,000,000**	**4,234,562,700**
Habitat Projects on Federally Managed Lands				**3,000,000**	**17,500,000**	**50,000,000**	**5,000,000**		**75,500,000**
Early Restoration (through Phase IV)				28,110,000	15,629,367	259,625,700	80,000,000		383,365,067
2. Restore Water Quality									
Nutrient Reduction (Nonpoint Source)				**5,000,000**	**35,000,000**	**20,000,000**	**27,500,000**	**22,500,000**	**110,000,000**
Water Quality (e.g., Stormwater Treatments, Hydrologic Restoration, Reduction of Sedimentation, etc.)					**300,000,000**				**300,000,000**
3. Replenish and Protect Living Coastal and Marine Resources									
Fish and Water Column Invertebrates			**380,000,000**						**380,000,000**
Early Restoration Fish and Water Column Invertebrates			20,000,000						20,000,000
Sturgeon			**15,000,000**						**15,000,000**
Sea Turtles		**60,000,000**	**55,000,000**	**5,500,000**	**20,000,000**	**10,000,000**	**5,000,000**	**7,500,000**	**163,000,000**
Early Restoration Turtles		29,256,165						19,965,000	49,221,165
Submerged Aquatic Vegetation						**22,000,000**			**22,000,000**
Marine Mammals		**19,000,000**	**55,000,000**	**5,000,000**	**5,000,000**	**50,000,000**	**10,000,000**		**144,000,000**
Birds		**70,400,000**	**70,000,000**	**30,000,000**	**40,000,000**	**148,500,000**	**25,000,000**	**20,000,000**	**403,900,000**
Early Restoration Birds		1,823,100		145,000	2,835,000	71,937,300		20,603,770	97,344,170
Mesophotic and Deep Benthic Communities			**273,300,000**						**273,300,000**
Oysters		**64,372,413**		**10,000,000**	**20,000,000**	**26,000,000**	**20,000,000**	**22,500,000**	**162,872,413**
Early Restoration Oysters				3,329,000	5,370,596	14,874,300	13,600,000		37,173,896
4. Provide and Enhance Recreational Opportunities									
Provide and Enhance Recreational Opportunities				**25,000,000**	**63,274,513**	**38,000,000**	**5,000,000**		**131,274,513**
Early Restoration Recreational Opportunities			22,397,916	85,505,305	120,543,167	22,000,000	18,957,000	18,582,688	287,986,076
5. Monitoring, Adaptive Management, Administrative Oversight									
Monitoring and Adaptive Management		**65,000,000**	**200,000,000**	**10,000,000**	**10,000,000**	**225,000,000**	**7,500,000**	**2,500,000**	**520,000,000**
Administrative Oversight and Comprehensive Planning		**40,000,000**	**150,000,000**	**20,000,000**	**20,000,000**	**33,000,000**	**22,500,000**	**4,000,000**	**289,500,000**
Adaptive Management NRD Payment for Unknown Conditions	**700,000,000**								**700,000,000**
Total NRD Funding	**$700,000,000**	**$349,851,678**	**$1,240,697,916**	**$295,589,305**	**$680,152,643**	**$5,000,000,000**	**$295,557,000**	**$238,151,458**	

*The total restoration funding allocation for the Early Restoration work; each restoration type; and monitoring, adaptive management, and administrative oversight is $8.1 billion (plus up to an additional $700 million for adaptive management and unknown conditions).

5.10.3 Sense of Restoration Potential by Restoration Type

Based on the Trustees' experience implementing restoration projects and resource management programs, the Trustees have determined that $8.1 billion in restoration funds (plus up to an additional $700 million for adaptive management and unknown conditions) will provide appropriate and sufficient restoration to compensate for natural resources injured by the spill. By allocating restoration funds across resource groupings and supporting habitats, the Trustees will maximize the likelihood of appropriately compensating the public for all of the quantified and inferred resource and service injuries described in Chapter 4, Injury to Natural Resources. Because specific projects have not yet been proposed and selected, it is not possible to definitively forecast what on-the-ground restoration will be implemented over time.

