White Paper on Gulf of Mexico Water-Quality Monitoring:

Providing Water-Quality Information to Support Informed Resource Management and Public Knowledge

December 2013

Gulf of Mexico Alliance
Water Quality Team - Monitoring Workgroup

GOMA Monitoring Workgroup, White Paper Writing Team*

Alice Dossett	Mississippi Department of Environmental Quality
Charles Kovach	Gulf of Mexico Alliance
Raymond Leary	Florida Department of Environmental Protection
Fred Leslie	Alabama Department of Environmental Management
Kathryn (Kate) Muldoon	Florida Department of Environmental Protection
Troy Pierce	U.S. EPA, Gulf of Mexico Program Office
Andrew Shepard	Florida Institute of Oceanography/ Gulf of Mexico University Research Collaborative
Lynn Sisk	Alabama Department of Environmental Management
James (Sam) Stribling	Tetra Tech, Inc.
Steve Wolfe	Florida Institute of Oceanography/Gulf of Mexico Alliance

**Note, document reviewed by Workgroup members and comments incorporated before release.*

Cite as: GOMA Water Quality Team 2013, White Paper on Gulf of Mexico Water-Quality Monitoring. Tallahassee, FL.

Contents

(hot linked, click on Contents page number to go to that location in document)

GLOSSARY OF ACRONYMS

ACWI –Advisory Committee on Water Information,
ADCNR - Alabama Department of Conservation and Natural Resources
ADEM - Alabama Department of Environmental Management
AIRMoN- Atmospheric Integrated Research Monitoring Network
BLM - Bureau of Land Management
BOEM - Bureau of Ocean Energy Management
CAA - Clean Air Act
CRMSW- Coastal Research and Monitoring Strategy Workgroup
CWA - Clean Water Act
CZMA - Coastal Zone Management Act
DMAC – Data Management Advisory Committee (GOMA)
DOC – Department of Commerce
DOI – Department of Interior
EMAP – Environmental Monitoring and Assessment Program
EPA - U.S. Environmental Protection Agency
FDEP – Florida Department of Environmental Protection
FIO – Florida Institute of Oceanography
FMP – Foundational Monitoring Program
FWPCA - Federal Water Pollution Control Act
FWS - U.S. Fish and Wildlife Service
GBI – Gulf Benthic Index
GCERC - Gulf Coast Ecosystem Restoration Council
GCERSOMTP - Gulf Coast Ecosystem Restoration Science, Observation, Monitoring and Technology Program (part of RESTORE Act)
GCERTF - Gulf Coast Ecosystem Restoration Task Force
GCOOS - Gulf of Mexico Coastal Ocean Observing System
GCOOS-RA - Gulf of Mexico Coastal Ocean Observing System, Regional Association
GCRL - Gulf Coast Research Laboratory
GEM - Gulf of Alaska Ecosystem Monitoring and Research Program
GMN - Gulf Monitoring Network
GoM – Gulf of Mexico
GOMA - Gulf of Mexico Alliance
GOMRI – Gulf of Mexico Research Initiative
GOMURC - Gulf of Mexico University Research Collaborative
GRIIDC – Gulf Research Initiative Information and Data Cooperative
HABs – Harmful Algal Blooms
IBI – Index of Biological Integrity
ITFM - Intergovernmental Task Force on Monitoring Water Quality

GLOSSARY OF ACRONYMS (continued)

LUMCON - Louisiana Universities Marine Consortium
MDEQ - Mississippi Department of Environmental Quality
MMI – Multimetric Index
MMS - Minerals Management Service
NADP – National Atmospheric Deposition Program
NARS - National Aquatic Resource Surveys
NASA - National Aeronautics and Space Administration
NASQAN – National Stream Quality Assessment Network
NAWQA – National Water Quality Assessment Program
NCA – National Coastal Assessment
NCCR - National Coastal Condition Report
NDBC – National Database Center
NEPA - National Environmental Policy Act
NERRS - National Estuarine Research Reserve System
NGO - non-governmental organization
NMFS – National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NOS – National Ocean Service
NPDES - National Point Source Discharge Elimination System
NRC - National Research Council
NRCS – Natural Resources Conservation Service
NS&T - National Status and Trends
NSF - National Science Foundation
NSIP - National Streamflow Information Program
NWI - National Wetlands Inventory, USFWS
NWQMC – National Water Quality Monitoring Council
OCS - Outer Continental Shelf
OCSLA - Outer Continental Shelf Lands Act
ORD - Office of Research and Development, USEPA
OSC – Outer Continental Shelf
OWOW - Office of Wetlands, Oceans, and Watersheds, USEPA
RESTORE Act - Resources and Ecosystems Sustainability, Tourism Opportunities and Revived Economy of the Gulf Coast Act
RTF - Gulf Coast Restoration Trust Fund
SFTE - sources, fate, transport, and effects
SLA - Submerged Lands Act
SOP – standard operating procedure
STORET - STOrage and RETrieval System, an EPA WQ database
TMDL - Total Maximum Daily Load
UNOLS - University-National Oceanographic Laboratory System

GLOSSARY OF ACRONYMS (concluded)

USACE - U.S. Army Corps of Engineers
USDA - U.S. Department of Agriculture, Natural Resources Conservation Service/
USDOI – U.S. Department of Interior
USFWS - U.S. Fish and Wildlife Service
USGS - U.S. Geological Survey
USM - University of Southern Mississippi
USN - U.S. Navy
WHOI - Woods Hole Oceanographic Institute
WQ - Water Quality

White Paper on Gulf of Mexico Water-Quality Monitoring

EXECUTIVE SUMMARY

The Gulf of Mexico Alliance (GOMA), a long-term coordinating body comprised of the five Gulf states and its federal, academic, non-governmental organization (NGO), and private partners, is recommending the implementation and funding of a Gulf-wide water quality monitoring network to specifically address questions more fundamental than those answered by existing monitoring programs. Monitoring in the Gulf of Mexico began during the Age of European Exploration to measure currents and bathymetry and later intensified due to increased commerce and military needs. Monitoring efforts in and around the Gulf were, and are, conducted for socioeconomic, geologic, physical, chemical, biological, and ecological purposes. Although numerous entities currently monitor parts of the Gulf, sometimes in concert, GOMA has identified three outstanding issues that require the implementation and funding of a Gulf Monitoring Network (GMN): 1) combined efforts fail to constitute a comprehensive, coordinated or cohesive water quality-monitoring network due to large gaps in the areas monitored and variability in data quality objectives, field or laboratory standard operating procedures (SOPs), analyte selection, monitoring frequency, or other comparability issues; 2) monitoring by state, federal, and local programs is subject to intermittent funding reductions or elimination resulting in spatial and temporal data gaps; and 3) the existing monitoring is insufficient to address priority issues that have been identified in the Gulf and that can only be addressed by monitoring, including assessing the success of restoration projects.

GOMA's monitoring priorities focus on improving the comparability of data collected around the Gulf, developing a framework for an integrated Gulf monitoring network, and improving how monitoring data and the information developed from monitoring data is delivered to coastal managers and to the public. In its 2006 and 2009 Action Plans, GOMA recognized the priority need to develop a Gulf-wide integrated monitoring system. To address the three outstanding issues identified above, GOMA, its partners, and coordinating Mexican agencies organized a series of workshops and conference calls to identify its priority monitoring questions and to design a monitoring network for the Gulf. The resulting monitoring strategy, described in detail in GOMA 2013, includes meshed monitoring designs for each scale of the Gulf: the estuaries, the coastal areas (coastline out to the 10 m contour), the shelf (10 m to the edge of the Continental Shelf), and the deep Gulf. The scaled monitoring designs complement and feed into each other to provide a basic overall understanding of Gulf drivers, such as

circulation patterns and vertical and horizontal processes. The Gulf Monitoring Network (GMN) design is the minimum monitoring system that is capable of addressing the priority monitoring questions identified by GOMA (Appendix A). This minimum Gulf-wide monitoring system is designed to incorporate or dovetail with existing plans (e.g. GCOOS glider and mooring/buoy planning and the Gulf Hypoxia Implementation Plan) to incorporate all parameters needed for a representative GMN.

The goals of the Gulf Monitoring Network are to: integrate monitoring and related research and technology development efforts to aid in answering local, regional, and Gulf-wide questions; promote inter-agency data sharing and the expansion of international partnerships; and provide real-time or near real-time observations and provide synthesized information and products. GOMA provides specific recommendations including implementation, oversight, and evaluation for attaining the GMN goals, as well as meeting restoration goals in the Gulf.

GOMA proposes to develop agreements with existing Gulf monitoring programs, which validates the intention to build the GMN from these programs rather than to supplant them. Finally, metrics measuring the usefulness of the GMN will be developed during implementation meetings, and will ultimately be used to gauge the effectiveness of ongoing Gulf restoration efforts.

A. INTRODUCTION

The Gulf of Mexico Alliance (GOMA) includes six Priority Issue Teams that implement the Governors' Action Plan II. Two of these teams, the Water Quality (WQ) Team and the Nutrients and Nutrient Impacts Team, are primarily focused on water quality issues. While the WQ Team addresses regional scale water quality priorities, the Nutrients Team was established to investigate nutrient sources, fate, transport, and effects in the Gulf of Mexico and coastal waters and to facilitate nutrient criteria and reduction efforts. As a consequence, these two teams work closely to coordinate their efforts

The WQ Team consists of state, federal, academic, non-governmental organization (NGO), and private members from the U.S. as well as members from Mexican counterparts. The Team is composed of four workgroups: Monitoring, Mercury in Seafood, Pathogens, and Harmful Algal Blooms (HABs).

The Monitoring Workgroup's Action Plan includes creation of a framework to support Gulf-wide monitoring. As part of this effort, the Workgroup has collaborated with the agencies and entities that make up GOMA as well as the Gulf Coast Ecosystem Restoration Task Force (GCERTF), the Hypoxia Task Force, and the Gulf of Mexico Coastal Ocean Observing System (GCOOS) to create an organizing structure and design for the Gulf Monitoring Network (GMN).

The Clean Water Act of 1972 (CWA) and its amendments established as a national priority the restoration and maintenance of the "chemical, physical, and biological integrity" of the nation's waters (FWPCA 2008), and has been evaluated, refined, and reaffirmed on a number of occasions (NRC 1990, 2001; Karr 1991; Newton 1992; Griffiths et al. 2012). Monitoring is critical for successful implementation of CWA objectives in support of water resource quality (Newton 1992). Objective, technically-defensible, and broadly informative environmental monitoring and assessment is necessary for understanding the status and trends of natural resources, the principal human-controlled factors affecting ecosystem conditions, and those management actions necessary for effective management of ecosystem stressors.

Monitoring within the Gulf of Mexico has a long history; however, it was not always intended for water quality purposes. Monitoring efforts in and around the Gulf were, and are, conducted for socioeconomic, geologic, physical, chemical, biological, and ecological purposes (e.g., Bosch et al. 2013). Agencies and individuals that have conducted the monitoring and data collection are varied, including federal, state and local government agencies, academia, private-sector organizations (both for- and non-profits), and volunteers. Some of the monitoring is required under various state and federal laws, while other efforts support research and exploration. The methods employed are just as varied.

Some of the earliest records of monitoring within the Gulf are from the age of exploration (from the 1500s through colonial times; e.g., Pillsbury 1891, GulfBase 2013). During this time, information on hydrology, specifically bathymetry and currents, was collected for navigational purposes. By the eighteenth and nineteenth centuries, monitoring that focused on commerce and military needs was implemented. Much of this early monitoring was crude and not well organized by today's standards.

By the early 1900s, monitoring in and around the Gulf had become more sophisticated and coordinated. During this period, many of the institutions and organizations that monitor the Gulf were established. This period also saw the rise of monitoring associated with research and academia. Monitoring associated with oil and gas exploration and commercial fisheries management increased at a rapid pace, as did research and development by the military. After 1950, monitoring in the Gulf steadily began to increase due to elevated environmental awareness and subsequent legislation, as well as innovations brought about in field and laboratory technology. For a more complete history of monitoring in and around the Gulf of Mexico, see Appendix B.

Today, monitoring continues in and around the Gulf to better understand its ecology and to manage its resources. However, monitoring by multiple agencies for different purposes has often produced data that are not suitable for broad application. Field sampling, laboratory analyses, and data analyses methods used are often appropriate only for the goals and objectives of individual monitoring programs or entities. However, when methods from all programs are viewed in aggregate, they exhibit substantial diversity. Many times, this practice creates the appearance of gaps in the data, but it can be more accurately described as gaps in the usability of the data, as well as a lack of communication and coordination amongst agencies. This reality results in increased costs and duplication of efforts. Monitoring programs should also be flexible enough to evolve with technological advancements, so the data generated can be accessible, usable, relevant, and integrated.

An important issue in the design of any environmental monitoring activity is that of spatial and temporal scale (NRC 1990, Wu et al. 2006, Loucks et al. 2006). Trowbridge and Jones (2009) used a probability-based monitoring design to assess coastal estuaries in the northeastern US, and described strengths and weaknesses of the approach, essentially stating that strength or distinctness of indicator response varies based on density and placement of sampling locations. For example, it has been demonstrated repeatedly that water quality characteristics of freshwater inflows can affect ecological conditions in coastal and estuarine systems (e. g., Holland et al. 2004, Lehrter 2009). While the numbers of major freshwater inflows to the Gulf of Mexico are fairly well understood (Darnell and Defenbaugh 1990, Slade 1992, ACWI/NWQMC 2006), a large number of minor systems and groundwater sources are not. Large-scale ecological monitoring of estuarine and near-coastal waters has been called for and implemented in

the Gulf of Mexico (Summers et al. 1995, EPA 1999, and subsequent reports of the National Coastal Condition Assessments[1]), but often these efforts do not provide information of sufficient rigor at smaller scales to address state- or estuary-specific questions. This issue was echoed by the National Research Council (NRC 1990), the Intergovernmental Task Force on Monitoring Water Quality (ITFM 1995), and the Coastal Research and Monitoring Strategy Workgroup (CRMSW 2000) when these organizations specifically pointed out the broad lack of consistency in information regarding beach closures, eutrophication, harmful algal blooms, the areal extent and fragmentation of salt marshes, sea grasses, coral reefs, and other important habitats, and the loss of species, changes in species mix, or rates of invasions by exotic species.

GOMA efforts (GOMA 2006, 2009) are intended to help rectify many of these issues. Technical rationale at four spatial scales (Table 1) is based on the need to better understand the interrelationships of ecosystem processes among the geographic strata.

Table 1. Rationale for monitoring regions in the Gulf Monitoring Network (GOMA 2013).

Zone/system	Rationale
Estuaries	To understand the fluxes of nutrients and other important constituents into and out of the estuary, whether from tributaries, runoff, groundwater, or tidal exchange with coastal waters, and to tie them into the adjoining coastal model to relate them to near shore processes.
Coastal (shore to 10m deep)	To understand the relationships between discharges from the coast and the regimes and processes affecting nutrients and the constituents of interest in coastal waters, including effects of estuarine discharges and the flows to and from adjacent coastal areas and offshore (shelf) areas and processes.
Shelf (10m to 200m deep)	To provide information on boundary conditions to coastal and deep Gulf models, to understand status and trends of nutrients and other important constituents as well as fluxes delivered to and from the shelf, and identify and to better understand circulation patterns (and how they affect constituent fate and transport).
Deep Gulf (>200m deep)	To provide information on boundary conditions for shelf models, to understand fluxes of nutrients and other important constituents between deep water and the shelf, and to identify and better understand circulation patterns (and how they affect constituent fate and transport).

The purpose of this document is to provide the background setting and to describe technical/scientific, programmatic, and policy foundations of GOMA's proposed GMN, as well as potential budgetary support. It will also provide specific recommendations for attaining these goals, and specific factors that allow evaluation of success.

1 http://water.epa.gov/type/oceb/assessmonitor/nccr/index.cfm

B. Current Monitoring at the State and Federal Level

The numerous monitoring activities that occur throughout the Gulf of Mexico and its air- and watersheds are directed at a diverse array of physical, chemical, and biological targets, at multiple spatial and temporal scales. Our focus in this section is on the primary sustained national efforts of three federal entities as they relate to coastal water quality monitoring (the National Oceanic and Atmospheric Administration [NOAA], part of the Department of Commerce [DOC]; the Unites States Geological Survey [USGS], part of the Department of the Interior [DOI]; and the Environmental Protection Agency [EPA]). The National Science Foundation largely funds research-related activities as opposed to monitoring. The Department of Agriculture and the U.S. Army Corps of Engineers (USACE) also conduct limited monitoring and, in recent years, the National Aeronautics and Space Administration (NASA) has increased its participation. Four agencies account for almost 95% of all federal dollars directed for coastal ocean issues (Figure 1). EPA spends far more of its research resources in other regions than in the Gulf (Figures 2 and 3).

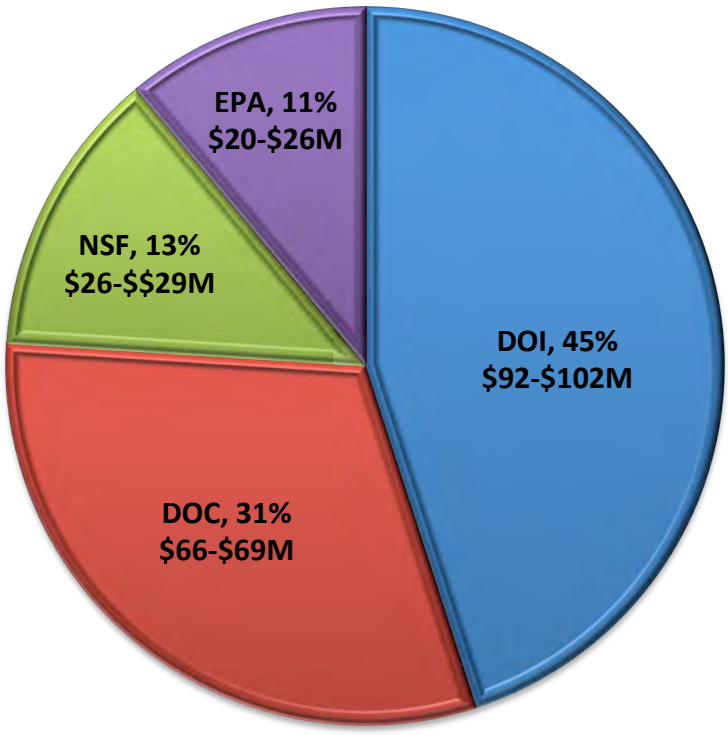


Figure 1. Range of annual expenditures 1991-1993 (data from Committee on Environment and Natural Resources Research 1995).

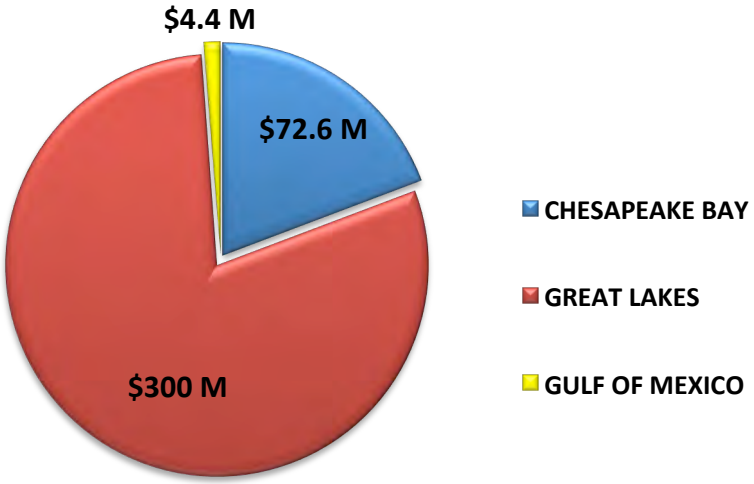


Figure 2. Projected EPA appropriations to Great Waterbody Regions for 2013 (from G. Car, EPA Gulf of Mexico Program Office, New Orleans, LA. 6/4/12).

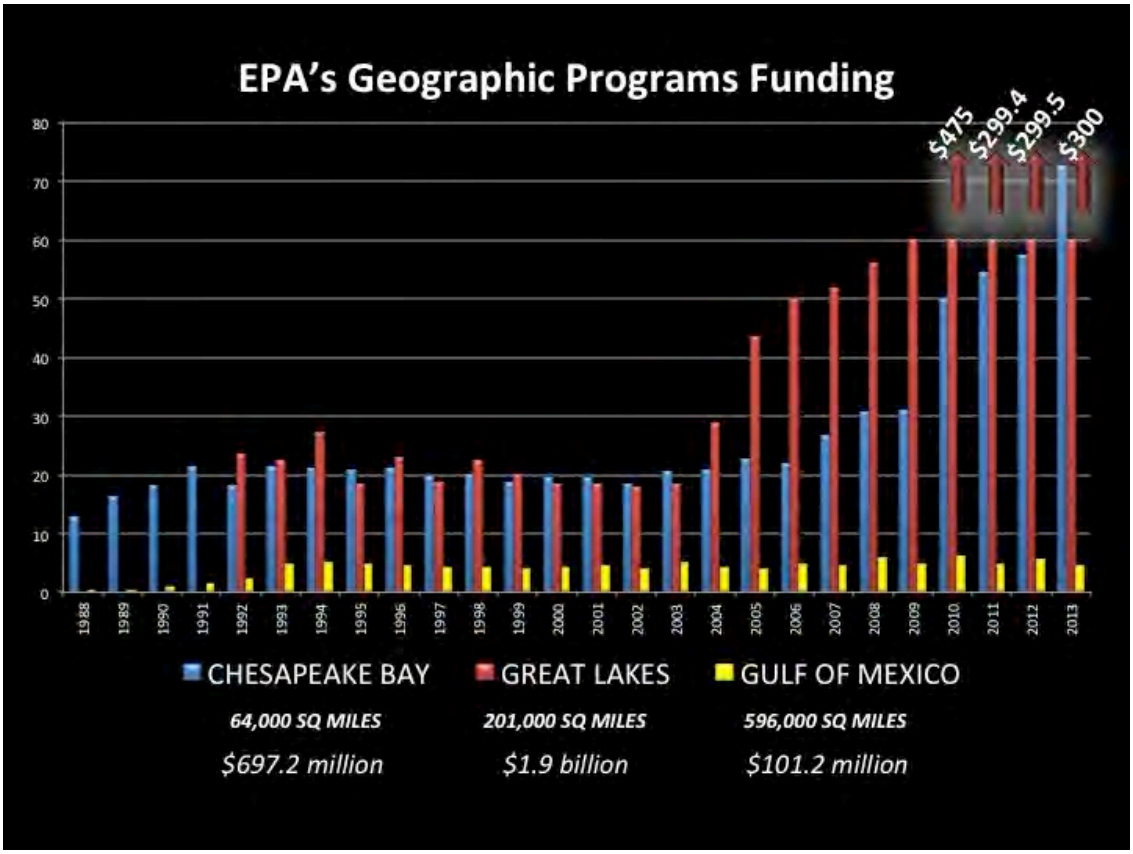


Figure 3. Congressional appropriations through EPA to Great Waterbody Regions, 1998-2013 (projected) (from G. Car, EPA Gulf of Mexico Program Office, New Orleans, LA. 6/4/12).

Basic information about the overall involvement of federal government agencies in ocean sciences can be found in Appendix C1, that of state agencies in Appendix C2, and information on Regional Monitoring and Volunteer Organizations in Appendices C3 and C4, respectively.

Through the Coastal Ecosystems Program of the EPA, the National Coastal Condition Report (NCCR) describes the ecological health of coastal waters at regional and national scales. First issued in 2002 and most recently updated in 2012, the NCCR is a collaborative effort among EPA and other federal agencies, as well as state, regional, and local organizations. It is the only statistically valid measure of water quality on a nationwide scale that communicates water quality and water resource conditions to the public and provides managers with the information to target water quality actions. The fourth NCCR was based primarily on the EPA's National Coastal Assessment (NCA) data collected between 2003 and 2006 (EPA 2012). The NCA, NOAA's National Marine Fisheries Service (NMFS) and National Ocean Service (NOS), and the Fish & Wildlife Service (FWS) National Wetlands Inventory (NWI) contributed most of the information presented in the 2012 report. The 2012 report also presents analysis of temporal changes in coastal condition from 1990 to 2006, with regional chapters focusing on changes mainly from 2000 to 2006. In the Gulf, overall conditions have remained in the poor-to-fair range over the time period, but drivers across the Gulf vary as documented in the 2012 report. Overall Gulf status results for the 2012 assessment year are in Figure 4.

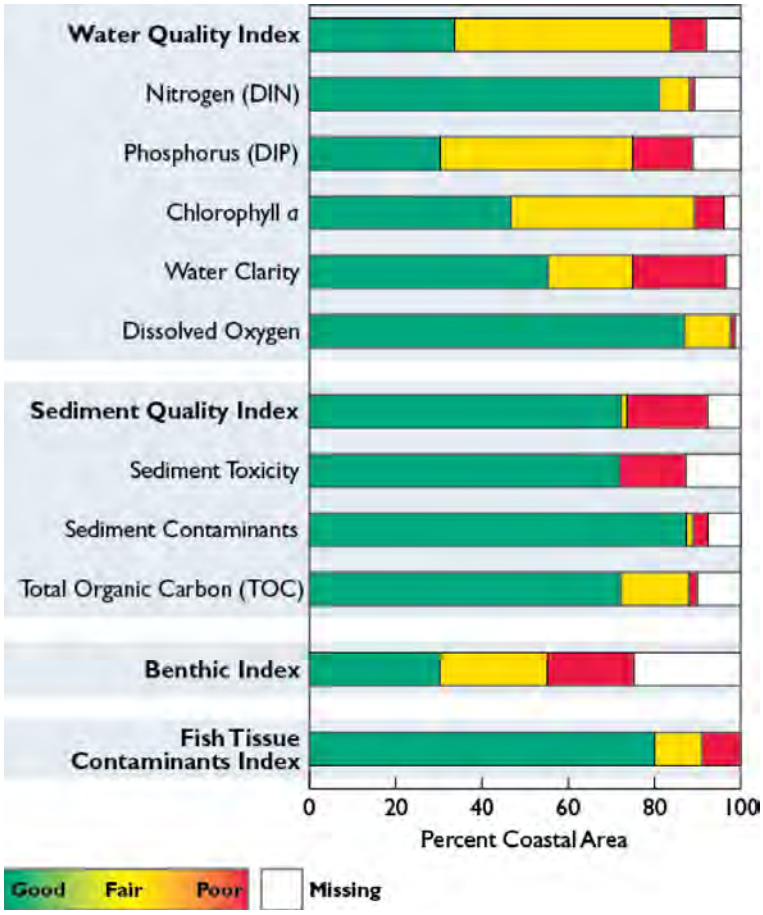


Figure 4. Percentage of coastal area of Gulf Coast region achieving each ranking for all indices and component indicators (EPA 2012).

Other agency evaluations include the monitoring of atmospheric deposition, specifically chemicals in the atmosphere that are deposited onto the Earth's surface in wet and dry forms that contribute to coastal water pollution. The National Atmospheric Deposition Program (NADP), a

cooperative effort of many different groups, measures deposition of a number of pollutants at >200 sites (Committee on Environment and Natural Resources Research 1995). Of the more than 200 sites in the NADP, very few are located in coastal areas, and less than 20 percent of sites in the Atmospheric Integrated Research Monitoring Network (AIRMoN) are located in coastal areas.

Despite the existence of the many programs described above, their combined efforts do not constitute a comprehensive, coordinated or cohesive water quality-monitoring network. One severe limitation of current efforts is the limited monitoring of freshwater loadings (flow and concentration) as input to coastal waters.

National streamflow monitoring has been greatly reduced (U.S. Commission on Ocean Policy 2004), particularly in coastal areas, due to funding cuts at USGS and many partner agencies. The National Streamflow Information Program (NSIP) has eliminated a number of stream gages, including long-term gages that are critical for studying climate change (USGS 2013). To fully realize its potential, the stream-gaging network needs to be modernized and gaps in coverage filled. Funding cuts have also affected water quality monitoring programs, resulting in reductions in the number of sampling sites and sampling frequency. National Water Quality Assessment (NAWQA) coverage has been reduced in recent years, leaving out much of the coastal region and risking its credibility as a representative national program (Alexander et al. 1996).

Budget constraints have also affected the National Stream Quality Assessment Network (NASQAN). At its peak in 1978, this program included 520 fixed-station sampling sites on moderate and large rivers, which provided monthly estimates of flow rates, suspended sediment, nutrients, trace metals, indicator bacteria, and phytoplankton (U.S. Commission on Ocean Policy 2004). About 140 of the sites were located in areas helpful to estimating the input of water and materials to estuaries. Currently, this program focuses only on monitoring the water quality of the nation's largest rivers with a total of 32 stations and excludes most coastal regions.

The NOAA National Status and Trends (NS&T) Program is currently limited by the number of sites sampled per state and the lack of full representation of estuarine habitats in those states. The program samples mollusks for contaminants only every other year, and less frequently for sediments.

Although the biological/ecological sampling and assessments by the EPA Environmental Monitoring and Assessment Program (EMAP) and National Aquatic Resource Surveys' (NARS) activities are consistent, spatially broad and statistically valid, there are shortcomings to the utility of their results. Mostly driven by their own budget constraints, assessment reports typically summarize assessments and other ecological information at broad spatial scales, reducing their usefulness for smaller areas, such as state-level coastal zones, individual inland estuaries, specific freshwater

inflows, or permitted and non-permitted dischargers. It is a reporting issue that has solid potential for resolution through increased density of sampling locations and more spatially-focused analyses.

