Gulf Coast Ecosystem Restoration Council
Applicant and Proposal Information Summary Sheet

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Project Identification

Project Title: **Gulf of Mexico Habitat Mapping and Water Quality Monitoring Network**

State(s): FL, AL, MS, LA, TX | County/City/Region: ALL

General Location: *Projects must be located within the Gulf Coast Region as defined in RESTORE Act. (attach map or photos, if applicable)*

Project would be conducted across the Gulf with potential targeted case study areas.

Project Description

RESTORE Goals: *Identify all RESTORE Act goals this project supports. Place a **P** for Primary Goal, and **S** for secondary goals.*

_P_ Restore and Conserve Habitat
_P_ Restore Water Quality
_S_ Restore and Revitalize the Gulf Economy
_S__ Replenish and Protect Living Coastal and Marine Resources
_S__ Enhance Community Resilience

RESTORE Objectives: *Identify all RESTORE Act objectives this project supports. Place a **P** for Primary Objective, and **S** for secondary objectives.*

_S_ Restore, Enhance, and Protect Habitats
_S_ Restore, Improve, and Protect Water Resources
_S_ Protect and Restore Living Coastal and Marine Resources
_S_ Restore and Enhance Natural Processes and Shorelines
_S__ Promote Community Resilience
_S__ Promote Natural Resource Stewardship and Environmental Education
_P__ Improve Science-Based Decision-Making Processes

RESTORE Priorities: *Identify all RESTORE Act priorities that this project supports.*

_X_ Priority 1: Projects that are projected to make the greatest contribution …
_X_ Priority 2: Large-scale projects and programs that are projected to substantially contribute to restoring…
_X_ Priority 3: Projects contained in existing Gulf Coast State comprehensive plans for the restoration ….
_X_ Priority 4: Projects that restore long-term resiliency of the natural resources, ecosystems, fisheries …

RESTORE Commitments: *Identify all RESTORE Comprehensive Plan commitments that this project supports.*

_X_ Commitment to Science-based Decision Making
_X_ Commitment to Regional Ecosystem-based Approach to Restoration
_X_ Commitment to Engagement, Inclusion, and Transparency
_X_ Commitment to Leverage Resources and Partnerships
_X_ Commitment to Delivering Results and Measuring Impacts

RESTORE Proposal Type and Phases: *Please identify which type and phase best suits this proposal.*

___ Project ___ Planning _X_ Technical Assistance ___ Implementation
_X_ Program

Project Cost and Duration

Project Cost Estimate:		**Project Timing Estimate**:
Total :	**$21,401,000 over 5 years**	Date Anticipated to Start: April 2015 Time to Completion: 5 years Anticipated Project Lifespan: > 20 years

Gulf-wide Habitat and Water Quality Monitoring Network

1.0 Executive Summary

A comprehensive environmental monitoring network for habitat and water quality is a foundational element necessary to make scientifically-sound decisions regarding the health and viability of the Gulf of Mexico ecosystem. Relevant information is required for managers operating at different geographic scales to make informed decisions to effectively manage ecosystem resources across the Gulf of Mexico. The Gulf Ecosystem Restoration Council (Council) requires a spatially and temporally comprehensive multi-media monitoring network to track the condition of important ecosystem components, including water quality and other habitat features which sustain its living resources. In the context of Gulf protection and restoration, an environmental monitoring network will provide this information which is necessary to support the development, selection, and application of successful management and restoration project alternatives, and inform adaptive management decisions at the local, state, and regional levels.

Monitoring is currently being conducted in the Gulf of Mexico by a variety of state, federal, local, academic, and private entities. Over recent years many organizations, including the Gulf of Mexico Alliance (GOMA), the Gulf of Mexico Coastal Ocean Observing System (GCOOS), and the National Academy of Sciences, have stated the need to coordinate this monitoring into a cohesive gulf-wide network for use in science-based decision-making, to determine and prioritize monitoring needs and gaps, and to fill high-priority monitoring needs. NOAA and USGS propose to establish just such a Gulf-wide monitoring network, initially focused on habitat and water quality, but expandable to include all types of monitoring activities as the list of targeted items for Council restoration grows. This monitoring network is essential to building the scientific foundation needed to realize the Gulf Coast Ecosystem Restoration Council's goals and objectives of habitat and water quality restoration and conservation, and improving its science-based decision-making processes.

The formation of the Gulf-wide habitat and water quality monitoring network begins as a joint NOAA/USGS-led effort that takes maximum advantage of long-established, existing scientific and management strengths and track records of the two agencies – NOAA's "blue-water" open ocean expertise, USGS's freshwater or "brown-water" expertise, and their combined expertise in "green-water", estuarine and coastal zones. This 5-year program will lay the foundation for a governance structure and implementation strategy for an integrated network that leverages the breadth of current state, federal, or other regional programs to acquire existing and new habitat and water quality data, ensures quality assurance/quality control, and enhances data sharing and preservation. The network will establish consistent baselines that will effectively detect and track changes at the project level and landscape scale arising from planned activities (conservation, restoration), extreme weather events (storms, cold snaps), climate change/sea level rise, and accidents (ship groundings, oil spills). The monitoring network will be designed in accordance with adaptive management principles to insure strong connections with restoration decision-making and maximize opportunities for learning.

The basic approach to building the Gulf habitat and water quality monitoring network is to: 1) adopt, or construct as needed, a comprehensive inventory of existing habitat and water quality observations and monitoring programs in the Gulf;[1] 2) evaluate the suitability/applicability of each program and its existing and prospective data; 3) coordinate and integrate appropriate existing observations and monitoring systems to form a regional monitoring network with an integrated data management structure; 4) identify information gaps; and 5) strategically supplement and refine observations and monitoring systems to fill the acknowledged gaps with available capabilities and capacity of all the regional partners. Although this proposal is being led by NOAA and USGS, both of whom bring existing resources, capacities, and expertise, the monitoring network will employ a collaborative organizational structure that will incorporate all restoration partners through the development of a monitoring Community of Practice (CoP). The CoP provides opportunities to: share lessons-

[1] Inventories of Gulf of Mexico monitoring efforts have been developed (e.g., Appendices C – E, GOMA Water Quality Team 2013, White Paper on Gulf of Mexico Water-Quality Monitoring. Tallahassee, FL.)

learned, best practices, and resources; collect high-quality data and maintain consistency and compatibility in data used to help assess restoration success of Council-selected projects; and help ensure that the many existing and new monitoring programs (such as NAS, NOAA RESTORE Act Science Program) are leveraged by the Council, reducing duplication of efforts and monitoring costs for Council-funded projects, and the Gulf ecosystem as a whole. The CoP will use strategic workshops, and other collaborative tools, to conduct the inventory, identify gaps, develop criteria for prioritizing monitoring needs and collaboratively develop the regional network to fill these needs.

Gaps in habitat data collection will be strategically filled using mapping, assessment, and monitoring of numerous parameters describing the seafloor (e.g., depth, topography, and geomorphology), upstream, estuarine/coastal habitats, and associated benthic communities. While habitat mapping is a valuable stand-alone product, it is also a foundational platform upon which other research and management programs can be built. We will catalogue existing aerial mapping coverages, prioritize gaps relative to management needs, and execute high-quality data collection to produce habitat maps at multiple scales and resolutions. NOAA and USGS have successfully utilized this approach and will bring to the Gulf of Mexico a comprehensive habitat classification strategy that includes use of existing NOAA, USGS, and USFWS land cover databases (NLCD, C-CAP, NWI) and use of the Coastal and Marine Ecological Classification Standard (CMECS). This comprehensive strategy will allow for the interoperability of habitat data collected from disparate sources across the Gulf of Mexico.

Likewise, water quality monitoring gaps will be addressed by: (1) evaluating the comprehensive inventory and gap analysis of existing water quality monitoring programs from upstream, freshwater inflows, to estuarine and coastal habits, and out to blue waters; (2) holding workshops, building on the work of the GOMA and others, to glean details of existing data sets, data access, study designs, standard operating procedures, instrumentation, products generated, and local concerns of experts and users; (3) augmentation/refurbishment of existing program infrastructure with modern instrumentation and broader sensor suites; and (4) strategic placement of additional water quality measurement instruments (and/or AUVs) to improve modeling capabilities, fill gaps between systems, cover deeper waters, and target high-use locations where accident risks are greatest.

This innovative, joint NOAA/USGS effort and the use of the monitoring CoP will generate a well-designed and broadly communicated program that addresses the region's needs, without growing the federal government presence. Cross-institutional support will be garnered by inclusive management, data collection, open access to standardized data, involvement of gulf-wide experts, active stakeholder involvement, and a system that is adaptable to changing needs and priorities. Longer-term support will be achieved as stakeholders realize the benefits of the program, which will include participation of pooled regional expertise in monitoring and analyses, shared data streams that provide broader context for local studies and problems, and easy access to historical and current environmental data.

2.0 Proposal Narrative

2.1. Proposal introduction and background

Monitoring information must be made available to managers operating at different geographic scales for making informed decisions and modifying their actions as needed to effectively manage ecosystem resources across the Gulf of Mexico. Ecosystem-based adaptive management is a process wherein actions are modified in relation to their efficacy for restoring or maintaining an ecological system in a desired state or ecological potential (Holling and Gunderson 2002). A key component of adaptive management is a feedback mechanism based on characterizing current ecosystem conditions and measured responses to management actions supplemented with an understanding of the system dynamics and baseline condition. This information is obtained through rigorous monitoring, modeling, and research combined into integrative assessments and synthesis (Walker, et al. 2012).

Establishment of baseline conditions for watersheds and estuarine, coastal, and offshore waters will provide reference points from which to measure ecosystem change and management effectiveness (e.g., efficacy of protected resource recovery plans or habitat restoration methods). Ultimately, a comprehensive network using the most innovative capabilities will result in long-term improvements to the quality and availability of spatially explicit data strengthening resource assessments, indicator development, and ecosystem models, and improving their utility as decision-support tools in the Gulf of Mexico.

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

To have access to these data and derived tools, resource managers require a spatially and temporally comprehensive multi-media monitoring network to determine the condition of important ecosystem components, including the climatological, biogeochemical, physical oceanographic and other habitat features critical to fully understand the health and demographics of living resources. Likewise, in the context of Gulf protection and restoration, a comprehensive observations and monitoring network will provide the data foundation necessary to support the development and selection of management and restoration project alternatives at the individual project and regional scales.

NOAA and USGS propose to establish a Gulf-wide network for habitat and water quality monitoring essential to realizing the Gulf Coast Ecosystem Restoration Council's goals and objectives of: habitat and water quality restoration and conservation; and improving its science-based decision-making processes. The serious lack of time-series data on habitat and water quality throughout the Gulf region hampers Deepwater Horizon oil spill damage assessment and can compromise RESTORE's restoration efforts. Moreover, lack of data weakens ensuing response, assessment, and recovery efforts stemming from future events. This program will be an investment in the next generation of comprehensive environmental management tools to generate information that will allow identification and proactive management of at-risk areas; and lessen the potential for damaging situations. The foundation for these tools is monitoring and assessment approaches that will be used to quantify ecosystem status, ecosystem trajectory, and predict ecosystem response to both injury and restoration.

The Gulf Coast Ecosystem Restoration Task Force recommended the development of a comprehensive monitoring strategy that would integrate existing monitoring networks, assemble and share monitoring data, and ensure data collected would support management decision-making (Walker et al. 2012). Monitoring in the absence of an adaptive management framework commonly leads to a disconnect within decision-making processes, and limits the learning that results from monitoring (Steyer and Llewellyn 2000, Convertino et al. 2013).

Habitat and water quality are two major focus areas identified by the Council for inclusion in its initial Comprehensive Plan under the goals of the RESTORE Act (GCERC 2014). This program will be an important step toward developing its capacity to monitor, diagnose, and act upon changes in the Gulf's open water and coastal environments. The term "habitat" refers to biotic and abiotic seafloor, the water column, estuarine, coastal, and watershed features that support living aquatic resources, including hard- and soft-bottom substrates, oyster, coral and artificial reefs, seagrass meadows, algal plains and mudflats, and mangrove and herbaceous marshes. We use "water quality" broadly to encompass physicochemical habitat properties (temperature, salinity, turbidity, pH, dissolved oxygen) and chemical and biotic constituents (nutrients, contaminants, Chl *a*) that can influence processes ranging from physiological through ecological. The program focuses on water quality and habitat monitoring and assessment spanning from blue water to brown water, and will be a foundation for other important related facets of the ecosystem (e.g., living marine resources, development planning, human community planning, and sustainability) which are not the express focus for this competition.

An oyster reef example

How the monitoring network would improve restoration decision-making

In order to restore degraded oyster reef habitat it is first necessary to locate the appropriate site(s) for the restoration activity. This entails developing a clear understanding of suitable habitat available for oyster survival, growth, and reproduction, which a function of benthic habitat type and condition, water quality (depth, salinity, temperature, and dissolved oxygen), hydrodynamics, and sedimentation regime. The information that must be gathered to build this understanding comes from integrated habitat and water quality observation, mapping, and monitoring efforts. Furthermore, this information will inform reef project design, construction methodology, and implementation. Finally, post-restoration monitoring will provide tools to evaluate the efficacy of the selected restoration methods, including quantification of ecosystem services, and inform future protection and restoration efforts at the project level, and across the region.

The proposed Gulf-wide habitat and water quality monitoring network is a 5-year program designed to lay the foundation for an integrated system of data collection and sharing to establish ecosystem baselines. The program's premise is that more effective, holistic, and integrated approaches to managing the Gulf ecosystem can be achieved by cooperative work across institutional and disciplinary boundaries. The monitoring network is a joint, interagency, NOAA/USGS effort that takes advantage of long-established scientific strengths and track records of the agencies – NOAA's blue-water expertise; USGS's brown-water expertise; and their combined expertise in green-water, coastal zones, in close collaboration with ongoing efforts by state and regional entities. The network will effectively be able to detect and track changes arising from planned activities (conservation, restoration), extreme weather events (storms, cold snaps), climate change/sea level rise, and accidents (ship groundings, oil spills).

To further transcend traditional boundaries, NOAA and USGS will partner with external monitoring practitioners throughout the Gulf to inventory existing efforts and to develop the regional monitoring network. These monitoring practitioners will be part of a larger monitoring community of practice (CoP). The CoP provides opportunities to: leverage collective capabilities and capacity, share lessons-learned, best practices, and resources; discuss ways to collect high-quality data and maintain consistency and compatibility in data used to assess restoration success; and help ensure that existing and new monitoring programs (e.g., NAS, NOAA RESTORE Act Science Program) are leveraged by the Council, reducing or eliminating duplication of efforts and monitoring costs for Council-funded projects. Although this proposal is being led by NOAA and USGS, the monitoring network will employ a collaborative organizational structure and decision-making processes that will incorporate all restoration partners.

Program Goals and Objectives: This effort will lay the foundation for a regional habitat and water quality monitoring and assessment network built by coordinating existing observations and monitoring programs. It will rely upon standardized and repeated measurements in the field, a well-structured data management system that will ensure standardized data formats, high data quality standards, open sharing of methods, protocols, and

data, and an effective framework to disseminate data. Monitoring network objectives include: (1) achieving coordination and uniformity of methods among entities currently involved in habitat assessment and water quality measurement by facilitating a Gulf region monitoring CoP; (2) bridging from the present system of largely independent sampling programs of limited scope, to an enterprise-level, organized, efficient, responsive Gulf-wide program that supports multiple end-users; and (3) expanding the network to cover a wide range of water depths, substrates, habitats, and biogeographic zones within the Coastal, Shelf, and Basin Ecological Regions. The monitoring network development described in this proposal lays the foundation for improving the region's scientific and system management capabilities and enhancing human community preparedness in the event of future natural and anthropogenic disturbances/disasters.

We are aware that some of the activities proposed here are synergistic with activities proposed in with the joint EPA/USGS monitoring proposal. Should that project be funded, we will work with EPA to avoid duplication, to maximize complementarity, and to adjust budgets accordingly.

HABITAT MAPPING, ASSESSMENT, AND MONITORING

Habitat mapping will identify the defining characteristics of aquatic and terrestrial environments including seafloor depth, bottom topography, rugosity (small-scale variations in the height of the seafloor surface), geomorphology, benthic biological communities, and estuarine and coastal habitats. Habitat mapping can identify biologically active areas with associated living aquatic resources such as commercially and recreationally important fishes and invertebrates, and vegetation community transition areas susceptible to sea-level rise. Habitat-mapping products provide foundational baselines to address high-priority science and management needs in the Gulf, including broad-scale natural-resource characterizations; ecosystem-based approaches to fisheries management; conservation of critical seafloor and coastal habitats (seagrass, oyster reef, deep-sea corals, mesophotic reefs, and rocky/live bottom reefs) and protected species (sea turtles, marine mammals, corals, some fishes); vegetation community dynamics and associated species of concern; detection of ecosystem change in relation to both natural events (hurricanes, sea-level rise) and potential anthropogenic impacts (oil spills); informing spatial-planning decisions related to multi-sector uses of aquatic ecosystem spaces; as well as the identification of places suitable for or in need of restoration actions. While habitat mapping has been identified as a fundamental need in the Gulf for restoration and damage assessment purposes, there are few products to adequately support this spatially explicit process. For example, an analysis of the current inventory of habitat-mapping products for Florida indicates that contemporary data of sufficient resolution, quality, and type are available for only about 5% of the state, and that derived habitat-mapping products are available for only about 1% of the state's marine waters.

