Deepwater Horizon

Louisiana Trustee Implementation Group

Monitoring and Adaptive Management Activity Implementation Plan: Modeling to Inform Sustainable Oyster Populations in Louisiana Estuaries

May 2022

Implementing Trustee: LDWF

Introduction

The Deepwater Horizon (DWH) oil spill settlement in 2016 provides the Natural Resource Damage Assessment (NRDA) Trustees (Trustees) up to $8.8 billion, distributed over 15 years, to restore natural resources and services injured by the spill. As described in the DWH oil spill Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement (PDARP/PEIS; DWH NRDA Trustees 2016), the Trustees selected a comprehensive, integrated ecosystem approach to restoration. The Final PDARP/PEIS considers programmatic alternatives, composed of Restoration Types, to restore natural resources, ecological services, and recreational use services injured or lost as a result of the DWH oil spill incident. As shown in the PDARP/PEIS, the injuries caused by the DWH oil spill affected such a wide array of linked resources over such an enormous area that the effects must be described as constituting an ecosystem-level injury. The PDARP/PEIS and information on the settlement with British Petroleum Exploration and Production Inc. (called the Consent Decree) are available at the Gulf Spill Restoration website.

Given the unprecedented temporal, spatial, and funding scales associated with the DWH oil spill restoration effort, the Trustees recognized the need for robust Monitoring and Adaptive Management (MAM) to support restoration planning and implementation. One of the programmatic goals established in the PDARP/PEIS is to "Provide for Monitoring, Adaptive Management, and Administrative Oversight to Support Restoration Implementation" to ensure that the portfolio of restoration projects provides long-term benefits to natural resources and services injured by the spill (Appendix 5.E of the PDARP/PEIS). This framework allows the Trustees to evaluate restoration effectiveness, address potential uncertainties related to restoration planning and implementation, and provide feedback to inform future restoration decisions.

This project will contribute to meeting the Trustee Restoration Goal outlined in the PDARP/PEIS to replenish and protect living coastal and marine resources for the Oysters Restoration Type (Section 5.5.9 of the PDARP/PEIS). The project will provide an oyster metapopulation model, which will provide outputs of Specific, Measurable, Achievable, Relevant, Appropriate Timeline (SMART) objective measures including larval transport and recruitment patterns (SMART Objective 3b), size-based density and biomass estimates (SMART Objective 3c), and provide data to develop a SMART Objective related to reef sustainability (Fundamental Objective 2), developed by the Louisiana Trustee Implementation Group (LA TIG). Outputs from this project will enable managers to assess the impacts of enhanced or restored reef location on recruitment to other existing (or proposed) reefs, larval survival, and growth of oysters on existing and proposed reefs, and reef connectivity.

Document Purpose

This MAM Activities Implementation Plan (MAIP) describes the proposed MAM activities that were suggested in the LA TIG MAM Strategy for addressing three of the Oyster MAM needs:

- "*Review available data, ongoing monitoring metrics and methodologies, including simple shell budget models to plan a recommended approach on reporting*,"
- *"Develop a metapopulation model that considers both larval transport dynamics and on-reef oyster growth, mortality, and reproduction*," and

- *"Synthesize data and/or larval transport and recruitment modeling/ genetic studies, over spatial extent of constructed brood reefs and oyster cultch areas, to determine linkage between reefs and develop thresholds for sustainability."*

These activities are intended to support the oyster SMART high-level objectives of balancing growth of oyster populations on NRDA-enhanced and restored reefs with ecologically sustainable public harvesting, and spatially connecting source and sink reefs for larval transport to foster resilience and sustainability of oyster populations. The activities described in this document meet these high-level oyster SMART objectives by providing output that will enable the Louisiana Department of Wildlife and Fisheries (LDWF) to evaluate locations for oyster cultch plants and broodstock reefs. Generally, the model will enable managers to assess the impacts of enhanced or restored reef location on recruitment to other existing (or proposed) reefs, larval survival, and growth of oysters on existing and proposed reefs, and reef connectivity. This model will enable management of oysters to move from individual reef level to assessment of a network or metapopulation of reefs under current and future predicted conditions, a shared objective by the Regionwide Trustee Implementation Group (RWTIG). These MAM activities are consistent with the LA TIG MAM Strategy and the DWH Final PDARP/PEIS.