Recognizing that the restoration potential of $8.1 billion could be difficult to conceptualize, the Trustees developed this section to provide the reader with examples to convey a sense of the magnitude of restoration that could be implemented with the funding provided, by restoration type. This section is intended only as a demonstration of restoration potential and is not intended to foreshadow any future Trustee restoration plans. It must be emphasized that the inclusion of restoration examples here is not intended to suggest that the Trustees have made any decisions in this Draft PDARP/PEIS regarding the number, type, or combinations of restoration projects they intend to develop. The examples below were drawn from Early Restoration projects, past NRDA case examples, select literature references, and similar projects implemented in the Gulf of Mexico to provide a sense of the restoration potential that could be accomplished within each funding allocation by restoration type. Note the dollar values used below include the allocation by restoration type without the dollars from agreed-to Early Restoration projects.

- **Goal: Restore and Conserve Habitat.**
  - **Restoration Type—Wetlands, Coastal, and Nearshore Habitats**.

    - The Trustees allocate funds throughout all five Gulf state restoration areas to restore coastal and nearshore habitats—such as wetlands, oysters, SAV, beaches, dunes, islands, and barrier headlands—either individually or in combination with one another.
    - For illustration purposes only, the $225.5 million allocated under this restoration type to Florida, Alabama, Mississippi, and Texas could be sufficient to restore over 1,500 acres of wetlands, or to restore and enhance thousands of acres of primary and secondary dune habitat, or to acquire over 10,000 acres of sensitive, coastal habitats, or to restore between 10,000 to 45,000 acres of subtidal oyster reefs, or to construct as many as 200 acres of nearshore oyster reef, or to restore over 150 acres of SAV habitat, or to restore over 1,000 acres of barrier island complexes.
    - Due to the large proportion of the wetlands and coastal and nearshore habitat funding allocated to Louisiana, wetland projects identified in the Louisiana Master Plan were used to evaluate the potential magnitude of benefits achievable here. However, as described in Section 5.5.2, the restoration dollars could be used for a variety of restoration approaches. For illustration purposes only, the approximately $4 billion

allocated to Louisiana for this restoration type could be sufficient to create 20,000 to 40,000 acres of coastal marsh in Louisiana (LA Master Plan[9]) along hundreds of miles of shoreline, supporting the diversity of fish, birds, and animals that depend on coastal marsh.

  - **Restoration Type—Habitat Projects on Federally Managed Lands.** For illustration purposes only, the $75.5 million allocated for restoration on federal lands could be sufficient to restore hundreds of acres of wetlands, or to restore and enhance over 2,000 acres of primary and secondary dune habitat, or to restore over 50 acres of SAV habitat, or to restore as many as 400 acres of barrier island complexes (Phase I FERP and Phase III FERP).

- **Goal: Restore Water Quality.**

  - **Restoration Type—Nutrient Reduction (nonpoint source)**. For illustration purposes only, the $110 million allocated to restore water quality through nonpoint source reductions could reduce nitrogen loadings to Gulf Coast waters by tens to hundreds of thousands of metric tons (Doering et al. 1999). Depending on existing water quality threats, this load reduction could reduce the occurrence and extent of localized hypoxia and HABs, resulting in ecosystem-scale benefits to existing and restored habitat and resources.

  - **Restoration Type—Water Quality (e.g., Stormwater Treatments, Hydrologic Restoration, Reduction of Sedimentation, etc.).** For illustration purposes only, the $300 million allocated to this restoration type could be sufficient to retrofit stormwater ponds to improve treatment of hundreds of millions of gallons of stormwater or more, equivalent to over 1,000 Olympic size swimming pools (Schueler et al. 2007). This additional treatment would result in a reduction in nutrients, pathogens, and other pollutants discharged to coastal waters, resulting in reduced occurrences of beach and shellfish closures, thus benefiting recreational use of coastal waters.

