Monitoring the Effects of Coastal Wetland Restoration on Fish and Invertebrates Monitoring and Adaptive Management Activity Implementation Plan

June 2022

1. 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 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. 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 spatial area that the effects must be described as constituting an ecosystem-level injury. The PDARP/PEIS and information on the settlement with BP Exploration and Production Inc. (called the Consent Decree) are available at the Gulf Spill Restoration website.

Wetlands in the Barataria and Terrebonne Basins and along the Louisiana coast were among the most heavily oiled parts of the Gulf Coast shoreline in the aftermath of the 2010 DWH oil spill. This oiling and the associated response activities damaged these fragile habitats and accelerated ongoing wetland loss in coastal Louisiana. Louisiana's coastal wetlands serve as foundational habitat that supports living coastal and marine resources for the entire coastal nearshore ecosystem of the broader Gulf of Mexico. In addition to the damages to the habitat itself, the extensive oiling of these areas resulted in direct mortality and sublethal effects to many of the fishes and invertebrates that rely on these shorelines. The PDARDP/PEIS recognized the important role that coastal habitat restoration would play in helping restore injured fish and invertebrate species. The comprehensive, integrated restoration portfolio 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. Habitat restoration activities conducted under the Wetlands, Coastal, and Nearshore Habitats (WCNH) Restoration Type complement the types of restoration activities conducted under the Fish and Water Column Invertebrates Restoration Type to more fully restore for the injuries to these species (DWH NRDA Trustees 2016).

Given the unprecedented temporal, and spatial 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. As such, 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 MAM Activity Implementation Plan (MAIP) addresses the need to develop reasonable reference ranges and restoration targets for fish and invertebrate species for activities conducted under the

Wetlands, Coastal, and Nearshore Habitats (WCNH) Restoration Type. These reference ranges and targets will be used to develop Specific, Measurable, Achievable, Relevant, appropriate Timeline (SMART) Objectives for several of the fundamental objectives developed by the Louisiana Trustee Implementation Group (LA TIG) as described in the LA TIG MAM Strategy (DWH LA TIG 2021).

2. Purpose of this document

This MAIP describes a MAM activity for establishing nekton (i.e., mobile fish and invertebrates that actively swim or utilize the water column) reference ranges and restoration targets, which are needed to evaluate the outcomes of LA TIG restoration activities that provide habitat for injured nekton species. This MAM activity is intended to support evaluation of regional outcomes within the Louisiana Restoration Area; perform data aggregation and data management; resolve critical information gaps and uncertainties for restoration planning, inform restoration decision-making; and perform monitoring to inform the design and implementation of future restoration projects. This document provides information about the activities to be implemented and the data gaps and uncertainties they will address; describes their applicability to the PDARP/PEIS; describes their consistency with the programmatic alternative selected by the DWH Trustees in the PDARP/PEIS, Oil Pollution Act (OPA), and compliance with National Environmental Policy Act (NEPA).

3. MAM Activity Overview: *Monitoring the Effects of Coastal Wetland Restoration on Fish and Invertebrates*

This MAM activity aligns with the LA TIG's MAM Strategy (DWH LA TIG 2021) by addressing WCNH and Cross-Restoration Type Fundamental Objectives and SMART Objective/MAM Needs:

Fundamental Objectives addressed:

- WCNH #7: Provide benefits to estuarine dependent fish and invertebrates (nekton and benthic) at a variety of life stages through habitat restoration
- Cross Restoration Type #1: Maximize the combined benefits of the various Restoration Types and approaches across the overall restoration portfolio (PDARP Section 5.5.1)
- Cross Restoration Type #4: Provide for equivalent pre-spill baseline ecosystem communities and productivity

SMART Objective/MAM Needs addressed:

1. WCNH #7a: Develop reference ranges for density and relative abundance of target fish and invertebrate guilds or species, based on natural variability of relative abundance and density at appropriate reference sites; identify the distance from a restored area at which a restoration effect could be detected.
2. WCNH #7b: Estimate the effects of changes in habitat availability and type, and other restoration actions, **on estuarine community structure**, food web, and population connectivity.
3. WCNH #7c: Within 5 years, quantify habitat characteristics appropriate for target fish and invertebrate guilds or species.
4. Cross Resource #1a: Evaluate the efficacy of various strategies in land creation/restoration (diversions, marsh platform creations, barrier island restoration, ridge restoration)
5. Cross Resource #1b: Quantify wetland net ecosystem carbon balance at pre-spill/post-spill time scales and basin/sub-basin spatial scales, including export to nearshore Gulf of Mexico

6. Cross Resource #4a: Develop approach to understand and assess how the DWH NRDA restoration portfolio can maximize support to ecosystem communities' primary and secondary productivity.
7. LA TIG Programmatic #2: Relative effectiveness of different restoration approaches are identified

3.1 MAM Activity Description

This MAM activity is a targeted data collection and analysis effort to establish reference ranges and restoration targets and assess data gaps for focal nekton species and/or guilds associated with Louisiana's estuarine and coastal habitats. Nekton reference ranges and restoration targets are needed as basis for evaluating progress and success of LA TIG restoration activities intended to provide habitat for the nekton types injured as a result of the DWH oil spill. Reference ranges would identify the typical ranges in variation for marsh-associated nekton communities and be reflective of a relevant 'baseline' immediately prior to implementing a majority of NRDA restoration activities, including existing salinity regimes. However, these reference conditions (Jakobsson et al. 2020) would also require characterization of natural spatiotemporal variability at intra- and interannual, and perhaps longer, time scales. Reference ranges will serve as a point of comparison for nekton community conditions observed at restoration sites, where monitoring data are often collected over a much shorter time period. Restoration targets will similarly incorporate natural spatiotemporal variability but will focus on assessing age of previously restored marsh habitats, recently created via placement of dredged material, as a factor that drives targets at specific time points as a marsh restoration project and its habitat values matures. Both reference ranges and restoration targets would be used to assess localized marsh creations effects on nekton, such as changes in species' abundance and/or community composition, at locations adjacent to ongoing and future marsh creation activities.

