

Ocean Conservancy

CHARTING THE GULF

Analyzing the Gaps in Long-term
Monitoring of the Gulf of Mexico



SPONSORS

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Charting the Gulf:

Analyzing the Gaps in Long-term Monitoring of the Gulf of Mexico

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EXECUTIVE SUMMARY

We must continue to invest in the research and monitoring we need to better understand impacted resources and their role in the ecosystem.

In April 2010, the mobile drilling unit *Deepwater Horizon* exploded and sank in the northern Gulf of Mexico, discharging millions of barrels of crude oil and resulting in the unprecedented use of nearly two million gallons of chemical dispersant. The disaster impacted habitats, wildlife, fisheries and coastal communities. At the time of the BP *Deepwater Horizon* oil disaster, the scientific community was virtually unanimous on one point: Knowledge about how species and habitats in the Gulf would respond to oil and dispersant exposure, and the information needed to support their recovery, was woefully deficient (Graham et al., 2011; Norse & Amos, 2010; Peterson et al., 2012).

Given the magnitude of the oil disaster and the unparalleled resources targeted at restoration, Ocean Conservancy produced *Charting the Gulf: Analyzing the Gaps in Long-term Monitoring of the Gulf of Mexico* to better understand what information is available, where gaps exist and where we might focus our collective efforts to identify critical gaps in monitoring and observation (Table 1) in order to support a successful restoration initiative. These gaps, if left unfilled, could hinder our ability to understand

if, how and why our natural resources are recovering from the BP oil disaster and responding to broader restoration efforts.

In order to build a foundation for ecosystem monitoring in the Gulf, Ocean Conservancy compiled an extensive inventory of existing and past natural resource monitoring efforts and conducted an expert-based assessment of long-term monitoring needs. This information was used to identify gaps in monitoring for species and habitats impacted by the BP oil disaster, but its applicability is much broader, given the wide range of coastal and marine restoration and management activities currently underway in the Gulf. Restoration programs such as the Gulf Coast Ecosystem Restoration Council or the National Fish and Wildlife Foundation Gulf Environmental Benefit Fund can use the inventory to identify existing monitoring efforts related to their project evaluation and regional monitoring needs. By accessing and leveraging existing monitoring activities included in this inventory, restoration program managers will be able to track recovery of a target resource more efficiently and cost-effectively through reducing duplication and enhancing coordination.



Ocean Conservancy's analysis was conducted using 12 resource categories identified by the *Deepwater Horizon* Natural Resource Damage Assessment (NRDA) Trustees (2012), plus one for the ecosystem drivers in the Gulf. These ecosystem drivers, such as freshwater inputs, size and location of low oxygen areas (known as "dead zones"), ocean temperature and chemistry, could explain why species or habitats are not responding to restoration efforts or recovering as expected. Knowledge of these drivers and other important parameters allows scientists to take the pulse of the Gulf and gives restoration decision-makers the wide-angle, ecosystem lens through which they can understand successes or setbacks and change course accordingly.

Just as a doctor cannot make a diagnosis and prescribe treatment without knowing anything about a patient's overall health and

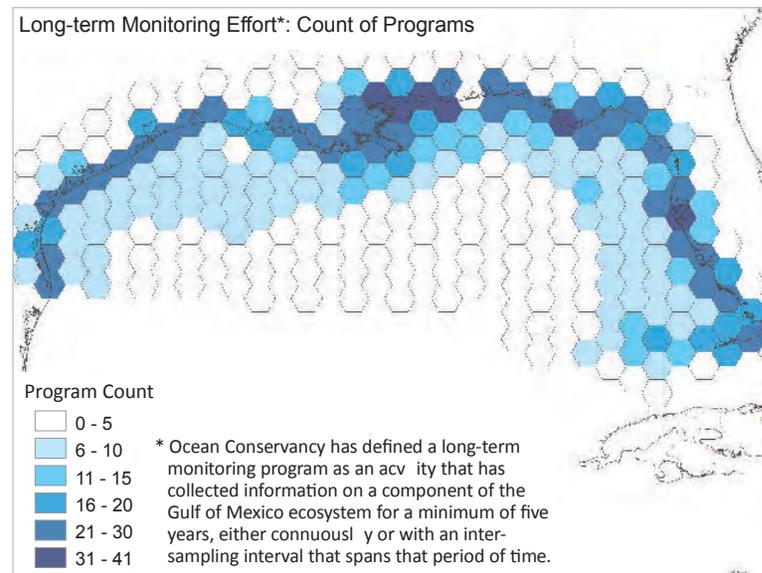


Figure 1: Coverage map of long-term monitoring efforts in the Gulf

The analysis reveals three overarching findings:

1. There are many existing monitoring efforts that restoration decision-makers can use to track the recovery of injured natural resources. Building on these existing efforts will improve consistency, efficiency and coordination.
2. There are gaps in monitoring and in our understanding of natural resources in the Gulf that must be addressed in order to effectively evaluate recovery and thus the success of restoration programs in the Gulf ecosystem.
3. As a group, the species and habitats in the offshore environment are monitored to a lesser degree than coastal or terrestrial species and habitats (Figure 1). Addressing the currently disjointed monitoring system and moving toward a Gulf-wide ecosystem monitoring network will provide a more efficient, integrated and accessible tool for ecosystem information.

history, decision-makers cannot successfully restore the resources impacted by the BP oil disaster without understanding the overall health and history of the ecosystem. Monitoring is critically important in the aftermath of an ecosystemwide event like the BP oil disaster, because it helps scientists track the vital signs of the ecosystem and inform subsequent recovery actions. An integrated monitoring network will also help decision-makers anticipate emerging stressors in the ecosystem such as climate change.

For restoration to be successful, we must continue to invest in the research and monitoring we need to better understand impacted resources and their role in the ecosystem. Targeted and sustained investments in science shed crucial light on ecosystem health and lead to new tools and better management decisions.

Resource Category	Key Findings of Gap Analysis
Ecosystem Drivers	<ul style="list-style-type: none"> • Observing system mostly concentrated along coast or nearshore waters. • Ocean observing network is sparse or inoperable with inadequate/unstable findings. • Observations are primarily limited to surface waters. • Need better integration of drivers into status and trends assessments for species and habitats.
Deep-water Communities	<ul style="list-style-type: none"> • Limited long-term monitoring of impacted areas. • Monitoring is small-scale and isolated. • Almost no sustained monitoring of deep-water communities.
Water Column and Invertebrates	<ul style="list-style-type: none"> • No monitoring below 200 meters. • Methods and gear limit collection of smaller organisms. • No monitoring of gelatinous zooplankton.
Birds	<ul style="list-style-type: none"> • Little to no monitoring of pelagic species. • Existing monitoring targets distribution, abundance and density. • Limited monitoring of ecosystem drivers and stressors.
Marine Mammals	<ul style="list-style-type: none"> • Monitoring is fragmented. • Limited pelagic monitoring. • More monitoring needed for status and trends in many species.
Marine Fish	<ul style="list-style-type: none"> • More studies for adult pelagic species needed. • Limited sustained monitoring in pelagic waters. • Limited data on Gulf habitats.
Sea Turtles	<ul style="list-style-type: none"> • No long-term monitoring of male or juvenile turtles. • Observer coverage low or absent in Gulf fisheries. • Some nest monitoring is dependent on volunteer capacity.
Nearshore Sediments & Associated Resources	<ul style="list-style-type: none"> • No assessment of physiological, developmental or genetic response to oil. • Regionwide surveys not sustained. • Reliance on short-term intensive studies.
Oysters	<ul style="list-style-type: none"> • Mapping efforts not coordinated. • Gulf-wide metrics not standardized. • Oyster harvest activities are the most rigorously tracked.
Submerged Aquatic Vegetation	<ul style="list-style-type: none"> • All priority species are monitored. • Aerial surveys limited in range and frequency. • New programs provided opportunities to fill gaps.
Shallow- and Mid-water Corals	<ul style="list-style-type: none"> • Most monitoring is at national marine sanctuaries. • An integrated sentinel site program does not currently exist for monitoring climate change impacts. • No Gulf-wide efforts for regional trends and comparisons.
Shorelines	<ul style="list-style-type: none"> • Gaps in monitoring of shoreline stressors and ecological processes. • Monitoring of shoreline elevation and extent of coarse habitat is widespread.
Terrestrial Species	<ul style="list-style-type: none"> • Some species have Gulf-wide coverage; for others, only isolated monitoring exists. • Existing monitoring is focused on threatened/endangered species or harvestable species.

Table 1: Key findings of long-term monitoring gap analysis, by resource category.

INTRODUCTION

In April 2010, the mobile drilling unit *Deepwater Horizon* exploded and sank in the northern Gulf of Mexico, discharging millions of barrels of crude oil into Gulf waters and impacting habitats, wildlife and ecosystem services. Restoration from the BP oil disaster is underway and will continue for years, even decades. In addition to traditional restoration activities, long-term ecosystem monitoring is essential to understand if resources are recovering and how changes in the Gulf ecosystem are influencing their rate of recovery. Monitoring data will enable restoration planners to evaluate project effectiveness and adjust strategies for better outcomes. In addition, the government's ability to detect delayed or worsening oil disaster injuries – and its basis for accessing a reserve set aside by BP for further natural resource damages unknown at settlement – will hinge on information provided through a comprehensive and sustained monitoring effort (*In re: Oil Spill*, Confidentiality Order, E.D. La. July 2, 2015).

At the time of the BP oil disaster, the scientific community was virtually unanimous on one point: Knowledge about how species and habitats in the Gulf would respond to oil and dispersant exposure, and equally important, the information needed to support their recovery, was woefully deficient. The

need for more complete information on the abundance and ecology of species led to the dedication of a portion of the oil disaster criminal and civil fines to Gulf ecosystem monitoring and research (Bjorndal et al., 2011).

In order to build a foundation for ecosystem recovery monitoring in the Gulf, Ocean Conservancy compiled an extensive inventory of existing and past natural resource monitoring efforts and conducted an expert-based assessment of long-term monitoring needs. This information was used to identify gaps in monitoring for species and habitats impacted by the BP oil disaster, but its applicability is much broader, given the wide range of coastal and marine restoration and management activities currently underway in the Gulf.

The results of the inventory and analysis reveal three important overarching findings:

1. There are many existing monitoring efforts that restoration decision-makers can use to track the recovery of injured natural resources. Building on these existing efforts will improve consistency, efficiency and coordination.
2. There are gaps in monitoring and in our understanding of natural resources in the Gulf that must be addressed in order to effectively evaluate recovery and thus the success of restoration programs in the Gulf ecosystem.
3. As a group, the species and habitats in the offshore environment are monitored to a lesser degree than coastal or terrestrial species and habitats (Figure 1). Addressing the currently disjointed monitoring system and moving toward a Gulf-wide ecosystem monitoring network will provide a more efficient, integrated and accessible tool for ecosystem information.



Sand dunes and sea oats, Florida Gulf Coast

Long-term ecosystem monitoring is essential to understand if resources are recovering and how changes in the Gulf ecosystem are influencing their rate of recovery.

Ocean Conservancy's analysis was conducted using 12 resource categories identified by the *Deepwater Horizon* Natural Resource Damage Assessment (NRDA) Trustees, plus one for ecosystem drivers. Like the monitoring needs discussed above, the inventory of monitoring efforts (Appendix D) has broader application. For example, restoration programs such as the Gulf Coast Ecosystem Restoration Council or the National Fish and Wildlife Foundation Gulf Environmental Benefit Fund can use the inventory to identify existing monitoring efforts related to their project evaluation and regional monitoring needs. By accessing and leveraging existing monitoring activities included in the inventory, restoration managers will be able to track recovery of a target resource more efficiently and cost-effectively, reducing duplication and enhancing coordination.

The environmental impact of the BP oil disaster is significant and not yet fully understood. In addition to the immediate and devastating impacts of shorelines and wildlife coated in oil, the less visible, sublethal impacts of oil can slow the recovery of affected resources and services. In some cases, residual oil and injuries resulting from an oil disaster may persist or not be fully understood for years after the incident, and a full recovery from oil disaster injuries can take decades (Rice et al., 2007). Studies of the *Exxon Valdez* oil spill show that oil remains in Prince William Sound after more than 25 years, and some injured resources have not fully recovered. Using the *Exxon Valdez* oil spill as an analogue, a 25-year oil disaster recovery monitoring program is needed in the Gulf, particularly for an event as large and complex as the BP oil disaster.

Timely and accurate information on the status of injured populations, habitats and ecosystem services is essential for recovery planning, as is the understanding of how marine conditions affect rates of recovery. Decision-makers faced with making substantial investments in restoration need to know when to redirect resources or adjust strategies for better results if species or habitats are not showing signs of improvement. Under the Oil Pollution Act of 1990, the responsibility of restoring natural resources to their pre-oil spill condition and monitoring recovery rests exclusively with the *Deepwater Horizon* Trustees (15 CFR, Sec. 990.10). Therefore, the *Deepwater Horizon* Trustees overseeing the Natural Resource Damage Assessment and related restoration activities are in the best position to administer a long-term recovery monitoring program for resources injured by the BP oil disaster.

The Evolution of Monitoring in the Northern Gulf of Alaska Marine Ecosystem Following the *Exxon Valdez* Oil Spill

In the first few years after the 1989 *Exxon Valdez* oil spill, the state and federal government agencies took advantage of existing programs to track recovery of individual species. In some instances, they greatly expanded the existing sampling schemes in spatial or temporal intensity; in others, they added new programs where gaps existed. For the most part, these programs were designed to meet the individual agency mandates for specific species. For example, the Alaska Department of Fish and Game monitored many of the pink salmon spawning streams in the heart of the spill zone by measuring egg mortality and numbers of returning spawning adults (Bue, 1996; Sharr et al., 1995). In another example, the U.S. Fish and Wildlife Service designed a program just to monitor populations of sea otters (Garrott, 1993). While these programs were capable of detecting population changes, they could not explain unanticipated changes in populations or lack of recovery. As a result, when pink salmon populations took a downturn in Prince William Sound in 1991 and 1992, and the Pacific herring population crashed in 1993 and 1994, the restoration program had no ready answers for fishermen, who were expecting sharp improvements in fishing conditions, not downturns. The pressing question became, "Why aren't resources recovering as expected?" In order to get the answers to this question, a new phase of monitoring and research began in 1994, which went much further than individual agency mandates and instead emphasized an ecosystem approach and the need to understand ecological relationships between species and their environments (*Exxon Valdez* Oil Spill Trustee Council, 2003). In the instance of pink salmon recovery, the Sound Ecosystem Assessment Program and related efforts uncovered a whole web of relationships among oceanographic forcing factors, plankton production, salmon predators and hatchery fry release strategies that drove population fluctuations (Cooney et al., 2001) and helped restoration planners better understand the processes affecting recovery.

RESULTS AND LESSONS LEARNED

This chapter contains the results of Ocean Conservancy's analysis of long-term monitoring priorities and gaps for natural resources impacted by the BP oil disaster. This analysis is not intended to be a prescription for recovery monitoring, but it can be used as a reference document for planning and prioritizing activities under a broader restoration program.

Results of the Gap Analysis

The goal of this assessment is threefold:

- 1) identify the pool of long-term monitoring efforts applicable to BP oil disaster recovery monitoring;
- 2) identify priority long-term data collection or research activities needed to assess if natural resources are returning to their pre-oil disaster condition, and what is or is not driving their recovery; and
- 3) characterize the spatial, temporal and taxonomic gaps in monitoring coverage for each priority.

Analysis results are presented in 13 natural resource profiles, each containing the following elements:

- A short narrative summarizing the findings of the analysis;
- A table containing the long-term monitoring or research priorities and the types of gaps identified for each priority. (Note: The priorities included are summ-

arized versions of those identified. The full priorities are listed in Appendix B);

- A set of bullets briefly explaining or elaborating on gaps presented in the table. (Note: Expanded descriptions of the gaps are included in Appendix C); and
- A map showing the approximate geographic coverage of long-term monitoring efforts, and a related timeline chart illustrating the duration of relevant programs. (Note: Some programs listed in the map legend or on the timeline chart might not be mapped. Program numbers on the map correspond to those in Appendix D.)

The Ecosystem Drivers profile is organized differently from the other 12 profiles. This section includes an overview of ecosystem drivers, a summary of existing programs and graphics unique to this category.



Laughing gulls, Padre Island

Process at a Glance

A review of relevant publications identified a suite of important resource-specific monitoring needs. These needs were reviewed for areas of overlap and synthesized to capture overarching monitoring priorities (see Appendix B). Experts were then asked to confirm the list of priorities for monitoring resource recovery and to add any priorities they thought were omitted. (See names of experts in Acknowledgments).

The recovery monitoring priorities for each of the 13 resource categories were cross-referenced with an inventory of principal long-term monitoring efforts in an attempt to match data collection activities with monitoring priorities. Matching a priority with a corresponding survey effort included an assessment of whether a survey, program or suite of programs could satisfy a given data collection priority in space and time or for relevant species. If a monitoring effort could not meet a data need, a gap was identified. More specifically, if a monitoring effort collects or collected the type of information identified by a monitoring priority across a relevant geographic footprint, during relevant times of the year (e.g., life history stages such as migration or spawning) or for relevant species, then it was labeled as meeting a monitoring need. See Appendix D for additional information on the long-term monitoring programs used in the analysis.

Interpreting the Gaps

The template in Table 2 is an example of the tables included for the 13 resource profiles, excluding Ecosystem Drivers, to demonstrate the monitoring or research priorities and corresponding gaps. (For additional information on how gaps are defined, see Appendix A.)

Species: Using Priority A in the table as an example, there is no gap under Species because the relevant species, Species X or Species Z in this case, are both found to be monitored under existing effort(s) in the inventory. If any priority species or areas were not found to be monitored, then there would be a full gap across this category. “N/A” is shown in the Species column for resource categories for which priority species were not identified.

Space: Again using Priority A, although some monitoring coverage exists for this natural resource category within the U.S. Gulf of Mexico, this coverage is incomplete, resulting in a partial gap for Space with respect to any priority areas/sites identified for the category.

Time: Coverage in Time for Priority A is characterized as a full gap because the identified monitoring efforts do not collect data during critical times of the year (or for important life stages) for the natural resources in this category.

MONITORING/RESEARCH PRIORITY	GAP			PRIORITY SPECIES OR AREA		
	SPECIES	SPACE	TIME	Species X (or area)	Species Y (or area)	Species Z (or area)
Priority A	No gap	Partial gap	Full gap	●		●
Priority B	Partial gap	Full gap	Full gap		●	
Priority C	Full gap	No gap	No gap	●	●	
Priority D	Full gap	Partial gap	Partial gap	●	●	●

Table 2: An example of how gap analysis results are presented in resource profiles.

Gaps in monitoring coverage across relevant species, time or space are based on an inventory of eligible principal programs (See Appendix A for definition of “eligible”). While the inventory is comprehensive, it is not exhaustive, so it is possible that relevant programs were omitted from the inventory. Programs not captured in the inventory and therefore excluded from the analysis could result in false-positives for gap identification. That is, gaps identified in the analysis are not gaps in reality, because there are programs in place to collect the data needed. Within the context of this analysis, gaps in monitoring coverage are based on an interpretation of monitoring needs and existing coverage, and should be considered proxies for the adequacy of coverage relative to each priority. They are not necessarily an indication of where monitoring should occur or the intensity or frequency with which monitoring should occur going forward. Determining where, when, what and how monitoring or research activities are carried out is the domain of experts working in close consultation with the *Deepwater Horizon* Trustees. Ultimately, these experts will need to consider many factors, including which gaps are important to fill and to what degree monitoring needs to be enhanced, in developing a monitoring program that is representative and statistically valid to assess the status and trends for a resource category, species or habitat. The geographic scope of the analysis and portrayal of gaps, unless

otherwise noted, apply only to the coastal and marine environments of the United States.

Data Collected Under the Natural Resource Damage Assessment

This analysis excluded the studies and related data collection activities initiated under the *Deepwater Horizon* NRDA for injured natural resources. The primary reasons are that the injury studies generally did not meet the definition of an eligible long-term monitoring program (i.e., a minimum five-year data record), and the details of monitoring efforts were often not available to the public.

The studies initiated under NRDA undoubtedly generated unique and insightful data not available through any other program. Therefore, if not already doing so, the *Deepwater Horizon* Trustees should consider continuing or reinstating NRDA studies, or relevant elements, under a long-term *Deepwater Horizon* oil disaster monitoring program, particularly where gaps in coverage have been identified and non-NRDA monitoring efforts are not already in place. There is precedent for integrating data collection efforts initiated under NRDA into long-term recovery monitoring and research efforts, as was the case after the *Exxon Valdez* oil spill.





Natural Resource Profiles

The following Resource Profiles (pages 11-38) present gap analysis findings for 13 natural resource categories:

- Ecosystem drivers
- Deep-water communities
- Water column and invertebrates
- Birds
- Marine mammals
- Marine fish
- Sea turtles
- Nearshore sediments and associated resources
- Oysters
- Submerged aquatic vegetation
- Shallow- and mid-water corals
- Shorelines
- Terrestrial species

Ecosystem Drivers



If a resource is not responding to restoration actions, it may be due to natural forces or chronic stressors acting as a drag on recovery.

Summary

The Gulf of Mexico is a dynamic ecosystem influenced by natural forces and human activities, such as the BP oil disaster. The factors that drive changes in the broader Gulf ecosystem have important implications for restoration. For example, if a resource is not responding to restoration actions, it may be due to natural forces or chronic stressors acting as a drag on recovery. These prevailing environmental processes (physical, chemical and biological) help explain why fish populations might vary in abundance from year to year, how ongoing changes in ocean chemistry could impact species and how shifting species distributions can cause long-term impacts on fisheries. Ecosystem drivers ultimately influence the rate and degree of recovery of injured resources, so

consideration of these critical processes is important to overall restoration success.

More than 200 discrete data collection efforts exist in the Gulf that can potentially provide data on the environmental parameters needed to track key ecosystem processes. While the large number of efforts might give the impression that these drivers are comprehensively monitored, it is important to recognize that gaps in coverage essential to understanding trends in Gulf conditions, and their effects on marine life, still remain. For instance, the network of ocean observation stations in the Gulf may at times be incomplete due to funding cuts or the geographic patchiness of stations, with the majority located closer to the coast than offshore. In addition, the low resolution of some data limits their precision

and usefulness, particularly satellite-based observations of the sea surface for temperature, currents and salinity. While instruments provide valuable information on the marine environment, biological drivers cannot be effectively monitored wholly by ocean sensors alone, and thus on-the-water sampling is also needed. Finally, the disjointed nature of monitoring efforts makes it more difficult to locate and integrate oceanographic data into status and trends assessments for species and habitats injured by the BP oil disaster. These data will help better explain what ecosystem drivers might prevent some species from recovering, species such as bottlenose dolphins or oysters that in turn influence the ecosystem through their numbers as top predators or habitat engineers.

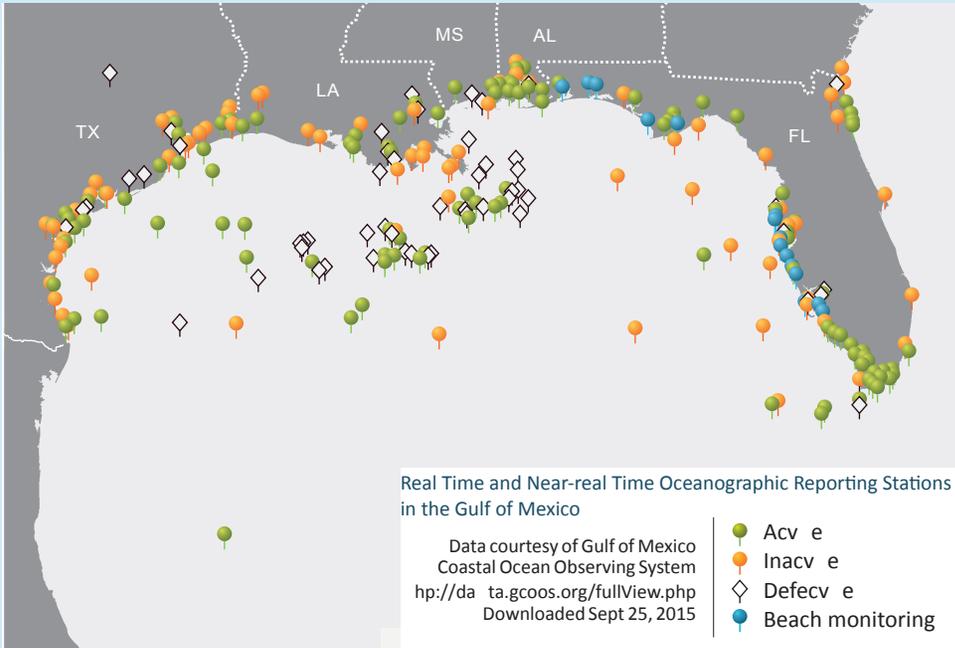
Measuring every ecologically important parameter is neither practical nor needed to understand changes in populations or habitats. The ecosystem drivers most likely to affect natural recovery should be monitored, as well as factored into recovery scenarios and restoration strategies.

What Ocean Conditions to Monitor?

As restoration efforts scale up, the following parameters will be important to track at the appropriate scale, whether seasonally, annually or over many decades:

- Sea level across the Gulf, as well as currents, salinity, acidity (pH), dissolved oxygen and temperature with depth from nearshore to offshore waters
- The volume and concentrations of nutrients, sediment, organic matter and freshwater in the discharge of the Mississippi and other major rivers
- Primary production (e.g., carbon fixation, dissolved oxygen concentrations) on shelf and offshore
- Wind events across the continental shelf critical in transporting larvae or juvenile crabs, shrimp and fish into estuaries, and basin-scale ocean circulation, e.g., Loop Current and its eddies

Ecosystem Drivers



KEY LESSONS

- Observing system is mostly concentrated along coast or nearshore waters.
- Ocean observing network is sparse or inoperative with inadequate or unstable funding.
- Observations are primarily limited to surface waters.
- Better integration of drivers data into status and trends assessments for species and habitats is needed.