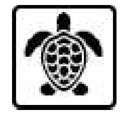
- **Goal: Replenish and Protect Living Coastal and Marine Resources.**

  - **Restoration Type—Fish and Water Column Invertebrates**. The allocation to fish restoration could be used to prevent otherwise avoidable mortality in commercial and recreational fisheries among other actions. For illustration purposes only, if the $380 million allocated for this project type was used to expand projects similar to the Early Restoration Pelagic Longline Bycatch Reduction Project, this funding could be sufficient to prevent tens of millions of pounds of fish from being incidentally caught and discarded as part of bycatch reduction projects (Phase IV FERP). Enabling commercial fisheries to adopt fishing practices that reduce post-release mortality of fishes in high-volume, high-bycatch fisheries (such as the shrimp trawl fisheries) could have resounding positive impact on fish populations.

[9] Based on average cost per acre of 2012 Louisiana Coastal Master Plan marsh creation projects.

- **Restoration Type—Sturgeon**. The allocation to Gulf sturgeon restoration could be used to improve sturgeon habitat in coastal areas and river and stream habitats, as well as to remove barriers to sturgeon migration within coastal riverine systems. For illustration purposes only, if the $15 million allocated to this restoration type was used to modify or remove known barriers to sturgeon river migration in combination with improving sturgeon habitat upstream of those barriers, it would be possible to restore more than 100 kilometers of riverine habitat to the benefit of hundreds of Gulf sturgeon from populations found in the northern Gulf of Mexico.

- **Restoration Type—Sea Turtles**. The allocation to sea turtle restoration could be used to implement an integrated suite of restoration projects that target different sea turtle life stages, similar to the Phase IV Sea Turtle Early Restoration Project (Phase IV FERP). For illustration purposes only, if the $163 million allocated to this restoration type was used to expand projects similar to the Gulf-wide Early Restoration effort, this funding could be sufficient to benefit hundreds of thousands of hatchlings and small juvenile sea turtles, tens of thousands of older juveniles, and/or thousands of adult sea turtles.



- **Restoration Type—SAV**. The allocation to SAV restoration could be used to implement multiple restoration approaches either individually or in combination. For illustration purposes only, if the $22 million allocated to this restoration type was used to implement SAV projects, the Trustees could restore over 100 acres of SAV.

- **Restoration Type—Marine Mammals**. The allocation to marine mammal restoration could be used to implement an integrated suite of restoration projects that target different marine mammal restoration needs including reducing bycatch, reducing interactions with hook-and-line gear, reducing illegal feeding and harassment, and expanding/enhancing stranding networks. For illustration purposes only, the $144 million in funding allocated to this restoration type could be used to increase the current funding levels seven fold (Fougeres 2015) through 2035 for each Gulf of Mexico marine mammal stranding network.

- **Restoration Type—Birds**. The allocation to bird restoration could be used to implement a diverse mix of projects intended to address various bird life stages, including, but not limited to, the conservation, creation, and/or enhancement of bird breeding and foraging habitat, reduction in human and animal predation, and establishment/re-establishment of breeding colonies. For illustration purposes only, if projects were implemented similar to those being implemented as part of Early Restoration (Phase II FERP, Phase III FERP, and Phase IV FERP), the $403.9 million allocated to this restoration type could result in implementation of a mix of projects that will restore in excess of tens of thousands of individual birds representative of the types of species injured by the spill.

- **Restoration Type—Mesophotic Reefs and Deep Benthic Habitats.** The allocation to mesophotic reefs and deep benthic habitats restoration could be used to

implement an integrated suite of restoration projects that befit these habitats, including managing marine protected areas. Costs associated with managing marine areas are related to the level of management (i.e., a higher level of management, including necessary science and education, may make management of similar sized parcels quite different in terms of cost) (Balmford et al. 2004). For instance the Flower Gardens Bank National Marine Sanctuary (FGBNMS) is managed at a cost of approximately $7,000 per square kilometer annually, but full funding of the management plan would cost close to $21,000 per square kilometer. Higher costs are associated with managing offshore resources that are difficult to access because of distance. For illustration purposes only, if management of mesophotic and deep benthic habitats in the Gulf has the same cost/area ratio as the fully funded level of the FGBNMS, about 650 square kilometers could be managed for the next 20 years under the $273.3 million allocated to this restoration type. This is approximately equivalent to the size of Padre Island, Texas.