Given the geographic focus of the majority of marsh restoration actions to be undertaken by the LA TIG under the WCNH Restoration Type, activities conducted under this MAM activity will focus on Terrebonne and Barataria Basins (Fig. 1). The project will rely heavily on existing data streams. Nekton abundance and community composition would be assessed using existing data (e.g., Louisiana Coastwide Fish and Shellfish Monitoring Program DIVER ID #157: Fisheries Independent Monitoring Program [FIMP], other potentially useful data sources) and would consider the historical time period covered by FIMP sampling data (e.g., FIMP seining has been conducted since 1986), to the extent possible, as well as extensive intra-annual field sampling (e.g., monthly for FIMP seining). This sampling duration and frequency will be conducive to detecting trends in inter- and intra-annual natural variability of nekton abundances and communities. Given the relatively short duration of pre- and post-restoration project monitoring, understanding and applying these longer-term trends will be crucial for interpretation of project-associated nekton monitoring. Additionally, new data collection using fixed-area sampling gear (i.e., drop samplers and throw-traps) will also be conducted to improve understanding of trends in nekton densities. These data will complement the nekton abundance data (i.e., catch-per-unit-effort [CPUE] available from existing sampling gears). This new data collection would also build upon our understanding of nekton-marsh habitat associations, especially for previously restored sites and for smaller species which are less likely to be efficiently caught by gears utilized by LDWF FIMP (Rozas and Minello 1997, Taylor et al. 2020), by targeting specific sub-habitats (i.e., open water adjacent to marsh edge [throw-trap], marsh edge and marsh interior [drop sampler]) or species' life stages that are not targeted by current FIMP sampling activities.

Both FIMP and fixed-area nekton samples would be matched with habitat characteristics derived from existing data streams collected at Coastwide Reference Monitoring System (CRMS; DIVER ID #249) and/or System Wide Assessment Monitoring Program sites (Hijuelos et al. 2013, The Water Institute of the Gulf 2019). While not an exhaustive list, habitat characteristics of interest will include marsh vegetation community composition and cover, water temperature and salinity regimes (mean conditions, variability, etc.), and inundation. Landscape configuration is another habitat characteristic that would be used to interpret variability in nekton reference ranges and restoration targets. The development and selection of a number of landscape configuration metrics will be conducted in partnership with DOI-USGS to leverage their concurrent wetland habitat area MAM activity. A concurrently implemented DOI-led MAM activity , "Quantifying Changes in Wetland Area and Habitat Types in the DWH Louisiana Restoration Area 1985-Present with Remote Sensing," will develop historical and current annual trends in wetland habitat area across southeast Louisiana marshes and at previously constructed marsh restoration projects; these products will then be further processed to produce landscape configuration metrics (e.g., area, edge, fragmentation) used to inform nekton-marsh habitat landscape relationships.