MAM Activity Overview:

Background

This project will provide an oyster metapopulation model to be applied in Louisiana estuaries, providing managers with the tool to examine reef connectivity through larval transport, and enable informed decisions aimed at achieving the following LA TIG oyster fundamental and SMART objectives:

- Oysters - Fundamental Objective 2: Maintain a neutral or positive shell budget on all restored reefs – either naturally (self-generated preferable) or through continued addition
    - SMART Objective 2a: Objective related to shell budgets of DWH NRDA restored oyster reefs to be developed based on current MAM need and activity 2a
- Oysters - Fundamental Objective 3: Maintain sufficient recruitment to, and survival of oysters on, restored reefs to maintain viable multi-generational oyster populations
    - SMART Objective 3a: Objective related to maintenance of multiple size classes of oysters (e.g., spat, seed, and sack) to be developed based on current MAM need and activity 3a
    - SMART Objective 3b: All reefs show larval settlement at least once within each 5-year period
    - SMART Objective 3c: All DWH NRDA restored reefs are at or above the minimum threshold for spawning-sized oysters (20 seed-sized oysters, 25 mm or larger, per square meter) at least once within each 4-year monitoring window following project implementation.

- Oysters - Fundamental Objective 5: Utilize restoration techniques which will increase the likelihood of larval input and settlement to promote development of restored reefs

- SMART Objective 5a: Objective related to recruitment measured in density of oyster spat on DWH NRDA restored oyster reefs to be developed based on current MAM need and activity 5a.

This is a foundational data and analysis project with ecosystem-level importance that involves the development of an estuary-level oyster metapopulation model that connects larval transport; reef persistence; and oyster growth, mortality, and reproduction in each coastal basin or estuary to provide data to develop and inform SMART objectives (2a, 3a, b, c, and 5a). The oyster metapopulation model will be set up and validated to the extent possible with existing oyster monitoring data using hydrodynamic model simulations of most recent years for up to three priority areas targeted for oyster restoration. The coupled hydrodynamic-oyster metapopulation approach will then be used to run up to three simulation scenarios for future foreseeable conditions which included different oyster reef and cultch plant designs for basin-scale restoration. Although this project will not directly address SMART objectives 7a and 7b, this modeling can help to inform oyster filtration rates of the DWH NRDA restored oyster reefs to be developed based on current MAM need (7a), and help to provide estimates of on-reef oyster size and density via the population modeling, and maintenance of oyster reefs via the shell budget modeling, as reef habitat estimates for other estuarine species (7b). This proposed project expands an ongoing LDWF project using oyster larval transport and geospatial habitat suitability (HSI) models to evaluate oyster cultch plant locations for the three priority basins targeted for restoration. Oyster restoration and management for Louisiana estuaries is important to the overall functioning and productivity of the coastal ecosystem, and the coupled modeling framework can be used by LDWF, the Coastal Protection and Restoration Authority (CPRA), and the LA TIG for continued evaluation of future scenarios, the Coastal Master Plan, and evaluation of various other habitat restoration or water resource projects.

The model developed and validated for existing conditions will be run under different future environmental, restoration and management scenarios, to help select restoration and management options. Without this metapopulation model, managers will only be able to monitor progress toward SMART objectives after restoration and management activities have occurred. The coupled Hydro/Water Quality (WQ) and oyster metapopulation framework will be available to LDWF and CPRA for model application and alternatives analysis of other water resource or Coastal Master Plan projects. The predicted outcomes of the oyster metapopulation model can also be validated by field monitoring of the oyster grounds after the restoration and management activities have occurred, with additional field monitoring planned and funded through the adaptive monitoring and management program.

This project is necessary to achieving the oyster high-level objectives of ensuring spatial connectivity between reefs, and balancing restored reef success with public harvest. The approach proposed here was recently recommended in a report inventorying oyster models available and identifying future needs to help inform management and restoration (La Peyre et al. 2021) and would provide output that directly responds to oyster SMART objectives. In addition, this approach would enable managers and restoration practitioners to estimate SMART objective outcomes to proposed and future management activities and environmental (climate) conditions. Outputs from this project will directly inform managers regarding selection of site locations and provide predicted restoration outcomes, for overall oyster resources, as opposed to individual reef outcomes. The detailed oyster metapopulation modeling approach using basin-scale hydrodynamic models to drive larval transport and on-reef processes will additionally complement the existing oyster habitat suitability mapping projects aiming to identify

coastal areas in Louisiana best suited for supporting cultch plants and alternative oyster culture methods. The oyster metapopulation model will predict whether on-reef oyster growth and reproduction are viable, and whether the identified suitable coastal areas are potential sources or sinks for larval production and recruitment.