NOAA and USGS have the necessary expertise and capacity to lead the coordination of habitat mapping in the Gulf (see Section 9-B for specifics); however, the CoP will identify, prioritize and fill habitat mapping gaps by coalescing critical and complementary scientific expertise and mapping assets within NOAA and USGS with other Gulf of Mexico state, federal, and academic partners (Figure 2). This partnership will aid technology transfer to state partners, and institute a process whereby the states and others can provide targeted input as to where habitat-mapping and restoration activities should occur, as well as participate in data acquisition when relevant capabilities and capacity are available.

The habitat-mapping component will bring together a suite of technologies and assets to document the spatial distribution and condition of aquatic and terrestrial habitats, from the shoreline to the deep sea, where NOAA has partnered with BOEM to map deep sea biological communities, and inland emergent vegetation communities where USGS and USFWS have partnered to update National Wetland Inventories. These activities span multiple ecological regions of the Gulf (Figure 1). The technology implemented will be based on physical location, and will include acoustic imaging (side-scan, multibeam), satellite and aerial imagery, airborne bathymetric LiDAR, unmanned system technologies (ROV, AUV), and companion optical verification systems (ROV-mounted still cameras and video, drop cameras, and towed cameras). Areas targeted for mapping will be based upon a set of criteria developed by consensus within the CoP, but most likely will include known

data gaps (such as unmapped areas), anticipated hot spots of biological activity (oyster reefs, wetlands, deep-sea corals, mesophotic reefs), and regions where recent restoration has occurred. The habitat-mapping efforts will utilize authoritative mapping guidelines, requirements, and standards such as those described in Cowardin et al. (1979), and will incorporate metrics to track and evaluate the success of these efforts.

The habitat-mapping component of this program will provide valuable information to address a variety of restoration and other high-priority science and management needs. While the proposed program is conceived initially as a 5-year endeavor, the foundational benefits of having such a network in place should extended into future years through a continuation of related work as warranted. This extension will allow us to develop a time-series to detect changes in habitats over time and attribute these changes to either natural variability or anthropogenic activities.

WATER QUALITY MONITORING

Water quality monitoring will take advantage of existing comprehensive networks and national data collection and quality assurance standards of NOAA, USGS, and other agencies as appropriate. There are about 1,600 real-time, continuously monitored gaged sites on streams, bays, and wetland locations operated by personnel from USGS Water Science Centers in the 5 Gulf States (includes the Mississippi River Basin locations). Within this gage network, flow is monitored continuously at 1,150 stream locations, water quality sondes are deployed at about 300 locations (water temperature, specific conductance, pH, dissolved oxygen, turbidity, nitrate, CDOM, etc.), and water quality samples are collected at about 250 locations (analyzed for mostly sediment and/or nutrients). In addition, there are about 390 wetland sites that are operated within the Coastwide Reference Monitoring System (CRMS) in Louisiana as part of a collaborative effort between the State of Louisiana and the USGS National Wetlands Research Center in Lafayette, LA. The purpose of this network is to monitor and evaluate the effectiveness of coastal wetland restoration projects. Data available through CRMS include hydrology, herbaceous marsh vegetation, forested swamp vegetation, soil properties, soil accretion, and surface elevation.

Data from USGS gaging networks will be integrated with similar networks operated by NOAA, such as the National Estuarine Research Reserve System (NERRS) of 28 reserves (Figure 3), including five in the Gulf of Mexico (Rookery Bay NERR, Florida; Apalachicola NERR, Florida; Weeks Bay NERR, Alabama; Grand Bay NERR, Mississippi, and Mission Aransas NERR, Texas). The NERRS System-wide Monitoring Program (SWMP) is a coastal observing system that collects data from standardized instrumentation for a comprehensive suite of water quality and weather parameters across a wide geographic area and over a continuous operating period (17 years), using standardized protocols.

Both agencies operate integrated databases that serve monitoring data to the public via web interfaces. For the USGS, all data collected by Water Science Centers are entered into the National Water Information System (NWIS) and are served to the public via the NWIS web interface (NWISweb). The NERRS operates a centralized programmatic database that is interoperable with other databases in the Gulf region. Both databases meet national standards for data archival, metadata and quality assurance, and provide efficient and effective portals for data access and interpretations.

The USGS National Stream Quality Accounting Network (NASQAN) and NOAA SWMP data have been instrumental in identifying hypoxia/anoxia events that impact coastal ecosystems by providing indicators of estuarine water quality and coastal habitat condition. The data have been used to establish health risk criteria, track hazardous material spills, enhance weather and flood forecasts and ecosystem response predictions, and for search and rescue operations.

In addition to the freshwater and estuarine monitoring programs described above, we will partner with GOMA to work towards the goals of a Gulf-wide water quality monitoring network (GMN) to: integrate existing and new monitoring and related research and technology development efforts to aid in answering local, regional, and Gulf-wide questions; promote inter-agency data sharing and the expansion of international partnerships; and provide real-time or near real-time observations and provide synthesized information and

products. GOMA provides specific recommendations including implementation, oversight, and evaluation for attaining the GMN goals, as well as meeting restoration goals in the Gulf. Furthermore, we will collaborate with the Ocean Observing Systems programs (NOAA-IOOS, GCOOS and SECOORA) that have grown from experimental deployments to the current state of canvasing entire coastlines. These programs are maturing and are now moving toward standardization of methods and collection of essential observational variables (EOVs) as part of the Global Ocean Observing System (IOC/UNESCO). Of the 43 EOVs considered, 10 currently are being pursued on the grounds of both feasibility and impact on system management. This project will review the EOVs recommended, maintain those currently monitored by NERRS, and augment with additional locations and variables related to regional issues as appropriate – including known and emerging contaminants. Important variables that cannot be measured easily will be identified and forwarded as priority research items for instrument development through the RESTORE Science Program.

Fixed platforms throughout the Gulf (e.g., energy development/production and navigational infrastructure) offer excellent opportunities for deploying, operating, and maintaining water quality instrumentation. The USGS has fixed monitoring platforms available along the Gulf coastline, many of which are flood-hardened and protected against storm surge. These platforms and the water quality instrumentation installed at each provide opportunity to determine overall trends in critical water quality parameters through time to assess Gulf health at fixed locations. It is recommended that additional water quality monitoring equipment be installed at other locations around the Gulf to complete a bay and estuary monitoring network similar to that installed along the coasts of Louisiana and Mississippi. The fixed network could include installation of monitoring equipment at newly constructed platforms or at fixed buoys operated by NOAA.

However, because the platforms are stationary, another solution is required for sampling the large areas between fixed stations. Autonomous underwater vehicles (AUVs) are now mature and useful technologies that are under-utilized in the Gulf. Contemporary AUVs have mission durations approaching a full year and can operate without intervention across all of the water masses seen in the Gulf of Mexico. They are also capable of surveying to depths of 1000 m with deeper capabilities currently under development; these are depths at which we have sparse information. Glider fleets operate in several areas of the US exclusive economic zone; the US Navy relies on them for battle-space characterization, and one recently completed a survey across the entire Atlantic Ocean. These vehicles can be re-tasked via satellite communications while at sea, and telemeter data to shore-side stations or fixed monitoring platforms via those same communication links. These capabilities allow gliders to offer a cost-effective continuous presence in the environment far beyond the ability and costs associated with ships. Thus, gliders are critical to establishing baseline conditions in the increasingly developed offshore zones in the Gulf. This program proposes to establish an adaptable AUV fleet in the Gulf of Mexico as an integral component of the monitoring network to fill spatial gaps and increase sampling in data deficient offshore and deep areas of the Gulf.

Data Management System – This program seeks a unified data management system to aggregate, quality assure, store, and disseminate environmental data for the Gulf. There are a variety of active data management entities in the Gulf region, including NOAA's National Coastal Data Development Center, Gulf of Mexico Coastal Ocean Operating System, and Gulf Research Initiative Information and Data Cooperative, as well as national-level efforts such as the USGS and NOAA programs mentioned above. These programs have an established history of regional cooperation in collaboration with GOMA. Leveraging existing systems and expertise, we will build an integrated, standards-based, largely virtual system that will support web-based discovery of and access to data streams for diverse end users. The system will utilize existing capabilities (web portals, catalogues, archives) where possible, adding new capabilities as necessary.

This program will establish clear and consistent data management, monitoring, adaptive management, and science delivery policies as part of its overarching strategy. It will include on-line tools and spatial mapping applications for data discovery, dissemination, and integration building, for example, off of previous USGS successes with regional monitoring and adaptive management programs (e.g., Louisiana's CRMS,

Nonindigenous Aquatic Species, Joint Ecosystem Modeling, Coastal Information Management System, etc.) (see Section 7 Data/information sharing). Throughout, standards for data description, formats, and services (for catalogue queries, Web mapping and data access) will be employed to promote interoperability. These data sharing policies and standards will enhance the ability of the Joint Synthesis and Prediction program (proposed separately) to produce beneficial analysis, synthesis, and data products, and will promote seamless integration into other standards-based data management infrastructures ranging from RESTORE Council partners, regional and national mapping programs such as NOAA's *Gulf of Mexico Data Atlas* and USGS's *The National Map,* or state programs such as Mississippi Coastal Improvement Program or Louisiana Coastal Information Management System. This approach minimizes the loss of institutional knowledge by operating under a long-term data management plan and maximizes data exposure and availability through compliance with international data sharing standards.

2.2 Implementation methodology

Inventory and Evaluation of Existing Habitat and Water Quality Data – The methodology for a comprehensive monitoring network in the Gulf of Mexico will be based on inventory and evaluation of existing data as the first step. Gaps will be analyzed with input gathered from all stakeholders to determine regional spatial priorities. These regional spatial priorities will then be filled with new data collection via a variety of methods. The new and existing data will then be shared in an interoperable data system. Monitoring products (e.g., habitat classification maps, spatial analysis tools) will be created from this interoperable data system to meet management and scientific needs in the Gulf of Mexico. A large body of habitat mapping data, water quality data, and monitoring products has already been produced for the Gulf. As an example, a detailed description of present NOAA and USGS data collection efforts, databases, data repositories, and related information is provided in Section 9-C. However, disparate groups (federal, state, academic, private sector, and NGOs) conducted these efforts to support a variety of purposes with no centralized governance structure to coordinate and consolidate information and strategically plan future collection efforts. The lack of regional coordination and a centralized repository has limited the awareness, dissemination, and ultimately the utility of this information.

Discovering data that are not in a public inventory requires close coordination with external mapping and monitoring groups to identify and request missing information. USGS has assessed vulnerabilities of coastal shorelines and wetland and seagrass status and trends. NOAA has taken similar action in many marine environments, including the Pacific Coast of Washington (Figure 4). In doing so, USGS and NOAA were able to identify important but missing data sets, create visualization tools for users to see the extent of existing mapping and monitoring coverage of specific habitats, and further a process to evaluate the reuse of existing data (Menza et al. 2014). USGS proposes to conduct a similar effort in the Gulf, with NOAA conducting an additional step of translating habitat data into the CMECS framework to facilitate data comparison and interoperability in marine environments. Combining these approaches will contribute to a more seamless inventory. This framework will also be useful for incorporating products from new data collection efforts.

Planning for future mapping and water quality monitoring in the Gulf requires this comprehensive understanding of available data, but it is also important to assess data quality and utility. Data are collected for a variety of applications across a range of standards, which can impact their utility for meeting contemporary needs. Assessing the quality of existing data and the data collection procedures is a critical planning step to determine if the available data will be appropriate to meet current needs, or new data collection is necessary. There are many active state, regional, and national monitoring programs in the Gulf region utilizing standard monitoring methodologies and operating procedures. Some of these methodologies are current (e.g., Stockdon et al. 2012), whereas others have been in place for decades and utilize older sampling approaches. Our data library will categorize existing procedures and a minimum acceptable standard will be recommended to the Council for adoption, once vetted within the monitoring CoP. In many cases, the best available information will be sufficient, but new data collection may be necessary when more resolved or contemporary data are needed or

data gaps exist. To ensure consistent and compatible data are collected from all Council projects and can be synthesized into larger ecosystem assessments, minimum quality assurance and quality control guidelines must be met. Data quality policies of existing Gulf and watershed monitoring programs will be reviewed for five aspects of data quality -- representativeness, completeness, comparability, accuracy, and precision. From this assessment, the Gulf monitoring CoP will develop guidelines to support the Council's review of new proposals based on these five aspects of data quality.

Determining Regional Spatial Priorities – Defining the parameters for a comprehensive habitat mapping and water quality monitoring effort is challenging. Achieving consensus among a broad range of users is inherently difficult, particularly in regard to explicit management challenges, the types of products needed, and locational priorities. Monitoring investments must also strategically consider the applications of these data for management activities including regulatory considerations, living marine resource management, coastal development, conservation lands identification, risk assessment, change analysis, and anthropogenic impacts. This process must embrace conditions that encourage the maximum utility of the data and support multiple applications. Success will result from the inclusion of collaborators across state, federal, academic, and NGOs (non-governmental organizations) for cost-sharing and the identification of needs, applications, and priorities (Battista and O'Brien 2012).

We will use a stepwise process for consensus-building that starts with the development of standard criteria against which monitoring gaps and needs will be scored. The CoP will then score the identified needs and gaps relative to how well they meet these criteria. This process has been employed to develop consensus when developing ecosystem indicators and minimizes bias helping broad groups of stakeholders reach consensus (Doren et al., 2009).

Through this method, we will implement a quantitative process to spatially prioritize habitat mapping and water quality monitoring. We will investigate status and trends and spatial-temporal variability of areal extent of marine, estuarine, freshwater, and terrestrial habitats and will utilize information contained in existing large-scale land-cover detection databases such as the USGS National Land Cover Database Program, the USGS Coastal Hazards Portal, the NOAA Coastal Change Analysis Program, and the National Wetland Inventory, along with habitat quality information available through the USGS Landsat Program and other platforms. This dataset will be a baseline for RESTORE Council projects focused on habitat protection and restoration. Physical and environmental factors will be included to develop a multi-criteria evaluation to assess effects of habitat extent variation, providing information that we can then use to develop optimized Gulf-wide monitoring designs and indicators of restoration success based on these attributes.

A participatory geographic prioritization process will be implemented to identify regions of importance to maximize the effectiveness of available funding. This approach promotes the interaction and engagement of stakeholders through the use of spatial information to address decision-making processes about specific landscapes. The priority focus areas identified will likely encapsulate the convergence of several factors, including ecosystem value, potential for restoration, multiple-use conflict, regulatory issues, resource management, susceptibility to impact from future incidents, and potential for further coastal development. This approach has been used previously to design and develop Louisiana's CRMS (Steyer et al. 2003). Much like what will be needed for the RESTORE monitoring program, CRMS integrates data from multiple spatial and temporal scales and multiple sources generating visualizations, tools, and reports geared towards a wide range of user groups (Figure 5). The spatial-prioritization process, used in conjunction with a data inventory, will provide valuable direction for developing subsequent planning efforts and investment in data collection directed towards locations of highest importance and collecting data to address the explicit management needs identified (Battista and O'Brien 2014).

High-resolution circulation models with the ability to assimilate data and conduct observing system simulation experiments (OSSEs) in the Gulf of Mexico (Halliwell et al. 2014) will also be employed to provide purely objective information on the prioritization of monitoring needs and optimization of water quality data

collection. OSSEs are a broadly used technique for evaluating the improvement an observational system offers to the model and vice versa. They can ask, for example, if all stations in a suite of four are equally valuable for estimating salinity; if a station should be moved to another location; and how much improvement is gained by deploying new monitoring station(s). They can estimate the loss of precision and accuracy associated with the loss of a monitoring station(s). Thus, OSSEs can help inform the optimal configuration of the monitoring system and the intelligent expansion and contraction of this monitoring system. Conducting iterative OSSEs as monitoring systems are implemented creates a positive feedback, whereby the observational system improves the model that in turn improves the observational system, and so on. This system was vital to the development of weather forecasting in the US.