- **Restoration Type—Oysters**. The allocation to oyster restoration could include projects that address oyster reef restoration within both the nearshore and subtidal zones. For illustration purposes only, if oyster reef were restored within either the nearshore or subtidal zone, it is possible that thousands to tens of thousands of acres of oyster reef could be created using the approximately $162.9 million allocated to this restoration type. As described in Section 5.5.9, oyster restoration may also provide ecological functions for estuarine-dependent fish species, vegetated shoreline and marsh habitat, and nearshore benthic communities.

- **Goal: Provide and Enhance Recreational Opportunities.**

- **Restoration Type— Provide and Enhance Recreational Opportunities.** The funds available to provide and enhance recreational opportunities could be used to implement projects that will restore or improve access to resources or further enhance recreational opportunities at existing facilities through improvements and education. Such projects are similar to many Early Restoration projects. For illustration purposes, if projects similar to the Early Restoration recreational use projects were implemented, the approximately $131.3 million allocated to this restoration type could be sufficient to enhance park amenities and access at many parks and public lands throughout the Gulf of Mexico or to acquire and conserve hundreds to thousands of acres of coastal land.

The Trustees identified a comprehensive, integrated ecosystem restoration plan as the best approach to address the ecosystem-scale injuries that resulted from the *Deepwater Horizon* incident. The Trustees' preferred restoration alternative includes restoration types that can benefit multiple resource injuries. Similarly, individual resource injuries may be compensated for by multiple restoration types. While uncertainties about the precise extent of those injuries are inherent in the scientific process, the magnitude of potential restoration in this Draft PDARP/PEIS, taken as a whole, gives the Trustees confidence that the preferred alternative will fully compensate for the injured natural resources and services.

5.10.4 Subsequent Restoration Planning

This chapter envisions what the Trustees could accomplish under Alternative A through the incremental series of restoration decisions that flow from this Draft PDARP/PEIS. Subsequent restoration plans shape the restoration that is ultimately implemented under this Draft PDARP/PEIS, and Chapter 7, Governance, describes generally how subsequent restoration planning will occur.

In summary, the Trustees, via Trustee Implementation Groups (TIGs) for each restoration area, will prepare series of subsequent restoration plans to propose and select specific projects for implementation. The TIGs will also continue the implementation and monitoring of Early Restoration projects (Appendix 5.B, Early Restoration; Table 5.B-2 shows the Early Restoration projects by restoration area [TIG]).[10] The restoration plans will propose specific projects that will be consistent with this Draft PDARP/PEIS and will be presented for public review and comment. Individual projects will contribute to one or more of the goals established for the relevant restoration type(s), and will be based on one or more of the restoration approaches analyzed for the relevant restoration type in Appendix 5.D, Restoration Approaches and OPA Evaluation. In evaluating projects, the Trustees will take into account the planning and implementation considerations described in this chapter and its appendices, and restoration planning will be informed both by public comment on the draft plans and by adaptive management to support science-based decisions. As restoration implementation and science in the northern Gulf of Mexico evolve, the Trustees may also update Appendix 5.D to ensure restoration approaches remain the best available to the Trustees over the life of this PDARP/PEIS implementation. Significant changes to Appendix 5.D would be made available to the public for review and comment. More details on this process may be found in Chapter 7, Governance.

[10] The Open Ocean restoration area includes four Early Restoration projects that were approved in Phases III and IV for $22,397,916 million for restoration on federally managed lands. These projects are reflected in Open Ocean for purposes of Early Restoration accounting. For purposes of subsequent project identification and selection associated with this Draft PDARP/PEIS, the remaining Open Ocean funding is allocated to fish and water column invertebrates, sturgeon, sea turtles, marine mammals, birds, and mesophotic and deep benthic communities.

5.11 References

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