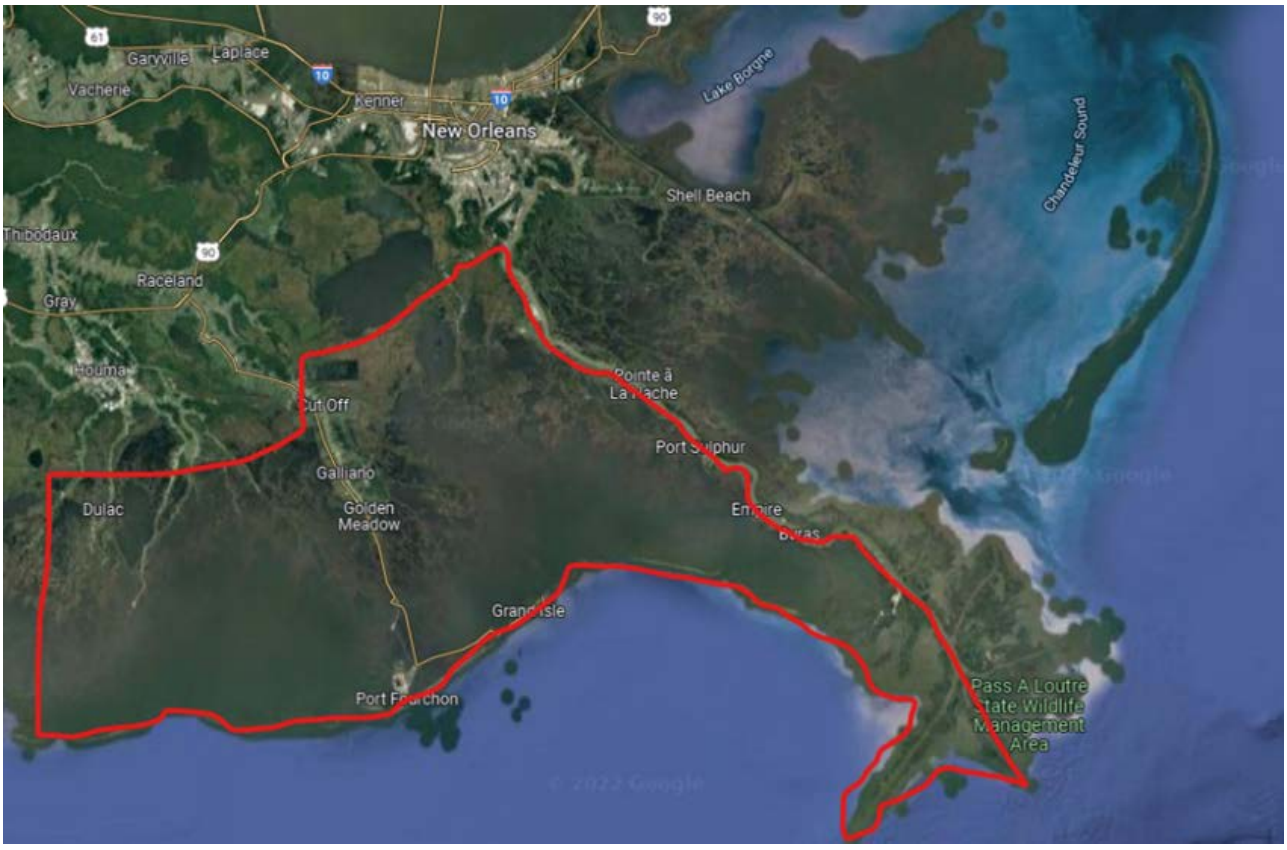

Fig. 1: Aerial view of southeastern Louisiana; the red enclosed region highlights Barataria and Terrebonne Basins that are the focus of this MAIP.

Intended outcomes:

- Provide the data needed for the LA TIG to finalize the WCNH SMART objective #7, “Provide benefits to estuarine dependent fish and invertebrates (nekton and benthic) at a variety of life stages through habitat restoration” and drafting SMART Objective MAM needs #7a, #7b, and #7c in the LA TIG MAM Strategy.
- Provide data needed by the LA TIG to help inform Cross-Restoration Type objective #1, "Maximize the combined benefits of the various Restoration Types and approaches across the overall restoration portfolio” by addressing MAM need #1a and #1b in the LA TIG MAM Strategy associated with community structure, quantifying wetland net ecosystem carbon balance.
- Provide data needed by the LA TIG to help inform Cross-Restoration Type objective #4, "Support injured species (trophic structure) via the estuarine food web structure (benthic and pelagic)” and "Provide for equivalent pre-spill baseline ecosystem communities and productivity” by addressing MAM need #4a in the LA TIG MAM Strategy associated with community structure.
- Inform restoration planning and implementation by informing selection of restoration project design features that maximize habitat benefits for associated fish and invertebrates (LA Programmatic #2).

b. Background

The LA TIG recognized the need to develop reference ranges for nekton density and relative abundance respective of natural variability and also to identify spatial and temporal ‘distances’ from marsh creation activities at which habitat benefits can be reasonability quantified (WCNH SMART Objective #7a in DWH LA TIG 2021). Filling this need related to recovery of nekton communities in created marshes will complement existing research on marsh utilization by nekton in unrestored marshes (e.g., see meta-analyses in Hollweg et al. 2020a, 2020b). Landscape configuration can strongly influence the relative habitat value of created and restored marshes to fish and invertebrate communities. The proposed activity will inform restoration project design and monitoring, specifically whether modifications to existing planning and implementation of marsh creation projects (Hood 2015, James et al. 2021) could optimize habitat value for injured fish and invertebrate species while still supporting the longevity of subaerial marsh.

c. Objectives

This MAM activity has multiple objectives:

1. Determine reference range values for nekton species’ abundances, densities, biomass, size distributions, community composition, and diversity (e.g., richness, Shannon diversity) with consideration of natural spatiotemporal variability and with respect to landscape features.
2. Determine restoration target values for nekton species’ abundances, densities, and community composition, and diversity (e.g., richness, Shannon diversity) with consideration of natural spatiotemporal variability and with respect to landscape features as well as age or state of maturation of a restored marsh habitat.
3. To inform restoration targets, FIMP associated abundance data will need to consider and identify the distance from a marsh creation site at which a restoration effect could be detected (I.e., and influence of the change in landscape on species’ abundance, community composition, and/or diversity).
4. Quantify habitat characteristics appropriate for target fish and invertebrate guilds or species.

5. Identify data gaps or limitations that could not be addressed within the project's scope.
6. Provide guidance that can inform future marsh construction and monitoring to maximize habitat value for target nekton species and guilds.
7. Develop draft SMART Objective related to abundances and densities of target fish and invertebrate species and/or guilds (WCNH #7a, #7b: community structure) for TIG consideration and finalization.
8. Develop draft SMART Objective related to habitat characteristics (WCNH #7c) for TIG consideration and finalization.
9. Provide information to inform future development of the a SMART Objective related to maximizing benefits of Restoration Type approaches (Cross-Restoration Type #1a and Programmatic #2).
10. Provide baseline information to inform future development of a SMART objective associated with wetland net ecosystem carbon balance (Cross-Restoration Type #1b).
11. Provide baseline information to inform future development of a SMART objective associated with secondary productivity to understand and assess how the DWH NRDA restoration portfolio can maximize ecosystem communities' secondary productivity (Cross Restoration Type #4a).

d. Tasks

This MAM activity includes three tasks:

Task 1: Compile and analyze existing fish and invertebrate data for coastal Louisiana and development of fixed-area sampling protocol. Identify and analyze existing published and unpublished datasets that can be used to help develop:

- ***Identify* specific fish and invertebrate species and/or guilds to target** for development of reference ranges and restoration targets. This would entail a working meeting(s) with key project subject matter experts and LA TIG representatives to build consensus on targeted fish and invertebrate species and/or guilds.
- ***Identify reference ranges*** for target fish and invertebrate species' abundance (CPUE) and community metrics with respect to natural variability (e.g., seasonality, extreme weather events) and habitat characteristics (e.g., salinity regime, landscape configuration, hydrology, proximity to restoration projects); and,
- ***Identify restoration targets*** for target fish and invertebrate species' abundance (CPUE) and community metrics with respect to restored marsh age and the incorporation of water features (e.g., creeks, ponds) while accounting for influential sources of variability such as natural variability, habitat characteristics identified during development of the reference ranges, and distance from a marsh creation project at which an effect can be detected.
- Task 1 will also include developing the sampling design, protocol, and site selection for the fixed-area sampling described in Task 2, which would be influenced by the results of the analyses conducted in this task. These analyses may also identify data gaps that will not be addressed within the scope of this project.
- Draft WCNH SMART Objectives related to abundances of target fish and invertebrate species and/or guilds will also be developed as part of Task 1, for use in LA TIG discussions to finalize WCNH SMART objectives #7a, #7b, and #7c.

Task 2: Collect new data through field work to characterize fish and invertebrate densities within coastal Louisiana restored and reference marshes using fixed-area sampling approaches. Conduct

three years of fish and invertebrate sampling using a fixed-area sampling strategy that incorporates the ecological understanding gleaned during Task 1. Fixed-area sampling will target marsh platforms and the waters immediately adjacent to it. This additional sampling will result in a dataset that can be analyzed to determine nekton species' and guilds' density respective of natural spatiotemporal variability and habitat characteristics including landscape configuration.

Task 3: Analyze Task 2 coastal Louisiana fixed-area fish and invertebrate density dataset:

- ***Identify reference ranges*** for fish and invertebrate species' densities (# m^{-2}) and community metrics with respect to natural variability (e.g., seasonality, extreme weather events) and habitat characteristics (e.g., salinity regime, landscape configuration, hydrology, proximity to restoration projects); and,
- ***Identify restoration targets*** for fish and invertebrate species' densities (# m^{-2}) and community metrics with respect to age of marsh creation and incorporation of water design features (e.g., creeks, ponds) while concurrently accounting for influential sources of variability such as natural variability and habitat characteristics identified during development of reference ranges.
- Quantify habitat characteristics appropriate for target fish and invertebrate guilds or species (in support of Cross-Resource SMART Objective #4a).
- Draft WCNH SMART Objectives related to densities of target fish and invertebrate species and/or guilds, for use in LA TIG discussions to finalize WCNH SMART objectives #7a, #7b, and #7c.

e. Activity Implementation Description

Task 1: Compile and analyze existing fish and invertebrate data for coastal Louisiana and develop a fixed-area sampling protocol

Task 1 will review and synthesize existing datasets (FIMP and other published/unpublished data, nearby CRMS sites for habitat characteristics, USGS landscape configuration metrics) and identify previously constructed marsh restoration projects (e.g., Coastal Wetlands Planning, Protection and Restoration Act [CWPPRA]) for development of nekton abundance reference ranges and restoration targets (abundances, biomass, size distribution, community composition, and diversity (e.g., richness, Shannon diversity) as well as identify data gaps and/or limitations. Data analyses to determine reference ranges and restoration targets will account for sources of intra- and interannual variability natural variability (e.g., seasonality, extreme weather events) and habitat characteristics (e.g., salinity regime, landscape configuration, and hydrology) which may affect the distribution and abundance of marsh-associated nekton species and communities. Development of reference ranges will also need to carefully consider proximity to and resulting influence of nearby, previous marsh restoration activities, and/or other changes to the landscape such as coastal protection projects (e.g., flood gates), in order to eliminate these effects from derived reference range values or, conversely, identify subsets of sites that could be reasonably considered as 'effected' by nearby restoration activities. To establish restoration target values, a common ecological analytical approach known as "space-for-time substitution" will be employed (Pickett 1989). As part of this MAM activity, a set of previously constructed marshes representing a span of ages (relatively new construction to 20+ year in age) and salinity regimes will be identified to assess nekton community condition relative to the developmental trajectory of constructed marshes, compensating for a shortage of long-term (>5 year) monitoring associated with large-scale marsh creation, especially within brackish and intermediate marshes. Restoration targets will consider

and, where possible, control for explicitly constructed and naturally developing water features (e.g., creek and ponding features), marsh construction approaches (e.g., confined vs. unconfined marsh creation), and habitat differences (e.g., small vs. large grained sediment, salinity regime of the created marsh, edge:interior ratio) of differing marsh construction approaches and/or project locations. Some of these aspects could be quantitatively considered via landscape analyses that would inherently incorporate them as landscape differences (e.g., edge:interior ratio as influenced by development of water features or due to construction approach). However, these differences are not presently considered as different 'factors' or 'classes' that could be explicitly incorporated within analytical frameworks. Even if explicit incorporation within the analytical framework cannot be achieved, these factors will need to be considered during interpretation of proposed restoration targets.