Habitat Mapping Data Collection – NOAA is a recognized leader in seafloor and coastal habitat mapping to support marine conservation, disaster response, resource management, regulatory management, and navigational safety, and USGS is a recognized leader in land-based mapping of terrestrial and aquatic habitats. NOAA and USGS together bring unparalleled expertise and ability to provide the Gulf and its watershed mapping services that address the size in scope and complexities of the Gulf region. Unique strengths include: (1) experience planning and executing seafloor-mapping projects, (2) experience in classifying estuarine and coastal habitats and conducting status and trends assessments; (3) a large number of assets that can be directed to this effort including ships, small boats, aircraft, sensors, and personnel, and (4) leadership in developing mapping standards, methods, and protocols for characterizing marine, estuarine, freshwater, and terrestrial habitats.

NOAA and USGS utilize a variety of sensor types to conduct seafloor mapping of coastal, estuarine, and marine environments from brown water to blue water (0-1,000 m depths). The optimum sensor for a project largely depends upon the spatial scale of the feature of interest (e.g., sediment grain size, biological cover, geomorphology, or cultural resources), water depth, and continuity of data coverage needed (Figure 6). Sensor types are generally grouped into three categories: (1) active and passive optical, (2) acoustic, and (3) physical sampling (ground truthing) (Figure 7). We propose to utilize a range of technologies that are best suited for the needs identified by the stakeholders during the prioritization process. A detailed description of sensor types is provided in Section 9-D.

Ground truthing – The quality-control process for habitat mapping requires visual ground truthing surveys. Typically, an unsupervised (computer automated) habitat classification is generated from acoustic and satellite mapping activities. Subsequently, visual surveys are conducted over each habitat class to verify the extent, character, and composition of habitats (Figures 8 and 9). Physical sampling tools include grab samplers and push-cores that measure sediment composition. Visual sampling tools include still and video cameras that measure abundance and size of fish and corals, for example. Deep-water surveys typically rely on Remotely Operated Vehicles (ROVs) or Autonomously Operated Vehicle (AUVs) to conduct ground truthing activities. The result of the ground truthing effort is a supervised (manual) habitat classification that refines and reinterprets the unsupervised classification effort.

Product Creation – Habitat maps describe the spatial distribution and abundance of aquatic and terrestrial resources. USGS will conduct a Gulf-wide assessment of status and trends of valued ecosystem attributes using aerial photography and satellite imagery. Valued ecosystem attributes include extent of shallow water, shoreline, wetlands, and important wildlife species (including endangered species). Information from USGS programs focusing on upstream freshwater ecosystems, wetlands, barrier islands, and species such as sea turtles, manatees, anadromous fish, wading birds, and shorebirds will form the basis of this assessment. This effort also will leverage data and information from state and federal agencies and programs (e.g., NOAA's C-CAP, DOI Landscape Conservation Cooperatives, and NPS Vital Signs Program). A list of ecosystem attributes to be assessed will be developed initially from a literature review of existing status and trends. An early project task

will be to finalize this list based on input from the monitoring CoP. The social-ecological value of these attributes and consensus on their suitability as indicators of restoration success will also be conducted.

Typically, habitat maps have been created from remotely sensed imagery using manual, pixel- and object-based classification. However, studies have shown that these classification methods alone are not ideal because the maps they produce: (1) are not synoptic, (2) are time-consuming to develop, (3) have low thematic resolutions, or (4) have low thematic accuracies. To address these deficiencies, NOAA has developed a novel, semi-automated object and pixel-based technique which can combine remotely sensed data (e.g., satellite, LiDAR, multibeam, sidescan) to characterize coastal ecosystems. The technique uses principal components analysis, edge-based segmentation, and Quick, Unbiased, and Efficient Statistical Trees (QUEST) to successfully partition the remote-sensing imagery into distinct habitat combinations of major and detailed geomorphological structure, as well as major and detailed biological cover (Figure 10) (Costa et al. 2013).

The NOAA approach uses algorithms to partition remotely sensed imagery into polygons (representing the boundaries of distinct habitat features) by determining their location relative to other features or by grouping neighboring pixels with similar spatial, spectral, and textual characteristics. The benefit of this method is that it is an efficient and objective way to develop habitat maps using spatial and textual information at multiple spatial scales, with a variety of remote sensing sources to cover the area of interest. This approach has been widely implemented by NOAA in multiple regions and has proven utility for application in seafloor mapping.

Anticipated Seafloor Mapping Products – The following product types are anticipated as part of the mapping effort, but the specific types of products will be defined by the prioritization process. Figure 11 illustrates the seafloor mapping products described below.

Seafloor Topography and Intensity - To provide meaningful and verifiable information about the distribution and composition of seafloor habitats, topographic and backscatter-derived images (intensity products) depicting the composition, roughness, and texture of the seafloor, are required. These data, combined with additional products that provide depth and topographic relief, are the foundation for building tools that identify and delineate benthic habitats. These products are critical precursors for determining the types and distribution of habitats, so that management can make informed decisions on where to focus restoration efforts and evaluate conservation effectiveness.

Derived Morphometrics - Surfaces derived from primary source data can highlight characteristics of the seafloor to provide additional context to delineate and identify seafloor habitat types. (e.g., curvature, plan curvature, profile curvature, rugosity, slope, standard deviation of slope, Bathymetric Position Index (BPI) and Topographic Roughness Index (TRI)). BPI will discern a flat area on top of a reef from a flat area at the base of a reef. TRI is comparable to rugosity, but it operates at coarser scales. These products are important building blocks for determining benthic habitats, and for determining how marine resources depend on the habitats for feeding, growth, refuge, and migration.

Benthic Habitats: Benthic habitat maps provide information about the extent and composition of estuarine, coastal, and marine resources. Knowledge of the associated species present, habitat structure, and physical characteristics of a habitat are critical to their management and conservation, and help to generate predictive habitat suitability maps that can anticipate the occurrence of these habitats in poorly surveyed regions. Benthic habitat data will be attributed and organized using the CMECS standard as a way to integrate data derived from the various technologies and to add to the existing data already in the CMECS inventory framework.

Biological – These data include mapping of biogenic sub-tidal and intertidal habitats including but not limited to seagrass, oyster beds, mangroves, hard-bottom reefs, as well as shallow, mesophotic, and deep-water corals. Habitat mapping products help to identify biologically sensitive areas, in order to support informed restoration and spatial-planning actions.

*Geological – Sediment texture and grain size distributio*n - Mud, sand and gravel-dominated areas provide very different habitats, so sediment grain-size composition and texture are essential components for habitat classification.

Sedimentary environment - the stability and suitability of different habitats for various species depend erosion, deposition and transportation of sediment. Mapping these sedimentary environments is important for habitat, but also helps planners anticipate the potential for change.

Water Quality Monitoring Data Collection - Gulf-wide estuarine, coastal, and marine water quality monitoring will begin with a comprehensive inventorying of systems currently in place, starting from inventory work done by GCOOS. We then will build upon the existing infrastructure and the comprehensive water quality monitoring program using NOAA's NERRS as a prototype. This prototype network will be expanded geographically and to include elements from Status and Trends and Stream Gauge programs by NOAA, EPA, and USGS. The complete network will be augmented by BOEM 5-yr planning exercises, NOAA/NSF-supported IOOS programs around the country, and large-scale interdisciplinary oceanographic research programs such as the South Atlantic Bight Recruitment Experiment and US GLOBEC. Subsequent steps will consist of: (1) augmenting existing coastal water quality stations (NERRS, CRMS) to an expanded network that includes heavy-use, high-risk locations (e.g., ports, passes, industrial sites), and also covers less-used sites that may serve early-warning roles or controls for Before-After Control-Impact (BACI) analyses; (2) establishing a network of offshore water quality and biota monitoring stations associated with oil-gas rigs, buoys, NOAA observation platforms, and other structures; (3) deploying a fleet of water quality sensor-equipped autonomous underwater vehicles (AUVs) persistently occupying transects in key areas, those that lack fixed sampling gear, or those that are difficult and expensive to sample – including the shelf and deep-water GOM; and (4) using a high-resolution hydrodynamic circulation modeling system that links coastal and offshore data streams and that supports the design, streamlining, and maintenance of the entire network, and facilitates interpretation of collected data. The latter will incorporate feedback loops between observational data and advanced circulation modeling (via OSSEs) that will lead to more accurate circulation models, more effective station placement, and more accurate data interpretation. This overall approach will enable "Objective Analyses" (Lynch and McGillicuddy 2001) that entails assessment, and ultimately, expansion of existing water quality monitoring instrument arrays to form a synoptic, Gulf-wide network.

The basic model for water quality data collection will be that of the NOAA NERRS with its established array of water quality stations and an excellent quality control program. This program will extend that array and large sections of its quality control program to the major estuaries, wetlands, and coastal ocean of the Gulf. Typical variables will be measured (N, P, Chl), as well as contaminants (mercury, PAHs, and harmful materials) that could be released due to accident or severe weather. In addition to instrumented water quality measurements, sediment samples will also be collected regularly. Local technicians will maintain the stations. This program could easily be paired with programs such as Mussel Watch to examine contaminant loadings and toxicity in organisms. Station siting will be informed by a combination of land-use data, water flow information, ocean color, habitat types, and planned use in the area or watershed. Such stations will also be established in association with oil platforms, oil industry service vessels, etc., to broaden the footprint. A quality control system will ensure that all instruments, measurements, and data are appropriate. This system will also examine the data automatically to identify deviations from expected patterns and will notify users deviations. Problems will be reported to appropriate local, state, and federal representatives for further investigation or management action.

The primary tools for water quality monitoring will include logging data sondes with a basic sensor suite (e.g., temperature, depth, conductivity, turbidity) and additional sensors (e.g., nitrate, ammonium, crude/refined oil) in modular fashion, and the network of existing sensors from participating water quality monitoring efforts. Data sondes will be deployed inshore and offshore.

Inshore and nearshore water quality monitoring: Workshops will be held and site visits made with those charged with data sondes to assess the: (1) spatial distribution and duration of data sonde arrays; (2) type, age, and condition of existing data sondes; (3) number, type, and temporal resolution of parameters; (4) standard operating procedures; and (5) data QA/QC, storage and dissemination policies. The proposed program will then

provide modern instrumentation as needed, sensor add-ons, and advice and guidelines for optimal sonde placement given both local and broader network needs.

Offshore water quality monitoring: This program element will take advantage of the broad spatial distribution of oil-gas rigs, buoys (NDBC, GCOOS, and navigation) and C-MAN stations which blanket the northern Gulf to address major water quality concerns.

Some oil-gas rigs are already instrumented. This program will select additional rigs for instrumentation to form a grid of communicating nodes which represents the wide range of water depths, substrates, and biogeographic zones. Each rig is a unique, vertically oriented reef habitat, albeit artificial, for fishes and invertebrates. These structures attract exploited reef and pelagic fish, which in turn, attract commercial and recreational fishing activity. The structures also attract numerous protected species. However, owing to their position, configuration, and operation, each rig poses a differential, persistent threat to Gulf habitats, water quality, and living resources, especially if they fail catastrophically. The purpose of this program element is two-fold: (a) to establish a platform-based monitoring network for offshore water; and (b) to advance capabilities to anticipate outcomes of rig failures on marine habitats and resources through hydrodynamic simulation modeling of water quality.

2.3. Monitoring and adaptive management of the project or program

The program components will use adaptive management to accommodate evolving needs of stakeholders and unforeseen events (e.g., oil spills, natural disasters) that may require a refocusing of priorities, or any changes in program protocols and scope. This process will involve feedback from state, federal, business, and academic partners to focus habitat-mapping and water quality monitoring efforts in areas of greatest concern and in need of management action (see Section 2.2 above). Such a process is based on the utilization of well-proven decision-support tools used successfully by members of the proposed science team in various other U.S. coastal regions (Battista and O'Brien 2014).

Adaptive management also can affect the choice of technologies employed by the mapping and water quality efforts. While the capabilities of these data acquisition technologies are well understood by scientists that use them, resource managers may be uncertain about how these datasets and the subsequent products can inform decision-making. Improving the discourse and mutual understanding between the data collector and the end user will help define what products are most effective to address regional management applications. Choosing the appropriate technology to fit a given management application is relatively straightforward, but only if the intent of the management application is understood. This will be an iterative process.

NOAA and USGS will work closely with stakeholders to better understand and adapt the best technology(s) suitable for a particular application. Scientists can provide guidance on the mapping and monitoring products possible, cost details, time to produce, and available sensors. Likewise, the resource manager can evaluate the information needed to support management decisions and describe the types and accuracy of information needed and the analytical products they require.

The proposed monitoring program will be adaptive in that a subset of water quality sensors will be relocated after evaluation of the quantity and quality of information that each yields, especially as that information pertains to local circulation patterns and variability. Data from this monitoring program will complement the Synthesis and Prediction effort separately proposed by USGS.

2.4. Measures of success for the proposed project or program

BOTH – The development of a coordinated monitoring network that incorporates existing and new data from all efforts in the Gulf region, shared freely with all partners. Other measures include the use of the consolidated monitoring resources by RESTORE Council projects. Monitoring can help evaluate whether restoration goals are met, whether conditions have changed with respect to the project baseline, and whether the restoration techniques were successful and could be used elsewhere. Interactions through the monitoring CoP will lead to improved quality of monitoring plans, greater standardization in monitoring protocols and QA/QC,

and reduced duplication of monitoring efforts. For both habitat mapping and water quality we will: 1) inventory and evaluate all data and programs; 2) Identify gaps and needs; 3) Develop criteria for prioritizing monitoring gaps and need; 4) Develop a prioritized list of monitoring gaps and needs; 5) Fill the highest priority needs; and 6) Collect the data required to reduce uncertainties and increase the likelihood of restoration success.

HABITAT MAPPING, ASSESSMENT, AND MONITORING -- The development of new, high-quality habitat maps for priority areas of the Gulf, from inland brown water habitats to deep blue water habitats. Additional measures include: (1) the ability of these products to accurately characterize aquatic and terrestrial habitats; (2) the areal extent and spatial resolution of these products; (3) a broad use of program data and products by scientists, managers, and educators; and (4) establishment of an enduring habitat monitoring system for the Gulf of Mexico and its watershed that will provide information for activities ranging from fisheries management, to land-use planning, to early identification of problem areas and long-term trends.

WATER QUALITY MONITORING – (1) an expanding set of compatible water quality data available to the science and management community; (2) determination of baseline water quality conditions; (3) broad use of program data and products for scientists, managers, and educators globally; and (4) an advanced, integrated water quality/circulation modeling framework with OSSE capabilities to improve the water quality monitoring network.

2.5. Risks and uncertainties of the proposed activities

BOTH: The evaluation of existing data, identification of needs and gaps, and prioritization of needs and gaps through stakeholder engagement as we propose to do via the CoP is an inherently complex task that involves reaching consensus among stakeholders with disparate goals and agendas. We will minimize the likelihood that consensus cannot be reached by developing regional priorities based upon a process that has successfully been employed for the selection of ecosystem indicators among an equally disparate group of stakeholders. Namely, we will focus on first identifying all gaps and developing criteria to prioritize gaps within the CoP.

A comprehensive monitoring network is the foundation for reducing risks and uncertainty in resource management and ecosystem restoration. The monitoring network will collect the information necessary to determine the trajectory of the ecosystem, the success of restoration projects to date, and thus will result in an ability to provide the council with information regarding which restoration projects will likely reverse undesired trends and conditions in the ecosystem. Thus, the development of this network will increase the likelihood that water quality and habitat restoration will be successful and is essential as the Council implements adaptive management.

HABITAT MAPPING, ASSESSMENT, AND MONITORING: This program is low risk with minimal associated uncertainties. The technologies utilized are effective and are well-suited to the tasks at hand. NOAA is a world leader in bathymetric mapping and USGS in terrestrial mapping. The agencies possess the hardware, software, human resources, and expertise needed to complete the mapping, monitoring, and habitat classification activities. Components not available in existing inventories are readily available through long-standing relationships with federal, state, and academic partners. There is a low likelihood of budget growth due to little capital equipment needs. Personnel cost increases have been factored into budgets. Our adaptive management approach will allow us to respond to unforeseen events and evolving stakeholder needs, helping to minimize the risk of failure.

Some foreseeable risks to our mapping efforts include inclement weather and equipment failures. We will plan field surveys during favorable times of year and budget for extra weather down-time days. The extra days also can account for any equipment downtime. The long-term (5-year) duration of the program can accommodate any necessary shifts in schedules as well. Finally, research platforms will be selected based on their safety and performance records, among other factors.

WATER QUALITY MONITORING: Risks for this component are in maintaining a collaborative network across institutions and longer-term financial support. These are not small challenges as they require a

different mode of operation than has been fielded in the past. However, we these issues are surmountable with a properly designed and well-communicated program that addresses the region's needs and is inclusive of existing programs. Cross-institutional support will be garnered through the monitoring CoP and by inclusive management, data collection, open access to standardized data, adaptation to changing needs and priorities. Longer-term support will be achieved as stakeholders realize the program benefits, including access to pooled regional monitoring and analytical expertise, shared data streams, and easy access to historical and current environmental data.