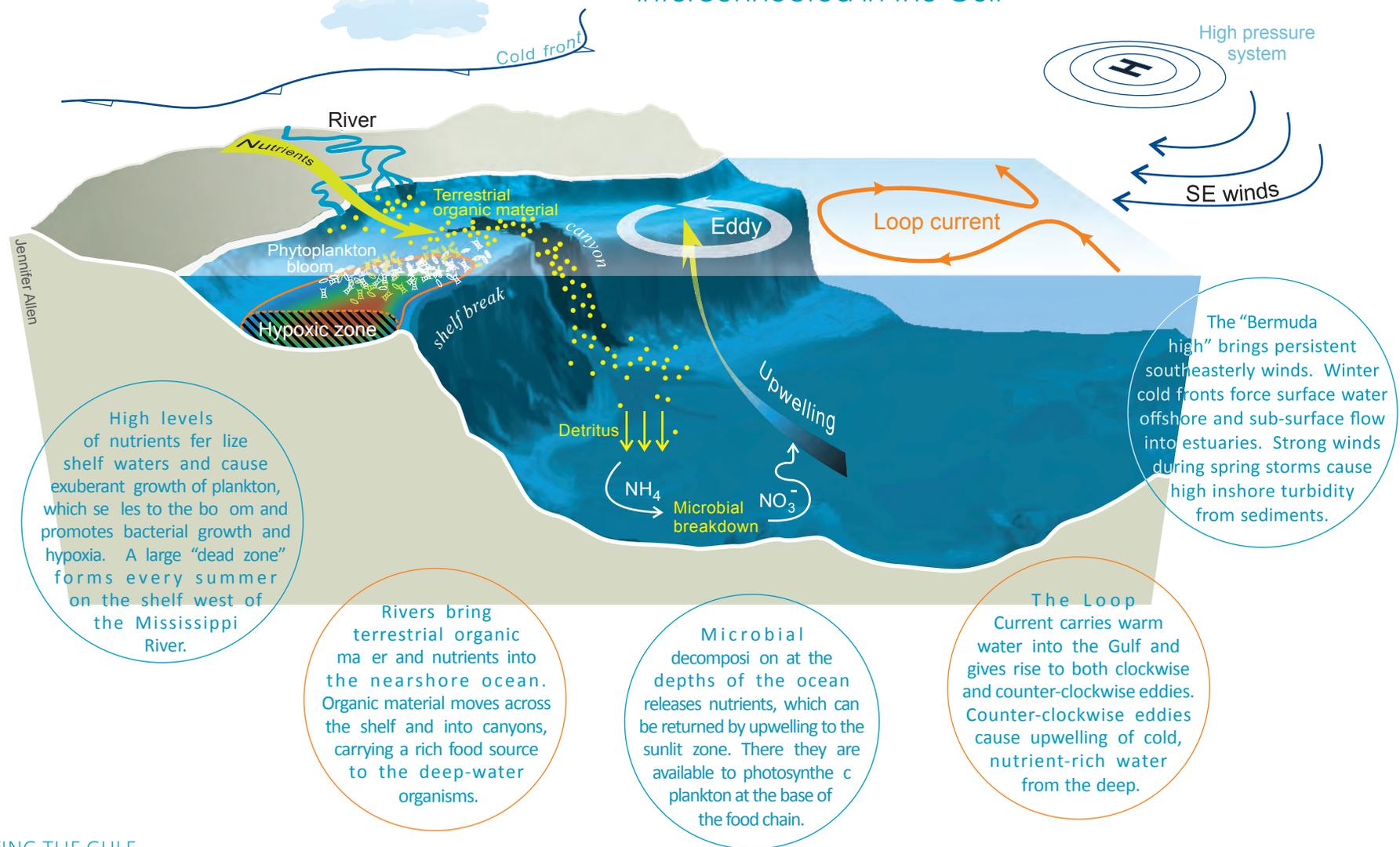
Monitoring Priorities and Example Programs for Ecosystem Drivers

Monitoring Priority	Sampling Scale	No. of projects Current/Closed	Example Programs
Currents	Bay/estuary to oceanic	36 / 2	Ocean Surface Topography Mission/JASON-2, Univ. of S. Mississippi CODAR High Frequency Radar, Wave-Current-Surge Information System for Coastal LA
Temperature, pH, salinity, total suspended solids	Bay/estuary to coastal sea	98 / 14	EPA Env. Monit. Assessmt. Prog., Suwannee River Water Mgmt. District Water Resource Monit. Prog., LA Dept. of Env. Quality Ambient Surface Water Quality Monitoring
Bottom-water dissolved O ₂	Coastal sea	2 / 1	LUMCON Hypoxia in the NGOM, Texas A&M Mechanisms Controlling Hypoxia Project
Dissolved O ₂ point samples	Bay/estuary to oceanic	58 / 11	Florida Aquatic Preserve Program, Texas Coastal Ocean Observation Network
River discharge (fresh water)	Bay/estuary	3 / 0	USGS National Water Information System, ACOE Water Levels of Rivers and Lakes
Nutrients	Bay/estuary to oceanic	30 / 23	FL Dept. of Env. Protection Strategic Monitoring Program for TMDLs, EPA National Aquatic Resource Surveys National Coastal Assessment
Chlorophyll <i>a</i> or ocean color	Bay/estuary to oceanic	23 / 7	Mississippi Dept. of Env. Quality Coastal Assessment Program, NERR
Phytoplankton	Bay/estuary	3 / 0	Texas Observatory for Algal Succession Time-series, Mote Marine Lab Red Tide Program
Winds	Bay/estuary to oceanic	10 / 5	SeaWinds on QuickSCAT satellite, NOAA National Data Buoy Center
Sea level	Bay/estuary	10 / 0	NOAA National Water Level Observation Network

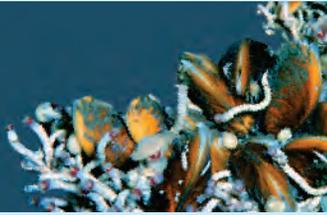
	OCEANOGRAPHIC PROCESSES	EFFECTS ON SPECIES OR HABITATS (EXAMPLES)
Physical	<ul style="list-style-type: none"> Speed and direction of water currents in the sea are largely driven by differences in salinity and temperature of seawater, creating varying seawater densities from place to place. Currents are also affected by atmospheric pressure gradients and the resulting winds. Water temperature and salinity together determine water density, and they also influence physiological processes in marine organisms adapted to live within certain ranges of environmental conditions. Water turbulence affects light penetration, distribution of nutrients and ability of predatory fish to locate smaller prey (e.g., plankton). 	<ul style="list-style-type: none"> Large-scale eddies move land-based nutrients into the oceanic realm where they enable numerous marine mammals to thrive close to shore. Large shifts in the temperatures or salinities of estuaries (too little or too much fresh water or salt water) can stress or kill plants and animals not adapted to rapidly changing conditions. Inshore turbidity in the north central Gulf can be excessive, with prolonged strong spring winds suspending large quantities of sediments that can limit plankton production via shading.
Chemical	<ul style="list-style-type: none"> Of the thousands of chemicals in seawater and sediments, the most important are: oxygen, carbon dioxide, nitrogen, silica and phosphorus-containing nutrients, iron, and various forms of dissolved organic carbon. These are all critical in sustaining marine life, but it is mainly nutrients, both natural and anthropogenic, and oxygen that are known to be most often limiting or in excess in the Gulf. 	<ul style="list-style-type: none"> The dead zone, an oxygen-depleted area that appears every summer in the northern Gulf, decreases suitable habitat for bottom dwellers such as brown shrimp and blue crabs, potentially affecting their contribution to Gulf fisheries and prey availability for sea turtles recovering from the BP oil disaster.
Biological	<ul style="list-style-type: none"> Food inputs to the marine ecosystem come from: (1) primary producers (e.g., phytoplankton, seaweeds, and rooted plants such as seagrasses, mangroves and marsh plants), (2) chemoautotrophs (e.g., sulfur bacteria and methanotrophs), (3) bacterioplankton and other producers, and (4) imports of land-based particulate and dissolved carbon. This supply of organic matter is consumed by animal respiration and excretion, disease, lost reproductive output and predation by other species. Consumptive processes dictate the oceanic food webs, which depict how energy flows in the ocean among trophic levels and species, critical to driving recovery and to managing for sustained delivery of ecosystem services. 	<ul style="list-style-type: none"> A year of lower primary production due to high winds and turbid water would result in less food for various species of forage fish, potentially affecting recovery or leading to alternate ecosystem states.

Conceptual Diagram of Selected Ecosystem Drivers in the Gulf

Physics and biology are tightly interconnected in the Gulf



Deep-water Communities



There is little long-term monitoring of these communities.

Summary

Deep-water communities* in the northern Gulf of Mexico were impacted by the BP oil disaster due to exposure to oil, gas and chemical dispersants. Although they are sensitive to threats from oil and gas industrial activities, there has been little long-term monitoring of these communities due to their remote location and the depths they occupy. Long-term monitoring is important for tracking their recovery and identifying appropriate restoration actions. There are full and partial gaps across all aspects of the monitoring priorities for this category due to the small-scale and opportunistic nature of identified monitoring

efforts. The priorities for monitoring are to document the distribution and structure of oiled and unoled deep-water communities, understand their role in the ecosystem, and track how they respond to disturbance. After the BP oil disaster, new research was initiated in the deep-water environment and some researchers were able to revisit sites studied prior to 2010. For example, the Ecosystem Impacts of Oil and Gas Inputs to the Gulf (ECOGIG) consortium, funded by the Gulf of Mexico Research Initiative, is one effort that will have five or more years of data as sites are revisited throughout 2015. The Natural Resource

Damage Assessment will likely continue to generate monitoring data as restoration efforts are initiated and recovery progress is tracked. Building off new and past efforts, there is an opportunity to generate data that can be used for long-term trend analyses and to further our understanding of deep-water communities and how they respond to disturbance.

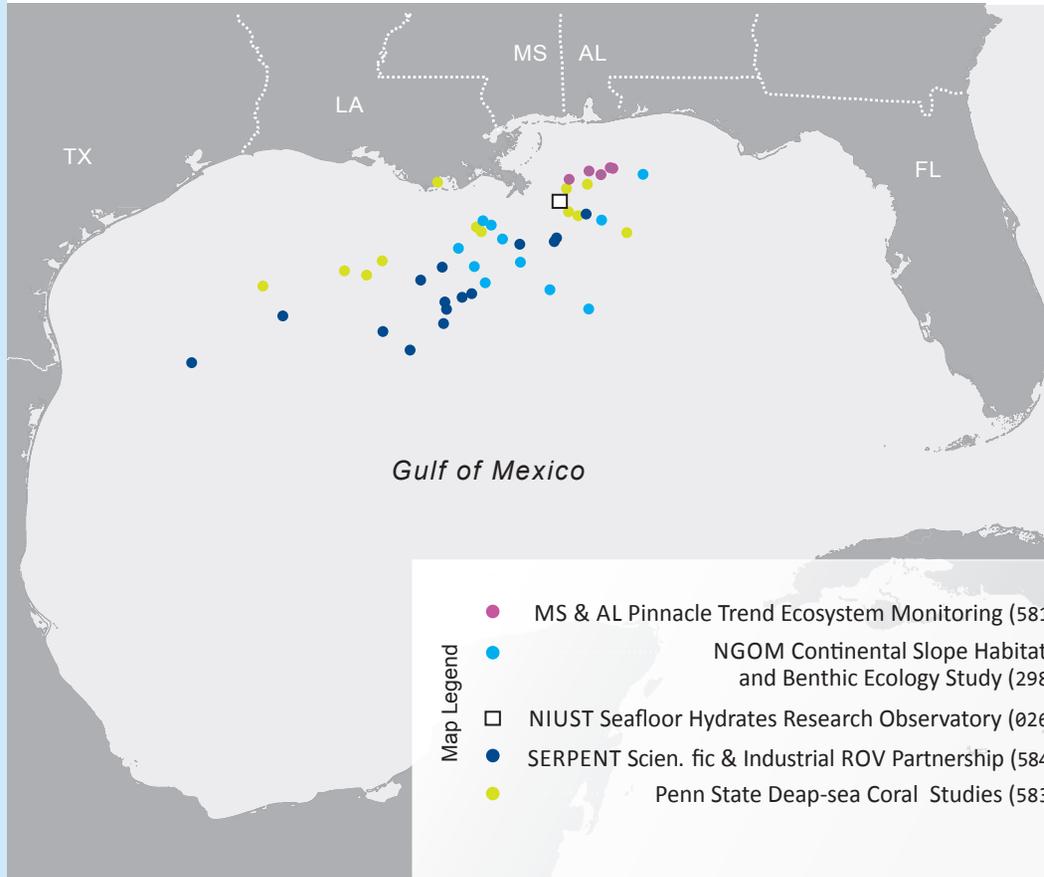
* In the 2012 NRDA status update, NOAA defines deep-water communities in the Gulf as those existing deeper than 200 feet. For our analysis we used this depth definition, although we further differentiated between shallow- and mid-water corals by only considering those communities on the continental slope or deeper for the deep-water communities category.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY AREAS Contaminated deep-water seafloor communities	EXPLANATION OF GAPS
	Species	Space	Time		
Monitor deep-water habitat use by mobile fauna	1 (N/A)	2 (Full gap)	2 (Full gap)	●	1- Not applicable (no priority species identified). 2- No sustained Gulf-wide effort addresses this priority. 3- Isolated efforts, no Gulf-wide coverage. 4- Monitoring efforts opportunistic and intermittent.
Map distribution/structure/condition of deep-water communities	1 (N/A)	3 (Partial gap)	4 (Partial gap)	●	
Long-term monitoring of deep-water communities to understand vulnerability and recovery after disturbance	1 (N/A)	3 (Partial gap)	2 (Full gap)	●	
Monitor deep-sea microbial communities to understand fate and effect of dispersant compounds	1 (N/A)	2 (Full gap)	2 (Full gap)	●	

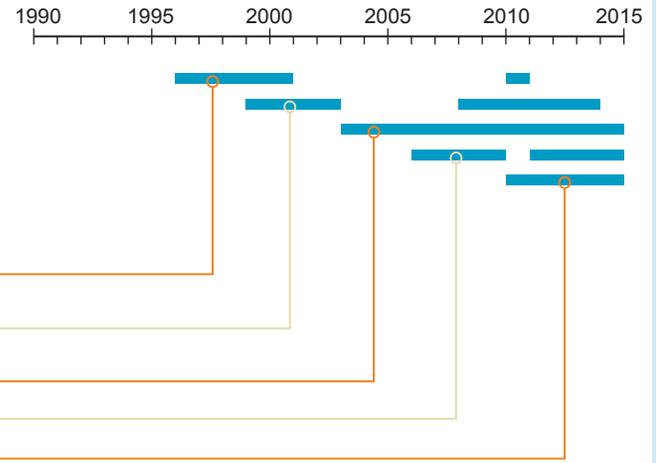
Deep-water Communities

Profile page 2



Existing Studies

DEEP-WATER COMMUNITIES LONG-TERM MONITORING



KEY LESSONS

- Limited long-term monitoring of impacted areas.
- Monitoring is small-scale and isolated.
- Almost no sustained monitoring of deep-water communities.



Water Column and Invertebrates



A better understanding of community composition of the deep pelagic zone is needed.

Summary

The epipelagic (surface to 200 meters deep) and mesopelagic (200 to 1,000 meters deep) ecosystems were exposed to a toxic mixture of oil and dispersant as they spewed from the Macondo wellhead at a depth of 1,500 meters, spreading horizontally and rising towards the Gulf surface.¹ The impacts in the pelagic sphere are challenging to document, because water masses and their fauna are in constant motion. That is, repeated measures at the same places and depths over time are actually sampling different organisms, unlike benthic ecosystems where organisms are stationary or move little.

Therefore the gaps in knowledge of oil impacts in this environment reflect not only the inherent limits of monitoring, but also the lack of many long-term data sets from past monitoring. Current priorities in response to the BP oil disaster are to better understand community composition of the deep pelagic zones and to track changes in the distribution of zooplankton and other components of the food chain, including the many gelatinous water column feeders that inhabit the water column. The current network of monitoring efforts sample exclusively the upper 200 meters of the water

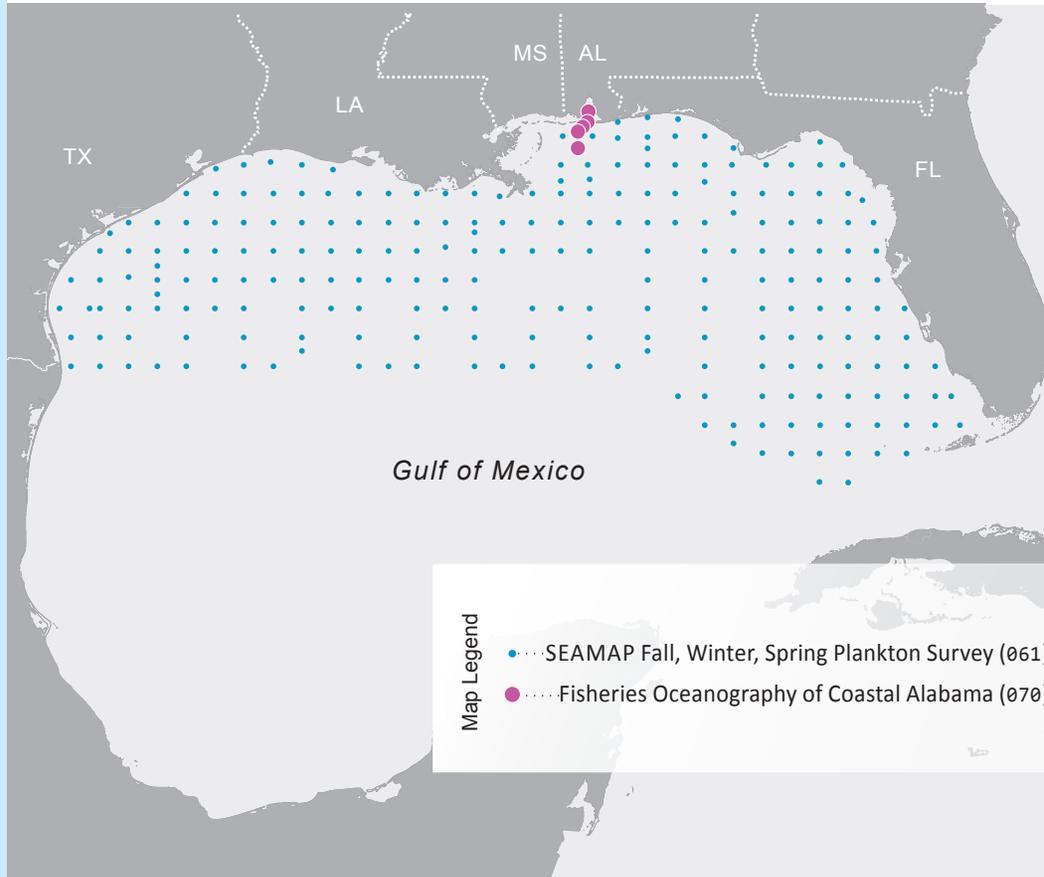
column and is designed mainly to document fish egg and larval abundance in support of commercial and recreational fisheries management, leaving gaps in water column coverage and species. To track recovery of the full Gulf ecosystem and to assess risk from future changes, monitoring should target the status and dynamics of these communities, particularly the deep-water communities of which we know relatively little.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES					EXPLANATION OF GAPS
	Species	Space	Time	Whole community	Copepods, chaetognaths, decapods, ostracods, amphipods	Mysids, copepods	Jellyfish, larvaceans, ctenophores, salps, squid		
Pelagic community composition at index sites near depth zone of well blowout	1	1	1	●				1- No mesopelagic/bathypelagic monitoring. 2- Copepods underrepresented due to gear limitations. 3- No sampling below 200 m depth. 4- Less sampling in summer and winter. 5- No testing of hydrocarbon exposure. 6- No sampling designed for delicate gelatinous organisms.	
Zooplankton densities in oil spill impact zone / changes in base of food chain as indicator of recovering fish populations	2	3	4		●				
Mysid and copepod species composition in suspected oiled areas / test for chronic hydrocarbon exposure as bio-indicator of residual oil and proxy for recovery of predator fish species	5	3	4			●			
Density of gelatinous zooplankton and water column feeders	6	6	6				●		

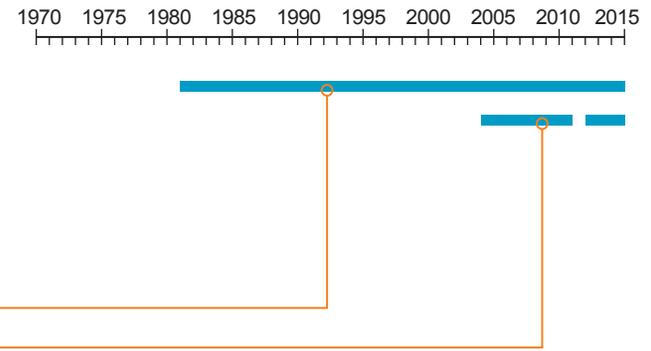
Water Column and Invertebrates

Profile page 2



Existing Studies

WATER COLUMN & INVERTEBRATES LONG-TERM MONITORING



KEY LESSONS

- *No monitoring below 200 meters.*
- *Methods/gear limit collection of smaller organisms.*
- *No monitoring of gelatinous zooplankton.*



Birds



There is a lack of integration and standardized monitoring protocols across the Gulf.

Summary

The BP oil disaster had significant impacts on birds in the Gulf of Mexico. Injuries from oil and dispersant exposure and habitat damage directly killed birds, affected long-term health and possibly caused loss of prey. The *Deepwater Horizon* Trustees estimate up to 84,500 total birds were killed as a result of the BP oil disaster, though some estimates are much higher. Long-term monitoring is needed to track the recovery of bird populations, as well as the habitats and ecosystem processes supporting impacted species. Numerous long-term monitoring efforts are occurring or have occurred around the Gulf

coastline. Monitoring of pelagic birds, however, has been largely absent. Many of the existing monitoring efforts target individual species (e.g., mottled duck) or groups of birds (e.g., shorebirds) and allow for some analysis of species status and trends. One challenge for resource managers and a recurring finding in this review of monitoring priorities is a lack of integration and standardized monitoring protocols across the Gulf. In addition to determining abundance, density and distribution, there is a need to monitor influential ecosystem variables, spatial habitat use and species-specific stressors to better understand

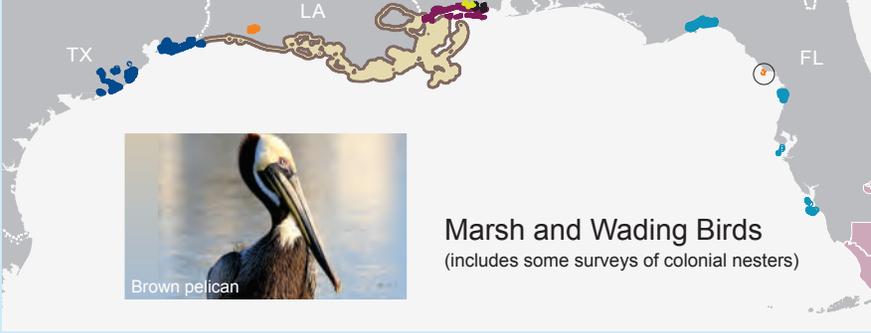
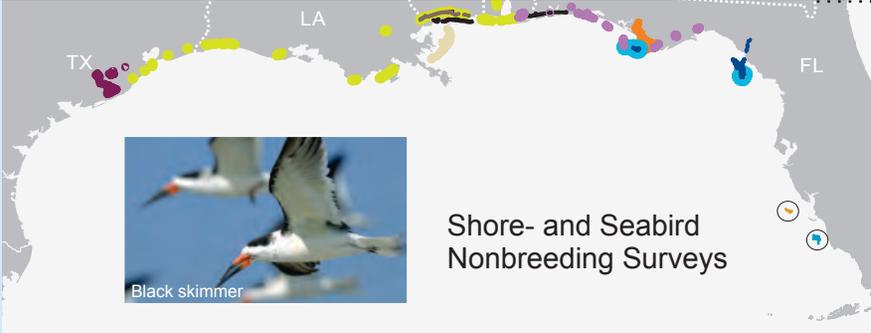
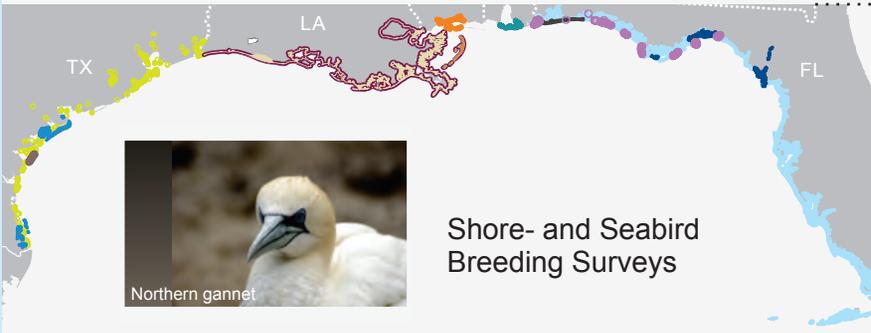
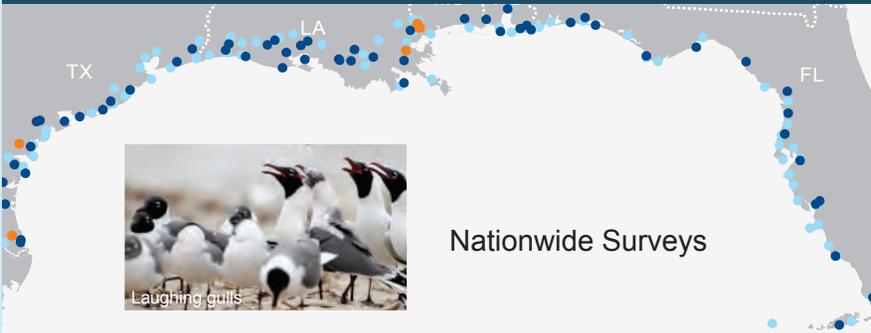
why and how bird populations are changing. Although a few monitoring programs are collecting this broader information, including the Monitoring Avian Productivity and Survivorship Program, these priorities have full or partial gaps due to the limited number of species and areas that are monitored. Recovery monitoring, with emphasis on expanding surveys to the pelagic environment and collecting data types beyond population parameters such as ecosystem drivers and stressors, will provide needed information to better understand Gulf-wide bird trends.

Gaps Identified

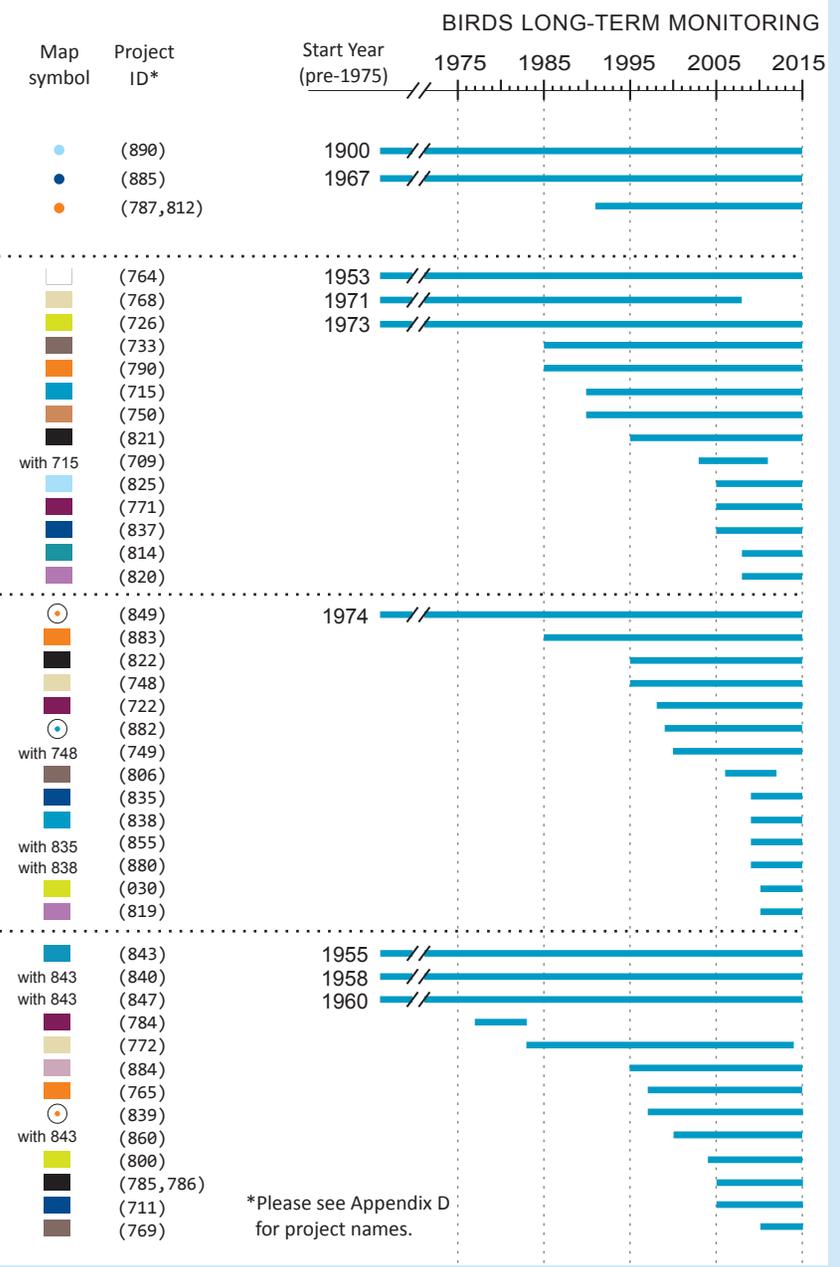
MONITORING PRIORITY	Gap			PRIORITY SPECIES Common loon American white pelican Brown pelican Royal tern Black skimmer Laughing gull Northern gannet	EXPLANATION OF GAPS
	Species	Space	Time		
Spatial use of habitat types	1	1	1	●	1- No monitoring efforts meet this priority. 2- Monitoring is absent for one or more priority species. 3- Very few monitoring efforts collect this type of information. 4- Monitoring is limited or absent altogether for some species. 5- Existing monitoring efforts meet this priority.
Species-specific stressors, measures of health of individuals and populations	2	3	3	●	
Abundance, density and distribution of populations affected by the BP oil disaster	2	4	5	●	
Key ecosystem variables and system drivers, and their impacts on avian populations	2	3	5	●	

Full gap ■
 Partial gap ■
 No gap ■
 GAP LEGEND

Birds



Existing Studies



*Please see Appendix D for project names.

Marine Mammals



We knew very little about their status before the oil disaster.