Concurrent to this project, DOI-USGS will be conducting a MAM activity analyzing historical and current annual trends in wetland habitat area across southeast Louisiana marshes and at previously constructed marsh restoration projects using Landsat (30 m resolution) and Sentinal-2 (10 m resolution) satellite imagery. This landscape configuration time series would be used to develop time series landscape metrics using the FRAGSTATS software (McGarigal and Marks 1995). While selection of landscape metrics to utilize will be conducted during the first year of MAM activity implementation, these metrics could include hydrological connectivity and access, proportion of marsh within the landscape, patch aggregation index, edge:interior ratio, edge interspersion, and area-weighted mean patch fractal dimension (McGarigal and Marks 1995, Hood 2015, James et al. 2021). This information will be leveraged during analysis of target fish and invertebrate species and guilds' associations with landscape conditions and will be incorporated along with other sources of spatiotemporal variation (e.g., salinity regime, vegetation community, etc.). Early during the implementation of Task 1, a working meeting(s) will be needed to identify the fish and invertebrate species and/or guilds that would be targeted for development of reference ranges and restoration targets associated with existing LDWF sampling. Discussions will also need to identify specific LDWF sampling gear approaches to focus on for development of reference ranges and restoration targets. This activity will include subject matter experts associated with implementing this project and LA TIG representatives (e.g., small working group) in order to build consensus on the fish and invertebrate targets. It is anticipated that some preliminary analyses of fish and invertebrate abundances may be needed to inform these discussions; therefore, the majority of these meeting(s) will take place approximately midway through Task 1 implementation. However, it is also necessary to define the analytical framework and process early during Task 1 with an initial meeting of the project working group. For example, identification of extreme events (e.g., freeze events or specific hurricanes) necessary for consideration of latent, protracted, or other responses would need to be conducted at the onset of Task 1 analyses.

Task 1 activities will result in a summary report that includes the following:

- Target fish and invertebrate species/guilds, definition of a reference sites for the purposes of nekton community assessment, and identification of previously created marshes to target during analytical and field activities as identified by consensus within the LA TIG.
- Combinations of existing FIMP/CRMS site pairs as appropriate reference sites.
- Restoration projects identified along an age continuum and with consideration of incorporated water features (e.g., creeks, ponds) that can be paired and analyzed with existing nearby sampling data (FIMP, CRMS) to inform development of appropriate fish and invertebrate restoration targets (e.g., recovery curve trajectories following restoration).
- To the extent possible, identified FIMP/CRMS site pairs will be used to develop *reference ranges* which consider an agreed upon recent time period (e.g., past 5 years) as the reference time period. These analyses will incorporate spatiotemporal and structural/landscape habitat conditions to quantify

target fish and invertebrate species' and guilds' abundance, biomass, size distributions, community composition, and diversity. These analyses will include power and sensitivity analyses to improve sampling efficiencies.

- To the extent possible, identified FIMP/CRMS site pairs associated with identified prior marsh creation projects will be used to construct restoration trajectories across an age continuum and identify *restoration targets* using analyses that incorporate spatiotemporal and structural/landscape habitat conditions to quantify target fish and invertebrate species' and guilds' abundance, biomass, size distributions, community composition, and diversity. These analyses will consider distance and time from a previously restored area at which a restoration effect (e.g., a change in species' abundance and/or community composition) could be detected as well as quantify the influence of incorporated water features (e.g., creeks, ponds) and landscape configuration on resulting habitat value of restored marsh sites to the extent possible. Previously identified reference sites will serve as a basis for comparison. These analyses will also include power and sensitivity analyses to improve sampling efficiencies.
- Compilation and synthesis of current published and unpublished fixed-area gear sampling datasets and preliminary analyses/synthesis to inform development of the fixed-area sampling strategy.
- A strategy, including sampling design, protocol, and selected sampling sites, for implementing a fixed-area sampling approach to quantify nekton density associated with reference and previously restored areas that complements existing/ongoing nekton abundance sampling. The strategy will incorporate findings regarding spatiotemporal habitat variability, landscape metrics and incorporation of water features at previously restored areas and will incorporate checks on sampling power and sensitivity, where possible.
- Identify and report data gaps, limitations, and lessons learned associated with the use of existing datasets and also recommendations for approaches for future abundance sampling and analysis.

Task 2: Collection of new data through field work to characterize fish and invertebrate densities within coastal Louisiana restored and reference marshes using fixed-area sampling approaches.

Task 2 will implement the fixed-area sampling strategy developed during Task 1 to quantify fishes and (non-sessile) invertebrate (e.g., shrimps/crabs) communities on a per-unit area basis and with respect to marsh sub-habitats by directly targeting the marsh platform itself and waters immediately adjacent to it. For budgeting purposes, this draft sampling strategy assumes fixed-area sampling (e.g., drop sampler, throw-trap) at 40 reference sites (across habitat-gradients such as salinity regime [e.g., saline, brackish, and intermediate]) and at 12 previously restored marsh locations (i.e., 4 age classes with 2 locations for each age while also allowing a likely need to replicate across salinity regime) with 3 replicates sites at each previously restored location (i.e., 36 sites in previously restored marshes). This would result in a total of 76 sampling sites. Within each sampling site, sampling is anticipated to be conducted across three marsh sub-habitats (open water adjacent to marsh edge, marsh edge, and marsh interior) with duplicate sampling to incorporate duplication within each sub-habitat (3x2=6 samples per site per sampling event). Summing across these sampling design levels of sites, sub-habitats, and duplication, this sampling approach would lead to 456 fixed-area samples per sampling event. Fixed-area sampling would be conducted on a seasonal basis (4 sampling events yr^{-1}; 1,824 samples yr^{-1}) across three years yielding a total of 5,472 fixed-area samples over the course of the project. Sampling events will attempt to control for water level by consistently sampling during high tide windows; however, water level and/or tidal stage may need to be considered during later analyses. During each sampling event, habitat

characteristics (e.g., marsh vegetation density and community composition of drop samplers) and environmental parameters (e.g., water temperature, salinity, pH, dissolved oxygen, etc. at time of sampling) will be collected immediately prior to or in conjunction with fixed-area sampling. Post-sampling laboratory processing of fixed-area samples will identify organisms to the species level or lowest taxonomic level possible and include measurements of organism size in order to develop size-distributions.