2.6. Outreach and education opportunities

HABITAT MAPPING, ASSESSMENT, AND MONITORING: There will be considerable educational opportunities. NOAA has existing relationships with academic institutions to provide at-sea experience in bathymetric and coastal mapping, providing a dual benefit – the students gain real-world experience and NOAA realizes cost savings. Additionally, NOAA's Teacher-at-Sea Program will provide educators for ground truthing expeditions – experiences which will be relayed to thousands of K-12 students. This project will also use student interns to synthesize monitoring plans, SOPs, and data quality standards under the guidance of experienced practitioners. State and federal aquatic ecosystem managers will receive timely updates on program discoveries and their feedback will be used to adapt the selection of target locations. Lastly, the general public will be informed of program discoveries through existing pathways maintained by NOAA and USGS Public Affairs officers.

WATER QUALITY MONITORING: This program component will actively pursue broad use of products by education and outreach specialists, leading to increased understanding and awareness of the Gulf ecosystem. Water quality data are especially conducive for teaching the principles of empirical data collection and quantitative analyses at all education levels. The readily accessible data collected as part of this program represent great opportunities for educators in grade school, undergraduate, and graduate settings to apply mathematical skills and to raise knowledge of the oceans, their living resources, and the socioeconomic-environmental trade-offs involved with society's use of the Gulf.

2.7. Leveraging of resources and partnerships

Partners include but are not limited to GOMA, GCOOS, GOMURC, state resource management agencies, state Centers of Excellence, and the federal agencies listed below.

HABITAT MAPPING, ASSESSMENT, AND MONITORING: This proposal benefits from substantial leveraging of resources and partnerships. NOAA and USGS maintain a large fleet of vessels capable of operating in inland coastal waters and wetlands and the littoral and blue water environments. These vessels are equipped with the instrumentation required to complete or facilitate all proposed activities and their sailing schedules can accommodate all requests needed for program success. NOAA/USGS human resources include world leaders in bathymetric and topographic mapping, monitoring and habitat classification. Considerable cost reductions are present in the budget request of this program due to use of existing NOAA/USGS equipment, labor, and intellectual capacity. Where it is more economical or in those few cases where NOAA/USGS does not possess the required capabilities and/or capacity, collaborating partners have agreed to participate in the program and provide specialized equipment and expertise through existing agreements.

As this program matures, it is anticipated that additional collaborations will be developed in both the scientific and management arenas. The potential range for these developing partnerships is extremely wide as there are very few activities in research or management which do not benefit significantly from high quality maps annotated with geomorphological and biological data.

WATER QUALITY MONITORING: This program expects to strengthen long-standing, and establish new, partnerships within NOAA (SEFSC, ORR, AOML), DOI (USGS/NPS/BOEM/FWS), EPA, NAS, DOD, USACE, academics, and state and local partners. An additional partner that will be extremely beneficial is the oil-gas companies who own and operate the offshore instrumented platforms. These companies have substantial

engineering expertise, resources enabling transport of people and equipment, and instrumentation that could aid in habitat characterization, environmental sensing, data transmission, to name just a few assets. Therefore, under ideal circumstances, the oil-gas companies themselves would help facilitate and partially subsidize implementation of this program.

2.8. Proposal project/program benefits

BOTH: Reliable data and subsequently developed decision support tools are the foundation for an adaptive management regime that is based upon the use of best available science. The network proposed here will directly enable the Council to achieve its mission of science-based comprehensive Gulf ecosystem restoration by providing the means to determine and prioritize management needs, select and implement the most effective and efficient conservation actions, and measure the results to determine progress, and adjust course as needed. The network can provide this spatially-explicit information at the project scale to determine the efficacy of specific methodologies individually, all the way up the regional ecosystem scale to evaluate progress towards the Council's principle goal of restoring a sustainable Gulf of Mexico Ecosystem. As stewards of RESTORE Act funds dedicated to a variety of restoration projects, it will be necessary for the Council to communicate the impact of their comprehensive restoration activities on society, both regionally and nationally. This monitoring network will form the observational backbone that is necessary to be able effectively communicate progress on Gulf ecosystem restoration and make science based decisions.

As highlighted in the Comprehensive Plan, there are a number of co-benefits that can emerge from restoration activities. These might include improved recreational opportunities, storm surge protection, and habitat for important commercial fish species. Many of these co-benefits can have positive economic impacts such as job and income creation beyond the time that the actual restoration process is taking place. The monitoring network will measure the positive changes in the environment brought about by restoration activities that can then be translated into economic benefits. Moreover, all of the monitoring network monies will be spent in the Gulf. Local people will be used to maintain instrument arrays and conduct habitat mapping activities creating jobs and economic opportunities. CoP workshops will rotate around the Gulf increasing revenues to local businesses.

HABITAT MAPPING, ASSESSMENT, AND MONITORING: This program will have numerous resource, fishery, and safety management benefits, which all depend on reliable data pertinent to assessing ecosystem trajectory and health. Program implementation will have lasting benefits to the protection and well-being of the Gulf ecosystem, dependent human communities, and the regional economy. Specific benefits to be derived include improved ability to stratify and post-stratify analyses for fishery-independent surveys, which in turn will yield more accurate assessments, more informed management of fishes and their habitats, and more efficient and effective designs for resource surveys. This effort also will shed light on the importance, relationships, and roles of natural and artificial reefs in population dynamics and trends, management, monitoring, and assessment of reef and pelagic fish. The program also will allow: establishment of baseline status of estuarine and coastal habitats and water quality; better prediction and assessment of anthropogenic and natural event impacts on habitats and water quality; and detection of habitat and water quality change and trends for incorporation into ecological models. The program will lead to improved standardization of habitat mapping data through direct technical transfer of methodologies, standards, processing procedures, protocols, and standardized classification techniques. Other benefits include acquisition of new data on deep-sea corals and mesophotic coral reefs and valuable insight on additional sites for restoration. The program will generate quantitative information about ecological services benefits provided by previous restoration efforts, serve as indicators of locations conducive for restoration, and provide baseline information on habitats in affected areas to inform management decisions and determine restoration efficacy at multiple scales. Additional benefits include improved assessment of restoration needs and prioritization of restoration sites to ensure consistent naming of habitat types and subsequent assignment of ecosystem services. Of particular value will be the

development of data frameworks to support future mapping and water quality assessment, trend analyses, and data management.

WATER QUALITY MONITORING: The information collected and shared by this program will have numerous resource, fishery and safety management benefits, which all depend on reliable and representative data pertinent to ecosystem health assessment. Implementation of this program will benefit the protection and well-being of the Gulf ecosystem, dependent human communities, and the regional economy.

3.0 Location Information

Because this effort is Gulf-wide, and ultimately will be based upon a network architecture that uses existing monitoring efforts, enhanced by strategically filling gaps identified during the inventory and assessment process which includes the monitoring CoP, we will not yet explicitly describe the exact habitat mapping or water quality mapping sites. We have developed the core of the budgets using cost per unit effort of data acquisition, processing, product development and dissemination.

4.0 High-Level Budget Narrative

HABITAT MAPPING, ASSESSMENT, AND MONITORING

Category	Days per year	Cost per day	Cost per year	Number of years	Total cost
Scalable Costs					
Shallow Water Mapping	28	$5,000	$140,000	4	$560,000
Shallow Water Groundtruthing	14	$5,000	$70,000	4	$280,000
Deep Water Mapping	28	$15,000	$420,000	4	$1,680,000
Deep Water Groundtruthing	32	$25,000	$800,000	4	$3,200,000
Fixed Costs					
Labor			$858,600	5	$4,293,000
Equipment					$220,000
Licensing			$33,000	5	$165,000
Travel			$12,000	5	$60,000
Supplies			$14,500	4	$58,000
Inventory and Prioritization of Existing Data, CoP workshops					$300,000
Classification of Existing Habitat Data					$835,000
Estuarine and Coastal Vegetated/Unvegetated Habitat Mapping			$300,000	4	$1,200,000
Estuarine and Coastal Vegetated/Unvegetated Habitat Ground truthing			$50,000	4	$200,000
					$13,051,000

Table 1: Habitat Mapping, Assessment, and Monitoring Budget Summary

Mapping, monitoring, and habitat classification costs contain scalable and fixed components. **Scalable costs** include at-sea mapping and ground truthing, which can be easily manipulated by altering the number of days at sea for each activity. As proposed, these activities include 28 days per year of shallow (green) water (5-50m) sidescan mapping, 14 days per year of shallow water ground truthing, 30 days per year of deep (blue) water (50-1000m) multibeam mapping and 34 days per year of deep water ground truthing. The ratio of mapping to ground truthing is higher in shallow water as mapping coverage per day is much greater in deep water due to the physics of the surveying equipment. **Fixed costs** include labor for at-sea data collection, processing of acoustic bathymetric data, analyses of ground truthing video and biological samples, CoP governance and prioritization workshops, application of habitat classification schemes and compilation of results. **Fixed costs** also include labor for remote sensed data compilations, classifications, status and trends assessments, analysis of variation over time, and delivery of baseline data results. The at-sea data and remote sensed collection efforts will take place for four years; the final year will be needed to complete analyses and prepare the final report. Additional fixed costs include capital equipment, supplies, travel, and an initial inventorying and prioritization of existing data to allow selection of target sites for proposed mapping and classification of existing data using the CMECS classification scheme.

WATER QUALITY MONITORING

Category	Days per year	Cost per day	Cost per year	Number of years	Total cost
Labor			$700,000.00	5	$3,500,000
Logging data sondes ; 250 units			$1,500,000.00	1	$1,500,000
Autonomous Underwater Vehicles; 7 units			$1,750,000.00	1	$1,750,000
Travel			$50,000.00	5	$250,000
Supplies			$100,000.00	4	$400,000
Regional User Workshops (6 events)			$100,000.00	3	$300,000
Software & Liscensing			$150,000.00	3	$450,000
Instrument Deployment/Recovery			$50,000.00	4	$200,000
				Grand total:	**$8,350,000**

Table 2: Water Quality Monitoring Budget Summary

Water quality monitoring costs are described in Table 2. Major items include labor, logging data sondes (250 units), autonomous underwater vehicles (7 gliders), regional user workshop expenses (6-8 events), software development expenses, and instrument deployment/recovery expenses. Labor costs include an overall water quality network coordinator plus administrative assistant; a small team of technical personnel (engineers and programmers) with expertise in set-up, calibration, deployment and repair of water quality instrumentation (i.e., logging data sondes and gliders) and management of their respective data streams; and a physical oceanographer to support circulation modeling. The logging data sondes, each equipped with an extended suite set of sensors, will be distributed among existing monitoring efforts to replace old units and expand their collective footprints. The AUVs (gliders) minimally will have the same sensor suite as the logging data sondes, but will allow water quality data collection: (a) in areas where fixed platforms do not exist; and (b) in response to episodic, or otherwise unpredictable events. Workshops will be held to assess local and regional needs, develop action plans, and to ensure uniformity of methods among current and future water quality data collectors. Other budget items include supplies (in support of water quality measurement instruments as well as office essentials), travel (primarily for coordinator to liaise as needed and the technical team to troubleshoot), software (licensed, off-the-shelf as well as custom-developed) and logistics expenses associated with instrument deployment and recovery.

5.0 Environmental Compliance Checklist

Please check all federal and state environmental compliance and permit requirements as appropriate to the proposed project/program.

Environmental Compliance Type	Yes	No	Applied For	N/A
Federal[2]				
National Marine Sanctuaries Act (NMSA)				X
Coastal Zone Management Act (CZMA)				X
Fish and Wildlife Coordination Act				X
Farmland Protection Policy Act (FPPA)				X
NEPA – Categorical Exclusion	X			
NEPA – Environmental Assessment				X
NEPA – Environmental Impact Statement				X
Clean Water Act – 404 – Individual Permit (USACOE)				X
Clean Water Act – 404 – General Permit(USACOE)				X
Clean Water Act – 404 – Letters of Permission(USACOE)				X
Clean Water Act – 401 – WQ certification				X
Clean Water Act – 402 – NPDES				X
Rivers and Harbors Act – Section 10 (USACOE)				X
Endangered Species Act – Section 7 – Informal and Formal Consultation (NMFS, USFWS)				X
Endangered Species Act – Section 7 - Biological Assessment (BOEM,USACOE)				X
Endangered Species Act – Section 7 – Biological Opinion (NMFS, USFWS)				X
Endangered Species Act – Section 7 – Permit for Take (NMFS, USFWS)				X
Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) – Consultation (NMFS)				X
Marine Mammal Protection Act – Incidental Take Permit (106) (NMFS, USFWS)				X
Migratory Bird Treaty Act (USFWS)				X
Bald and Golden Eagle Protection Act – Consultation and Planning (USFWS)				X
Marine Protection, Research and Sanctuaries Act – Section 103 permit (NMFS)				X
BOEM Outer Continental Shelf Lands Act – Section 8 OCS Lands Sand permit				X
NHPA Section 106 – Consultation and Planning ACHP, SHPO(s), and/or THPO(s)				X
NHPA Section 106 – Memorandum of Agreement/Programmatic Agreement				X
Tribal Consultation (Government to Government)				X
Coastal Barriers Resource Act – CBRS (Consultation)				X
State				
As Applicable per State				X

[2] Although future habitat and water quality monitoring activities are envisioned in the future after inventory, gap analysis, planning and prioritization takes place, significant impacts are not anticipated. The mapping activities and technologies that are proposed to be applied will not have the potential for deleterious effects on marine mammals, other protected, or managed species, and will therefore have no effect under the Marine Mammal Protection Act or Endangered Species Act. Likewise, the water quality monitoring technology envisioned to potentially be deployed is not anticipated to have any significant effect either. Existing NOAA/USGS categorical exclusion(s) for monitoring and research will be applied as appropriate.

6.0 Data / Information sharing plan

The data management proposed for this effort will describe the environmental data types to be collected, data stewardship and preservation, and the standards surrounding data descriptions, collection formats and sharing protocols. Furthermore, the effort will leverage the USGS data management capacities currently managing data from numerous federal and State projects across the Gulf of Mexico region.

Environmental Data Types – This project will be coordinating and synthesizing monitoring and observational data as well as data products from hydrologic, oceanographic, morphologic, geological, ecological and human-use systems in the Gulf of Mexico. Where applicable, pre-defined standard data formats will be promoted for use for each data type. All monitoring and observational data as well as created analysis and visualization products will be represented within the proposed infrastructure. Having prior experience in collecting, maintaining, and/or analyzing these data types, USGS can leverage existing processes and infrastructures in place to aid in the storage, transformation, and dissemination of these types of data.

Stewardship/Preservation - Through numerous ongoing data management activities, USGS has amassed the infrastructure in various key locations across the Gulf of Mexico necessary to support large-scale monitoring and modeling activities. Web services enable relational tabular monitoring databases and spatial databases to be seamlessly integrated into other platforms through web mapping services (WMS), web coverage services (WCS), or OpenDAP interfaces. Additionally, USGS can leverage the existing scientific and data management platform, ScienceBase, providing a centralized permanent archive for USGS data and information products. All new data collected under this program will be submitted to a recognized national archive for long-term preservation.

Standards -

Data Description (metadata) - All digitally managed data will contain FGDC- and/or ISO-compliant descriptive metadata describing data content. The required metadata will facilitate the discovery of relevant project information and promote data use for future gulf restoration efforts.

Sharing Protocols (WAF and CSW) - The USGS will initially consolidate data and information on the existing "USGS and the Gulf of Mexico" website at gom.usgs.gov. Web accessible folders (WAF) and catalog services for the web (CSW) will be utilized so that all data, metadata, standards, catalogs, and inventories assembled as a part of this proposal will be maintained through web services and exposed online for access by all users with a web browser. Data discovery, access, and visualization services will utilize the open source ESRI Geoportal Server promoting authoritative data integrity and easy-to-use data discovery technologies.USGS will leverage capacity and expertise from other successful data management activities to publicly expose data, visualizations, charting, and interactive maps to the user. The interactions between USGS computer scientists and researchers, both federal and academic, have resulted in powerful data management systems allowing scientists to abandon traditional desktop spreadsheets for online systems exposing complex query and reporting functionality. Examples of such systems are:

Coastwide Reference Monitoring System (CRMS) http://lacoast.gov/crms_viewer2/Default.aspx
Joint Ecosystem Modeling (JEM) - Biological Databasehttp://jem.gov/Map
Nonindigenous Aquatic Species (NAS)
http://nas.er.usgs.gov

Policy - Data and information discovery, access and preservation will follow federal mandates and policy guidance on open data policies that has been outlined and described in OMBM-13-13, OMB Circular A-130, and OMB Circular A-16. These open data policies include machine-readable and open formats, data standards, and common metadata catalogue services for all new information creation and collection efforts. A shared, distributed data design will be utilized that leverages existing data management activities among federal, state, and academic institutions to promote the use, sharing, and dissemination of both geospatial and non-geospatial data and information.