There is considerable variation in the ways states select monitoring sites, the kinds of tests they perform, the methods they use to determine causes and sources of pollution, and the analytical approaches they choose to evaluate water quality. To be fully effective, the monitoring data collected by states, territories, nongovernmental organizations, and volunteers should be coordinated with a national monitoring network.

The primary state agencies involved in the monitoring of coastal water quality in each state in the Gulf region are identified in the Appendix C2, along with web links for their main websites. These state environmental agencies collaborate with various other state agencies in the execution of their water quality monitoring and reporting requirements. These agencies typically include a state fish/wildlife agency, a public health agency, and a water supply/management entity.

The primary focus of the majority of environmental water quality monitoring programs at the state level is documenting and understanding the quality of its coastal environments, as well as requirements for reporting to the federal government under provisions of the CWA, particularly Section 303. Additional state water quality monitoring related to coastal environments focuses on the protection of public health, the protection of wildlife, and water resource management for supply purposes. The integration of these activities across the Gulf States as they relate to monitoring the health of the coastal environment is incomplete, and identification of redundancy and overlap is an ongoing process required to ensure complementary data across the region.

C. THE GOMA GULF MONITORING NETWORK (GMN)

1. GOMA's Role in Water Quality Research and Monitoring

The WQ Team implements many of the water-quality portions of the GOMA Governors' Action Plans (e.g., GOMA 2009) and is composed of four workgroups. Each focuses on one of the priorities listed below:

WQ-1.1, reducing risk of disease-causing pathogens (Pathogens Workgroup);

WQ-1.2, minimizing occurrence and effects of harmful algal blooms (HABs Workgroup);

WQ-1.3, identifying sources of mercury in Gulf seafood (Mercury Workgroup); and

WQ-1.4, improving monitoring of Gulf water resources (Monitoring Workgroup).

These issues are far-reaching and are best addressed through regional-scale efforts such as GOMA.

The need for development of an integrated monitoring system for the Gulf of Mexico to address regional water resource problems was identified early on as a GOMA priority (GOMA 2006, 2009). GOMA, as an entity for regional ocean governance, is the logical place to address this need. The Monitoring Workgroup is the lead on this effort, with the participation of the rest of the WQ Team and several of the other GOMA teams, particularly the Nutrients Team.

GOMA's monitoring priorities also focus on improving the comparability of data collected around the Gulf, developing a framework for an integrated Gulf monitoring network, and improving how monitoring data and the information developed from monitoring data is delivered to coastal managers and to the public. GOMA WQ Team efforts include conducting "round robin" testing to assess how much sampling, measurements, and analyses differ among Gulf monitoring programs. The WQ Team also conducts an annual Monitoring Forum to improve communications among Gulf monitoring entities and to help standardize methods.

2. Background and History of the Gulf Monitoring Network

To address regional-scale water quality, the GOMA WQ & Nutrients Teams, collectively with the GCERTF and coordinating with Mexican agencies, organized a series of workshops and conference calls to develop and implement a process for identifying consensus water quality monitoring priorities for the Gulf of Mexico. This effort involved a wide array of multinational experts from around the Gulf including U.S. and Mexican federal, state, academic, and NGO entities.

In November 2011, a Monitoring Forum was held in Pensacola, FL that focused on implementing long-term monitoring in the Gulf. At this meeting, GOMA strategically

identified priorities that are most crucial to the five Gulf States and worked with Mexican agencies and entities to coordinate with their priorities.

An important outcome of the meeting was the identification of a set of GOMA priorities for long-term water-quality monitoring. These priorities, which underwent follow-up review by each of the five GOMA states before being finalized, are:

1. Long-term monitoring to support nutrient management and reduction efforts.
2. Long-term monitoring to support GOMA water quality human-health priorities: coastal pathogens, harmful algal blooms, and mercury in fish.

An additional priority identified was to establish central coordination of potential funding for a Gulf monitoring network. This priority arose from the potential difficulties created should GMN funding arrive through multiple pathways.

To address these priorities, the Workgroup has collaborated with the agencies and entities that make up GOMA as well as the GCERTF, the Hypoxia Task Force, and the GCOOS-RA, to create an organizing structure for the Gulf Monitoring Network (GMN). To begin to address these priorities, a multi-scale design process for the Gulf Monitoring Network (GMN) was initiated. Contributors included the above entities as well as monitoring design experts, water quality modelers, and experts in the fields of nutrients, pathogens, HABs, and mercury.

As part of the GMN development process, the most-important questions that are best identified through long-term monitoring were identified for each of the monitoring priorities and for each of the three scales (Gulf-wide, regional, and estuary/coastal segment).

3. Gulf Monitoring Network Goals

The primary goals of the Gulf Monitoring Network were identified through meetings, workshops, and conference calls among WQ Team and GOMA partners during the first six months following the 2011 Monitoring Forum. They are:

a. Integrate monitoring and related research and technology development efforts to aid in answering local, regional, and Gulf-wide questions:

Regional coastal water quality issues call for the development of a Gulf Monitoring Network (GMN) that interlaces existing monitoring programs into one cohesive unit - estuarine, coastal, and offshore water. This network would not only assist in providing a variety of tools to help answer regional questions, but could also be extended to answer Gulf-wide questions, including queries on detecting and forecasting of harmful algal blooms and pathogens, to revealing pathways by which mercury moves through the Gulf food webs into its seafood. As a majority of the water quality issues within the

Gulf of Mexico know no political boundary, it is to everyone's benefit that the states that share these waters coordinate with each other as much as possible.

Monitoring technologies are advancing rapidly, increasing the pace, scope and efficiency of monitoring activities. The proposed GMN will promote technology transfer, including providing test-beds, observations standards, and implementing new technologies. Widely-used tools for monitoring ecological condition also include different indexes that integrate the complexity of aquatic biota and have a robust capacity for reflecting the effects of multiple, complex, and temporally variable stressors. The Index of Biological Integrity (IBI)[2] also known as a multimetric index (MMI), is used in coastal and estuarine areas to assess ecological health. Recently, GOMA re-calibrated a benthic MMI for the Gulf of Mexico using an expanded dataset (GOMA 2011) to assess the condition of biological resources. The resulting Gulf Benthic Index (GBI) characterizes a variety of stressors and conditions, including nutrients, water chemistry, physical characteristics, hydrology, and climatic conditions, which is information critical to management decision-making (see Appendix D).

Using the 25th percentile of the reference distribution as the degradation threshold, the GBI indicated benthic conditions in estuarine and near-coastal waters of the Gulf to be 56% degraded (GOMA 2011). For a Gulf-wide management objective, GOMA proposes that by2035, less than 25% of the Gulf coastal waters will be rated as poor (=degraded) for benthic conditions. Success at achieving this goal can be used to assess the effectiveness of the ongoing restoration efforts, and the GMN will provide the data necessary for this assessment.

b. <u>Promote inter-agency data sharing and the expansion of international partnerships:</u>

Gulf States are currently concerned with many of the same monitoring issues. A synergetic relationship to promote interagency method and data sharing and the expansion of partnerships, including internationally, is beneficial. Existing monitoring programs across the Gulf of Mexico often use different techniques and technologies. While these methods are generally suitable for the needs of the program carrying out the monitoring, the ability to compare and combine data collected by them is limited.

---

[2] The IBI/MMI was originally developed for fish in Illinois streams (Karr et al. 1986). Different forms of the MMI have subsequently been developed and calibrated for estuarine and near-coastal systems in the Gulf of Maine, the Chesapeake Bay, areas of the Virginian and Carolinian Provinces, southern California Bight, and San Francisco Bay (Hale and Heltsche 2008, Paul et al. 2001, Weisberg et al. 1997, Llansó et al. 2002, Borja et al. 2008, Van Dolah et al. 1999, Hyland et al. 1999, 2003, Smith et al. 2001, Ranasinghe et al. 2004, and Thompson and Lowe 2004). For the Gulf of Mexico/Louisianan Province, benthic invertebrate MMI have been developed for system-wide application (Engle et al. 1994, Engle and Summers 1999), and more spatially-focused for Tampa Bay (Florida), the Calcasseiu Estuary (Louisiana), and the Lavaca-Colorado Estuary (Texas) (Malloy et al. 2007, Pollack et al. 2009, Carr and Gaston 2002).

Sharing and leveraging data can assist in targeting efforts to improve the data comparability needed to create a Gulf of Mexico-wide integrated monitoring system. Data from a unified effort can be used to identify areas in need of remediation, feed models needed for forecasting harmful algal blooms and pathogen risk, allow assessment of water quality, and allow for monitoring of water quality trends. Another example of a common monitoring issue is the need for support in development of the Nutrient Criteria Framework and coastal nutrient criteria.

c. Provide real-time or near real-time observations that support adaptive management:

One of the goals of the GMN is to provide a near real-time status of selected Gulf characteristics based on current information. Examples include, but are not limited to, establishing near real-time pathogen monitoring and harmful algal bloom detection. Identification of pathogens and the detection, tracking, and forecasting of harmful algal blooms are pertinent pieces of information that may be used by coastal managers to gauge the potential impact on human-health and the coastal economy. Additionally, these data could be used by researchers and regulators to help determine the underlying causes within specific coastal waters and thus help minimize or eliminate their impacts.

While these issues may have real-time application for assessing and controlling risk of impacts to beachgoers, timely information on other potential effects to human health are equally important. For example, minimizing impact or identifying and reducing the potential risk of consuming seafood that may be high in mercury concentrations helps to curtail health risks, aids in determining primary sources, assists in predicting effects, and helps to communicate information to public health advisory groups.

d. Provide synthesized information and products that support adaptive management:

The GMN must also ensure that results are effectively communicated to the policymakers and the public, including a straightforward communication of the scientific uncertainty associated with them. Of primary importance is that the interpretation of scientific findings and the disseminated information are readily available to key decision makers and the public so that informed land-use and management decisions, early project design coordination, support of local biodiversity and conservation and response to public concern can be accomplished in a timely manner. By doing so, policymakers, as well as the public, may better understand the importance and vulnerabilities of coastal areas.

4. Gulf of Mexico Monitoring Network Design

a. Physical system design

The monitoring strategy, described in detail in GOMA 2013, includes meshed monitoring designs for each scale of the Gulf: the estuaries, the coastal areas (coastline out to the 10 m contour) (Figure 5), the shelf (10 m to the edge of the Continental Shelf), and the deep Gulf (Figure 6). The draft monitoring designs complement and feed into each other to provide a basic overall understanding of Gulf drivers, such as circulation patterns and vertical and horizontal processes. More specifically, the designs also focus on how the flux, transport, fate, and sources and sinks of important constituents, such as nutrients, respond to these drivers and processes. The larger-scale shelf and deep-Gulf designs are proposed to use a combination of remote sensing, fixed stations, and flow-through meters on ships to obtain a clearer understanding of the larger ecosystems. The smaller monitoring scales, estuaries and coastal segments, are designed as templates to both support design of an estuary monitoring system that integrates with the GMN or—if sufficient information is unavailable—provide a starting point for intensive studies. Such studies can assist local decision-making to inform permanent station placement, sampling frequency, and required analytes and measurements needed to integrate with the Gulf-wide network.

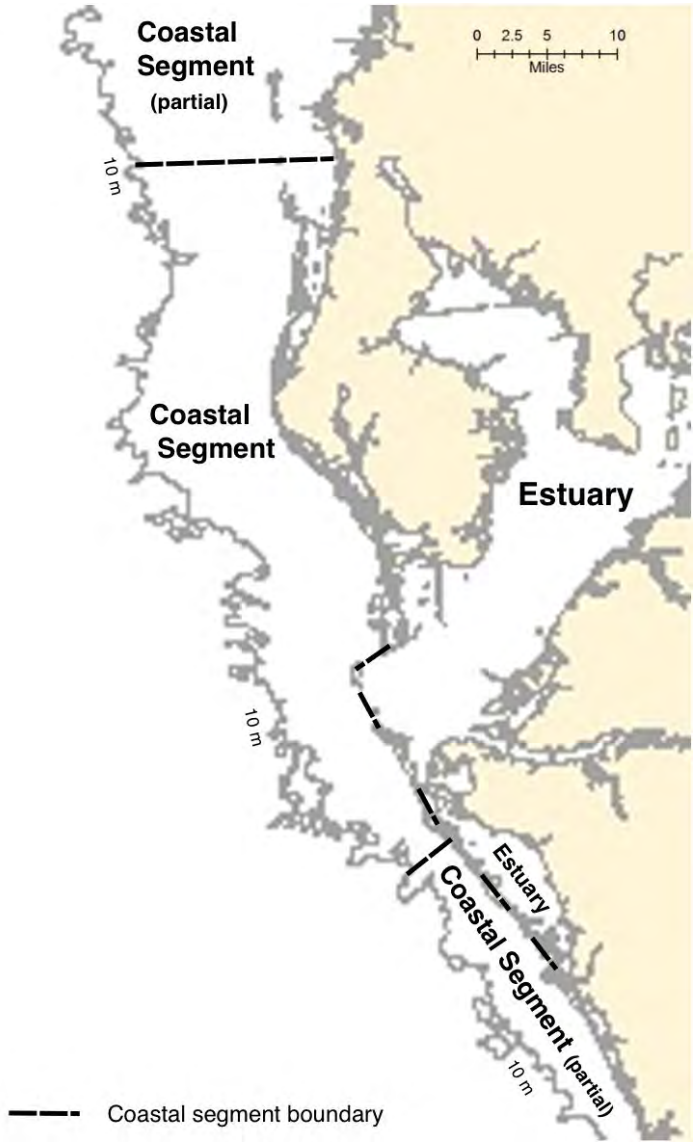


Figure 5. Example of coastal segment and estuary monitoring areas.

The design is a monitoring strategy using satellite imagery as a backdrop to develop models of water circulation and nutrient transport and fate, with fixed pilings/buoys

collecting continuous data at key locations to add information about depth-related factors, to ground-truth the satellite data, and to validate the models. The strategy incorporates additional information collected during maintenance trips to the piling- and buoy-mounted instruments, with collections at both fixed intermediate stations and via flow-through measurements and sampling between buoys. In shallower parts of the Gulf, this basic data-collection scheme is augmented by probabilistic sampling to improve the ability to detect change over time.

The overall conclusion is that monitoring of the open Gulf and continental shelf areas is required to properly understand and predict nutrient and other constituent loads and effects in coastal and estuarine waters. Most importantly, participants emphasized that coastal and estuarine models need to properly account for nutrient and other important constituent inputs transported from Gulf upwelling events and coastal watersheds, as well as those from uplands and rivers draining to the area of interest.

The details of the monitoring designs for nutrients, mercury, HABs, and pathogens and their associated physical and chemical parameters can be found in GOMA 2013.

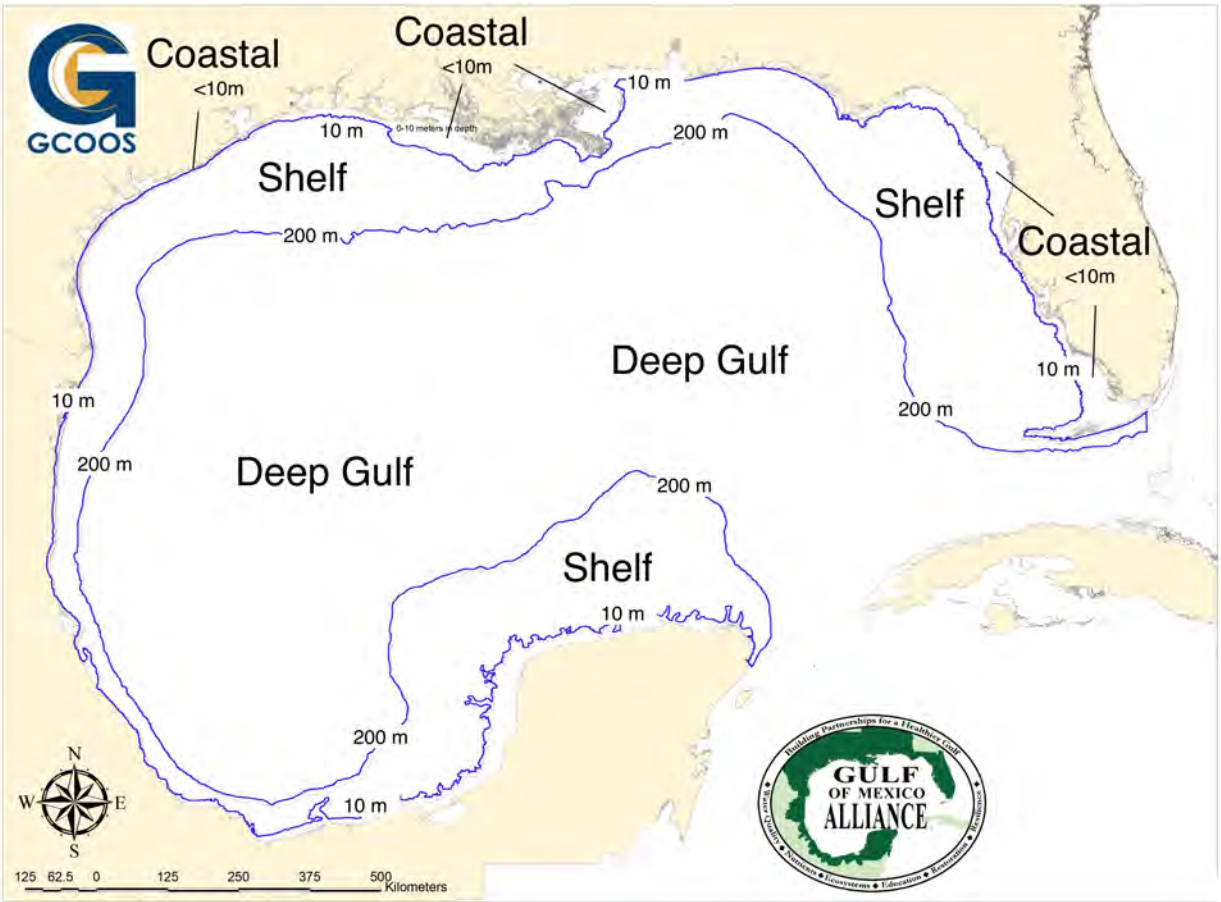


Figure 6. Gulf of Mexico coastal and offshore monitoring areas

b. Data management

One of the problems with existing Gulf monitoring is the prevalence of incompatible and/or non-comparable data collected by the many monitoring entities operating across the Gulf of Mexico. GOMA currently addresses this issue through the WQ Team's field and analytical round robins, the establishment of its Data Management Advisory Committee (DMAC), and the tools developed or identified by DMAC to facilitate data upload, management, and alignment (http://www.gulfofmexicoalliance.org/about/dmac.html). Metadata and data crosswalks are also being used to align existing datasets for comparison and analysis. However, the establishment of the GMN, with standardized metadata and data collection, is expected to minimize many data comparability issues.

GMN data management will be addressed through facilities established at the Gulf Research Initiative Information and Data Cooperative (GRIIDC) as part of the Gulf of Mexico Research Initiative (GOMRI). These facilities are capable of supporting expansion to store, archive, and distribute GMN data. These data would be publicly available to all who have need, including the monitoring programs built upon the GMN foundation.

The implementation planning described in the next section will include responsibility for data handling, analysis, and interpretation.

c. Implementation planning

One of the major aspects of establishing the GMN is development of an implementation plan. GOMA has scheduled workshops for devising implementation strategies and drafting the implementation plan. Among the issues to be solved are:

i. Design

- Establishing sampling location, frequency & parameters
- Selecting equipment and sensors
- Constructing local designs
- Evaluating monitoring programs and revising designs
- Development/calibration/validation of models
- Facilitating the Gulf States' development of estuarine and coastal-segment monitoring plans.

ii. Identifying and engaging monitoring entities as participants (in each scale or region)

- Personnel
  - Identifying the appropriate agency/entity by location
  - Training

iii. Infrastructure

- Vessels
- Platforms

- Equipment and consumables

iv. Coordination and logistics

v. Computer resources

- Data storage, access & archiving
- Modeling
- Data analysis
- Data visualization
- Data transmission
- Data dissemination

vi. Satellite technologies

- Time
- Algorithm development
- Product development
- Satellite maintenance and replacement

vii. Formalizing GMN organization

- External review board (technical) to make recommendations, with coordinating "council" authorizing final decisions based on those recommendations
- Consideration of redundancy planning for unexpected 'departures' from collaborating programs
- Identification and coordination of funding arriving to GMN
- Identification and management of funding distributed by GMN
- Network status and reporting

viii. Appropriate analytical capacity

ix. Data comparability

- QA/QC & protocol development

x. Equip purchase and maintenance

xi. Physical sample archival

xii. Coordinating sampling and sampling resources

- Ensure that the GMN operational schedule is publicly accessible to help other entities coordinate monitoring.

xiii. Data handling

- Identification of entity to manage and maintain data, and conduct QA/QC on data received from monitoring network (data management).
- Identification of entity to perform data analysis and assessment for inclusion in reporting

D. RECOMMENDATIONS

The GMN combines the efforts of existing plans (e.g. GCOOS glider and mooring/buoy planning and the Gulf Hypoxia Implementation Plan) with a Gulf regional perspective toward all parameters needed for a representative GMN. Through the three GMN Workshops and subsequent correspondence among Network partners, the following specific recommendations for completing GMN development and implementation across the Gulf were reached by consensus:

Recommendation 1. Complete implementation planning.

Recommendation 2: Arrange sufficient funds to support long-term sustainable water quality monitoring.

Recommendation 3: Create a coordinating structure to oversee distribution of monitoring funds as described in the Gulf Monitoring Network proposal to the Gulf Restoration Council via the Florida portal[3].

Recommendation 4: Implement the GMN design, which includes collaboration among Gulf monitoring entities, including state and federal agencies, GCOOS, academic institutions, and NGOs and with Mexico.

Recommendation 5: Ensure open availability of GMN data in an agreed-upon format, accessible through a single portal. It should be available to the public, government agencies, academic research institutions, or other NGOs.

[3] . A two-step process whereby an independent technical review panel external to any Gulf of Mexico stakeholder or other interests would make recommendations on distribution of available funds. A coordinating council composed of representatives from Gulf monitoring programs and key monitoring-data and monitoring-information users would make final decisions, based on the recommendations of the external review panel and explaining any differences.

E. LITERATURE CITED (INCLUDING FROM APPENDICES)

ACWI/NWQMC. 2006. *A National Water Quality Monitoring Network for U.S. Coastal Waters and their Tributaries*. Prepared by: The Advisory Committee on Water Information, and the National Water Quality Monitoring Council. Requested by: The Council on Environmental Quality, The National Science and Technology Council, and The Joint Subcommittee on Ocean Science and Technology. April 2006. 99pp. Available via URL (accessed 02/12/13): *http://acwi.gov/monitoring/network/design/*.

Agassiz, A. 1888. Three Cruises of the United States Coast and Geodetic Survey Steamer "Blake" In the Gulf of Mexico, in the Caribbean Sea, and Along the Atlantic Coast of the United States, from 1877 to 1880. In Two Volumes. Volumes I & II. Houghton, Mifflin and Company, The Riverside Press. Cambridge, MA. N.O.A.A. reprint.

Alabama Department of Environmental Management (ADEM). 2001. Functional Analysis & Records Disposition Authority. Revision Presented to the State Records Commission January 25, 2001.

Alabama Department of Environmental Management (ADEM). 2013. Inside ADEM. World Wide Web electronic publication. http://www.adem.state.al.us/inside/Default.cnt. 02 February 2013.

Alexander, R.B., A.S. Ludtke, K.K. Fitzgerald, and T.L. Schertz. 1996. Data from Selected U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN) on CD-ROM. USGS Open-File Report 96-337. http://pubs.usgs.gov/dds/wqn96cd/html/report/hiswqn.htm

Allan, J.D., P.B. McIntyre, S.D.P. Smith, B.S. Halpern, G.L. Boyer, Andy Buchsbaum, G.A. Burton, Jr., L.M. Campbell, W.L. Chadderton, J.J.H. Ciborowskii, P.J. Doranj, T. Eder, D.M. Infante, L.B. Johnson, C.A. Joseph, A.L. Marino, A. Prusevich, J.G. Read, J.B. Rose, E.S. Rutherford, S.P. Sowa, and A.D. Steinman. 2013. Joint analysis of stressors and ecosystem services to enhance restoration effectiveness. *Proceedings of the National Academy of Sciences* 110 (1): 372–377. www.pnas.org/cgi/doi/10.1073/pnas.1213841110

Austin, D., T. Priest, L. Penney, J. Pratt, A.G. Pulsipher, J. Abel, and J. Taylor. 2008. History of the Offshore Oil and Gas Industry in Southern Louisiana. Volume I: Papers on the Evolving Offshore Industry. U.S. Department of Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study MMS 2008-042. New Orleans, LA.

Bache, A.D. 1859. Report: The Superintendent of the Coast Survey, Showing the Progress of the Survey During the Year 1858. Executive Document No. 14 to the 35th Congress of the United States. William A. Harris. Washington, D.C. N.O.A.A. reprint.

Bache, A.D. 1861. Notes on the Coast of the United States. Memoirs VI & VII Western Coast of Florida from Cape Sable on the South to Ocilla River on the North. U.S. Coast Survey. Blockade Strategy Board. N.O.A.A. reprint.

Borja A, Bricker SB, Dauer DM, Demetriades NT, Ferreira JG, Forbes AT, Hutchings P, Jia X, Kenchington R, Marques JC, Zhu C (2008) Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide: Marine Poll. Bull. 56: 1519–1537

Bosch, J., S. McLean, H. Garcia, A. Dausman and J. Kurtz. 2013. Supporting Gulf of Mexico Research with Historical Data. Presented by J. Bosch at the Gulf of Mexico Oil Spill and Ecosystem Science Conference. January 21 – 23, 2013 New Orleans, LA.

Bricker SB, Clement CG, Pirhalla DE, Orlando SP, Farrow, DRG (1999) National Estuarine Eutrophication Assessment. Effects of Nutrient Enrichment in the Nation's Estuaries. NOAA,

National Ocean Service, Special Projects Office and National Centers for Coastal Ocean Science, Silver Spring. http://spo.nos.noaa.gov/projects/cads/nees/Eutro_Report.pdf

Bricker SB, Ferreira JG, Simas T (2003b) An integrated methodology for assessment of estuarine trophic status: Ecol. Modelling 169**:** 39-60

Bricker SB, Longstaff B, Dennison W, Jones A, Boicourt K, Wicks C, Woerner J (2007) Effects of Nutrient Enrichment in the Nation's Estuaries: A Decade of Change, National Estuarine Eutrophication Assessment Update. NOAA Coastal Ocean Program Decision Analysis Series No. 26. National Centers for Coastal Ocean Science, Silver Spring, MD. 322 pp. http://ccma.nos.noaa.gov/news/feature/Eutroupdate.html

Bricker SB, Longstaff B, Dennison W, Jones A, Boicourt K, Wicks C, Woerner J (2008) Effects of Nutrient Enrichment in the Nation's Estuaries: A Decade of Change: Harmful Algae 8: 21-32

Bureau of Ocean Energy Management (BOEM). 2013. OCS Lands Act History. World Wide Web electronic publication. http://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Outer-Continental-Shelf/Lands-Act-History/OCSLA-HIstory.aspx. 10 January 2013.

Committee on Environment and Natural Resources Research. 1995. Setting a new course for U.S. coastal ocean science. Phase I: Inventory of federal programs; Phase II: The strategic framework. Washington, DC: National Science and Technology Council, CENR. 111 pp.

CRMSW. 2000. Clean Water Action Plan: Coastal Research and Monitoring Strategy. Prepared by: the Coastal Research and Monitoring Strategy Workgroup. September 2000. Available from: http://water.epa.gov/type/oceb/upload/2004_10_13_oceans_nccr_H2Ofin.pdf.

Darnell, R.M., and R.E. Defenbaugh. 1990. Gulf of Mexico: Environmental overview and history of environmental research. *American Zoologist* 30: 3-6.

Devlin M, Bricker S, Painting SJ (2011) Comparison of five methods for assessing impacts of nutrient enrichment using estuarine case studies: Biogeochem. 106(2): 135-136

Elvers, D. and J.B. Johnston. 1976. Identification and Mapping of Fishing Banks on the Outer Continental Shelf of the Gulf of Mexico. In: Proceedings of the Twenty-Eighth Annual Gulf and Caribbean Fisheries Institute. Pp. 35 – 48. Miami, FL.

The Encyclopedia of Alabama. 2013. Dauphin Island Sea Lab and Estuarium (DISL). World Wide Web electronic publication. http://www.encyclopediaofalabama.org/face/Article.jsp?id=h-2426. 24 January 2013.

EPA. 1999. Ecological Condition of Estuaries in the Gulf of Mexico. EPA 620-R-98-004. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, Florida.

EPA. 2012. National Coastal Condition Report IV. EPA-842-R-10-003. April 2012. United States Environmental Protection Agency, Office of Research and Development/Office of Water, Washington, DC 20460. http://www.epa.gov/nccr.

Ferreira JG, Simas T, Nobre A, da Silva, MC, Schifferegger K, Lencart-Silva J (2003) Identification of Sensitive Areas and Vulnerable Zones In Transitional and Coastal Portuguese Systems. Application of the United States National Estuarine Eutrophication Assessment to the Minho, Lima, Douro, Ria de Aveiro, Mondego, Tagus, Sado, Mira, Ria Formosa and Guadiana systems: INAG/IMAR

Ferreira JG, Bricker SB, Simas TC (2007a) Application and sensitivity testing of an eutrophication assessment method on coastal systems in the United States and European Union: J. Environ. Manage. 82(4): 433-445

Foden J, Devlin MJ, Mills DK, Malcolm SJ (2011) Searching for undesirable disturbance: an application of the OSPAR eutrophication assessment method to marine waters of England and Wales: Biogeochem. 106: 157–175

FWPCA. 2008. Federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.) As amended through P.L. 110-288, July 29, 2008. As in effect January 4, 2011. Full text available from: http://www.waterboards.ca.gov/laws_regulations/docs/fedwaterpollutioncontrolact.pdf.