Summary

Marine mammals inhabiting the pelagic and nearshore regions of the northern Gulf were impacted by the BP oil disaster. Yet we knew very little about their status before the oil disaster due to the remote habitats of the Gulf that many of these species occupy. Due to limited knowledge of the distribution and abundance of a majority of these species, as indicated by the variance in population estimates of stock assessments, defining recovery goals is challenging. Priority monitoring activities for recovery include the need to better define population status and understand conditions affecting population health. In most

cases, current monitoring efforts for marine mammals do not adequately address the long-term recovery priorities identified in this analysis. Full gaps—or at minimum, partial gaps—characterize the level of existing coverage available to address recovery monitoring. The majority of research and monitoring efforts to date have been short-term observations to document diversity and distribution in the Gulf of Mexico. These studies have mainly assessed acute impacts from petroleum exploration and production, while the limited network of long-term monitoring programs relies heavily on aquariums or private marine

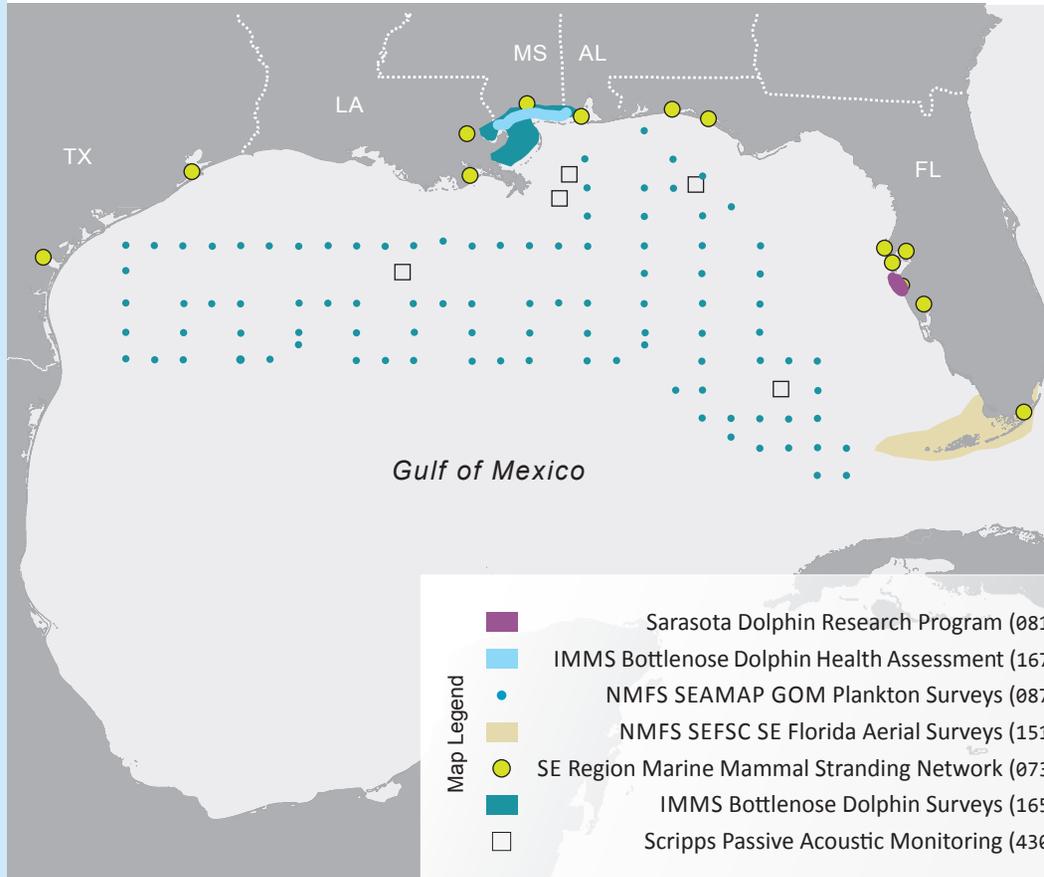
mammal institutes. The fragmented and sporadic history of monitoring marine mammals limits the ability to track population status or recognize long-term trends. Therefore, investment in an integrated monitoring network to track species status, chronic oil exposure effects or other stressors slowing recovery should be established so managers and restoration officials can take necessary actions to facilitate recovery. Marine mammals have very long life spans. The effects of a major disaster like the BP oil disaster can be present in the population for many years.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES						EXPLANATION OF GAPS
	Species	Space	Time	Bottlenose dolphin	Atlantic spotted dolphin	Bryde's whale	Sperm whale	Beaked whale	Pelagic delphinids	
Strandings and animal health	1	1	1	●						<p>1- Monitoring exists but capacity limited; depends on volunteer response.</p> <p>2- Monitoring occurs, but more is needed to better meet priority.</p> <p>3- Monitoring occurring in isolated areas.</p> <p>4- Existing survey(s) meet this priority.</p> <p>5- Monitoring coverage is spatially dispersed.</p> <p>6- Monitoring is not occurring for at least one priority species.</p> <p>7- No Gulf-wide assessment to date.</p> <p>8- No monitoring survey meets this priority.</p>
Abundance and distribution nearshore	2	3	4	●	●	●				
Abundance and distribution offshore	2	5	4				●	●	●	
Stock structure	6	7	4	●		●	●			
Population demographics and reproduction	2	7	4	●						
Habitat use	8	8	8	●			●	●		
Bycatch and interactions, commercial and recreational fisheries	2	2	2	●						

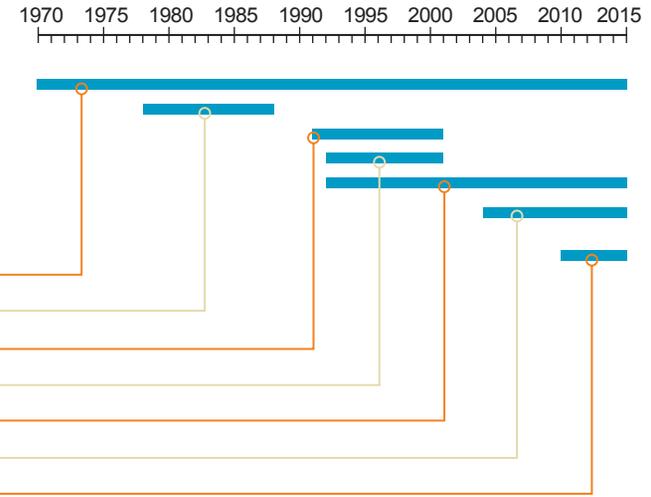
Marine Mammals

Profile page 2



Existing Studies

MARINE MAMMAL LONG-TERM MONITORING



KEY LESSONS

- *Monitoring is fragmented.*
- *Limited pelagic monitoring.*
- *More monitoring needed to determine status and trends in many species.*



Marine Fish



Priorities can be fulfilled by enhancing or integrating existing monitoring programs.

Summary

Marine fish populations were impacted by the BP oil disaster due to exposure to pollutants and contaminated or lost habitat. The *Deepwater Horizon* Trustees estimate that between 2 and 5 trillion fish larvae were killed in the surface and subsurface zones during the disaster. This is in addition to early reports of shifting reef fish community structures and contaminated Atlantic bluefin tuna spawning grounds. Monitoring to track recovery should include documenting contaminant loads, life history development and shifts in community structure. To assess impacts to fish habitat while providing for better population

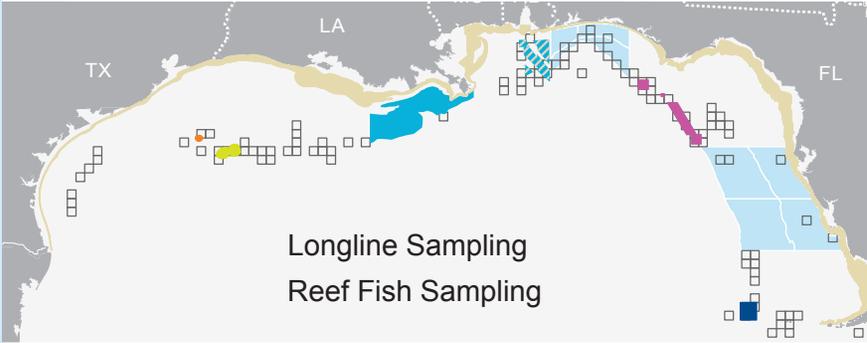
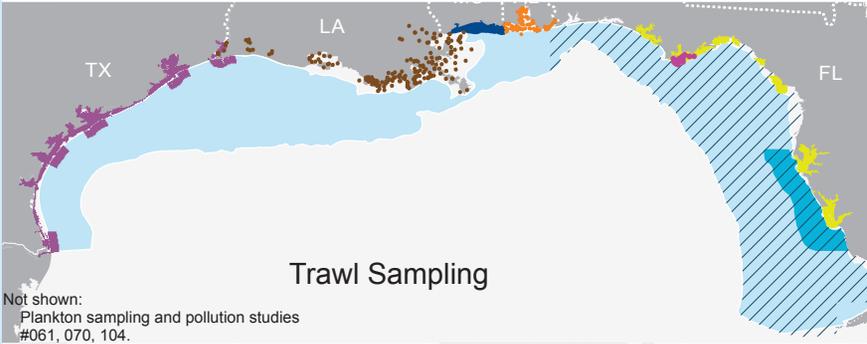
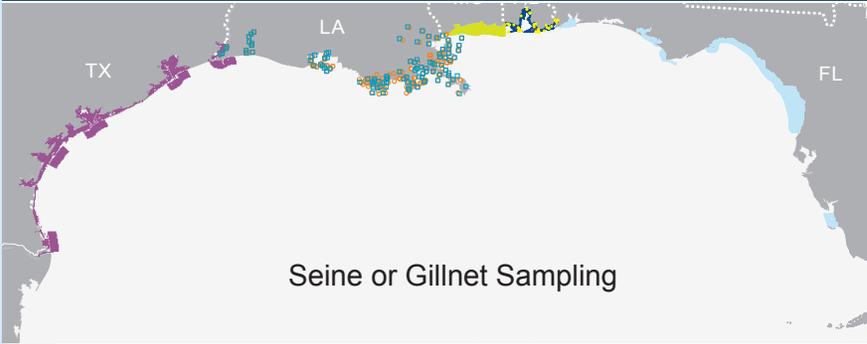
assessments, a recovery monitoring program should address the need for high-resolution habitat maps and the ability to detect basic changes in the ecosystem that affect fish populations. Assessment of existing monitoring efforts indicates many partial gaps, especially in pelagic waters, where sampling adult life stages is challenging due to their high degree of mobility across vast areas of the ocean. Fishery-dependent data provide some information associated with these gaps, but due to high potential for bias derived from the way the data is collected, we were limited in how we assessed these data. Recovery monitoring priorities can be

fulfilled by enhancing or integrating the many existing monitoring programs to track long-term trends from the BP oil disaster. For example, the species composition and abundance indices generated from fishery-independent and -dependent data are used to assess fish population health. The Southeast Area Monitoring and Assessment Program is a well-established fishery independent monitoring program that could be supplemented with validated fishery-dependent data from relevant commercial and recreational fisheries to support recovery monitoring goals and to provide an assessment of long-term trends.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES														EXPLANATION OF GAPS					
	Species	Space	Time	Reef fish	Sciaenids	Mahi	Gulf menhaden	Flounders	Gulf killifish	Tunas	Amberjack	Swordfish	Cobia	Billfishes	Red snapper	Tripletail	Mackerel		Silversides	Anchovies	Reef, Corals, Oyster, SAV		
Sampling for PAH exposure and toxicity effects	1	2	2	●	●	●	●	●	●														1- No monitoring of PAH levels in priority species.
Changes in migratory behavior and life history parameters	3	3	4							●	●	●	●	●	●	●	●						4- No pelagic ichthyoplankton surveys in summer or shrimp/groundfish surveys in spring/summer.
Fishery-independent sampling nearshore and offshore	3	3	4	●		●	●			●				●					●	●			
Mapping impacted nursery grounds / benthic habitats	5	5	5																		●		5- No sustained broad-scale habitat mapping.

Marine Fish



Fishery-dependent Sampling*

*Not mapped due to variability in area sampled.

Existing Studies

SEINE/GILLNET

- TPWD FIS (065)
- AMRD FAMP Shoreline Sampling (526)
- LDWF FIM Gillnet Sampling (441)
- LDWF FIM Seine Sampling (442)
- AMRD FAMP Gillnet Sampling (525)
- GOMS Shark Pupping & Nursery Area (032)
- MDMR IJF Coastal Finfish Gillnet Surv. (528)

TRAWL

- MDMR GCRL FIS (067/529)
- TPWD FIS (065)
- ADMR FAMP Trawls (524)
- SEAMAP GOM Trawl Survey (060)
- FWC Estuarine Surveys (069)
- FWC FIM Baitish Surveys (519)
- LDWF Shellfish Monit. Prog. Trawls (445)
- ANERR Juvenile Fish Monitoring (129)
- FWC SEAMAP Groundfish (520)

REEF FISH

- E&W FGB Long-term Monitoring (131)
- SEAMAP GOM Reef Fish Survey (062)
- FGB Stetson Bank Coral Monitoring (314)
- NMFS NGOM MPA Surveys (315)
- NMFS Pulley Ridge Fish Survey (316)
- FWC - SEAMAP Reef Fish (522)

LONGLINE

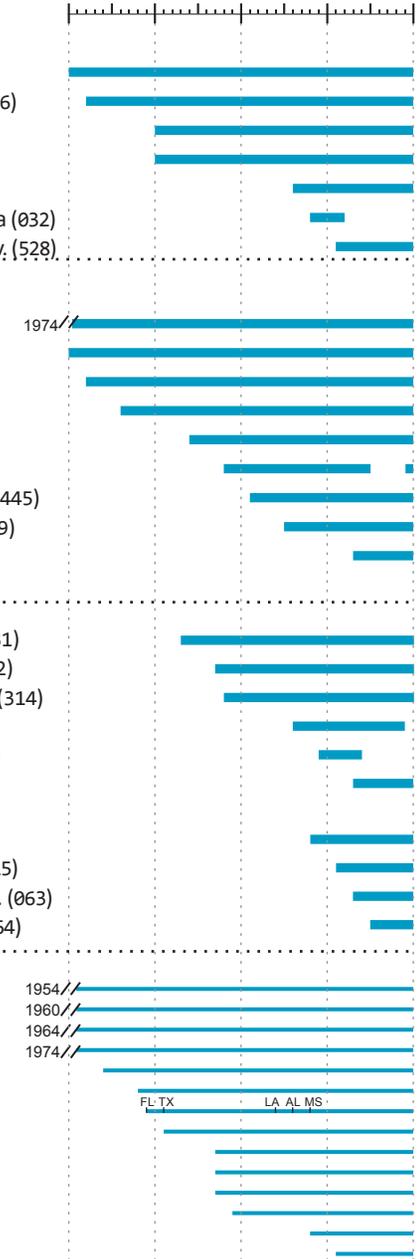
- DISL FIS (124)
- DISL-UNF PAHs in Coastal Sharks (125)
- SEAMAP Insh. Bo om Longline Surv. (063)
- SEAMAP Vertical Longline Survey (064)

FISHERY-DEPENDENT

- SEFSC Cooperative Tagging Center (894)
- FL Annual Canvas Data Survey (898)
- Menhaden Captains Daily ... Assessmts (37)
- Marine Sport Harv. Prog. (Creel Surveys) (58)
- Marine Recr. Info. Program (MRIP) (56)
- Trip Interview Program (34)
- Dealer Trip Ticket Reports (50, 54, 53, 51, 52)
- GulfFIN Head Boat Port Sampling (57)
- Shrimp Observer Program (39)
- Gillnet Observer Program (41)
- Pelagic Longline Observer Program (897)
- Bo om Longline Observer Program (40)
- GulfFIN Biological Sampling (35)
- GOM Vertical Line Observer Prog. (42)

MARINE FISH LONG-TERM MONITORING

1975 1985 1995 2005 2015



Sea Turtles



The status of males and developmental life stages is virtually unknown.

Summary

Floating oil and dispersant directly contaminated sea turtles as well as their habitat and food resources. The oil disaster occurred during the height of the nesting season in the Gulf of Mexico, so many nests were required to be relocated to a surrogate beach outside of the spill zone to protect sea turtles during disaster response. In order to gauge recovery from these types of impacts, recovery monitoring needs to assess the population conditions of affected species across the Gulf ecosystem and the multitude of factors influencing their return to pre-spill population levels. Long-term priorities for

recovery monitoring include designing and funding more statistically valid surveys to expand the scope of data collected from the existing network of monitoring programs. A majority of the monitoring priorities are defined as partial or full gaps, such as the reliance of beach nesting surveys on volunteer capacity, which creates a partial gap in geographic and yearly coverage. Historically, population trends have been derived from the number of nesting females active each season. Therefore the status of adult males and early developmental life stages are virtually unknown, and is another important gap in

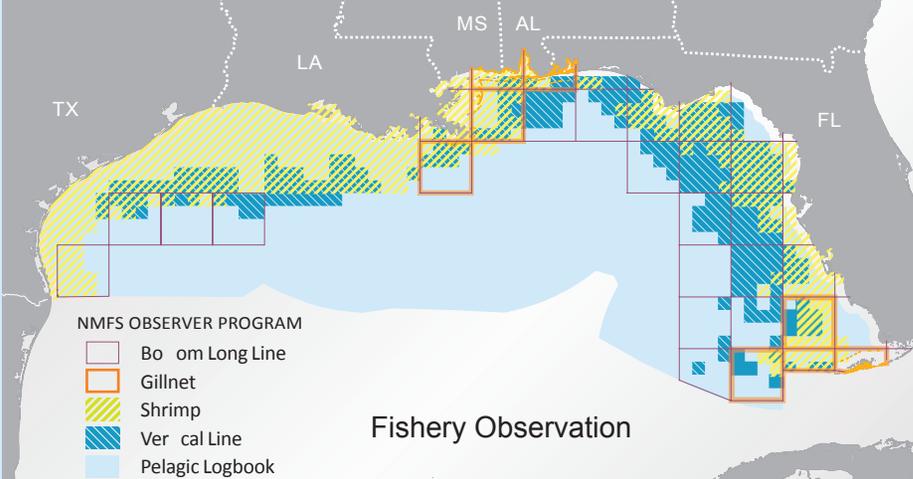
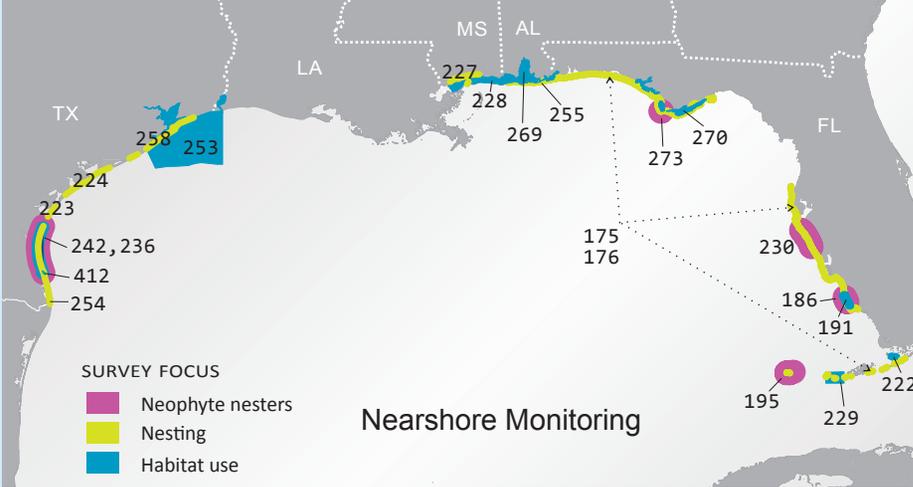
knowledge. Implementing priority activities and addressing specific gaps in coverage to track progress toward long-term recovery targets, as well as to assess future risks to the species, should be enhanced by supplementing the current monitoring infrastructure. Enhancing the current fishery observer program, as was done through Natural Resource Damage Assessment Early Restoration, and expanding long-term, in-water monitoring surveys are specific activities that would address multiple recovery monitoring goals.

Gaps Identified

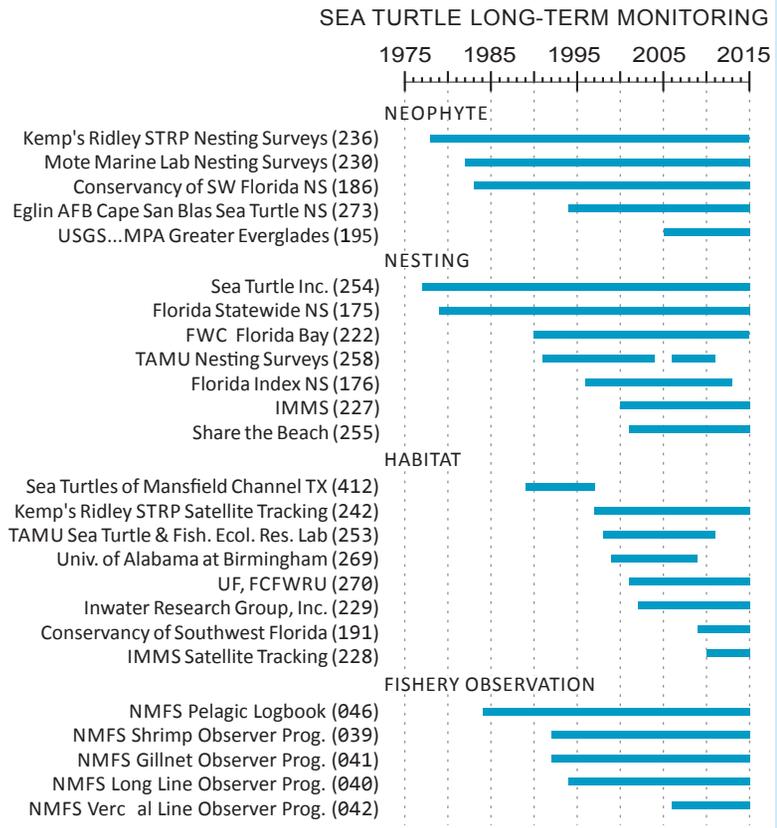
MONITORING PRIORITY	Gap			PRIORITY SPECIES		EXPLANATION OF GAPS
	Species	Space	Time	Kemp's ridley	Loggerhead	
Continue/expand evaluation at nesting beaches	1	2	2	●		1- Existing efforts observe all priority species. 2- Data primarily from volunteer surveys; may be limited by volunteer and staff resources. 3- Neophyte assessment is concentrated at 4 locations and effort varies during the nesting season. 4- Habitat assessment is limited to females from 5 beaches and 7 in-water areas. There is less effort outside of nesting season for tracking habitat use. 5- Very limited coverage of observers on fishing vessels. 6- No sustained toxicity assessment outside NRDA.
Monitor neophyte (first-time) nesters	1	3	3	●		
Assess reproduction and potential oil effects	6	6	6	●	●	
Identify foraging, breeding, inter-nesting, migratory habitat	1	4	4	●	●	
Monitor incidental take from U.S. and Mexico fisheries	1	5	5	●	●	

Full gap ■
 Partial gap ■
 No gap ■
 GAP LEGEND

Sea Turtles



Existing Studies



KEY LESSONS

- No monitoring of male or juvenile turtles.
- Few or no observers in Gulf fisheries.
- Some nest monitoring depends on volunteers.



Nearshore Sediments & Associated Resources



Early monitoring efforts have not been converted into sustained programs for regionwide assessments.

Summary

The coastal submerged habitats and their benthic communities were exposed to BP oil in varying states of weathering, from dispersed oil droplets to dense, submerged tar mats. These habitats constitute a large area of the northern Gulf of Mexico affected by the BP oil disaster. The sampling techniques for tracking recovery of benthic and epibenthic communities involve analyzing finite samples or direct visual observations of small areas representative of the habitats and communities impacted by the BP oil disaster. Therefore, it is important that monitoring uses statistical survey designs that allow

assessment of this large area based on data derived from finite, discrete samples. Monitoring priorities include measuring hydrocarbon concentrations in sediments and tissues of animals, benthic community responses to contamination, and the toxicological effects on marine life. Gaps in these priorities exist due to the lack of sustained, broad-scale monitoring efforts addressing these priorities. Significant investments in research and monitoring have been made to design valid sampling schemes and identify the indicators required to provide the scientific evidence to detect and track individual-

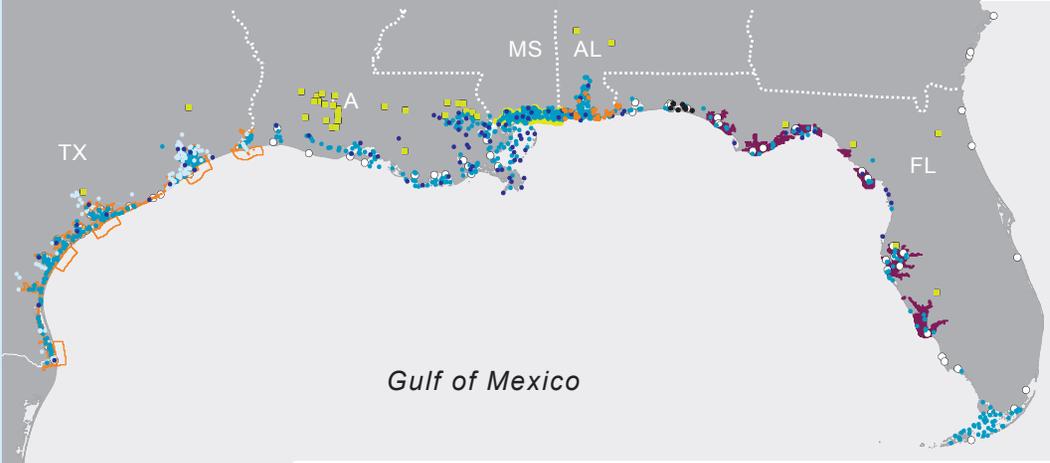
and community-level responses. However, these earlier investments have not been utilized in sustained monitoring programs to understand the status and trends in contaminant exposure or the long-term impacts to these ecological communities.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES / SITE					EXPLANATION OF GAPS
	Species	Space	Time	Areas oiled by BP hydrocarbons	Nearshore benthic communities	Coastal fishes	White and brown shrimp	Blue crab	
Monitor hydrocarbons in nearshore subtidal sediments with comparison to baseline data	1	2	2	●					1- Not applicable (no priority species identified). 2- Many programs have been scaled down or become inactive, sampling locations are sparse, and/or focus is intensive short-term only.
Monitor nearshore benthic/epibenthic species and develop multivariate assessment of community impacts of hydrocarbon exposure	3	3	4		●				3- All macroinvertebrate species potentially sampled in major bays and estuaries. 4- Resampling interval too long to assess acute impacts.
Monitor exposure of benthic organisms to PAH and oiled sediments with emphasis on divergent gene expression, developmental abnormalities and physiological responses	5	5	5			●	●	●	5- No toxicity monitoring.

Nearshore Sediments & Associated Resources

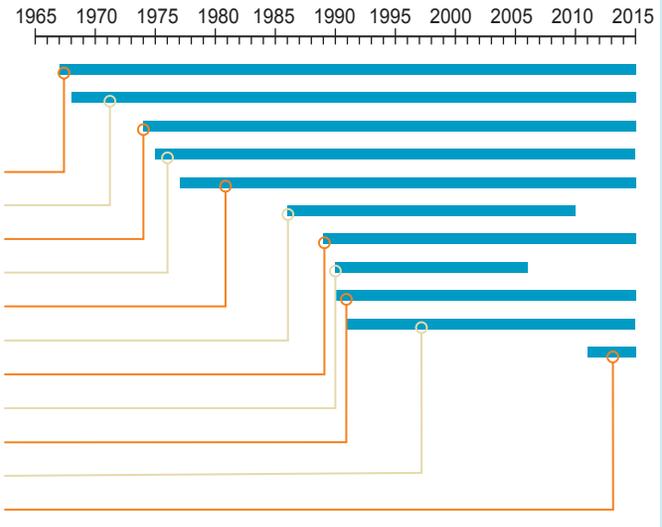
Profile page 2



Not shown:
 (442) LDFW FIM inshore/nearshore seine
 (119) NOAA NST bioeffects
 *EPA National Coastal Assessment markers are not necessarily indicative of repeated sampling locations.

Existing Studies

NEARSHORE SEDIMENTS & ASSOC. RESOURCES LONG-TERM MONITORING



KEY LESSONS

- *No assessment of physiologic, developmental, or genetic response to oil.*
- *Regionwide surveys not sustained.*
- *Reliance on short-term, intensive studies.*



Mullet on sandy bottom

Oysters



Gaps exist due to a lack of a comprehensive mapping effort.

Summary

Gulf oysters, *Crassostrea virginica*, were impacted by exposure to oil and dispersant during the BP oil disaster and by fresh water released from salinity control structures in Louisiana to keep oil from reaching nearshore habitats. Oysters, which are commercially harvested in the Gulf of Mexico, have historically been monitored for fisheries management and human health concerns within each Gulf state. For example, the Department of Human Health in Louisiana has monitored oyster meat at 600 to 800 sampling stations coastwide for the presence of human pathogens since the 1980s. In addition to continuing to monitor oyster

harvest activities, priorities for the long-term recovery monitoring of oysters include mapping reefs Gulf-wide, developing and implementing standard metrics (e.g., oyster abundance and spat density), and tracking oyster disease and environmental conditions. Gaps exist in oyster reef mapping efforts due to a lack of a coordinated, comprehensive mapping effort and outdated maps of oyster culture areas. Oyster disease monitoring is coordinated through the Oyster Sentinel online community, but due to the limited or voluntary nature of resources, this activity has been opportunistic and intermittent. Temperature

and salinity are consistently measured in conjunction with oyster harvest and human pathogen monitoring; however, pH and dissolved oxygen are not, but are important parameters for tracking climate change effects. Further monitoring efforts that include standardized metrics and coordinated mapping efforts would greatly contribute to a more comprehensive picture of oyster communities. In addition, due to the long-term nature of many oyster monitoring programs, numerous opportunities to build from existing long-term data sets to inform and track restoration decisions can be leveraged.