- White House "Open Data Policy" (OMB M-13-13) of May 9, 2013 which supports the related Executive Order of May 9, 2013 (Making Open and Machine Readable the New Default for Government Information). This policy requires federal agencies to collect or create information in a way that supports downstream information processing and dissemination activities. This includes using machine readable and open formats, data standards, and common core and extensible metadata for all new information creation and collection efforts.

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

7.0 Reference list of literature cited in the proposal

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9.0 Other

A. The monitoring activities proposed here will be completely compatible with and appropriate for coordination with several regional monitoring efforts (e.g., GCOOS build-out plan, GOMA, Gulf Restoration Science Program Coordination Team, NOAA RESTORE Science Program, etc.). We are actively engaged with these and other federal and state programs to collaborate and coordinate under the auspices of this proposal. More details to come in the next iteration.

B. NOAA is a recognized leader in habitat mapping to support coastal intelligence and place-based management solutions, as evidenced by NOAA's experience mapping habitat in over 20,000 km^2 of coastal waters. NOAA's core expertise in habitat mapping includes the development and application of Federal Geographic Data Committee (FGDC) habitat-classification standards, authoritative standards on data acquisition, and protocols on habitat-mapping methodologies. Similarly, the USGS's National Land Cover Institute covers topics from local to global scales, and is an important source of land cover data sets for the Gulf region. Existing Federal standards provide the organizational structure and process necessary for consistent classification of habitat types across all of the agencies collecting data in this program. NOAA and USGS have experience working with various partners, especially states, to map and characterize aquatic and terrestrial habitats in biologically sensitive areas. Examples include mapping and characterizing deep-sea corals and mesophotic reefs in the Gulf of Mexico in a NOAA partnership with the University of South Florida in the early 2000s; and USGS mapping the vulnerability of Gulf of Mexico shorelines and adjacent habitats to storms. Lastly, NOAA and USGS have the largest inventory of federal civilian agency assets, expertise, and technologies for habitat mapping (ships, aircraft, unmanned vehicles, remotely sensed imagery, and personnel).

C. NOAA currently hosts the most comprehensive repository of seafloor and coastal mapping data for the Gulf and the nation at-large. NOAA's National Geophysical Data Center (NGDC) and Office for Coastal Management (OCM) compiles, archives, and distributes bathymetric data from coastal and open-ocean areas http://maps.ngdc.noaa.gov/viewers/bathymetry/ and http://coast.noaa.gov/digitatlcoast/. These collections accept information from any party, but are incomplete, as data submission is voluntary. The USGS and NOAA, along with other partners, maintain the U.S. Interagency Elevation Inventory (USIEI), which is a catalog of high-accuracy topographic and bathymetric data for the United States and its territories. This resource is a comprehensive, nationwide listing of known high-accuracy topographic data, including LidAR and If SAR, bathymetric data, multibeam data, and bathymetric LiDAR. The information provided for each elevation dataset includes many attributes such as vertical accuracy, point spacing, and date of collection. A direct link to access the data or information about the contact organization is also available through the inventory.

The USIEI is being used to support the 3D Elevation Program (3DEP), which is an initiative to systematically collect enhanced elevation data in the form of high-quality LiDAR data over the United States on an 8-year schedule. The USGS was designated by the Office of Management and Budget in 2002 (OMB Circular A–16) as the lead federal agency for terrestrial elevation data. The 3DEP initiative is designed to fulfill that leadership responsibility and to ensure that the needs of the nation for high-quality 3D elevation data are being met. The initiative includes many partners – federal agencies and state, tribal, and local governments, who will work together to build on existing programs to complete the national collection of 3D elevation data.

3DEP acquisitions, orthoimagery, and other geospatial-related services, may make use of the USGS Geospatial Product and Service Contracts (GPSC). USGS provides assistance to agencies who wish to use the GPSC. The USGS Commercial Partnership Team (CPT) drafts task orders based on an agency's specific product requirements, conducts negotiations with the contracting firms, and manages each task throughout its lifecycle. The USGS National Geospatial Technical Operations Center (NGTOC) can assist in performance of data quality assurance and validation of contractor-produced data.

The National Map partnership network cultivates and maintains long-term relationships with partners and develops agreements for The National Map and other initiatives that support USGS and partner programs. Partnerships are the foundation of The National Map because they leverage funding across organizations as a way to provide significant cost savings, reduce redundancy in geospatial data acquisition and stewardship, and ensure the availability of common base data to a broad range of users and applications. An addition to the long-standing partnership functions of The National Map is an emerging initiative to systematically reach out to priority user communities. The goal of user engagement is to gather feedback on the products and services of The National Map so that future development will best meet USGS science objectives and provide the greatest value and impact for the nation. Priority user communities include Geologic Mapping and Hazards, Natural Resources Conservation, and Water Resources.

D. Types of Sensor Data

Optical Data

LiDAR - NOAA and USGS routinely operate active optical sensors for nearshore and coastal mapping (0-30 m depths) and topography (0 - +10 m) to characterize upland, shoreline, intertidal, and submerged habitat features. Assets include airborne bathymetric/topographic LiDAR and digital photography systems which can be flown on a number of fixed-wing NOAA and USGS aircraft. These systems are ideal for quickly and accurately characterizing near-shore habitats, particularly where the operation of surface vessels is dangerous or inefficient. These systems provide high-resolution nearshore bathymetry, topography, and intensity data used for various mapping applications (Costa et al. 2009), including coastal change and vulnerability assessments (Guy et al. 2013, 2014).

Satellite and Aerial – Multispectral commercial satellite imagery and high-resolution aerial photography is routinely used by NOAA and USGS to synoptically map large coastal regions. Data collected from these acquisition systems have been used extensively to map shallow-water habitat, shoreline, wetlands, and other topographic features, and to assess valued ecosystem attributes. These approaches have proven to be very cost-effective for repeated monitoring of specific locations which could help support ecosystem service valuation and tracking (Monaco et. al 2012).

Acoustic

The USGS and NOAA collect a variety of geophysical measurements obtained from acoustic instrumentation deployed from large oceangoing vessels as well as smaller watercraft. Bathymetry and seafloor texture are obtained using single-beam, swath, and multibeam echosounders. Sidescan sonars can sample seafloor texture. Seabed properties, sand thicknesses, and other geologic structure are sampled with sub-bottom systems such as chirp and other low-frequency systems. These systems have been deployed extensively in the shallow regions of the Gulf of Mexico by USGS for research, resource mapping, and vulnerability assessments (Buster et al. 2014, Dewitt et al. 2014a, b) and for operational surveying has been conducted widely by NOAA for navigation and habitat assessment.

Multibeam - NOAA routinely operates a range of multibeam echosounder (MBES) sonar systems to conduct seafloor mapping along our nation's coasts. NOAA owns and operates a full range of sensors (e.g., Reson, R2Sonic, Kongsberg) optimized for collecting data along the continuum of water depths from 2 meters to full ocean depths. NOAA also partners with state universities to place university assets on NOAA ships. MBES data from these systems yield information on both seafloor topography (slope and relief) and seafloor hardness. MBES systems have the advantage of being able to collect coincident high-resolution bathymetry and seafloor intensity to discern habitat types. (Figure 13).

Sidescan - NOAA utilizes high frequency sidescan (SSS) and interferometric sidescan (PDBS) sonars for imaging the seafloor. Multiple sensor frequencies and types are used (e.g., L-3 Klein Associates, Marine Sonic technology, Geoacoustics, Benthos, and Teledyne) on a variety of platforms and configurations including towed, hull-mounted, AUV, unmanned surface vessels and large to small vessels. Sidescan sonars have the optimum advantage of being able to collect large swaths of data at very high resolution, particularly in shallow waters. (Figure 14).

LETTERS OF SUPPORT

FLORIDA INSTITUTE OF OCEANOGRAPHY
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St. Petersburg, Florida 33701
Telephone: (727) 553-1100
Fax: (727) 553-1109

November 4, 2014

Steven D. Giordano, J.D.
NOAA/NMFS
Southeast Regional Office
263 13th Avenue South
Saint Petersburg, FL 33701

Dear Mr. Giordano,

I write on behalf of the Florida Institute of Oceanography (FIO) and as Chair for the Gulf of Mexico University Research Collaborative (GOMURC) Members Board, in support of NOAA's proposal to the Gulf Coast Restoration Council entitled, "*Gulf of Mexico Habitat Mapping and Water Quality Monitoring Network*." The project is deserving of Council support and we endorse collaboration with the region's academic and state science and technology communities.

We encourage the Council members to focus the Final Priorities List on this type of project that supports comprehensive (interdisciplinary, integrated across broad time and space scales) ecosystem restoration. Proposed activities are fundamental to providing the required knowledge for assessing recovery, adaptive management actions, and establishing baseline data for recovery and future event response. Two priority actions include: Collection of new data will be based on modeling needs, and gaps in required ecosystem indicators; and recognition of the need for a backbone information management framework that can support and integrate data and information from all restoration programs, plus many other existing research programs, and generate accessible, relevant outputs.

This project calls for a co-managed approach that engages many potential regional stakeholders and partners. The proposal recognizes the importance of building on established programs and providing a framework for identifying and filling gaps, and leveraging partnerships. We understand this proposal is a combination of support for both NOAA assets, and other federal, state and local operational assets. No one restoration program can carry the burden for the ecosystem-level monitoring required to track Gulf-wide recovery and make wise restoration decisions. It is not clear, however, perhaps reasonably so at this stage, how the organization or budget is specifically divided up among entities. Minimally, we would suggest Figure 7 at least include general statements that cover agreements with academia, businesses and state governments under both ground-truthing and acoustics mapping sensors (this is how NOAA has operated). Also not described in the draft we reviewed is an organizational structure that utilizes co-management elements and processes (e.g., advisory boards, cooperative agreements, shared leadership, coordination/communication activities with other restoration entities). The next iteration should at least outline a mixed business model for the organization and implementation/budgeting of activities.

Thank you for the opportunity to comment and engage with NOAA on these important activities, both for Gulf-wide restoration and sustainability of natural capital for future generations.

Sincerely,

William Hogarth

Dr. William Hogarth
Director, Florida Institute of Oceanography

See http://www.fio.usf.edu/about-us/fio-members for current FIO Council members.

November 17, 2014

Ms. Penny Pritzker, Commerce Secretary
U.S. Department of Commerce 1401
Constitution Ave., NW Washington DC,
20230

Council-Selected Restoration Component Project Submission – Gulf-Wide Habitat Mapping and Water Quality Monitoring Network

Madam Secretary,

On behalf of the Gulf of Mexico Reef Fish Shareholders' Alliance, I am writing to express our support for the Department of Commerce's **Gulf-wide Habitat Mapping and Water Quality Monitoring Network** proposal.

The Shareholders' Alliance is a non-profit organization that represents the interests of commercial reef fish fishermen and other stakeholders in the Gulf of Mexico. We work hard to maintain accountability and conservation-based management for our region's fisheries. By working closely with regional managers, state agencies, and federal representatives, we strive to improve fishery regulations and ensure that we can continue to provide the American public with a sustainable source of domestically-caught Gulf of Mexico seafood. Everything we do is founded in our belief that conservation and stewardship protect fish populations *and* fishermen's businesses.

The Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States (RESTORE) Act has directed a substantial portion of the Clean Water Act penalties to achieve large-scale restoration projects that restore and protect the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, coastal wetlands and economy of the Gulf Coast. High quality habitat maps are a critical component of the successful restoration of all of these important elements, but have a particular relevance to the fisheries that I and my fellow fishermen depend on.

Improved habitat mapping supports effective fisheries management. A better profile of seafloor topography can clarify associations between fish species, fisheries productivity and natural or artificial habitats, giving scientists more accurate information on species distributions and abundances across like habitats. Habitat mapping provides fishery scientists and resource managers with the information necessary to detect changes in abundance of fish populations and clarify their relationship with other marine species like corals. Filling the gaps that currently exist in Gulf habitat maps will dramatically improve fishery-independent data collection and stock assessments by facilitating comparisons of species distributions and abundances across like habitats. This will allow scientists to sample more precisely by habitat type and improve the quality of information used to assess the health of both fish and wildlife populations. Improved assessments leads to better management in which stocks recover, and fishing businesses and communities remain profitable for today and the next generation of fishermen.

As our Gulf of Mexico reef fish resources continue to rebuild, we must improve our ability to assess population health and track oil spill recovery. High quality habitat maps play an essential role in this process, and we offer our enthusiastic support for the proposed program.

Thank you for your attention to this critical matter. William

(Bubba) Cochrane, President
Gulf of Mexico Reef Fish Shareholders' Alliance

November 17, 2014
Ms. Penny Pritzker
Commerce Secretary
U.S. Department of Commerce
1401 Constitution Ave., NW
Washington DC, 20230

Support for Gulf-Wide Habitat Mapping and Water Quality Monitoring Network

Ms. Pritzker,
On behalf of the Snook and Gamefish Foundation's 4,500 members, I wish to express support for your agency's **Gulf-wide Habitat Mapping and Water Quality Monitoring Network** proposal for funding under the Council-Selected restoration component of the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE). The Snook and Gamefish Foundation is dedicated to ensuring a brighter future for all fisheries by giving a voice to the recreational angler. We applaud your agency in your efforts to obtain funding for high quality habitat maps that are an essential element to successful, comprehensive, restoration of Gulf marine ecosystems and fisheries.

The Snook and Gamefish Foundation is committed to the protection and restoration of estuarine and coastal water habitats and quite simply, without a thorough inventory of Gulf marine resource habitats, fishery scientists and resource managers lack the precise information necessary to optimally manage the modern demands fishermen have to sustainably access and utilize the resource. Habitat mapping is an investment in effective fisheries and natural resource management that provides fishery scientists and resource managers with the information necessary to detect changes in abundance of fish populations, and clarify associations between fish species and fisheries productivity on natural and artificial habitats. In turn, this enables scientists to more accurately assess species distributions and abundances across like habitats.

Improvements like this have the ability to dramatically improve fishery independent data collection and stock assessments and I applaud your agency's effort for the Gulf Coast Ecosystem Restoration Council to include it in their Draft Funded Priorities List.

Thank you,

Brett Fitzgerald, Executive Director
Snook & Gamefish Foundation
1505 West Terrace Drive

Lake Worth FL 33460
brett@snookfoundation.org
561-707-8923

A copy of the official registration and financial information may be obtained from the Division of Consumer Services by calling toll-free (800-435-7352) within the state. Florida registration: CH11670.

TradeWinds
ISLAND RESORTS ON ST.PETE BEACH

November 17, 2014

Ms. Penny Pritzker Commerce
Secretary
U.S. Department of Commerce 1401
Constitution Ave., NW Washington DC,
20230

RE:Support for Gulf-Wide Habitat Mapping and Water Quality Monitoring Network Ms. Pritzker:

As President and Chief Operating Officer of TradeWinds Resorts, the largest resort operation on the west coast of Florida and as former Chairman of the Florida Restaurant and Lodging Association during the BP Deepwater Horizon OilSpill, I am writing to express support for your agency's Gulf-wide Habitat Mapping and Water Quality Monitoring Network proposal for funding under the Council-Selected restoration component of the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE). High quality habitat maps are an essential element to successful,comprehensive, restoration of our natural resources, ecosystems,marine wildlife, beaches, coastal wetlands,coastal economy,and fisheries.

As Ihave learned through my close partnerships with Dr. Bill Hogarth at the University of South Florida's Marine Science Program as well as Dr. Guy Harvey from a strategic business partnership, high-quality habitat maps are a necessary tool to effectively manage marine resources. Quite simply,without a thorough inventory of Gulf marine resource habitats, fishery scientists and resource managers lack the precise information necessary to sustainably meet the growing and at times conflicting demands of the diverse stakeholders dependent on a healthy, resilient Gulf of Mexico.

Habitat mapping supports effective fisheries and natural resource management by providing fishery scientists and resource managers with the information necessary to detect changes in abundance of fish populations,and clarify associations between fish species,fisheries productivity on natural and artificial habitats. This in turn, enables scientists to more accurately assess species distributions and abundances across like habitats.
Improvements like this have the ability to dramatically improve fishery independent data collection and stock assessments.

Marine environment restoration has been a challenge inthe aftermath of the BP Deepwater Horizon oil spill and Iapplaud your agency's effort for the Gulf Coast Ecosystem Restoration Council to include it intheir Draft Funded Priorities List.