Furlong, L. 1796. The American Coast Pilot. Blunt and March. Newburyport, MA. N.O.A.A. reprint.

Furlong, L. 1800. The American Coast Pilot. Blunt. Newburyport, MA. N.O.A.A. reprint.

Galtsoff, P. S. 1954. Gulf of Mexico, Its Origin, Waters, and Marine Life. Fishery Bulletin 89. Fishery Bulletin of the Fish and Wildlife Service. Volume 55. U.S. Government Printing Office. Washington D.C.

Garmendia M, Bricker S, Revilla M, Borja A, Franco J, Bald J, Valencia V (2012) Eutrophication assessment in Basque estuaries: Comparing a North American and a European method: Estuaries and Coasts 35(4): 991-1006

GOMA. 2006. Governors' Action Plan for Healthy and Resilient Coasts. 2006-2009. Gulf of Mexico Alliance.

GOMA. 2009. Governors' Action Plan II for Resilient and Healthy Coasts. 2009-2014. Gulf of Mexico Alliance.

GOMA. 2011. *Benthic Index of Biological Integrity for Estuarine and Near-Coastal Waters of the Gulf of Mexico.* Tetra Tech, Inc., Center for Ecological Sciences, Owings Mills, MD for the Gulf of Mexico Alliance (GOMA) and the Mississippi Department of Environmental Quality, Surface Waters Division, Jackson, MS. 79 pp. plus 4 appendixes. (For further information, contact Ms. Natalie Guedon-Segrest [601-961-5150, or by email natalie_segrest@deq.ms.state.us]).

GOMA. 2013. Gulf Monitoring Network: Monitoring Design. GOMA Water Quality Team. Tallahassee, FL . www.GulfofMexicoAlliance.org

Gooch-Moore, J., K.D. Goodwin, C. Dorsey, R.D. Ellender, J.B. Mott, M. Ornelas, C. Sinigalliano, B. Vincent, D.Whiting and S.H. Wolfe. 2011. New USEPA water quality criteria by 2012: GOMA concerns and recommendations. Journal of Water and Health Vol 9 No 4 pp 718–733.

Goode, G.B. 1884 – 1887. The Fisheries and Fishery Industries of the United States. Section I, Natural History of Useful Aquatic Animals (1884); Section II, A Geographical Review of the Fisheries Industries and Fishing Communities for the Year 1880 (1887); Section III, The Fishing Grounds of North America (1887). U.S. Government Printing Office. Washington, D.C. N.O.A.A. reprint.

Griffiths, C., H. Klemick, M. Massey, C. Moore, S. Newbold, D. Simpson, P. Walsh, and W. Wheeler. 2012. U.S. Environmental Protection Agency valuation of surface water quality improvements. *Review of Environmental Economics and Policy* 6 (1): 130–146. doi:10.1093/reep/rer025.

GulfBase. 2013. GulfBase: Resource Database for Gulf of Mexico Research. F. Moretzsohn, J.A. Sánchez Chávez, and J.W. Tunnell, Jr. (Eds.). World Wide Web electronic publication. http://www.gulfbase.org. 07 January 2013.

Hogue, H.B. 2010. Reorganization of the Minerals Management Service in the Aftermath of the Deepwater Horizon Oil Spill. Congressional Research Service Report for Congress. Prepared for Members and Committees of Congress. 7-5700 R41485.

Holland, A.F., D.M. Sangera, C.P. Gawlea, S.B. Lerberg, M.S. Santiagoa, G.H.M. Riekerka, L.E. Zimmerman, and G.I. Scott. 2004. Linkages between tidal creek ecosystems and the landscape and

demographic attributes of their watersheds. *Journal of Experimental Marine Biology and Ecology* 298: 151–178.

ITFM. 1995. The strategy for improving water-quality monitoring in the United States: Final report of the Intergovernmental Task Force on Monitoring Water Quality. Open-File Report 95-742. U.S. Geological Survey, Reston, Virginia. 25 pp., with technical appendixes under separate cover, 117 pp. Available from: http://acwi.gov/itfm.html.

Karr, J. R. 1991. Biological integrity: A long-neglected aspect of water resource management. *Ecological Applications* 1:66–84.

Lehrter, J.C. 2008. Regulation of eutrophication susceptibility in oligohaline regions of a northern

Gulf of Mexico estuary, Mobile Bay, Alabama. *Marine Pollution Bulletin* 56: 1446–1460.

Loucks, O.L., H.J. Stone, and B.M. Kahn. 2006. Scaling and Uncertainty in Region-Wide Water Quality Decision-Making. Chapter 17 (pages 315-325), IN, J. Wu, K.B. Jones, H. Li, and O.L. Loucks (editors), *Scaling and Uncertainty Analysis in Ecology. Methods and Applications.* Springer, Dordrecht, Netherlands. ISBN-13 978-1-4020-4664-3.

Louisiana Universities Marine Consortium (LUMCON). 2013. Welcome to Louisiana Universities Marine Consortium. World Wide Web electronic publication. http://www.lumcon.edu/. 02 February 2013.

Macauley, J.M., J.K. Summers, and V.D. Engle. 1999. Estimating the ecological condition of the estuaries of the Gulf of Mexico. *Environmental Monitoring and Assessment* 57: 59–83.

Mahadevan, K. 2010. Mote Marine Laboratory: Exploring the Secrets of the Sea Since 1955, a Historical Perspective. Mote Marine Laboratory. Sarasota, FL.

National Oceanic and Atmospheric Administration (NOAA). 2013. The Estuary Restoration Act & NOAA. World Wide Web electronic publication. http://www.era.noaa.gov/materials/resources.html. 10 January 2013.

Newton, B. J. 1992. The U.S. Clean Water Act: Programmatic Needs and Experiences. Chapter 69, IN, D.H. McKenzie, D.E. Hyatt, and V.J. McDonald (editors), *Ecological Indicators*, Vol. 2. Elsevier Applied Science, London and New York. Pp. 1211-1217. ISBN 1-85166-722-9.

NRC. 1990. Managing Troubled Waters. The Role of Marine Monitoring. Committee on a Systems Assessment of Marine Environmental Monitoring, National Research Council, National Academy Press, Washington, DC. 136 pp. ISBN 0-309-57173-1. Available from: http://www.nap.edu/catalog/1439.html.

NRC. 2001. *Assessing the TMDL Approach to Water Quality Management.* Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and Technology Board, National Research Council, National Academy Press, Washington, DC. 122 pp. ISBN 0-309-07579-3. Available from: http://www.nap.edu/catalog/10146.html.

Oil Spill Commission (OCS). 2011. The History of Offshore Oil and Gas in the United States. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Staff Working Paper No. 22. World Wide Web electronic publication. http://www.oilspillcommission.gov/resources#staff-working-papers. 24 June 2011.

Owen, E.W. 1975. Trek of the Oil Finders: A History of Exploration for Petroleum. Semicentennial Commemorative Volume, Memoir 6, Chapter 14. Pp. 748 – 818. American Association of Petroleum Geologists. Tulsa, OK.

Palmer, M.A. 2009. Reforming watershed restoration: science in need of application and applications in need of science. *Estuaries and Coasts* 32: 1–17. DOI 10.1007/s12237-008-9129-5

Palmer, M.A., E.S. Bernhardt, J.D. Allan, P.S. Lake, G. Alexander, S. Brooks, J. Carr, S. Clayton, C.N. Dahm, J.F. Shah, D.L. Galat, S.G. Loss, P. Goodwin, D.D. Hart, B. Hassett, R. Jenkinson, G.M. Kondolf, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, and E. Sudduth. 2005. Standards for ecologically successful river restoration. *Journal of Applied Ecology* 42: 208–217. doi: 10.1111/j.1365-2664.2005.01004.x.

Pillsbury, J.E. 1891. The Gulf Stream: Methods of the Investigation and Results of the Research. Appendix No. 10 from the Annual Report of the Coast and Geodetic Survey for 1890. U.S. Government Printing Office. Washington, D.C. N.O.A.A. reprint.

Rabbit, M.C. 1989. The United States Geological Survey: 1879 – 1989. U.S. Geological Survey Circular 1050. U.S. Government Printing Office.

Rounsefell, G.A. 1963. Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries. Circular 154. U.S. Government Printing Office. Washington D.C.

Shor, E.N. 1983. Scripps in the 1950s: A Decade of Bluewater Oceanography. The Journal of San Diego History. 29(4). World Wide Web electronic publication. http://www.sandiegohistory.org/journal/83fall/scripps.htm. 14 March 2007.

Sigsbee, C.D. 1880. Deep-Sea Sounding and Dredging: A Description and Discussion of the Methods and Appliances Used on Board the Coast and Geodetic Survey Steamer "Blake." U.S. Government Printing Office. Washington, D.C. N.O.A.A. reprint.

Slade, R.M. 1992. Status on the Gulf of Mexico: Preliminary Report on Inflows from Streams. Publ. no. 800R92005. US Environmental Protection Agency, Office of Water, Gulf of Mexico Program, Freshwater Inflow Subcommittee. 84pp. Available from: *http://nepis.epa.gov/* (accessed 02/112/13).

Stribling, J.B. 2011. Partitioning Error Sources for Quality Control and Comparability Analysis in Biological Monitoring and Assessment. Chapter 4 (pp. 59-84), IN, Eldin, A.B. (editor), *Modern Approaches to Quality Control*. ISBN 978-953-307-971-4. InTech Open Access Publisher. DOI: 10.5772/22388.

Summers, J.K., J.F. Paul, and A.R. Roberston. 1995. Monitoring ecological condition of estuaries in the United States. *Toxicology and Environmental Chemistry* 49: 93-108.

Trowbridge, P.R., and S.H. Jones. 2009. Detecting water quality patterns in New Hampshire's estuaries using National Coastal Assessment probability-based survey data. *Environmental Monitoring and Assessment* 150:129–142. DOI 10.1007/s10661-008-0683-x

U.S. Army Corps of Engineers (USACE). 2007. The U.S. Army Corps of Engineers: A History. U.S. Army Corps of Engineers. EP 870-1-68.

USACE. 2013a. The U.S. Army Corps of Engineers: A Brief History. World Wide Web electronic publication. http://www.usace.army.mil/About/History/BriefHistoryoftheCorps.aspx. 10 January 2013.

USACE. 2013b. The U.S. Army Corps of Engineers: Estuary Restoration Act. World Wide Web electronic publication. http://www.usace.army.mil/Missions/Environmental/EstuaryRestoration.aspx. 10 January 2013.

U.S. Commission on Ocean Policy. An Ocean Blueprint for the 21st Century. Final Report. Washington, DC, 2004. Available at http://www.oceancommission.gov

U.S. Department of the Interior. 2012. Oil and Gas Lease Utilization, Onshore and Offshore. Updated Report to the President. World Wide Web electronic publication. http://www.doi.gov/news/pressreleases/upload/Final-Report.pdf. 22 January 2013.

U.S. Environmental Protection Agency (USEPA) (2008) National Coastal Conditions Report III. United States Environmental Protection Agency, Office of Research and Development/Office of Water, Washington, DC, 20460. EPA/842-R-08-002. http://www.epa.gov/nccr

USGS. 2013. Florida USGS Threatened and Endangered Stations – 101. http://streamstatsags.cr.usgs.gov/ThreatenedGages/gmaps/fl_gm_base.html

Vollenweider RA, Giovanardi F, Montanari G, Rinaldi A (1998) Characterization of the trophic conditions of marine coastal waters with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index: Environmetrics 9: 329–357

Wasson, T. 1948. Creole Field, Gulf of Mexico, Coast of Louisiana. In: Structure of Typical American Oil Fields: A Symposium on the Relation of Oil Accumulation to Structure, Volume III. J.V. Howell (Ed.). Pp. 281 – 298. American Association of Petroleum Geologists. Tulsa, OK.

Whitall D, Bricker S, Ferreira JG, Nobre A, Simas T, Silva MC (2007) Assessment of eutrophication in estuaries: Pressure-state-response and source apportionment: Environ. Manage.: 40: 678-690, doi 10.1007/s00267-005-0344-6

Woods Hole Oceanographic Institute (WHOI). 2013. History and Legacy. World Wide Web electronic publication. http://www.whoi.edu/main/history-legacy. 14 January 2013.

Wu, J., K.B. Jones, H. Li, and O.L. Loucks (editors). 2006. *Scaling and Uncertainty Analysis in Ecology. Methods and Applications*. Springer, Dordrecht, Netherlands. 351 pp. ISBN-13 978-1-4020-4664-3.

Xiao Y, Ferreira JG, Bricker SB, Nunes JP, Zhu M, Zhang X (2007) Trophic assessment in Chinese coastal systems - Review of methods and application to the Changjiang (Yangtze) Estuary and Jiaozhou Bay: Estuaries and Coasts 30(6): 901-918

Zaldivar JM, Cardoso AC, Viaroli P, Newton A, de Wit R, Ibanez C, Reizopoulou S, Somma F, Razinkovas A, Basset A, Holmer M, Murray N (2008) Eutrophication in transitional waters: an overview: Transitional Waters Monographs 1: 1–78

APPENDIX A.
GOMA MONITORING PRIORITIES AND ASSOCIATED MONITORING QUESTIONS

Monitoring Priority #1: Nutrients [4]

Monitoring Questions at the Estuary or Coastal Segment scale

High priority

1) What is the spatial and temporal variation in nutrient (carbon, nitrogen, phosphorus, silicate) concentrations in the estuary or coastal segment?
2) What is the long-term trend in nutrient loading to the estuary or coastal segment?
3) Which biological/chemical/physical indicators are most susceptible to nutrient enrichment in the estuary or coastal segment?
4) What is the long-term trend in nutrient export from the estuary or coastal segment?

Medium priority

1) Are nutrients contributing to harmful algal blooms (HABs) within the estuary or coastal segment?
2) What is the temporal variation in nutrient loading to the estuary or coastal segment?
3) What is the long-term trend in biological or chemical responses to nutrients in the estuary or coastal segment?

Low priority

1) Is groundwater a significant source of nutrients to the estuary or coastal segment?
2) Which nutrient(s) is limiting the biological/chemical/physical response within the estuary or coastal segment?

Monitoring Questions at the Regional scale (In order of priority)

1) What is the spatial and temporal variation and trends of nutrient loadings and concentrations within the region?
2) Which biological/chemical/physical indicators are most susceptible to nutrient enrichment within the region?

---

[4] The GOMA Nutrients Team developed the prioritized list of nutrient questions that are best addressed through monitoring.

3) What is the long-term trend in biological/chemical/physical responses to nutrients in the region?
4) What is the relationship between nutrient loadings and the development of hypoxic zones within the region?
5) What are the trends in the size, frequency, and duration of hypoxic water within the region?
6) Are nutrients contributing to harmful algal blooms (HABs) within the region?

Monitoring Questions at the Gulf-wide scale (In order of priority)

1) Which biological/chemical/physical indicators are most susceptible to nutrient enrichment in the Gulf of Mexico?
2) What is the spatial and temporal variation and trends in nutrient concentrations within the Gulf of Mexico?
3) How do circulation patterns in the Gulf of Mexico affect nutrient concentrations?

Monitoring Priority #2a: Harmful Algal Blooms [5]

Overarching question: How do the frequency, distribution and duration of Harmful Algal Blooms compare to phytoplankton community during non-bloom periods and what are the linkages to environmental and climatic factors?

All Scales:

1) – What is the spatial and temporal distribution of HAB species?
2) – What are the frequency, distribution, and duration of bloom events?
3) – What is the linkage between environmental (and other) conditions and HAB development/maintenance?

Continental Shelf and Deep Water scales: What is the presence/persistence of HAB toxins in all matrices?

Monitoring Priority#2b: Pathogens [6]

[5] The HABs Workgroup of the GOMA WQ Team developed the list of HAB questions that are best addressed through monitoring and their order of priority.

[6] The Pathogens Workgroup of the GOMA Water Quality Team developed the list of pathogen questions that are best addressed through monitoring and their order of priority.

Overarching question: What are the sources, distributions, and fates of pathogens of public health concern, and are there environmental factors related to climate change that influence these patterns?

All Scales: How do pathogens of public health concern vary spatially and temporally and what are their associated environmental factors across the Gulf?

Estuary and Coastal Segment scales: How do pathogens of public health concern vary spatially and temporally and what are their associated environmental factors across the Gulf, especially in shellfish harvesting areas and human swimming areas (e.g., bathing beaches)?

Monitoring Priority #2c: Mercury [7]

Overarching areas of monitoring need:

1) What is the status and trends of mercury in fish tissue to determine if management efforts are effective?
2) What is the status and trends of mercury in critical food-web components?
3) Data to develop the Gulf of Mexico mercury model (to identify the sources of mercury in Gulf seafood).
    - **a.** What are the atmospheric fluxes?
    - **b.** What are the riverine fluxes to the Gulf?
    - **c.** What are the transport and fluxes of mercury across the Gulf (circulation)?
    - **d.** What is the spatial variation in sediment and water column methylation rates taking place between the flux boundaries?

Atmospheric monitoring questions

1) What is the wet and net dry surface exchange flux of elemental mercury, particulate mercury, gaseous oxidized mercury, and methylmercury between the atmosphere and the waters of the Gulf of Mexico, and how do these fluxes vary spatially and temporally?
2) What is the wet and net dry surface exchange flux of elemental mercury, particulate mercury, gaseous oxidized mercury, and methylmercury between

[7] The Mercury Workgroup of the GOMA Water Quality Team developed the list of mercury questions that are best addressed through monitoring and their order of priority.

the atmosphere and Gulf of Mexico watersheds, and how do these fluxes vary spatially and temporally?

Estuary Monitoring Questions

1) What are the fluxes of dissolved and particulate mercury and methylmercury from rivers to estuaries around the GOM?
2) How do estuarine processes (e.g., scavenging, Hg methylation) alter the concentrations of these Hg species?
3) What are the net fluxes of mercury and methylmercury from estuaries to coastal waters of the GOM?

APPENDIX B.
HISTORIC TIMELINE FOR GULF WATER-QUALITY MONITORING

Compiled by Raymond Leary, FDEP

Although many of GOMA's partners are mentioned in this review, it does not contain a complete list, and is not intended to rank or rate those conducting monitoring in and around the Gulf. The author apologizes for the exclusion of any agencies, institutions, programs, legislation, technological advances, or important publications (or any other important milestones) relevant to monitoring in and around the Gulf of Mexico.

1513 Ponce de León officially discovers Florida and notes the existence of a strong current off the coast of Florida (1st known record of the Gulf Stream; e.g., Pillsbury 1891, GulfBase 2013).

1719 Lemoyne de Sérigny produces a map of Pensacola Bay including currents and tidal ranges during exploration of the northern Gulf (GulfBase 2013).

1720 Devin produces a map of the Louisiana coast with soundings, shallows, and reefs around St. Louis Bay (GulfBase 2013).

1776 Captain Bernard Romans publishes *A Concise Natural History of East and West Florida* detailing his 1774 exploration of the northeast Gulf, including a detailed chart, and species lists.

1796 The American Coast Pilot published by Blunt and March (first edition; written by Captain Lawrence Furlong); the third edition is published in 1800.

1802 U.S. Army Corps of Engineers established by an act of Congress (Military Peace Establishment Act; USACE 2007).

1807 U.S. Coast Survey established by an act of Congress (An Act to Provide for Surveying the Coasts of the United States, 2 Stat. 413; it was established in the Treasury Department, but later transferred to the U.S. Navy, and back to Treasury, then Navy, and finally back to Treasury; National Archives 2013).

1830 U.S. Naval Depot of Charts and Instruments established (NAVOCEANO 2013).

1836 The Republic of Texas establishes the General Land Office (GLO 2013).

1839 U.S.S. Vandalia, commanded by Uriah B. Levy, conducts a hydrographic research in Texas and Louisiana waters of the Gulf (Galtsoff 1954).

1842 Commander Matthew F. Maury (considered the founder of oceanography) named Hydrographer of the Navy in the Depot of Charts and Instruments (NAVOCEANO 2013).

1844 Alexander D. Bache becomes the second Superintendent of the U.S. Coast Survey and begins exploring the Gulf Stream and detailing the Gulf coast (e.g., Bache 1859, Bache 1861, Galtsoff 1954, GulfBase 2013).

1848 Geological Survey of Alabama established.

1854 U.S. Navy Depot of Charts and Instruments renamed the U.S. Naval Observatory and Hydrographical Office (NAVOCEANO 2013).

1855 The Florida Board of Trustees of the Internal Improvement Trust Fund (portions of which would become part of the Florida Department of Environmental Protection) established to oversee the management of public lands (includes shores/coasts, submerged lands, etc.; FDOS 2013).

1866 The U.S. Naval Observatory and Hydrographical Office is split into two separate offices, creating the Hydrographic Office (NAVOCEANO 2013).

1871 U.S. Congress establishes Commission on Fish and Fisheries (16 Stat. 593) administered by the Smithsonian Institution (e.g., Hobart 1996, Cart 2004).

1872 Sir William Thompson (Lord Kelvin) invents the mechanical sounding machine (E.g. Agassiz 1888, Theberge 1989).

1874 The U.S. Coast Survey vessel *Blake* begins surveys the Gulf using a Thompson Machine under the command of Commander John A. Howell; Lieutenant Commander Charles D. Sigsbee takes command of the vessel in December of the same year (Sigsbee 1880).

1877 U.S. Coast Survey vessel *Blake* continues surveys the Gulf under the command of Lt. Commander Sigsbee, who significantly improves the Thomson machine to the point it becomes known as the Sigsbee sounding machine; soundings produce the first modern bathymetric map; Professor Alexander Agassiz (son of Louis Agassiz) joins the Blake and conducts studies benthic organisms of the Gulf; a total of three surveys are conducted from 1877 to 1880 (Professor Agassiz's first cruise (1877–78) was in the Gulf, Sigsbee continued work in the Gulf until relieved of command by Commander J.R. Bartlett; the second (1878–79) started in the Atlantic, briefly traveled in the Gulf (Florida Keys and Cuba only) and Caribbean; the third cruise (1880) on the Blake was along the Atlantic and under the command of Cmdr. Bartlett for the 2nd and 3rd cruises); from 1874 through 1878 the Blake collects the following data: depths, temperature profiles, sediment samples, water column samples for analyses, current measurements, and biological profiles from surface to bottom for a large portion of the Gulf of Mexico (e.g.; Sigsbee, 1880, Agassiz 1888, Theberge 1989).

1878 U.S. Coast and Geodetic Survey (formerly the U.S. Coast Survey) established within the Department of the Treasury (20 Stat. 215).

1879 U.S. Geological Survey established by the Organic Act of the U.S. Geological Survey (20 Stat. 394; Rabbitt 1989).

Texas Fish Commission established.

1884 The U.S. Commission of Fish and Fisheries sends the steamer *Albatross*, under the command of Lt. Commander Z. L. Tanner, to collect information on the natural history and fisheries of the Gulf (e.g., Tanner 1886, Galtsoff 1954).

Texas Fish Commission abolished.

1888 U.S. Commission on Fish and Fisheries becomes an independent federal agency (e.g., Hobart 1996, Cart 2004).

1889 Florida Department of Health established (FDOH 2013).

1891 John E. Pillsbury publishes Appendix No. 10 – 1890. The Gulf Stream – A Description of the Methods Employed in the Investigation, and the Results of the Research documenting historical reports of the Gulf Stream, as well as measurements of the current (including through the Yucatan Channel and the Straits of Florida) in the U.S. Coast and Geodetic Survey 1890 report to the Superintendent.

1894 U.S. Geological Survey begins stream gaging (28 Stat. 372, 398).

1895 The U.S. Commission on Fish and Fisheries send the steamer *Fish Hawk*, under the command of Lt. Franklin Swift, to the gulf to study its fisheries; the *Fish Hawk* would conduct many surveys in the Gulf until 1913 (e.g., Galstoff 1954, Allard 1999).

Texas Fish and Oyster Commission established.

1899 Rivers and Harbors Act (30 Stat. 1151); regulates dumping and filling harbors (this portion also known as the Refuse Act); USACE to monitor (USACE 2013a).

1903 Congress establishes the Bureau of Fisheries within the Department of Commerce and Labor (formerly the Commission on Fish and Fisheries) and transfers the U.S. Coast and Geodetic Survey to Department of Commerce and Labor (Department of Commerce Act; 32 Stat. 825).

1904 Breton National Wildlife Refuge established by Executive Order (unnumbered series).

USGS begins gaging of the Brazos River (earliest gaging record for the Gulf; Slade 1992).

1907 Alabama Department of Game and Fish (a predecessor of the Alabama Department of Conservation and Natural Resources) established.

Shell Keys National Wildlife Refuge (E.O. 682) established.

Texas Fish and Oyster Commission merged with the Game Department to become the Texas Game, Fish, and Oyster Commission.

1908 Pine Island (E.O. 939), Matlacha Pass (E.O. 943), and Island Bay (E.O. 958) National Wildlife Refuges established.

1909 Louisiana Board of Commissioners for the Protection of Birds, Game and Fish established.

1910 Louisiana Board of Commissioners for the Protection of Birds, Game and Fish merges with the Louisiana Oyster Commission to form the Louisiana Department of Conservation (the name would change to the Conservation Commission of Louisiana in 1912, and back to Louisiana Department of Conservation in 1918); during the 1930s the Water Pollution Control Division is established in the Department, which conducted water quality monitoring for the state.

1912 Public Health Service Act (37 Stat. 309); the newly formed U.S. Public Health Service surveys and studies sanitation, sewage, and pollution issues.

1913 Texas Board of Water Engineers (a predecessor of the Texas Commission on Environmental Quality (TCEQ)) established by the Texas Irrigation Act (TCEQ 2013).

The Florida Department of Game and Fish (a predecessor of the Florida Fish and Wildlife Conservation Commission) established, and the post of State Game and Fish Commissioner created (Ch. 6535, Laws of Florida).

1914 First use of acoustics for depth measurements (Fessenden Oscillator; Daniel Colloden had measured the speed of sound waves traveling through water in 1826, and Lewis Nixon was using sound to detect icebergs in 1906; SONAR (SOund, NAvigation and Ranging) would be perfected over the following years, with the onset of WWI; e.g., Theberge 1989).

1916 National Park Service Organic Act (39 Stat. 535) establishes the National Park Service; monitors water quality in conjunction with other U.S. DOI agencies; part of NAWQA.

1917 Key West Biological Station (Fisheries Commission; was abandoned due to lack of funds and returned to previous owners in 1929; Cart 2004).

1919 Alabama Department of Game and Fish renamed the Alabama Department of Conservation.

1920 Minerals Leasing Act (41 Stat. 437) repeals the General Mining Act of 1872, allowing the federal government to lease public lands for mining purposes.

1922 U.S. Naval Hydrographic Office makes the first practical SONAR devices, and begins using aerial photography for surveillance purposes.

1923 Alabama Department of Conservation's name changed to Department of Game and Fisheries.

The U.S. Navy establishes the Naval Research Laboratory (NRL).

1924 Oil Pollution Act (43 Stat. 604, OPA; repealed in 1970 by Water Quality Improvement Act, WQIA); U.S. ACOE (later U.S. C.G.) responsible for monitoring these waters (U.S. navigable coastal waters; spills, intentional releases, etc.) and apprehend violators.

1927 The Florida Department of Game and Fresh Water Fish (a predecessor of the Florida Fish and Wildlife Conservation Commission) established (Ch. 11838, Laws of Florida).

1929 Brazos River Authority established.

Executive Order 5158 establishes Cedar Keys National Wildlife Refuge.

1930 Woods Hole Oceanographic Institute established (**Note:** the first fisheries laboratory in the U.S. was established here in 1871 as part of the Fishery Commission; however, an actual station was not established until 1885, and the private lab was established in 1930; e.g., Hobart 1996, Cart 2004).

1931 Bass Biological Laboratory established (Charlotte County Historical Center 2013, Mahadevan 2010).

St. Marks National Wildlife Refuge (E.O. 5740) established.

1933 The Florida State Board of Conservation established (CH. 16178, Laws of Florida).

1934 Fish and Wildlife Coordination Act (48 Stat. 401) authorizes the Secretaries of Agriculture and Commerce to, among other things, study the effects of effluents (domestic and industrial) and other pollutants on wildlife.

1935 The Florida Game and Fresh Water Fish Commission (a predecessor of the Florida Fish and Wildlife Conservation Commission) established (Ch. 17016, Laws of Florida).

Alabama Department of Game and Fisheries renamed Department of Conservation of Game, Fish, and Seafoods.

Delta National Wildlife Refuge (E.O. 7229) established.

Rockport Marine Laboratory established on the houseboat *Vivian* (Aransas Pathways 2013).

1936 First offshore oil lease in the northern Gulf of Mexico (in Louisiana waters).

1937 First offshore oil field discovered in Louisiana waters (first in northern Gulf).

Sabine (E.O. 7764) and Aransas (E.O. 7784) National Wildlife Refuges established.

Texas Game, Fish, and Oyster Commission adds the Coastal Division.

1938 First offshore well drilled in Texas waters (no oil found).

The Palmetto Key field station of the American Museum of Natural History established (it would close in 1942 due to WWII).

1939 Alabama Department of Conservation of Game, Fish, and Seafoods renamed Department of Conservation.

1940 U.S. Fish and Wildlife Service (FWS) established within the U.S. Department of the Interior under an Executive Branch reorganization (from Bureau of Fisheries; 54 Stat. 1232; includes NWRs, National Wetlands Inventory (NWI; status and trends for wetlands and deepwater habitats), monitors water quality in conjunction with other U.S. D.O.I. agencies).