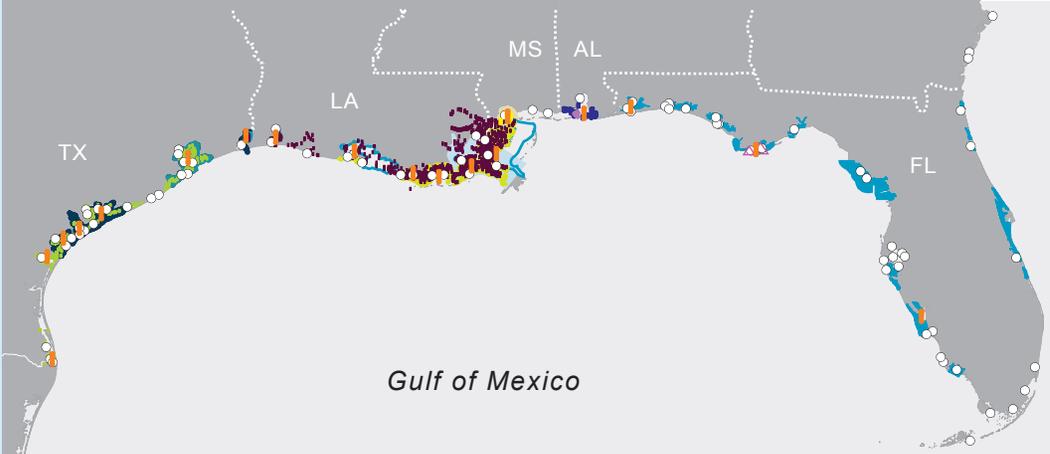
Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY AREAS Oyster reefs impacted by the BP oil disaster, either through contamination or response efforts.	EXPLANATION OF GAPS
	Areas	Space	Time		
Map reef distribution Gulf-wide	1	2	3	●	1- Not applicable (no priority species identified). 2- Monitoring exists, but is not comprehensive. 3- Monitoring opportunistic or intermittent. 4- Some metrics/conditions are not monitored. 5- No Gulf-wide or sustained standardized metrics. 6- Monitoring at current efforts sufficient to track status and trends. 7- Oyster harvest monitored across Gulf.
Monitor reefs using standard metrics at historically sampled, injured, response and random sites	1	5	5	●	
Monitor environmental conditions (temperature, O ₂ , salinity)	1	4	6	●	
Monitor oyster disease	1	2	3	●	
Monitor harvest	1	7	7	●	

GAP LEGEND

- Full gap
- Partial gap
- No gap
- N/A

Oysters

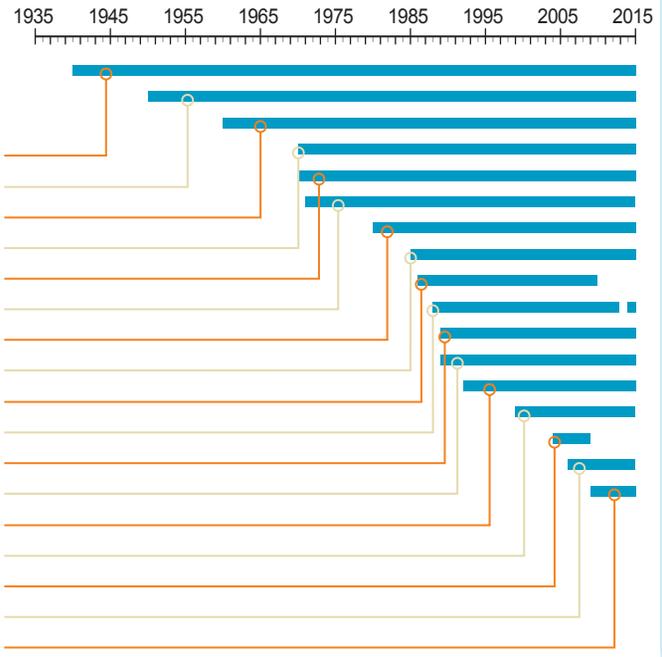


Symbol	Monitoring Program (ID)
Light green square	Mississippi State Shellfish Harvest Area Monitoring (550)
Dark green square	Texas State Shellfish Harvest Area Monitoring (549)
Dark blue square	ADPH Shellfish Monitoring Program (541)
Orange vertical bar	Oyster Sentinel (455)
Light blue square	Florida Shellfish Harvest Area Monitoring (540)
Purple square	Alabama Fishery-Independent Oyster Monitoring (534)
White square with blue border	LDWF Annual Oyster Stock Assessment (546)
Black square	TPWD Coastal Fisheries Resource Monitoring (610)
White circle	NOAA NST Mussel Watch (102)
Light blue square	LDWF Nestier Tray Coastal Oyster Sampling (547)
Dark teal square	LDHH Molluscan Shellfish Program (658)
Light green square with 546	TAMU Galveston Seafood Safety Lab (481)
Light green square with 545	LDWF Oyster Dredge Sampling (545)
Light green square with 548	LDWF Oyster Harvest Monitoring (548)
Pink triangle	Apalachicola NERR Oyster Growth Project (542)
Yellow square with 539	Mississippi Interjurisdictional Oyster Visual Monitoring (539)
Yellow square with 538	Mississippi Interjurisdictional Oyster Dredge Monitoring (538)

Not shown:
 (544) DISL Oyster Habitat Assessment.
 Project (144) GCRL Oyster Assessment & Monitoring (dates unknown) is mapped with (550).

Existing Studies

OYSTERS LONG-TERM MONITORING



KEY LESSONS

- *Mapping efforts not coordinated.*
- *Gulf-wide metrics not standardized.*
- *Harvest activities are the most rigorously tracked.*



Oyster reef

Submerged Aquatic Vegetation



In addition to broader geographic coverage, there is a need for more frequent aerial surveys.

Summary

The BP oil disaster affected submerged aquatic vegetation, or rooted vascular plants that grow up to the water surface but not above it, through exposure to oil and dispersants and physical damage during spill response. The impacts affected individual seagrasses, but also made seagrasses more susceptible to other disturbances.² Six priority species of seagrasses in the northern Gulf of Mexico were identified: *Halodule wrightii*, *Thalassia testudinum*, *Syringodium filiforme*, *Halophila engelmannii*, *Halophila decipiens* and *Ruppia maritima*. The priorities for submerged aquatic vegetation

recovery monitoring are to 1) conduct aerial surveys to track bed extent, and 2) document percent cover and shoot density of submerged aquatic vegetation beds. Current gaps in seagrass percent cover and density monitoring occur along the coast of Texas and in key areas along Florida's coast, including the southwest, west central and Big Bend regions. The gaps in aerial surveys span the same areas of the Texas and Florida coasts, as well as the areas of Louisiana, Mississippi and Alabama where seagrasses exist. In addition to broader geographic coverage in recovery areas, such as

Gulf Islands National Seashore, there is a need for more frequent aerial surveys. The National Park Service Inventory and Monitoring Program at Padre Island and Gulf Islands national seashores and the Texas Seagrass Monitoring Network are two examples of major existing sources of monitoring data that are not yet considered long-term, but could meet that threshold if continued for more than five years, and would provide valuable gap-filling information.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES						EXPLANATION OF GAPS
	Species	Space	Time	<i>Halodule wrightii</i>	<i>Thalassia testudinum</i>	<i>Syringodium filiforme</i>	<i>Halophila engelmannii</i>	<i>Halophila decipiens</i>	<i>Ruppia maritima</i>	
Aerial surveys to detect changes in SAV coverage	1	2	3	●	●	●	●	●	●	1- All priority species are monitored. 2- Key areas of the Gulf not monitored. 3- Monitoring frequency doesn't meet standard. 4- Existing surveys sufficient to track status and trends.
Monitor seagrass percent cover and shoot density to track natural recovery from physical damage	1	2	4	●	●	●	●	●	●	

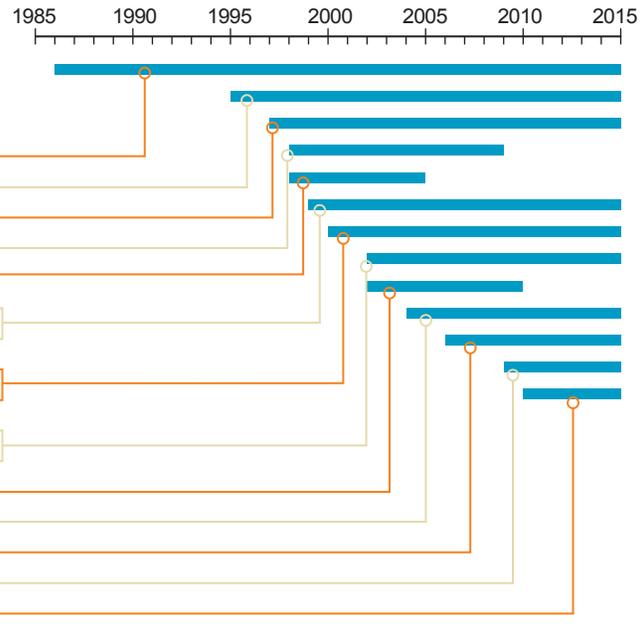
Submerged Aquatic Vegetation



Map Legend	Monitoring Program	Year Range
Light Blue	Tampa Bay Seagrass Monitoring (565, 566)	1985 - 2015
Pink Dot	Florida Keys NMS Seagrass Monitoring (135, 296)	1985 - 2015
Light Blue Box	Springs Coast Seagrass Monitoring (563)	1985 - 2015
Red	Ten Thousand Islands Seagrass Monitoring (573)	1985 - 2015
Brown	Rookery Bay NERR Seagrass Monitoring (572)	1985 - 2015
Black	FDEP Sarasota Bay Seagrass Monitoring (567)	1985 - 2015
Light Green	Charlotte Harbor Seagrass Monitoring (570)	1985 - 2015
Yellow	St Andrews Bay Aquatic Preserve Seagrass Monitoring (556)	1985 - 2015
Light Green	Big Bend Seagrasses Aquatic Preserve Region Seagr. Monit. (560)	1985 - 2015
Purple	FWRI/FWC Seagrass Integrated Monitoring (555, 558, 559, 561)	1985 - 2015
Green	Estero Bay Seagrass Monitoring (571)	1985 - 2015
White Circle	St Joseph Bay Aquatic Preserve Seagrass Monitoring (557)	1985 - 2015
Yellow	Sarasota County Seagrass Monitoring of Sarasota Bay (568)	1985 - 2015
Dark Blue	Western Pinellas County Seagrass Monitoring (564)	1985 - 2015
Light Green	Choctawhatchee Basin Alliance Seagrass Monitoring (554)	1985 - 2015
Orange	Dauphin Island Sea Lab Seagrass Monitoring (122)	1985 - 2015

Existing Studies

SUBMERGED AQUATIC VEGETATION LONG-TERM MONITORING



KEY LESSONS

- *All priority species are monitored.*
- *Aerial surveys are limited in range and frequency.*
- *New programs provide opportunities to fill gaps.*



Diverse green algae

Shallow- and Mid-water Corals



Monitoring efforts are not integrated in a manner to allow broad geographic comparability.

Summary

Monitoring of shallow- and mid-water corals should be modified or expanded to assess long-term impacts from exposure to hydrocarbons or chemical dispersants during the BP oil disaster. The monitoring priorities for shallow- and mid-water corals include developing high-resolution distribution maps of these ecosystems within the Gulf, monitoring marine conditions that affect recovery and establishing sentinel sites for elucidating long-term trends from global climate change. The current focus of long-term monitoring is primarily to track community status and species composition of coral reefs and

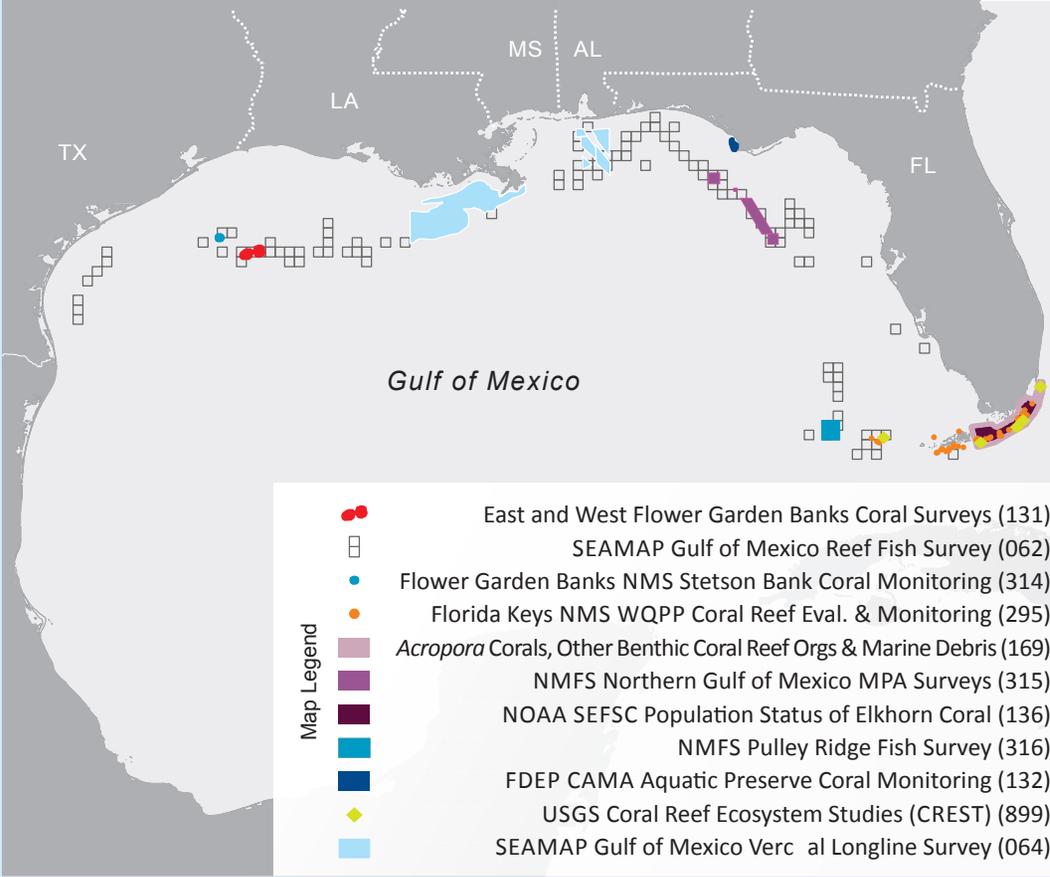
associated fish communities. The majority of existing monitoring efforts are conducted in marine protected areas such as the national marine sanctuaries and habitat areas of particular concern, which are managed through fishing gear restrictions. These protected area programs are invaluable, as they help establish the record of baseline conditions in the face of catastrophic events like the BP oil disaster. These long-term data records can serve as reference conditions for documenting oil impacts of other reef communities throughout the Gulf of Mexico and can aid in tracking recovery. The existing long-

term efforts address some monitoring priorities, but overall they are either not integrated in a manner that allows for broad geographic comparability, or they are limited in scope and not designed for tracking BP oil disaster recovery. In order to establish a scientifically defensible monitoring program for recovery tracking, significant additional investments need to be made to develop and expand the monitoring network that can not only inform recovery status but also begin to create a regionwide understanding of broadscale impacts from ecosystem drivers, such as climate change.

Gaps Identified

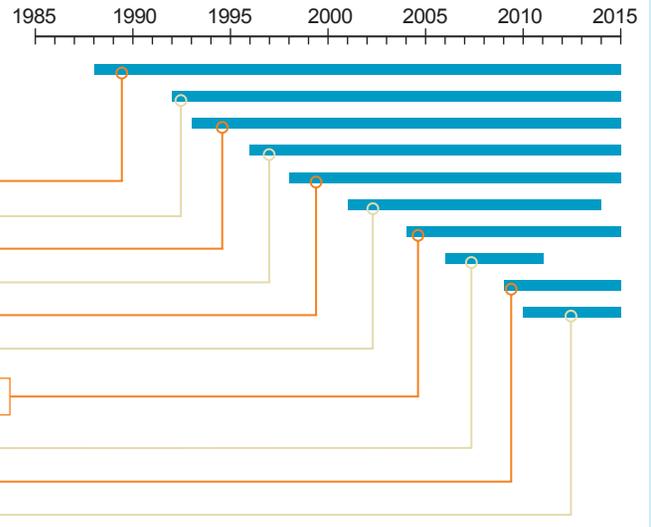
MONITORING PRIORITY	Gap			PRIORITY AREAS		EXPLANATION OF GAPS
	Species	Space	Time	Areas in oiled region of Gulf	Flower Garden Banks NMS, Madison-Swanson MPA, Dry Tortugas NP, Pulley Ridge HAPC	
Quantify status and trends of Gulf corals	1	2	3	●		1- Not applicable (no priority species identified). 2- Majority of efforts are limited to the national marine sanctuaries. 3- Existing surveys meet this priority. 4- Monitoring efforts are opportunistic and intermittent. 5- Several long-term surveys have been terminated. 6- No sustained monitoring of full suite physical/chemical parameters. 7- An integrated sentinel program does not yet exist.
High resolution mapping of coral and hard-bottom habitats	1	2	4	●		
Monitor community processes at existing restoration projects	1	2	5	●		
Full suite physical/chemical monitoring	1	6	6	●		
Sentinel site monitoring / climate change / ocean acidification	1	7	7		●	

Shallow- and Mid-water Corals



Existing Studies

SHALLOW- AND MID-WATER CORALS LONG-TERM MONITORING



KEY LESSONS

- *Most monitoring is at national marine sanctuaries.*
- *No integrated sentinel site program for monitoring climate change impacts.*
- *No Gulf-wide efforts for regional trends.*



Shorelines



Many monitoring programs capture how shoreline extent, elevation and habitat are changing, but not why.

Summary

Northern Gulf Coast shorelines were heavily impacted from oiling and the subsequent response during the BP oil disaster. The most heavily impacted shorelines, as indicated on Shoreline Cleanup and Assessment Team (SCAT) maps, were in Louisiana. In Mississippi, Alabama and Florida there was also heavy to moderate shoreline oiling, although to a lesser extent than Louisiana. Long-term recovery monitoring priorities include documenting and understanding changes in landforms and habitats, sediment biogeochemistry, and stressors that could impact rates of recovery. In

addition, there is a need to monitor invertebrates as indicators of chronic exposure to oil-derived PAHs and other types of coastal pollution. There are varying levels of gaps depending on the information collected by existing monitoring efforts. For example, Landsat is a global remote sensing satellite program that captures data useful for creating coarse-resolution land cover information consistently and broadly; therefore, there are no gaps in habitat coverage monitoring. Other parameters such as shoreline elevation are generally monitored using LiDAR and Sediment Elevation Tables. However, gaps in this type of

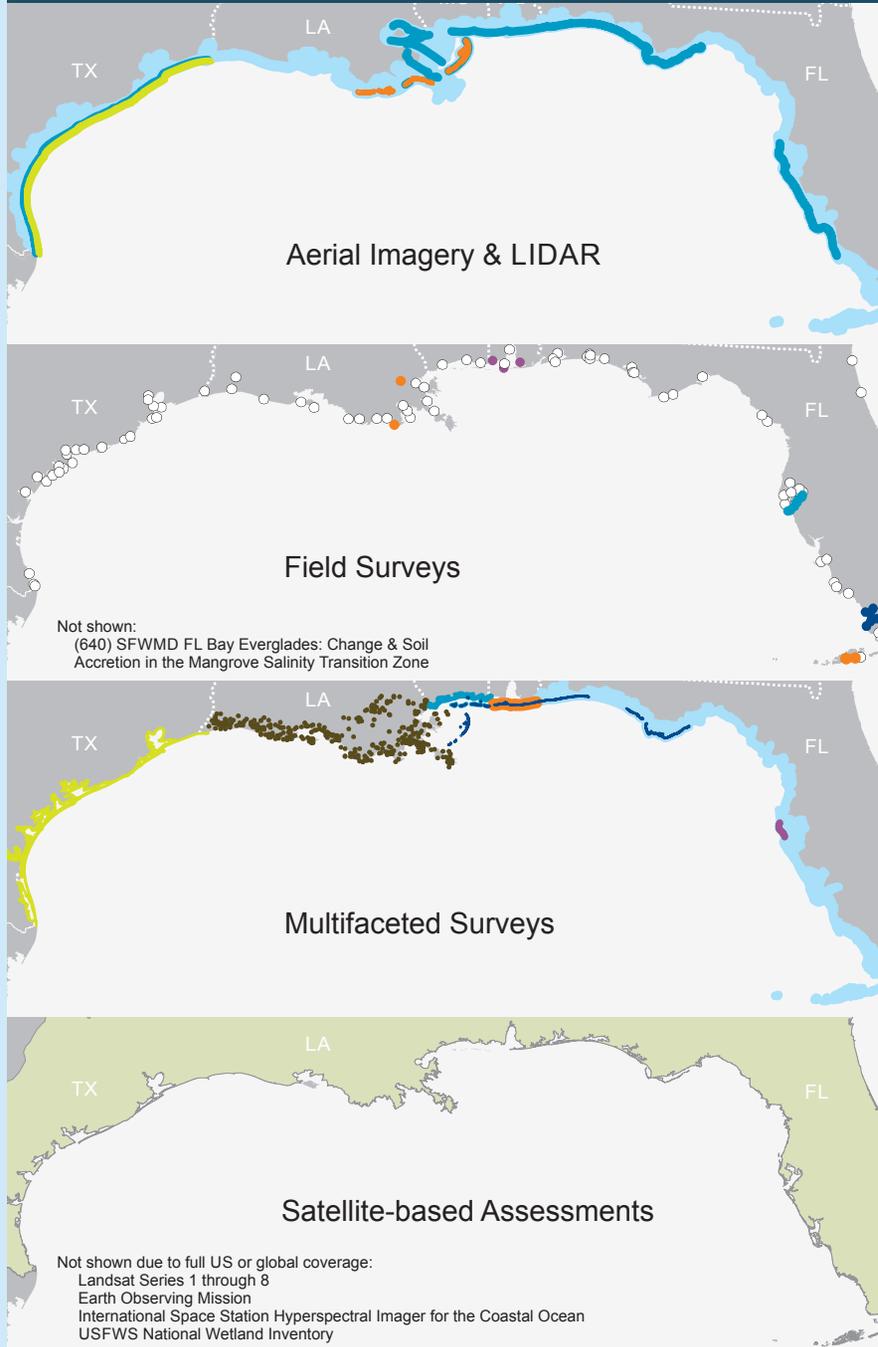
information exist, as some programs do not gather data on the physical forces causing changes in elevation such as sediment accretion or wave energy. Due to these gaps, many monitoring programs capture how shoreline extent, elevation and habitat are changing, but not why. Based on the findings of our analysis, monitoring the long-term recovery of shorelines would benefit greatly by widening the geographic coverage of monitoring and incorporating metrics to measure the processes behind changes in shoreline status.

Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES/AREAS				EXPLANATION OF GAPS
	Species	Space	Time	Oiled/impacted areas from SCAT maps	Forested and herbaceous wetland vegetation spp.	Wetlands, uplands, ridges, barrier islands	Coquina clams	
Monitor shoreline position and form	1	2	3	●				1- Not applicable (no priority species identified).
Monitor vegetative communities	4	5	4		●			2- Monitoring of elevation is occurring, but ecological process monitoring is lacking in some areas. 3- Monitoring does not capture all seasons.
Monitor spatial integrity of shoreline habitats	1	4	4			●		4- Monitoring meets this priority. 5- Monitoring is not Gulf-wide.
Document changes in soil condition, specifically re: PAHs	1	6	4	●				6- Monitoring does not capture PAH-related effects.
Monitor additional shoreline stressors that could impact recovery	1	5	4	●				7- No sustained long-term monitoring is occurring.
Monitor intertidal invertebrates as indicator of coastal pollution	7	5	7				●	

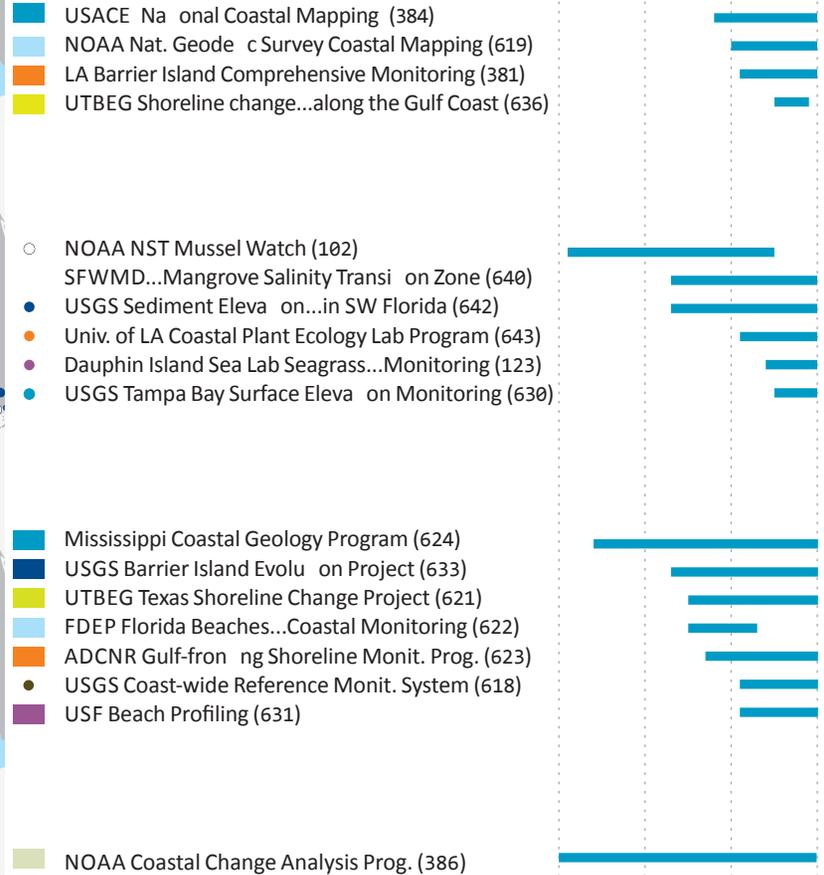
Shorelines

Profile page 2



Existing Studies

SHORELINE LONG-TERM MONITORING



Mangrove shoreline, Florida Keys

Terrestrial Species



Priorities include estimating population sizes, distribution and habitat impacts.

Summary

Terrestrial species in the northern Gulf of Mexico were impacted by the BP oil disaster either due to habitat disturbance from oil contamination or directly from response efforts. In addition, residual oil in nearshore habitat and restoration actions adjacent to dunes and upper marsh habitat should be closely monitored to identify and avoid any impacts to terrestrial species' habitats. Historically, monitoring of terrestrial species has focused on those species with a legal harvest such as the American alligator, as well as those species that are listed as endangered or threatened under state and

federal law such as beach mice. Monitoring priorities for terrestrial species include estimating population sizes, distribution and habitat impacts to the diamondback terrapin, American alligator and beach mice species. In addition, monitoring of arthropods could provide important information to better understand community dynamics and trophic interactions in oiled marshes. Partial and full gaps were identified for these priorities due to limited seasonal or geographic sampling of terrestrial species, limited reporting to the public or insufficient data to understand population trends and seasonal

fluctuations. For example, the diamondback terrapin has been monitored opportunistically in isolated areas, and overall efforts have not been sustained, repeated or consistent. Since the BP oil disaster, new monitoring efforts of terrestrial species have been initiated, such as those conducted by the Center for Coastal Studies at Texas A&M University-Corpus Christi to track diamondback terrapins along the central Texas coast, that if continued will provide an opportunity to fill gaps and build a foundation for long-term monitoring.