Keith Overton, CHA
President & COO

KO/jmc

ISLAND GRAND RESORT | OUTPOST

ufb

CORPORATE OFFICE 5600 GULF BOULEVARD ST. PETE BEACH, FL 33706 727.363.2215 FAX 727.363.2221 JUSTLETGO.COM

Charter Fishermans Association

November 17, 2014 Ms.
Penny Pritzker
Commerce Secretary
U.S. Department of Commerce 1401
Constitution Ave., NW Washington
DC, 20230

Support for Gulf-Wide Habitat Mapping and Water Quality Monitoring Network

Ms. Pritzker,
The Charter Fisherman's Association would like to express support for the Department of Commerce's Gulf-wide Habitat Mapping and Water Quality Monitoring Network proposal for funding under the Council-Selected restoration component of the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act. High quality habitat maps are an essential element of successful restoration of the natural resources, ecosystems, marine and wildlife habitats, beaches, coastal wetlands, coastal economy, and the fisheries that we depend on.
Notably, habitat mapping supports effective fisheries and natural resource management. High-quality habitat maps provide fishery scientists and resource managers with the information necessary to detect changes in abundance of fish populations, and clarify associations between fish species, fisheries productivity and natural or artificial habitats, giving scientists more accurate information on species distributions and abundances across like habitats.
Improvements to Gulf habitat maps will dramatically improve fishery independent data collection and stock assessments by facilitating comparisons of species distributions and abundances across like habitats, allowing scientists to sample more precisely by habitat type and improve the quality of information used to assess the health of both fish and wildlife populations.
In recognition of the important role of habitat maps both in sustainably managing the region's fisheries as well as in the overall success of Gulf restoration in the years to come, we offer our support for this program and encourage the Gulf Coast Ecosystem Restoration Council to include it in the Draft Funded Priorities List.

Sincerely,

Shane Cantrell
Executive Director
Charter Fisherman's Association

November 17, 2014

Secretary Penny Pritzker
U.S. Department of Commerce 1401
Constitution Ave., NW Washington DC,
20230

Support for Gulf-Wide Habitat Mapping and Water Quality Monitoring Network

Sec. Pritzker:

We, the undersigned, are writing to express support for the Department of Commerce's **Gulf-wide Habitat Mapping and Water Quality Monitoring Network** proposal for funding under the Council- selected restoration component of the RESTORE Act. High-quality habitat maps are an essential element of successful restoration of the natural resources, ecosystems, marine and wildlife habitats, beaches, coastal wetlands, coastal economy, and the fisheries that we depend on.

Notably, habitat mapping supports effective fisheries and natural resource management. High-quality habitat maps provide fishery scientists and resource managers with the information necessary to detect changes in abundance of fish populations and clarify associations between fish species, fisheries productivity and natural or artificial habitats, giving scientists more accurate information on species distributions and abundances across like habitats. Improvements to Gulf habitat maps will dramatically improve fishery-independent data collection and stock assessments by facilitating comparisons of species distributions and abundances across like habitats, allowing scientists to sample more precisely by habitat type and improve the quality of information used to assess the health of fish and wildlife populations.

In recognition of the important role of habitat maps both in sustainably managing the region's fisheries, as well as in the overall success of Gulf restoration in the years to come, we offer our support for this program and encourage the Gulf Coast Ecosystem Restoration Council to include it in the Draft Funded Priorities List.

Thank you,

Captain Billy Archer Captain
Eric Mahoney Daisy Mae VI
Inc.
Circle H Charters Captain Gary
Jarvis Back Down 2 Inc. Savory
Restaurants LLC
Naples Guides Association Captain Will
Geraghty

Gulf Restoration Center
307 Tchoupitoulas Street, Suite 300
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Ocean Conservancy

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November 17, 2014

Secretary Penny Pritzker
U.S. Department of Commerce 1401
Constitution Ave., NW Washington DC,
20230
RE: Gulf-Wide Habitat Mapping and Water Quality Monitoring Network proposal

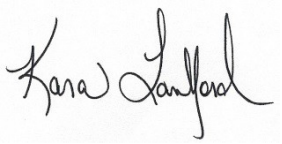
Sec. Pritzker:

On behalf of Ocean Conservancy, please accept the following comments in support of the Department of Commerce's Gulf-wide Habitat Mapping and Water Quality Monitoring Network proposal for the Gulf Coast Ecosystem Restoration Council's Funded Priorities List. The RESTORE Act provides a once-in-a- generation opportunity to invest in foundational ecosystem science and restoration initiatives that set the Gulf of Mexico on a course to long-term recovery and sustainability. As primary stewards for the marine environment, the Department of Commerce is in a unique position to make investments that benefit marine resources and the communities that depend upon them. Ocean Conservancy has consistently recommended habitat mapping as a transformative restoration initiative, and we thus strongly support the mapping and monitoring network proposal.

Increasing the coverage of high-quality Gulf habitat maps supports better marine resource management, including sustainable fisheries. The proposed program for assessing and integrating existing information and filling priority gaps will benefit Gulf fisheries and also provide foundational information for the comprehensive ecosystem restoration work to come. Filling the gaps that currently exist in Gulf habitat maps will dramatically improve our understanding of the amounts, types and locations of marine habitats, providing valuable information for assessments of fish and wildlife populations. This will provide better information to natural resource managers to track recovery, guide future restoration efforts and inform sustainable-use decisions.

As we track Gulf resource recovery from the BP oil disaster and other chronic issues, collecting habitat data will prove a worthwhile investment across both coastal and marine ecosystems. Comprehensive restoration will require complete inventories of information, and we therefore strongly support this project for inclusion on the Funded Priorities List.

Sincerely,



Kara Lankford
Interim Director, Gulf Restoration Program Ocean
Conservancy

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

NOV 17 2014

The Honorable Penny Pritzker
Secretary of Commerce
Washington, DC 20230

Dear Madam Secretary:

As the RESTORE Council (Council) moves forward in selecting projects for the Funded Priorities List (FPL), the Department of the Interior (DOI) supports the Department of Commerce (DOC) proposal to the Council titled *Gulf of Mexico Habitat Mapping and Water Quality Monitoring Network*. For the current FPL, the Council is focusing on Habitat and Water Quality Gulf ecosystem restoration projects. This proposed monitoring network will help ensure successful Council-funded projects while also fulfilling the Council's commitment to measuring results and reporting impacts.

Scientists in each of our Agencies have been working together on this proposal to leverage their expertise in support of Gulf ecosystem restoration. Both the United States Geological Survey (USGS) and the National Oceanic Atmospheric Administration (NOAA) have successful track records in monitoring to assess the success of restoration. This proposal brings together the best monitoring and habitat mapping expertise USGS and NOAA have to offer. With the USGS's monitoring and habitat mapping expertise as well as existing water quality networks in coastal watershed areas (brown water), NOAA's monitoring expertise and networks in the open ocean (blue water), and their overlapping expertise in green water, we are able to join together with greater strength and lesser costs. These strengths enable us to support and leverage existing networks and reporting impacts on Council-funded projects than either Agency could do alone.

It is also challenging to build long-term sustainable ecosystem restoration projects that are subject to both natural and anthropogenic conditions such as hurricanes, storms, contaminate spills, and urban and agricultural development. However, both USGS and NOAA have successful records in evaluating and establishing sustainable restoration projects. We can bring the best technical expertise together to identify the data that needs to be collected and analyzed to assess projects, and aid project managers in designing long-term sustainable restoration projects.

Because DOI and DOC are both Council Members, this partnership is important both to the success of Gulf Restoration and in the function of the Council as a whole. If funded, we look forward to partnering in this work to ensure long-term sustainable Council-funded ecosystem restoration projects.

Sincerely,

Benjamin E. Milakofsky
Deputy Chief of Staff

List of experts: The following individual have agreed to be considered as external experts for this project.

Nate Booth, USGS – data integration and analytical applications
Tim Carruthers, The Water Institute of the Gulf – conceptual models, ecological report cards, adaptive management
Tim Dellapenna, Texas A&M University – geologic data collection expertise and equipment
Betsy Gardner, NOAA – geospatial mapping and data management
Matt Howard, Gulf of Mexico Coastal Ocean Observing System – water quality, mapping products
Mike Lee, USGS – water quality, statistical analyses
Mike Miner, BOEM – coastal geomorphology, marine minerals
Paul Montagna, Texas A&M University, Harte Research Institute for Gulf of Mexico Studies – monitoring
Maitane Olabarrietta, University of Florida – modeling
Ed Patino, USGS – water quality, statistical analyses
Richard Rebich, USGS – water quality, statistical analyses, modeling
Dale Roberts, USGS – water quality, modeling, statistical analyses
Tim Saultz, USGS – LiDAR and photo acquisition
Martha Segura, NPS – monitoring program development
Steve Traxler, USFWS – habitat conservation, status and trends
Robert Twilley, LSU – integrated ecosystem assessments, monitoring/modeling integration
Brett Webb, University of South Alabama – data acquisition (water levels, waves, bathymetry)
Jennifer Wozencraft, USACE – LiDAR

Figures

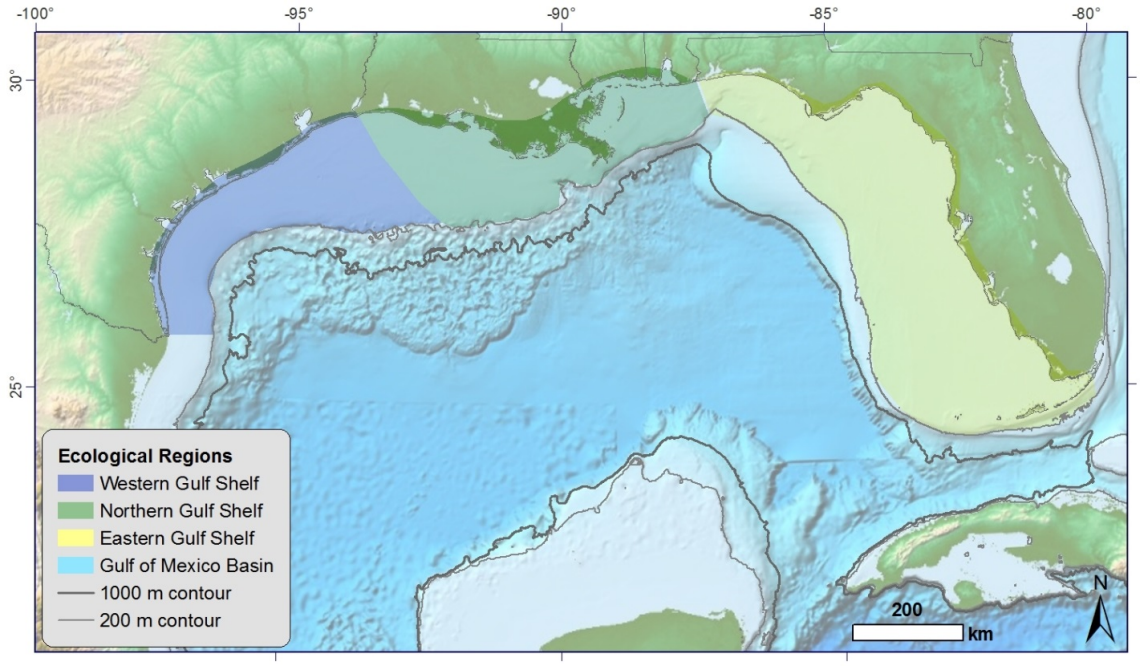


Figure 1: A map of the four ecological regions proposed for habitat mapping – the Western, Northern, and Eastern Gulf of Mexico shelves, and the Gulf of Mexico Basin.

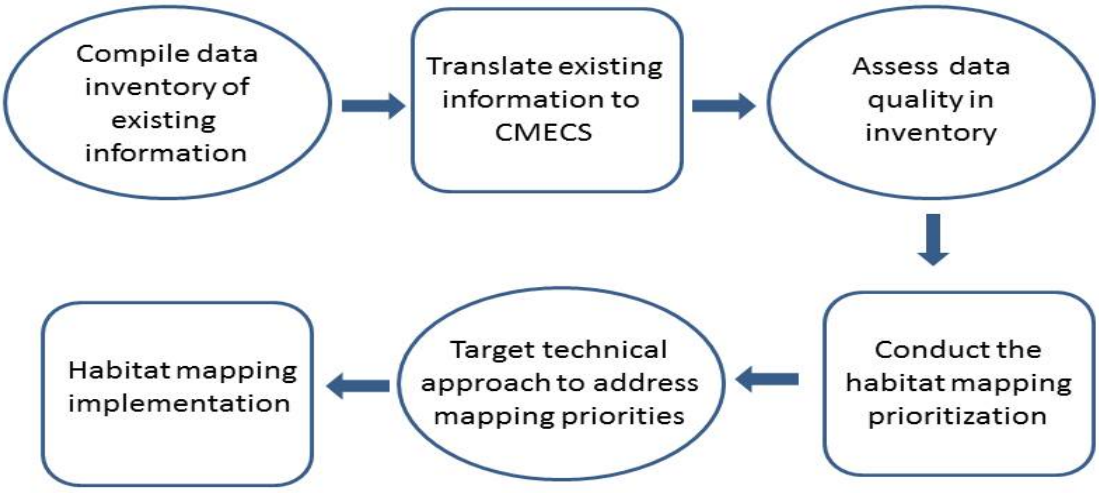


Figure 2: Habitat mapping framework – a conceptual diagram showing the proposed implementation framework for the NOAA habitat mapping activities in the Gulf region.

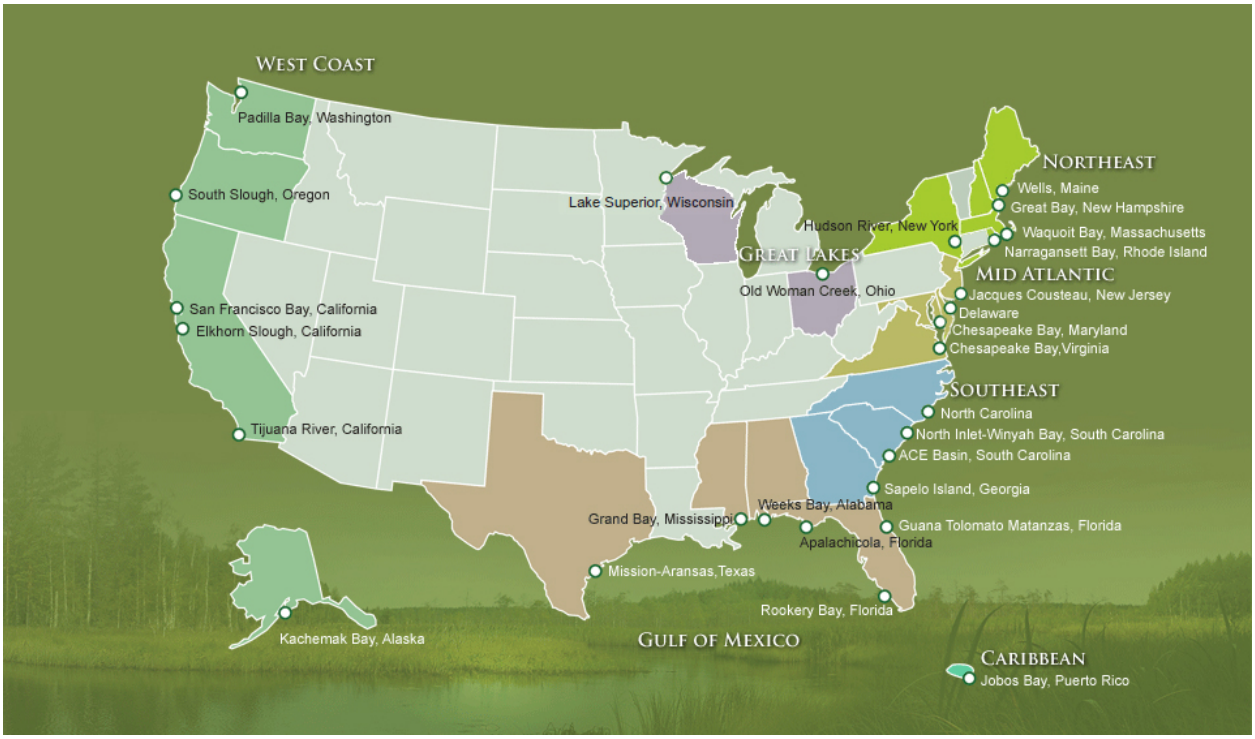


Figure 3: National Estuarine Research Reserve Sites. There are five NERRS sites within the Gulf of Mexico. This project intends to use the NERRS model to provide broader coverage across the Gulf and out into the offshore environment.