1941 First offshore oil discovery in Texas waters.

Chassahowitzka National Wildlife Refuge established.

The University of Texas Marine Science Institute formally established in Port Aransas (originally at Galveston in 1900, but destroyed by a hurricane the same year (tried again 15 years later in the same location, but hit by another storm)).

1943 University of Miami's Marine Laboratory (renamed the U.M. Rosenstiel School of Marine and Atmospheric Science in 1969) formally established.

1944 Louisiana Department of Wild Life and Fisheries established from the Louisiana Department of Conservation (the name would change again in 1952 (Louisiana Wild Life and Fisheries Commission) and in 1975 (Louisiana Department of Wildlife & Fisheries, the current agency)).

1945 J.N. "Ding" Darling National Wildlife Refuge established.

Alabama establishes the Oil and Gas Board.

1946 Bureau of Land Management (BLM) established.

Laguna Atascosa National Wildlife Refuge established.

Office of Naval Research (ONR) established (P.L. 79-588); Navy Oceanographic Meteorological Automatic Device (NOMAD) buoy developed in the late 1940s for the Navy's offshore data collection program marking a shift in the use of marine buoys for military, navigation and mooring purposes to meteorological and oceanographic (scientific) purposes.

1947 The Mississippi Academy of Sciences establishes the Gulf Coast Research Laboratory (GCRL).

The Florida Legislature appropriates money to support the U.M. Marine Laboratory as an agency of the State Board of Conservation; serves as the State's marine lab until the one in St. Petersburg is established.

First exploratory oil well drilled in Florida waters.

University of Corpus Christi founded (it later becomes Texas Agricultural & Mechanical University, Corpus Christi (TAMU-CC)).

A permanent building constructed for the Rockport Marine Laboratory (Aransas Pathways 2013).

1948 The [Federal] Water Pollution Control Act (P.L. 80-845; later amendments name it CWA or WQA) administered by the Public Health Service.

The Gulf and Caribbean Fisheries Institute established at the University of Miami's Marine Laboratory.

Texas Game, Fish, and Oyster Commission officially establishes the Rockport Marine Laboratory (dedicated in 1948 (MFR 1988), opens 1948 (TPWD 1999); Galtsoff 1954 gives the date as 1949).

1949 Coastal monitoring in Alabama by the Alabama Water Improvement Advisory Commission.

The Florida State University Oceanographic Institute opens as a coastal laboratory at Alligator Harbor, south of Tallahassee. It operates until 1968 when it is moved and renamed.

South Florida Water Management District (originally called the Southern Florida Flood Control District, the name would change with the passage of the Florida Water Resources Act) established; Florida's first WMD.

Gulf States Marine Fisheries Commission (GSMFC) established (P.L. 81-66).

1950 Fort Crockett selected as the U.S. FWS Fisheries (later the NMFS) Research Laboratory; this would later house the TAMU-Galveston Marine Laboratory in 1957, as well

The Bureau of Commercial Fisheries Mississippi Laboratory at Pascagoula established; transferred to NOAA NMFS in 1970.

Federal Aid in Sport Fishing Act.

National Science Foundation (NSF) established.

1951 Scripps Institute of Oceanography conducts extensive research of sediments in the northern Gulf for the American Petroleum Institute.

First oil test wells drilled in Mobile Bay (no oil found).

Bulletin of Marine Science of the Gulf and Caribbean founded within the U.M. Marine Laboratory.

Pinellas National Wildlife Refuge established.

Seahorse Key Marine Laboratory established by the University of Florida.

FWS begins "comprehensive research in oceanography and fisheries resources of the Gulf of Mexico" (Galtsoff 1954).

Texas Game, Fish, and Oyster Commission renamed Texas Game and Fish Commission.

1952 TAMU-Galveston Marine Laboratory established.

1953 Outer Continental Shelf Lands Act and the Submerged Lands Act play a role in offshore oil leasing and exploration.

Texas Water Pollution Control Advisory Council established within the Texas Department of Health.

Howard T. Odum publishes Dissolved Phosphorus in Florida Waters which relates phosphorus to red-tide blooms.

1954 BLM began leasing submerged lands in the GOM for oil, gas, and sulfur mining.

Paul Galtsoff publishes Gulf of Mexico Its Origin, Waters, and Marine Life in the Fishery Bulletin of the Fish and Wildlife Service.

International Convention for the Prevention of Pollution of the Sea by Oil.

1955 Cape Haze Marine Laboratory established (would become Mote Marine Laboratory).

The Florida State Board of Conservation establish the Florida Marine Laboratory at Bayboro Harbor in St. Petersburg (this becomes the Florida Marine Research Laboratory in 1969, FMRI in 1988, and later FWRI in 2004; over the years it goes from the State Board of Conservation to FDNR (1969), then to FDEP (1993), then finally to FFWCC in 1999).

1956 Water Pollution Control Act (P.L. 84-660).

Fish and Wildlife Act (16 USC 742) directs a program of fisheries research; establishes the Bureaus of Commercial Fisheries and of Sport Fisheries and Wildlife.

1957 Texas Water Development Board (another predecessor of TCEQ) established.

Texas Game and Fish Commission begins a statewide water quality survey.

1959 U.S. military begin the CORONA program beginning satellite remote sensing; the program continues through 1972 and the images are declassified in 1995.

1960 Television and Infrared Observational Satellite (TIROS-1) launched by the DOD and NASA, the first experimental weather satellite; in 1966 the satellites became operational and were named TIROS Operational Satellites (TOS) and were renamed Polar Orbiting Environmental Satellites (POES) in 1970 with the establishment of NOAA; from 1978 the satellites would carry the Advanced Very High Resolution Radiometer (AVHRR) used in many oceanographic models.

1961 Oil Pollution Act (P.L. 87-167) expanded the area of coverage for the 1924 Act from 3 mi. to 50 mi.

Texas Water Pollution Control Board established through the Texas Pollution Control Act.

Southwest Florida Water Management District established.

Centro de Investigacio´n y de Estudios Avanzados del Instituto Polite´cnico Nacional (CINVESTAV-IPN, Center for Research and Advanced Studies of the National Polytechnic Institute; Yucatan, Mexico; one of six Mexican marine labs) established (for the Mexican Gulf states: one campus located in Merida, Yucatan and one in Ciudad Victoria, Tamaulipas).

Moody National Wildlife Refuge established.

John C. Stennis Space Center Established.

1962 Texas Water Commission (another predecessor of TCEQ) established.

Padre Island National Seashore established (Act to Provide for the Establishment of Padre Island National Seashore, P.L. 87-712).

The U.S. Naval Hydrographic Office renamed the U.S. Naval Oceanographic Office.

The Cuban Academy of Sciences established (Law 1011).

1963 Texas Parks and Wildlife Department established with the merger of Texas Parks Board and the Texas Game and Fish Commission; the Department manages the State's four Coastal Preserves.

Anahuac National Wildlife Refuge established.

Multibeam SONAR (SONAR Array Sounding System (SASS)) developed for the USN by General Instruments; the first commercial unit (Sea Beam) was produced in 1975, but was not successful until 1980 (e.g., Theberge 1989, Farr 1980).

1964 WHOI builds the Deep Sea Vehicle (DSV) *Alvin* to study the deep sea (Office of Naval Research contract)

Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309).

Water Resources Research Act of 1964 (P.L. 88-379) establishes National Institutes for Water Resources.

1965 Water Quality Act (P.L. 89-234; later amendments name it Clean Water Act) set water quality standards; Federal Water Pollution Control Administration (within the Department of Health, Education, and Welfare) established.

Texas Water Rights Commission (another predecessor of TCEQ) established.

Instituto de Oceanologia (Institute of Oceanography, Cuba) founded.

University of South Florida, St. Petersburg (USF) established.

The Florida Marine Laboratory begins exploring the Florida Shelf with the Hourglass Cruises (1965–1967).

1966 National Wildlife Refuge System Administration Act.

Clean Water Restoration Act (P.L. 89-753); amends the 1924 OPA and the 1948 FWPCA; authorizes a comprehensive study of the effects of pollution in the estuaries and

estuarine zones of the U.S. on fish and wildlife, sport and commercial fishing, recreation, water supply, etc.

National Sea Grant College and Program Act establishes Sea-Grant (four Sea-Grant college programs in the Gulf).

The Interagency Committee on Oceanography's Ocean Engineering Panel of recommends that the USCG investigate the consolidation of a national data buoy system.

Estero Bay Aquatic Preserve established (Florida's first aquatic preserve).

Mississippi Air & Water Pollution Control Commission established.

Bureau of Commercial Fisheries establishes the Panama City Laboratory.

The President's Reorganization Plan No. 2 of 1966 transfers the Federal Water Pollution Control Administration to the Department of the Interior from the Department of Health, Education, and Welfare.

1967 Texas Water Quality Board established through the Texas Water Quality Act.

The National Council for Marine Research Resources and Engineering Development endorsed the formation of the National Data Buoy Development Program (NDBDP) under the purview of the USCG.

USF Marine Science Program established.

Florida Institute of Oceanography established.

The Sanibel-Captiva Conservation Foundation (SCCF) incorporated.

1968 Estuary Protection Act (P.L. 90-454) authorizes the Secretary of the Interior, in conjunction with other agencies, to study the estuaries (including the water) of the United States; requires to assessments of impacts of commercial and industrial developments upon estuaries.

St. Vincent and San Bernard National Wildlife Refuges established.

Florida State University Coastal and Marine Laboratory established, replacing the Oceanographic Institute that opened in 1949.

The Alabama Marine Sciences Consortium established (Ch. 45-16, Alabama Code).

1969 National Environmental Policy Act (P.L. 91-190; passed in 1969 but enacted Jan. 1, 1970).

The Texas Solid Waste Disposal Act authorizes the Texas Water Quality Board to regulate industrial solid waste, and the Texas Department of Health to regulate municipal solid waste.

The Florida Department of Natural Resources established (Ch. 69-106, Laws of Florida); combines all or some functions of the following: State Board of Conservation, the Canal Authority, the Commission on Marine Sciences and Technology, the Florida Keys

Aqueduct Commission, the Board of Parks and Historic Memorials, the Outdoor Recreational Development Council, the Board of Drainage Commissioners, and the Suwannee River Development Authority (in 1975, the Board of Trustees of the Internal Improvement Trust Fund also became part of the Department of Natural Resources (Ch. 75-22, Laws of Florida)).

The Florida Department of Air and Water Pollution Control (Ch. 69-109, Laws of Florida) established from the Florida Air and Water Pollution Commission (the name is changed to the Florida Department of Pollution Control in 1971 (Ch. 71-22, Laws of Florida), and later portions become part of the FDOH and FDER (Ch. 75-22, Laws of Florida)).

The Florida Department of Agriculture and Consumer Services established through the Executive Reorganization Act.

The Alabama Marine Sciences Consortium begins publication of Journal of Marine Science (later becomes Northeast Gulf Science and then Gulf of Mexico Science, published by DISL).

Texas Parks and Wildlife Department established the Perry R. Bass Marine Fisheries Research Station in Palacios (TPWD 2003).

1970 Water Quality Improvement Act (P.L. 91-224); repeals original OPA; amends 1966 Clean Water Restoration Act; changes the name of the Federal Water Pollution Control Administration to the Federal Water Quality Administration.

Reorganization Plans Nos. 3 and 4 of 1970 (84 Stat. 2090) establishes NOAA and EPA; dissolves Federal Water Quality Administration, National Air Pollution Control Administration, the Environmental Control Administration from the Department of Health, Education and Welfare and specific environmental agencies from the Departments of Agriculture and Interior and transfers their duties and responsibilities to EPA; Bureau of Commercial Fisheries transferred from FWS to NOAA and renamed National Marine Fisheries Service; NDBDP is transferred from USCG to NOAA and renamed National Data Buoy Office (NDBO) within the National Ocean Service (NOS) and located in Mississippi (through an MOA, the USCG continues to assist in the program; data from buoys are transmitted to NOAA Geostationary Operational Environmental Satellites (GOES) hourly; by 1979 there are three 12-m deep-sea buoys in the Gulf).

Centro de Investigaciones Marinas (Center for Marine Research, University of Havana, Cuba) founded.

Estacion de Investigaciones Marinas El Carmen (Marine Research Station El Carmen), Instituto de Ciencias del Mar y Limnología (ICML; CEDUCAD, Universidad Autónoma de Chiapas-UNAM; Campeche, Mexico) founded.

EPA- Gulf Ecology Division established.

1971 Alabama's legislature established the Dauphin Island Sea Laboratory.

Alabama Department of Conservation and Natural Resources established (The Division of Marine Resources are housed here; Ch. 220-3 Alabama Administrative Code).

TAMU becomes one of the first four Sea-Grant colleges in the U.S. (the first in the Gulf).

Gulf Islands National Seashore (P.L. 91-660) established.

1972 Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) FWPCA; later amended by CWA.

NASA launches the Earth Resource Technology Satellite (ERTS-1), which would later become known as Landsat-1 (the Thematic Mapper (TM) would not be added until Landsat-4 in 1982).

Coastal Zone Management Act (CZMA; P.L. 92-583); establishes National Estuarine Research Reserves (NERRs; originally Estuarine Sanctuaries, renamed in the 1988 reauthorization); NERRs intended for long-term monitoring, research, education and stewardship.

Marine Protection, Research, and Sanctuaries Act (also known as the Ocean Dumping Act, later known as the National Marine Sanctuaries Act, NMSA); establishes National Marine Sanctuaries (NMS); authorizes research and coastal water quality monitoring.

Florida's five Water Management Districts (four border the Gulf) established (Florida Water Resources Act, Ch. 72-299, Laws of Florida; shifts focus from strictly flood control to broad-based resource management for the previously existing WMDs).

The Louisiana Legislature passes Act 460 establishing the Governor's Council on Environmental Quality (GCEQ).

Mississippi Coastal Program mandated (Section 51-15-6 Mississippi Code of 1972).

1973 International Convention for the Prevention of Pollution from Ships regulates oil, chemical, sewage and garbage discharges.

NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) moves to Virginia Key (AOML, UM's Rosenstiel School of Marine and Atmospheric Science, NOAA's Southeast Fisheries Science Center, the Miami Seaquarium, and the Maritime and Science Technology Academy (MAST Academy) are all located together on Virginia Key, Miami).

University of Texas Pan American establishes the Coastal Studies Laboratory.

University of Corpus Christi becomes Texas Arts & Industries University at Corpus Christi.

1974 Egmont Key National Wildlife Refuge established.

1975 Key Largo NMS established (2nd NMS).

Florida Department of Environmental Regulation established (Florida Environmental Reorganization Act of 1975, Ch. 75-22, Laws of Florida).

ERES-2 (later known as Landsat-2) launched.

Instituto de Ecologıa, A.C. (INECOL; Ecology Institute; La Mancha, Veracruz, Mexico) founded; Mexican research laboratory specializing in coastal ecology, especially in the study and management of coastal tropical forests, dunes and mangroves.

Alabama Department of Public Health (Ch. 22, Alabama Administrative Code) established.

Florida passes the Florida Aquatic Preserve Act (FAPA; Section 258.36 Florida Stats.).

Louisiana merges GCEQ with the technology transfer operations of the Department of Administration to form the Governor's Office of Science, Technology and Environmental Policy (OSTEP).

Sandhill Crane National Wildlife Refuge established.

1976 Resource Conservation and Recovery Act (RCRA, 42 USC 6901) governs disposal of solid and hazardous wastes; compliance monitoring.

The Sea Grant Improvement Act amends the National Sea Grant College and Program Act of 1966 and adds the State University System of Florida to the program (2nd in the Gulf).

Louisiana Department of Natural Resources (R.S. 36:351) established; houses the Office of Coastal Management which regulates the use of Louisiana's coastal zone

The U.S. Naval Oceanographic Office relocated to the National Space Technology Laboratory at the John C. Stennis Space Center.

Gulf of Mexico Fishery Management Council established by the Fishery Conservation Management Act (Magnuson-Stevens Fishery Conservation and Management Act).

Cuba establishes the Comisión Nacional para la Protección del Medio Ambiente y los Recursos Naturales (COMARNA, the National Commission for the Protection of the Environment).

1977 Clean Water Act (P.L. 95-217) amends the FWPCA.

Texas Department of Water Resources (TDWR) established.

Texas A&I University at Corpus Christi becomes Corpus Christi State University.

Mexico and U.S. establish MEXUS-Gulf [fisheries research] Program.

DISL begins publication of Northeast Gulf Science (formerly the Journal of Marine Science and later the Gulf of Mexico Science).

1978 NASA renames the ERES satellites Landsat and launches Landsat-3 and TIROS-N; Nimbus-7 research and development satellite launched with CZCS (Coastal Zone Color

Scanner) radiometer to map surface temperature, salinity (based on color (gelbstoffe)), chlorophyll and sediment concentrations creating a foundation for future satellite color sensors, such as SeaWiFS and MODIS.

LSU becomes a Sea-Grant college.

Rookery Bay National Estuarine Research Reserve, the Gulf of Mexico's first NERR founded

The Louisiana State and Local Coastal Resources Management Act (LA R.S. 49:214.21 et seq.) enacted.

Mississippi Department of Natural Resources established, consolidating the following agencies: Mississippi Geological Survey, the Board of Water Commissioners, the Air and Water Pollution Control Commission, the Park Commission, and the Mineral Lease Commission.

Texas Point National Wildlife Refuge established.

Fish and Wildlife Improvement Act (P.L. 95-615) authorizes cooperative research programs for fish and wildlife resources.

1979 Louisiana Universities Marine Consortium (LUMCON) established.

Alabama Coastal Area Management Program established.

First offshore oil discovery in Alabama waters.

Apalachicola National Estuarine Research Reserve founded.

NOAA-6 satellite launched.

Lower Suwannee National Wildlife Refuge established.

1980 Act to Prevent Pollution from Ships (P.L. 96-478) ships in U.S. waters, or U.S. ships anywhere, must follow pollution prevention guidelines established in the International Convention for the Prevention of Pollution from Ships of 1973.

Comprehensive Environmental Response, Compensation, and Liability Act (P.L. 96-510; CERCLA) addressed hazardous waste spills and further regulates oil spills (NRDA regulations).

Bon Secour (P.L. 96-267), McFaddin and Crocodile Lake National Wildlife Refuges established.

National Aquaculture Act (16 USC 2801-2810).

Mexico and U.S. sign the MEXUSGULF Plan to coordinate response to hazardous material discharges in the Gulf.

1981 Looe Key National Marine Sanctuary established (6th NMS).

NOAA-7 satellite launched.

TAMU Geochemical and Environmental Research Group (GERG) founded at the Galveston campus.

The GSMFC establishes the Southeast Area Monitoring and Assessment Program (SEAMAP).

1982 Minerals Management Service established.

Alabama Department of Environmental Management established (AL Legislative Act No. 82-612).

Landsat-4 satellite launched; equipped with TM (7 spectral channels and 30m resolution).

The NDBO is renamed the National Data Buoy Center and transferred to NOAA's NWS; in conjunction with the USCG, the C-MAN program is established to collect meteorological and oceanographic data around lighthouses.

Mississippi/Alabama Consortium achieves Sea-Grant college status.

USACE publishes *Evaluation of Marsh/Estuarine Water Quality and Ecological Models: an Interim Guide* summarizing the knowledge of estuarine, coastal, and marsh ecosystems models.

1983 Aransas (P.L. 98-66), Crystal River National Wildlife Refuge established.

Louisiana Department of Environmental Quality (LDEQ) established.

Big Boggy National Wildlife Refuge established.

1984 National Fishing Enhancement Act; requires monitoring at artificial reefs.

Hazardous and Solid Waste Amendments (HSWA) to RCRA.

Landsat-5 and NOAA-9 satellites launched.

Land Remote Sensing Policy Act of 1984 (15 USC 4201).

Corpus Christi State University (later known as TAMU-CC) establishes the Center for Coastal Studies, its first research center.

Water Resources Research Act (42 USC 10301 et seq.) amended.

1985 Texas Water Commission and Texas Water Development Board re-established (transfers regulatory enforcement to the Texas Water Commission, and planning and finance responsibilities to the Water Development Board).

Louisiana Department of Wildlife and Fisheries' Grand Terre Research Facility renamed the Lyle S. St. Amant Marine Laboratory of Louisiana.

The Gulf and Caribbean Fisheries Institute becomes an independent not-for-profit corporation.

Texas Parks and Wildlife Department's Resource Protection Branch elevated to Division status; given authority over fish and wildlife resources, particularly in relation to water quality.

1986 Congress passes the Superfund Amendments and Reauthorization Act (SARA), re-authorizes CERCLA, and creates the Toxic Release Inventory (TRI); compliance monitoring.

SPOT-1 (French) and NOAA-10 satellites launched.

Weeks Bay National Estuarine Research Reserve founded (through the Emergency Wetlands Resources Act (P.L. 99-645); this Act authorized the acquisition of the land that would become Bayou Savage National Wildlife Refuge, est. 1990, as well).

Lamar University establishes the Center for Coastal and Marine Studies.

Texas GLO begins its Adopt-A-Beach Program.

The Mississippi Research Consortium (MRC) established, includes Jackson State University, Mississippi State University, the University of Mississippi, and the University of Southern Mississippi.

1987 Water Quality Act (P.L. 100-4) establishes National Estuary Program with this amendment to the CWA (FWPCA).

MOS-1 (Marine Observation Satellite; Japanese) launched.

Corpus Christi State University establishes the Conrad Blucher Institute for Surveying and Science.

Ley General del Equilibrio Ecológico y la Protección al Ambiente (LGEEPA; General Law for Ecological Balance and Environmental Protection) established (effective 1988); environmental protection law that covers water, air, hazardous materials, etc.; administration and monitoring of Marine Protected Areas.

1988 NOAA-11, IRS-1A (Indian), and RESURS-01 (Russian) satellites launched.

Cameron Prairie National Wildlife Refuge established.

Galveston Bay National Estuary Program established (33 USC 1330; Texas Estuaries Act, Texas Water Code 5.601 – 5.609).

Gulf of Mexico Program initiated by the EPA.

1989 NASA begins flying planes equipped with AVIRIS (Airborne Visible/Infrared Imaging Spectrometer).

Sarasota Bay National Estuary Program (33 USC 1330) established.

Mississippi Department of Natural Resources restructured and the Mississippi Department of Environmental Quality established.

Grand Bay National Wildlife Refuge established.

Corpus Christi State University becomes Texas A&M University-Corpus Christi (TAMU-CC).

Comisión Nacional del Agua (CONAGUA; the National Water Commission) established to manage and preserve Mexico's water resources.

Texas Institute of Oceanography established at TAMU-Galveston.

1990 Florida Keys National Marine Sanctuary and Protection Act (P.L. 101-605; merges the Key Largo and Looe Key NMSs).

Oil Pollution Act (P.L. 101-380) establishes liabilities and recovery methods; amends section 311 of the Clean Water Act to clarify federal response authority for oil spills.

SPOT-2 and MOS-1b satellites launched.

Centro de Ecologıa, Pesquerıas y Oceanografıa del Golfo de Mexico (Center for Gulf of Mexico Ecology, Fisheries, and Oceanography, EPOMEX (one of Mexico's marine labs); Campeche, Mexico), Universidad Autónoma de Campeche, founded.

Coastal Wetlands Planning, Protection and Restoration Act (P.L. 101-646).

Barataria-Terrebonne and Tampa Bay National Estuary Programs (33 USC 1330) established.

Bayou Savage National Wildlife Refuge established.

The Keys Marine Laboratory established.

Gulf of Mexico Foundation (GMF) incorporated as a 501(c)3 not-for-profit; in 1993 receives its first grant to direct the Gulf of Mexico Regional Research Program.

1991 Texas legislature creates the Texas Natural Resource Conservation Commission, (effective Sept.1, 1993).

NOAA-12, ERS-1 (European Space Agency (ESA)) and IRS-1B satellites launched.

Tampa Bay National Estuary Program established.

Texas Oil Spill Prevention and Response Program established within the Texas GLO.

1992 Oceans Act (P.L. 102-587) amends the Marine Protection, Research, and Sanctuaries Act; Clean Vessel Act is a subtitle within the Act; amends or establishes much ocean-related legislation.

Flower Garden Banks NMS established (10th NMS; An Act to Provide for the Designation of the Flower Garden Banks National Marine Sanctuary, P.L. 102-251).

JERS-1 (Japanese) and Topex/Posiedon (U.S. and French; designed to detect minute changes in sea-level) satellites launched.

Land Remote Sensing Policy Act (P.L. 102-555).

National Oceanic and Atmospheric Administration Act (P.L. 102-567) establishes the National Marine Monitoring Program.

Mississippi Coastal Preserves Program (Coastal Wetlands Protection Act, Miss. Code Ann. sec. 49-27-1 et. seq.) established (includes monitoring and water quality requirements within the program); creates 16 Coastal Preserves.

Coastal Bend Bay National Estuary Program established (33 USC 1330; Texas Estuaries Act, Texas Water Code 5.601 – 5.609).

Procuraduría Federal de Protección al Ambiente (PROFEPA; Federal Agency of Environmental Protection) established; monitors compliance; conducts investigations, inspections and environmental audits.

National Park Service Water Resource Division (WRD) begins the Servicewide Inventory and Monitoring Program.

MMS funds the integration of Acoustic Doppler Current Profilers (ADCP) to NDBC moored buoys (first three off the coast of California).

1993 Alabama Coastal Watershed Survey Program established.

Texas Natural Resource Conservation Commission established; integrating the Texas Water Commission.

The Florida Department of Environmental Protection is established, merging the FDER and FDNR (Florida Environmental Reorganization Act, Ch. 93-213, Laws of Florida).

SPOT-3 and IRS-P1 satellites launched.

Eckerd College establishes the Galbraith Marine Science Laboratory.

1994 IRS-P2 and RESURS-02 (Russian) satellites launched.

Mississippi Department of Marine Resources (MDMR) established.

Secretaría de Medio Ambiental, Recursos Naturales y Pesca (SEMARNAP; Secretariat of the Environment, Natural Resources and Fishing) established.

Cuba establishes the Ministerio de Ciencia, Tecnología y Medio Ambiente (CITMA, the Ministry of Science, Technology and Environment; Decree-Law No. 147), replacing the Cuban Academy of Science and COMARNA; houses the Department of Environmental Policy.

1995 ERS-2, RADARSAT (Canadian), and IRS-1C satellites launched.

The National Estuarine Research Reserves' System-Wide Monitoring Program established.

Mobile Bay and Charlotte Harbor National Estuary Programs (33 U.S.C. 1330) established.

Texas General Land Office (GLO) establishes the Texas Automated Buoy System (TABS).

Florida Keys National Marine Sanctuary begins its Water Quality Monitoring Project.

Gulf of Mexico States Accord (GOMSA) established (in conjunction with the Gulf of Mexico States Partnership, Inc., a 501(c)6 not-for-profit, that funds research in the Gulf, among other efforts).

1996 National Marine Sanctuaries Preservation Act (P.L. 104-283; amendment to NMSA) adds Stetson Bank to Flower Gardens Bank NMS.

Research section of U.S. FWS transferred to USGS.

IRS-P3, PRIRODA (Russian), and ADEOS-1 (Japanese; includes sensors for measuring ocean color and temperature) satellites launched.

Ten Thousand Islands and Brazoria National Wildlife Refuges established.

Marine Minerals Resources Research Act (P.L. 104-325) established.

The National Park Service Water Resource Division (WRD) documents surface water quality monitoring in and around Everglades National Park (study area includes Florida Bay) from 1937.

Northeast Gulf Science changes its name to Gulf of Mexico Science.

1997 Seastar (with SeaWiFS multi-spectral sensor for measuring ocean color), Lewis (commercial built, TRW Space and Electronics Group; failed), IRS-1D, and EarlyBird (commercial, Earth Watch Inc.; failed) satellites launched.

Texas Coastal Management Program federally approved and is administered by the Coastal Coordination Council, consisting of the following agencies: the General Lands Office (lead agency), Parks and Wildlife Commission, the Texas Commission on Environmental Quality, the Texas Water Development Board, the Texas Transportation Commission, and the State Soil and Water Conservation Board and the Director of Texas Sea-Grant and four gubernatorial appointees.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (AKA Gulf [of Mexico] Hypoxia Task Force) established.

U.S. Navy begins its Autonomous Underwater Vehicle (AUV) program (includes Unmanned Undersea Vehicles (UUVs), as well) in conjunction with WHOI.

1998 Florida Department of Health establishes its Healthy Beaches program.

SPOT-4 and NOAA-15 satellites launched.

MDMR and USGS enter into agreement to install, operate, and maintain sondes within Mississippi Sound.

President Clinton announces the Clean Water Action Plan.

1999 The Florida Fish and Wildlife Conservation Commission established by amendment to the Florida Constitution.

The Division of Aquaculture created within FDACS.

EOS-1/Terra with MODIS (Moderate-Resolution Imaging Spectroradiometer), Landsat-7, Oceansat/IRS-P4, CBERS-1 (Chinese/Brazilian), and IKONOS (completely commercial, Lockheed Martin Corp.) satellites launched.

Grand Bay National Estuarine Research Reserve founded.

The Gulf of Mexico Large Marine Ecosystem: Assessment, Sustainability, and Management published by UNIDO Gulf LME Program.

2000 Estuaries and Clean waters Act (P.L. 106-457, AKA Estuary Restoration Act) establishes guidelines for monitoring of restoration projects within U.S. estuaries and is administered by the ACOE in conjunction with NOAA, FWS, EPA and USDA/NRCS.

E.O. 13158 expands protection for Marine Protected Areas.

Oceans Act of 2000 (P.L. 106-256) establishes the United States Commission on Ocean Policy.