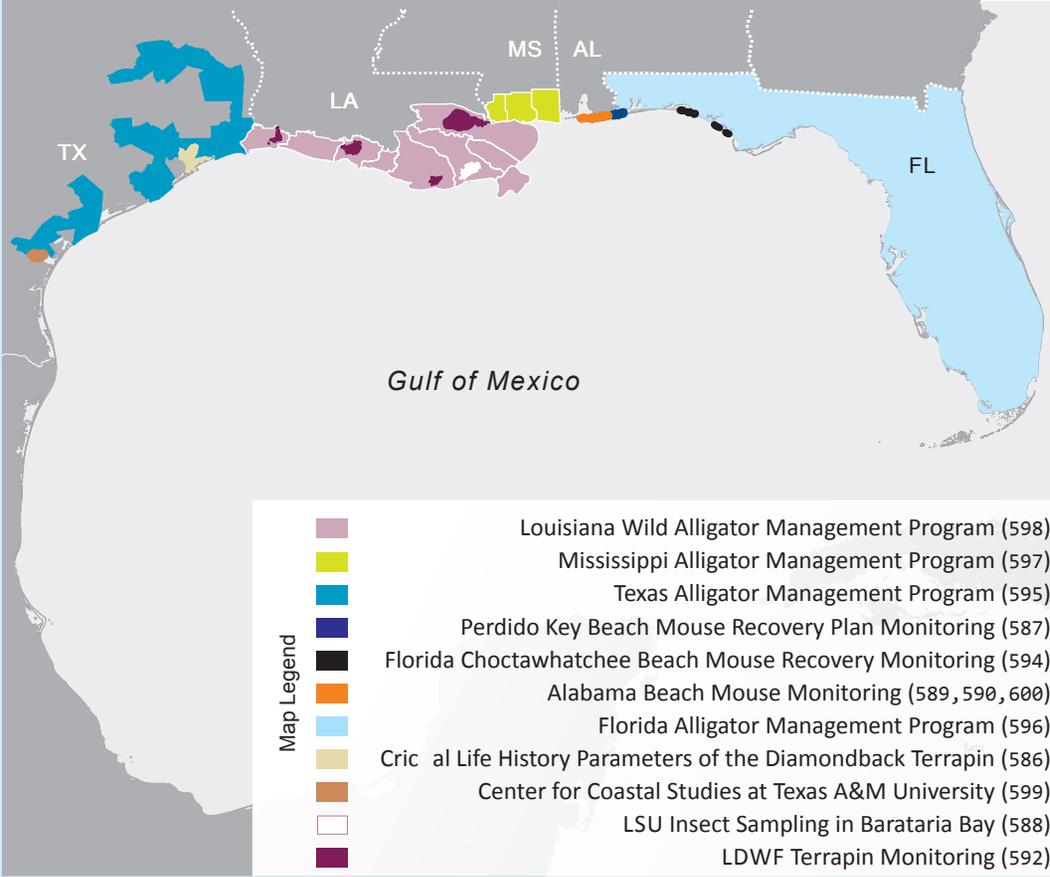
Gaps Identified

MONITORING PRIORITY	Gap			PRIORITY SPECIES				EXPLANATION OF GAPS
	Species	Space	Time	Beach mouse	American alligator	Diamondback terrapin	Insects & spiders	
Demography, distribution and habitat use of injured species	1	2	3	●	●	●		1- All priority species are monitored. 2- No distribution-wide efforts. 3- Sustained sampling is limited and important trends in seasonality are missing. 4- Alligators are monitored in all Gulf states. 5- Important trends in seasonality are missing for alligators. 6- Isolated monitoring occurring in Louisiana.
Alligator populations and annual harvest	1	4	5		●			
Status and trends of terrestrial arthropods in oiled marshes	6	6	6				●	

Full gap ■
 Partial gap ■
 No gap ■

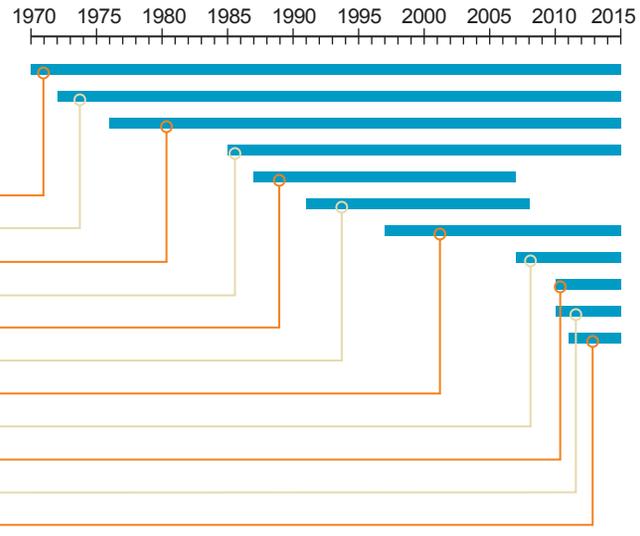
GAP LEGEND

Terrestrial Species



Existing Studies

TERRESTRIAL SPECIES LONG-TERM MONITORING



KEY LESSONS

- *Some species have Gulf-wide coverage; for others, only isolated monitoring exists.*
- *Focus is on threatened/endangered species.*



Overarching Lessons Learned

Throughout Ocean Conservancy's analysis of recovery monitoring efforts and needs, several overarching themes and cross-cutting monitoring priorities emerged. Instead of repeatedly describing these within multiple resource categories, they are discussed here as additional monitoring needs that should be integrated into long-term oil disaster recovery monitoring efforts.

Residual Oil Monitoring

Due to the wide geographic distribution of leaked oil, which could last decades in certain environments, tracking residual oil in the environment and its continuing impacts are key components of a broader recovery monitoring program (Carls et al., 2012). Exposure to lingering oil can result in chronic impacts such as genetic defects, compromised health (including effects on growth or reproduction) and even destabilized predator-prey relationships (Peterson et al., 2003). Because oil weathers most slowly when buried in sediments, remaining oil including polycyclic aromatic hydrocarbons are a concern for animals living in or near contaminated sediments. Monitoring benthic habitats is an identified priority for susceptible marine fish, nearshore sediments and associated resources and shorelines. However, residual oil impacts

are not necessarily limited to these resource groups, so more extensive monitoring may be needed. In tracking residual oil and its potential effects, the following should be taken into account:

- The fate of the oil (i.e., where it went and what remains);
- The geochemical nature of the environment where the residual oil resides (e.g., buried in sediment on the sea bottom or on beaches and likely to be exposed by storms);
- The concentration of the oil (mainly in sediments of beaches, marshes and the sea bed), its chemical composition and degree of weathering;
- The accumulation of oil and its metabolites in key organisms that are still exposed and its potential toxicity; and
- The rate of oil degradation in various environments, specifically including redox and nutrient conditions that determine degradation rate.

Establishing Environmental Condition

Sufficient baseline information is not available for some habitats impacted by the BP oil disaster, such as deep-sea benthos, and this complicates efforts to accurately measure impact and recovery. In habitats

showing signs of oil disaster injury for which there is insufficient data, gathering baseline information was consistently identified as a priority for monitoring. Alternatively, researchers can use reference areas to assess the degree of damage, infer recovery rates of injured habitats or consider appropriate actions that will aid recovery. For example, habitat mapping can document the distribution and condition of Gulf habitats, which is useful for identifying uninjured reference sites that contain comparable conditions to injured areas. Mapping and a broader baseline understanding are a priority for oyster reefs, shorelines, deep-water communities, shallow-water and mid-water corals, and hard-bottom marine fish habitats.

Monitoring and Research: A Symbiosis for Gulf Restoration

Monitoring is done to understand where, when and how ecological change is occurring, and research is carried out to learn what is possibly causing the change. Their goals are complementary, and there is a need for both, particularly when trying to understand how ecological systems and relationships interact in the Gulf in ways that affect restoration outcomes. Without research, the data that accumulate from monitoring only reveal changes in the

coastal or marine environment but do not explain them. Long-term monitoring data are extremely useful in guiding research questions that ask the “how” of observed change; whereas research helps scientists to determine the “what” to monitor. One example takes place in the mesopelagic ecosystem of the deep Gulf (from 200 to 1,000 meters deep), an ecosystem that was directly and repeatedly exposed to BP oil and applied dispersant. Many species at these depths migrate to the surface layer of the ocean every night, but there are major species in this zone that have yet to be named, let alone understood for how they function or interrelate (Hopkins et al., 1994; Kaltenberg et al., 2007). Therefore, conducting basic research on the mesopelagic organisms and their roles would help the scientific community to better understand how this ecosystem was injured.

Integrating and Coordinating Gulf-wide Efforts

Many Gulf monitoring efforts are uncoordinated, patchy, intermittent or even duplicative (NAS, 2014; NAS, 2015). It is common for monitoring efforts around the Gulf to use different monitoring protocols to track the same natural resource. These characteristics of monitoring make it difficult or impossible to make Gulf-wide comparisons of monitoring data or understand long-term trends in resource

condition. Additionally, a disjointed network of monitoring within and across habitats or taxa makes it difficult to make inter-disciplinary connections. For example, information about how a recovering species' prey resources are changing could inform restoration managers' understanding of why a species is not recovering. Moving from a disjointed system to a coordinated monitoring paradigm in the Gulf would improve our understanding of recovery and ecosystem change.

Leveraging Existing Projects and Programs

Ocean Conservancy's assessment identifies monitoring priorities for which existing programs might be able to provide relevant data for tracking the recovery of resources injured by the BP oil disaster. See Table 3 for examples of monitoring efforts managed by agencies or academic institutions that represent sources of data for recovery monitoring. It is possible that the monitoring infrastructure already in place across the Gulf can address the gaps in coverage at critical times of the year, in critical locations or for priority species, provided the active programs are appropriately modified or expanded and receive the supplemental resources needed to accommodate the goals of restoration decision-makers to assess Gulf-wide recovery.

Using existing Gulf programs to monitor sea turtles impacted by the BP oil disaster

Ocean Conservancy's assessment identified a partial gap in space and time for the priority of monitoring incidental take of sea turtles from U.S. and Mexican commercial fisheries. Building off existing programs, the *Deepwater Horizon* Trustees' Sea Turtle Early Restoration Project is starting to address this gap in monitoring. The proposed project includes a 10-year enhancement of NOAA's long-standing observer program for documenting sea turtle bycatch in the shrimp trawl fishery, and a 10-year increase in law enforcement patrols to enforce the use of turtle excluder devices on shrimp vessels in Texas waters. The proposed restoration activities help address the gap by strengthening the ability of fisheries managers and law enforcement officials to document – and ultimately deter and decrease – lethal interactions as a means of aiding the recovery of affected species.



Table 3: Examples of Existing Monitoring Efforts that Can Inform Injured Resource Recovery Monitoring

Survey Name	Target Resources	Sampling Location	Program Duration	Managing Entity
Southeast Area Monitoring and Assessment Program* Fall and Summer Shrimp/Groundfish Survey	Commercially and recreationally important fish and invertebrates (abundance, distribution, species length-frequency and environmental conditions)	U.S. waters, inshore to 50-60 fathoms offshore	1981 - current	A partnership of state, federal and regional agencies
North American Breeding Bird Survey	Breeding birds (point counts)	Throughout North America; multiple sites in Gulf of Mexico	1966 - current	U.S. Geological Survey and Canadian Wildlife Service
Scripps Passive Acoustic Monitoring for Marine Mammals	Marine mammals (detect presence and track changes in distribution by recording vocalizations)	Northeastern Gulf of Mexico	2010 - current	Scripps Institute of Oceanography Whale Acoustic Laboratory
Louisiana Wild Alligator Management Program	American alligator (nest density, population estimates, harvest parameters, environmental conditions, mark and recapture of farm-released alligators)	Coastal Louisiana	1970 - current	Louisiana Department of Wildlife and Fisheries
Seagrass Integrated Mapping and Monitoring Program	Seagrasses (presence or absence, species composition, percent cover, abundance using the Braun-Blanquet scale and aerial imagery)	Florida coastline	1992 - current	Florida Fish and Wildlife Conservation Commission
Coastwide Reference and Monitoring System	Sediment (elevation, accretion, subsidence, salinity and type), marsh and forest vegetation (cover, species composition, relative abundance, dominance, richness and height), and wetland characterization (land/water ratio, duration and frequency of flooding)	Coastal Louisiana	2003 - current	Louisiana Coastal Protection and Restoration Authority and the U.S. Geological Survey
Fisheries Oceanography of Coastal Alabama	Zooplankton, ichthyoplankton and environmental parameters (count, weight, taxa, biovolume, water, water temperature, depth, etc.)	Alabama nearshore area and continental shelf	2004 - 2015	Dauphin Island Sea Lab

* Administered by the Gulf States Marine Fisheries Commission with participation from the following agencies: Alabama Department of Conservation and Natural Resources, Marine Resources Division; Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute; Louisiana Department of Wildlife and Fisheries; Mississippi Department of Marine Resources; Gulf Coast Research Laboratory; Texas Parks and Wildlife Department; National Marine Fisheries Service, Southeast Fisheries Science Center; and the Gulf of Mexico Fishery Management Council.

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ACRONYMS

ADCNR	Alabama Department of Conservation and Natural Resources	MPA	Marine Protected Area
ADPH	Alabama Department of Public Health	NAS	National Academy of Sciences
AFB	Air Force Base	NERR	National Estuarine Research Reserve
AFAMP	Alabama Fisheries Assessment and Monitoring Program	NGOM	Northern Gulf of Mexico
AMRD	Alabama Marine Resources Division	NIUST	National Institute for Undersea Science and Technology
ANERR	Apalachicola National Estuarine Research Reserve	NMFS	National Marine Fisheries Service
CAMA	(Office of) Coastal and Aquatic Managed Areas	NMS	National Marine Sanctuary
DISL	Dauphin Island Sea Lab	NOAA	National Oceanic and Atmospheric Administration
ECOGIG	Ecosystem Impacts of Oil and Gas Inputs to the Gulf	NRDA	Natural Resource Damage Assessment
EPA	Environmental Protection Agency	NS	Nesting Survey(s)
FAMP	Fisheries Assessment and Monitoring Program	NST	National Status and Trends
FCFWRU	Florida Cooperative Fish and Wildlife Research Unit	PAH	polyaromatic hydrocarbons
FDEP	Florida Department of Environmental Protection	ROV	remotely operated vehicle
FGB	Flower Garden Banks	SEAMAP	Southeast Area Monitoring and Assessment Program
FIM	Fishery-independent Monitoring	SEFSC	Southeast Fisheries Science Center
FIS	Fishery-independent Sampling or Fishery-independent Survey	SERPENT	Scientific and Environmental ROV Partnership Using Existing Industrial Technology
FWC	Florida Fish and Wildlife Conservation Commission	SFWMD	South Florida Water Management District
FWRI	Florida Fish and Wildlife Research Institute	STRP	Sea Turtle Recovery Project
GCRL	Gulf Coast Research Laboratory	TAMU	Texas A&M University
GOM	Gulf of Mexico	TCEQ	Texas Commission on Environmental Quality
GOMS	Gulf of Mexico States	TPWD	Texas Parks and Wildlife Department
GulfFIN	Gulf of Mexico Fisheries Information Network	USACE	United States Army Corps of Engineers
HAPC	Habitat Area of Particular Concern	USF	University of South Florida
IJF	Interjurisdictional Fisheries	USGS	United States Geological Survey
IMMS	Institute for Marine Mammal Studies	UTBEG	University of Texas Bureau of Economic Geology
LDHH	Louisiana Department of Health and Hospitals	WQPP	Water Quality Protection Program
LDWF	Louisiana Department of Wildlife and Fisheries		
MAPS	Monitoring Avian Productivity and Survivorship		
MDMR	Mississippi Department of Marine Resources		

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EXPERT REVIEW OF MONITORING PRIORITIES

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Marine Mammals

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Marine Fish

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Sea Turtles

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Nearshore Sediment and Assoc. Res.

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Oysters

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Shallow- and Mid-water Corals

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Shorelines

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Oysters

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Shallow- and Mid-water Corals

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Terrestrial Species

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Gray snapper, Gulf of Mexico

APPENDIX A: METHODS

Ocean Conservancy's Charting the Gulf: Analyzing the Gaps in Long-term Monitoring of the Gulf of Mexico consisted of three main phases: 1) creating an inventory of long-term monitoring efforts relevant to impacted natural resources; 2) identifying high-priority monitoring or data collection activities needed to track the status of species or habitats recovering from the BP oil disaster; and 3) identifying gaps in space, time and priority species/areas coverage for each monitoring priority. Phases one (inventory) and two (priorities) were carried out simultaneously, and phase three (gap analysis) was completed only after phases one and two were complete for each resource category.

PHASE 1: INVENTORY OF LONG-TERM MONITORING

The first phase of the gap analysis project began with an inventory of long-term monitoring efforts in the Gulf relevant to 12 resource categories of natural resources used by the *Deepwater Horizon* Trustee Council, plus one additional resource category for ecosystem drivers. The inventory captures information on individual monitoring efforts obtained through meetings with resource experts and a review of primary literature and monitoring plans,

such as the Gulf of Mexico Alliance Gulf Monitoring Network white paper (2013) and the Gulf Coastal Ocean Observing System build-out plan (2014). Ocean Conservancy met or corresponded with nearly 300 individuals from federal and state agencies, academia and nonprofits. These communications were essential to compiling information on the geographic and temporal scope, sampling methods, and focal species of long-term monitoring programs in the Gulf.

For purposes of the gap analysis, the inventory was not intended to be an exhaustive catalog of every monitoring effort in existence, but instead a targeted search for programs that met two requirements: 1) a minimum data record of five years of continuous sampling or a minimum of two sample years that span the five-year range, and 2) a principal source of information for resource assessment or management. A principal program is a program believed to be the most relevant to tracking the status and health of injured natural resources and meets at least one of the following criteria:

1. **Geographic Scope:** The monitoring program covers a majority of the resource extent for an administrative or management agency's jurisdiction of the resource, or it is Gulf-wide. (e.g.,

- SEAMAP, sanctuary assessments or state-level seagrass surveys);
2. **Primary Data Source:** The program serves as the primary source of information on the resource for the managing agency charged with assessing the particular resource (e.g., Florida FWC sea turtle index nesting beaches or USFWS waterfowl harvest assessments);
3. **NRDA Resource Category:** The program directly monitors the resource defined by a NRDA resource category. (e.g., NOAA's coastal change and analysis program for shorelines);
4. **Foundational Data Source:** The program does not directly monitor an injured resource, but data from the program is used by management agencies or the research community to understand population, habitat or ecosystem dynamics (e.g., currents, sea surface temperature or ocean color) and the sampling scheme has broad coverage in space and time; or
5. **Limited Data Availability on the Particular Resource:** There are such limited data sources within an administrative boundary (federal or state waters) for a resource category that any existing programs classify as primary (e.g., deep-water communities).

Ocean Conservancy documented approximately 640 long-term monitoring efforts in the full inventory, ranging from abiotic characteristics of the marine environment to population assessments of forage fish and colonial nesting shorebirds. The above filter was applied to select a subset of inventory programs eligible for inclusion in the gap analysis (see Appendix D for a summary). The subset represents those monitoring programs in the inventory that collect information relevant to the assessed priorities.

Records in the Inventory

The inventory is a collection of metadata for approximately 640 active or discontinued long-term monitoring efforts in coastal areas or marine waters of the U.S. Gulf. Monitoring data themselves are not captured. The table below provides a summary of the fields for which information on each of the individual

efforts was obtained. The goal of the inventory was to capture as many efforts as possible that could provide pre- and post-disaster data on natural resource condition for use in status and trends assessments, or serve as historical record for those efforts that are no longer active. There are likely environmental monitoring efforts in the coastal or offshore areas of the Gulf that are not documented in this inventory because they were either not relevant to the project's goals or were not identified. Metadata fields included in the inventory are shown in Table 4.

Natural Resource Categories

The natural resource categories used in Ocean Conservancy's assessment of monitoring coverage and gaps are, with one exception, the same as those used by the *Deepwater Horizon* Trustee Council. Ocean Conservancy chose the NRDA resource categories to help ensure the findings can

be easily integrated into long-term restoration planning and monitoring efforts for impacted resources and habitats. Ecosystem drivers is the one category that was not identified by the *Deepwater Horizon* Trustee Council but included in this analysis. The category of human use, such as recreational fishing or beach activities, was excluded from this analysis because it falls outside the ecological focus of the assessment. The recreational, socio-economic and human health impacts of the BP oil disaster are important topics for further study and should be included in long-term studies to ensure lingering harm is documented and Gulf Coast communities affected by the disaster are made whole. The National Academy of Sciences Gulf Research Program has identified community resilience and human health issues as a priority for research in its document *The Gulf Research Program: A Strategic Vision* (2014).

Table 4: Metadata fields for monitoring efforts included in the inventory

- | | | |
|--------------------------------------|---------------------------|---------------------------------------|
| ● Unique identifier number | ● Project time frame | ● Data publicly available? |
| ● Program/monitoring name | ● Program start date | ● Data acquired by Ocean Conservancy? |
| ● Program website | ● Program end date | ● Data stored in a database? |
| ● Sampling method(s) | ● Managing entity | ● Point of contact |
| ● What is monitored | ● Funding source(s) | ● Contact email address |
| ● Sampling frequency and schedule | ● Funding future | ● Contact phone number |
| ● Parameters measured | ● Data location | ● Notes about the program |
| ● Discontinues (e.g., missing years) | ● Spatial data collected? | |
| ● Where sampling occurs | ● Data format | |

PHASE 2: IDENTIFICATION OF PRIORITY MONITORING ACTIVITIES

The second phase of Ocean Conservancy's assessment included the identification and verification of priority activities for monitoring the recovery of natural resources impacted by the BP oil disaster. The identification of recovery monitoring activities began with a literature review of publications relevant to the BP oil disaster or specific resource categories for recommendations pertaining to long-term monitoring needs. Peer-reviewed research papers on oil disaster impacts and NRDA Trustee reports were particularly helpful. An attempt was made to identify the highest data collection priorities to guide decision-makers and avoid a lengthy list of priorities. Where applicable, relevant species or geographic areas were included for each priority to highlight resources for which there is evidence of injury, and therefore, the need for long-term monitoring is more urgent.

Following the literature review, Ocean Conservancy consulted subject matter experts either through email or phone interviews, asking them to verify the monitoring priorities on a resource-by-resource basis. Each expert confirmed whether a given priority was indeed an important data collection or research activity

for assessing post-BP oil disaster resource condition and recovery. Experts were given the opportunity to add priorities and any relevant species they thought were important and missing from the list. Ocean Conservancy approached a minimum of two expert reviewers per resource category. Expert input was incorporated and priorities were revised or synthesized further to improve clarity and avoid duplication. The result was a list of resource-specific monitoring priorities that could then be cross-referenced with the inventory of eligible efforts for determining gaps in coverage (See Appendix B for expanded priorities).

PHASE 3: ANALYSIS OF GAPS IN MONITORING COVERAGE

The third phase of Ocean Conservancy's assessment determined whether, and to what extent, the long-term monitoring priorities identified in phase two could be met through efforts documented in the inventory. Approximately 400 entries in the inventory were used in the analysis because they met the definition of an eligible or principal monitoring effort. The goal was to highlight the most significant gaps in broad coverage at the regional level, and not produce an exhaustive list of high-resolution, localized gaps. Three categories of coverage were analyzed with respect to each monitoring priority: 1) priority species, 2) space and 3)

time. The objective of the analysis was to determine whether an existing effort provided the relevant data needed to supplement tracking recovery of a particular resource category during critical times of the year (e.g., migration, spawning) across the U.S. Gulf.

A deviation from this approach involved the assessment of monitoring programs for ecosystem drivers. The physical aspects of the marine ecosystem do not lend themselves to identification of gaps in the same manner as the NRDA injury categories for living marine resources or habitats. Therefore the assessment of gaps in species, geography and time did not apply. Instead we approached the assessment of ecosystem drivers by summarizing the types of monitoring programs that exist and described a select few high-level gaps. In describing the general gaps in the observation system for monitoring broad-scale ecosystem drivers we relied on input from the Gulf Coastal and Ocean Observing System, specifically the build-out plan: *A Sustained, Integrated Ocean Observing System for the Gulf of Mexico (GCOOS): Infrastructure for Decision Making* (2014). This plan describes the needs for an enhanced observing system to meet societal goals beyond the capabilities of the system in existence today.

Interpreting Gaps

Gaps in monitoring coverage are based on an interpretation of monitoring needs and existing coverage, and should be considered proxies for the adequacy of coverage. However, a gap is not a prescription for what type, where or how frequently monitoring should occur. Ultimately, decision-makers will need to consider many factors, including which gaps are important to fill and to what degree

monitoring needs to be enhanced, in developing a monitoring program that is representative and statistically valid to assess the status and trends for a resource category, species or habitat. In addition, it is possible that the analysis overstated gaps in coverage or identified gaps that do not exist in reality due to missing monitoring efforts.

Gap Definition Guidelines

Ocean Conservancy staff prepared guide-

lines (Table 5) to help ensure the gap categories (priority species, space, and time) and degrees of gaps (full, partial or no gap) were defined clearly and could be applied consistently across resource categories. In many cases, the difference between gap categories is nuanced and required a judgement call based on input from experts and a review of published reports and papers. The intent of defining gaps is to provide a high-level assessment of monitoring associated with each priority.

Table 5: Gap definition guidelines

PRIORITY SPECIES		
Identified as priorities because of exposure to hydrocarbons/dispersants or evidence of injury, as identified by experts or in publications.		
<p>■ Full Gap</p> <p>Primary criterion: One or more of the priority species are not sampled by monitoring. (The full gap is assigned to the “priority species” category, not the full resource category.)</p> <p>Note: Monitoring coverage of non-priority species was not within the parameters of this category for analysis.</p> <p>Hypothetical example: A full gap would apply when monitoring abundance of a priority marine fish species, or suite of priority marine fish species, is not associated with any existing program, and therefore no coverage exists for the species of concern.</p>	<p>■ Partial Gap</p> <p>Primary criterion: Monitoring exists for all priority species, but may be too limited for assessing status and trends.</p> <p>Hypothetical example: Monitoring abundance of a priority marine fish species, or suite of priority marine fish, occurs under existing program(s), but the coverage is insufficient to meet the priority needs (based on reports, personal communication with subject matter experts, review of literature or professional opinion of Ocean Conservancy staff).</p>	<p>■ No Gap</p> <p>Primary criterion: Priority species are sampled, or susceptible to sampling. Existing monitoring sufficiently addresses needs of understanding priority species.</p> <p>Hypothetical example: Monitoring abundance of a priority marine fish species, or suite of priority marine fish, occurs under an existing program(s) such that sufficient data are available to satisfy the monitoring priority.</p>

Table 5: Gap definition guidelines (continued)

SPACE

Applies not only to the identified priority species or areas but the full resource category.

■ Full Gap

Primary criteria: Any situation in which at least one of the primary criteria is met:

1. No sustained monitoring exists for an important area.
2. Status and trend assessment is not possible for that area.

Hypothetical example: *Monitoring sea turtle nesting success is not conducted at beaches throughout the U.S. Gulf.*

■ Partial Gap

Primary criteria: Any situation in which at least one of the primary criteria is met:

1. Sustained monitoring exists but does not meet the full needs of addressing the specific monitoring priority or is determined to be geographically limited.
2. Monitoring exists but may be too limited for assessing status and trends.

Hypothetical example: *Monitoring sea turtle nesting success is conducted at key beaches throughout the U.S. Gulf, but insufficient data are collected, or not enough beaches are sampled to obtain data needed for status and trends assessments.*

■ No Gap

Primary criteria: Any situation in which at least one of the primary criteria is met:

1. Monitoring appears sufficient for assessing status and trends.
2. Monitoring represents a system of sentinel sites, designed for that purpose.

Note: Sustained monitoring exists in areas needed to adequately assess long-term status and trends of the priority species or habitat (e.g., appropriate sentinel sites are established that are intended to represent similar communities or species across the full range of occurrence, with the understanding that the sampling design was specifically created to support the needs of sentinel site assessment).