Objectives and Tasks

The objective of this project is to provide an oyster metapopulation model that will provide outputs of SMART objective measures including larval transport and recruitment patterns (SMART Objective 3b), size-based density and biomass estimates (SMART Objective 3c), and provide data to develop a SMART Objective related to reef sustainability (Fundamental Objective 2). This will be done through provision of:

1) A modeling platform that simulates spatial and temporal dynamics of larval transport, individual oyster growth/reproduction/mortality, oyster reef growth, and reef maintenance for planning and implementation of oyster restoration. This platform can be used to understand linkages between reefs of different densities and size classes, including larval provision, and recruitment across space and time.
2) Reports, maps, and journal papers on predicted larval transport and settlement, recruitment success, oyster reef growth, survival and reproduction estimates, and oyster reef size structure, density, and/or biomass outputs under foreseeable future conditions that are consistent with the Louisiana Coastal Master Plan, oyster restoration strategies, and coastal habitat restoration scenarios.

To achieve this objective, this MAIP proposes five activities (Figure 1):

- Activity 1: Incorporate the oyster larval transport model under development with LDWF (Sable) including larval oyster dispersal, size-based vertical movement, and settlement criteria with recruitment measured among the oyster reef networks existing within the priority coastal basins.

- Activity 2: Update the oyster individual Dynamic Energy Budget (DEB) model to improve individual-based performance across the oyster life cycle, particularly during early development of oyster spat after settlement on the reefs. Activity 2 (Figure 1) includes leveraging the existing on-reef population models to inform each other and simulate oyster size class growth and survival, reproduction, shell maintenance and surface area for larval recruitment (i.e., spat settlement) in relation to salinity, temperature, and food availability (chl-a).

- Activity 3: Couple the larval transport model (Activity 1) and the existing on-reef oyster Individual-Based Models (single on-reef model for each defined reef/oyster area in the basin connected by larval transport model, Activity 2) that will quantify and provide larval oyster settlement and recruitment among the reefs/oyster grounds, and on-reef filtration, growth,

reproduction, and mortality of oyster size classes, as well as reef growth, degradation, and shell budget of the reefs within the estuarine network.

- Activity 4: Provide spatial and temporal dynamics of larval settlement distribution and recruitment among the reef networks, and post-settlement oyster size structure, density, biomass and spawning of the oyster reefs under existing or current years simulated by spatially-resolved basin-scale hydrodynamic/water quality models providing fine-scale current velocities (x,y,z), salinity, temperature, and chl-a conditions that drive the oyster processes in the coupled oyster metapopulation model (Activity 3, comprised of Activity 1 and Activity 2). Use the existing oyster field monitoring data within the coastal basin to help validate the modeled outputs. Modeled metapopulation outcomes will address MAM oyster SMART objectives 3b (frequency of larval settlement on an annual time scale), 3c (size class density on an annual time scale), and provide data to help develop MAM oyster SMART objectives related to shell budgets and oyster filtration. The oyster metapopulation model will be driven by current velocities, temperature, salinity, and potentially Chl-a concentrations (food proxy) generated from the coupled basin-scale Hydro/WQ model. The Hydro/WQ models that best represent the coastal basin seasonal circulation patterns and estuarine gradients over years are in the process of being selected for coupling with the oyster larval transport model framework (Sable, current LDWF project). Selected Hydro/WQ models will be leveraged for use in this project and must be current (past-2010), already calibrated and validated for the selected coastal basins, and previously supported by CPRA and partner agencies for water resource and coastal restoration projects, to assure the model bathymetry and boundary conditions, outputs (current velocities, salinity, temperature), and simulated scenarios are consistent with the Coastal Master Plan and State projects. The water quality model in Figure 1 is shown because simulated salinity, temperature (and chl-a, though not often simulated or validated for coastal Louisiana) may need further validation or included within the selected hydrodynamic model simulations. In that case, the team includes expertise in water quality modeling (Wang at USGS, Senior WQ Experts at DSLLC) if any of the variables need added or validated to the hydrodynamic framework.