Instituto de Ciencias Marinas y Pesquerías (ICIMAP; Institute of Marine Science and Fisheries; currently in Boca del Rio, Veracruz, originally established, and formerly called Centro de Ecología y Pesquerías, in Xalapa, Veracruz).

Harte Research Institute for Gulf of Mexico Studies established.

Methane Hydrate Research and Development Act (amended in 2005; P.L. 106-193); Gulf sea floor observatory established in 2005.

Secretaría de Medio Ambiente y Recursos Naturale (SEMARNAT; Ministry of the Environment and Natural Resources) established (formerly SEMARNAP; fisheries transferred to the Agriculture Ministry); the Comisión Nacional de Áreas Naturales Protegidas (CONANP; National Commission of Natural Protected Areas) also established this year.

Beaches Environmental Assessment and Coastal Health Act (P.L. 106-284, BEACH Act) amends the CWA.

2001 Texas legislature adopts HB 2912, which continues the Texas Natural Resource Conservation Commission for another 12 years and includes a provision for its name to change to the Texas Commission on Environmental Quality by 2004.

QuickBird satellite launched.

New College establishes the Pritzker Marine Biological Research Center.

2002 EOS-2 (MODIS)/Aqua, EnviSat (ESA), SPOT-5, and NOAA-17 satellites launched.

Texas Commission on Environmental Quality (TCEQ) formally established.

The National Park Service Water Resource Division (WRD) documents surface water quality monitoring in areas of Tampa Bay near the De Soto National Memorial from 1966.

Sanibel-Captiva Conservation Foundation establishes its Marine Laboratory.

The National Institute for Undersea Science and Technology (NIUST) established as a partnership of USM, UM, and NOAA' Undersea Research Program (NURP).

2003 CBERS-2 and ORBIMAGE-3 satellites launched.

The National Park Service Water Resource Division (WRD) documents surface water quality monitoring in and around Padre Island National Seashore from 1941 as part of the Servicewide Inventory and Monitoring Program.

2004 TCEQ initiates the Environmental Monitoring and Response System (EMRS) to measure environmental conditions in real time.

Florida Gulf Coast University (FGCU) establishes the Coastal Watershed Institute (CWI).

Gulf of Mexico Alliance (GOMA) formed.

Mexico's Instituto de Ecologia and Harte Research Institute publish *Diagnóstico ambiental del Golfo de México* (translated to English in 2009 as: *Environmental Analysis of the Gulf of Mexico*) for SEMARNAT.

2005 The Gulf of Mexico Coastal Oceans Observing System (GCOOS) Regional Association established within Integrated Oceans Observing System (IOOS).

The Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act (P.L. 109-148) establishes Louisiana Coastal Protection and Restoration Authority (LACPRA; formed from restructuring the Louisiana Wetlands Conservation and Restoration Authority).

GOMA comes out with first *Gulf of Mexico Governors' Action Plan*, which includes improving Gulf monitoring as a priority.

2006 Mission-Aransas National Estuarine Research Reserve founded.

Water Resources Research Act of 2006 (P.L. 109-471).

Mexico's National Environmental Policy for Oceans and Coasts (Política Ambiental Nacional para el Desarrollo Sustentable de Océanos y Costas) presented by SEMARNAT.

NOAA's Northern Gulf Institute (a NOAA Cooperative Institute which partners with the following academic institutions: Mississippi State University (MSU), University of Southern Mississippi (USM), Louisiana State University (LSU), Florida State University (FSU) and the Dauphin Island Sea Lab (DISL)) established at the John C. Stennis Space Center.

2007 Texas legislature amends Texas Water Code establishes new regulatory approaches for surface water flow in river, bay, and estuarine systems.

CBERS-2B satellite launched.

National Strategy for the Marine and Coastal Ordinance (Estrategia Nacional para el Ordenamiento Ecológico del Territorio en Mares y Costas) presented by SEMARNAT.

NASA's Applied Science Program creates the Gulf of Mexico Initiative to assist GOMA in addressing priority issues (**NOTE:** there is another Gulf of Mexico Initiative (GoMI) within the USDA/NRDC to help farmers improve water quality through sustainable production; created in response to the 2010 oil spill).

Sanibel-Captiva Conservation Foundation launches its RECON (River, Estuary, and Coastal Observing Network) program.

Estuaries and Clean waters Act amended by the Water Resources Development Act of 2007 (P.L. 110-114).

USGS establishes the Gulf Coast Science Forum; partners include: GOMA, NPS, FWS, Louisiana Coastal Area Science Board, Mississippi Coastal Improvements Program, and Pontchartrain Institute for Environmental Sciences.

2008 Comisión Intersecretarial para el Manejo Sustentable de Mares y Costas (CIMARES; Commission for Sustainable Management of Seas and Coasts) established to provide Mexico with a National Policy for Seas and Coasts.

Mote Marine Laboratory hosts the Gulf of Mexico Science Forum.

Gulf of Mexico Research Plan (GMRP) developed by the Gulf's Sea-Grant College Programs.

2009 The Lyle S. St. Amant Marine Laboratory renamed the Louisiana Department of Wildlife and Fisheries Research Laboratory.

Vester Field Station established by Florida Gulf Coast University.

Gulf of Mexico Large Marine Ecosystem (LME) project formally established; Project Coordination Unit based in Mexico City, Mexico.

Harte Research Institute publishes Gulf of Mexico Origin, Waters, and Biota (three volumes of seven published through 2011) summarizing the 50 years since Galtsoff's publication.

GOMA comes out with *Gulf of Mexico Governors' Action Plan II*, which continues priority of improving Gulf monitoring.

2010 Secretary of the Interior orders MMS be divided into three separate entities (MMS renamed the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE)): Office of Natural Resource Revenue, Bureau of Ocean Energy Management (BOEM), and Bureau of Safety and Environmental Enforcement (BSEE).

Gulf Coast Ecosystem Restoration Task Force (GCERTF) established by Executive Order

Gulf of Mexico Research Initiative (GoMRI) established.

Gulf of Mexico University Research Collaborative (GOMURC) established

2011 BOEM and BSEE formally established.

MRC revises the GMRP in response to the Deepwater Horizon oil spill.

GOMA WQ Team holds *Monitoring Forum 2011* workshop to identify GOMA water-quality monitoring priorities in the Gulf of Mexico, launching effort to establish an integrated Gulf Monitoring Network (GMN) built on existing monitoring programs.

2012 SPOT-6 satellite launched.

2013 GOMA WQ Team releases draft monitoring design for Gulf Monitoring Network and proposes establishing stable support for long-term monitoring in the Gulf

APPENDICES C–E.
EXISTING GULF OF MEXICO WATER-QUALITY MONITORING PROGRAMS

Compiled by Charles Kovach

APPENDIX C1.
OVERVIEW OF FEDERAL PROGRAMS WITH WATER-QUALITY MONITORING ACTIVITIES

From: Federal Ocean And Coastal Activities Report To The U.S. Congress For Calendar Years 2008 and 2009. Report Prepared by The White House Council on Environmental Quality and The White House Office of Science And Technology Policy. Issued November 16, 2010

1. DEPARTMENT OF AGRICULTURE

a) Natural Resources Conservation Service (NRCS)

Conservation Technical Assistance (CTA)

Environmental Quality Incentives Program (EQIP)

Wetland Reserve Program (WRP)

b) National Institute of Food and Agriculture (NIFA)

Research and Education

Integrated Activities

c) Agricultural Research Service (ARS)

Managing Coasts and Their Watersheds Account

The Marine Aquaculture Account

d) National Forest Service

Gulf of Mexico Research and Development

2. DEPARTMENT OF COMMERCE

4) National Oceanic and Atmospheric Administration (NOAA)

National Ocean Service (NOS)

Mapping and Charting

Ocean Assessment Program

Coastal Management

Office of Response and Restoration (OR&R)

National Marine Fisheries Service (NMFS)

Fisheries Research and Management

Protected Species Research and Management

Oceanic and Atmospheric Research (OAR or NOAA Research)

The National Sea Grant College Program

National Weather Service (NWS)

Marine Observations

Marine Weather Services

Tropical Cyclone Support

Tsunami Program

National Environmental Satellite, Data, and Information Service (NESDIS)

Environmental Satellite Observing Systems

Ocean Remote Sensing

NOAA Data Centers and Information Services

Office of Marine and Aviation Operations

e) National Institute of Standards and Technology

3. DEPARTMENT OF DEFENSE

a) Defense Advanced Research Agency (DARPA)

b) Office of the Secretary of Defense Sciences

Strategic Environmental Research & Development Program (SERDP)

Environmental Security Technology Certification Program (ESTCP)

c) Department of the Navy

Office of Naval Research (ONR)

Naval Ocean Sciences

Applied Ocean Research

National Oceanographic Partnership Program

Marine Mammals

Oceanographer of the Navy

Oceanography Program

Oceanography – Research and Development to Support Operations

Geospatial Information and Services

d) U.S. Army Corps of Engineers

Construction

Operation and Maintenance

Mississippi River Tributaries

Regional Sediment Management

4. DEPARTMENT OF ENERGY

a) Office of Science

Biological and Environmental Research

b) Office of Fossil Energy R&D

Methane Hydrates Research

Natural Gas Technology

Ultra-Deepwater and Unconventional Natural Gas

c) Office of Energy Efficiency & Renewable Energy

Water Power Program

5. ENVIRONMENTAL PROTECTION AGENCY

a) Office of Water

Place-based Programs:

- Gulf of Mexico Program
- Mississippi River/Gulf of Mexico Watershed Nutrient Task Force
- National Estuary Program/Coastal Ecosystems

Coastal and Marine Pollution Control Programs:

- Regulation of Material for Dumping into the Ocean
- Vessel Pollution
- BEACH Program Grants
- Recreational Water Criteria
- National Marine Debris Program
- Other Clean Water Act Programs

Aquatic Invasive Species Program

Assessing Coastal Conditions:

- Ocean and Coastal Field Assessments

Monitoring and Assessment at the Regional and National Scale

b) Office of International and Tribal Affairs

c) Office of Air and Radiation

Great Waters Program

d) Office of Enforcement and Compliance Assistance (OECA)

Vessel General Permit (VGP) Implementation/OECA and the Regions

6. DEPARTMENT OF HEALTH AND HUMAN SERVICES

a) National Institutes of Health

National Institute of Environmental Health Sciences

Fogarty International Center (FIC)

International Cooperative Biodiversity Groups (ICBG) Program

b) Agency for Toxic Substances and Disease Registry

Division of Health Studies

7. DEPARTMENT OF HOMELAND SECURITY

a) Federal Emergency Management Agency

Flood Map Modernization Fund

Disaster Relief Fund

Pre-Disaster Mitigation Fund

National Flood Insurance Fund (NFIF)

Flood Mitigation Assistance Program

Repetitive Flood Claims Program

Severe Repetitive Loss Program

b) U.S. Coast Guard

Maritime Safety

Maritime Mobility

Protection of Natural Resources

8. DEPARTMENT OF THE INTERIOR

a) U.S. Geological Survey

Geographic Research, Investigations and Remote Sensing

Geological Hazards Assessments

Geologic Landscape and Coastal Assessments

Geologic Resource Assessments

Hydrologic Monitoring, Assessments, and Research

Cooperative Water Program

Water Resources Research Act

Biological Research & Monitoring

Global Climate Change

b) Bureau of Land Management

c) Bureau of Ocean Energy Management, Regulation, and Enforcement

OEMM – Offshore Energy and Minerals Management – Outer Continental Shelf Lands

Environmental Studies Program

Technology Assessment and Research (TA&R) Program

Marine Spatial Planning

ROMM – General Administration

Oil Spill Research

Coastal Impact Assistance Program

d) National Park Service

Operation of the National Park System

Everglades Restoration and Research

e) Fish and Wildlife Service

Resource Management

Construction

Sport Fish

Coastal Wetland Conservation Grants

The Clean Vessel Act Program

North American Wetlands Conservation Fund Grant Program

f) Natural Resource Damage Assessment and Restoration

g) Office of insular Affairs

Assistance to Territories: Coral Reef Initiative

h) Office of the Secretary

ONRR – The Office of Natural Resources Revenue

9. MARINE MAMMAL COMMISSION

10. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

11. NATIONAL SCIENCE FOUNDATION

a) Directorate for Geosciences, Division of Ocean Sciences

b) Directorate for Biological Sciences (Ocean-Related Research)

12. SMITHSONIAN INSTITUTION

a) National Museum of Natural History

Smithsonian Environmental Research Center

Smithsonian Tropical Research Institute

The Marine Environmental Sciences Program (MESP)

13. DEPARTMENT OF STATE AND USAID

a) Department of State: Bureau of Oceans, Environment and Science (OES)

International Fisheries Commissions

Economic Support Funds (ESF), OES Partnerships

Diplomatic & Consular Programs

b) The U.S. Agency for International Development

Development Assistance Accounts

14. DEPARTMENT OF TRANSPORTATION

a) Maritime Administration

Environmental Initiatives:

- Ballast Water and Related Technologies
- Air Emissions/Energy
- Other Discharges
- Marine Generated Noise

Operations and Training

Assistance to Small Shipyards

MARAD's Maritime Security Program (MSP)

The Maritime Guaranteed Loan Program (Title XI)

The Ocean Freight Differential Program

Ship Disposal Program

b) Office of the Secretary

Transportation Planning, Research and Development

15. DEPARTMENT OF THE TREASURY

a) Global Environment Facility

GEF Operations

APPENDIX C2 – KEY FEDERAL WATER-QUALITY MONITORING PROGRAMS

1. Environmental Protection Agency (EPA)

EPAs primary involvements in ocean monitoring are described here. Ocean and coastal protection activities emphasize habitat protection, partnerships, programs addressing ocean-based and land-based sources of coastal and ocean pollution, and water quality monitoring and assessment.

a) Environmental Monitoring and Assessment Program (EMAP)

Aimed to develop the tools and science needed for a state-based statistical monitoring framework to determine trends in the condition of all the nation's aquatic ecosystems. This program used a probabilistic sampling design that relies on data from many sites of similar habitat type as the best estimate for overall condition of that habitat. A variety of information was collected through this program, including water column parameters, sediment chemistry and toxicity, and measurements of benthic communities. While the program provided the benefits of a probabilistic approach, the design was not as well suited for trend analysis. This is now carried out through the National Coastal Condition Reports.

b) National Coastal Condition Report

Coastal monitoring data are obtained from programs such as the EPA's National Coastal Assessment and the Fish & Wildlife Service National Wetland Index, and includes the following data:

c) Coastal-Ocean Condition Data

Obtained from a series of offshore studies conducted to assess the status of ecological condition and potential stressor impacts throughout various coastal-ocean (shelf) regions of the United States.

d) Offshore Fisheries Data

Obtained from programs such as NOAA's Marine Monitoring and Assessment Program and Southeast Area Monitoring and Assessment Program.

e) Advisory Data

Provided to the EPA by states or other regulatory agencies and compiled in nationally maintained databases. The fish consumption advisory data provide information about chemical contaminants in locally caught fish, and beach advisory data provide information about warnings and beach closures associated with the presence of elevated levels of human pathogens at swimming beaches.

The following caveat is provided in the latest NCCR:

"Why Doesn't This Assessment Use More of the Available Data Sets?

Many other sets of monitoring data are available for estuarine and coastal areas around the United States; however, these data sets were not included in this report for several reasons. Most of these data sets were not collected using a probabilistic survey design and, therefore, are not representative of the entire region covered by the

sampling program. For example, the locations of the monitoring stations used to collect the data may have been selected to meet specific program goals, such as monitoring water quality near wastewater-discharge points. Also, these monitoring programs are conducted by different agencies or organizations and use various methods for data collection, analysis, and evaluation. The parameters and time frames monitored may also vary between monitoring programs. Unlike the NCA "snapshot" data, these types of monitoring programs often provide long-term data suitable for assessing program goals or monitoring changes in coastal condition over a longer time period in the areas targeted by these efforts; however, it would be difficult to compare these data sets on a regional or national basis to assess coastal condition or integrate them into the NCCR IV assessment."

f) Office of Water

BEACH Program Grants

Microbiological testing and monitoring of coastal recreation waters support notifying the public of possible exposure to disease-causing microorganisms in coastal recreation waters.

National Marine Debris Program

Supports the International Coastal Cleanup Campaign with grant funding and also supported the National Marine Debris Monitoring Program, which is a statistically based national monitoring program to assess trends and sources of marine debris.

Other Clean Water Act Programs

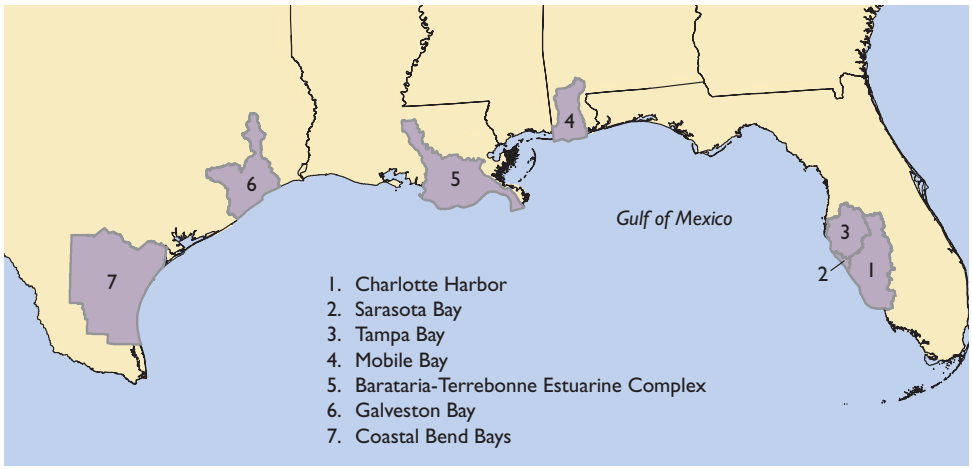
Water quality standards and criteria; point source discharge permit program; technical assistance/grant program to address nonpoint source pollution; total maximum daily load program; and water quality monitoring and reporting.

Ocean and Coastal Field Assessment

The research vessel (RV) Bold is EPA's monitoring and research vessel, and is used with other Federal and State agencies and universities to monitor the health of ecosystems and study biological and chemical problems in them.

EPA also conducts monitoring through its National Estuary Program. As National Estuary Program sites were created, they included an extensive characterization phase and an estuary-specific monitoring plan. Although most continue monitoring to evaluate the effectiveness of their implementation efforts, there is no program-wide monitoring strategy.

g) National Estuary Programs



http://water.epa.gov/type/oceb/nep/index.cfm

1 Charlotte Harbor, FL **http://www.chnep.org/**

2 Sarasota Bay **http://sarasotabay.org/**

3 Tampa Bay **http://www.tbep.org/**

4 Mobile Bay **http://www.mobilebaynep.com/**

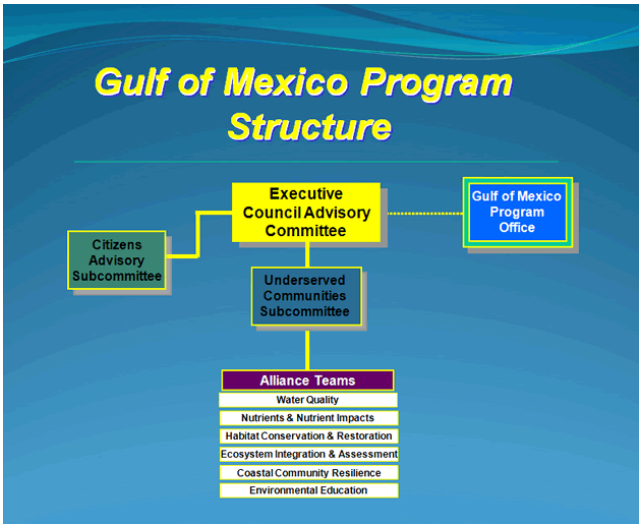
5 Barataria-Terrebonne, LA **http://www.btnep.org/BTNEP/home.aspx**

6 Galveston Bay, TX **http://www.gbep.state.tx.us/**

7 Coastal Bend Bays & Estuaries, TX **http://www.cbbep.org/**

h) Gulf of Mexico Program

http://www.epa.gov/gmpo/



In 1988, EPA began the Gulf of Mexico Program as a non-regulatory program founded on partnership, science-based information, and citizen involvement. The mission of the Program is to facilitate collaborative actions to protect, maintain, and restore the health and productivity of the Gulf of Mexico in ways consistent with the economic wellbeing of the Region.

i) Gulf Ecology Division **http://www.epa.gov/ged/**

The mission of GED is to provide credible scientific approaches to assess ecological condition, determine effects and causes of ecosystem impairments, predict risks to plant and animal populations and ecosystems, and support development of criteria to enhance and protect coastal systems of the Gulf of Mexico and the southeastern United States.

Coastal assessment and services team

Develops and implements methods to determine condition, ecosystem services, and values of coastal habitats, including wetlands and coral reefs; identifies stressors responsible for harm or deterioration; and predicts future consequences of management and policy alternatives.

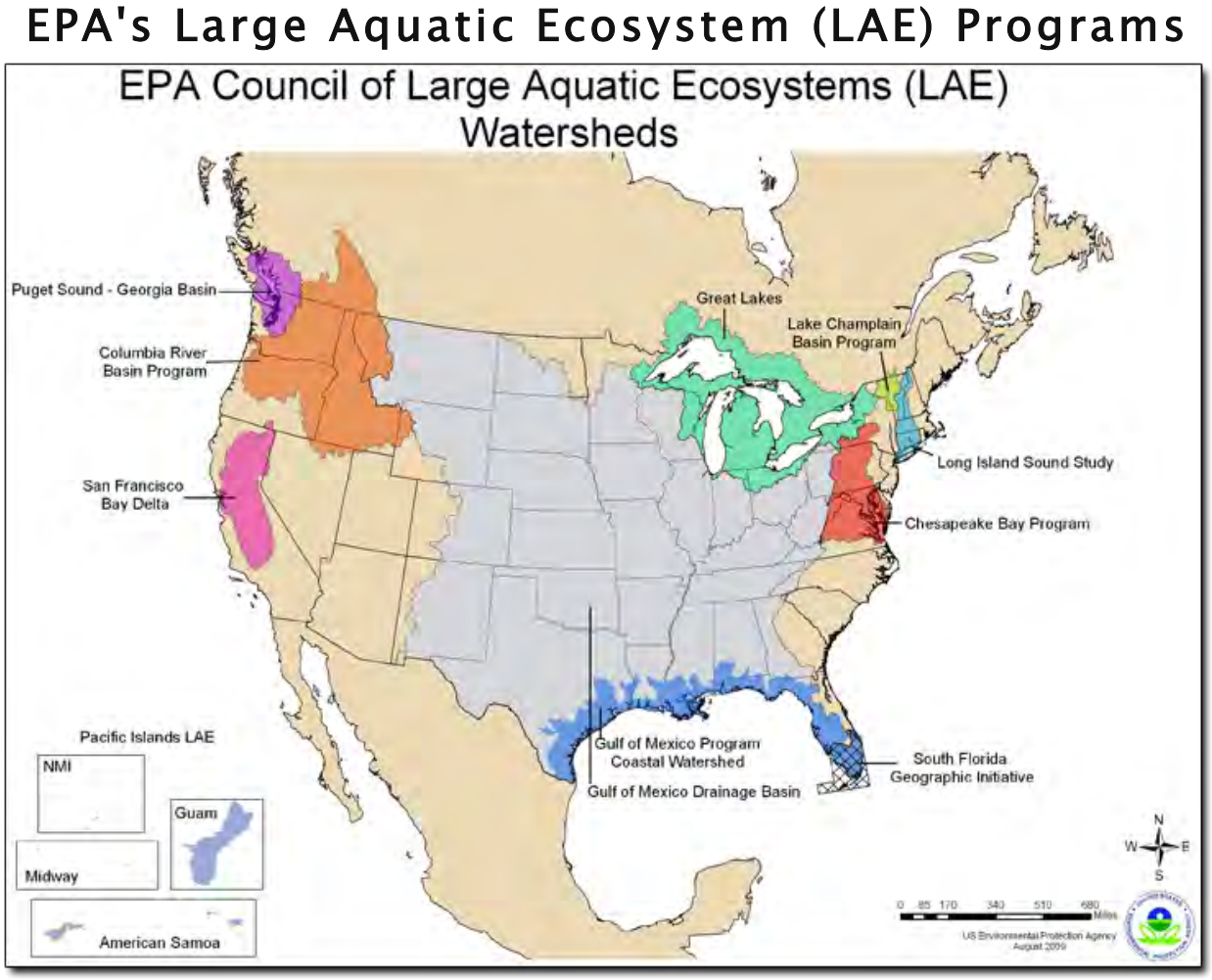
Nutrients team

Develops a suite of model applications, data products and other tools to assess and predict relationships between nutrients and ecosystem responses in estuaries and near-coastal receiving waters such as the Gulf of Mexico hypoxic zone.

Ecotoxicology team

Assesses effects on aquatic and wildlife species, and provides predictive tools and models for estimating species sensitivity, chemical modes of action, and population-level responses.

j) Council of Large Aquatic Ecosystem Watersheds



South Florida Geographic Initiative

http://www.epa.gov/region4/water/southflorida

The 10 LAE programs administered by EPA conduct long-term planning and management to address the complex factors that contribute to the deterioration. It includes the lakes, rivers, wetlands, and estuaries of these important ecosystems. These geographic-based programs involve private and public stakeholders at the local and regional levels to address specific problems, such as loss of habitat, polluted runoff, and invasive species. Their activities include water quality monitoring, working with States to negotiate pollution controls, and educating citizens regarding the causes and cures for these environmental problems. EPA provides funding, guidance, and technical support that builds the capacity of the LAE programs to restore and protect their ecosystems with input from local partners.

2. National Oceanic and Atmospheric Administration (NOAA)

Primary engagement in ocean monitoring by NOAA is through the following:

a) International Ocean Observing System (IOOS)

b) Federal Ocean Acidification Research and Monitoring (FOARAM)

The FOARAM Act of 2009 mandates an active monitoring and research program to determine potential impacts of decreased ocean pH and carbonate saturation states.

c) Oceanic and Atmospheric Research (OAR or NOAA Research)

Monitoring and understanding the influence of atmospheric constituents, including greenhouse gases and aerosols that may affect climate or influence air quality.

d) National Weather Service

Marine Observations

Continuous, real-time monitoring of ocean and atmospheric elements supports weather, water, and seasonal climate prediction. Operates the National Data Buoy Center (NDBC), which designs, develops, operates, and maintains a marine observational network of over 150 data collection buoys and 55 coastal stations.

Office of Marine and Aviation Operations

Conducts hydrographic surveys to support nautical charting; oceanographic and atmospheric research to study global climate change; fisheries-stock and marine-mammal assessments; and monitoring of coastal habitats and pollution trends.

e) Hypoxia Monitoring

NOAA has supported monitoring of the large hypoxic zone (Dead Zone) over the Louisiana/Texas continental shelf in the northern Gulf of Mexico since 1990. Since 2000, this support has come through NOAA's Northern Gulf of Mexico Ecosystem and Hypoxia Assessment Program (NGOMEX), a legislatively mandated competitive program through the Harmful Algal Bloom and Hypoxia Research and Control Act. This effort includes ship surveys and observation systems, and the measurement of hypoxic areal extent generated from from a mid-summer shelf-wide survey is the metric used by the Hypoxia Task Force to inform progress of Mississippi River watershed management practices in mitigating the dead zone. Expansion of monitoring has occurred in recent years through activities informed by the Gulf Hypoxic Zone Monitoring Implementation Plan (2009, revised in 2012), which lays out a strategy for an effective, comprehensive, and sustainable monitoring program that increases spatial and temporal coverage by expanding ship surveys and observing systems, and incorporating routine deployment of autonomous underwater vehicles (gliders). The Plan can be found at:
http://www.ncddc.noaa.gov/activities/healthy-oceans/gulf-hypoxia-stakeholders/

f) Aquatic Resource Monitoring Programs

http://ccma.nos.noaa.gov/about/coast/nsandt/default.aspx

COAST's National Status & Trends

Mussel Watch

Objectives

Mussel Watch supports NOAA ecosystem-based management through an integrated program of environmental monitoring, assessment, and research to describe the current status of pollution and to detect changes in the environmental quality of our nation's estuarine and coastal waters. These interrelated activities are designed to provide coastal managers with national context to measures of local and regional environmental condition. Outcomes include a status of contaminant concentrations around the U.S. Monitoring activities are designed to quantify and assess spatial and temporal trends in coastal contamination, and to provide a baseline to assess impacts of anthropogenic and natural events, including chemical spills, tropical storms, and hurricanes.

Time Frame, 1986 - Present

Mussel Watch Program is the longest continuous, nationwide contaminant-monitoring program in U.S. coastal waters. The program analyzes sediment and bivalve tissue chemistry for a suite of organic contaminants and trace metals to identify trends at over 300 selected coastal sites from 1986 to present.

Mussel Watch Contaminant Monitoring

http://ccma.nos.noaa.gov/about/coast/nsandt/musselwatch.aspx

Parameters monitored include sediment and bivalve tissue chemistry for over 100 organic and inorganic contaminants; bivalve histology; and *Clostridium perfringens* (pathogen) concentrations. This project regularly quantifies PAHs, PCBs, DDTs and its metabolites, TBT and its metabolites, chlorinated pesticides and toxic trace elements.