Hypothetical example: *Monitoring sea turtle nesting success is conducted at a sufficient number of geographically stratified key beaches throughout the U.S. Gulf to track status and trends.*

Table 5: Gap definition guidelines (continued)

TIME		
Addresses time and seasonality of existing surveys; focus of gap analysis is on existing surveys only.		
<p>■ Full Gap</p> <p>Primary criteria: Any situation in which at least one of the primary criteria is met:</p> <ol style="list-style-type: none"> 1. Sustained sampling is no longer accurate. 2. Important seasonality is missed from current sampling. 3. Complete life stage missed that is crucial for understanding the success of restoration during current sampling. <p>Hypothetical example: <i>Monitoring sea turtle nesting success is not possible because data are not collected during sea turtle nesting season under an existing program, regardless of species.</i></p>	<p>■ Partial Gap</p> <p>Primary criteria: Any situation in which at least one of the primary criteria is met:</p> <ol style="list-style-type: none"> 1. Sustained sampling is limited for a given season, or important trends in seasonality are missed from current sampling. 2. Sustained sampling is limited for a given life stage. 3. Inter-year intervals exist between sampling efforts, creating discontinuities in data time series. <p>Additional criterion: Situations in which species or habitats are monitored, but not all seasons or times are sufficient as determined by reports, subject matter expert personal communication, literature or professional opinion of Ocean Conservancy staff.</p> <p>Hypothetical example: <i>Monitoring sea turtle nesting success is conducted, but is limited because sampling only occurs during part of the nesting season, or sampling is conducted too irregularly from year to year to identify clear trends.</i></p>	<p>■ No Gap</p> <p>Primary criteria: Any situation in which at least one of the primary criteria is met:</p> <ol style="list-style-type: none"> 1. Sustained monitoring documents all important life stages and/or seasons of the resource category needed for status and trend assessment. 2. Monitoring sufficiently addresses needs of understanding the specific monitoring priority. <p>Hypothetical example: <i>Monitoring sea turtle nesting success is conducted on all key nesting beaches consistently each year such that data are available for identifying status and trends.</i></p>

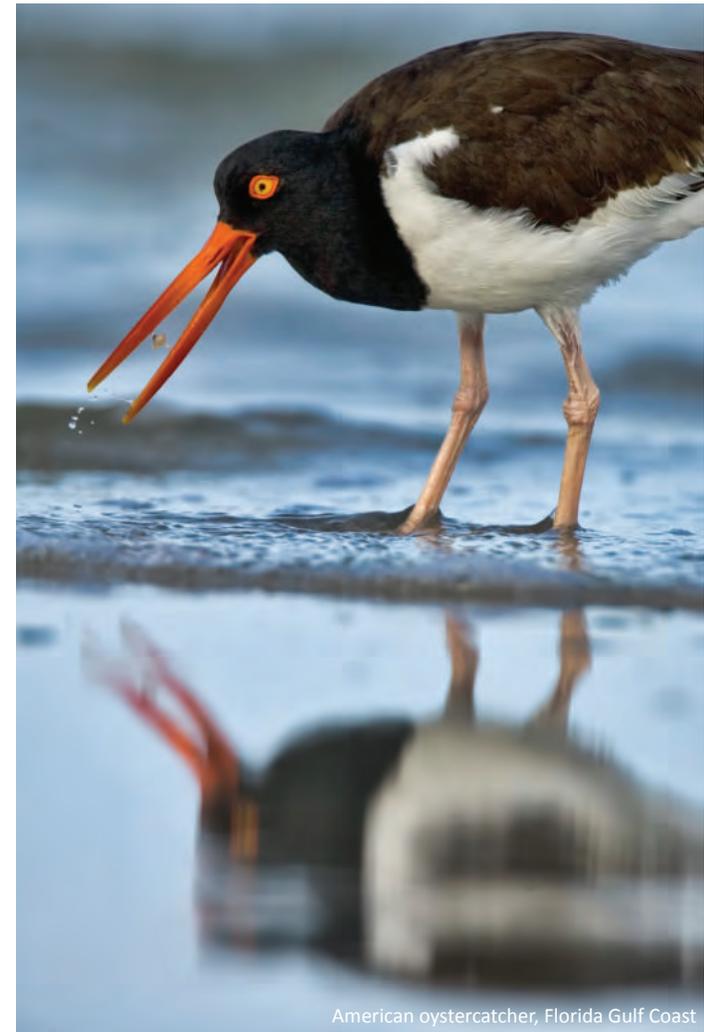
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American oystercatcher, Florida Gulf Coast

APPENDIX B: EXPANDED PRIORITY TABLES

Included in Appendix B are the long-term monitoring and research needs identified through our literature and expert review processes. Some of these priorities were further synthesized or combined during our internal and expert review process to avoid duplication or improve clarity of the priority.

Ecosystem Drivers ^[1]	
Monitoring/Research Priority	Priority Species or Area
Sea level across the Gulf; currents, salinity, acidity (pH), dissolved oxygen and temperature with depth from nearshore to offshore waters	No priority species or areas were identified for ecosystem drivers because of their range of influence.
The volume and concentrations of nutrients, sediment, organic matter and freshwater in the discharge of the Mississippi and other major rivers	No priority species or areas were identified for ecosystem drivers because of their range of influence.
Primary production (carbon fixation and dissolved oxygen concentrations) on shelf and offshore	No priority species or areas were identified for ecosystem drivers because of their range of influence.
Wind events across the shelf critical in transporting larvae or juvenile crabs, shrimp and fish into estuaries, and basin-scale ocean circulation like the intensity of the Loop Current and its eddies	No priority species or areas were identified for ecosystem drivers because of their range of influence.
Abundances of keystone species, such as apex predators, keystone forage fishes, and habitat engineers, which help organize ocean and coastal ecosystems (The gap analyses for the 12 natural resource categories address this priority, so it is not included in the ecosystem drivers section.)	No priority species or areas were identified for ecosystem drivers because of their range of influence.

Deep-water Communities ^[2,3,4,5,6,7,8,9,10,11]	
Monitoring/Research Priority	Priority Species or Area
Monitor deep-water habitat use by mobile fauna including larger fish species	Contaminated deep-water seafloor communities
Map the distribution, structure and condition of deep-water communities	Contaminated deep-water seafloor communities
Establish long-term monitoring studies of deep-water communities to further understand the vulnerability and recovery trajectories of these communities to/from disturbance including exposure to petroleum hydrocarbons	Contaminated deep-water seafloor communities
Monitor deep-sea microbial community structure to understand the fate and effect of dispersant compounds in the environment	Contaminated deep-water seafloor communities

Appendix B: Detail of monitoring priorities (continued)

Water Column and Invertebrates ^[3,12,13]	
Monitoring/Research Priority	Priority Species or Area
Mesopelagic and bathypelagic community composition at index sites near depth zone of well blowout	Whole community study
Zooplankton densities in oil disaster impact zone to detect changes in base of food chain as indicator of recovering marine fish populations	Copepods, chaetoganths, decapods, ostracods, and amphipods and include whole community enumeration of samples
Monitor mysid and copepod species composition in areas of suspected oiling and test individuals for chronic hydrocarbon exposure as a bioindicator of residual oil and a proxy for the recovery of predatory fish species	Nearshore: Mysid shrimp and copepods; Offshore: Copepods
Densities of gelatinous zooplankton and water column feeders	Shelf/off-shelf: Jellyfish, larvaceans, doliolids, salps and squid

Birds ^[3,6,10,13,14,15,16,17]	
Monitoring/Research Priority	Priority Species or Area
Monitor avian species spatial use of habitat types to understand the importance of specific habitats to local bird populations	Common loon, American white pelican, brown pelican, royal tern, black skimmer, laughing gull and northern gannet
Identify species-specific stressors, develop measures of health (e.g., productivity) and gather information on stressors and the health of individuals and populations (especially for those species affected by the BP oil disaster or oil and gas activities or those that are of conservation concern)	Common loon, American white pelican, brown pelican, royal tern, black skimmer, laughing gull and northern gannet
Monitor abundance, density and distribution of bird populations impacted by the BP oil disaster	Common loon, American white pelican, brown pelican, royal tern, black skimmer, laughing gull and northern gannet
Identify and monitor key ecosystem variables (e.g., prey density, availability of roost sites and distance among high quality sites), ecosystem drivers and their respective impacts on avian populations and species' habitat use of the region	Common loon, American white pelican, brown pelican, royal tern, black skimmer, laughing gull and northern gannet
Maximize integration of monitoring projects; develop and implement standardized regional monitoring protocols and integrate into a centralized, publicly accessible database to monitor coastal bird populations (Identify operations and management responsibility of the database)	Not a monitoring priority, but an overarching need

Appendix B: Detail of monitoring priorities (continued)

Marine Mammals ^[18, 19, 20, 21, 22, 23, 24, 25, 26]	
Monitoring/Research Priority	Priority Species or Area
Observe and assess stranded mammals to collect complete life history information (morphometrics, body condition, reproductive status, age, stock ID, stomach contents) and to determine mortality and injury rates, likely cause of death, overall health (including immune function, hormone levels, evidence of disease, exposure to toxins, etc.)	Primarily nearshore bottlenose dolphins, other marine mammal species when they strand
Monitor abundance and distribution of marine mammal stocks in nearshore (coastal and bay/sound/estuary) waters (<200m)	Bottlenose dolphins, Atlantic spotted dolphins, Bryde's whales
Monitor abundance and distribution of marine mammal stocks in offshore waters (>200m)	Sperm whales, beaked whales, pelagic delphinids
Determine stock structure of marine mammal populations	Bay/sound/estuary bottlenose dolphins, Bryde's whales, sperm whales
Assess population demographics and reproductive rates (by monitoring and tracking mother/calf pairs)	Bay/sound/estuary and coastal bottlenose dolphins
Assess habitat use (and potential vulnerability to various natural and human-caused activities) by monitoring diving and foraging behavior, habitat associations and correlations with other oceanographic factors	Bottlenose dolphins, sperm whales, Bryde's whales
Monitor interactions and incidental bycatch in U.S. Gulf commercial and recreational fisheries, with an emphasis on the commercial shrimp trawl fishery and the recreational hook-and-line fishery	Bottlenose dolphins (western coastal and northern coastal stocks in bay/sound/estuary stocks throughout the Gulf)
Contribute data to regional (Gulf of Mexico) database(s) such as the Gulf of Mexico Dolphin Identification System established for fin-based photo-identification of marine mammals	Not a gap analysis priority, but an overall need

Marine Fish ^[3, 27, 28, 29, 30, 31, 32]	
Monitoring/Research Priority	Priority Species or Area
Collect samples of fish, including eggs, larvae and adults, and conduct toxicity testing by analyzing liver and bile, as well as whole body samples, for PAH metabolites as an indicator of chronic PAH exposure and determine effects of that exposure	Bottom-dwelling shelf fishes, including reef fish (e.g., snappers and groupers), sciaenids, mahi, Gulf menhaden, flounders, Gulf killifish
Monitor changes in movement or migratory behavior and life history parameters such as fish condition (e.g., deformities), growth rates and related survivorship, and reproductive impairment	Tunas, amberjack, swordfish, mahi, cobia, billfish, red snapper, tripletail, king mackerel, Spanish mackerel
Nearshore and offshore fishery-independent sampling of larvae, juveniles and adults to detect persistent differences in fish population dynamics, fish community structure or trophic effects of the BP oil disaster	Bluefin tuna, billfishes, mahi, reef fish, Gulf menhaden in 0 year class, silversides, anchovies
Conduct regional mapping to identify and delineate benthic habitats which serve as nursery grounds or essential fish habitat that may have been impacted by oil/dispersants	Natural reef, corals, oyster reef, submerged aquatic vegetation

Appendix B: Detail of monitoring priorities (continued)

Sea Turtles ^[3,33,34,35,36,37]	
Monitoring/Research Priority	Priority Species or Area
Continue or expand efforts at nesting beaches to collect data on reproductive or demographic parameters, such as number of nests, clutch size, length of incubation, emergence success, nesting success and hatching sex ratios, to assess long-term declines in populations	Kemp's ridley
Monitor neophyte (first-time) nesters and measure proportion of neophytes to returning nesters to measure adult recruitment identified by body and clutch size, hatching success, and tag returns	Kemp's ridley
Assess potential exposure and effects of oil disaster on nesting females, their nests and their eggs by tagging females for post- and inter-nesting distribution information, chemical and toxicological analysis of embryo mortalities and hatching success and survival rates	Kemp's ridley, loggerhead
Identify important marine foraging, breeding and inter-nesting habitats and determine migratory pathways among foraging grounds and between foraging grounds and nesting beaches	Kemp's ridley, loggerhead
Design and implement statistically valid monitoring programs in all federal and state fisheries that have potential to interact with sea turtles, and quantify the impact of those activities on the species; monitor incidental take from U.S. and Mexico fisheries	Kemp's ridley, loggerhead

Nearshore Sediments and Associated Resources ^[3,30,38,39,40,41]	
Monitoring/Research Priority	Priority Species or Area
Monitor the presence/absence and concentrations of hydrocarbons associated with the BP oil disaster in sediments collected from nearshore subtidal areas for comparison to baseline data	Areas impacted by hydrocarbons associated with the BP oil disaster
Monitor the density, abundance, biomass and benthic species associated with nearshore sediments/communities and develop an index of biointegrity or a multivariate approach to measure community impacts of petroleum exposure	Areas impacted by hydrocarbons associated with the BP oil disaster and comparable unoiled areas
Study long-term, chronic or sublethal exposure of benthic organisms to PAHs and oiled sediments, with emphasis on detecting divergent gene expression, developmental abnormalities (e.g., cardiovascular defects in embryonic fish, delayed hatching), or physiological response (e.g., compromised immunological, life history traits)	Coastal fishes, white shrimp, brown shrimp, blue crabs

Appendix B: Detail of monitoring priorities (continued)

Oysters ^[6,9,42,43,44]	
Monitoring/Research Priority	Priority Species or Area
Map the distribuon and ar ea of oyster reefs Gulf-wide to be er manage for sustainable fisheries, reef rebuilding and restoraon (using , for example, scan sonar to conduct nearshore habitat mapping)	Oyster reefs impacted by the BP oil disaster through contaon or r esponse efforts (as idenfied in the 2012 NRDA Status Update)
Consistently and rigorously monitor oyster reefs using standard performance metrics (e.g., cultch density, oyster area) to quanfy fishery and ec osystem service changes. This includes monitoring restoraon pr ogress and effecv eness at historically sampled sites, injured sites, response sites (e.g., freshwater diversions) and random sites. In many cases, this will require expanding the number of sites and number of replicate samples across monitoring efforts. Notes: 1) For metrics, start with the Basic Universal Metrics developed by Bagge et al. (2014): 1. reef areal dimensions, 2. reef height, 3. oyster density, 4. oyster size-frequency distribuon, and adapt or add addional par ameters (e.g., cultch density, oyster abundance) as necessary. 2) A determinaon of the err or of esma on of s tock abundance should precede any determinaon of the number of sit es and replicates needed. Such a determinaon w ould likely suggest that indeed the number of sample sites and replicates should be increased.	Oyster reefs impacted by the BP oil disaster through contaon or r esponse efforts (as idenfied in the 2012 NRDA Status Update)
Monitor environmental condions (e. g., temperature, dissolved oxygen, pH and salinity) near oyster reefs (The strategic placement of automated environmental monitoring staons in o yster-growing areas is one strategy.)	Oyster reefs impacted by the BP oil disaster through contaon or r esponse efforts (as idenfied in the 2012 NRDA Status Update)
Expand efforts to monitor oyster disease occurrence, frequency and distribuon Gulf -wide and consistently (A Gulf-wide oyster disease monitoring program exists [www.oystersennel.or g] and should be enhanced not duplicated.)	Oyster reefs impacted by the BP oil disaster through contaon or r esponse efforts (as idenfied in the 2012 NRDA Status Update)
Monitor oyster fisheries harvest	Oyster reefs impacted by the BP oil disaster through contaon or r esponse efforts (as idenfied in the 2012 NRDA Status Update)
Submerged Aquatic Vegetaon ^[45,46,47]	
Monitoring/Research Priority	Priority Species or Area
Conduct aerial imagery surveys of submerged aquac v egetaon and perf orm advanced imagery analysis to produce a fine-scale submerged aquac v egetaon classific aon capable of detecng chang es in submerged aquac v egetaon c overage	<i>Halodule wrightii</i> , <i>Thalassia testudinum</i> , <i>Syringodium filiforme</i> , <i>Halophila engelmannii</i> , <i>Halophila decipiens</i> , <i>Ruppia maritima</i>
Monitor natural recovery of seagrasses scarred by propellers of response vessels by measuring percent cover and shoot density; assess local reference sites to determine if baseline condions or background factors (e.g., poor water quality, disease) might affect recovery of injured sites	<i>Halodule wrightii</i> , <i>Thalassia testudinum</i> , <i>Syringodium filiforme</i> , <i>Halophila engelmannii</i> , <i>Halophila decipiens</i> , <i>Ruppia maritima</i>

Appendix B: Detail of monitoring priorities (continued)

Shallow- and Mid-water Corals ^[3,6,8,9,48,49]	
Monitoring/Research Priority	Priority Species or Area
Long-term datasets to help quantify the abundance, distribution, status and trends of Gulf corals	Species/areas in oiled region of Gulf
<p>Complete habitat mapping (including ground-truthing) in the Gulf of Mexico using high-resolution bathymetric surveys, to document and track distribution of all coral reefs and hard-bottom habitats</p> <p>Notes: 1) "Emergent rock substrate often supports 'live-bottom' communities consisting of sponges, hydroids, corals, and sea whips that can attract dense fish populations. These communities, while common and widespread, are not adequately mapped to permit a detailed assessment." (NRDA Status update, 2012). 2) Habitat mapping is not the same type of repeated measurement that is referenced in the other priorities. Instead, it is a sustained effort to map these habitats in the Gulf over a long-term period of time to fill knowledge gaps. Repeated mapping will be required to document change in the distribution and condition of benthic communities and species assemblages.</p>	Species/areas in oiled region of Gulf
Monitor existing restoration projects and compare to results from undamaged coral reefs to learn about community processes that are important for recovery, such as coral reproductive biology, coral recruitment, algal growth, links between coral health/habitat provision and fish populations, resistance to perturbations, and coral reef ecosystem resilience	Species/areas in oiled region of Gulf
Monitor key physical and chemical data in real and near-real time at coral reef sites, including temperature, salinity, PAR, UV, water clarity, nutrients, and carbon dioxide, to relate environmental changes with observed responses (Jones et al., 2000), such as coral bleaching, algal blooms, and disease events	Species/areas in oiled region of Gulf
Monitor climate change and ocean acidification impacts on coral at sentinel sites to establish baselines for future events or management actions	Flower Garden Banks National Marine Sanctuary, Madison-Swanson MPA, Dry Tortugas National Park and Pulley Ridge HAPC

Appendix B: Detail of monitoring priorities (continued)

Shorelines ^[6,9,50,51]	
Monitoring/Research Priority	Priority Species or Area
Monitor shoreline position and form by measuring shoreline erosion, accretion, subsidence and sediment elevation table	Oiled/impacted areas from SCAT maps
Monitor vegetative communities (e.g., composition, abundance, diversity and productivity of shoreline plant communities)	Forested and herbaceous wetland vegetation species
Monitor spatial integrity of shoreline habitats to understand changes in habitat distribution, landscape habitat size and type, fragmentation, connectivity, and relative location	Wetlands, uplands, ridges and barrier islands
Document changes in soil condition (e.g., organic matter content and biogeochemical processes including the fate of PAHs)	Oiled/impacted areas from SCAT maps
Monitor additional (non-BP oil disaster) shoreline stressors that could impact rates of recovery, such as sea level rise, wave energy and the fate and transport of sediment	Oiled/impacted areas from SCAT maps
Monitor intertidal invertebrates for abundance, size distributions and presence of contaminants (PAH concentration) as a biological indicator of coastal pollution	Coquina clams

Terrestrial Species ^[52,53,54,55,56]	
Monitoring/Research Priority	Priority Species or Area
Monitor the occurrence, extent and severity of disturbance or diminishment of habitat from oil disaster response activities or restoration actions, specifically, habitats that are currently or potentially occupied by injured terrestrial species (e.g., diamondback terrapin, American alligator and beach mice species) (This priority is addressed under “shorelines,” so not included in the Terrestrial Species gap analysis)	Beach mice species, American alligator, diamondback terrapin
Gather long-term observations to understand demography, distribution and habitat use of injured terrestrial species	Beach mice species, American alligator, diamondback terrapin
Monitor habitat changes (e.g., salinity changes from diversions), map and incorporate changes into management plans (This priority is addressed under “Shorelines,” so not included in the Terrestrial Species gap analysis)	Beach mice species, American alligator, diamondback terrapin
Monitor alligator populations and the number of individuals harvested annually during the nuisance alligator season, as well as sex and size of harvested individuals	American alligator
Monitor long-term status and trends of terrestrial arthropod populations in oiled marshes	Ants, crickets and spiders

Literature Review (MONITORING PRIORITIES)

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Blue crab, Louisiana Gulf Coast

APPENDIX C: EXPANDED GAP DESCRIPTIONS

Deep-water Communities			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Monitor deep-water habitat use by mobile fauna including larger fish species	N/A	Full gap. No Gulf-wide efforts address this priority. Only localized monitoring of mobile fauna use of deep-water habitats is occurring. The SERPENT program opportunistically documents occurrences of mobile fauna near oil and gas infrastructure; however, this type of qualitative data is not sufficient to understand status and trends of organisms.	Full gap. No sustained long-term monitoring of mobile fauna use of deep-water habitats is occurring. The SERPENT program operates opportunistically when ROVs are not being used for oil and gas purposes; however, this type of qualitative data is not sufficient to understand status and trends of these organisms.
Map the distribution, structure and condition of deep-water communities	N/A	Partial gap. Isolated mapping efforts have documented the distribution of some deep-water communities; however, there is no Gulf-wide comprehensive coverage to be able to characterize the status and changes in deep-water communities.	Partial gap. Monitoring efforts have been opportunistic and intermittent. There have been limited opportunities to characterize the condition of deep-water communities over time.
Establish long-term monitoring studies of deep-water communities to further understand the vulnerability and recovery trajectories of these communities to/from disturbance including exposure to petroleum hydrocarbons	N/A	Partial gap. No Gulf-wide efforts exist to address this priority; however, there are small areas in the Gulf in which repeated monitoring of deep-water communities has occurred. Specific efforts have focused on sediment bacteria, small protists and metazoans. In addition, monitoring efforts have been initiated post-BP oil disaster both for NRDA and other programs that will capture many priorities. At the time of publication, many of these studies were either not available to the public or did not span at least five years.	Full gap. No sustained long-term monitoring efforts document all deep-water communities' life stages or seasons.
Monitor deep-sea microbial community structure to understand the fate and effect of dispersant compounds in the environment	N/A	Full gap. No monitoring of deep-water microbial communities is occurring anywhere in the Gulf.	Full gap. No sustained long-term monitoring of deep-water microbial communities is occurring.

Appendix C: Detail of gap explanations (continued)

Water Column and Invertebrates			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Mesopelagic and bathypelagic community composition at index sites near depth zone of well blowout	Full gap. No monitoring of mesopelagic and bathypelagic communities.	Full gap. No monitoring at mesopelagic and bathypelagic depths.	Full gap. No monitoring at mesopelagic and bathypelagic depths.
Zooplankton densities in oil disaster impact zone to detect changes in base of food chain as indicator of recovering marine fish populations	Partial gap. Copepods underrepresented due to sampling gear limitations, particularly mesh size.	Partial gap. Areas deeper than epipelagic zone (>200m depth).	Partial gap. Less sampling during summer and winter seasons.
Monitor mysid and copepod species composition in areas of suspected oiling and test individuals for chronic hydrocarbon exposure as a bioindicator of residual oil and a proxy for the recovery of predatory fish species	Full gap. Copepods and mysid shrimp underrepresented due to sampling gear limitations. No testing of hydrocarbon exposure in long-term efforts.	Partial gap. Areas deeper than epipelagic zone (>200m depth) and all areas for testing hydrocarbon exposure through long-term efforts.	Partial gap. Less sampling during summer and winter seasons.
Densities of gelatinous zooplankton and water column feeders	Full gap. Net-based gear not optimized for sampling delicate, gelatinous organisms.	Full gap. No sampling in Gulf designed to target delicate, gelatinous organisms.	Full gap. No sampling designed to target delicate, gelatinous organisms.

Birds			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Monitor avian species spatial use of habitat types to understand the importance of specific habitats to local bird populations	Full gap. No monitoring of spatial use of habitat types for priority species is occurring.	Full gap. No long-term monitoring targeting spatial use of habitat types is occurring anywhere in the Gulf.	Full gap. No long-term monitoring targeting spatial use of habitat types is occurring at any time during the year.
Identify species-specific stressors, develop measures of health (e.g., productivity) and gather information on stressors and the health of individuals and populations. (especially for those species affected by the BP oil disaster or oil and gas activities or those that are of conservation concern)	Full gap. Monitoring of species-specific stressors is limited or absent for priority species. NRDA monitoring may provide this type of monitoring for priority species exposed to oil.	Partial gap. The Florida Park Service District One shorebird surveys are the only long-term monitoring efforts that focus on species-specific stressor tracking; however, efforts cover disturbance for only five Gulf species (snowy plover, Wilson's plover, American oystercatcher, least tern and black skimmer) and do not measure indicators of health.	Partial gap. Although very few efforts collect this type of information, the one that does gathers sufficient information to track disturbance through all seasons for the five species (snowy plover, Wilson's plover, American oystercatcher, least tern and black skimmer) monitored.
Monitoring abundance, density, and distribution of bird populations of species impacted by the BP oil disaster	Full gap. Monitoring of northern gannet abundance, density and distribution is not occurring, and little for common loons; therefore, not all priority species are monitored.	Partial gap. Monitoring is occurring for colonial wading birds and shorebirds around the Gulf, but pelagic bird monitoring is not occurring.	No gap. Existing monitoring of priority colonial wading birds and shorebirds is occurring, and existing surveys are repeated during all seasons.
Identify and monitor key ecosystem variables (e.g., prey density, availability of roost sites, and distance among high quality sites), ecosystem drivers and their respective impacts on avian populations and species' habitat use of the region	Full gap. Monitoring of ecosystem variables and drivers is not occurring for all priority bird species.	Partial gap. Very few monitoring efforts are targeting ecosystem variables and drivers for birds. The Monitoring Avian Productivity and Survivorship Program monitors songbird vital rates and environmental conditions at a few long-term sites around the Gulf, and the Everglades wading bird monitoring efforts tracks annual precipitation trends in addition to wading bird monitoring; however, these efforts are limited in spatial extent and across ecosystem variables.	No gap. The few programs that meet this priority do gather information to track the status and trends of species and targeted ecosystem variables.

Appendix C: Detail of gap explanations (continued)

Marine Mammals			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Observe and assess stranded mammals	Paral g ap. Very limited response capacity for all species.	Paral g ap. Lowest response capacity in offshore waters as well as Texas Coastal Bend, western Louisiana, Big Bend of Florida, southeast Florida and Mexico.	Paral g ap. Volunteer response is opportunisc and v aries depending on availability of resources and trained staff.
Monitor abundance and distribuon of marine mammal stocks in nearshore (coastal and bay/sound/estuary) waters (<200m)	Paral g ap. Monitoring occurring for all priority species but is very limited, and there are no sustained efforts for species such as Atlanc spo ed dolphins when they move into offshore areas.	Paral g ap. Sustained monitoring occurs only in Sarasota Bay, Mississippi Sound and from 1992-2001 in southeast Florida.	No gap. For nearly all species assessed through currently existng pr ograms, all seasons and life stages are potenally documented during the few currently existng sur veys.
Monitor abundance and distribuon of marine mammal stocks in offshore waters (>200m)	Paral g ap. A majority of survey effort has been visual assessments; therefore crypc species, such as beaked whales, are historically under-represented.	Paral g ap. Data limited by detecon range of 5 existng passiv e acousc sur vey staons in the northern Gulf and ship-based visual survey transects of SEAMAP ichthyoplankton sampling in pelagic waters during 1991-2001 sampling period.	No gap. For nearly all species assessed through currently existng pr ograms, all seasons and life stages are potenally documented during the single currently existng sur vey.
Determine stock structure of marine mammal populaons	Full gap. Status and trends not possible for most bolenose dolphin s tocks and all Bryde's and sperm whales.	Paral g ap. Monitoring isolated to Mississippi Sound and Sarasota Bay, therefore, a Gulf-wide assessment of stock structure is not possible.	No gap. For nearly all species assessed through currently existng pr ograms, all seasons and life stages are potenally documented during the few currently existng sur veys.
Assess populaon demogr aphics and reproducv e rates	Paral g ap. Very limited sustained demographic monitoring.	Paral g ap. No Gulf-wide status and trends possible with lack of sustained monitoring beyond survey areas in Mississippi Sound and Sarasota Bay.	No gap. For nearly all species assessed through currently existng pr ograms, all seasons and life stages are potenally documented during the few currently existng sur veys.
Assess habitat use	Full gap. No sustained monitoring to assess full suite of habitats used for any species.	Full gap. No sustained monitoring to assess full suite of habitats used beyond survey areas in Mississippi Sound and Sarasota Bay.	Full gap. No sustained monitoring to assess full suite of habitats used during any season or life stage.
Monitor bycatch and interacons in U .S. Gulf commercial and recreaonal fisheries	Paral g ap. All species potenally det ected by observers on commercial fishing vessels, but no means of documeng bolenose dolphin in teracon on priv ate recreaonal fishing boa ts and for-hire vessels.	Paral g ap. Observer coverage is low across all fisheries of federal waters, lower on vessels permi ed for state waters and no coverage on private recreaonal fishing boats and for-hire vessels. Observer coverage is unknown for vessels in Mexican fishery, but expected to be lower than U.S. waters.	Paral g ap. Very limited coverage of observers on fishing vessels annually, during all seasons, and none on private vessels.