Sampling strategy development conducted under Task 1 will select both reference and previously restored marsh sampling locations to maximize their utility to assess nekton densities relative to existing FIMP and CRMS sites. Reference sites will be sampled across relevant habitat characteristics and environmental gradients strongly associated with nekton communities as identified during Task 1 activities. Similarly, sampling of previously restored locations would incorporate aspects of restoration age (8 sites), and, nested within that to the extent possible, previously restored locations that incorporated water features (e.g., creeks, ponds) and/or terracing intended to maximize habitat value for fish and invertebrates) (4 sites).

Upon completion of Task 2, a summary report will be produced that summarizes the characteristics of the fixed-area sampling activities including, but not necessarily limited, to a detailed description of the sampling design, protocol, and sites as implemented; summaries of the number of samples collected; summaries of the numbers of individual species/taxa/guilds collected; and lessons learned related to the effectiveness of fixed-area sampling methods. The lessons learned will be important information that can be incorporated into future project-level monitoring. A digital database or spreadsheet including nekton density and all sampling data compiled during implementation of Task 2 will also be developed using established DIVER data templates, as described in Section 2.6.3.1 of the MAM Manual (DWH NRDA Trustees 2021) and following consultation with the DIVER data management team.

Task 3: Analysis of Task 2 coastal Louisiana fixed-area fish and invertebrate density dataset.

Task 3 will analyze the newly collected fixed-area nekton data collected under Task 2. These analyses would complement those conducted under Task 1 and, where possible, incorporate those habitat characteristics (e.g., CRMS hydrologic metrics, landscape metrics) and marsh creation design/construction aspects as identified during Task 1 that correlate with or drive nekton communities during the development of nekton density (# m^{-2}) and community composition reference ranges and restoration targets. Lessons learned as well as identification of data gaps and/or limitations resulting from these analyses will be important for implementation of future fixed area monitoring.

Early during the implementation of Task 3, a working meeting(s) will be needed to identify the fish and invertebrate species and/or guilds that would be targeted for development of reference ranges and restoration targets associated with fixed-area sampling. This activity will include subject matter experts associated with implementing this project and LA TIG representatives in order to build consensus on the fish and invertebrate targets. It is anticipated that some preliminary analyses of fish and invertebrate densities may be needed to inform these discussions; therefore, the meeting(s) will take place approximately midway through Task 3 implementation.

Task 3 activities will result in a summary report that includes the following:

- Target fish and invertebrate species/guilds as identified by consensus within the LA TIG.
- Fixed-area sampling/CRMS site pairs; *reference ranges* and *restoration targets* for variability in target fish and invertebrate species' and guilds' density, biomass, size distributions, community composition,

and diversity; and spatiotemporally varying habitat, including landscape, and other environmental drivers' influence on that variability.
- Identify *restoration targets*, including restoration trajectories for maturing marsh restoration projects across an age continuum.
- Quantify influence of incorporated water features (e.g., creeks, ponds) in landscape configuration on resulting habitat value of restored marsh sites.
- Data gaps, limitations, and lessons learned associated with the use of existing datasets and with the sampling and analysis protocol (e.g., efficiencies identified through power and sensitivity analyses and spatiotemporal analyses).
- Revised sampling and analysis methods based on lessons learned, and suggested future approaches to fill identified data gaps.
- High level discussion of integration of Task 2 monitoring data within the ecosystem modeling that supports monitoring plans for the Louisiana System Wide Assessment and Monitoring Program (SWAMP).
- Draft SMART Objectives with quantitative restoration targets for abundance and density of target fish and invertebrate species and/or guilds, and habitat characteristics associated with those quantitative targets, for the LA TIG to use in discussions to finalize WCNH SMART Objectives #7a and #7c.

Results of data analyses will be documented in a digital database or spreadsheet, or appended to the database developed in Task 2, using established DIVER data templates and following consultation with the DIVER data management team. It is anticipated that the activities of this MAIP will result in at least two peer-reviewed publications that describe the analytical findings of Task 1 and Task 3, respectively. As described in the PDARP/EIS, restoration information can be communicated to the public via published research; publishing these findings via peer-reviewed publications would also ensure accessibility to and utility of this data for the scientific community.

Potential challenges: Data analysis/synthesis will consider a broad array of environmental variability (e.g., seasonality, climate variability, extreme weather events) and habitat conditions and/or gradients (e.g., salinity regime, landscape and hydroperiod metrics, prior marsh restoration influence). Analysis of the drivers of fish and invertebrate community variability and restoration project effects will consider other aspects of existing datasets (e.g., species identifications, sampling gear or approach, etc.) in species-specific and community level analyses, and will quantify the range of uncertainty associated with fish and invertebrate community characteristics. If weather or safety protocols (e.g., COVID-19) impact sampling frequency, sampling may need to be extended.

h. Budget

The total budget for this activity, including Trustee Labor associated with drafting and review of the SMART objectives, is $5,327,348 (Table 1). Funds withdrawal request for Task 2 and Task 3 would occur after a check-in with the LA TIG related to Task 1 development of a sampling plan.

The project will leverage past LA TIG investments in monitoring activities (e.g., FIMP, CRMS) as well as other past investments in LA coastal ecosystems (e.g., historical NOAA datasets) and a concurrent DOI-led MAM project. This MAIP will leverage existing investments in CRMS and FIMP.

Table 1. Summary budget for the proposed MAM Activity.