Monitoring Data - Bioeffects

http://ccma.nos.noaa.gov/about/coast/nsandt/bioeffects.aspx

Bioeffects Assessment Program

Objectives

Utilization of consistent methods over the life of the program allows for comparison of the magnitude and extent of contaminant effects relative to other locations throughout the US, and over time. All data are generated following strict performance-based quality control and quality assurance protocols. Data are available to regional, federal, state and local resource managers and the public via publications, presentations and a website data portal. The Program identifies and assesses biological effects associated with contaminant exposure. Over forty intensive regional studies have been conducted since 1986 using the Sediment

Quality Triad approach, which utilizes a stratified random sampling method to determine the areal extent of contaminated sediments. The data include: sediment chemistry, toxicity, and species diversity and quantity for the same suite of organic contaminants and trace metals as the Mussel Watch Program. This information is integrated into a comprehensive assessment of the health of the marine habitat.

g) NOAA's Estuaries Programs

http://www.epa.gov/nheerl/arm/programpages/noaa_programs.htm

Over the past few decades, a range of monitoring strategies and techniques has been used to address many of the Nation's coastal and estuarine environmental issues. Traditionally, monitoring has involved efforts to inventory the characteristics of coastal and estuarine areas, their resources and the human pressures that threaten them. This type of monitoring quantifies the existing acres of seagrasses and agricultural fields, for example. More recently, the role of monitoring has been expanded to include an examination of the complex cause-and-effect relationships that have developed through human-induced pressures on coastal areas, such as the effects of metals, pesticides and nutrients on fish abundance, reproductive success and ability to feed. Although monitoring provides critical information about the state of the environment, financial and personnel resources are and will continue to be constrained. New monitoring approaches will be necessary to ensure a return of highly valuable information for this investment.

h) NOAA's National Estuarine Eutrophication Assessment

Eutrophication indices provide a simplified way to evaluate nutrient related water-quality conditions, to link the nutrient sources that are probable causes of degradation, and to predict future conditions as a means of informing development of successful management measures. The NOAA's National Estuarine Eutrophication Assessment (NEEA), although it does not conduct its own monitoring, fulfills the goals of the Gulf Monitoring Network (above) using monitoring results from monitoring programs of a diverse group of federal, state, non-governmental and academic partners to develop a comprehensive evaluation of eutrophication in Gulf of Mexico region estuaries and other estuaries around the US coastline. The NEEA includes assessment of 141 US systems, 38 are located in the Gulf of Mexico, by application of the Assessment of Estuarine Trophic Status (ASSETS) tool (Bricker et al., 1999, 2003, 2007, 2008; www.eutro.org; www.eutro.us) which, like other water quality indices (e.g., EPA NCA, US EPA, 2008; TRIX, Vollenweider et al. 1998; WFD-BC, Garmendia et al., 2012; WFD-UK, Devlin et al., 2011, Foden et al., 2011; others in Borja et al., 2008 and Zaldivar et al., 2008), is an aggregated model that uses a combination of chemical and biological water-quality indicators and indices. The ASSETS tool includes quantitative and semi-quantitative components, and uses field data, models and expert knowledge in a Pressure-State-Response framework to evaluate eutrophic conditions, primary causes of observed eutrophic impacts, and what to expect in the future given projected changes in

nutrient load. Applied over multiple timeframes for a single system, and to multiple systems, these indices allow tracking of trends in individual systems and comparison among systems on a consistent basis.

The ASSETS model evaluates three components of eutrophication: (i) *Influencing Factors* combines natural susceptibility and human-related nutrient inputs (Figure 1); (ii) *Eutrophic Condition* estimates level of impact based on five indicators (Figure 2); and (iii) *Future Outlook* evaluates potential changes that may occur based on natural susceptibility and expected changes in nutrient load (Figure 3). The final step combines

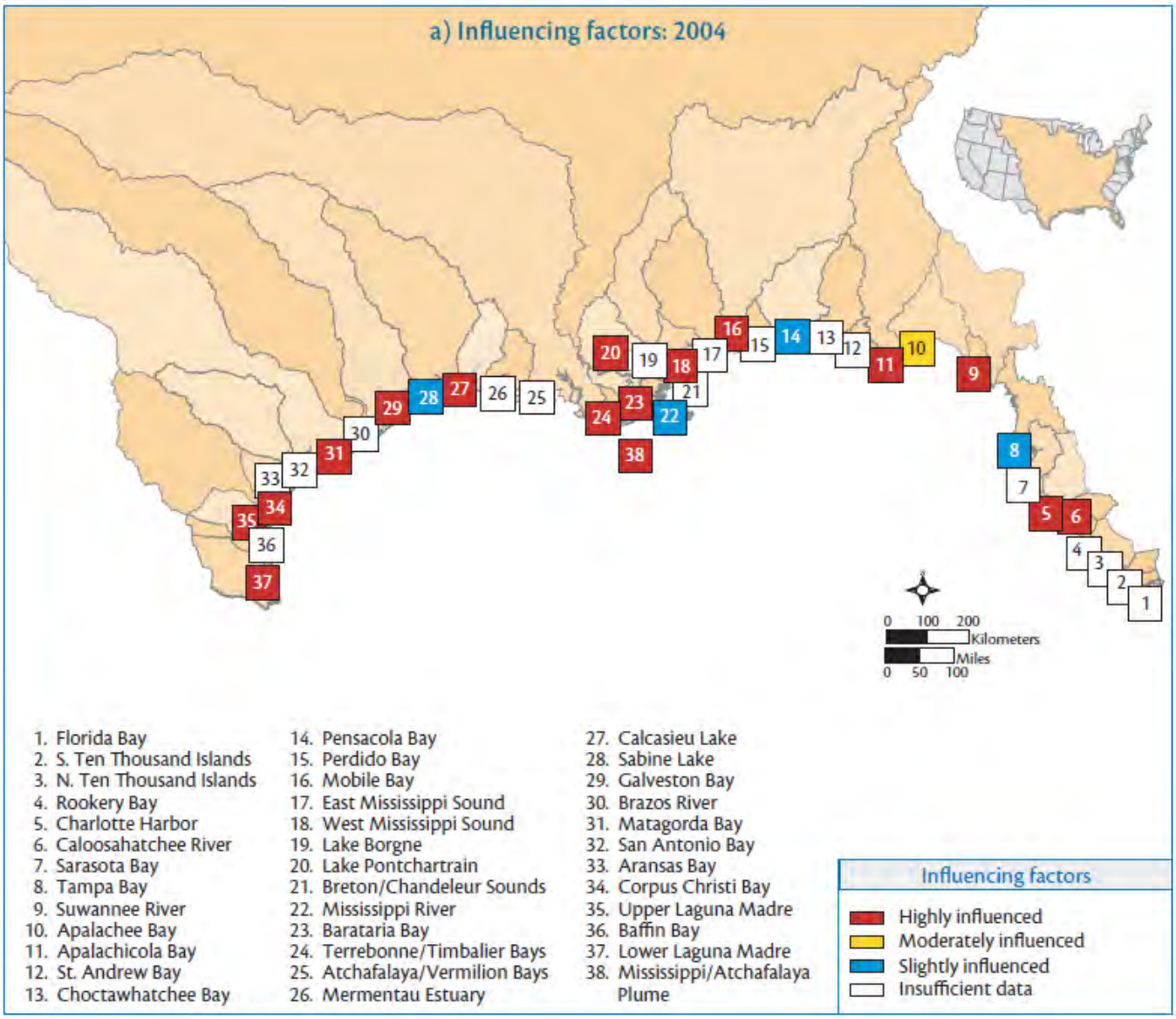


Figure 1: Map of influencing factors ratings in the Gulf of Mexico region. (from Bricker et al., 2007).

the categorical (i.e., high, moderate, low) results for the three components into a single overall rating called ASSETS (Bricker et al., 2003, 2008; Whitall et al., 2007). This assessment approach uses quantitative and qualitative data to determine trophic status. For example, to evaluate the 'typical' extreme concentrations over the annual cycle, algal bloom concentrations are represented as the 90th percentile of annual chlorophyll *a*

data. The ASSETS tool is straightforward in both required parameters and calculations, and is designed to provide management-level guidance, including for poorly sampled coastal systems. It was originally developed for U.S. coastal system assessment (Bricker et al., 2003, 2007) but has also been tested extensively in European systems (e.g., Ferreira et al., 2003, 2007a; Devlin et al., 2011; Garmendia et al., 2012), and in other parts of the world (e.g., Xiao et al., 2007). It is available as a downloadable desktop program at http://www.eutro.org/register.

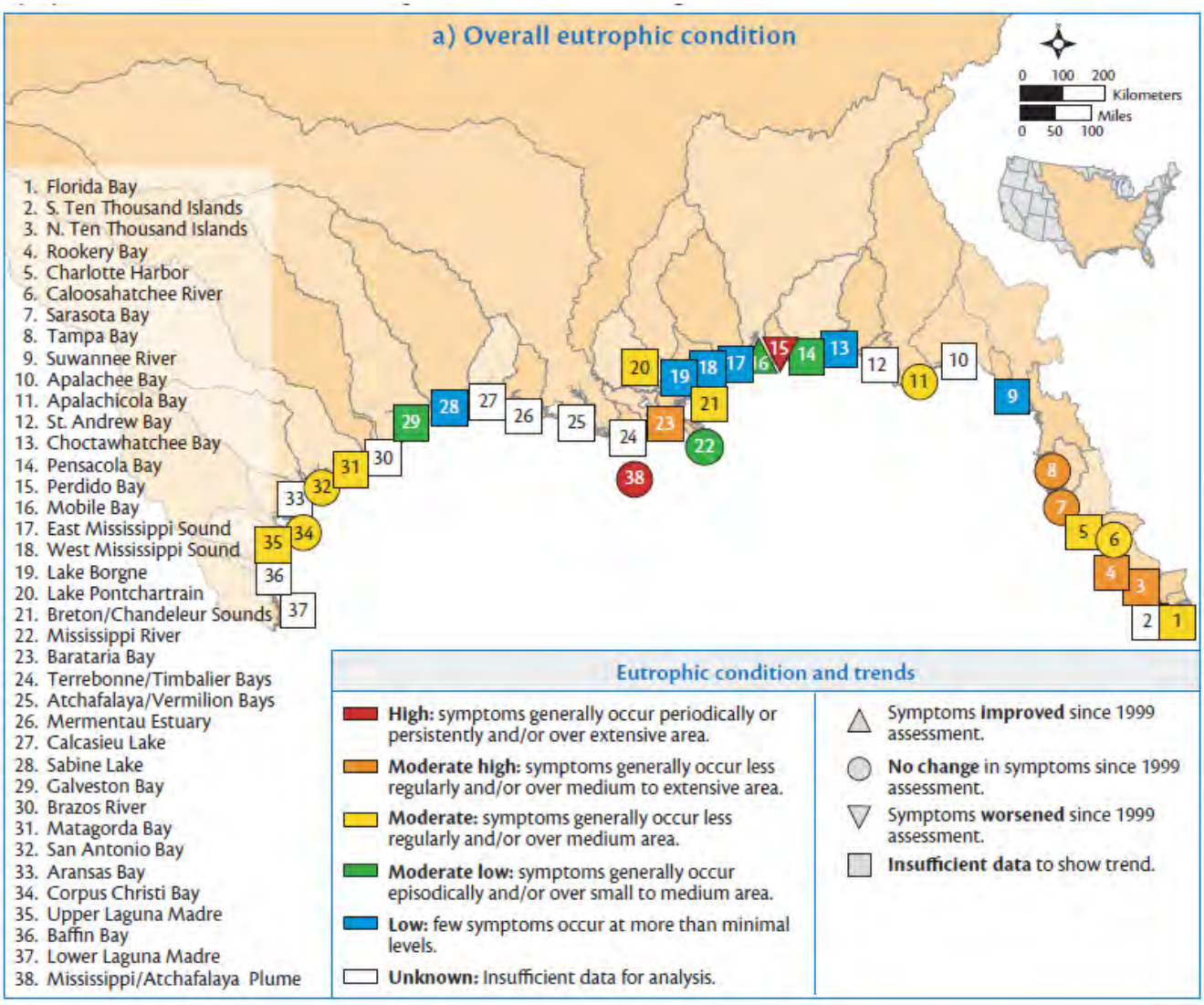


Figure 2: Map of eutrophic condition ratings in the Gulf of Mexico region (from Bricker et al. 2007).

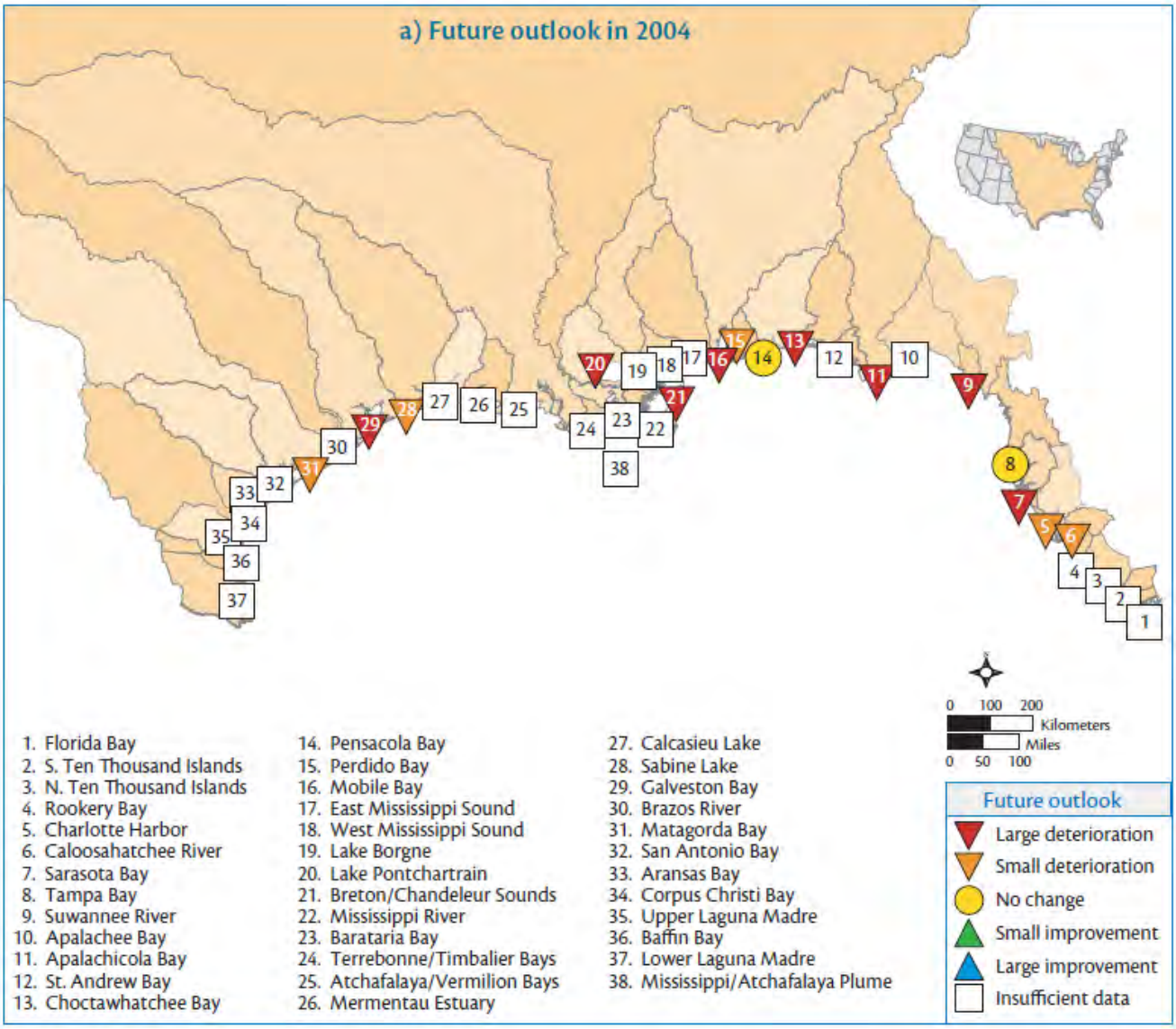


Figure 3: Map of Gulf of Mexico future outlook in the early 2000s (from Bricker et al., 2007).

i) Introductory and additional information on the NOAA web site:

state-of-coast.noaa.gov/bulletins/html/mcwq_12/mcwq.html

National Marine Sanctuaries:

Florida Keys
http://floridakeys.noaa.gov/fknms_map/welcome.html

Flower Gardens
http://www.ncddc.noaa.gov/website/google_maps/FGB/mapsFGB.htm

National Estuarine Research Reserves:

Rookery Bay, FL
http://nerrs.noaa.gov/Reserve.aspx?ResID=RKB

Apalachicola Bay, FL
http://nerrs.noaa.gov/Reserve.aspx?ResID=APA

Weeks Bay, AL
http://nerrs.noaa.gov/Reserve.aspx?ResID=WKB

Grand Bay, MS
http://nerrs.noaa.gov/Reserve.aspx?ResID=GRD

Mission-Aransas, TX
http://nerrs.noaa.gov/Reserve.aspx?ResID=MAR

3. U.S. Geological Survey (USGS)

Through its hydrologic monitoring, assessments, and research programs, USGS monitors approximately 600 stream gages located within the U.S. tidal zone. Primary contributions to coastal conditions monitoring are from the following programs:

a) Hydrologic Monitoring, Assessments, and Research

Provides the base stream flow and water-quality data for characterization of riverine inputs into coastal ocean waters, and funds studies of estuaries. The scope of the studies includes hydrodynamic modeling and water quality and habitat characterization; the information available supports the priorities of the National Ocean Policy.

b) Monitoring Large Rivers in the National Stream Quality Accounting Network (NASQAN)

The National Streamflow Information Program is a network of about 7,000 stream gages nationwide, and about 6,000 of these stations are linked to an Earth-satellite-based communications system. The majority of the stream-gaging stations are jointly funded in partnerships with more than 800 state, local, and tribal governments or other federal agencies, and the data are available in real time to conduct water resource projects and for NOAA's National Weather Service to forecast floods. In addition, USGS conducts long-term water quality and quantity monitoring through the NASQAN at fixed locations on large rivers around the country. USGS also operates the National Water Quality Assessment, which uses a regional focus to study status and trends in water, sediment, and biota in forty-two major river basins and aquifer systems.

Surface-Water-Quality Networks—The Office of Water Quality maintains three surface-water networks that are intended to provide stakeholders with reliable information over time for a fixed set of stations.

Large rivers and the quality of water at the terminus of large watersheds entering receiving waters are monitored routinely at 33 stations through the NASQAN and at 5 stations through the National Monitoring Network, as needed by the Integrated Ocean Observing System and the proposed U.S. Ocean Action Plan. Smaller rivers and streams are monitored at 114 stations through the National Water-Quality Assessment (NAWQA) Program "Status and Trends" network, which consists of 114 sites across the Nation.

Five sites are monitored as part of the National Monitoring Network, three in the Gulf region:

Brazos River near Rosharen, TX
Mississippi R. above Vicksburg, MS (at mile 438)
Apalachicola R near Sumatra, FL
Delaware R. at Trenton, NJ
Hudson River below Poughkeepsie, NY

This information sheet describes the 5-year (2008-2013) mission, objectives, and locations of the NASQAN large rivers component of the Network. The NASQAN network has a long history (since 1973) and several re-designs over the 35 years. Information on NASQAN can be accessed at http://water.usgs.gov/nasqan/ and http://pubs.usgs.gov/dds/wqn96cd/html/report/contents.htm.

Since its peak of operation with about 500 sites (1980s), the NASQAN network has been reduced to 33 stations. The mission of NASQAN, however, remains the same, which is to annually monitor and assess concentrations and loads of selected constituents delivered by major rivers to coastal waters of the U.S., and to monitor and to identify major source areas in selected inland sub-basins that contribute significantly to adverse conditions in receiving waters.

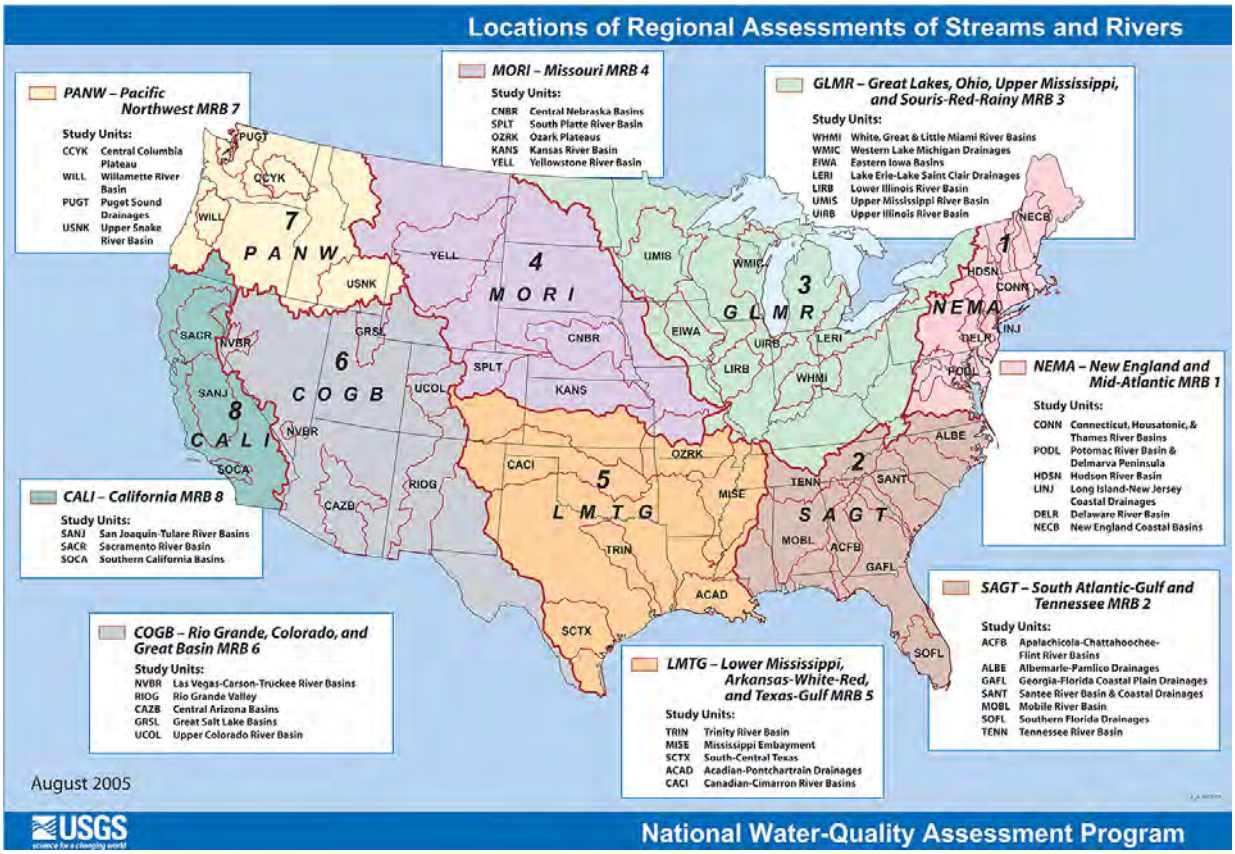
National-scale objectives of NASQAN are to assess: (1) concentrations and loads of nitrogen, phosphorus, carbon, silica, dissolved solids, selected pesticides, and suspended-sediment to coastal waters of the U.S.; and, (2) changes in concentrations and loads of these constituents through time. National objectives are accomplished at 13 sites through bimonthly sampling, supplemented by 6 samples representing variable hydrologic and seasonal conditions. The 13 sites account for about 80 percent of the stream flow, suspended sediment, total nitrogen, and total phosphorus discharging to coastal waters from the conterminous U.S.

Additional NASQAN objectives, specific to the Mississippi River Basin and hypoxia in the Gulf of Mexico, are to determine (1) seasonal loads of total and dissolved nutrients from the Mississippi River Basin to the Gulf of Mexico; (2) concentrations and loads of total and dissolved nutrients in major sub-basins and selected smaller watersheds within the Mississippi River Basin; and, (3) changes in loads and concentrations of constituents through time in major sub-basins and selected watersheds within the Mississippi River Basin. Objectives for the Mississippi River Basin and Gulf are accomplished at 20 sites in the Basin. The information is directly relevant to the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (http://www.epa.gov/msbasin/).

NASQAN findings describe concentrations and constituent transport and delivery of loads over time, as well as possible linkages to basin characteristics, natural and human sources, and land activities through periodic summary and trend analyses at national and large-basin scales.

c) NAWQA, River and stream monitoring

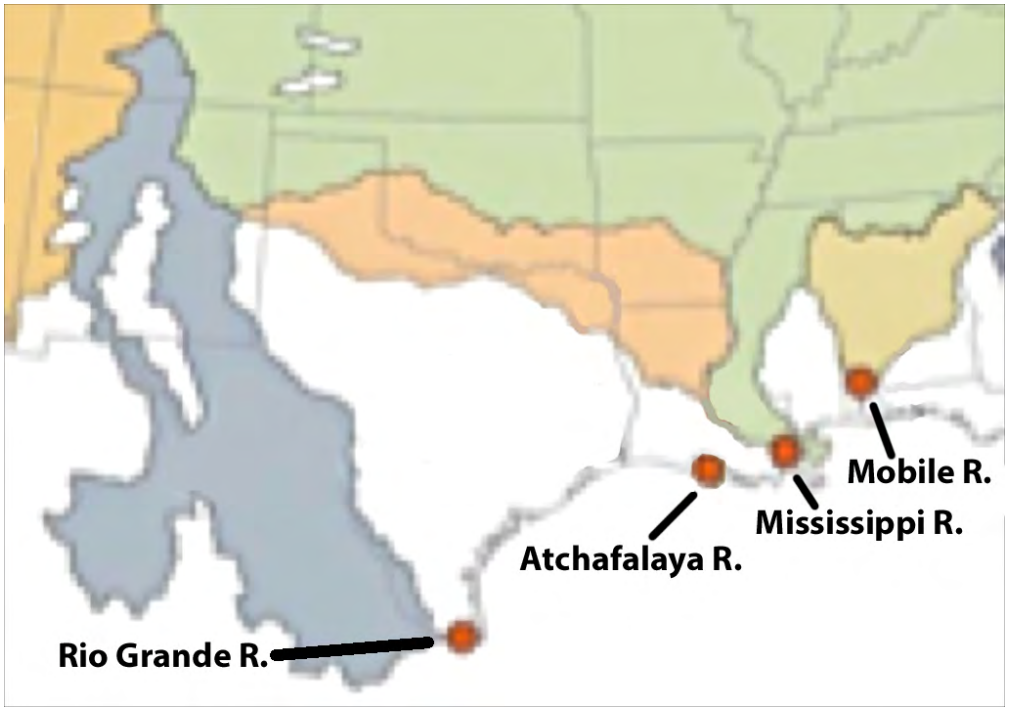
NAWQA surface-water fixed sites (114) vary in the degree to which they are monitored and the land uses they represent. A brief description and map of these sites are at http://water.usgs.gov/nawqa/studies/mrb/mrb_sites.html. Fourteen of the 114 sites represent agricultural and urban "core" sites, and are used to monitor conditions in rivers that drain agricultural areas in 8 major river basins (see figure below) and urban areas in 4 of the major river basins. These sites are measured frequently to assess intra-annual variations, generally between 12-22 times each year. The remaining sites are used to monitor smaller agricultural and urban watersheds and are sampled on a rotational schedule, varying every 2 to 4 years. More detailed information on this network can be accessed at: http://water.usgs.gov/nawqa/studies/mrb/mrb_factsheet.pdf



Flow, concentrations, and loads are measured at four sites discharging to coastal waters of the Gulf of Mexico (below).

In the Gulf region:

Mobile River at Mt. Vernon, AL
Mississippi River at Belle Chasse, LA
Atchafalaya River at Melville, LA
Rio Grande near Brownsville, TX



Flow, concentrations, and loads are measured in 20 priority sub-basins within the Mississippi River Basin that contribute significantly to adverse conditions in the Gulf of Mexico (below).

Ohio River at Cannelton Dam at Cannelton, IN
White River at Hazleton, IN
Wabash River at New Harmony, IN
Tennessee River at Hwy 60 near Paducah, KY
Ohio River at Dam 53 near Grand Chain, IL
Mississippi River at Clinton, IA
Illinois River at Valley City, IL
Mississippi River Below Grafton, IL
Iowa River at Wapello, IA
Des Moines River at Keosauqua, IA
Missouri River at Omaha, NE
Platte River at Louisville, NE
Missouri River at Hermann, MO
Mississippi River at Thebes, IL
Arkansas River at David D Terry Lock and Dam below Little Rock, AR
Yazoo River below Steele Bayou near Long Lake, MS
Mississippi River near St. Francisville, LA
Mississippi River at Baton Rouge, LA
Wax Lake Outlet at Calumet, LA
Atchafalaya River at Morgan City, LA

d) Information and Links to USGS Aquatic Resource Programs

http://www.epa.gov/nheerl/arm/programpages/usgs_programs.htm

Directory of USGS web sites and information: www.usgs.gov/network/

Water Resources of the United States: **water.usgs.gov**

National Water-Quality Assessment (NAWQA) Program: **water.usgs.gov/nawqa/**

Collects and interprets data about water chemistry, hydrology, land use, stream habitat, and aquatic life

Model-based assessment, not Design-Based (Probability Based Surveys)

National Hydrography Dataset (NHD)

Comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells.

Availability of data for a specific area can be determined through the web site
nhd.usgs.gov

4. National Water Quality Monitoring Council http://acwi.gov/monitoring/

Provides a forum to improve the Nation's water quality through partnerships that foster increased understanding and stewardship of our water resources.

a) Water Quality Portal http://www.waterqualitydata.us/

A cooperative service sponsored by the USGS, EPA, and NWQMC.

b) National Environmental Methods Index (NEMI) https://www.nemi.gov

An index of chemical, biological, toxicity, physical, regulatory, and statistical analysis methods.

c) Contaminant Biology Program http://www.usgs.gov/envirohealth/

Investigates effects and exposure of environmental contaminants to the Nation's living resources, particularly those under the stewardship of DOI.

d) Status and Trends Program http://www.usgs.gov/ecosystems/status_trends/index.html

APPENDIX D1.
OVERVIEW OF STATE PROGRAMS WITH WATER-QUALITY MONITORING ACTIVITIES

1. Alabama

a) Alabama Department of Environmental Management (ADEM) Water Quality Monitoring Programs: www.adem.state.al.us

Coastal Waters Monitoring Program (CWMP)

The CWMP provides data that can be used to assess current water quality conditions, identify trends in water quality conditions and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria for estuaries and coastal rivers and streams in Alabama.