- Activity 5: Provide forecasted spatial and temporal dynamics of larval settlement distribution and recruitment among the reef networks, and post-settlement oyster size structure, density, biomass, and spawning of the oyster reefs using for foreseeable future environmental conditions that are consistent with the Louisiana Coastal Master Plan and include proposed coastal habitat restoration, and oyster restoration and management scenarios. The foreseeable future conditions will be generated from the selected Hydro/WQ model for each basin, and coupled to the estuary-wide oyster metapopulation model in Activity 4. The modeled metapopulation outcomes will address the same MAM oyster SMART objectives listed in Activity 4.

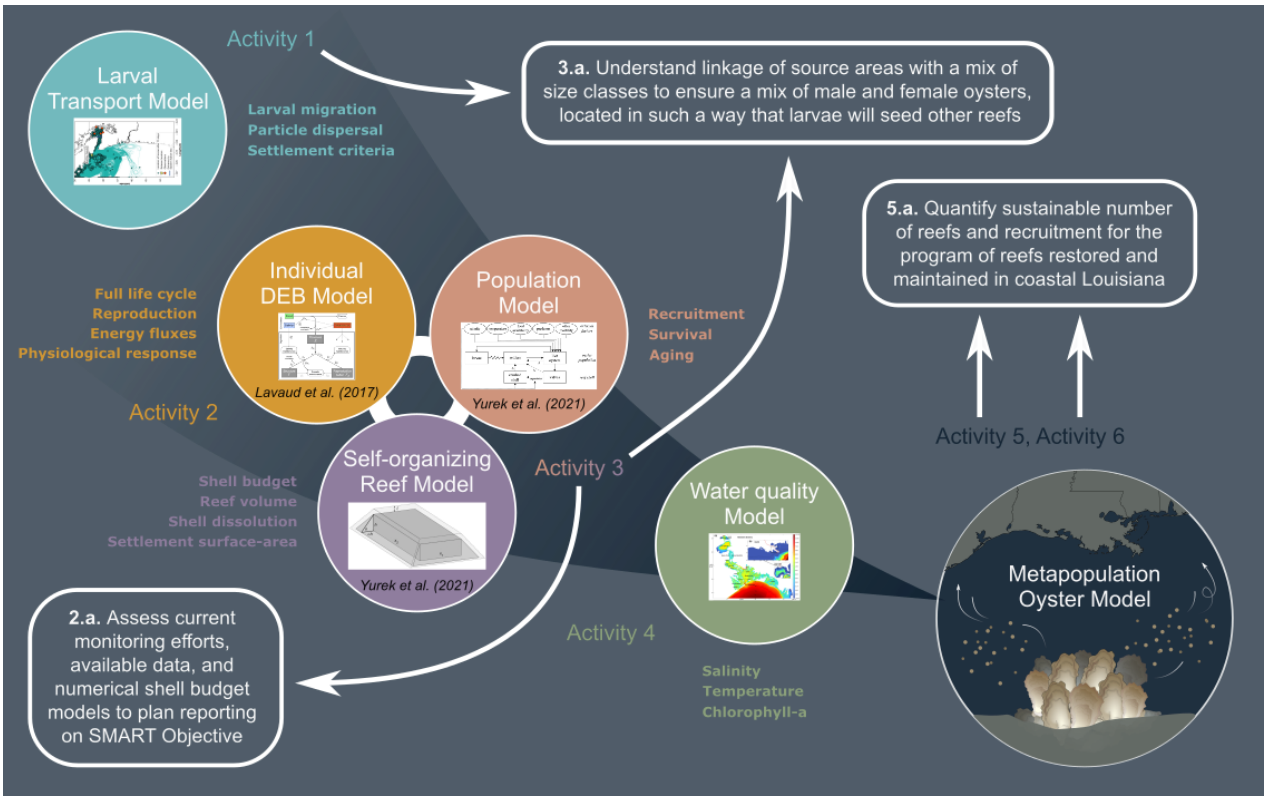

Figure 1. Proposed project framework to address suggested MAM oyster needs 2a, 3a, and 5a and address SMART Objectives 3b and 3c.

Budget

The total budget of $2,251,670 (Table 1) for this activity includes completion of Activities 1-5 CPRA's participation, and LDWF's oversight and implementation role.