Monitoring the Effects of Coastal Wetland Restoration on Fish and Invertebrates Budget	
Cost Items	**Cost Estimate**
Task 1	$618,855
Task 2	$2,830,542
Task 3	$618,855
MAM Activity Management, Oversight, and Reporting	$301,529
CPRA Labor Associated with participation and coordination throughout project	$125,000
LDWF Labor Associated with participation and coordination of multiple SMEs throughout project	$240,000
DOI Labor Associated with draft SMART Objectives and coordination with DOI wetlands/habitat MAIP	$108,264
Total MAM Activity Cost Without Contingency	$4,843,045
Contingency (10%)	$484,305
TOTAL ESTIMATED COST	$5,327,350

i. Timeline

The activities described above will be conducted over a six (6) year project implementation period (Table 2). The first and second years of implementation will focus on gathering existing datasets related to nekton abundances and densities and habitat characteristics datasets as well as analysis/synthesis of these datasets. Coordination of landscape configuration metrics would likely be dependent on progress on the DOI *Wetland Area and Habitat Types* MAM activity that is also being funded during this FY22 LA TIG MAIP cycle; therefore, final incorporation and analyses will carry into the project's second year. Initial results from analysis and synthesis conducted during the first year will be integrated into development of a sampling design, protocol, and site selection for the fixed-area nekton density sampling activities to be conducted during Task 2. Task 1 would culminate with writing of the report describing the findings, lessons learns, gaps identified, etc. during the second year. Task 1 will also include a check-in with the LA TIG related to the sampling plan to be used for Tasks 2 and 3; the check-in may occur before the conclusion of Task 1 in consideration of contracting timelines.

Draft SMART objectives for nekton abundances will be developed during year two.

Task 2, which covers the implementation of the fixed-area field sampling campaign, would be initiated at the beginning of project year two with field operations continuing for a total of three (3) years, and

thus ending in year four. It is anticipated that lab work associated with analyzing fixed-area samples collected in year four would likely not be completed until the earlier months of year five; this consideration has been built into the cost for Task 2. Upon completion of the associated lab work, the report writing for Task 2 would then be finalized. While initial analyses associated with completion of Task 3 could be conducted in year five; finalizing the analysis and writing of the report would not be possible until the entire dataset would be available, likely midway through year five. Thus, the Task 3 fixed-area sampling analysis and final report would be completed in year six. At the same time, development of draft SMART objectives for nekton densities would be conducted during year six.

Table 2. Summary of timeline for implementing the proposed MAM Activity.

Year	Task	Activities
1,2	1	Compilation and initial analysis of existing nekton abundance, density, and habitat characteristics datasets.
1	1	Development of fixed-area sampling design.
2	1	Final analysis and synthesis of existing nekton abundance and density, report writing for Task 1, TIG check-in related to sampling plan.
2,3,4,5	2	Implement fixed-area sampling campaign; report writing for Task 2; database completion for Task 2.
3,4,5	3	Initial analysis of fixed-area sampling dataset.
6	3	Finalize analysis of fixed-area sampling dataset, report writing for Task 3.
6	3	Development of initial SMART objectives report; database completion for Task 3.

j. Implementation Roles

NOAA will be the Implementing Trustee and will be responsible for implementing the work under Tasks 1, 2, and 3, coordinating with the LA TIG and DOI project partners, providing overall direction and oversight for the MAM activity, including managing cooperator(s) agreement or contracts as needed, compliance, financial tracking, annual reporting, DIVER data management, and approval of deliverables. LA TIG agencies will have the opportunity to join a small working group to provide technical input into development and review of the deliverables for all three activities. Additionally, the Task 1 (fixed-area sampling design) and Task 3 (initial SMART objectives) deliverables will be sent to the full LA TIG for a 10-business-day review period. The SMART Objectives provided for Task 3 will not be considered finalized at the end of this project, but rather will serve as a starting point for further discussion and revision by the LA TIG.

k. Data Management and Reporting

The DWH Trustees, as stewards of public resources under OPA, will inform the public on the MAM activity's progress and performance. Therefore, NOAA 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* Trustees, 2016). All reports and final datasets created 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 2021). 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 Louisiana TIG members prior to releasing any data that are the subject of the request.

4. Consistency of MAM Activity with the PDARP/PEIS

This MAM activity is consistent with the DWH Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement (PDARP/PEIS) (DWH NRDA Trustees 2016) including a variety of restoration types (section 5.5) and restoration approaches (Appendix 5.D). This MAM activity supports the programmatic goals of (1) Restore and conserve habitat and (2) Provide for monitoring, adaptive management, and administrative oversight to support restoration implementation. As described in the PDARP (4.4.1), fish and invertebrates play important ecological roles such as serving prey or predators in food webs, and cycling and transporting nutrients and energy between nearshore and offshore areas between the surface and the deep sea. Many fish and invertebrates support robust commercial and recreational fisheries. In accordance with the ecosystem approach to restoration (PDARP5.5.1), the PDARP/PEIS identified a three-fold approach to address injuries to the broad cross-section of the fish and water column invertebrates impacted by the spill (PDARP5.5.6); this approach included coastal and nearshore habitat restoration, discussed and implemented under the Wetlands, Coastal, and Nearshore Habitats Restoration Type (Section 5.5.2).

For injuries to coastal habitats, including estuarine coastal wetland complexes, in the northern Gulf of Mexico and resources that use these habitats (e.g., fish, invertebrates, and birds), the PDARP states this goal:

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 (PDARP 5.5.2.1, Goals of the Restoration Type).

Furthermore, the PDARP/PEIS recognized that performance criteria as well as robust monitoring and adaptive management would be needed to determine the success of restoration or need for interim corrective action (PDARP 5.5.15). In order to achieve this, regional-scale environmental monitoring networks may need to be developed to support restoration planning, implementation, and evaluation in geographic areas where a large number of restoration projects are concentrated (PDARP 5.5.15). These activities would lead to increased likelihood of successful restoration and could also provide feedback to inform decision-making for current projects and refine the selection, design, and implementation of future restoration activities (PDARP 5.5.15).