Alabama Coastal Non-Point Pollution Control Program (ACNPCP)

The ACNPCP develops and implements targeted studies and projects that locate sites, identify, and document baseline water quality conditions that exist within the coastal county sub-watershed areas. These targeted studies correlate best management practices (BMPs) to land-uses and potential nonpoint source (NPS) impacts in close proximity to waterbodies within these counties.

Coastal Alabama Recreational Waters Program (BEACH)

Through the BEACH Act, the ADEM and the Alabama Department of Public Health (ADPH) provide enhanced monitoring and notification efforts for Alabama's public recreational waters. The goal of this program is to increase public awareness and provide valuable water quality information to help the public make more informed decisions concerning their recreational use of Alabama's natural coastal waters.

Fish Tissue Monitoring Program (FTMP)

The FTMP provides statewide screening of bioaccumulative contaminants in fish tissue, and to provide the Alabama Department of Public Health (ADPH) with data needed for determination of potential risk to those who consume fish from Alabama waters.

Rivers and Reservoirs Monitoring Program (RRMP)

The RRMP provides data that can be used to assess current water quality conditions, identify trends in water quality conditions and to develop Total

Maximum Daily Loads (TMDLs) and water quality criteria for rivers and reservoirs in Alabama.

Rivers and Streams Monitoring Program (RSMP)

The RSMP provides data that can be used to assess current water quality conditions, identify trends in water quality conditions and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria for rivers and streams in Alabama.

b) Alabama Department of Public Health Shellfish Monitoring Program:

www.adph.org

The ADPH Shellfish Monitoring Program monitors shellfish and the bays and estuaries where shellfish harvesting occurs for fecal coliforms and harmful algal blooms to minimize the risks associated with the consumption of Alabama grown shellfish.

c) Geological Survey of Alabama (GSA) Ecosystems Investigations Program:

www.gsa.state.al.us

The Ecosystems Investigations Program conducts biological surveys, water quality monitoring/assessments, and interdisciplinary watershed studies. GSA biologists accrue basic aquatic biological information through intensive field work that can be used to monitor and manage Alabama's water resources more effectively and efficiently.

d) Mobile Bay National Estuary Program (MBNEP):

www.mobilebaynep.com

The MBNEP is a voluntary program designed to bring together citizens, government agencies, business/industry, conservation and environmental organizations, and academic institutions to promote a community and culturally-based approach to watershed management.

e) Alabama Department of Conservation and Natural Resources

http://www.outdooralabama.com/

f) Alabama Department of Public Health

http://www.adph.org/

g) Alabama Department of Economic and Community Affairs – Office of Water Resources

http://www.adeca.alabama.gov/Divisions/owr/Pages/default.aspx

2. Florida

a) Florida Department of Agriculture and Consumer Services - Shellfish

http://www.freshfromflorida.com/Divisions-Offices/Aquaculture/Agriculture-Industry/Shellfish

b) Florida Department of Environmental Protection

http://www.dep.state.fl.us/

Water Management Districts http://www.dep.state.fl.us/secretary/watman/

Florida Geological Survey http://www.dep.state.fl.us/geology/

c) Florida Fish and Wildlife Conservation Commission

http://myfwc.com/

Fish and Wildlife Research Institute http://myfwc.com/research/

http://www.dep.state.fl.us/secretary/watman/

d) Florida Department of Health

http://www.doh.state.fl.us/

3. Louisiana

a) Louisiana Department of Environmental Quality (LDEQ)

LDEQ Ambient Surface Water Quality Monitoring

Surface water management seeks to protect the quality of all waters of the state, including rivers, streams, bayous, lakes, reservoirs, wetlands, estuaries, and many other types of surface water. The Louisiana Department of Environmental Quality collects ambient surface water data at approximately 125 sites across the state each month. This data is used for establishing water quality criteria or standards, assessment of conditions, and development of Total Maximum Daily Loads (TMDLs). TMDLs are one means of establishing water quality discharge permit limits and Nonpoint Source Pollution (NPS) reduction recommendations for the protection and improvement of surface water quality in Louisiana.

Over 600 monitoring sites have been established since 1958 but not all sites are currently in use. Data has been collected at some of these sites since the inception of the program; however, most sites were established more recently. In 1998 the department established a rotating basins monitoring program in order to expand the coverage of our monitoring efforts. Under this plan approximately 100 sites are selected each year for monitoring once a month. In addition, 21 sites on 16 water bodies are monitored every month of every year as long-term trend sites LDEQ's Inspection Division conducts ambient surface water monitoring (http://www.deq.louisiana.gov/portal/tabid/66/Default.aspx)

Quality Assurance Project Plan (QAPP) for Ambient Water Quality Monitoring Network (http://edms.deq.louisiana.gov/app/doc/view.aspx?doc=8739429&ob=yes&child=yes)

Ambient Water Quality Monitoring Data can be found at http://www.deq.louisiana.gov/portal/DIVISIONS/WaterPermits/WaterQualityAssessment/AmbientWaterQualityMonitoringData.aspx

LDEQ Aquifer Evaluation and Protection Unit

The Aquifer Evaluation and Protection Unit seeks to protect the quality of all waters found in underground aquifers as well as the surface water sources of that groundwater. For more information see: http://www.deq.louisiana.gov/portal/DIVISIONS/BusinessandCommunityOutreach/AquiferEvaluationandProtection.aspx

LDEQ Mercury Initiative

LDEQ's program to reduce and where possible eliminate mercury releases to the environment. For more information see http://www.deq.louisiana.gov/portal/PROGRAMS/MercuryInitiative.aspx

b) Coastal Protection and Restoration Authority of Louisiana (CPRA)

Coastwide Reference Monitoring Systems (CRMS)

CPRA maintains a Coastwide Reference Monitoring Systems (CRMS). CRMS is a multiple reference approach that uses aspects of hydrogeomorphic functional assessments and probabilistic sampling. This approach includes a suite of sites that encompass the range of ecological for each stratum, with projects placed on a continuum of conditions found for that stratum. For more information see http://www.lacoast.gov/crms2/Home.aspx and http://www.coastal.la.gov/index.cfm?md=pagebuilder&tmp=home&nid=129&pnid=76&pid=92&catid=0&elid=0.

c) Louisiana Department of Health and Hospitals (LDHH)

Fish Consumption and Swimming Advisories

Fish consumption and swimming advisories issued jointly by the Louisiana Department of Health and Hospitals (LDHH) and LDEQ. For more information see http://www.deq.louisiana.gov/portal/PROGRAMS/MercuryInitiative/FishConsumptionandSwimmingAdvisories.aspx

Beach Monitoring Program

The Louisiana Department of Health & Hospitals Beach Monitoring Program tests water at 26 beach sites along the Louisiana coast to determine whether the water quality meets Environmental Protection Agency (EPA) criteria. This program is part of the federal Beaches Environmental Assessment and Coastal

Health (BEACH) Act of 2000. The BEACH Act is an amendment to the Clean Water Act requiring all coastal states to develop programs for effective water quality monitoring and public notification at coastal recreational beaches. For more information see http://new.dhh.louisiana.gov/index.cfm/page/288.

d) Louisiana State University (LSU)

WAVCIS – Wave-Current-Surge Information System for Coastal Louisiana

The objective of WAVCIS (wave-current information system) is to provide wave information (sea state) including wave height, period, direction of propagation, water level, surge, near surface current speed and direction and meteorological conditions on a real time basis around the entire Louisiana coast. The monitoring program is designed, implemented and maintained by scientists and highly skilled technical support staff in the Coastal Studies Institute at Louisiana State University. For more information see http://www.wavcis.lsu.edu/.

e) Louisiana Department of Wildlife and Fisheries

http://www.wlf.louisiana.gov/

f) Southern Regional Water Program

http://srwqis.tamu.edu/louisiana/program-information/louisiana-target-themes/watershed-management/

g) Louisiana Geological Survey

http://www.lgs.lsu.edu/

4. Mississippi

Mississippi Department of Environmental Quality
http://www.deq.state.ms.us/

Mississippi Department of Wildlife, Fisheries, and Parks
http://www.mdwfp.com/

Mississippi State Department of Health
http://www.msdh.state.ms.us/

Mississippi Water Resources Association
http://www.mswater.org/members/water-management/

Mississippi Department of Environmental Quality – Office of Geology
http://www.deq.state.ms.us/MDEQ.nsf/page/geology_home

5. Texas

Long-term and special-purpose monitoring and research efforts on the Texas Coast are listed below. These programs are presented in terms of performing agencies and organizations. Programs are described very generally, and applicable websites for each program are listed as a source of specific information. The narrative descriptions focus on long-term continuing monitoring programs, but research programs that conduct focused, special-purpose sampling are also noted. This list is not intended to be all inclusive. For example, gulf-wide monitoring and research programs, such as those by the U.S. Geological Survey and the U.S. Environmental Protection Agency are not shown here. A more extensive compilation of researchers and projects is in the Gulf Database maintained by the Harte Institute (http://www.gulfbase.org/).

a) Texas Commission on Environmental Quality (TCEQ)

http://www.tceq.state.tx.us/ :

- Coordinated surface water quality monitoring

The TCEQ coordinates a surface water quality network involving approximately 1,800 monitoring sites across the state, in cooperation with a variety of River Authorities and other monitoring partners as part of the Clean Rivers Program. Conventional water quality parameters are typically collected on a quarterly basis at fixed monitoring sites. Additional parameters – such as toxic pollutants in water, bottom sediments, and fish tissue – are collected periodically at selected sites; and biological sampling for fish and benthic macroinvertebrates is also conducted. Data are collected under a uniform quality assurance program, and water quality data for the state are consolidated and maintained in an accessible database that contains up to 40 years of historical data. There are approximately 370 active sampling sites in tidal waters.

Overview: http://www.tceq.texas.gov/waterquality/monitoring/index.html

Sampling activities and location maps: https://cms.lcra.org/

Database availability and overview:
http://www.tceq.texas.gov/waterquality/monitoring/txwaterdata.html

Every two years, TCEQ evaluates recent water quality data for each major water body in the state assess compliance with water quality standards and identify areas that are not meeting applicable water quality standards. This evaluation is compiled in an integrated report on water quality, and the report includes a data summary for each assessed water body.
http://www.tceq.texas.gov/waterquality/assessment/305_303.html

- Special-purpose projects

In addition to long-term periodic monitoring, TCEQ conducts and participates in selected special-purpose sampling, in both fresh and tidal waters, to support programs such as setting total maximum loads: http://www.tceq.texas.gov/waterquality/tmdl/nav/tmdlprogramprojects.html and developing water quality standards: http://www.tceq.texas.gov/waterquality/standards/eq_swqs.html. A specific example is the evaluation of biocriteria and applicable site-specific uses and criteria in selected tidal streams, in coordination with the Texas Parks and Wildlife Department:

http://www.tceq.texas.gov/waterquality/tmdl/29-tidalstreams.html

b) Texas Department of State Health Services (TDSHS)

http://www.dshs.state.tx.us/:

- Surveys of contaminants in edible tissue of fish and shellfish

The mission of the Seafood and Aquatic Life Group at TDSHS is to protect the consumer from disease or other health hazards transmissible by oysters, clams, mussels and scallops and crab meat produced in or imported into Texas. The Seafood and Aquatic Life Group also protects recreational fishers from disease or contaminants found in fish and other aquatic species caught in Texas' lakes, rivers, bays or nearshore state waters. They carry out this mission by classification of shellfish growing areas, certification of molluscan shellfish shippers and crab meat processors, and testing tissue samples from fish and seafood harvesting areas.

Program description and seafood consumption advisories:
http://www.dshs.state.tx.us/seafood/

c) Texas General Land Office (GLO):

- Texas Beach Watch: coastal bacteria monitoring for swimmer notification

The Texas General Land Office coordinate the statewide beach watch program for Texas, and numerous coastal beaches are monitored for indicator bacteria to protect swimmer health. Advisories are posted if bacteria concentrations exceed threshold levels. An interactive map of monitoring sites and current conditions is available.

http://www.texasbeachwatch.com/

- Sediment characterization database

To support erosion control projects along the coast, GLO maintains a database and GIS layer/viewer with monitoring data characterizing sediment.

http://www.glo.texas.gov/what-we-do/caring-for-the-coast/coastal-erosion/index.html

d) Texas Parks and Wildlife Department (TPWD) http://www.tpwd.state.tx.us/:

- Coastal fisheries monitoring

TPWD has a long-term database of fish communities and trends in Texas coastal waters. Sampling of fish, macroinvertebrates, and oysters is conducted with a variety of gear types, such as gill net, bag seine, bay trawl, gulf trawl, and oyster dredge. Sampling is conducted to provide statistically defined relative abundance and time trends of major coastal species.

For program description of coastal fisheries monitoring, see pages 11-15 at: http://www.tpwd.state.tx.us/publications/nonpwdpubs/media/afs_fisheries_divisions_science_review_report.pdf

For data summaries of coastal fisheries monitoring in individual bays, see:

http://www.tpwd.state.tx.us/landwater/land/maps/gis/ris/catch_rate/index.phtml

- Seagrass monitoring

TPWD, in coordination with TCEQ and academic researchers (noted below), conducts special-purpose sampling and mapping of seagrasses along the Texas coast. For a description of these efforts, monitoring plans, and activities of the associated state workgroup, see: http://www.tpwd.state.tx.us/landwater/water/habitats/seagrass/index.phtml

- Harmful algal blooms

TPWD actively investigates, monitors, and provides public notice about harmful algal blooms such as red and brown tides along the Texas coast. For a description of this program and the current status of algal blooms, see:

http://www.tpwd.state.tx.us/landwater/water/environconcerns/hab/index.phtml

- Special-purpose monitoring

TPWD also conducts selective sampling for special-purpose projects, such as research to develop biocriteria and assess water quality in tidal streams (in coordination with TCEQ), at:

http://www.tpwd.state.tx.us/landwater/water/conservation/coastal_studies/uaa/index.phtml

e) Texas Water Development Board (TWDB) http://www.twdb.state.tx.us/:

- Monitoring the effects of freshwater inflows on individual major estuaries

The Texas Water Development Board coordinates a bays and estuaries program with the mission "to maintain a continuous data collection, modeling, and analytical study program focused on evaluating the freshwater inflow requirements necessary to maintain the health of Texas bays and estuaries."

Monitoring and data consolidation/evaluation efforts for this program include:

1. Maintain a hydrologic database of historical inflows into Texas bays and estuaries.

2. Collect, archive, and disseminate water quality data from representative sites located in Texas bays and estuaries.

3. Advance the development and application of hydrodynamic and conservative and non-conservative transport models for Texas bays and estuaries.

4. Monitor the effects of and provide information about freshwater inflow needs to support a sound ecological environment for use in water resources planning and management.

As part of this program, TWDB has measured salinity and other datasonde parameters at a variety of long-term sites, and TWDB participates in the TCOON coastal monitoring network described below.

http://www.twdb.state.tx.us/surfacewater/bays/index.asp

f) The Texas Coastal Ocean Observation Network (TCOON):

The Texas Coastal Ocean Observation Network (TCOON) is a State-of-the-Art water level monitoring network that is operational 24 hours a day seven days a week. Water level and meteorological data are provided to local, state, and federal coastal managers as well as the public in near real-time with conditions along the Texas coast from Sabine Pass to Port Isabel. TCOON is managed through cooperative agreements between the Texas General Land Office, the Texas Water Development Board, the U.S. Army Corps of Engineers and the National Oceanic and Atmospheric Administration (NOAA). The network is operated by the Conrad Blucher Institute for Surveying and Science at Texas A&M University Corpus Christi.

TCOON currently consists of 31 active stations along the Texas coast measuring many different environmental and physical parameters such as water levels, wind speed and direction, water, and air temperature, and atmospheric pressure. A select few TCOON stations collect and report salinity levels. TCOON provides this critical data to the sponsoring agencies, the public, the commercial shipping industry, marine construction companies, recreational boaters, and those responsible for marine safety, emergency response, and evacuations.

Data from select TCOON stations also support Physical Oceanographic Real-Time Systems (PORTS) developed by the National Ocean Service (NOS) Center for Operational and Oceanographic Products and Services (CO-OPS)PORTS is responsible for providing real-time oceanographic data and other navigation

products to promote safe and efficient navigation at major U.S. ports. The PORTS system provides reliable, real-time water level, meteorological, and water current information to harbor pilots, vessel captains, port authorities and a wide variety of other users. TCOON and NOAA water monitoring stations, along with acoustic Doppler current profiles comprise the data network for the Houston/Galveston PORTS and Sabine PORTS.

From: http://www.glo.texas.gov/what-we-do/caring-for-the-coast/environmental-protection/coastal-monitoring/index.html

g) Coastal Bend Bays National Estuary Program:

- Special purpose research projects and publications on the southern Texas coast

http://www.cbbep.org/publicationshome.html

h) Galveston Bay National Estuary Program (in TCEQ):

- Data repository, focused research, and publications on the Galveston Bay complex

http://www.gbep.state.tx.us/solutions-partners/data-mapping.asp

i) National Parks Service:

- Seagrass distribution and related water quality for Padre Island National Seashore

http://science.nature.nps.gov/im/units/guln/

http://science.nature.nps.gov/im/units/guln/monitoring/aquaticveg.cfm

j) Texas A&M University Corpus Christi - Conrad Blucher Institute:

- Overview

http://www.cbi.tamucc.edu/

http://lighthouse.tamucc.edu/Main/HomePage

- Division of Nearshore Research

Coordination of coastal monitoring projects in various Texas estuaries – in cooperation with a number of sponsors and participants – often with a focus on long-term measurements of salinity and water level.

http://lighthouse.tamucc.edu/Main/HomePage

- Coordination of the Texas Coastal Ocean Observation Network

Includes long-term monitoring of estuarine water levels; conducted with the Texas General Land Office, NOAA, the Texas Water Development Board, and the U.S. Army Corps of Engineers.

http://lighthouse.tamucc.edu/TCOON/HomePage

k) Texas A&M University Corpus Christi – Harte Institute:

- Overview

http://harteresearchinstitute.org/the-institute

- Gulfbase database of research efforts and information about the Gulf of Mexico

http://www.gulfbase.org/

- Biodiversity and Conservation database for Gulf of Mexico species

http://www.harteresearchinstitute.org/research

- Ecosystems and modeling – studies on inflow effects, climate change, estuarine ecology

http://www.harteresearchinstitute.org/research/ecosystems-a-modeling

- Fisheries and Ocean Health – studies on biota, habitat, water quality, hydrodynamics

http://www.harteresearchinstitute.org/ochealth-research

l) Texas A&M University Galveston:

- Overview: http://www.tamug.edu/research/Centers%20Labs/CentersLabs.html

- Phytoplankton Dynamics Lab – monitoring for phytoplankton, nutrients, biota

http://www.tamug.edu/phytoplankton/index.html

- Laboratory for Deep Sea Biology – sampling of deep benthos, monitoring dead zone

http://www.marinebiology.edu/Rowe/Home.htm

- Coastal and Wetlands Ecology Laboratory – ecological processes of marshes/wetlands

http://www.tamug.edu/armitage/AboutUs.html

- Laboratory for Oceanographic and Environmental Research – coordination of faculty research/sampling on phytoplankton, carbon cycling, primary productivity

http://loer.tamug.edu/index.htm

- Fisheries Ecology Lab – research on estuarine, coastal, pelagic, and coral reef fish

http://www.tamug.edu/rooker/

- Seafood Safety Lab – Research and monitoring bacteria in estuaries

http://www.tamug.edu/seafoodsafetylab/index.html

m) Texas Stream Team at Texas State University in San Marcos, Texas:
- Texas volunteer monitoring program, which includes selected estuary sites
http://txstreamteam.rivers.txstate.edu/

n) University of Houston Clear Lake – Environmental Institute of Houston:
- Research projects includes water quality, biological monitoring of coastal waters
http://prtl.uhcl.edu/portal/page/portal/EIH/research/research_projects

o) University of Texas Marine Science Institute at Port Aransas:
- Research studies and special-purpose monitoring on water chemistry, nutrient dynamics, phytoplankton composition and ecology, zooplankton dynamics
http://www.utmsi.utexas.edu/research.html

- Seagrass monitoring and research studies
http://texasseagrass.org/index.html

p) University of Texas, Pan Am at Edinburg, Coastal Studies Laboratory:
- Focused studies on southern estuaries in Texas: seagrass distribution, marine chemistry, sediment quality, GIS and coastal mapping, microbial ecology, red tide
http://portal.utpa.edu/utpa_main/daa_home/cose_home/csl_home/csl_research

q) Bureau of Economic Geology
http://www.beg.utexas.edu/

APPENDIX D2.
STATE MONITORING PROGRAMS, ADDITIONAL INFORMATION

1. Alabama: http://adem.alabama.gov/programs/coastal/default.cnt

a) Alabama Department of Environmental Management (ADEM)

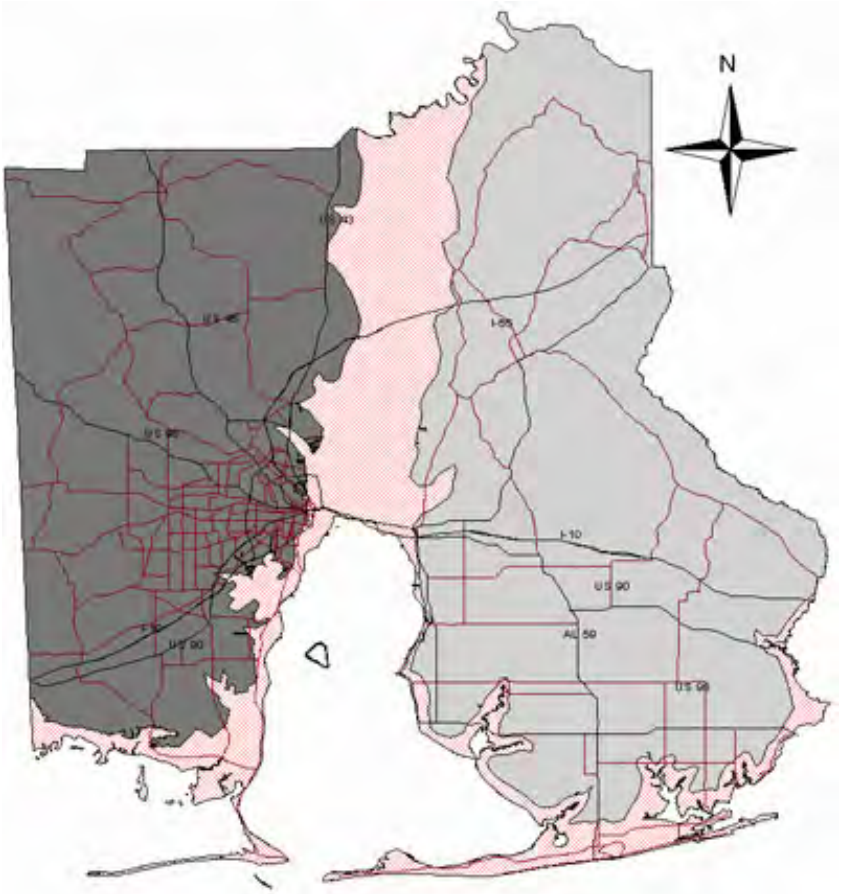
Coastal Programs

Coastal Permitting Information
Regulations Division 8
Beach Monitoring Information
Alabama's Coastal Marinas and Watersheds

Alabama Coastal Area Management Program

Alabama's Coastal Area Management Program (ACAMP) was approved and has been in effect since 1979. The program regulates various activities on coastal lands and waters seaward of the continuous 10-foot contour in Baldwin and Mobile Counties of Alabama.

Implementation of the ACAMP is shared by the Alabama Department of Conservation and Natural Resources-Coastal Section and the ADEM Coastal Section. ALDCNR-Coastal Section is responsible for planning activities while the ADEM Coastal Section is responsible for permitting, monitoring and enforcement activities, as detailed in the ADEM Division 8 Coastal Programs Rules (ADEM Admin. Code R 335-8).



Alabama Coastal Area Management Program Coastal Area Boundary

[Dark Gray - Mobile Area; Light Gray - Baldwin Area; Dotted Area - Coastal Area]

Other ADEM responsibilities and activities in the coastal area include:

- Development and implementation of the Alabama Coastal Nonpoint Pollution Control Program.
- Conducting the Coastal Watershed Survey Program.
- Coastal Zone Management Consistency Review of federally regulated activities, federal projects, federal permits and federal assistance to local communities in the coastal area.
- Conducting studies and projects related to coastal resource management and concerns.
- Providing assistance to local governments relative to coastal resource management issues through funding and technical assistance.
- Review of State Agency permits.

Coastal Zone Management

Implementation of the Alabama Coastal Zone Management Program is shared by ADEM and the Alabama Department of Conservation and Natural Resources (ADCNR). ADEM is responsible for the permitting, monitoring, and enforcement activities associated with the Coastal Area Management Plan and the regulations set forth in **ADEM Administrative Code R.335-8**.

These responsibilities include the review and permitting for the following projects when they occur within the Coastal Area: beach and dune construction projects, developments and subdivision of properties greater than five (5) acres in size, dredging and filling of state water bottoms and wetlands, the drilling and operation of groundwater wells with a capacity of 50 gpm or greater, the siting of energy facilities, and other various activities which may have an impact on coastal resources.

ADEM also reviews federal projects and activities, such as navigation development and maintenance and oil and gas development on the outer continental shelf, for consistency with the State's Coastal Management Program. The Coastal Program also funds or conducts studies and projects related to coastal area concerns and issues. Studies of historical erosion trends along the Gulf front beaches and of the possible effects that human activities, such as the maintenance of the Mobile Ship Channel, may be having on coastal erosion are examples of work funded by the Department.

Contact Information
ADEM
Attn: Coastal Program
4171 Commanders Drive
Mobile, Alabama 36615-1421
Telephone Number : (251) 432-6533
Fax Number: (251) 432-6598
coastal@adem.state.al.us

Coastal Watershed Survey Program

http://adem.alabama.gov/programs/coastal/watershedSurvey.cnt

Initiated in 1993 by the Mobile Field Office, this program utilizes a spectrum approach for assessing the condition of the small subwatersheds located in Alabama's Coastal Area.

The strategy of this program is to integrate data collected from the water column, sediment and macroinvertebrate samples with information on land use, topographic characteristics, wetlands, and project growth and

development, with a focus on the effect of non-point sources on these watersheds.

As of 2002, surveys were completed in 4 watersheds with other being conducted and/or scheduled. Copies of these surveys can be obtained from the ADEM Coastal Section office; downloaded in PDF format by clicking on watershed of your choice on the Water Quality Survey Study Reports Page; or by selecting the ones below:

Dog River 1994

Dog River 1995

Bon Secour River

Little Lagoon

Chickasaw Creek

b) Alabama Department of Environmental Management/Alabama Department of Public Health Coastal Alabama Beach Monitoring Program

http://adem.alabama.gov/programs/coastal/beachMonitoring.cnt

Coastal Alabama (Water Quality Summary)

c) Alabama Department of Conservation and Natural Resources-Coastal Section

Research and Management

http://www.outdooralabama.com/research-mgmt/

Aquatic Biodiversity Center - The Alabama Aquatic Biodiversity Center is the largest state non-game recovery program of its kind in the United States; its mission is to promote the conservation and restoration of rare freshwater species in Alabama waters, which will in turn restore cleaner water to Alabama's streams.

AL Comprehensive Wildlife Conservation Strategy - This CWCS defines those wildlife species in greatest need of conservation in Alabama and describes the actions necessary for their restoration. It is through this tool that we have the opportunity to work with conservation partners and the greater public to best utilize available resources to ensure that declining species are restored and common species remain common.

Landowner Assistance Programs - Landowner Assistance Programs

Wetlands Reserve Program - Administered by USDA's Natural Resources Conservation Service, the WRP provides eligible landowners the technical and financial assistance they need to address wetland, wildlife habitat, soil, water and related natural resource concerns on private agricultural land.

Studies of Listed Species - Section 6 Projects - Alabama Section 6 Projects, Species of Special Concern

Alabama Clean Waters Initiative - We all love Alabama's waters. And it's up to all of us to preserve the quality of this vital natural resource. In light of this, we've developed the Alabama Clean Waters Initiative.

State Wildlife Grants - State Wildlife Grants (SWG) are a new funding source from Congress to the Division of Wildlife & Freshwater Fisheries intended to identify and focus management on "species in greatest need of conservation."

Management of State Owned Lands

Weeks Bay NERR

Sport Fish Restoration - For more than 50 years, the Sport Fish Restoration fund has used money from anglers to improve habitat and fishery resources throughout the nation.

Hatcheries - Freshwater fish stocking and hatchery activities in Alabama.