LDWF will provide project oversight, technical input and review into the model and simulations. The U.S. Geological Survey (USGS) and academic experts and modelers, as well as the hydrodynamic modeling team, will support oyster larval transport and on-reef oyster modeling and coupling, Hydro/WQ model design, and simulations for driving the oyster metapopulation models, and input, evaluation, and review of modeled scenarios and outcomes.

Table 1. Summary budget for the proposed MAM Activity

Organization	Role	Cost
LDWF (including contractors)	LDWF project management, coordination, and oversight; oyster metapopulation model development, testing, coupling and simulations; hydrodynamic/water quality model adjustments and simulations, coupling with oyster models; modeling analyses and reporting; communication and participating as SME for the LA TIG groups	$1,995,715
U.S. Department of the Interior (DOI) (to fund USGS work)	On-reef oyster population and shell budget modeling; support hydro/water quality model coupling and testing; support model evaluation and reporting	$85,955
CPRA	CPRA participation/ coordination with Master Plan models, review of the model along the way, and review of final report and products.	$170,000
TOTAL		**$2,251,670**

Activity Implementation

Timeline

The five activities will be completed within a three-year period, as follows:

- Year 1: Metapopulation modeling framework set up and tested for existing conditions in the coastal basins scheduled for oyster restoration. Activities 1, 2, 3 completed within Year 1.
- Year 2: Hydrodynamic and water quality model simulations for existing conditions are completed and foreseeable future conditions are completed, and coupled with the oyster metapopulation model for model validation under existing conditions and foreseeable future conditions that include coastal habitat restoration and LDWF oyster restoration and management scenarios. LDWF is actively planning programmatic oyster cultch plants and

broodstock reef restoration, so the modeling will be completed in order to support LDWF with determining the locations in each basin. Some improvement and adjustments to Activity 3 may carry into Year 2. Activity 4 completed within Year 2.

- Year 3: Preparation of full and revised reports, maps, and journal papers on larval transport and settlement, recruitment success, oyster reef growth, survival and reproduction estimates, and oyster reef size structure, density, and/or biomass outputs under foreseeable future conditions, oyster restoration strategies, and coastal habitat restoration scenarios. Activity 5 completed within Year 3. Necessary model revisions, final evaluations and products (final modeling reports covering existing and future foreseeable conditions) provided in Year 3. Draft SMART Objectives #2a and #3a will be developed for LA TIG discussion and finalization.

Data Management and Reporting

The DWH Trustees, as stewards of public resources under the Oil Pollution Act (OPA), will inform the public on the MAM activity's progress and performance. Therefore, LDWF will report the status of the proposed activity via the Data Integration, Visualization, Exploration, and Reporting (DIVER) Restoration Portal annually, as outlined in Chapter 7 of the PDARP/PEIS (DWH NRDA Trustees 2016). All reports, maps, models, and other finalized datasets created or compiled as part of this activity will also be stored on the DIVER Restoration Portal. Data storage and accessibility will be consistent with the guidelines in Section 3.1.3 of the MAM Manual (DWH NRDA Trustees 2019). In the event of a public records request related to data and information that are not already publicly available, the Trustee to whom the request is addressed would provide notice to the other LA TIG members prior to releasing any data that are the subject of the request. Some of the data collected may be protected from public disclosure under federal and state law (e.g., personally identifiable information under the Privacy Act) and therefore would not be publicly distributed.

Consistency of MAM Activity with the PDARP/PEIS

The PDARP/PEIS establishes goals to replenish and protect living coastal and marine resources injured by the DWH oil spill. The PDARP/PEIS Oyster Restoration Type emphasizes oyster restoration that addresses the critical ecological process of oyster larvae recruitment, important because 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 (PDARP/PEIS Section 5.5.9 Restoration Type: Oysters).

The MAM activities proposed here are consistent with the following goals identified in the PDARP/PEIS for addressing injuries to oysters:

- *Restore oyster abundance and spawning stock to support a regional oyster larvae pool sufficient for healthy recruitment levels to subtidal and nearshore oyster reefs,* and
- *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* (PDARP/PEIS 5.5.9.1, Goals of the Restoration Type).