The activities described above will clearly address many of the key areas of restoration outlined in the PDARP/PEIS by leveraging a long-term data set and develop a new sampling protocol available for monitoring fish and invertebrate communities if future funding is prioritized for the approach. This MAIP will provide valuable data used to inform the planning and evaluation of large-scale restoration of coastal wetland habitat complexes. It is also consistent with the LA TIG MAM Strategy (DWH LA TIG 2021), supporting Cross-Restoration Type and WCNH Restoration Type Fundamental Objectives established, as described earlier in this MAIP.

5. National Environmental Policy Act (NEPA) Review

The Trustees' approach to compliance with NEPA summarized in this section is consistent with, and tiers where applicable from the PDARP/PEIS Section 6.4.14. Resources considered and impacts 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 Louisiana 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.

As discussed in Chapter 6 of the PDARP/PEIS, a TIG may propose funding a planning phase (e.g., initial engineering, design, and compliance) in one plan for a conceptual project, or for studies needed to maximize restoration planning efforts. This would allow the TIG to develop information needed leading to sufficient project information to develop a more detailed analysis in a subsequent restoration plan, or for use in the restoration planning process. Where these conditions apply and activities are consistent with those described in the PDARP/PEIS, NEPA evaluation is complete and no additional evaluation of individual activities is necessary at this time.

a. NEPA Review of MAM Activity: *Monitoring the Effects of Coastal Wetland Restoration on Fish and Invertebrates*

This activity would include minimally intrusive desk-top, data-based activities (Tasks 1, 3) and as such would not cause adverse impacts to any resource category and not require any additional environmental review, consistent with the previous evaluation in the PDARP/PEIS Section 6.4.14. Field activities (Task 2) would have minor impacts and are necessary to complete data-based activities (Task 3). Temporary impacts to the biological and physical environment could include short-term, temporary disturbance of intertidal and subtidal coastal wetland habitat complexes (e.g., marsh, mangrove, oyster, submerged aquatic vegetation [SAV], and shallow mud habitat) and associated species. These minor impacts would be caused by the use of fixed-area sampling gear that may temporarily disturb the marsh platform and benthic habitats (i.e., oyster and SAV) adjacent to marshes during sampling. The risk of entrapment of protected species (dolphins and sea turtles) while sampling is negligible given the small area sampled by fixed-area gear (~2.6 m^{-2}); however, protocols such as maintaining vigilant watches for protected species before deployment of the gear will be followed to further minimize this risk. Other minor impacts or disturbances could impact protected species or estuarine habitats due to the operation of small boats while conducting field sampling. To minimize or avoid these disturbances, best management practices will be used, such as operating at minimum safe speeds and maintaining vigilant watches while in transit by assigning designated individuals to observe for protected species. Field sampling will be conducted during daylight hours, thus maximizing the ability to observe potential interactions with protected species and habitats. Sampling will be conducted year-round, and thus a constant vigilance would be necessary for resident protected species, such as dolphins occurring in inshore waters. Analysis of the data collected, planning meetings, and preparation of reports are data-based components of this MAIP, but these activities would not cause adverse impacts to any resource category and not require any additional environmental review, consistent with the previous evaluation in the PDARP/PEIS Section 6.4.14.

Consistent with the analysis in Section 6.4.14 of the PDARP/PEIS, environmental consequences would be direct, short-term, minor impacts through the associated field work. NOAA has many years of

experience in this type of data collection and has previously developed specific protocols that must be adhered to should field operations lead to interactions with marine mammals, sea turtles, and Diamondback terrapins during sampling or other activities related to the execution of fieldwork. Based on review of the proposed activities against those actions previously evaluated in the PDARP/PEIS, no additional NEPA evaluation is necessary.

b. NEPA Conclusion

After review of the proposed activities against those actions previously evaluated in the PDARP/PEIS, the Louisiana TIG determined that the environmental consequences resulting from this MAM activity falls 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.

6. Compliance with Environmental Laws and Regulations

The Louisiana TIG has completed technical assistance with the appropriate regulatory agencies for this project. Project Tasks 1 and 3 consist of analysis of existing data and thus permits and consultations are not required. Task 2 of this project includes field sampling activities, and thus may require permitting and consultations with relevant state and federal agencies; where possible, existing permits and consultations will be reviewed to determine if they are sufficient to complete the work or if additional compliance work is needed. For the status of reviews under Federal regulatory statutes, see the table below.

Federal environmental compliance responsibilities and procedures follow the Trustee Council Standard Operating Procedures (SOP), which are laid out in Section 9.4.6 of that document. Following the SOP, NOAA as the Implementing Trustee will ensure that the status of environmental compliance (e.g., completed vs. in progress) is tracked in DIVER.

Documentation of regulatory compliance will be available in the Administrative Record that can be found at the DOI's 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/.

Table 3. Status of federal regulatory compliance reviews and approvals for the proposed project: Monitoring the Effects of Coastal Wetland Restoration on Fish and Invertebrates.

Federal Statute	Compliance Status
Bald and Golden Eagle Protection Act (USFWS)	Complete
Coastal Barrier Resources Act (USFWS)	In Progress
Coastal Zone Management Act	In Progress
Endangered Species Act (NMFS)	Complete
Endangered Species Act (USFWS)	Complete
Essential Fish Habitat (NMFS)	Complete

Marine Mammal Protection Act (NMFS)	Complete
Marine Mammal Protection Act (USFWS)	Complete
Migratory Bird Treaty Act (USFWS)	Complete
National Historic Preservation Act	Complete
Rivers and Harbors Act/Clean Water Act	In progress
National Environmental Policy Act	Complete, NEPA analysis described in Section 5, above.

7. References

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