Marine Fish			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Sampling fish eggs, larvae and adults for presence of PAH metabolites and determine toxicity effects of PAH exposure*	Full gap. No status and trends possible with lack of sustained monitoring of PAH levels.	Paral g ap. There is a single effort that monitors PAH levels in coastal sharks of the north-central Gulf. There are no other known sustained surveys.	Paral g ap. No status and trends possible with lack of sustained monitoring of PAH levels.
Changes in migratory behavior and life history parameters	Paral g ap. There are no fishery independent monitoring efforts that target the pelagic priority species, with the excepon of limit ed ichthyoplankton life stage sampling. Landings data from fishery-dependent surveys supplement informaon on these species but are limited by inherent bias from non-random fishery selecvity .	Paral g ap. Area of lowest sustained fishery independent effort is in pelagic waters relav e to coastal bays and estuaries. Fishery dependent surveys of pelagic fishing acvity supplement informaon on pelagic w aters, but are limited by inherent bias from non-random fishery selecvity .	Paral g ap. No pelagic ichthyoplankton surveys in summer or shrimp/groundfish surveys in spring and summer of connen tal shelf waters.
Nearshore and offshore fishery-independent sampling of larvae, juvenile and adults to detect persistent differences in fish populaon dynamics, fish community structure or trophic effects of the oil disaster	Paral g ap. There are no monitoring efforts that target the pelagic priority species, with the excepon of limit ed ichthyoplankton life stages.	Paral g ap. Sampling is lowest in pelagic waters, with more effort in state coastal waters sampled.	Paral g ap. No pelagic ichthyoplankton surveys in summer or shrimp/groundfish surveys in spring and summer of connen tal shelf waters.
Regional mapping of nursery grounds and benthic essenal fish habitats that may have been impacted by oil/dispersants	Paral g ap. Very limited high resoluon benthic habitat mapping efforts that support more discrete delineaoon of the inial mosaic of essenal fish habit ate occurring. The exisng spar se efforts target reef habitats.	Paral g ap. No sustained efforts of connen tal slope and abyssal benthic habitats. Very limited habitat mapping efforts are conducted across the connen tal shelf, targeng hard bo om reef habitats.	Paral g ap. Mapping acvies are occurring but they are intermi ent with limited opportunies to provide assessment of habitat extent and condition with r epeat delineaoon thr ough me.

* Toxicity effects from lab studies are required to understand impact from PAH exposure

Appendix C: Detail of gap explanations (continued)

Sea Turtles			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Continue or expand evaluation efforts at nesting beaches in U.S.	No gap. Nesting activity of all species is monitored with existing surveys.	Partial gap. Data primarily derived from volunteer capacity, which depends on availability of resources and trained staff at nesting beaches.	Partial gap. Nest surveys and evaluations may be limited by volunteer and staff resources on nesting beaches throughout nesting season.
Monitor neophyte (first-time) nesters	No gap. Primary nesting beach in U.S. conducts saturation tagging.	Partial gap. Neophyte effort is concentrated at Padre Island National Seashore, Dry Tortugas National Park, and in Florida at Keewaydin Island and Cape San Blas.	Partial gap. Effort varies throughout nesting season at some locations that tag nesting females during short, discrete segments for research and monitoring projects.
Assess reproduction and potential exposure effects of oil	Full gap. No sustained assessment outside of NRDA.	Full gap. No sustained assessment outside of NRDA.	Full gap. No sustained assessment outside of NRDA.
Identify important foraging, breeding, inter-nesting and migratory habitats	No gap. Existing efforts monitor both priority species.	Partial gap. Assessment is limited to nesting females from 2 Texas beaches and 3 Florida beaches, and in-water areas from 5 Florida sites, 1 Alabama site and another in Mississippi.	Partial gap. There is much less tagging effort outside of nesting season for tracking habitat use.
Monitor incidental take from U.S. and Mexico fisheries	No gap. All species potentially detected by observers on fishing vessels or from fishery surveys.	Partial gap. Observer coverage is low across all fisheries of federal waters, lower on vessels permitted for state waters and no coverage on private recreational fishing boats and for-hire vessels. Observer coverage is unknown for vessels in Mexican fishery, but expected to be lower than U.S. waters.	Partial gap. Very limited coverage of observers on fishing vessels annually, during all seasons.

Nearshore Sediments and Associated Resources			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Hydrocarbons in sediments collected from nearshore subtidal areas for comparison to baseline data	N/A	Partial gap. The sampling locations are very sparse across the northern Gulf.	Partial gap. Most sediment toxicity monitoring programs have been downscaled in recent years; others have been active nationwide for many years but are short-term, intensive studies at the project site level.
Monitor benthic and epibenthic species associated with nearshore sediments/communities and develop multivariate approach to measure community impacts of hydrocarbon exposure	No gap. All benthic and epibenthic macroinvertebrate species are potentially detected in areas sampled.	No gap. All major estuaries and bays have been sampled by existing, downscaled or terminated programs.	Partial gap. Monitoring programs that assess benthic community assemblages either do not resample areas or the return interval is too long to track exposure from acute impacts.
Exposure of benthic organisms to PAHs and oiled sediments, with emphasis on detecting divergent gene expression, developmental abnormalities or physiological response	Full gap. No species are assessed for physiological, developmental or genetic responses to hydrocarbon exposure beyond contaminant presence in bodily tissue.	Full gap. There are no monitoring efforts in the region that assess for physiological, developmental or genetic responses to hydrocarbon exposure beyond contaminant presence in bodily tissue.	Full gap. There have not been monitoring efforts in the region that assessed for physiological, developmental or genetic responses to hydrocarbon exposure beyond contaminant presence in bodily tissue.

Appendix C: Detail of gap explanations (continued)

Oysters			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Map the distribution and area of oyster reefs Gulf-wide	N/A	Partial gap. Although mapping exists in parts of all Gulf states, there are no comprehensive and consistent mapping efforts Gulf-wide.	Partial gap. There are gaps in consistent mapping across the Gulf due to the date and frequency with which reefs have been mapped.*
Monitor oyster reefs using standard metrics to consistently and rigorously monitor oyster reefs at historically sampled sites, injured sites, response sites and random sites	N/A	Full gap. There are no established standard monitoring metrics or protocols for oysters Gulf-wide. Some parameters, such as oyster abundance, are measured in all Gulf states; however, the methods by which measurements are made are not standardized.	Full gap. There are no sustained standardized monitoring metrics for oysters in the Gulf that capture all of these parameters. Some metrics are captured on a sustained and reoccurring schedule; however, there are no standardized metrics across programs.
Monitor environmental conditions (e. g., temperature, dissolved oxygen and salinity) near oyster reefs	N/A	Partial gap. Key environmental conditions are not monitored across oyster sites in the Gulf. While temperature and salinity are consistently monitored at oyster sites across all Gulf states, monitoring of pH and dissolved oxygen is a gap at many known oyster sites in Louisiana, Alabama and Mississippi.	No gap. Monitoring of environmental conditions occurs at least quarterly, and often more frequently at established monitoring efforts. This is sufficient to track status and trends; however, expanding monitoring to more sites based on a statistical design would add value.
Monitor oyster disease occurrence, frequency and distribution Gulf-wide and consistently	N/A	Partial gap. Gaps exist across all five Gulf states for oyster disease monitoring. The oyster sennel network monitors oyster disease at 18 sites across the Gulf, and Alabama conducts fishery-independent monitoring; however, this leaves large gaps across Gulf oyster reefs. Specifically, gaps exist at impacted sites along the Louisiana coast landward of Chandeleur Sound to the Mississippi state line, coastal Mississippi outside of one site near Bay St. Louis, and in coastal Florida from Pensacola to Apalachicola.	Partial gap. Monitoring is intermittent and opportunistic at established sites, which leaves gaps throughout the year and across numerous years.
Monitor oyster fisheries harvest	N/A	No gap. Oyster fisheries harvest is monitored at sites across all Gulf states.	No gap. Oyster harvest is monitored during time frames relevant to harvest and is sufficient to track the status and trends of oyster fisheries harvest.

* There are no sustained mapping efforts to map the distribution and area of oyster reefs Gulf-wide. However, once these parameters are established, the frequency with which mapping efforts will need to be repeated should be determined by the desired goals.

Submerged Aquatic Vegetation			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Conduct aerial surveys of submerged aquatic vegetation to detect changes in coverage.	No gap. All species are potentially surveyed by existing aerial surveys.	Paragap. Gaps in seagrass aerial surveys occur in Texas, Louisiana, Mississippi, Alabama and in Florida in the following areas: between Cape Romano and Key West, between Anclote Key and Cedar Keys, and from the Suwannee River to Alligator Point. Short-term monitoring has occurred in Texas in Corpus Christi, in Copano, Aransas, Nueces, and Redfish bays, and from Upper Laguna Madre to Lower Laguna Madre.	Paragap. All but one of the monitoring efforts has gaps in time. The frequency with which monitoring should occur is based on recommendations made by the Florida Seagrass Integrated Mapping and Monitoring program that aerial surveys be conducted at least every six years to track status and trends of seagrass beds. The one exception is the Sarasota Bay effort, which repeats aerial surveys every two years.
Monitor seagrass percent cover and shoot density to track natural recovery from physical damage	No gap. All seagrass species are potentially monitored by existing percent cover and shoot density monitoring efforts.	Paragap. Gaps in monitoring of seagrass cover and density occur throughout Texas and in Florida in the following areas: from Perdido Bay to Choctawhatchee Bay, in Waccasassa Bay, in the southern Springs Coast, in portions of the inshore Ten Thousand Islands, in Volusia County, and in large areas offshore of Florida's Big Bend and the Ten Thousand Islands.	No gap. Existing monitoring surveys are sufficient to track the status and trends of submerged aquatic vegetation areas.

Appendix C: Detail of gap explanations (continued)

Shallow- and Mid-water Corals			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Quantify status and trends of Gulf corals	N/A	Partial gap. Representative coral sites outside the Flower Garden Banks and Florida Keys national marine sanctuaries are not surveyed.	No gap. Existing annual monitoring surveys at the Flower Garden Banks and Florida Keys national marine sanctuaries remain active.
High-resolution habitat mapping to document and track distribution of coral and hard-bottom habitats*	N/A	Partial gap. There are limited sustained mapping efforts to document and track coral or hard-bottom habitat distribution outside of established sites in the Flower Garden Banks and Florida Keys national marine sanctuaries.	Partial gap. Monitoring efforts have been opportunistic and intermittent. There have been limited opportunities to document and track distribution of priority coral communities through time.
Monitor community processes at existing restoration projects and compare trends to undamaged coral reefs	N/A	Partial gap. There is limited integration of protocols for monitoring community processes across sites. Representative coral reefs that exist outside the Flower Garden Banks and Florida Keys national marine sanctuaries or the marine protected area survey locations: Madison-Swanson, Steamboat Lumps, The Edges, Twin Ridges and Northern Banks.	Partial gap. Several long-term surveys have been terminated at potential reference sites: St. Joseph Bay Aquaculture Reserve, Pulley Ridge, Madison-Swanson, Steamboat Lumps, The Edges, Twin Ridges and Northern Banks.
Monitor full suite of key physical and chemical data to relate environmental changes with observed responses, such as coral bleaching, algal blooms and disease events	N/A	Full gap. No sustained monitoring of a full suite of key physical and chemical parameters beyond the study sites of the Flower Garden Banks and Florida Keys national marine sanctuaries.	Full gap. No sustained monitoring of full suite of key physical and chemical parameters beyond temperature.**
Monitor climate change and ocean acidification impacts on coral at sentinel sites to establish baselines for future events or management actions	N/A	Partial gap. Very limited sustained monitoring of metrics tracking climate change and ocean acidification outside the Florida Keys Reef Tract. An integrated sentinel site program does not currently exist.	Full gap. While limited biannual monitoring along the Florida Keys Reef Tract remain active, there is an absence of an integrated sentinel site program to establish consistent baseline conditions.

* Habitat mapping is not the same type of repeated measurement that is referenced in the other priorities. Instead, it is a sustained effort to map these habitats in the Gulf over a long-term period of time to fill knowledge gaps. Repeated mapping will be required to document change in the distribution and condition of benthic communities and species assemblages.

** Temperature is the only physical parameter measured continuously at select sites.

Shorelines			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Monitor shoreline position and form	N/A	Paragap. Although elevation and topography are monitored around the Gulf, there appear to be gaps in areas landward of barrier islands in Mississippi and Alabama and in Texas for some ecological processes (e.g., accretion and erosion).	Paragap. There are gaps throughout the year because existing sustained monitoring efforts occur annually. This monitoring schedule does not capture seasonal changes.
Monitor vegetative communities	No gap. Existing monitoring programs monitor both forested and herbaceous wetland vegetation species.	Paragap. Gaps in monitoring occur along the coasts of Texas, Mississippi, Alabama east of Mobile Bay and along the Florida Panhandle.	No gap. Existing monitoring efforts capture seasonality and complement each other in a way that fills inter-annual variation.
Monitor spatial integrity of shoreline habitats	N/A	No gap. At a coarse scale existing remote sensing programs and associated classification programs cover all Gulf shoreline habitats.	No gap. Existing Landsat scans provide data to monitor shoreline land cover type at an interval of every 16 days.
Document changes in soil condition (specifically related to PAHs)	N/A	Paragap. The Louisiana Coastwide Reference Monitoring System monitors soil condition in Louisiana, and the USGS Barrier Island Evolution Project monitors sediment of barrier islands in the northern Gulf. However, PAH presence and impacts are not identified as monitoring targets. Therefore, gaps exist along the coast of Texas for all soil condition monitoring, and along Louisiana, Mississippi, Alabama & Florida for monitoring PAH presence and effects.	No gap. The existing Louisiana Coastwide Reference Monitoring System monitors sediment biannually, which captures seasonal trends and is based on a statistically designed monitoring schedule.
Monitor additional shoreline stressors that could impact rates of recovery	N/A	Paragap. Barrier islands are monitored along the coast of Louisiana, Mississippi, Alabama & Florida. Gaps in stressor monitoring occur along the coast of Texas and in areas landward of barrier islands in Mississippi and Alabama.	No gap. Monitoring frequency varies across efforts from annually, quarterly or biannually. This wide range of sampling frequency will capture trends across seasons.
Monitor intertidal invertebrates as a biological indicator of coastal pollution	Full gap. No long-term monitoring of coquina clams is occurring.	Paragap. Only the Mussel Watch program captures this priority. Gaps exist in areas not monitored through Mussel Watch, such as in the Big Bend region of Florida and the Texas Coastal Bend.	Full gap. Long-term monitoring was occurring through Mussel Watch; however, these sampling stations were terminated in 2015.

Appendix C: Detail of gap explanations (continued)

Terrestrial Species			
Monitoring/Research Priority	General Gaps- Species	General Gaps- Space	General Gaps- Time
Gather long-term observations to understand demography, distribution and habitat use of injured terrestrial species	No gap. All priority species have some level of long-term monitoring; however, monitoring is not sufficient to assess status and trends of diamond back terrapins. For the beach mice species, the details of existing monitoring efforts are unknown, so the adequacy of these efforts is also unknown.	Full gap. There are no Gulf-wide efforts to monitor terrestrial species. No sustained monitoring exists Gulf-wide, and status and trend assessments are not possible for terrestrial species in many areas of the Gulf.	Partial gap. There are limited monitoring efforts that collect data on terrestrial species for all seasons and life stages. Sustained sampling is limited for terrestrial species, and important trends in seasonality are missed from current sampling.
Monitor alligator populations and the number of individuals harvested annually, including nuisance alligators, as well as sex and size of harvested individuals	No gap. The priority species, American alligator, is monitored to meet this priority.	No gap. American alligators are monitored in all Gulf states including areas with harvest; however, the details of the monitoring efforts in Alabama are unknown.	Partial gap. Important trends in seasonality for American alligators are missed from current sampling.
Monitor long-term status and trends of terrestrial arthropod populations in oiled marshes to understand trophic interactions and shifts	Full gap. There are no efforts that meet this need. Preliminary monitoring has been conducted by Dr. Linda Hooper-Bui at LSU in some Louisiana oiled marshes.	Partial gap. There are no Gulf-wide efforts to monitor terrestrial arthropod species; however, limited short-term monitoring is occurring in some oiled marshes in Louisiana.	Full gap. There are no efforts that monitor all seasons or life stages of terrestrial arthropods.

APPENDIX D: A SUBSET OF LONG-TERM MONITORING EFFORTS IN THE GULF OF MEXICO DERIVED FROM FULL INVENTORY

Field definitions

ID:	The database reference number (simple integer format). Please note, the numbers are not the count of programs and are not necessarily listed in sequential order. They are cataloged in the order they were identified.
Monitoring Program or Effort Name:	The reference name assigned to the monitoring activity in the database.
Summary:	General reference category of parameters monitored by the program.
Start-End Years:	The year an aspect of the monitoring activity was initiated and the year the program was concluded or no longer active.

ID	Monitoring Program or Effort Name	Summary	Start-End Years
1	Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Drifting Buoys	Currents	1995- 2012
2	Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Moored Instrument Array	Temperature, salinity, ocean currents	1995- 2012
3	Atlantic Oceanographic and Meteorological Laboratory (AOML) South Florida Program Synoptic Shipboard Surveys	Water chemistry	1995- 2012
4	Argos	Sea surface variables, currents, biogeochemical observations	2001- Current
5	National Data Buoy Center	Sea surface variables	1967- Current
6	National Water Level Observation Network	Currents, sea surface variables	1812- Current
7	National Water Information System	Flow rates, water levels, water quality, water use	Undetermined- Current
8	United States Army Corp of Engineers Water Levels of Rivers and Lakes	Flow rates, water levels, water quality	mid-1800s- Current
9	Sea-Viewing Wide Field-of-View Sensor (SeaWiFS)	Water quality	1997- 2010
10	Ocean Color Monitor	Ocean color	2009- 2014
11	Envisat	Sea surface variables	2002- 2012
12	Aqua	Atmosphere, sea surface variables, ocean color	2000- Current
13	Aquarius	Sea surface variables	2011- 2015
14	Visible Infrared Imaging Radiometer Suite (VIIRS)	Land and ocean imagery, atmosphere, land and sea surface variables, ocean color	2011- Current
15	Ocean Surface Topography Mission/JASON-2	Sea surface variables	2008- Current
16	Quick Scatterometer (QuikSCAT)	Wind	1999- Current
17	JASON-1	Sea surface variables, circulation	2001- 2013
18	Landsat-7	Landcover	1999- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
19	Landsat Data Continuity Mission/Landsat-8	Landcover	2013- Current
20	Polar Orbiting Environmental Satellites, Initial Joint Polar-Orbiting Operational Satellite System	Sea surface variables, water quality, atmosphere	1978- Current
21	Oceansat-1	Winds, sea surface variables, water quality, algal blooms, atmosphere	2009- 2014
22	Geostationary Operational Environmental Satellite (GOES)- East	Atmosphere, sea surface variables, land, sun	1975- Current
23	University of Southern Mississippi High Frequency Coastal Ocean Dynamics Applications Radar (CODAR)	Currents	2007- Current
24	University of South Florida Coastal Ocean Monitoring and Prediction System High Frequency Coastal Ocean Dynamics Applications Radar (CODAR)	Currents	Undetermined- Current
25	University of Miami/Rosenstiel School of Marine and Atmospheric Science High Frequency Wave Radar (WERA)	Currents	Undetermined- Current
26	National Institute for Undersea Science and Technology (NIUST) Seafloor Hydrates Research Observatory	Deep-sea vent science	2003- Current
27	Mobile Bay Environmental Monitoring	Weather, water quality	2003- Current
30	Coastal Bird Survey	Bird counts	2010- Current
32	Gulf of Mexico States Shark Pupping and Nursery Area (GULFSPAN)	Shark population ecology, water quality	2003- 2007
34	Trip Interview Program	Marine catch and bycatch	1983- Current
35	Gulf of Mexico Fisheries Information Network (GulfFIN) Biological Sampling	Marine fishery catch, effort, and participation	2002- Current
37	Menhaden Captains Daily Fishing Report and Dockside Assessments	Marine catch and bycatch	1964- Current
39	Shrimp Observer Program	Marine harvest and bycatch	1992- Current
40	Bottom Longline Observer Program	Marine harvest and bycatch	1994- Current
41	Gillnet Observer Program	Marine harvest and bycatch	1993- Current
42	Gulf of Mexico Vertical Line Observer Program	Marine harvest and bycatch	2006- Current
46	Large Pelagic Logbooks	Marine harvest and bycatch	1986- Current
50	Florida Dealer Trip Ticket Reports	Commercial marine catch and bycatch	1984- Current
51	Alabama Dealer Trip Ticket Reports	Commercial marine catch and bycatch	2001- Current
52	Mississippi Dealer Trip Ticket Reports	Commercial marine catch and bycatch	2003- Current
53	Louisiana Dealer Trip Ticket Reports	Commercial marine catch and bycatch	1999- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
54	Texas Dealer Trip Ticket Reports	Commercial marine catch and bycatch	1986- Current
56	Marine Recreational Information Program (MRIP)	Marine recreational catch and effort	1979- Current
57	Gulf of Mexico Fisheries Information Network (GulfFIN) Head Boat Port Sampling	Marine recreational catch and effort	1986- Current
58	Marine Sport Harvest Program (Creel Surveys)	Marine recreational catch and bycatch	1974- Current
60	Southeast Area Monitoring and Assessment Program (SEAMAP)- Gulf of Mexico Fall & Summer Shrimp/Groundfish Survey	Marine fisheries, environmental	1981- Current
61	Southeast Area Monitoring and Assessment Program (SEAMAP)- Gulf of Mexico Fall, Winter & Spring Plankton Survey	Marine fisheries	1981- Current
62	Southeast Area Monitoring and Assessment Program (SEAMAP)- Gulf of Mexico Reef Fish Survey	Marine fisheries	1992- Current
63	Southeast Area Monitoring and Assessment Program (SEAMAP) - Gulf of Mexico Inshore Bottom Longline Survey	Marine fisheries, environmental data	2008- Current
64	Southeast Area Monitoring and Assessment Program (SEAMAP) - Gulf of Mexico Vertical Longline Survey	Marine fisheries	2010- Current
65	Texas Parks and Wildlife Department Fishery Independent Sampling	Marine fisheries, water quality	1975- Current
67	Mississippi Department of Marine Resources and Gulf Coast Research Laboratory Fishery Independent Sampling	Marine fisheries	1974- Current
69	Florida Fish and Wildlife Conservation Commission Fishery Independent Monitoring Estuarine Surveys	Marine fisheries, water quality	1989- Current
70	Fisheries Oceanography of Coastal Alabama	Marine fisheries	2004- 2015
71	National Wetland Inventory	Wetland distribution	1974- Current
73	Marine Mammal Health and Stranding Response Program	Marine mammal stranding	1992- Current
81	Sarasota Dolphin Research Program	Dolphin photo-identification, population ecology, radio tracking	1970- Current
87	Southeast Area Monitoring and Assessment Program (SEAMAP)- Plankton Sampling	Plankton ecology	1991- 2001
91	Texas Observatory for Algal Succession Time-series	Phytoplankton bloom potential	2008- Current
92	Southwest Florida Red Tide Program	Phytoplankton bloom potential, water quality	Undetermined- Undetermined
95	Harmful Algal Bloom Marine Observation Network	Phytoplankton bloom potential, water quality, currents, wind	2000- Current
102	National Status and Trends Mussel Watch	Bivalve health	1986- 2010
104	National Listing of Fish Advisories	Fish advisories	1993- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
115	Environmental Monitoring Assessment Program	Water quality, sediment chemistry and toxicity, benthic ecology, fish tissue toxicity	1990- 2006
116	Hypoxia in the Northern Gulf of Mexico	Water quality, hypoxia	1985- Current
117	Mechanisms Controlling Hypoxia Project	Water quality, hypoxia	2003- 2014
118	National Aquatic Resource Surveys National Coastal Assessment	Water quality, sediment quality, benthic community ecology, coastal habitat loss, fish tissue contaminants	1990- Current
119	National Status and Trends Bioeffects program	Coastal contamination, sediment toxicity, benthic macroinvertebrate toxicity	1986- Current
120	National Water Quality Assessment	Water contamination, sediment toxicity, aquatic organism tissue toxicity	1991- Current
121	Louisiana Ambient Surface Water Quality Monitoring	Water quality	1958- Current
122	Dauphin Island Sea Laboratory Seagrass Monitoring	Seagrass characterization	2009- Undetermined
125	Monitoring Polycyclic Aromatic Hydrocarbons in Coastal Sharks	Shark tissue toxicity	2006- Current
129	Apalachicola National Estuarine Research Reserve Juvenile Fish and Benthic Macroinvertebrate Monitoring	Fish and benthic macroinvertebrate abundance, water quality	2000- Current
131	Long-term Monitoring of the East and West Flower Garden Banks	Coral reef ecology and health	1988- Current
132	St. Joseph Bay Coral Monitoring	Coral distribution	2006- 2011
135	Florida Keys National Marine Sanctuary Seagrass Monitoring Project	Seagrass ecology	1995- Current
136	Population Status of Elkhorn Coral	Coral distribution	2004- Current
137	Texas Stream Team	Water quality	1991- Undetermined
138	Seasonal Variation in Nutrients and Microalgal Community Composition	Phytoplankton bloom potential, water quality	2007- 2009
140	Dauphin Island Sea Laboratory Environmental Monitoring	Weather, water quality	1998- Current
144	Oyster Assessment and Monitoring	Oyster reef ecology, water quality	Undetermined- Undetermined
151	Southeast Florida Aerial Surveys	Aerial surveys for marine animals and human use	1992- 2001
165	Institute for Marine Mammal Studies Botox Dolphin Surveys	Dolphin population ecology, behavior, water quality	2004- Current
166	Institute for Marine Mammal Studies Botox Dolphin Stranding Response Program	Dolphin stranding	1984- Current
167	Botox Dolphin Health Assessments	Dolphin health	1978- 1988
169	Abundance, Distribution, and Condition of <i>Acropora</i> Corals, Other Benthic Coral Reef Organisms, and Marine Debris	Benthic condition, marine debris	1998- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
175	Florida Statewide Nesting Beach Survey	Sea turtle nesting	1979- Current
176	Florida Index Nesting Beach Sea Turtle Nesting Surveys	Sea turtle nesting	1996- 2013
186	Conservancy of Southwest Florida Nesting Surveys	Sea turtle nesting	1983- Current
191	Southwest Florida Satellite Tracking Program	Sea turtle satellite tracking	2009- Current
195	Threatened and Endangered Sea Turtles in Marine Protected Areas of the Greater Everglades	Sea turtle satellite tracking	2005- 2018
222	Long-Term In-Water Studies of Sea Turtles in Florida Bay	Sea turtle in-water population dynamics	1990- 2016
223	Mustang Island Sea Turtle Nesting Surveys	Sea turtle nesting surveys	Undetermined- Undetermined
224	Matagorda Peninsula Sea Turtle Nesting Surveys	Sea turtle nesting surveys	Undetermined- Undetermined
227	Institute of Marine Mammal Studies Sea Turtle Nesting Surveys	Sea turtle nesting surveys	2000- Current
228	Institute of Maine Mammal Studies Sea Turtle Satellite Tracking	Sea turtle satellite tracking	2010- Current
229	Inwater Research Group, Inc. Key West National Wildlife Refuge Sea Turtle Surveys	Sea turtle nesting surveys	2002- 2017
230	Mote Marine Laboratory Sea Turtle Nesting Surveys	Sea turtle nesting surveys	1982- Current
236	Kemp's ridley Sea Turtle Recovery Project Nesting Survey	Sea turtle nesting surveys	1978- Current
242	Kemp's ridley Sea Turtle Recovery Project Satellite Tracking Study	Sea turtle satellite tracking	1997- Current
253	Texas A&M University In-Water Sea Turtle Studies	Sea turtle in-water population dynamics	1998- 2011
254	South Padre Island and Boca Chica Sea Turtle Nesting Surveys	Sea turtle nesting surveys	1977- Current
255	Alabama Sea Turtle Nesting Surveys	Sea turtle nesting surveys	2001- Current
258	Texas A&M University Sea Turtle Nesting Surveys	Sea turtle nesting surveys	1991- 2011
269	University of Alabama at Birmingham In-Water Sea Turtle Research Program	Sea turtle in-water population dynamics	1999- 2009
270	Northwest Florida In-Water Sea Turtle Studies	Sea turtle in-water population dynamics	2001- 2018
273	Eglin Air Force Base Cape San Blas Station Sea Turtle Nesting Surveys	Sea turtle nesting surveys	1994- Current
295	Florida Coral Reef Evaluation and Monitoring Project	Coral reef ecology	1996- Current
296	Florida Keys National Marine Sanctuary Seagrass Monitoring Project	Seagrass distribution and abundance	1995- Current
297	Florida Keys National Marine Sanctuary Water Quality Monitoring Project	Water quality	1995- Current
298	Northern Gulf of Mexico Continental Slope Habitats and Benthic Ecology Study	Deep sea benthic ecology	1999- 2014
299	Louisiana Universities Marine Consortium (LUMCON) Environmental Monitoring	Weather, water quality	1991- Current
300	Texas Automated Buoy System	Weather, sea surface conditions, currents	1995- Current
301	Texas Coastal Ocean Observation Network	Weather, sea surface conditions, water quality	1988- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
302	Wave-Current-Surge Information System for Coastal Louisiana	Weather, sea surface conditions, currents	2005- Current
303	River, Estuary and Coastal Observing Network	Water quality	2007- Undetermined
304	Florida State University Center for Ocean-Atmospheric Prediction Studies	Weather, water quality	2007- 2013
314	Stetson Bank Coral Monitoring	Coral reef ecology, water quality	1993- Current
315	Northern Gulf of Mexico Marine Protected Areas Surveys	Marine protected area conditions	2001- 2014
316	Pulley Ridge Fish Survey	Deepwater reef ecology	2004- 2009
317	Terra Ceia Aquatic Preserve Water Quality Monitoring	Water quality	Undetermined- Current
318	Everglades National Park Water Quality Monitoring	Water quality	Undetermined- Current
320	Louisiana Offshore Oil Port Oil Platform Environmental Monitoring	Wind, sea surface conditions, weather	Undetermined- Current
321	Scripps Institution of Oceanography Wave Buoy	Waves, sea surface temperature	Undetermined- Current
322	United States Environmental Protection Agency and Mexican Government Cooperative Program	Wind, weather	2011- Current
323	ATP Oil and Gas Corporation Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
324	Amerada Hess Corporation Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
325	Anadarko Petroleum Corporation Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
326	BHP Billiton Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
327	British Petroleum, Inc. Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
328	Chevron Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
329	ConocoPhillips Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
330	ENI Petroleum Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
331	El Paso E&P Company, L.P. Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
332	ExxonMobil Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
333	Freeport-McMoRan Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
334	Helix Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
335	Kerr-McGee Oil and Gas Corporation Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
336	LLOG Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
337	Maersk Drilling USA Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
338	Marathon Oil Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
339	Mariner Energy, Inc. Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
340	Marubeni Oil and Gas, Inc. Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
341	Murphy Exploration & Production Company Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
342	Newfield Exploration Company Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current
343	Noble Energy, Inc. Acoustic Doppler Current Profiler (ADCP)	Currents	Undetermined- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
344	Petrobras- USA Acousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
345	Repsol Acousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
346	Shell Internaonal E&P Ac ousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
347	Statoil Hydro Acousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
348	Stone Energy Acousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
349	Total USA, Inc. Acousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
350	Walter Oil and Gas Corporaon Ac ousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
351	Williams Acousc Doppler Curr ent Profiler (ADCP)	Currents	Undetermined- Current
352	Central Gulf Ocean Observing System USM3M01 Buoy	Sea surface variables, wind, currents, waves, water quality	2004- 2013
354	Rookery Bay Naonal Es tuarine Research Reserve System-Wide Monitoring Program	Water quality	1996- Current
355	Apalachicola Naonal Es tuarine Research Reserve System-Wide Monitoring Program	Water quality	1995- Current
356	Week's Bay Naonal Es tuarine Research Reserve System-Wide Monitoring Program	Water quality	1995- Current
357	Grand Bay Naonal Es tuarine Research Reserve System-Wide Monitoring Program	Water quality	2004- Current
358	Mission Aransas Naonal Es tuarine Research Reserve System-Wide Monitoring Program	Water quality	2005- Current
359	Everglades Naonal P ark Hydrologic Monitoring Program	Weather, water quality	1988- Current
361	Naonal Marine Fisheries Ser vice Aerial Surveys	Aerial surveys	1989- 1998
381	Louisiana Barrier Island Comprehensive Monitoring	Barrier island ecology	2006- Current
384	Naonal Coas tal Mapping Program	Coastal mapping	2003- Current
386	Coastal Change Analysis Program	Coastal change analysis	1985- Current
387	Louisiana Marine Mammal & Sea Turtle Rescue Program	Marine mammal and sea turtle strandings	2000- Current
388	Alabama Marine Mammal Stranding Network Response Program	Marine mammal strandings	2008- Current
389	Emerald Coast Wildlife Refuge Stranding Response Program	Marine mammal strandings	1994- Current
390	Southwest Florida Stranding Response Program	Marine mammal strandings	1991- Current
391	Florida Aquarium Stranding Response Program	Marine mammal strandings	Undetermined- Current
392	South Florida Marine Mammal Stranding Response Program	Marine mammal strandings	Undetermined- Current
393	Texas Marine Mammal Stranding Network	Marine mammal strandings	1980- Current
394	Clearwater Marine Aquarium Stranding Response Program	Marine mammal strandings	Undetermined- Current
395	Gulf World Marine Park/Instut e Stranding Response Program	Marine mammal strandings	1970- Current
396	Louisiana Stranding Response Program	Marine mammal strandings	Undetermined- Current
397	Mote Marine Laboratory Stranding Response Program	Marine mammal strandings	Undetermined- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
398	Marine Mammal Pathobiology Laboratory Stranding Response Program	Marine mammal strandings	1974- Current
401	Moderate-Resolution Imaging Spectrometer (MODIS)	Water quality, phytoplankton bloom potential, atmosphere, surface water variables, land properties	2000- Current
402	Landsat-1	Landcover	1972- 1978
403	Landsat-2	Landcover	1975- 1983
404	Landsat-3	Landcover	1978- 1983
405	Landsat-4	Landcover	1982- 1993
406	Landsat-5	Landcover	1984- 2013
412	Relative Abundance, Temporal Patterns and Growth of Sea Turtles at Mansfield Channel, Padre Island, Texas	Sea turtle in-water population biology, satellite tracking	1989- 1997
418	Advanced Microwave Scanning Radiometer for EOS (AMSR-E)	Sea surface conditions, wind	2002- 2011
423	Advanced Earth Observing Satellite 2 (ADEOS II)	Wind	2002- Undetermined
430	Scripps Passive Acoustic Monitoring for Marine Mammals	Marine mammal acoustics	2010- Current
431	Galveston Bay Water Quality Monitoring	Water quality	1991- Current
432	Sabine River Water Quality Monitoring	Water quality	1998- Current
433	Guadalupe-Blanco River Water Quality Monitoring	Water quality	1987- Current
434	Mississippi Statewide Assessment (Total Maximum Daily Load) Program	Water quality, fish tissue toxicity	1992- Current
435	Earth System Research Laboratory	Weather	2014- Undetermined
437	Mississippi Ambient Air Monitoring	Air quality	2001- Undetermined
441	Louisiana Fisheries Independent Monitoring- Inshore and Nearshore Gillnet Sampling	Marine fisheries, water quality	1985- Current
442	Louisiana Fisheries Independent Monitoring- Inshore and Nearshore Seine Sampling	Marine fisheries	1985- Current
445	Louisiana Shellfish Monitoring Program- Fish Trawls	Marine fisheries	1996- Current
450	Lower Colorado River Authority (LCRA) Bay Monitoring Program	Water quality	1992- Undetermined
451	Texas Water Development Board (TWDB) Datasonde Program	Water quality	1986- Undetermined
453	Physical Oceanographic Real-Time System (PORTS)	Currents, density, water quality	1999- Undetermined
454	Texas Clean Rivers Program	Water quality	1968- Undetermined
455	Oyster Sentinel - Oyster Health Program	Oyster disease	1970- Current
456	Oyster Sentinel - Water Quality Program	Water quality, oyster health	1970- Undetermined
458	Lake Pontchartrain Water Quality Program	Water quality	2001- Undetermined
459	Alabama Water Watch (AWW)	Water quality	1993- Undetermined
460	Flower Garden Banks National Marine Sanctuary (FGBNMS) CTD Program	Water quality	1995- Current
461	Alabama Coastal Nonpoint Pollution Control Program	Water quality	1998- Undetermined
462	Texas Water Development Board (TWDB) Hydrology Program	Hydrology	1941- Undetermined
463	Texas Surface Water Quality Monitoring Program	Water quality, sediment quality	1967- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
464	Gulf Hypoxia Monitoring	Water quality, hypoxia, sediments	2002- 2010
465	Mississippi Coastal Assessment Program	Water quality, fish tissue toxicity	2007- Current
466	Florida's Strategic Monitoring Program for Total Maximum Daily Loads	Water quality	1998- Undetermined
467	Yellow River Marsh Aquatic Preserve Water Quality Monitoring	Water quality	2015- Undetermined
468	St. Joseph Bay Aquatic Preserve Water Quality Monitoring	Water quality	2005- 2011
469	Alligator Harbor Aquatic Preserve Water Quality Monitoring	Water quality	2001- 2011
470	Apalachicola Bay Aquatic Preserve Water Quality Monitoring	Water quality	2007- 2008
471	Big Bend Seagrasses Aquatic Preserve Water Quality Monitoring	Water quality	2004- Undetermined
472	St. Marks Marsh Aquatic Preserve Water Quality Monitoring	Water quality	2004- Undetermined
473	Terra Ceia Aquatic Preserve Water Quality Monitoring	Water quality	2004- 2011
474	Estero Bay Aquatic Preserve Water Quality Monitoring	Water quality	2005- Undetermined
475	Cape Romano Ten Thousand Islands Aquatic Preserve Water Quality Monitoring	Water quality	Undetermined- Undetermined
476	Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network	Water quality, weather	1998- Undetermined
477	Suwannee River Water Management District Water Resource Monitoring Program	Water quality	1994- Undetermined
478	Texas A&M University at Galveston Phytoplankton Dynamics Laboratory	Water quality, plankton	2008- Undetermined
479	Southwest Florida Water Management District- Project Coast	Water quality	1997- 2013
480	Southwest Florida Water Management District- Stream Water Quality Network- Coastal Rivers and Kings Bay Monitoring Programs	Water quality	2003- Undetermined
481	Texas A&M University Vibrio Monitoring in Oysters	Oyster disease	1989- Current
482	Texas Seafood and Aquaculture Group Water Monitoring Program	Water quality	1950- Undetermined
483	Texas Seafood and Aquaculture Group Tissue Monitoring Program	Marine fisheries tissue toxicity	1970- Current
502	National Centers for Environmental Prediction's Marine Surface Data	Sea surface variables	1991- 2011
504	University of West Florida Gulf of Mexico CTD Profile Program	Water quality	2004- 2012
505	Pensacola Bay Water Quality Monitoring Program	Water quality	2011- Undetermined
509	Southeastern Environmental Research Program	Water quality	1995- Undetermined
511	St. Andrew Baywatch Program	Water quality	1990- Undetermined
512	Matlacha Pass Aquatic Preserve Water Quality Monitoring Program	Water quality	2005- Undetermined
513	Coastal Charlotte Harbor Monitoring Network	Water quality	2002- Undetermined
514	Florida LAKEWATCH Program	Water quality	2000- Undetermined
519	Florida Fishery Independent Monitoring- Baiish Surveys	Marine fisheries, water quality	1993- Current
520	Florida Southeast Area Monitoring and Assessment Program (SEAMAP)- Groundfish Surveys	Marine fisheries, water quality	2008- 2018
521	Florida Southeast Area Monitoring and Assessment Program (SEAMAP)- Ichthyoplankton Surveys	Marine fisheries, water quality	2014- 2018