These MAM activities are consistent with these goals by enabling managers to assess the impacts of enhanced or restored reef location on recruitment to other existing (or proposed) reefs, larval survival, and growth of oysters on existing and proposed reefs, and reef connectivity. The basin-scale or estuary-

wide oyster metapopulation models that will be developed will enable management of oysters to move from individual reef level to assessment of a network or metapopulation of reefs under current and future predicted conditions. Therefore, this MAM activity is consistent with the PDARP/PEIS, including the Monitoring and Adaptive Management Framework, as described in Section 5.5.15.2. It is also consistent with LA TIG MAM Strategy (Deepwater Horizon Louisiana Trustee Implementation Group, 2021).

Evaluation of NEPA Requirements

The Trustees' approach to compliance with the National Environmental Policy Act (NEPA) summarized in this section is consistent with, and tiers where applicable from the PDARP/PEIS Section6.4.14. Resources considered and impact definitions (minor, moderate, major) align with the PDARP/PEIS. Relevant analyses from the PDARP/PEIS are incorporated by reference. Such incorporation by reference of information from existing plans, studies or other material is used in this analysis to streamline the NEPA process and to present a concise document that briefly provides sufficient evidence and analysis to address the LA TIG's compliance with NEPA (40 CFR 1506.3, 40 CFR § 1508.9). All source documents relied upon are available to the public and links are provided in the discussion where applicable.

NEPA Review of MAM Activity

The MAM activity would be limited to planning, data analysis, and modeling activities for the development of an oyster metapopulation model. None of the actions would negatively impact resources or have environmental consequences.

NEPA Conclusion

After review of the proposed activities against those actions previously evaluated in the PDARP/PEIS, the LA TIG determined that the environmental consequences resulting from this MAM activity fall within the range of impacts described in Section 6.4.14 of the PDARP/PEIS, thus no additional NEPA evaluation is necessary at this time.

Compliance with Environmental Laws and Regulations

The LA TIG has completed technical assistance with the appropriate regulatory agencies for this MAM activity based on the description in the MAIP. Because all proposed activities are desktop activities, NOAA and DOI, on behalf of the LA TIG, determined that no effects to ESA-listed species and habitats, designated Essential Fish Habitats (EFH) and marine mammals protected under Marine Mammal Protection Act (MMPA) are expected. Thus, consultations and permits from National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) are not required.

Additionally, the proposed project was evaluated under the following statutes through a BE form review and it was determined that the following statutes do not apply based on the nature of the work (desktop analysis only):

- Migratory Bird Treaty Act (USFWS)

- Bald and Golden Eagle Protection Act (USFWS)
- Coastal Zone Management Act
- Coastal Barrier Resources Act (USFWS)
- Rivers and Harbors Act/Clean Water Act
- National Historic Preservation Act (Section 106)

Documentation of regulatory compliance will be available in the Administrative Record that can be found at the DOI Online Administrative Record repository for the DWH NRDA (https://www.doi.gov/deepwaterhorizon/adminrecord). The current status of environmental compliance can be viewed at any time on the Trustee Council's website: http://www.gulfspillrestoration.noaa.gov/environmental-compliance/.

Activity Close Out

In accordance with Section 9.5.1.6 of the Trustee Council (TC) Standard Operating Procedures (SOPs), the Implementing Trustee shall provide the LA TIG with a closeout report after all activities and expenditures have been accomplished. The Final Report shall include a description and any documentation of the completed activity, estimated benefits to natural resources, the final funding balances and any transfers described in Section 7 of the TC SOPs, a summary of the results of monitoring, and any recommendations on adaptive management for the activity. Upon request, the Implementing Trustee shall provide the LA TIG with additional information and supporting documents to complete the closeout report.

References

Deepwater Horizon (DWH) Natural Resource Damage Assessment (NRDA) Trustees. 2016. Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement (PEIS). Available: http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan.

Deepwater Horizon (DWH) Natural Resource Damage Assessment (NRDA) Trustees. 2019. Monitoring and Adaptive Management (MAM) Procedures and Guidelines Manual Version 1.0. Available: https://www.gulfspillrestoration.noaa.gov/sites/default/files/2019-08%20MAM_Manual_FULL_Updated%202019.pdf.

La Peyre, M.K., Marshall, D.A., and Sable, S.E. 2021. Oyster model inventory: Identifying critical data and modeling approaches to support restoration of oyster reefs in coastal U.S. Gulf of Mexico waters: U.S. Geological Survey Open-File Report 2021–1063, 40 p., https://doi.org/10.3133/ofr20211063.