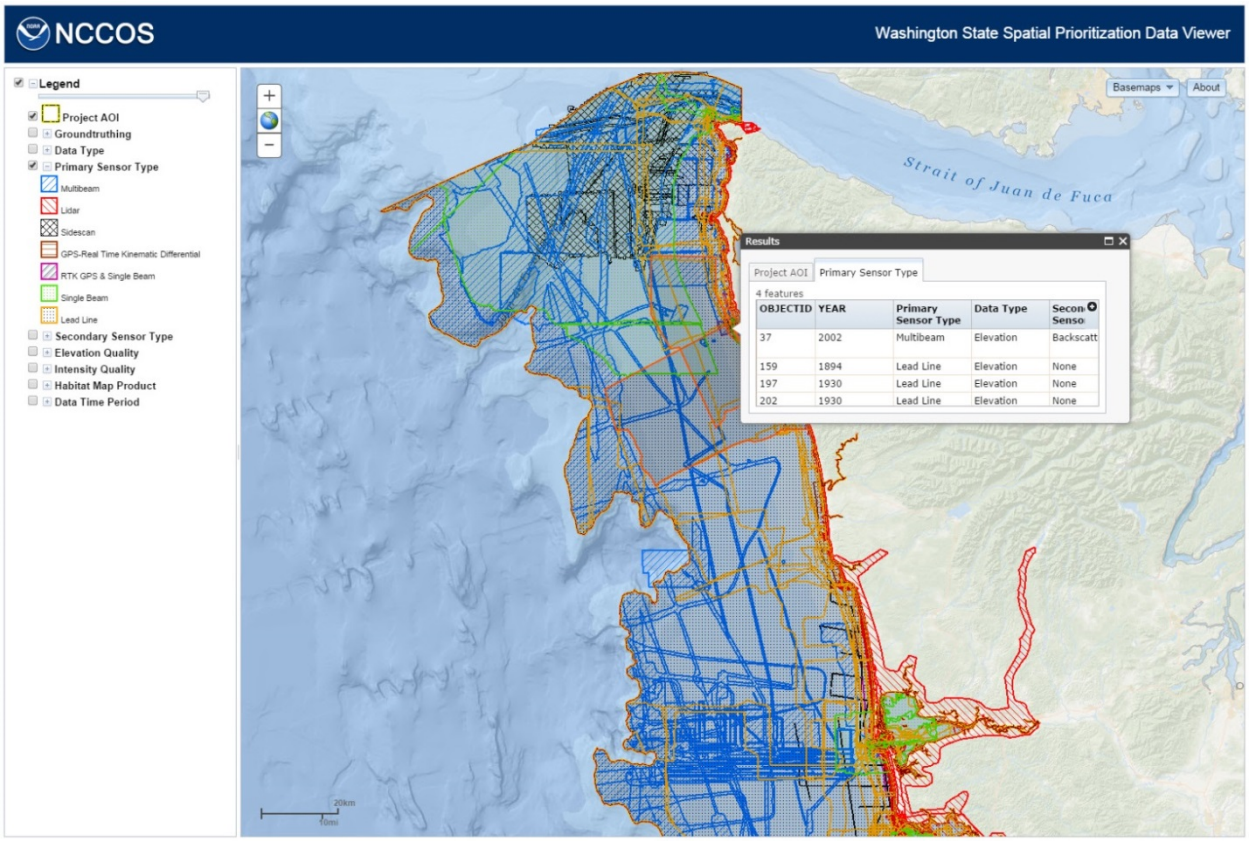


Figure 4. A screenshot showing the spatial data inventory and the web portal for seafloor map information along the Pacific Coast of Washington.

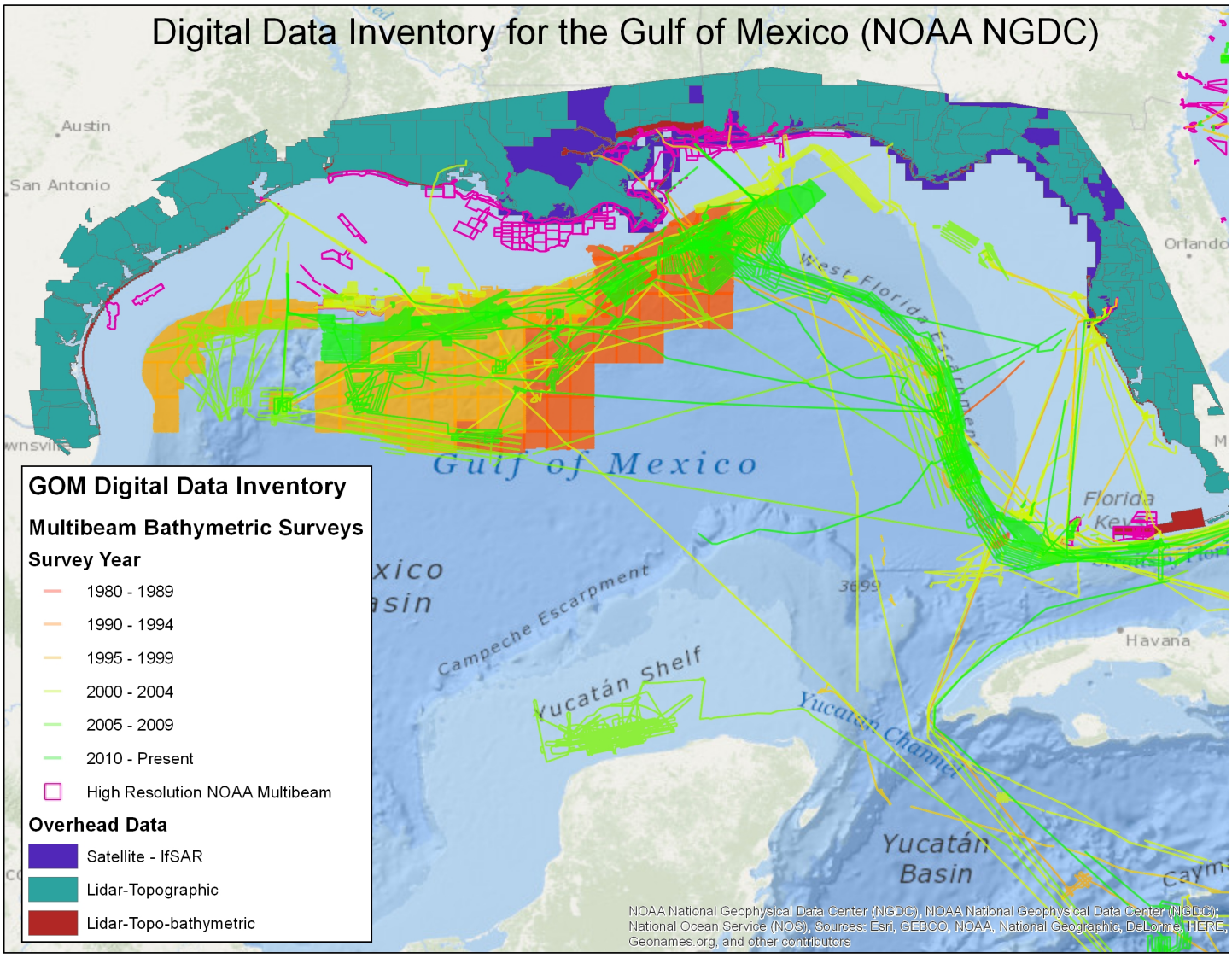


Figure 5. Digital Data Inventory of bathymetric surveys in the Gulf of Mexico.

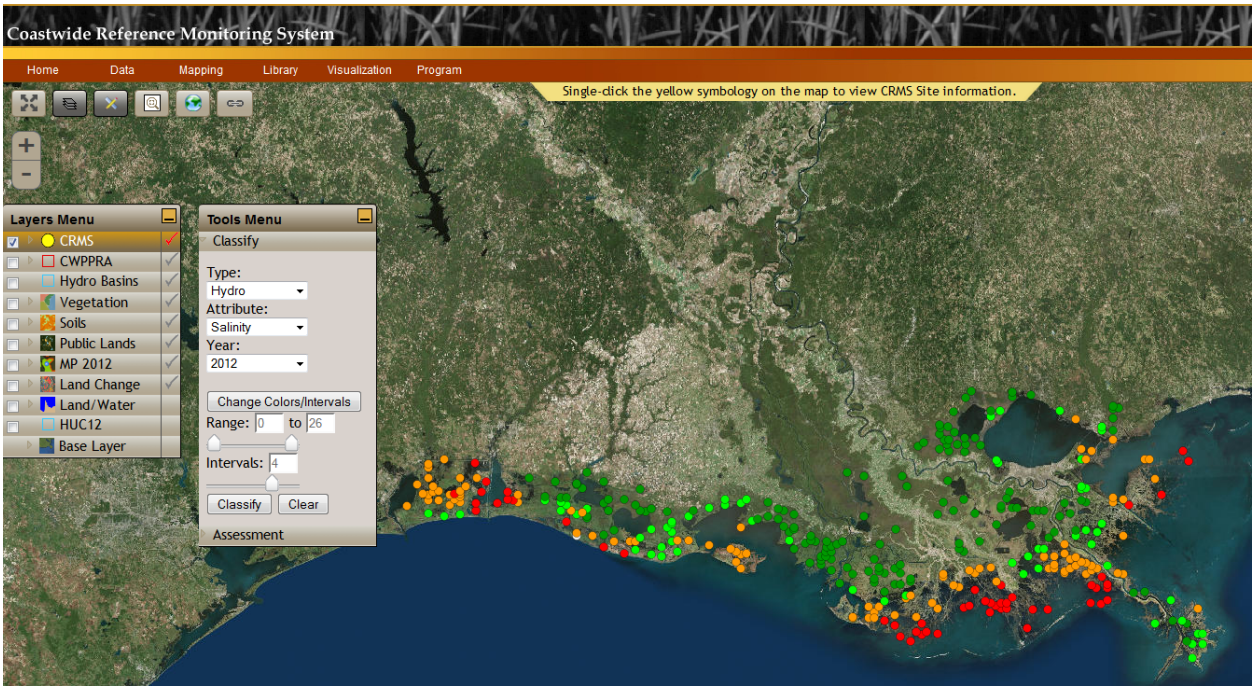


Figure 6: A web-based visualization from the Coastwide Reference Monitoring System (CRMS, www.lacoast.gov/crms2) illustrating wetland monitoring stations in coastal Louisiana and user-driven classification tools.

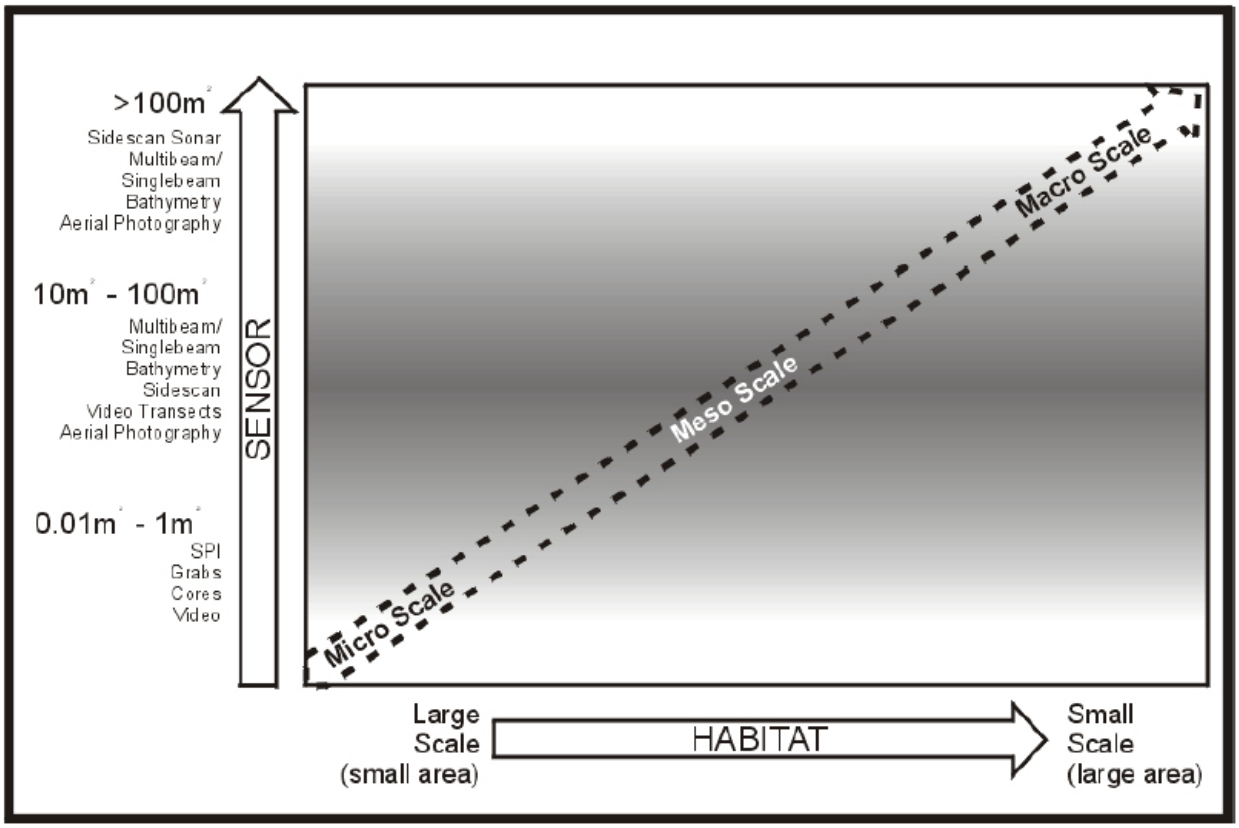


Figure 7: Relative scale of sensors and analysis for seafloor mapping (Andrews 2003).

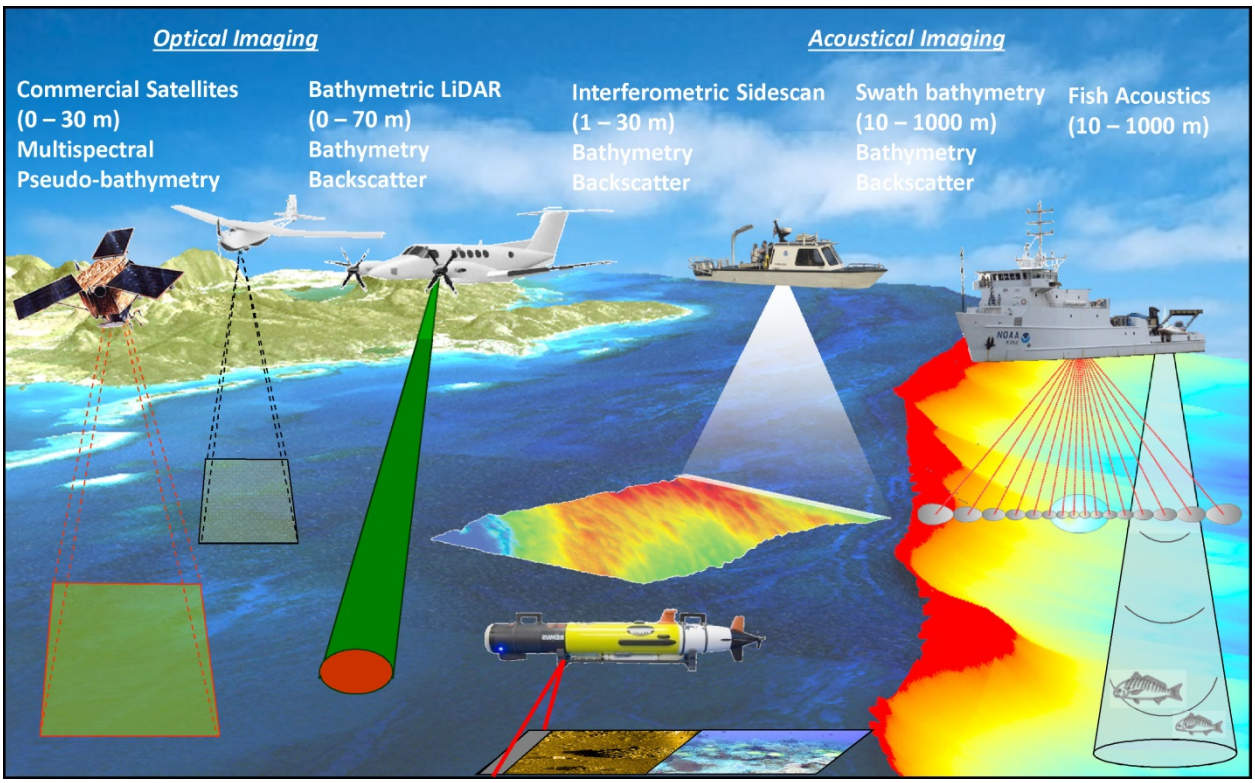


Figure 8: Sensor technologies – the variety of sensors used for seafloor mapping and their scale of resolution (Andrews 2003).