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
522	Florida Southeast Area Monitoring and Assessment Program (SEAMAP)- Reef Fish Surveys	Marine fisheries, water quality, habitat	2008- Current
524	Alabama Fisheries Assessment and Monitoring Program - Trawl Sampling	Marine fisheries	1977- Current
525	Alabama Fisheries Assessment and Monitoring Program - Gillnet sampling	Marine fisheries, water quality	2001- Current
526	Alabama Fisheries Assessment and Monitoring Program - Shoreline sampling	Marine fisheries, habitat	1977- Current
528	Mississippi Interjurisdictional Fisheries Coastal Finfish Gillnet Survey	Marine fisheries	2006- Current
529	Mississippi Interjurisdictional Fisheries Inshore Finfish Trawl Survey	Marine fisheries	2006- Current
532	Alabama Southeast Area Monitoring and Assessment Program (SEAMAP)- Ichthyoplankton Sampling	Marine fisheries, water quality, wind, waves, precipitation	1986- Undetermined
533	Mississippi Southeast Area Monitoring and Assessment Program (SEAMAP)- Ichthyoplankton Sampling	Marine fisheries, water quality, wind, waves, precipitation	1983- Current
534	Alabama Fishery Independent Oyster Monitoring	Oyster reef ecology	1971- Current
537	Choctawhatchee Basin Alliance Living Shorelines Oyster Reef Monitoring	Oyster reef ecology, water quality	2012- Current
538	Mississippi Interjurisdictional Oyster Dredge Monitoring Survey	Oyster reef ecology	2009- Current
539	Mississippi Interjurisdictional Oyster Visual Monitoring Survey Square Meter Sampling	Oyster reef ecology	2006- Current
540	Shellfish Harvesting Area Monitoring	Bivalve disease, water quality, rainfall, stage, phytoplankton bloom potential	1970- Current
541	Alabama Shellfish Monitoring Program	Oyster disease, phytoplankton bloom potential, water quality, depth, wind	1960- Current
542	Apalachicola National Estuarine Research Reserve Oyster Growth Project	Oyster reef population dynamics	2004- 2009
544	Dauphin Island Sea Laboratory Oyster Habitat Assessment	Oyster reef ecology, water quality	2003- Current
545	Louisiana Oyster Dredge Sampling	Oyster reef population dynamics	1992- Current
546	Louisiana Annual Oyster Stock Assessment and Sampling	Oyster reef population dynamics	1980- Current
547	Louisiana Department of Wildlife and Fisheries Neusee River Coastal Oyster Sampling	Oyster reef ecology	1988- Current
548	Louisiana Oyster Harvest Monitoring	Oyster harvest	1999- Current
549	Texas State Shellfish Harvest Area Monitoring	Oyster health, water quality, rainfall, stage, wind	1950- Current
550	Mississippi State Shellfish Harvest Area Monitoring	Oyster health, water quality, stage, wind	1940- Current
553	Pinellas County Ambient and Seagrass Monitoring Programs	Seagrass ecology, water quality	1998- Current
554	Choctawhatchee Basin Alliance Seagrass Monitoring	Seagrass ecology, water quality	2009- Current
555	Florida Seagrass Integrated Monitoring and Mapping Project	Seagrass mapping	Early 2000s- Current
556	St. Andrew Bay Aquaculture Reserve Seagrass Monitoring	Seagrass ecology	2000- Current
557	St. Joseph Bay Aquaculture Reserve Seagrass Monitoring	Seagrass ecology, water quality	2002- 2010

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
558	Franklin County Coastal Waters Seagrass Monitoring	Seagrass ecology, water quality	2006- Current
559	Northern Big Bend Seagrass Monitoring	Seagrass ecology, bay scallops and urchin density, water quality	2002- Current
560	Northern Big Bend Seagrasses Aquaculture Reserve Seagrass Monitoring	Seagrass ecology, water quality	2000- Current
561	Southern Big Bend Region Seagrass Monitoring	Seagrass ecology, water quality	2004- Current
563	Springs Coast Seagrass Monitoring	Seagrass ecology	1997- Current
564	Western Pinellas County Seagrass Monitoring	Seagrass ecology	2006- Current
565	Tampa Bay Seagrass Monitoring	Seagrass ecology	1986- Current
566	Tampa Bay Seagrass Mapping	Seagrass mapping	1988- Current
567	Sarasota Bay Seagrass Monitoring	Seagrass ecology	1999- Current
568	Sarasota County Seagrass Monitoring of Sarasota Bay	Seagrass ecology	2004- Current
569	Seagrass Integrated Mapping and Monitoring Program- Sarasota Bay Aerial Mapping	Seagrass mapping	1988- Current
570	Charlotte Harbor Seagrass Monitoring	Seagrass ecology	1999- Current
571	Estero Bay Seagrass Monitoring	Seagrass ecology, water quality	2002- Current
572	Rookery Bay National Estuarine Research Reserve Seagrass Monitoring	Seagrass ecology, water quality	1998- 2005
573	Ten Thousand Islands Seagrass Monitoring	Seagrass ecology, aerial mapping	1998- 2009
581	Mississippi-Alabama Pinnacle Trend Ecosystem Monitoring	Deep-sea biological communities, carbonate mound biogeochemistry	1996- 2011
583	Pennsylvania State Deep-Sea Coral Studies	Deep-sea octocoral growth	2010- 2017
584	Scientific and Environmental Remotely Operated Vehicle (ROV) Partnership using Existing Industrial Technology Project	Species observations near oil and gas operations	2006- Current
586	Critical Life History Parameters of the Texas Diamondback Terrapin, <i>Malaclemys terrapin littoralis</i>	Diamondback terrapin population biology	2007- Current
587	Perdido Key Beach Mouse Recovery Plan Monitoring	Beach mouse population dynamics	1985- Undetermined
588	Louisiana State University insect sampling in Barataria Bay	Insect abundance	2010- Undetermined
589	Alabama Beach Mouse monitoring in Bon Secour National Wildlife Refuge	Beach mouse population dynamics	1988- Current
590	Alabama Beach Mouse Detection/Nondetection Surveys in Baldwin County	Beach mouse population dynamics	1991- 2008
592	Louisiana Diamondback Terrapin Monitoring	Diamondback terrapin population dynamics	2011- Current
594	Florida Choctawhatchee Beach Mouse Recovery Monitoring	Beach mouse population dynamics	1987- 2007
595	Texas Alligator Management Program	Alligator counts	1976- Current
596	Florida Alligator Management Program	Alligator harvest management	1997- Current
597	Mississippi Alligator Management Program	Alligator management	1972- Current
598	Louisiana Wild Alligator Management Program	Alligator population dynamics	1970- Current
599	Nueces Estuary Diamondback Terrapin Monitoring	Diamondback terrapin population biology	2010- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
600	Alabama Beach Mouse Monitoring- Incidental Take Permit Habitat Conservaon Plan	Beach mouse populaon dynamics	Undetermined- Undetermined
602	St. Andrew Beach Mouse Monitoring	Beach mouse populaon dynamics	2000- Current
603	Texas Department of State Health Services Water and Sediment Monitoring	Water quality, sediment quality	2004- 2007
608	Florida Stone Crab Monitoring Program	Stone crab biology, water quality	1985- Current
610	Texas Oyster Resource Monitoring Program	Bivalve ecology	1985- Current
618	Coastwide Reference Monitoring System	Sediments, marsh and forest vegetaon, w etland characterizaon	2006- Current
619	Coastal Mapping Program	Shoreline change	2005- Current
620	Inventory and Monitoring Network Status and Trends	Sediment surface elevaon	2011- Current
621	Texas Shoreline Change Project	Shoreline change	2000- Current
622	Coastal Data Acquisition P rogram- Regional Coastal Monitoring	Shoreline change	2000- 2008
623	Gulf-Fronng Shor eline Monitoring Program	Shoreline change	2002- Current
624	Mississippi Coastal Geology Program	Shoreline change	1989- Current
625	Rookery Bay Naonal Es tuarine Research Reserve Shoreline Monitoring	Shoreline change	2001- Current
630	Tampa Bay Surface Elevaon Monit oring	Sediment surface elevaon	2010- Current
631	Pinellas County Beach Profiling	Shoreline change	2006- Current
632	Grand Bay Naonal Es tuarine Research Reserve Surface Elevaon Monit oring	Sediment surface elevaon	2011- Current
633	Barrier Island Evoluon P roject	Barrier island dynamics	1998- Current
636	Short-Term Shoreline Change and Beach/Dune Morphodynamics Along the Gulf Coast	Shoreline change	2010- 2014
640	Change and Soil Accreon in the Mangr ove Salinity Transion Z one	Sediment surface elevaon, v ertical accreon	1998- Current
642	Sediment Elevaon and Accumula on in R esponse to Hydrology, Vegetaon, and Disturbance in Southwest Florida	Sediment surface elevaon, v ertical accreon	1998- Current
643	University of Louisiana Coastal Plant Ecology Program	Sea surface condions	2006- Current
658	Louisiana Molluscan Shellfish Program	Bivalve health, water quality	1989- Current
708	Aransas Naonal Wildlif e Refuge Marsh Bird Survey	Marsh bird counts	2005- 2009
709	Aransas Naonal Wildlif e Refuge Winter Plover Survey	Shorebird counts	2003- 2011
711	Texas Naonal Wildlif e Refuge Secrev e Marsh Bird Survey	Marsh bird counts	2005- Current
715	Laguna Atascosa Naonal Wildlif e Refuge Plover Survey	Shorebird counts	1990- 2016
720	North American Breeding Bird Survey in Texas	Bird counts	1966- Current
722	San Bernard Naonal Wildlif e Refuge Migratory Shorebird Surveys	Shorebird counts	1998- Current
725	Chenier Plain, McFaddin, and Texas Point King and Clapper Rail surveys	Marsh bird counts	Undetermined- Undetermined
726	Texas Colonial Waterbird Survey (TCWS)	Waterbird counts	1973- Current
733	Mustang Island Bird Surveys	Bird counts	1985- Current
748	Breton Naonal Wildlif e Refuge Piping Plover Survey	Shorebird counts	1995- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
749	Breton Naonal Wildlif e Refuge Brown Pelican Banding	Waterbird banding	2000- Current
750	Colonial Seabird Producon Assessmen t	Seabird reproducv e success	1990- Current
755	Slit Sandpiper s Habitat Management Monitoring	Shorebird habitat assessment	2008- Undetermined
764	Lacassine Naonal Wildlif e Refuge Shorebird Surveys	Shorebird counts	1953- Current
765	Lacassine Naonal Wildlif e Refuge Wading Bird Nesng Sur vey	Wading bird nesng c ounts	1997- Current
768	Louisiana Brown Pelican Nesng and P roducvity Sur vey	Waterbird counts and producivity	1971- 2008
769	Louisiana Secrev e Marsh Bird Callback Surveys	Marsh bird counts	2010- 2015
771	Louisiana Coastal Bird Conservaon P rogram	Shorebird breeding pair counts	2005- 2015
772	Louisiana Colonial Waterbird Surveys	Waterbird nest counts	1983- 2014
775	Opportunisc P elagic Bird Surveys	Pelagic bird counts	1986- 2007
776	North American Breeding Bird Survey in Louisiana	Breeding bird counts	1967- Current
784	Mississippi Colonial Shrubnesng Sur vey	Breeding bird counts	1977- 1983
785	Mississippi Marsh Bird Research and Monitoring Program	Marsh bird counts	2005- Current
786	Mississippi Marsh Bird Research and Monitoring Program	Marsh bird counts	2005- 2012
787	Monitoring Avian Producvity and Sur vivorship (MAPS) Program	Bird counts	2000- Current
790	Audubon Least Tern and Black Skimmer Surveys	Shorebird nest counts	1985- Undetermined
800	Mississippi Sandhill Crane Naonal Wildlif e Refuge Secrev e Marsh Bird Survey	Marsh bird counts	2004- Current
806	Mississippi Nonbreeding Beach Shorebird Survey	Shorebird survey	2006- 2012
807	North American Breeding Bird Survey in Mississippi	Bird counts	1976- Current
812	Monitoring Avian Producvity and Sur vivorship (MAPS) at Bon Secour	Bird producivity and sur vivorship	2014- 2018
814	Bon Secour Naonal Wildlif e Refuge Shorebird Survey	Shorebird count	2008- Current
816	Colonial Water Bird Surveys of Florida	Water bird counts	Undetermined- Undetermined
818	Florida Park Service District 1 Shorebird Nesng Sur vey	Shorebird nest count	Undetermined- Undetermined
819	Florida Panhandle Nonbreeding Bird Surveys	Coastal bird counts	2010- Current
820	Florida Panhandle Shorebird Breeding Bird Surveys	Shorebird counts	2008- Current
821	Gulf Islands Naonal Seashor e Shorebird Nesng Sur vey	Shorebird nest counts	1995- Undetermined
822	Gulf Islands Naonal Seashor e Nonbreeding Shorebird Surveys	Shorebird counts	1995- Undetermined
824	Florida Nesng Secr ev e Marsh Bird Surveys	Marsh bird nest counts	Undetermined- Undetermined
825	Florida Statewide Colonial Bird Beach/Ground Nesng Sur vey	Colonial bird nest counts	2005- Undetermined
830	Tyndall Beach Air Force Base Nesng Bir d Surveys	Bird nest counts	Undetermined- Undetermined
831	Naonal P ark Service Comprehensive Bird Surveys	Bird counts	Undetermined- Undetermined
835	Cedar Keys Naonal Wildlif e Refuge American Oystercatcher Monitoring	Shorebird counts	2009- Current
837	Florida Naonal Wildlif e Refuge Shorebird Nesng Sur vey	Shorebird nest counts	2005- Current
838	Cedar Keys Naonal Wildlif e Refuge Non-Nesng Shor ebird and Seabird Surveys	Shorebird and seabird counts	2009- Current
839	Cedar Keys Naonal Wildlif e Refuge Wading Bird Flight-Line Counts	Wading bird counts	1997- Current

Appendix D: Inventory of Long-term Monitoring Projects (continued)

ID	Monitoring Program or Effort Name	Summary	Start-End Years
840	Chassahowitzka Naonal Wildlif e Refuge Colonial Waterbird Survey	Waterbird counts	1958- Current
841	Chassahowitzka Naonal Wildlif e Refuge Waterfowl Survey	Waterfowl counts	1958- Current
843	Egmont Key Colonial Waterbird Survey	Colonial waterbird counts	1955- Current
847	J.N. 'Ding' Darling Naonal Wildlif e Refuge Colonial Nesng Bir d Survey	Colonial nest counts	1960- Current
849	J.N. 'Ding' Darling Naonal Wildlif e Refuge Shorebird Survey	Shorebird count	1974- Current
852	Key West Naonal Wildlif e Refuge Piping Plover Wintering Survey	Shorebird counts	1990- Current
855	Lower Suwannee Naonal Wildlif e Refuge American Oystercatcher Monitoring	Shorebird counts	2009- Current
858	Lower Suwannee Naonal Wildlif e Refuge Florida Non-Nesng Shor ebird and Seabird Surveys	Shorebird and seabird counts	2009- Current
860	Pine Island Naonal Wildlif e Refuge Colonial Nesng Bir d Survey	Colonial bird nest count	2000- Current
861	Pinellas Naonal Wildlif e Refuge Colonial Waterbird Survey	Colonial waterbird count	1955- Current
864	St. Marks Naonal Wildlif e Refuge Colonial Wading Bird Breeding Survey	Colonial wading bird nest counts	1965- Current
865	St. Marks Naonal Wildlif e Refuge Non-Nesng Shor ebird and Seabird Surveys	Shorebird and seabird counts	2009- Current
867	St. Marks Naonal Wildlif e Refuge Least Tern Nesng Pla orm Survey	Shorebird nest counts	1986- Current
873	St. Marks Naonal Wildlif e Refuge Shorebird Monitoring Survey	Shorebird counts	1980- Current
878	St. Vincent Naonal Wildlif e Refuge American Oystercatcher Monitoring	Shorebird counts	2009- Current
880	St. Vincent Naonal Wildlif e Refuge Non-Nesng Shor ebird and Seabird Surveys	Shorebird and seabird counts	2009- Current
882	Ten Thousand Islands Naonal Wildlif e Refuge Internaonal Shor ebird Survey	Shorebird count	1999- Current
883	Apalachicola Naonal Es tuarine Research Reserve Coastal Shorebird Monitoring	Shorebird counts	1985- Current
884	Everglades Wading Bird Monitoring	Wading bird counts, nesng pair counts, nest success	1995- Current
885	North American Breeding Bird Survey	Bird counts	1967- Current
887	Florida Joint Coastal Permit Monitoring	Coastal monitoring; varies by permit	2008- Current
889	Internaonal Piping Plo ver Census	Shorebird counts	1991- Current
890	Christmas Bird Count	Bird counts	1900- Current
891	TOPEX/Poseidon	Sea surface variables	1992- 2006
894	Southeast Fishery Science Center Cooperav e Tagging Center	Marine fish tags	1954- Current
897	Pelagic Longline Observer Program	Marine Fisheries	1992- Current
898	Florida Annual Canvas Data Survey	Marine Fisheries	1960- Current
899	USGS Coral Reef Ecosystem Studies (CREST) Project	Coral calcificaon r ates	2009- Current



About Ocean Conservancy

Ocean Conservancy educates and empowers citizens to take action on behalf of the ocean. From the Arctic to the Gulf of Mexico to the halls of Congress, Ocean Conservancy brings people together to find solutions for our water planet. Informed by science, our work guides policy and engages people in protecting the ocean and its wildlife for future generations. With staff and offices in St. Petersburg, Florida; Mobile, Alabama; Baton Rouge and New Orleans, Louisiana; and Austin, Texas, Ocean Conservancy has been deeply engaged in Gulf of Mexico fisheries work for more than two decades and intensively on restoration of the Gulf ecosystem since the BP *Deepwater Horizon* oil disaster began.



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