2. Florida

http://www.dep.state.fl.us/water/monitoring/council/monitoring_resources.htm

a) Monitoring Resources

Existing Monitoring Efforts

- DOH beach monitoring
- DACS shellfish monitoring
- WMD monitoring – networks & projects
- County and local monitoring
- FWC - IMAP coastal/ocean monitoring
- DEP IWRM freshwater monitoring
- USGS National Water-Quality Assessment (NAWQA) Program
- National Estuarine Research Reserve (NERR) System-Wide Monitoring Program (SWMP)
- Ocean Observing Systems
  - U.S. Integrated Ocean Observing System (IOOS)
  - Gulf of Mexico Coastal Ocean Observing System (GCOOS)
  - Southeast Coastal Ocean Observing Regional Association (SECOORA)

Existing Collaborative Groups

- National Water Quality Monitoring Council (NWQMC))
- Gulf of Mexico Alliance (GOMA)
- South Atlantic Alliance
- Florida Oceans and Coastal Council (FOCC)
- Central Florida Water Initiative (CFWI)

Summaries / Reports

- Florida Coastal Water Resource Monitoring Framework (pdf - 481 KB)"
- Report on Hydrodynamic Models in Florida (pdf - 893 KB)
- Integrated Data Management System (Metadata Standards) – FOCC

Additional Resources

- FL FWC Marine Resource Aerial Imagery Database (MRAID)

b) Online Monitoring Catalogs and Data Portals

d. Name	e. Description	f. Geographic Extent
USGS National Water Information System (NWIS)	A searchable online database of water resource data. Results can be viewed online in tabular or graph format, or through the mapping application. Results can also be downloaded in tab-separated data format.	
USGS Water Data Discovery	Several interactive tools for searching past and current (real-time) water data and forecasts. Results can be displayed through online mapping applications and reports.	
EPA My Environment and US EPA Storage and Retrieval (STORET) / Water Quality Exchange (WQX) Data Warehouse	An online portal for environmental data. Results can be viewed using the online mapping application, or downloaded in shapefile, CSV, Excel, or KML format.	
National Water Quality Monitoring Council (NWQMC) Water Quality Portal	A searchable compilation of the USGS NWIS and EPA STORET/WQX databases. Results for monitoring station information and water quality data can be downloaded in KML, XML, Excel, CSV, or tab-separated data formats.	

National Ocean Council Data Portal	A portal for data, information, and tools to support coastal and marine planning. Several datasets are available as live map services, and data can be viewed and downloaded in a variety of formats.	Coastal United States, including Great Lakes, Pacific Islands, and Caribbean regions. - detailed map not available
NOAA Gulf of Mexico Data Atlas	An online atlas with data available in six topic areas (physical, biotic, living marine resources, economic activity, environmental quality, and jurisdictions). Maps have descriptions, explaining how the data was gathered and how it is relevant. Users can also link directly to the data.	
Gulf of Mexico Alliance (GOMA) Catalog of Monitoring Programs (in development, anticipated summer 2014)	A searchable online catalog and mapping application of metadata for monitoring projects in the Gulf of Mexico.	
Southeast Coastal Water Quality Monitoring Metadata Project (GA Coastal Research Council and NPS)	A searchable online database of long-term monitoring program metadata. Results can be viewed in tabular format online, or downloaded in CSV, KML, or XML format.	
Southeast Coastal Ocean Observing Regional Association (SECOORA) Biological and Habitat GIS	An online mapping application for viewing real-time ocean and meteorological observations and marine biological and habitat data.	

Gulf of Mexico Alliance (GOMA) Portal	A metadata catalog and data repository for Gulf of Mexico related geospatial datasets. Several datasets are available as live map services, and data can be viewed and downloaded in a variety of formats.	Gulf of Mexico region – detailed map not available
FDEP Map Direct - Marine Spatial Planning Map	An online mapping application for viewing marine and coastal data. Several datasets can be downloaded in shapefile format.	
Gulf of Mexico Ecosystem Portal	A searchable database of monitoring project metadata. Results can be viewed online in tabular format.	Gulf of Mexico region – detailed map not available
STORET Public Access Data Retrieval Site and FDEP Map Direct - STORET Focus	A searchable database and online mapping application for viewing STORET stations. Data from selected stations can be viewed online in tabular format or downloaded in text format.	
FL FWC Marine Resource Geographic Information System (MRGIS)	An online mapping application for viewing and querying spatial information related to marine resources. Results are available as printable maps or downloadable GIS layers.	

FL FWC Geospatial Assessment of Marine Resources (GAME)	An online mapping application for viewing a catalog of data sets and information related to coastal and marine habitats.	
Water Atlas (USF)	A searchable database of water resource information (data, metadata, documents). Results can be viewed online in tabular or graph format, or through the online mapping application or interactive graphs. Data can also be downloaded in Excel or text format.	
Florida Geographic Data Library Metadata Explorer	A portal of spatial data covering a variety of topics including land use/ land cover, hydrography, soils, transportation, boundaries, environmental quality, conservation, and census. Data sets are available for download in shapefile format.	State of Florida – detailed map not available
SRWMD Water Data Portal	An online mapping application for viewing water resources monitoring stations and their associated data. Data can be viewed online in graph format or downloaded in Excel format.	

SWFWMD Water Management Information System (WIMS)	A searchable database of water resource data, with an accompanying online mapping application. Results can be viewed online in graph or tabular format, or downloaded in CSV format.	
SFWMD DBHYDRO Browser and SFWMD DBHYDRO Google Earth tool	A searchable database of hydrologic, meteorologic, hydrogeologic and water quality data. Results can be viewed online in text format, downloaded in text or CSV format, or graphed. Stations with links to their corresponding data can also be viewed using the Google Earth tool.	
USGS South Florida Information Access (SOFIA)	A searchable database of research projects. Project summaries, work plans, metadata, publications, data, and maps can be viewed online.	
Comprehensive Everglades Restoration Plan (CERP) EverGlades Restoration data Extraction Tool (EGRET)	A searchable database and online mapping application only accessible by CERP participants. Database contains project metadata and associated data.	

c) Water Quality Assessment and Total Maximum Daily Loads Information

http://www.epa.gov/waters/ir/

3. Louisiana

a) 30th in Beachwater Quality

37% of samples exceeded national standards in 2010

Polluted urban and suburban runoff is a major threat to water quality at the nation's coastal beaches. Runoff from storms and irrigation carries pollution from parking lots, yards, and streets directly to waterways. In some parts of the country, stormwater routinely causes overflows from sewage systems. Innovative solutions known as green infrastructure enable communities to naturally absorb or use runoff before it causes problems. The U.S. Environmental Protection Agency is modernizing its national rules for sources of runoff pollution and should develop strong, green infrastructure-based requirements.

Most of Louisiana's coastline consists of wetlands. However, there are at least 19 coastal beaches lining nearly 30 miles of the Gulf of Mexico and estuarine shoreline, including the barrier island Grand Isle, as well as some beaches near the Texas border and on the shore of the estuary of Lake Pontchartrain. The state's coastal monitoring program is administered by the Louisiana Department of Health and Hospitals (LDHH).

During 2010, Louisiana's beaches were impacted by the BP oil disaster, which began with the April 20, 2010 explosion on the Deepwater Horizon rig and impacted most of the coastal beaches in the eastern half of the state. Oil flowed from the damaged well for three months, until it was capped on July 15, 2010. A total of 2,232 closing days at 11 beach segments were issued due to the spill in 2010, and many beaches remained closed into 2011 because of oil washing ashore and continued cleanup efforts. NRDC includes all oil spill closure days at all beaches in its oil spill totals, including closure days at beaches that were not monitored weekly for bacteria in 2010 and closure days that occurred outside of the monitoring season.

Also in 2010, beaches in Louisiana continued to experience lingering impacts from hurricanes Katrina and Rita (August and September 2005, respectively) as well as Gustav and Ike (September 2008). Use of Cameron Parish beaches remained below pre-storm levels, although it is slowly recovering as the area is rebuilt. Hackberry Beach in Cameron Parish remained inaccessible.[1]

With each water quality sample that is collected, data on water temperature, salinity, tide conditions, weather conditions, and wind direction and speed are also collected. In addition, the total precipitation for the 2 and 3 days prior to sample collection is estimated. No environmental variable was identified that could explain the record high enterococcus densities that were encountered in 2010.[1]

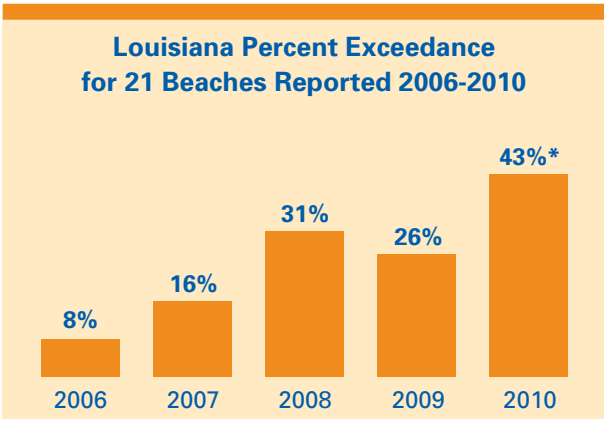
Key Findings in Louisiana[8]

Beachwater Contamination (% of samples exceeding state standards in 2010)

- Gulf Breeze (77%) in Cameron Parish
- Constance Beach (70%) in Cameron Parish
- Little Florida (67%) in Cameron Parish

Reported sources of Beachwater Contamination statewide (number of closing/advisory days)

- 91 (100%) unknown sources



*Why don't the 2010 percent exceedance values in this summary match? Only samples from a common set of beaches monitored each year from 2006–2010 are included in the bar chart. Because some beaches were not monitored in each of those years, the percent exceedance for this subset of beaches (43%) did not have the same value as the percent exceedance for all of the beaches monitored in 2010 (37%).

b) Monitoring Results

In 2010, Louisiana reported 29 coastal beaches. Of these, 27 (93%) were monitored once a week and 1 (3%) was monitored once a month. One beach (3%) was not monitored due to access constraints resulting from previous hurricanes. For this section of the report, NRDC looked at the percent of monitoring samples

[8] Natural Resources Defense Council *Testing the Waters 2011*

that exceeded the state's daily maximum bacterial standards. In 2010, 37%* of all reported beach monitoring samples exceeded the state's daily maximum bacterial standards. The beaches with the highest percent exceedance rates in 2010 were Gulf Breeze (77%), Constance Beach (70%), Little Florida (67%), Holly Beach 5 (63%), Rutherford Beach (63%), Holly Beach 4 (60%), and Long Beach (60%), all in Cameron Parish; Cypremort Point State Park (60%) in St. Mary Parish; Holly Beach 1, 2, 3, and 6 (57%) and Martin Beach (50%) in Cameron Parish, and Fontainebleau State Park (43%) in St. Tammany Parish. Cameron Parish had the highest exceedance rate (61%) in 2010, followed by St. Mary (60%), St. Tammany (43%), Orleans (21%), Calcasieu (20%), Lafourche (9%), and Jefferson (8%) parishes.

In addition to beaches monitored by LDHH under the BEACH Act, the Lake Pontchartrain Basin Foundation, a nonprofit, membership-based citizens' organization, has monitored additional beaches and sites around Lake Pontchartrain since 2000, but NRDC was unable to retrieve those monitoring results from the U.S. EPA, and those beaches are not included in this summary. Pontchartrain Beach was monitored again in 2010 by LDHH as part of an ongoing reexamination of the swim advisory on that portion of Lake Pontchartrain, and Fontainebleau State Park on Lake Pontchartrain has been regularly monitored by the state since the inception of the program.

c) Sampling Practices:

Monitoring is conducted from the beginning of April through the end of October. The LDHH determines sampling practices, locations, standards, and notification protocols and practices at Louisiana beaches monitored through the BEACH Act. Samples are collected 12 inches below the surface in water that is approximately 3 feet deep. Levels of beach use and perceptions of water quality determine monitoring priorities. Monitoring frequency does not increase after a beach is placed under advisory unless the contamination source has been identified and corrected, in which case more intensive sampling may be conducted.

d) Closings and Advisories

Total closing/advisory days for 8 events lasting six consecutive weeks or less decreased 81% to 91 in 2010 from 472 in 2009. For prior years, there were 221 days in 2008, 459 days in 2007, 5 days in 2006, and 406 days in 2005. In addition, there were 3 extended events (218 days total) and 25 permanent events (4,963 days total) in 2010. Extended events are those in effect more than six weeks but not more than 13 consecutive weeks; permanent events are in effect for more than 13 consecutive weeks. All closing and advisory days for 8 events lasting six consecutive weeks or less in 2010 were due to monitoring that revealed elevated

bacteria levels, as were over half of the permanent closing and advisory days. One hundred sixty of the extended days and 2,072 of the permanent days were due to the Gulf oil spill. A 42-day contamination advisory that was issued during the oil spill closure at Grand Isle Beach 1 is excluded from this analysis.

e) Standards and Procedures:

LDHH issues beach advisories based on water quality, but does not have the authority to issue beach closings under the beach-monitoring program. Local governments, however, can issue closings. Water quality standards are not met if any of the following are exceeded: 1) an enterococcus single-sample maximum standard of 104 cfu/100 ml, 2) an enterococcus geometric mean of 35 cfu/100 ml for five samples taken over a 30-day period, or 3) a fecal coliform geometric mean of 200 cfu/100 ml based on a minimum of five samples taken over no more than a 30-day period. Multiple samples are sometimes taken, and when they are, the results are averaged to determine whether standards are being exceeded.[1] An exceedance of any of these three standards can trigger an advisory, but the fecal coliform standard is rarely exceeded. [9]

Other than taking a resample to verify exceedances when the results are in doubt, which rarely happens, there is no protocol for forgoing an advisory when an exceedance is found. It is noteworthy that the majority of advisories in Louisiana result from exceedance of the enterococcus geometric mean criterion. If Louisiana issued beach advisories based only on the enterococcus single-sample maximum criterion, as many states do, 37% of the observed exceedances during 2010 would not have resulted in an advisory. [10]

Preemptive rainfall advisories are not issued. Louisiana's BEACH Program has examined data collected over many years to assess the relationship between indicator organism densities and environmental conditions (including water temperature, salinity, tide conditions, weather conditions, and wind direction and speed) at its beaches. The models that have been developed for each beach explain only a small fraction of the total variability in indicator organism density and cannot be used to issue precautionary advisories.

---

[9] Louisiana Department of Health and Hospitals. Louisiana BEACH Grant Report 2010 Swimming Season. March 2011.

Natural Resources Defense Council *Testing the Waters 2011*reflects data as of June 27, 2011.

[10] ibid

4. Mississippi

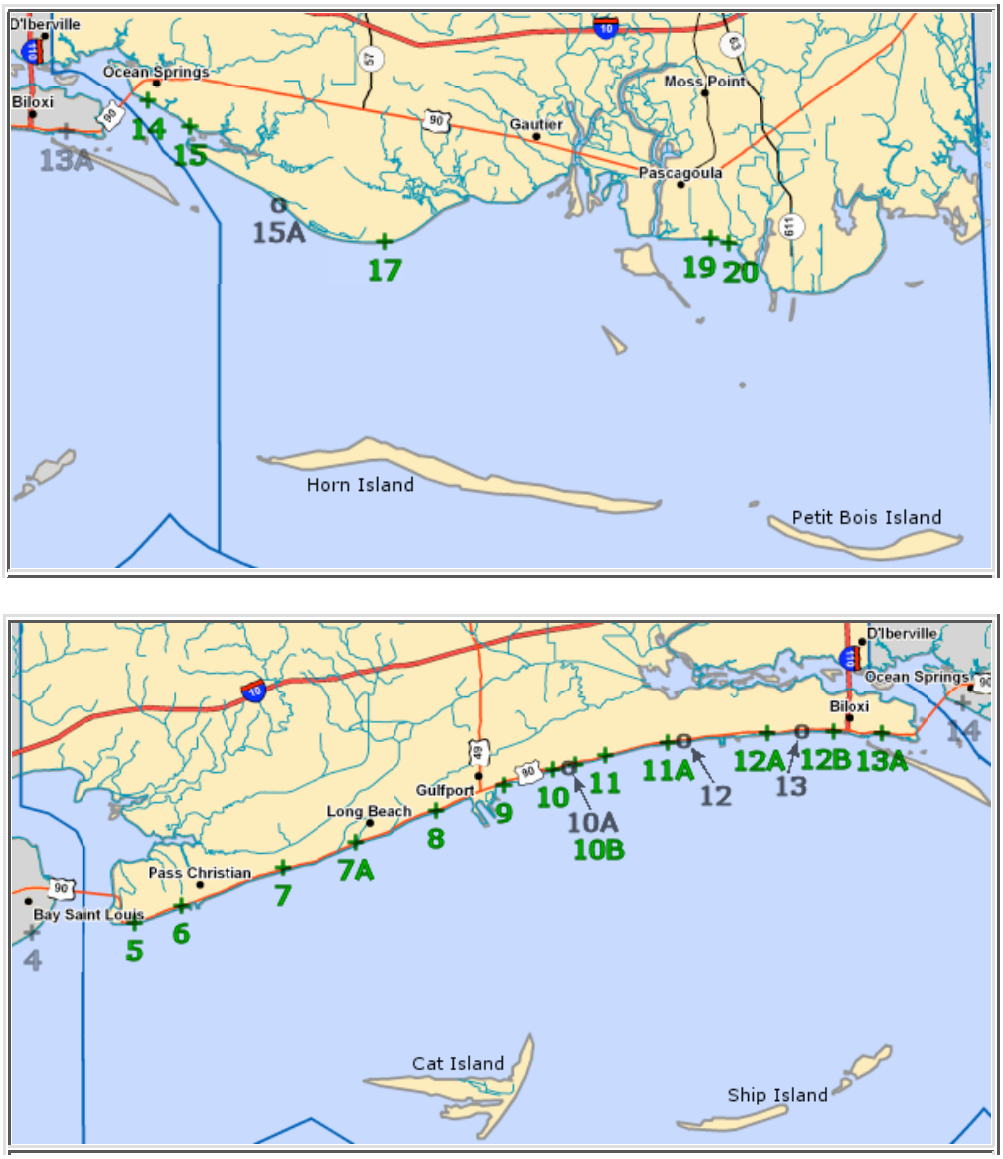
http://www.deq.state.ms.us/MDEQ.nsf/page/FS_SurfaceWaterQualityAssessments?OpenDocument

a) Surface Water Quality Assessments

MDEQ monitors the quality of surface water throughout the state. Monitoring data and information are used to make water quality assessments. Assessments are general characterizations of water body health. The state's most comprehensive assessment report is the Federal Clean Water Act Section 305(b) Water Quality Inventory Report.

Missisippi Beach Monitoring Program

http://www.usm.edu/gcrl/msbeach/index.cgi



Mississippi beach monitoring locations, east (upper), central (lower).

Mississippi beach monitoring locations, west.

5. Texas

http://www.glo.texas.gov/what-we-do/caring-for-the-coast/environmental-protection/coastal-monitoring/index.html

a) Coastal Monitoring

The Texas Coastal Ocean Observation Network (TCOON) is a State-of-the-Art water level monitoring network that is operational 24 hours a day seven days a week. Water level and meteorological data are provided to local, state, and federal coastal managers as well as the public in near real-time with conditions along the Texas coast from Sabine Pass to Port Isabel. TCOON is managed through cooperative agreements between the Texas General Land Office, the Texas Water Development Board, the U.S. Army Corps of Engineers and the National Oceanic and Atmospheric Administration (NOAA). The network is operated by the Conrad Blucher Institute for Surveying and Science at Texas A&M University Corpus Christi. TCOON currently consists of 31 active stations along the Texas coast measuring many different environmental and physical parameters such as water levels, wind speed and direction, water, and air temperature, and atmospheric pressure. A select few TCOON stations collect and report salinity levels. TCOON

provides this critical data to the sponsoring agencies, the public, the commercial shipping industry, marine construction companies, recreational boaters, and those responsible for marine safety, emergency response, and evacuations. Data from select TCOON stations also support Physical Oceanographic Real-Time Systems (PORTS) developed by the National Ocean Service (NOS) Center for Operational and Oceanographic Products and Services (CO-OPS)PORTS is responsible for providing real-time oceanographic data and other navigation products to promote safe and efficient navigation at major U.S. ports. The PORTS system provides reliable, real-time water level, meteorological, and water current information to harbor pilots, vessel captains, port authorities and a wide variety of other users. TCOON and NOAA water monitoring stations, along with acoustic Doppler current profiles comprise the data network for the Houston/Galveston PORTS and Sabine PORTS.

Texas Sediment Database
http://gisweb.glo.texas.gov/txsed/index.html

Texas Beach Watch
http://www.texasbeachwatch.com/

Gulf Beach Monitoring Programs
http://gcoos.tamu.edu/?page_id=1925

National Data Bout Center
http://www.ndbc.noaa.gov/

Gulf of Mexico MPA Network
http://www.mpa.gov/nationalsystem/gulf/

APPENDIX D3.
STATE PROGRAMS WITH BP OIL-SPILL MONITORING RESPONSIBILITIES

1. Alabama:
   - Department of Environmental Management (ADEM) / Department of Public Health (ADPH) Coastal Beach Monitoring Program
   - Office of Governor - Gulf of Mexico Oil Spill Information

2. Florida:
   - Florida Healthy Beaches Program
   - Florida Department of Environmental Protection

3. Louisiana:
   - Beach Monitoring Program
   - Louisiana Emergency

4. Mississippi:
   - Mississippi Beach Monitoring Program
   - Mississippi Department of Environmental Quality

5. Texas:
   - Texas Beach Watch
   - Texas Coastal Issues

APPENDIX E.
VOLUNTEER WATER-QUALITY MONITORING ACTIVITIES IN THE GULF

http://yosemite.epa.gov/water/volmon.nsf/VST!OpenView&Start=1&Count=30&Collapse=19 - 19

a) Alabama

Alabama Coastal Foundation
Alabama Water Watch
Cawaco RC & D Council, Inc.
Earth Team Volunteer Monitors
Flint Creek Watershed Project
Volunteer Monitoring
Friends of the Locust Fork River
River Watch
Lake Mitchell Home Owners and Boat Owners Association (H.O.B.O.s)
Lake Watch of Lake Martin
Logan Martin Lake Protection Association
Marshall County RSVP Water Watchers
Sand Mountain-Lake Guntersville Watershed Conservancy District
Save Our Saugahatchee, Inc. (S.O.S., Inc.)
Smith Lake Environmental Preservation Committee
Weeks Bay National Estuarine Research Reserve
Weeks Bay Water WatchWolf Bay Watershed Watch

b) Florida

Adopt-A-Lake
Aqua-Lab Project of the Okaloosa County Environmental Council
Cape Coral Canal Watch
Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network
Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network
Cooperative Tagging Center
Florida LAKEWATCH
Hillsborough County Stormwater Public Education Awareness Campaign (SPEAC)
Lake Management and Adopt-A-Pond Programs
Lake Okeechobee Lakewatch Rainfall Monitoring Program

Lee County Hyacinth Control District
Pondwatch
Lemon Bay Conservancy
Three Creek Watch
Marine Resources Council of East Florida
Citizen Volunteer Water Quality Monitoring Network
Nature Conservancy
Benthic and Water Quality Monitoring in the Florida Keys
Okeechobee Soil and Water Conservation District
Efficient Nutrient Use Through Improved Grazing Techniques Demonstration Project
Orlando Lakewatch
Reef Environmental Education Foundation (REEF)
Save the Bays Association, Inc.
Water Quality Monitoring of Moorings Bay and Clam Bay Systems
St. Andrew Bay Resource Management Association (RMA) Baywatch Program
Tampa Baywatch, Inc.
The H2O Guard

c) Louisiana

Enlighten Me Design's Tangipahoa River Volunteer Monitoring
Lake Pontchartrain Basin Foundation
River Watch & Canal Watch
Teche/Vermilion Blue Thumb Project

d) Texas

Aquifer Watch
Ark-Tex Council of Governments
Ash Sixth Grade Learning Center
Blum High School
Brazos Basin Volunteer Citizens' Monitoring Program
Caddo Lake Institute
Cypress Watershed Network
Caprock Chemistry
Churchill High School Texas Watch
Colorado River Watch Network

Lower Colorado River Authority
Eastern Hills Monitors
Texas Urban Watch
Edna Junior High School
El Rancho Cima Boy Scout Ranch
Blanco River Monitoring Program
Friends of the Frio
Galveston Bay Foundation
The Estuarine Sampling Team (TEST)
Gregory-Portland Junior High School Naturalist Club
Houston-Galveston Area Council

APPENDIX F.
THE CASE FOR ROUTINE BIOLOGICAL MONITORING IN GULF ESTUARINE AND COASTAL MONITORING

Compiled by James Stribling, Tetra Tech, Inc.

One of the principal goals of GOMA is to enhance the ecological health of the Gulf of Mexico, and, as such, it is important that valid and defensible estimates of ecological condition are produced from the design and implementation of this monitoring program. Widely-used tools for monitoring ecological condition include different indexes that integrate not only the complexity of aquatic biota, but also have a robust capacity for reflecting the effects of multiple, complex, and temporally variable stressors. The need for such a tool led to creation of the Index of Index of Biological Integrity (IBI) (also known as a multimetric index [MMI]), which was originally developed for fish in Illinois streams (Karr et al. 1986), and has been subsequently adapted for use with other assemblages, including invertebrates (aquatic snails, mollusks, crustaceans, worms, and mites), fish, and/or algae, and for other water body types, including estuaries, lakes and reservoirs, large rivers, and wetlands; and in many other geographic areas throughout North, Central, and South America, Europe, and increasingly, Asia. Different forms of the MMI developed for estuarine and near-coastal systems have been calibrated to the Gulf of Maine, the Chesapeake Bay, estuarine and near-coastal areas of the Virginian and Carolinian Provinces, southern California Bight, and San Francisco Bay (Weisberg et al. 1997, Hyland et al. 1999, 2003, Van Dolah et al. 1999, Paul et al. 2001, Smith et al. 2001, Llansó et al. 2002, Ranasinghe et al. 2004, Thompson and Lowe 2004, Borja et al. 2008, and Hale and Heltsche 2008). For the Gulf of Mexico/Louisianian Province, benthic invertebrate MMI have been developed for system-wide application (Engle et al. 1994, Engle and Summers 1999), and more spatially-focused for Tampa Bay (Florida), the Calcasseiu Estuary (Louisiana), and the Lavaca-Colorado Estuary (Texas) (Carr and Gaston 2002, Malloy et al. 2007, Pollack et al. 2009). More recently, GOMA has re-calibrated a benthic MMI for the Gulf of Mexico using a temporally-expanded dataset (GOMA 2011). The intent of GOMA in developing an MMI calibrated to conditions in the gulf is to obtain a tool to help assess the condition of biological resources with respect to a variety of stressors and conditions, including nutrients, water chemistry, physical characteristics, hydrology, and climatic conditions.

Regardless of the types of biological data used, reliability of these indexes depends on a number of factors, including consistency of sampling and analysis methods and their application, and calibration that sufficiently deals with variability resulting from seasonal, regional, and small-scale spatial influences, and that produce objective statements of data quality (Stribling 2011). This leads directly to enhancing

comparability, not only within-dataset (sample to sample), but also among-datasets (programs, labs, or years).

Different environmental management activities planned for the Gulf of Mexico are focused on improvement or protection of some aspect of the gulf ecosystem. Evaluating performance and effectiveness of those particular activities requires monitoring (sampling and analysis) of the constituents being managed. For example, the effectiveness of efforts to manage nutrients, sediment, or other pollutants can be evaluated by monitoring and assessing those particular constituents. Focused sampling and analysis activities are required for monitoring seafood contamination, fish stocks, stability and health of individual coastal wetlands, physical habitat quality, the extent and intensity of the hypoxic zone, and human health oriented pathogens/HAB. However, for making defensible statements of the effectiveness of ecosystem restoration in the Gulf of Mexico, spatially comprehensive, and routinely applied biological monitoring is necessary, and can be accomplished by gulf-wide monitoring using a benthic multimetric index as the principal indicator. Other assessments, much of which can and should be done simultaneously, may be needed to help identify the causes and sources of the environmental stressors leading to degraded biological condition.

Ecosystem restoration requires comprehensive conceptual planning based on appropriate ecological/scientific principles and properly-designed and broadscale sampling and analysis (Palmer 2009, Allan et al. 2013). As with any large ecosystem or body of water, ecological conditions in the Gulf of Mexico are exposed to cumulative stressors, many of which have been present for decades. Once restoration goals and objectives are defined for an ecosystem, management actions are designed and implemented to assist or allow ecological processes to function, thus contributing to movement toward the goal. If the goal is ecosystem health, just because one of multiple stressors is controlled or eliminated does not necessarily mean that restoration has been successful. Restoration is not elimination of stressors; restoration is attainment of some measure of ecosystem health that is specified as a goal.

Palmer et al. (2005) list 5 standards that could potentially be used for determining success in ecological restoration, but also state that answering the question of how much restoration improvement is enough is the most difficult. Very importantly, the point is made that determining sufficiency of restoration effort (with protection as the flip-side of the coin) is not only a scientific or technical issue, but also includes interests of public and policy-makers, and the transferability of the educational value to future watershed management efforts, that is, "lessons-learned". This concept of restoration success means that those areas assessed as being in worse conditions, with a higher percentage of degradation, can be managed not necessarily to attain unimpaired or

reference conditions, but to prevent additional stressor loads and gradually improve them over time.

In addition to providing a scientifically objective assessment of ecological conditions in the Gulf of Mexico, routine biological monitoring and assessment throughout the estuarine and near-coastal waters of the Gulf of Mexico will help identify those areas where cumulative stressors are most intense, ecosystem services are most at risk, and where focused restoration activities would likely be most effective. This is the scientific foundation and management rationale for the restoration goal stated in this report, that is, that: *by 2035, less than 25% of the Gulf estuarine and near-coastal waters will be rated as poor (=degraded) for benthic conditions*. Routine and consistent biological monitoring is necessary for this goal to be addressed. Further, it should be recognized that spatially focused assessment of data on a shorter-term basis (at 1-5 year intervals, for example) will inform management decisions for individual estuaries, zones, or freshwater inflows.