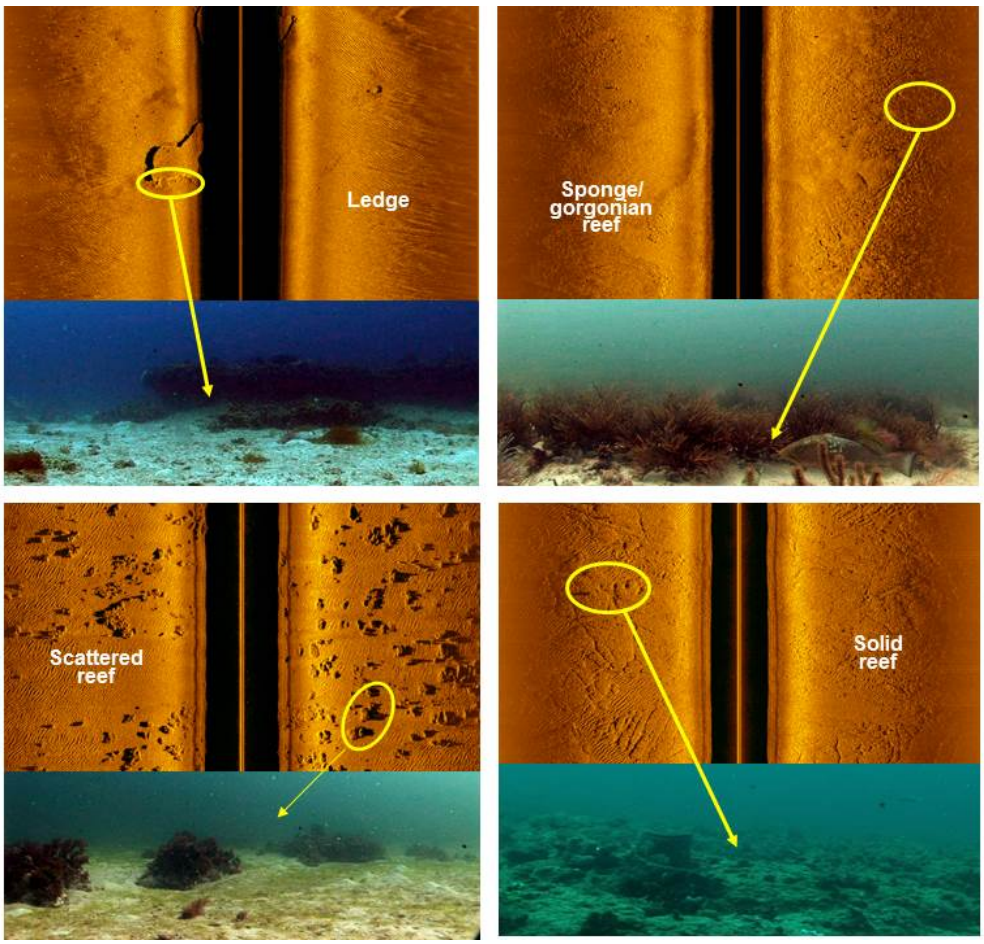


Figure 9: Sidescan sonar is routinely used to map shallow water environments in the Gulf of Mexico. The top of each panel shows seafloor habitat characteristics in sidescan imagery and the bottom of each panel shows relevant ground truthing of those feature types from visual surveys.

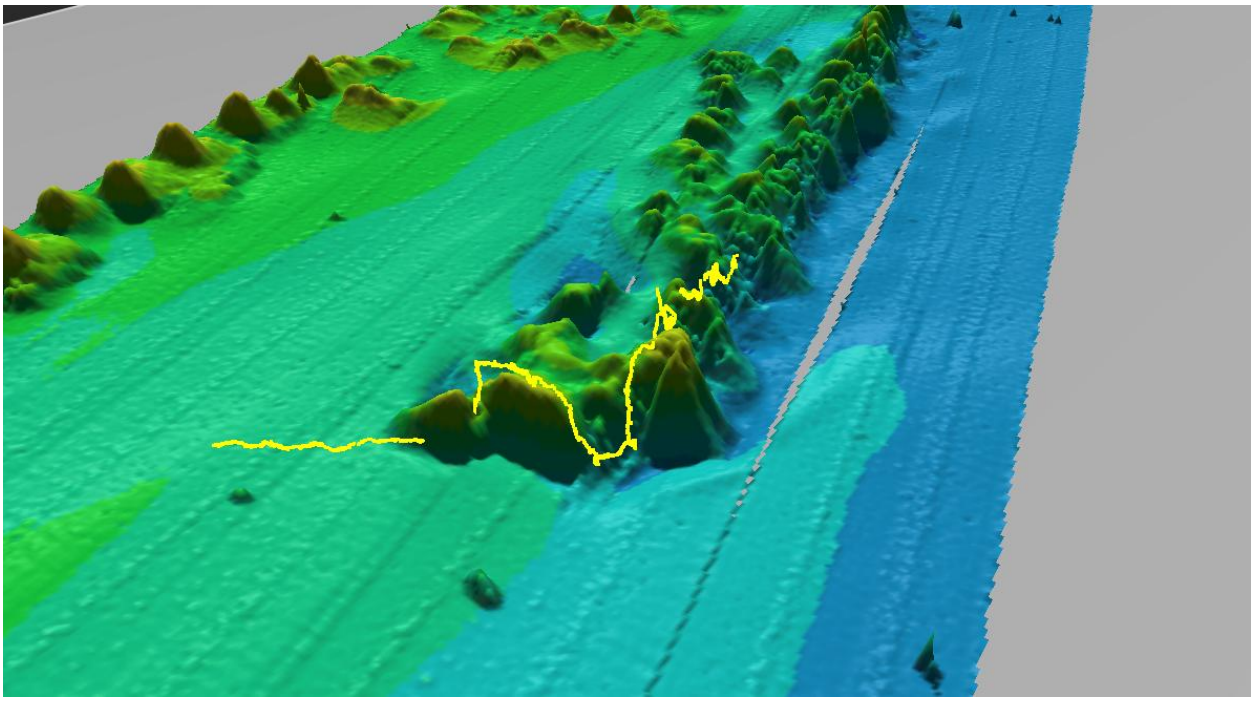


Figure 10: A perspective view from the east Florida shelf showing a remotely operated vehicle (ROV) trajectory superimposed over shaded-relief bathymetry collected by multibeam sonar. ROVs are used to conduct visual surveys of seafloor habitats and their biological communities.

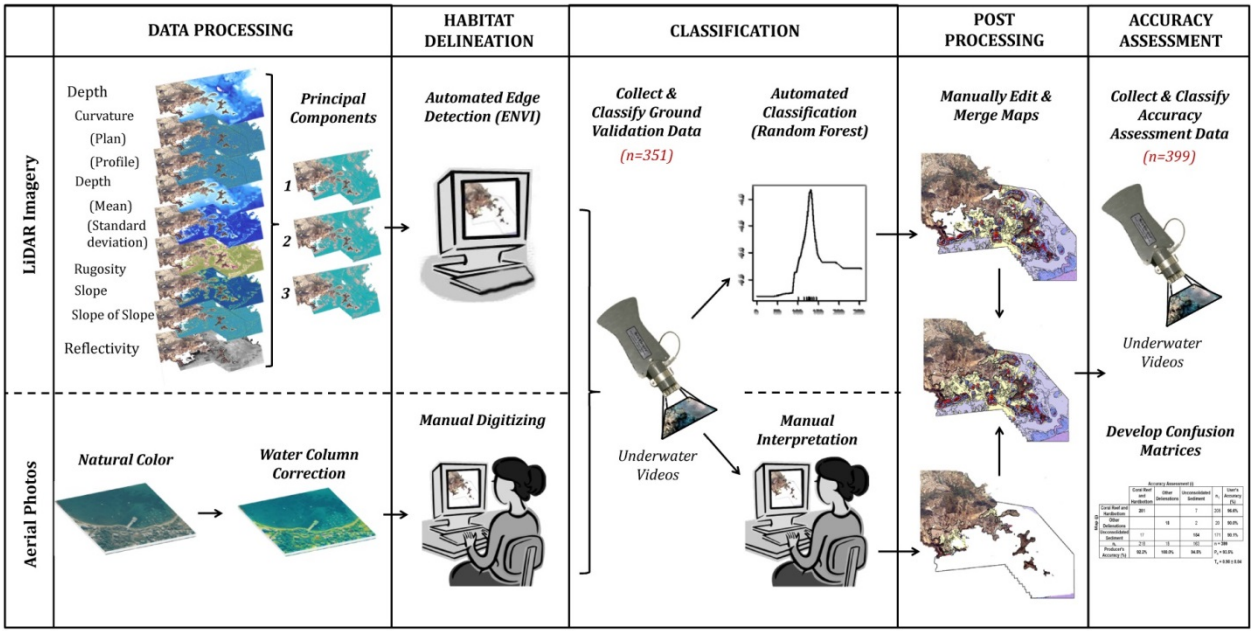


Figure 11: A diagram illustrating the sequence of steps taken to create seafloor habitat maps (Costa et al. 2013).

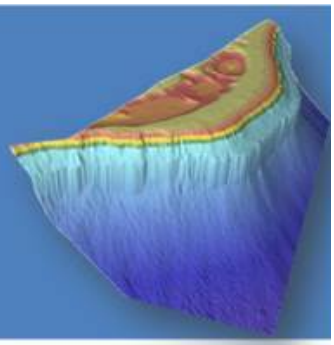
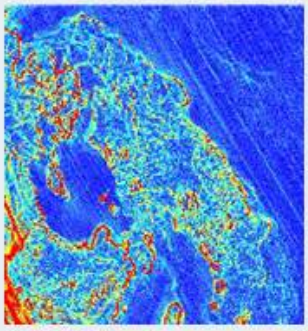
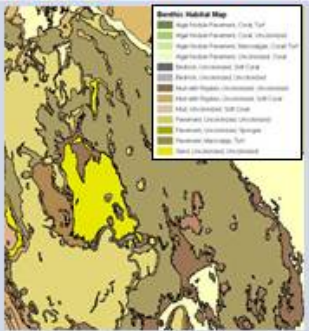
Seafloor Topography	**Derived from acoustic and optical bathymetry. A measure of seafloor relief.**	
Seafloor Intensity	Derived from acoustic and optical backscatter. A measure of seafloor roughness and hardness.	
Derived Morphometrics	Derived from topography and intensity surfaces (e.g. rugosity, slope, slope of slope, fractals,	
Benthic Habitats	Surficial habitats delineated from seafloor mapping data. Includes biological, sediment texture, grain size distribution, and sedimentary environments.	

Figure 12: Seafloor Products – four examples of seafloor mapping products that are anticipated to be produced for Gulf of Mexico benthic habitats.

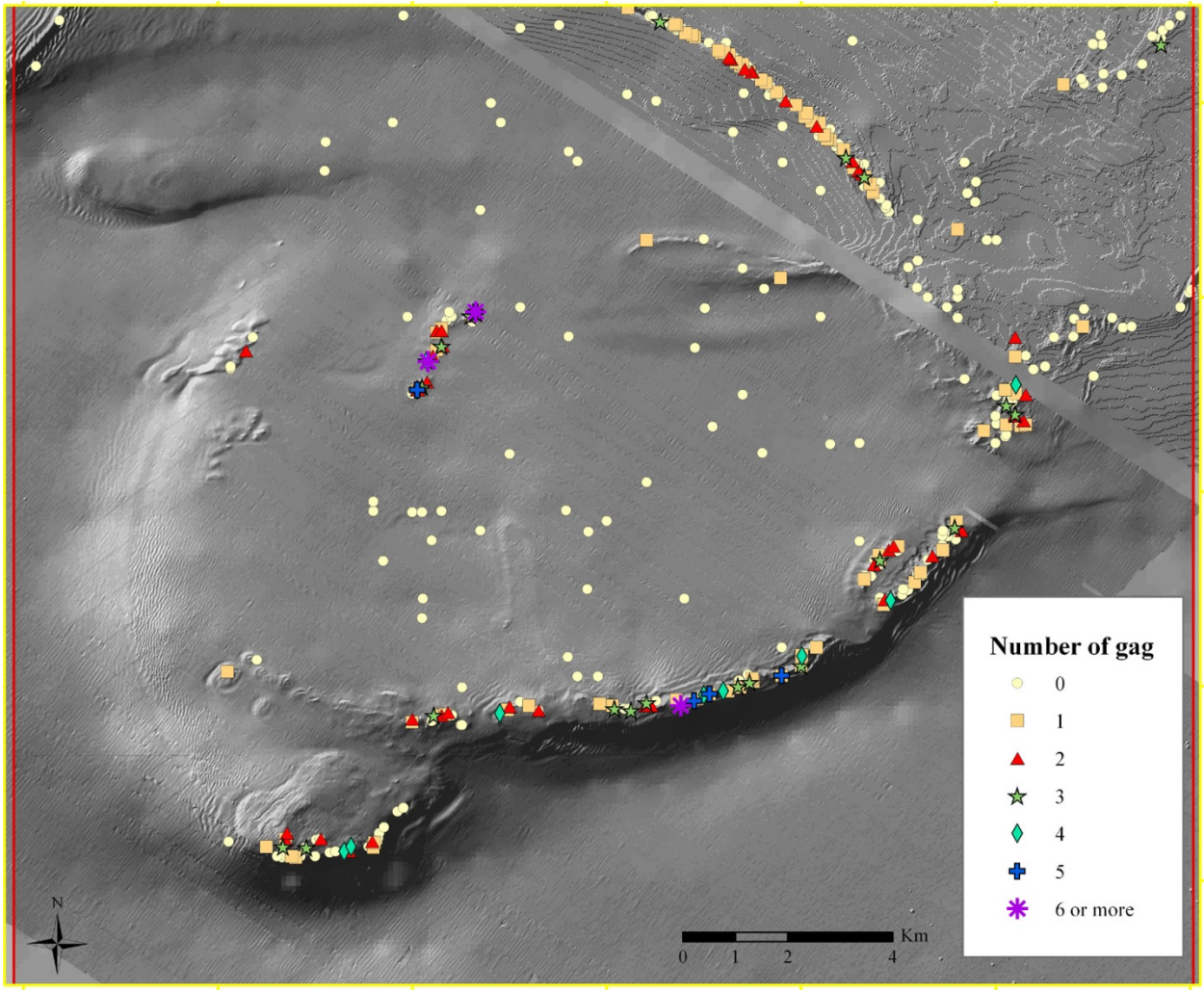


Figure 13: A map illustrating the numbers of gag grouper (*Mycteroperca microlepis)* observed in visual surveys over topographic features on Madison Swanson South Reserve off West Florida, as derived from multibeam bathymetry.

ELIGIBILITY REVIEW

Bucket 2 – Council Selected Restoration Component

PROPOSAL TITLE

Gulf of Mexico Habitat Mapping and Water Quality Monitoring Network

PROPOSAL NUMBER

DOC-2

LOCATION

Across the Gulf with potential targeted case study area

SPONSOR(S)

Department of Commerce, Department of the Interior

TYPE OF FUNDING REQUESTED (Planning, Technical Assistance, Implementation)

Technical Assistance

REVIEWED BY:

Bethany Carl Kraft/ Ben Scaggs

DATE:

11-18-14

1. Does the project aim to restore and/or protect natural resources, ecosystems, fisheries, marine and wildlife habitat, beaches, coastal wetlands and economy of the Gulf Coast Region?

◉ YES ○ NO

Notes:

Proposal aims to conduct a monitoring inventory, identify gaps, develop criteria for prioritizing monitoring needs and collaboratively develop the regional network to fill these needs.

2. Is the proposal a project?

○ YES ◉ NO

If yes, is the proposed activity a discrete project or group of projects where the full scope of the restoration or protection activity has been defined?

○ YES ○ NO

Notes:

3. Is the proposal a program?

(●) YES ( ) NO

If yes, does the proposed activity establish a program where the program manager will solicit, evaluate, select, and carry out discrete projects that best meet the program's restoration objectives and evaluation criteria?

(●) YES ( ) NO

Notes:

4. Is the project within the Gulf Coast Region of the respective Gulf States?

(●) YES ( ) NO

If no, do project benefits accrue in the Gulf Coast Region?

( ) YES ( ) NO

Notes:

Eligibility Determination

ELIGIBLE

Additional Information

Proposal Submission Requirements

1. Is the project submission overall layout complete? ***Check if included and formatted correctly.***

A. Summary sheet	☑	F. Environmental compliance checklist	☑
B. Executive summary	☑	G. Data/Information sharing plan	☑
C. Proposal narrative	☑	H. Reference list	☑
D. Location information	☑	I. Other	☑
E. High level budget narrative	☑		

If any items are NOT included - please list and provide details

Specific location information not included. Program calls for locations for habitat mapping and water quality monitoring to be specified as part of the inventory and assessment process.

2. Are all proposal components presented within the specified page limits (if applicable)?

◉ YES ○ NO

Notes: