Qualitative Gap Analysis Report

Gulf of Mexico Alliance: Identification and Characterization of Gulf Habitats
(NOAA Award # NA08NOS4730394)

(USF Acct. No. 47 10 1094 00)

Prepared for the Harte Research Institute for Gulf of Mexico Studies

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EXECUTIVE SUMMARY

This report provides a qualitative analysis of the gaps in currently available coastal and marine information within the Gulf of Mexico. The analysis was carried out as part of the Gulf Geospatial Assessment of Marine Ecosystems (GAME) project, whose aim is to create an inventory of existing physical, geological, biological, chemical, and human uses information in a Web-based database.

The goal of the qualitative analysis is to identify gaps in information categorized by GAME data classes (biological, chemical, geological, physical, and human use) and to provide a visual representation of gaps. Presence/absence maps were created using Geographic Information System software produced by the Environmental Systems Research Institute, Inc. (ESRI).

Throughout the Gulf of Mexico, the majority of the biological footprints created for this report are located within the 200 meter contour. Chemical data maps show the most gaps. Human use Activities information is especially concentrated in the northern Gulf of Mexico; this is due to the presence of oil and gas industry in this region. The majority of the information contained in the GAME Catalog belongs to the earth measurements/geomorphological class; therefore there appear to be fewer gaps in this class within the 200 meter contour. Gaps in physical information are difficult to properly determine due to the fact that most data sets are represented by large footprints. These large footprints represent remote sensing data.

This analysis is meant to provide researchers, scientists, and resource managers with a visual representation of the available data in the Gulf of Mexico so to make better informed decisions. In fact, significant information gaps may lead to poor decisions. In the long term the results of the analysis might guide the identification of data needed in a certain area and the development of a subsequent data acquisition strategy to fill the gaps.

The analysis conducted in this report has limitations: 1) it is static and 2) only provides a visual representation of the gaps in information. The qualitative gap analysis products contained in this report are just a snapshot taken at a specific time and they will need to be updated as more records are entered in the GAME Catalog. Also, it is recommended to move from a visual, qualitative analysis to a quantitative analysis based on experts' opinion that will allow a score to be assigned to each available data set.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Ms. Christy Fagundez and Mr. Bryan Welch (Florida Fish and Wildlife Conservation Commission/Fish and Wildlife Research Institute) in creating footprints in support of the GAME project.

A special thank you goes to Mr. René Baumstark (Florida Fish and Wildlife Conservation Commission/Fish and Wildlife Research Institute) for his efforts and support in the construction of the Multipurpose Marine Cadastre grid used in this report.

Sincere gratitude is extended to Dr. John C. Ogden (University of South Florida) for reviewing this report and providing helpful feedback and to Dr. Sandra Vargo (Florida Institute of Oceanography) for her continuous support.

The authors also want to convey thanks to the Harte Research Institute for Gulf of Mexico Studies and the National Oceanic and Atmospheric Administration Gulf Coast Services Center for providing the financial means to complete this work.

1. GOVERNANCE BACKGROUND

1.1 Introduction

The images of numerous dead fish washed ashore due to a harmful algal bloom event, of once white beaches and blue waters now covered by a layer of oil spilled by a boat running aground or by the most recent Deepwater Horizon blow out, of stressed and bleached coral reefs due to anomalously high temperatures, of the damage caused by the most recent hurricane now that barrier islands have lost their protective functionality because of human impacts, and many others are commonly seen on TV. However, they are not just images; it is reality. People who live and work along the coast or on the ocean are witnessing firsthand the dramatic decline of our marine resources due to natural and human disturbances. Marine ecosystems all over the world are under increasing anthropogenic pressure that causes serious and, sometimes, irreversible damage. This is the result of sector-by-sector management practices that have been carried out for, at least, the last 30 years. The current system of laws and regulations focuses on specific sectors and uses of the ocean and is consequently too fragmented to encompass entire ecosystems (UNEP/GPA 2006; Leslie & McLeod, 2007; Young et al., 2007; Douvere, 2008). A substantial shift in governance (Arkema et al., 2006; UNEP/GPA, 2006) is required to overcome this business-as-usual scenario (Young et al., 2007).

There is little evidence that current small-scale, single-issue management practices can stop or mitigate the growing human footprint in the ocean. This is the reason why concepts like Ecosystem-Based Management (EBM) and Coastal and Marine Spatial Planning (CMSP) hold considerable promise for holistic and adaptive ocean governance. These approaches also have the advantage of attracting more public attention to the social and economic importance of a healthy ocean.

Three elements are required for successful ocean governance: policy, organizational framework, and information. These, in order, are discussed in the following paragraphs.

1.2 Policy

In June 2009 President Obama established the Interagency Ocean Policy Task Force (Task Force) in response to the need for a National Policy for the stewardship of our ocean, coasts, and Great Lakes (The White Council on Environmental Quality, 2010). The Task Force published an Interim Report within 90 days of its creation and released an Interim Framework for Effective Coastal and Marine Spatial Planning in December 2009. Both reports include stakeholders' input and build on previous policy

efforts, such as the federally mandated U.S. Commission on Ocean Policy and the privately funded Pew Ocean Commission (Pew Oceans Commission, 2003; US Commission on Ocean Policy, 2004). The commissions both identified significant concerns regarding the sustainability of the use of U.S. ocean resources (Nicholas Institute for Environmental Policy Solutions, 2006) and recommended a science-driven, ecosystem-based approach to manage ocean and coastal resources (Pew Oceans Commission, 2003; US Commission on Ocean Policy, 2004).

The Task Force's Interim Report and Interim Framework were combined with public comments into the Final Recommendations of the Ocean Policy Task Force (Recommendations) issued on July 19, 2010 (The White Council on Environmental Quality, 2010). The Final Recommendations mandate the creation of a National Ocean Council to strengthen ocean governance and coordination and define the geographic scope of planning areas (framework) for the implementation of the ocean policy (The White Council on Environmental Quality, 2010). This will help bring order to the present conflicting and overlapping legal mandates and activities of federal and state agencies involved in ocean resources management (The White Council on Environmental Quality, 2010). Some of the policy elements in the Recommendations are: protection, maintenance, and restoration of healthy ecosystems and biological diversity; increase resiliency; use of the best available science; increase scientific understanding of marine ecosystems; and foster a public understanding of the value of the ocean, coasts, and Great Lakes.

In the Recommendations, the Task Force (The White Council on Environmental Quality, 2010) identified 9 priority objectives:

1. Ecosystem-Based Management (EBM);
2. Coastal and Marine Spatial Planning (CMSP);
3. Inform decision and improve understanding;
4. Coordinate and support;
5. Resiliency and adaptation to climate change and ocean acidification;
6. Regional ecosystem protection and restoration;
7. Water quality and sustainable practices on land;
8. Changing conditions in the Arctic; and
9. Ocean, coastal, and Great Lakes observations, mapping, and infrastructure.

Of interest to this report are the first two: EBM and CMSP as principles and tools to put into practice national laws and regulations at a regional level.

EBM, the recommended improved management strategy, is place-based and treats the ecosystem as a whole (Pew Oceans Commission, 2003; US Ocean Commission on Ocean Policy, 2004; McLeod et al., 2005; Sherman et al., 2005; Arkema et al., 2006; Crowder et al., 2006; Nicholas Institute for Environmental Policy Solutions, 2006; Nugent and Cantral, 2006; Young et al, 2007; Joint Ocean Commission Initiative, 2009). EBM is an integrated and adaptive management approach (McLeod et al., 2005; Sherman et al., 2005; Nugent and Cantral, 2006; Carollo et al., 2009) that goes beyond single sector management, examines links between living organisms and their environment and, considers human activities, their benefits, and their potential impacts (Browman and Stergiou, 2005; Arkema et al., 2006; Crowder et al., 2006; Ruckelshaus et al., 2008). This approach aims at maintaining healthy and resilient marine ecosystems and their functions, structures, and processes (Leslie and McLeod, 2007) so that they can provide services for current and future generations. EBM is an interdisciplinary, cooperative management method able to provide responses to complex pressures. An EBM strategy recognizes that there are interconnections within and among ecosystems and the people that depend upon them (Joint Ocean Commission Initiative, 2009). Human activities are considered as part of the ecosystem, as much as biotic and abiotic components and, as such, they must be managed and regulated. This broader definition of ecosystem, with boundaries not arbitrarily drawn on a map (Chornesky et al., 2010) to respect human jurisdictions, opens the door to an integrated assessment across disciplines: from biological to geological, physical, and socioeconomic.

In principle, the concept of EBM is clearly defined. As described in the most recent Packard report, EBM has moved closer to broader acceptance but is not yet implemented widely (Packard Foundation, 2010). There are great needs and opportunities for improving the practice of EBM: a more comprehensive governance structure, stronger coordination of various government and non-government entities (Armada et al., 2009), greater stakeholders' participation (Armada et al., 2009; Cochrane et al., 2009; Pollnac and Christie, 2009; Packard Foundation, 2010), and policy (U.S. Commission on Ocean Policy, 2004).

Planning has been done on land for decades; why not in the ocean? There are planning departments in every city, county, and state that create land use maps to inform development decisions

to minimize user conflicts. We must do the same in the ocean to maintain healthy ecosystems. CMSP identifies current and potential uses of the ocean and coasts while mapping natural resources and the geoenvironments ecosystems depend upon. It is an adaptive process that allows organizing compatible uses and reducing conflicting uses in the ocean and coastal environments while protecting marine ecosystems (Ehler and Douvere, 2009; The White House Council on Environmental Quality, 2010). CMSP is regional in scope and has a collaborative component. It is a practical way to create and establish a more rational organization of the use of marine space and the interactions between its uses, to balance demands for development with the need to protect marine ecosystems, and to achieve social and economic objectives in an open and planned way (Ehler and Douvere, 2009). Recently, a step-by step guide to CMSP has been published which presents clearly and with many examples its importance and how to do it. This exemplary work shows that while the tools and approaches of CMSP can be outlined, each location is unique in terms of engagement of the stakeholders and the local and national political apparatus (Ehler and Douvere, 2009).

1.3 Organizational Framework

The second element of successful ocean governance is an organizational framework in which federal, state, tribal, and local governments work with universities, Non-Governmental Organizations, and the private sector (The White House Council on Environmental Quality, 2010). Ideally, the new organizational framework would be a multilevel institutional setting that promotes interdisciplinary collaboration and research (Danter et al., 2000; Meffe et al., 2005; Leslie and McLeod, 2007; Olsson et al., 2008; Plasman, 2008). The newly established ecosystem management network would be an inter-organizational network with clearly defined goals that are widely communicated to all the stakeholders (Danter et al., 2000; Meffe et al., 2005; Nicholas Institute for Environmental Policy Solutions, 2005; Leslie and McLeod, 2007; Manring, 2007; Young et al., 2007; Ehler, 2008). In synthesis, the described organizational changes required to create an adaptive management network can be defined as a meaningful integration of people that promotes bridging science and policy (Meffe et al., 2005; Nugent and Cantral, 2006; Day, 2008; Douvere, 2008; Ehler, 2008; Olsson et al., 2008).

At present, in any area of the ocean and coastal environment, multiple agencies have management jurisdiction (Eagle, 2006). The current scenario creates undesired complexity and uncertainties that are a deterrent to public involvement. This shows a lack of clarity in agencies' responsibilities that result in a non-comprehensive management strategy (Pew Oceans Commission,

2003; US Commission on Ocean Policy, 2004). The organizational structure of any agency that has a claim on marine resources is too narrow to manage wide geographic areas and define broad scopes (Pew Oceans Commission, 2003; US Commission on Ocean Policy, 2004).

Regional ocean partnerships are, to date, probably the most appropriate bodies in place to implement regional ocean governance by merging scientific understanding and management policy into unprecedented large-scale coastal and ocean management (Hershman and Russell, 2006; Nicholas Institute for Environmental Policy Solutions, 2006; The White House Council on Environmental Quality, 2010). The Nation has been divided into 9 regional planning areas and, in recent years, a few regional partnerships were designed and formed: the Great Lakes Regional Collaboration, the Northeast Regional Ocean Council, the Mid-Atlantic Regional Council on the Ocean, the South Atlantic Alliance, the Gulf of Mexico Alliance, and the West Coast Governors' Agreement. One of these multi-party agreements is the Gulf of Mexico Alliance, a state-led initiative of the states of Alabama, Florida, Louisiana, Mississippi, and Texas. This partnership promotes regional collaboration with the aim of improving the ecological and economic health of the Gulf of Mexico. The five U.S. Gulf States have identified six priority issues that are regionally relevant and can be effectively addressed through increased collaboration at local, state, and federal levels and with non-governmental partners. This will be discussed in details in the next section.

1.4 Information

The third element of successful ocean governance is information. Scientists and natural resource managers recognize that CMSP and EBM need to be based on the best available science (Pew Oceans Commission, 2003; US Commission on Ocean Policy, 2004; Sherman et al., 2005; Arkema et al., 2006; Crowder et al., 2006; Nicholas Institute for Environmental Policy Solutions, 2006; Young et al., 2007; Joint Ocean Commission Initiative, 2009; Schempp et al., 2009; The White House Council on Environmental Quality, 2010). Information including, but not limited to, benthic habitats, oceanographic parameters such as temperature and salinity, bathymetry, and sediments should be gathered and analyzed through a geospatial assessment process. Human uses should also be mapped; those include shipping lanes, pipelines and cables, minerals leases, fishing zones, and aquaculture sites to name a few. The first step of the process requires identifying and cataloging existing spatial information from several different sources to create a repository. However, assembling the available data and determining the quality is a lengthy and painstaking process. A good understanding of the available information and

gaps in data is both a need and a challenge in order to manage human activities in ocean ecosystems. Data gap analysis maps would provide a tool for a better understanding of what information is available to support resource management decisions.

Knowing what information is available enables better planning and management of human uses of natural resources where there are competing demands. Also, gaps identification allows (1) avoiding overlap in data acquisition, (2) being as comprehensive as possible, practical in format, and clear in presentation, and (3) including sufficient detail to be of use for resource managers. Additional information related to information gaps can be found in the next sections.

A critical component of the geospatial assessment is to display information through Geographic Information System (GIS) software. Following the visualization, integration is required at the appropriate geographic scale to make the data suitable for decision makers. However, data integration across long established fields of study (Murawski, 2007; Carollo et al., 2009) to create a common vision of ocean resources (Commonwealth of Australia, 2005) is the most challenging step due to data compatibility.

A well performed geospatial assessment will assist multidisciplinary planning and could be used to inform the decision making process. Continually updated maps are the basis for the development and implementation of a coastal and marine spatial plan that allows assessment of changes under different management scenarios.

2. GULF OF MEXICO ALLIANCE

2.1 Introduction

Because the Gulf of Mexico waters and coasts provide critical natural and economic resources the lack of coordination and fragmented decision-making is seen as inadequate to address the new range of ocean uses. EBM and CMSP can address this situation, applying land planning tools to the marine environment to complement state regulation and coordinate coastal and ocean uses more effectively and efficiently and to maintain ecosystem health. The first regional step towards new ocean governance was taken in the Gulf a few years ago.

The social, economic and ecological emergency created by the intense 2004 and 2005 hurricane seasons was proof of the failure of traditional ocean governance due to the difficulties in dealing with broad-scale systems (Ruckelshaus et al., 2008; Carollo et al., 2010). These crises set the stage for the development of a new network for regional adaptive governance, i.e. an alternative approach for governing (Olsson et al., 2006) coastal and ocean resources in the Gulf of Mexico (Carollo et al., 2010).

Their cumulative impacts on the five U.S. Gulf States demonstrated the need for a joint response to common regional challenges (Crowder et al., 2006). To fulfill this need, the states of Florida, Alabama, Mississippi, Louisiana, and Texas formed a partnership called The Gulf of Mexico Alliance (GOMA), which is one of the regional ocean partnerships mentioned above. The unifying purpose of GOMA is to ''increase regional collaboration to enhance the ecological and economic health of the Gulf of Mexico'' (Gulf of Mexico Alliance, 2006). GOMA's objectives address both regional complexity and societal values in Gulf-wide planning and management processes. Therefore, GOMA furthers management practices aimed towards the broader perspective of ecosystems (Imperial, 1999) by bridging gaps across traditional disciplines at a regional scale.

Since the beginning, a Federal Workgroup, made up of 13 federal agencies coordinated by the U.S. Environmental Protection Agency (EPA), the Department of Interior, and the National Oceanic and Atmospheric Administration (NOAA), agreed to provide support to GOMA (Gulf of Mexico Alliance, 2006; Nugent and Cantral, 2006;), a State-led initiative.

The first roadmap of GOMA, the Governors' Action Plan I for Healthy and Resilient Coasts March 2006-March 2009 was issued in 2006 (Gulf of Mexico Alliance, 2006). This document guided the actions of researchers, scientists, and natural resource managers in their restoration and conservation efforts to make regional ecosystems more resilient. GOMA put forward 73 activities through the Action Plan I. By March 2009 the majority of these were completed and a few still in progress. The recognition of this success solicited wide-ranging stakeholder support. GOMA's structure has proved able to support (1) a change in ecosystem management and natural resource governance (Danter et al., 2000) at a regional level and (2) the participation and collaboration of federal, state, and local governments to the development and implementation (Imperial, 1999) of planned tasks (Carollo et al., 2010)

Currently, 6 priority issues are to be addressed by GOMA and are outlined in the Governors' Action Plan II for Healthy and Resilient Coasts 2009-2014, as follows (Gulf of Mexico Alliance, 2009):

(1) Water Quality;
(2) Habitat Conservation and Restoration;
(3) Ecosystem Integration and Assessment;
(4) Nutrient and Nutrient Impacts;
(5) Coastal Community Resilience; and
(6) Environmental Education.

A Priority Issue Team (PIT) was formed for each of the priority issues listed above. Each one of the five U.S. Gulf States assumed the leadership of at least a PIT (Carollo et al., 2010); for instance, Texas is the lead for the Ecosystem Integration and Assessment (EIA) PIT. All States assigned a member with voting privileges to each PIT so that all interests were represented. Federal, local, private, NGO's, and university representatives participate in all teams based on their skills and expertise. Each PIT defined its own long-term partnership goals and short-term actions with the potential for 5-year tangible accomplishments (Gulf of Mexico Alliance, 2009). The EIA PIT goals and activities are described in details in the next section.

2.2 Ecosystem Integration and Assessment Priority Issue Team

As described in the Action Plan II (Gulf of Mexico Alliance, 2009) the long-term partnership goals of the EIA PIT are to develop regional data systems that contain environmental and economic data; establish strategic partnerships to fill environmental and ecological data gaps; and provide ecosystem decision-support tools to address priority issues within the Gulf (Gulf of Mexico Alliance, 2009). Several actions will be taken by the EIA PIT members to achieve the long-term goals, but only two are of interest here: 1) provide resource managers and Alliance partners with access to a Gulf-wide data and ecosystem support services system and 2) data gap analysis (Gulf of Mexico Alliance, 2009). One EIA PIT project, the Gulf Geospatial Assessment of Marine Ecosystems, is in support of these actions and will be described in the next section.

From the start one of the issues faced by the EIA PIT, and in general by the Alliance, was the lack of a regional information system that would allow scientists, researchers, and other stakeholders easy access to information. The partnership structure allowed improving accessibility to available data and

information throughout the Gulf region. The Gulf of Mexico EcoWatch portal was built following the recommendations of the Alliance.

The sharing of information between groups is an example of increased communication opposed to a business-as-usual scenario in which information is usually compartmentalized (Danter et al., 2000; Olsson et al., 2006; Manring, 2007). The results already achieved by this team are an example of the continuous effort that is required to improve the access and sharing of spatial coastal and ocean information through cooperation (Strain et al., 2006) at a regional level (Carollo et al., 2010)

In synthesis, the steps that the EIA PIT has taken to date to further the implementation of marine EBM and CMSP show that the involved partners are working toward (1) continuing and improving cooperation, (2) bringing together a number of sources of knowledge and expertise, (3) sharing and synthesizing existing information, and (4) making the decision-making process a collaborative one (Carollo et al., 2010).

3. GULF GEOSPATIAL ASSESSMENT OF MARINE ECOSYSTEMS

In this time of ocean policy and framework development a new project was started. This project is nested within the GOMA framework and is in support of the application of new tools to allow access to available scientific information. At the very heart of the GOMA philosophy, this project promotes the sharing of information across boundaries and disciplines that in the past have proven to be a challenge for collaboration. This is especially important now in the aftermath of the recent British Petroleum Deepwater Horizon oil spill event.

3.1 Background information

The Gulf Geospatial Assessment of Marine Ecosystems (GAME) project, one of the EIA PIT endeavors, is a key step towards the determination of data availability and information gaps for ecosystem assessment. In fact, in line with the EIA PIT, one of the GAME project's objectives is to identify and catalog existing priority coastal, estuarine, nearshore and offshore Gulf habitat-related information (Gulf of Mexico Alliance, 2009).

The Gulf GAME project (http://research.myfwc.com/gulfgame) is an extension of the Florida GAME project that started in September 2005 as collaboration between the University of South Florida, the Florida Institute of Oceanography, and the Florida Fish and Wildlife Conservation Commission.

When the GAME project first started its original goal was to identify marine ecoregions to allow for a better management of coastal and marine resources through the implementation of EBM. This management approach would help address important issues arising from conflicting uses while striving for natural conservation in Florida coastal and marine waters.

Developing ecoregional approaches to aquatic resource management has been a key goal in Florida for many years. Significant progress has been made in reaching this goal in many of Florida's freshwater management programs (Griffith et al., 1994) but lack of resources has significantly delayed progress for the state's coastal and ocean systems. Marine ecoregions present special challenges since they are not easily compartmentalized and generally present a continuum of overlapping, often interdependent systems. Ecoregion identification is a critical component in managing ocean resources and developing the appropriate tools needed for integrated management, resource protection and, as appropriate, restoration.

A step-wise process was designed to allow for an integrated assessment of marine ecosystems. The steps are the following: (1) data discovery, (2) identification of data gaps, and (3) delineation of marine and coastal ecoregions for Florida.

The initial phase of the GAME project, data discovery, was designed to inventory physical, geological, biological, chemical, and human uses information in a Web-based database. Examples of spatial information include but are not limited to: (1) benthic habitats, e.g., hard bottom, submerged aquatic vegetation, oyster reef, and coral reefs; (2) oceanography, e.g., circulation patterns, salinity, and temperature; (3) bathymetry and coastal elevation; (4) bottom structure and sediment characteristics; (5) living marine resources; and (6) human use patterns (Carollo et al; 2009).

The project assembles, when possible, the many sources of existing data in a GIS format as discussed on page 8 and 9 of this report. This enables overlay of diverse information in a way that

permits transparent and intuitive visualization of habitats and other non-living and living marine resources.

As a first step in creating the inventory of existing coastal and marine information, an internet application (the GAME Survey) was designed and deployed to gather information and attendant metadata from researchers, resource managers, and other stakeholders (Carollo et al., 2009). The survey was created for data holders to enter information relative to their data sets through an easily accessible interface. The information entered via the online survey is stored in a database, called the GAME Catalog, which is a Microsoft Access relational database, easy to build and query.

It took a few months to plan the database in a way that would capture the most information with the fewest number of fields. This translates into a limited number of questions that data holders need to answer to enter a record through the online GAME Survey. This point was determined to be a key to the success of the project, i.e., acquire as much useful information about the data while requiring a minimal amount of time of the data producer (Carollo et al., 2009). Therefore, the GAME Catalog has a broad scope and catalogs disparate datasets, which are grouped by general classes. These classes are geological, biological, chemical, physical, and human-use.

Also, the Catalog is compliant to Federal Geographic Data Committee (FGDC) standards. The information collected is called “metadata lite”. This means that an entry in the GAME Catalog is not a full FGDC metadata record, but does address the core questions (who, what, when, why, where) that constitute a metadata record.

A key feature of the catalog is that the GAME records link directly to the desired datasets, providing that the data producer has the data available online.

A list was compiled of over 2200 researchers, scientists, and multiple stakeholders working for state, federal, local, private organizations, universities, and NGOs. An email invitation to fill in the GAME Survey and contribute to the Catalog was sent out a few months after the project started. Reminders are issued periodically. Also, GAME workshops and seminars have been held periodically around Florida and the other U.S. Gulf States to solicit participation. In general, the response and contribution from scientists and researchers has been very small (Carollo et al., 2009).

Unfortunately, during this first phase, a lack of willingness in sharing information was encountered. Some scientists chose not participate in the GAME project because they do not see the benefit of sharing their data. In fact, there are currently no incentives in place to stimulate scientists and researchers in sharing information. Moreover, scientists and researchers tend to retain their own data and information until they are able to publish their results via peer-reviewed journals. In many instances, even after the publication date, scientists and researchers are reluctant to share their data (Carollo et al., 2009).

However, making this project work is possible only through the sharing of knowledge and pooling of resources with properly prepared metadata. Unfortunately, it is not always mandatory to create attendant metadata. Therefore, many researchers still do not document their studies in this manner; thus, some fundamental information might not be captured through the GAME project.

In mid 2007 the data discovery phase was expanded to the Gulf of Mexico to support the activities of the then recently formed GOMA. GAME provided database infrastructure to establish baseline information and mapping system to inform resource management decisions Gulf-wide and Florida's east coast. The Gulf GAME data inventory has both a regional and local scope and focuses on gathering data and mapping ocean and coastal resources progressing from the estuaries offshore to the edge of the continental shelf. The Gulf GAME records feed into the EcoWatch portal and are searchable through its interface.

The availability of updated maps derived from a spatially organized database can allow rapid access to the information needed to enhance the understanding and protection of habitats and their associated marine resources. With such a tool in hand, the Gulf States and federal agencies can begin to make coordinated and complementary decisions concerning coastal waters that are based upon integrated information and directed research. This allows managers to better plan existing and future uses (e.g., commercial, recreational, conservation areas) of the Gulf of Mexico's sustainable marine resources, based upon the best available data and scientific models. It also helps to identify what types of data are missing and the areas lacking sufficient data. Significant data gaps might impede the implementation of EBM and CMSP; therefore, their upfront identification would be beneficial.

The current steps in the Gulf GAME project are to create and display presence/absence gap maps for all the Gulf States (qualitative gap analysis) and implement a quantitative gap analysis for the State of Florida. The qualitative gap analysis is the object of this report and it will be discussed in details in the next sections.

GAME is a working example of how increased communication can help to elevate the level of knowledge by the sharing of information. During the collaboration with GOMA EIA PIT, Gulf GAME has been successful in (1) improving multilevel collaboration, (2) increasing stakeholders' involvement, (3) cataloging and sharing existing information for bridging science and policy and (4) providing the tool for implementing consensus-based decision making based on the best available science.

3.2 Qualitative Gap Analysis

Gap analysis is a term used in several fields from business and economics to ecology. In general, the gap analysis is a tool that helps compare the actual situation with its potential or desired condition. Therefore, at its core there are two major questions: "What is the current situation?" and "What is the condition that can be achieved or is desired?". This systematic process highlights the difference, the "gap", between the optimized versus the current condition (http://www.ehow.com/way_5157021_gap-analysis-tutorial.html ; http://alumnus.caltech.edu/~rouda/T2_NA.html). In the business world if a company is not making the best use of its current resources then it may be performing at a level below its potential (http://en.wikipedia.org/wiki/Gap_analysis). In this setting, the gap analysis provides the company with information regarding areas which could be improved and prompts action in the areas being monitored to reach the target (http://www.adamssixsigma.com/Newsletters/data_analysis.htm).

In a scientific context, and specifically applied to biodiversity, the "gap analysis is a scientific method for identifying the degree to which native animal species and natural plant communities are represented in our present-day network of conservation lands. Those species and communities not adequately represented constitute "gaps" in conservation lands and efforts" (http://biology.usgs.gov/bio/gap.html). It was recognized that such a process was needed in order to move beyond a species-by-species approach that does not adequately address the persistent decline and fragmentation of natural landscapes (http://biology.usgs.gov/bio/gap.html). Under these circumstances, the gap analysis is possible through the sharing of information and promotes a more effective conservation of biodiversity.

Within the framework of the GAME project, “gap analysis” refers to the identification of gaps in information as described above (page 8 and 9). The need to (1) determine gaps in data and knowledge and (2) fill these gaps is common in the literature (Abell et al., 2002; Pew Oceans Commission, 2003; U.S. Commission on Ocean Policy, 2004; Western pacific Regional Fishery Management Council, 2005; The Nature Conservancy, 2006; Northern Gulf Institute Ecosystem Team, 2009; The Commonwealth of Massachusetts, 2009; Chornesky, 2010; Eastern Research Group, 2010; Packard Foundation, 2010). Information gaps need to be identified before management practices, such as EBM and CMSP, can be implemented; in fact, significant information gaps may lead to poor decisions. As highlighted in the WWF reports on terrestrial and fresh water ecoregion assessment data gaps are hindering proper management of natural resources (Abell et al., 2002; Dinerstein et al., 2000).

EBM and CMSP depend upon accurate information about the distribution of species, their spatial and temporal distributions, habitats of special importance such as spawning areas or regions of mass productivity, and human uses of these natural resources (Huston, 2002). Knowing where there are gaps in data is the cornerstone in alleviating (1) mismatches between spatial and temporal dimensions, and (2) misunderstanding of ecological processes (Huston, 2002).

Identifying and presenting the gaps in data on the front end of any planning or management process, such as EBM or CMSP, helps gain credibility with multiple stakeholders. Information that is presented clearly, transparently, and explicitly (such as in a GIS environment), allows better communication between different user groups.

The foundation of the qualitative gap analysis, object of this report, is in the collection and integration of available information relating to ocean and coastal natural resources, as described above. Information for the 5 U.S. Gulf States and Mexico has been gathered and stored in the GAME Catalog and footprints have been created for each record. The word “qualitative” denotes an early effort to produce maps showing data density; in the next phase of the project a more detailed “quantitative” gap analysis will be performed for the West coast of Florida. The goal of the qualitative analysis is to identify gaps in information categorized by GAME data classes (biological, chemical, geological, physical, and human use) and to provide a visual representation of gaps in GIS. It is the first step towards the identification of data needed in a certain area and a subsequent data acquisition strategy to fill the gaps.

It is important to note once again that the qualitative gap analysis products contained in this report are just a snapshot taken at a specific time and they will need to be updated as more records are entered in the GAME Catalog. Therefore this does not want to be a "complete" assessment; rather the gap analysis needs to remain an iterative process (http://biology.usgs.gov/bio/gap.html).

4. METHODS

4.1 Definitions

The information below is a general description of some common GIS terms and explanations that individuals not familiar with Environmental Systems Research Institute, Inc. (ESRI) software might find useful.

Shapefile

A shapefile stores non topological geometry and attribute information for the spatial features of a data set. The geometry for a data set is stored as a shape containing a set of vector coordinates. Shapefiles are useful because they do not have the processing overhead to a topological data structure, thus an increased drawing speed and editing ability. Shapefiles handle single features that overlap or are noncontiguous. They can support point, line and polygon features. Areas features are represented as closed loop, digitized polygons. Attributes (information about the shapefile: area, length, latitude, longitude, etc.) are held in a dBase format file. Each attribute record has a one-to-one relationship with the associated shape record. Point shapefiles consist of a pair of double-precision coordinates in the order X, Y. Line shapefiles are an ordered set of vertices that consist of one or more parts. A part is a connected sequence of two or more points. Parts may or may not be connected to one another and may or may not intersect one another. Polygon shapefiles consist of one or more rings. A ring is a connected sequence of four or more points that form a closed, non-intersecting loop (ESRI, 1998).

There are a number of ways to create GIS shapefiles. Shapefiles can be created by exporting any data source to a shapefile using ARC/INFO, Spatial Database Engine (SDE), or Arc View GIS software. Shapefiles can be digitized by hand using Arc View GIS feature creation tools and/or by programming using Python (Arc View GIS), MapObjects (ARC/INFO), or Simple Macro Language (SML) software (ESRI,

1998). Third party extensions are also available to use in the Arc View GIS environment. A very popular extension is XTools Pro. XTools Pro was originally developed as a set of spatial analysis, shape conversion, and table management tools for Arc View GIS (http://www.xtoolspro.com/). XTools Pro combines the functionality of ESRI's Arc Toolbox in a Windows-like application. Several common Arc Toolbox functions, such as "Create a Feature Class" have been developed in XTools Pro to be a 'one click' function to create a shapefile. From this feature in XTools Pro, a shapefile name, storage location, attribute information, and projection can be assigned. This was the method used for most of the shapefile footprints created for the gap analysis.

Raster/Grid

In its simplest form, a raster data set is a matrix of cells organized into rows and columns (or a grid) where each cell contains a value representing information. Aerial photographs, imagery from satellites, and scanned maps are examples of raster data sets. Raster data sets are useful for a number of reasons. It is a simple data structure, meaning that a matrix of cells with values representing a coordinate that can be linked to an attribute table. Raster data sets lend themselves to advanced spatial and statistical analysis. They also have the ability to store points, lines, and polygons uniformly (ESRI Arc GIS Help).

4.2 Step by step approach

One requirement for Federal Geographic Data Committee (FGDC) metadata is a spatial extent or bounding box for the dataset. The GAME catalog stores this information based on sectors that were developed for the online survey. GAME sectors are large areas depicting shore to shelf areas and were created to compartmentalize the FGDC requirement in lieu of having a large state, such as Florida, as a bounding box for a particular data set located in Tampa Bay. Additionally, the creation of GAME sectors allows for a more localized search of information in specific areas. Florida is divided into 4 sectors (Figure 1.). Sectors for the other U.S. Gulf States were developed by extending state lines out to the edge of the continental shelf, roughly the 200 meter bathymetric contour. Alabama, Mississippi, Louisiana, Texas, and Mexico are each represented as a sector (Figure 1.). GAME sectors were projected to Albers, North American Datum of 1983. The inherent problem with bounding boxes is that they do not accurately represent the true extent of the data. For this reason, shapefiles (footprints) were created to more precisely represent the data. Information in the GAME Catalog represented as a

shapefile and displayed on a map can be used to visually represent where data are present and where there is an absence of information, i.e. data gaps.

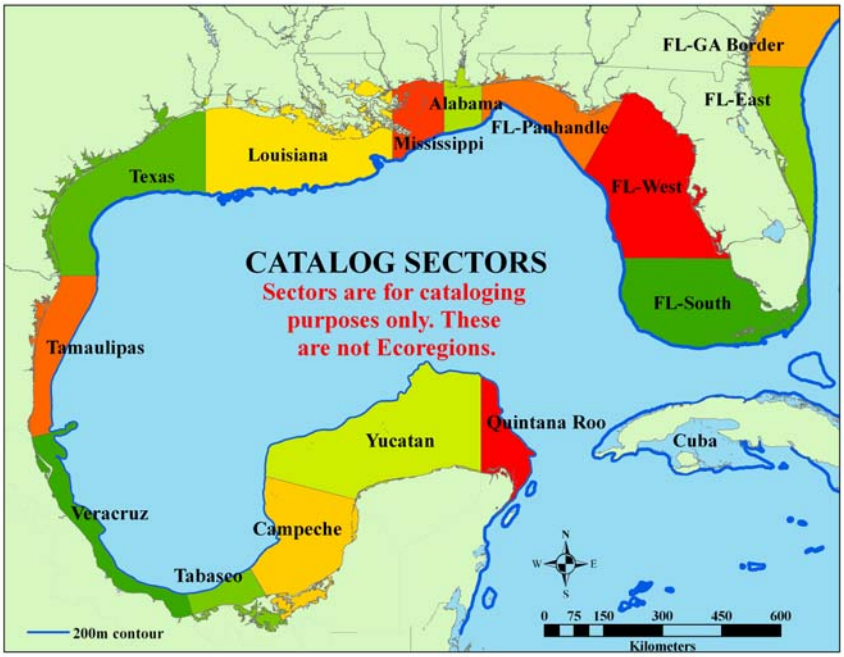

Figure 1. GAME sectors.

All work for the qualitative gap analysis was conducted using ESRI Arc GIS Desktop 9.3.1. Within this software program there are a suite of tools used to create the shapefiles that are contained in the Arc GIS Toolbox. Base map information was obtained from the Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute (FWC-FWRI) data holdings. A shapefile for the southeast United States was used as a shoreline for the Gulf of Mexico. This polygon data set is composed of state and country boundaries at a 1:100,000 scale. Bathymetric contour lines for the Gulf of Mexico were also obtained from FWC-FWRI. Specific information pertaining to these data sets can be found in their associated metadata.

Data used to create and display presence/absence gap maps for all of the Gulf States was obtained from the GAME Catalog. Each entry in the GAME Catalog was reviewed for links to any raw or processed data. If applicable, raw or processed data were downloaded from the source in a GIS format. Additional attributes (such as the corresponding identification number in the GAME catalog, project name if applicable, and catalog name) for each shapefile were created using the “Add Field” function from Arc GIS Toolbox to link the footprint back to its corresponding entry in the GAME Catalog.

If the data were available, every attempt was made to create a footprint using the raw or processed data. However, this was not always the case when dealing with GIS point shapefiles. Several studies were represented as clusters of points, sparse points, and or point locations spread out over large areas. A footprint encompassing all of the data locations would falsely represent the extent of the data. When dealing with point shapefiles of this nature, footprints were created by hand digitizing the area around the points using the XTools Pro function mentioned previously. The projection for all footprints was set to Albers, North American Datum of 1983.

Certain GIS line files, such as ship track lines, presented the same challenge. When these types of GIS files were encountered, ESRI's Arc Toolbox "Buffer" tool was used to create the footprint with the same projection as the point shapefiles above. The Buffer tool measures a user defined distance from a point, line segment, or polygon edge and creates an enclosed loop around the feature. A 5-10km buffer was applied to the shapefile and all overlapping buffers were set to dissolve so that the resulting footprint had more of a uniformed polygon like appearance.

A large number of entries in the GAME Catalog had no GIS component or the GIS information was unavailable. This was due to several reasons, e.g., the data were incomplete (meaning the research was still ongoing), the data set was a report, or there was no GIS information collected at the time of the study. When this type of information was encountered, footprints were created based on the Place Keyword (Study Area) collected through the GAME Survey. If information depicting the specific extent of the data was contained in the data set description from the GAME Survey or any metadata associated with the data set, all attempts were made to accurately represent the detailed extent of the study area. Study areas represented by bays, lagoons, and estuaries were extended to what was judged to be the entrance of the water body. For example, for a study conducted in Tampa Bay, Florida, or Corpus Christi Bay, Texas, with only the name of the study area given as reference to the data set's location, the extent of the footprint was hand digitized using the XTool Pro function with the projection set to Albers, North American Datum of 1983. For Florida, the extent of the footprint would be extended from the northern portions of Tampa Bay to the entrance of the bay around Fort Desoto and the Manatee River. For Texas, all of Corpus Christi Bay would be digitized out to the barrier island (Port Aransas to Mustang Island State Park). These manually digitized footprints were created subjectively given the amount of information contained in the data set description. Several data sets were obtained from reports with

online links to a PDF. If the PDF had a map of the study area or locations for study sites, footprints were manually digitized using any and all information contained in the report using the XTools Pro function with the projection set to Albers, North American Datum of 1983. In data sets that listed no (or very vague) study areas, entire GAME Sector footprints were manually digitized using the XTools Pro function mentioned above. There has been no literature found to support this type of shapefile creation for a qualitative gap analysis.

Gap analysis maps were created for each U.S. Gulf State and Mexico based on the GAME Classes (Biological, Chemical, Earth Measurements/Geomorphological, Human Uses Activities, and Physical). All shapefile footprints for a specific GAME Class were added to the base map information within an Arc View map project and made visible by selecting them. These shapefile footprints were set to a 70% transparency and represented in the same color scheme in each of their respective layer properties. When viewed on a map, the darker the color represented denser information.

In addition to the gap analysis maps mentioned above, shapefile footprints for the state of Florida were intersected with a Multipurpose Marine Cadastre (MMC) grid. A MMC grid is an integrated marine gridded system used for several types of Marine Spatial Planning. Data such as lease sites for oil and gas, aquaculture, Minerals Management Service Planning Areas, shipping lanes, bathymetry, and sea grass beds can be visualized together in a geospatial framework to assist in permitting decisions.

The MMC grid that was used is a GIS data set that represents the US National Grid 10,000 meter polygons for Florida and the surrounding Gulf of Mexico waters in the 16R and 17R grids. Grids were created for all of Florida and surrounding waters using the methodology in the "Guidelines for Building US National Grid Polygons with ArcGIS" from Florida Division of Emergency Management, using the 'fishnet" and "Add X,Y" tools documented in the data sets metadata. Grids were created for 16R and 17R individually in their respective UTM (Universal Trans Mercator) zones, North American Datum of 1983. To combine the two zones into a single file, first they were projected to Albers, then 'clipped' (Arc Toolbox tool) using the 16R and 17R from ESRI's UTM zones data set, and also projected to Albers. The clipped data sets were merged (Arc Toolbox tool) together into a single file. A topology was run to ensure that no overlaps or gaps between the zones were present.

Each MMC grid cell that intersected with a shapefile footprint inherited that shapefiles GAME identification number. Because of the large amount of overlapping shapefiles, MMC grid cells contained

multiple GAME identification numbers. An additional field ('concat') was created in the attribute table to combine the MMC label name and the GAME identification number. The attribute information table was exported to Microsoft Excel and the table was sorted on the concat field. This information showed each MMC grid cell and its corresponding GAME identification number. The concat field was then parsed to separate each individual MMC grid cell and a count of the number of different GAME identifications was calculated. The GAME identification sum for each MMC grid cell was calculated for the intersected grid in Arc View using the field calculator function from its attribute table. The resulting maps (Appendix C) showed presence/absence gap information in an MMC grid format.

5. RESULTS

There were a total of 2,298 shapefiles included in the qualitative gap analysis. A breakdown of this information can be seen in Table 1. It is important to mention here that the total number of data sets grouped by U.S. gulf state and GAME Class is significantly higher than the total number of shapefiles used in the analysis. This is due to the fact that one data set in the GAME catalog can be represented in multiple GAME Classes.

	Number of GAME Data Sets				
	Biological	**Chemical**	**Earth/ Geomorphological**	**Human Use Activities**	**Physical**
Alabama	244	97	165	132	187
Florida	568	167	609	176	361
Gulf wide	17	6	23	12	47
Louisiana	196	63	104	149	169
Mexico	12	4	3	4	13
Mississippi	146	75	88	86	116
Texas	211	65	101	78	158

Table 1. This table represents the number of GAME data sets per state separated by GAME Class.

Information in the GAME catalog was obtained from a diverse group of organizations. Federal, state, and local governments, Non-Government Organizations (NGO), universities, and private

organizations all contributed to information to the GAME Catalog. A list of the different types of contributing organizations can be found in Appendix A.

Types of Information in GAME catalog	Count
Bathymetry	298
Benthic Habitats	1181
Currents	544
Fisheries Information	571
Human Use	371
Nutrients	294
Ocean Color	193
Salinity	266
Temperature	347

Table 2. This table displays Game catalog search results based on certain search criteria.

The types of data sets contained in the GAME Catalog are as diverse as the organizations that have contributed information. Information can be queried in multiple ways. Keyword queries tend to return the broadest amount of information. Table 2 shows some general search information ranging from a broad topic such as benthic habitats to something as specific as salinity. The list of information in Table 2 is a sample of the different types of data that have been of particular interest to the GAME Project from the guidance of the EIA PIT. It is by no means a list of the only types of information contained in the catalog.

Biological	
Aquatic Preserves	Hydrophone Recordings
Artificial Reefs	Invertebrates
Catch per Unit Effort	Mangroves
Catch Rate	Marine Mammals
Chlorophyll	Mollusk
Coastal Zones	Oysters
Corals	Population Dynamics
Crustaceans	Reefs
Diversity	Salt Marshes
Dolphins	Seagrass
Endangered Species	Shellfish
Environmental Sensitivity Index	Submerged Aquatic Vegetation
Fisheries	Tidal Flats
Habitat	Turtles
Habitat Suitability	

Table 3. Breakdown of data types of Biological Information used in the gap analysis.

The types of data used to create shapefile footprints for the qualitative gap analysis maps were consistent for all of the Gulf States. Tables 3-7 show examples of this information.

There was considerable overlap of information from state to state, especially around state borders. Many shapefile footprints overlapped GAME Sectors. Every effort was made to keep state specific data sets within GAME Sectors for that state. This information was based on results from the online GAME survey. However, there were cases where data sets that were assigned to a specific state were displayed on another states gap analysis map. For example, a study conducted by Texas A&M University Corpus Christi on offshore benthic habitat was displayed in the Louisiana gap analysis map. This decision was made because most, if not all of the study locations fell within the Louisiana sector. This overlap is extremely apparent in the Florida, Louisiana, and Texas gap analysis maps.

Chemical	
Air-sea Fluxes	N Compounds
Bacteriology	Nutrients
Bioaccumulation	P Compounds
Biomarkers	Pollutants
Clay Minerals	S Compounds
Dissolved Organic Carbon	Sediments
Dissolved Oxygen	Submarine Springs
Fecal Coliforms	Suspended Matter
Hypoxia	Toxicity
Metals	Water Quality

Table 4. Breakdown of data types of Chemical Information used in the gap analysis.

Earth/Geomorphological	
Benthos	Hydrography
Bottom Type	Isopach
Continental Shelf	LiDAR
Contours	Remote Sensing
Depth	Sand Resources
Digital Elevation Model	Seafloor Topography
Environmental Sensitivity Index	Sediments
Erosion	Topography
Geology	Unsurveyed Areas
Grain Size	Water Masses

Table 5. Breakdown of data types of Earth/Geomorphological information used in the gap analysis.

Physical	
Circulation	Pressure
Coastal Zones	Remote Sensing
Currents	Surface Winds
Density	Tides
Downwelling	Turbidity
Hydrography	Upwelling
Mixed Layer Depth	Water Levels
Mooring Buoys	Water Masses
Navigation	Waves

Table 6. Breakdown of data types for Physical information used in the gap analysis.

Human Use Activities	
Aquatic Preserves	Managed Areas
Artificial Reefs	Marine Managed Areas
Beach Renourishment	Net Fishing
Beaches	Oil Spill
Boating	Parks
Borrow Areas	Permitting
Cables	Pipelines
Environmental Sensitivity Index	Platforms
Fisheries	Pollutants
Human Influence	Shipping
Legislation	Spoil Areas

Table 7. Breakdown of data types for Human Use Activity information used in the gap analysis.

ALABAMA/MISSISSIPPI

Due to the low number of records specific to Mississippi and the overlap of shapefile footprints for Alabama and Mississippi, the qualitative gap map for those two states were combined. Biological data sets footprints for Alabama and Mississippi contained a large number of reports from the Mineral Management Service (MMS). The resulting map (Appendix B, Map 1.) has a heavy concentration of footprints centered on Mobile Bay, AL, out to the 200 meter contour line. The reports from MMS appeared to focus in the area offshore of Alabama and just off of the Chandelier Island, MS.

Chemical data set footprints fall into this same pattern with moderate overlap between Alabama, Mississippi, and west Florida (Appendix B, Map 2.).

Earth/Geomorphological data set footprints (Appendix B, Map 3.) continue with the same areas of concentration. There were a few data sets that extended past the 200 meter contour that displayed grain size and sediment (see Table 5).

Human Use Activities for Alabama and Mississippi (Appendix B, Map 4.) tend to focus in and around Mobile Bay, AL, and The Grand Bay National Estuarine Research Reserve, MS.

Physical data set footprints distribution (Appendix B, Map 5.) is almost identical to the Biological gap map. The pattern highlighted here for the AL/MS gap maps is due to the large number of MMS reports in the GAME Catalog that encompass multiple GAME Classes.

FLORIDA

Florida by far has the most information in the GAME Catalog. Biological (Appendix B, Map 6.) and Earth/Geomorphological data set footprints (Appendix B, Map 8.) were concentrated on the West Florida Shelf, from the shore to the shelf break (200 meter contour). There were a few data sets provided by federal agencies whose spatial footprint extended past the 200 meter contour and out into the gulf.

Chemical data set footprints for Florida (Appendix B, Map 7.) were concentrated in the Panhandle area down to the Charlotte Harbor area and in the Florida Keys. This is due to several historical MMS studies that appeared to focus on the potential of oil and gas development in those areas of Florida.

Human Use data set footprints (Appendix B, Map 9.) were mainly limited to nearshore and state waters. A heavier concentration of Human Use data set footprints were located in the Big Bend area of Florida due to reports and studies conducted by the MMS for socioeconomic impacts related to oil and gas development. There is a noticeable decrease in Human Use Activities information just south of the Cedar Key area.

Physical data set footprints (Appendix B, Map 10.) extended past the 200 meter contour line due to numerous data sets reflecting remote sensing information (see Table 6). In fact, satellite information footprints cover very large areas.

LOUISIANA

Biological information for Louisiana (Appendix B, Map 11.) was concentrated in the bays, lagoons, rivers, and estuaries extending out past the 200 meter contour. The GAME Catalog contains numerous reports from the MMS for this area related to ecological characterization, species distribution, biological dynamics, benthic habitat, cetaceans, turtles, and how the oil and gas industry has affected this region. Nearshore studies from organizations such as the Louisiana Department of Wildlife and Fisheries and Louisiana State University tend to focus on coastal vegetation, oyster reefs, and sea bird information.

Chemical information (Appendix B, Map 12.) was most heavily concentrated nearshore and within the 200 meter contour. Most of the chemical information in the GAME Catalog is from the MMS as it relates to hypoxia and the oil and gas industry. This information tends to be concentrated around petroleum platforms.

Earth/Geomorphological footprints (Appendix B, Map 13.) extended well beyond state boundaries and overlap both Mississippi and Texas and were concentrated from inshore to well beyond the 200 meter contour. Information used to create these footprints was from sediments, deepwater hard bottom communities, oil and gas exploration and development along the Continental Slope, geomorphology, and topographic features.

Human Use footprints (Appendix B, Map 14.) were most heavily concentrated from inshore to the 200 meter contour. Theses footprints tend to be related to pipeline information, the oil and gas industry, lease block information, dispersant approval areas, environmental sensitivity indices, and wetland mitigation areas.

Physical footprints (Appendix B, Map 15.) had a very similar coverage to the Earth/Geomorphological footprints due to the fact that entries in the GAME Catalog for these two classes had overlapping information. Many of the reports produced by the MMS contained information for both classes. There are several multiple year reports from the MMS related to physical oceanography and circulation around the Louisiana and Texas Continental Shelf.

TEXAS

There was a large amount of footprint overlap for Texas and Louisiana. Biological information for Texas (Appendix B, Map 16.) was concentrated nearshore, inside the numerous barrier islands bordering the state. These footprints included information such as macrofaunal and infaunal samples for selected bays along the Texas coast, nekton use of different habitat types, biological assemblages, benthic macroinvertebrates, and historical oyster reef coverage. Most of the Biological footprints also focused on shelf edge (200 meter contour) areas extending around to the tip of Louisiana. The MMS conducted several multiple year studies around the Outer Continental Shelf (OCS) related to plankton and fisheries. The MMS also produced multiple reports related to the taxonomy of Polychaetes.

Chemical data sets (Appendix B, Map 17.) were concentrated in southern Texas offshore to the 200 meter contour due to numerous studies conducted in that area by the MMS that included OCS information related to chemical, oil and gas development, and chemosynthetic communities.

Earth/Geomorphological data sets (Appendix B, Map 18.) were concentrated in the southern Texas region and along the 200 meter contour. This concentration of geological footprints is again due to the fact that the MMS reports mentioned above also contain information related to this GAME Class. Other reports from the MMS found in the GAME Catalog that were used to create the Earth/Geomorphological footprints included OCS geology, shelf edge submarine banks, reefs, and topographic features. Nearshore information for this class included LIDAR (Light Detection and Ranging) information, ship channel areas, and bathymetry.

Human Use footprints (Appendix B, Map 19.) were focused in the many bays and Inner Coastal Waterways along the Texas coast. Information used to create these footprints includes shipping channel information, solid waste pollution on Texas beaches, and critical areas maps for oil spill vulnerability. Offshore Human Use footprints include information related to petroleum structure use and removal, explosive removal of petroleum structures, socioeconomic impacts relative to baseline and scenario conditions for oil and gas activities, lease block, and pipeline information.

Physical footprints (Appendix B, Map 20.) were concentrated inshore and out to the 200 meter contour from the Texas-Mexico border all the way to the mouth of the Mississippi River in Plaquemines County, LA. This heavy concentration of footprints is once again due to the multiple reports produced

by the MMS related to OCS studies of physical dynamics, physical oceanography, and ecosystem description. Other physical information used to create these footprints included automated buoy information, satellite imagery, hydrographic information, continental shelf circulation and transport studies, and coastal and ocean observation networks.

MEXICO

Data sets for Mexico were extremely limited (see Table 1.). Information in the gap analysis maps for Mexico (Appendix B, Map 20. to 25.) is limited to nearshore data sets for all GAME Classes except for Earth/Geomorphological. Information from the online survey for GAME ID #1163 (Sisal Reef Bathymetry) only states that it is a bathymetry grid (20 to 200 meter) for the shallow reefs for the Sisal region (Yucatan State Gulf coast).

GULFWIDE

Footprints for gulf wide information for all GAME Classes, except for Human Use Activities, tend to cover the whole gulf. Biological and Chemical footprints (Appendix B, Map 26. and 27.) are more concentrated in the northern gulf. Earth/Geomorphological footprints (Appendix B, Map 28.) cover all of the Gulf of Mexico. This is due to the fact that the MMS conducted multiple studies gathering information using ships of opportunity, buoys, and data from other researchers to compile their reports related to these two GAME Classes. Gulf wide Human Use footprints (Appendix B, Map 29.) are heavily concentrated in the northern gulf and tend to be related to socioeconomic impact studies due to oil and gas development and marine protected areas. Footprints representing Physical information (Appendix B, Map 30.) encompass the entire Gulf of Mexico, Cuba, and the east coast of Florida. This is due to the fact that much of this information is based on several of the Coastal Ocean Observing Systems and satellite information.

6. CONCLUSIONS

The majority of the information in the GAME Catalog is located within the 200 meter contour. The northern Gulf of Mexico, especially from Texas to Mississippi, contains the largest numbers of data sets for Human Use Activities. This is due to the presence of oil and gas activities in this region. Biological information appears to be consistent around the entire Gulf of Mexico, remaining within the 200 meter contour. However, there are a few federal Biological data sets for the state of Florida that

extended out past the 200 meter contour. Further review of these types of footprints is needed to confirm the actual extent of the data. Chemical information around the gulf appears to have the most gaps. Gaps in Physical information are difficult to properly determine due to the fact that most data sets are represented by large footprints. These large footprints can be related to remote sensing data. Satellite imagery, monitoring buoys, and coastal and ocean observation systems cover large areas resulting in large footprints.

The information contained in the GAME Catalog and the production of these gap analysis maps provide a first step required for successful ocean governance. Human uses of the marine environment can no longer be managed in small sectors regulated by individual states and agencies but need to be managed as part of whole interconnected ecosystems. The health and resiliency of these ecosystems is dependent upon the use of shared knowledge across all aspects of management. The multiple management jurisdictions in the marine environment make conservation efforts extremely difficult due to the fact that most agencies' scope or influence is too small to cover large geographic areas occupied by entire ecosystems. Additionally, gaps in information make management decisions difficult. Having gap analysis maps, like the ones contained in this report, can help guide agencies and organizations in filling these gaps to create a more robust baseline from which to make sound scientific management decision.

There is cornucopia of information contained in the GAME Catalog. Data sets range from historical baseline information to studies still in progress across all GAME Classes. Identifying what information is available and where there are gaps in the data is the foundation for creating coastal and marine ecoregions. The GAME project's efforts to inventory biological, chemical, geological, physical, and human processes across the entire Gulf of Mexico provides a sharing of this information in a Web-based database. Having this information displayed in a GIS environment makes visualization of data gaps more intuitive for resource managers and decision makers. These gaps in information can guide researchers and policy makers in focusing efforts for projects or funding opportunities in areas where there is little or no information.

As stated earlier in this report, the information stored in the GAME Catalog is just a snapshot taken at a specific time. Most of the information was readily available either through direct contact with

researchers and scientist or via the Web. For this qualitative gap analysis to be effective, updates to the maps will need to be completed periodically.

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Appendix A

List of Contributors

Apalachicola National Estuarine Research Reserve

Atlantic and Gulf Rapid Reef Assessment
Bermuda Biological Station for Research, Inc.
Biscayne National Park
Broward County
Caribbean Marine Research Center

Center for Op. Oceanographic Products and Services

Centro de Investigacion y de Estudios Avanzados
Charlotte County
Charlotte Harbor National Estuary Program
Coastal Planning & Engineering, Inc.
Cornell College

Dauphin Island Sea Lab

DermoWatch
East Coast Biologists, Inc.
Fish and Wildlife Research Institute
Florida Atlantic University
Florida Department of Agriculture and Consumer Services
Florida Department of Environmental Protection
Florida Department of Health

Florida Fish and Wildlife Conservation Commission

Florida Geographic Data Library
Florida Geological Survey

Florida Institute of Oceanography

Florida Institute of Technology

Florida International University

Florida State University
Geological Survey of Alabama
Geonex North American Operations, Inc.
Georgia Department of Natural Resources
Georgia Tech Savannah
Harbor Branch Oceanographic Institute
Health and Environmental Effects Research Lab
Integrated Program Office
International Sea Keepers Society
Jacksonville University
Joint Airborne Lidar Bathymetry Technical Center of Expertise

Ohio State University

Palm Beach Atlantic University
Pinellas County
Reef Ball Foundation
Reef Base
Reef Check Foundation

Reef Environmental Education Foundation

Reef Relief
ReefKeeper Int.
Research Planning, Inc.
Roffers Ocean Fishing Forecasting Service, Inc.
Rooker Bay NERR

Rosenstiel School of Marine and Atmospheric Science

Sarasota Bay Estuary Program
Sarasota County
Science Applications International Corporation
Scripps Institution of Oceanography

Skidaway Institute of Oceanography

Smithsonian Institution
Smithsonian Marine Station

South Atlantic Fisheries Management Council

South Florida Water Management District
Southeast Area Monitoring and Assessment Program

Southeast Coastal Ocean Observing Regional Association

Southeast Environmental Research Center

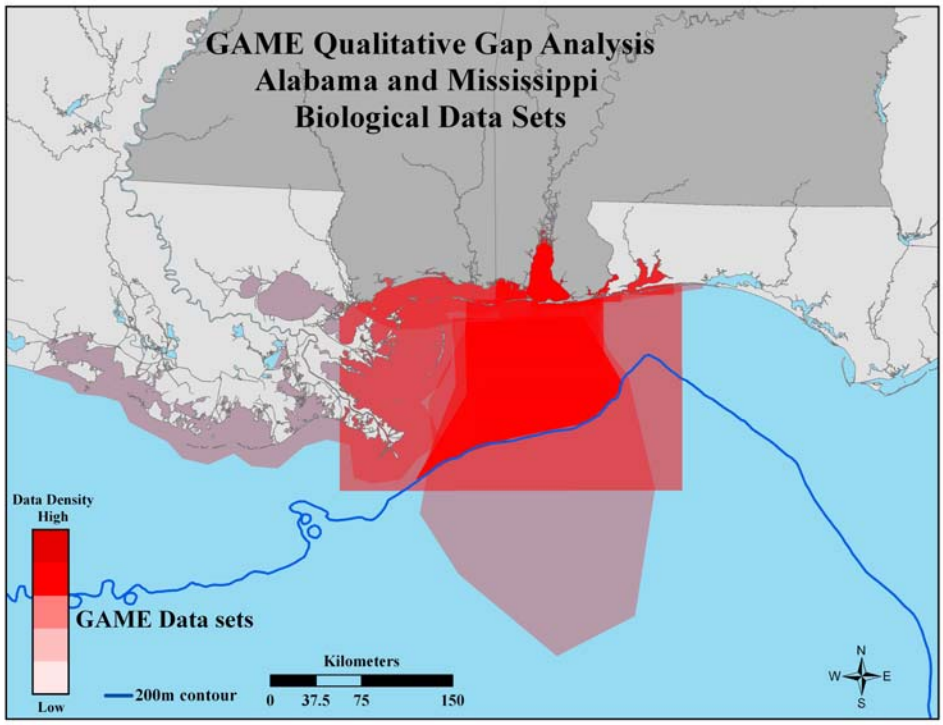
SouthEast U.S. Atlantic Coastal Ocean Observing System

Southwest Florida Water Management District
St. Johns River Water Management District
St. Lucie County
Swannee River Water Management District
Tampa Bay Estuary Program
Texas A&M University
Texas General Land Office
The Nature Conservancy
U.S. Department of Agriculture
U.S. Environmental Protection Agency

U.S. Fish and Wildlife Services

Lee County	U.S. Geological Survey
Louisiana State University	United States Army Corps of Engineers
Louisiana Universities Marine Consortium	Universidad Nacional Autónoma de México
Loxahatchee River Environmental Control District	Universidad Veracruzana
Manatee County	University of California
Minerals Management Service	University of Central Florida
Mobile Bay National Estuary Program	University of Collorado
Monterrey Bay Marine Research Institute	University of Florida
Mote Marine Laboratory	University of Miami
National Atmospheric Deposition Program	University of New Hampshire
National Center for Coral Reef Research	University of North Carolina
National Oceanic and Atmospheric Administration	University of North Florida
National Park Service	University of South Carolina
National Science Foundation	University of South Florida
Naval Oceanographic Office	University of Texas Institute for Geophysics
Naval Research Laboratory	University of Texas-Pan American
Nicholls State University	University of Washington
NOAA (Numerous branches)	University of West Florida
Northwest Florida Water Management District	URS Corporation
Nova Southeast University	Volusia County
Ocean Research & Conservation Association	Weeks Bay National Estuary Research Reserve
Office of Hazardous Materials	Mississippi State University - Department of Agricultural Economics

Appendix B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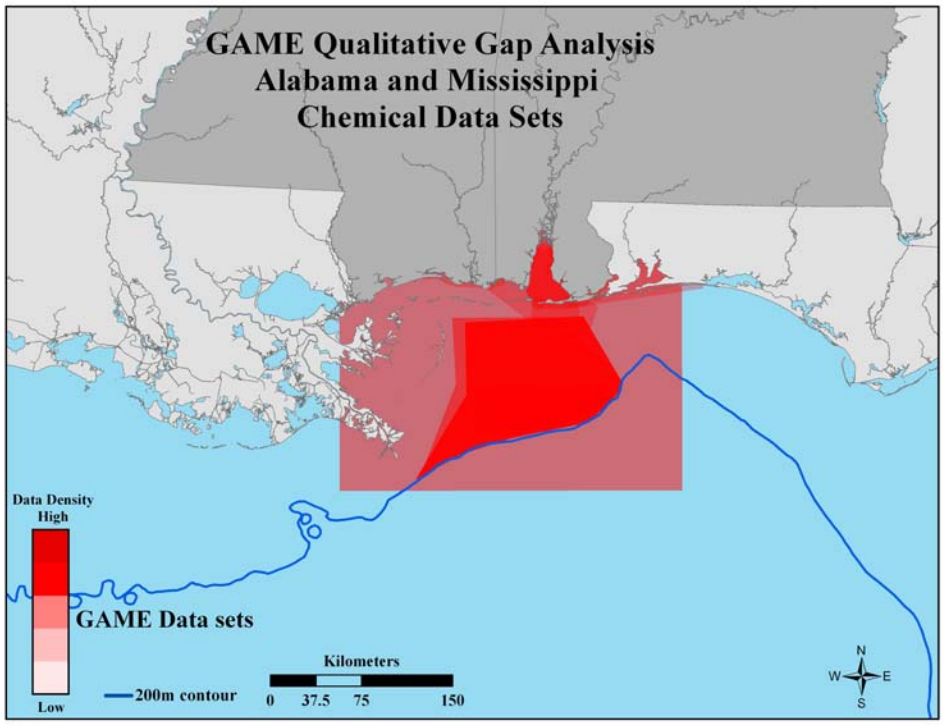
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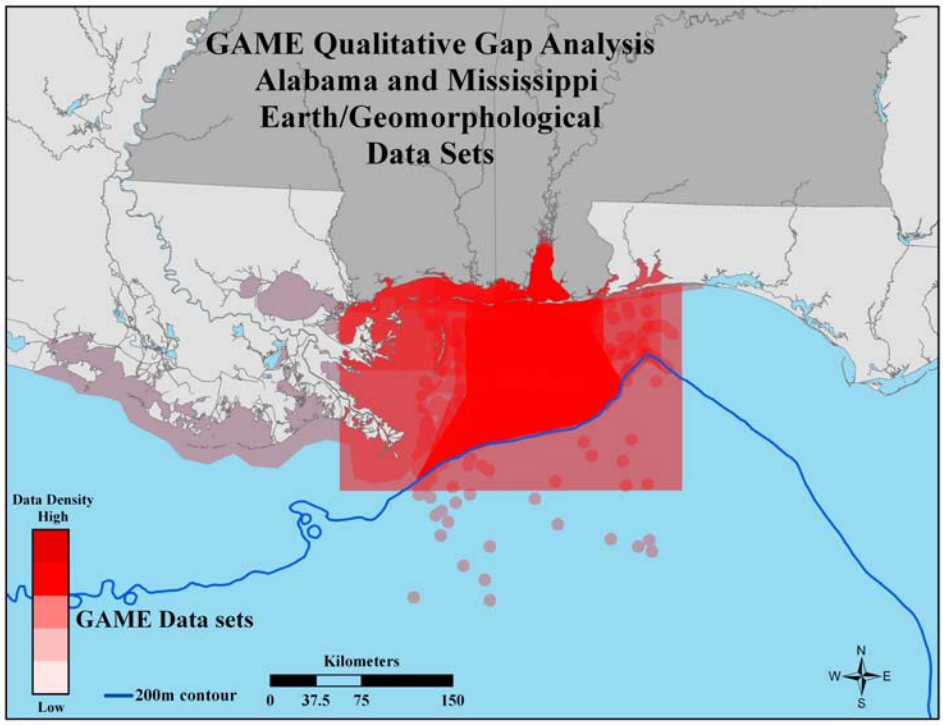
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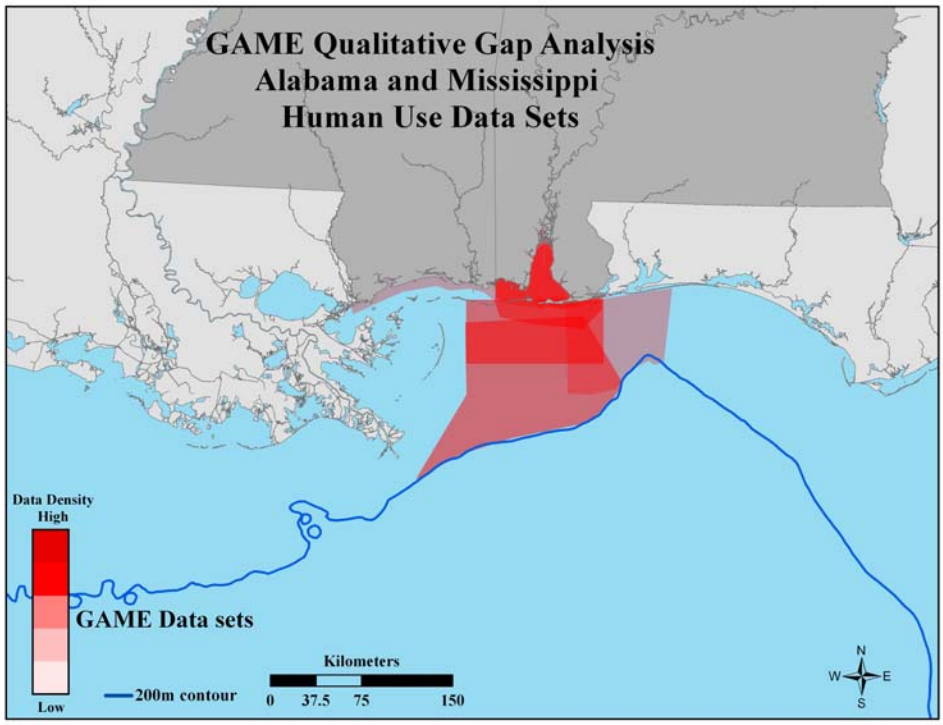
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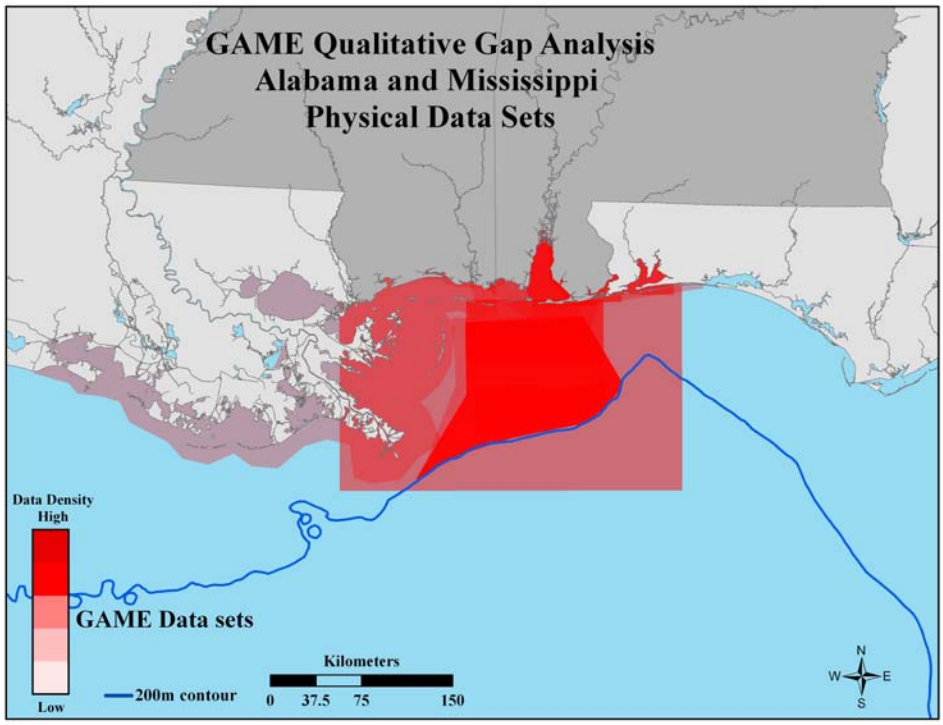
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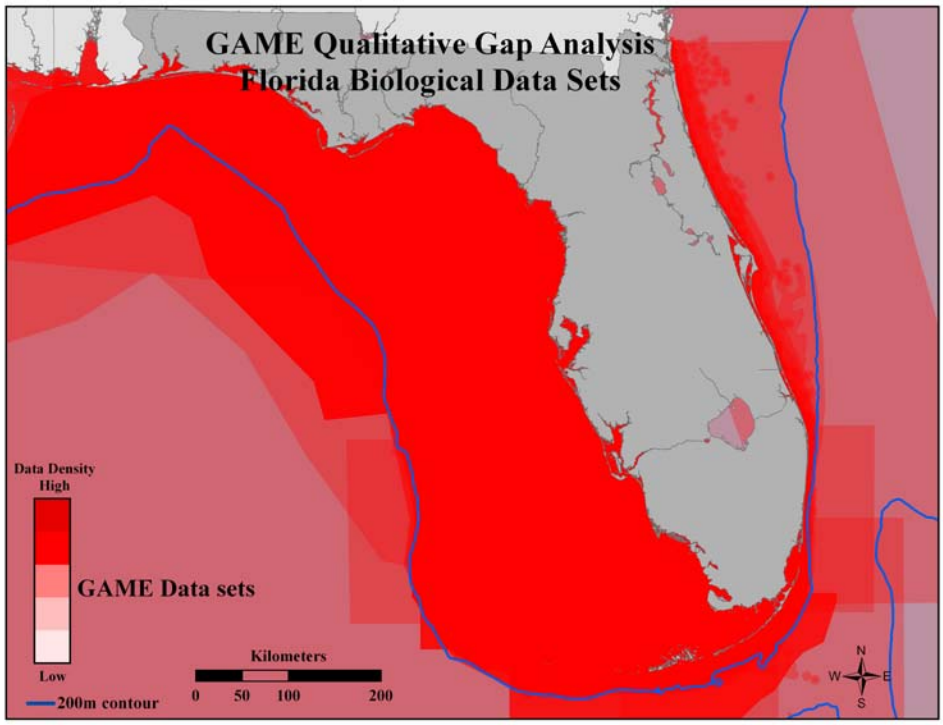
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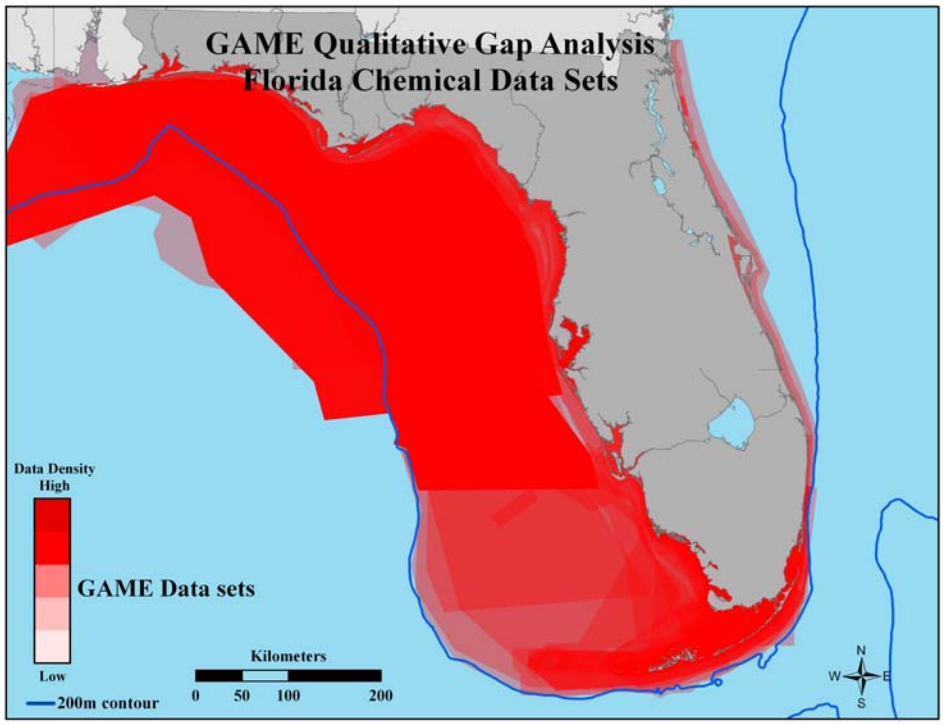
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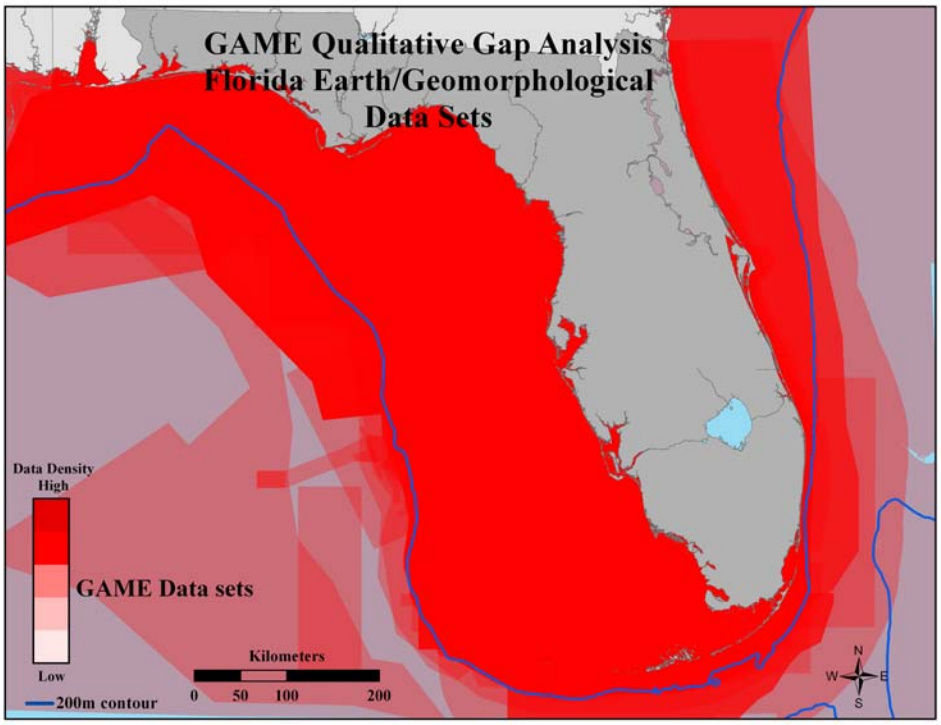
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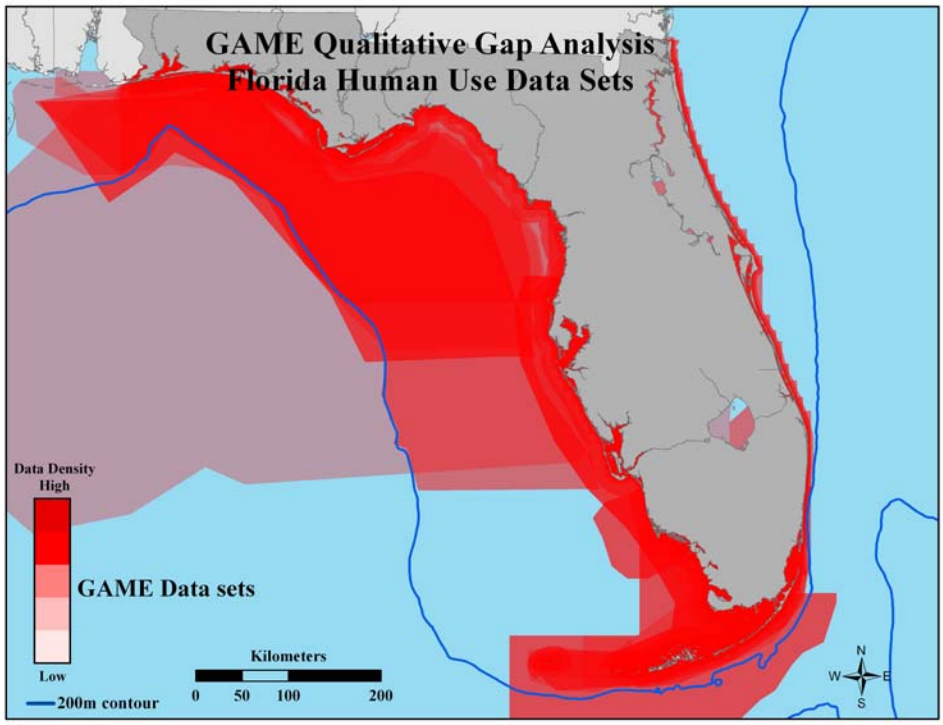
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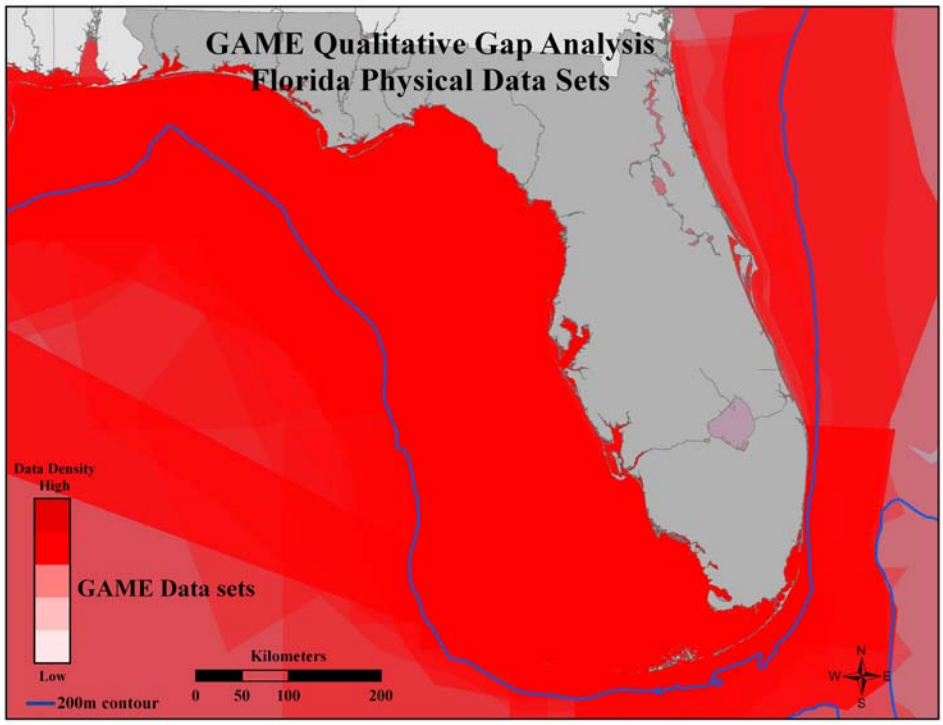
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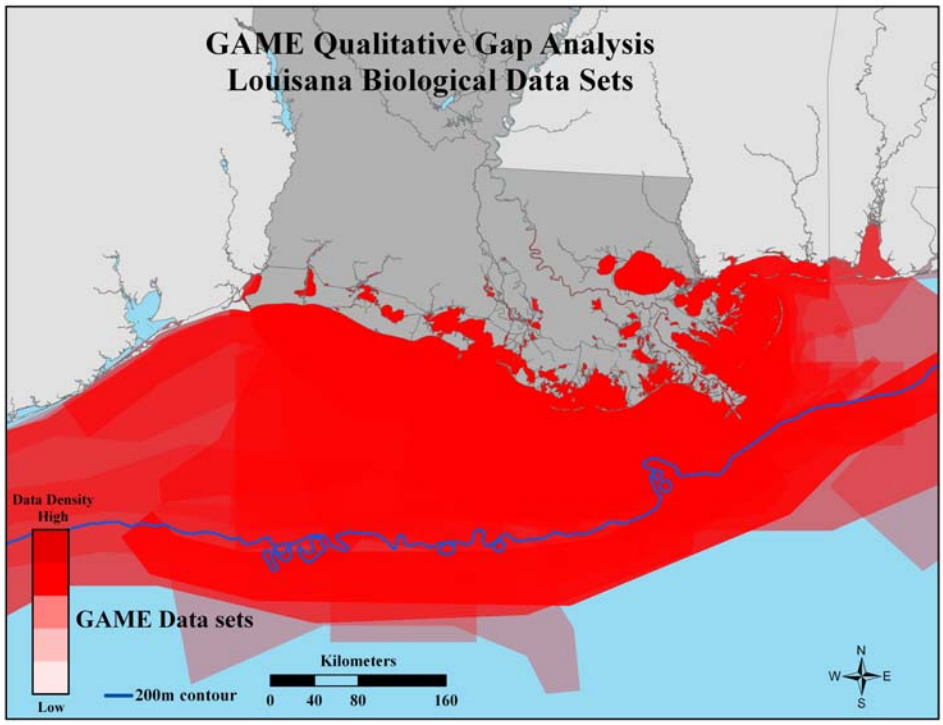
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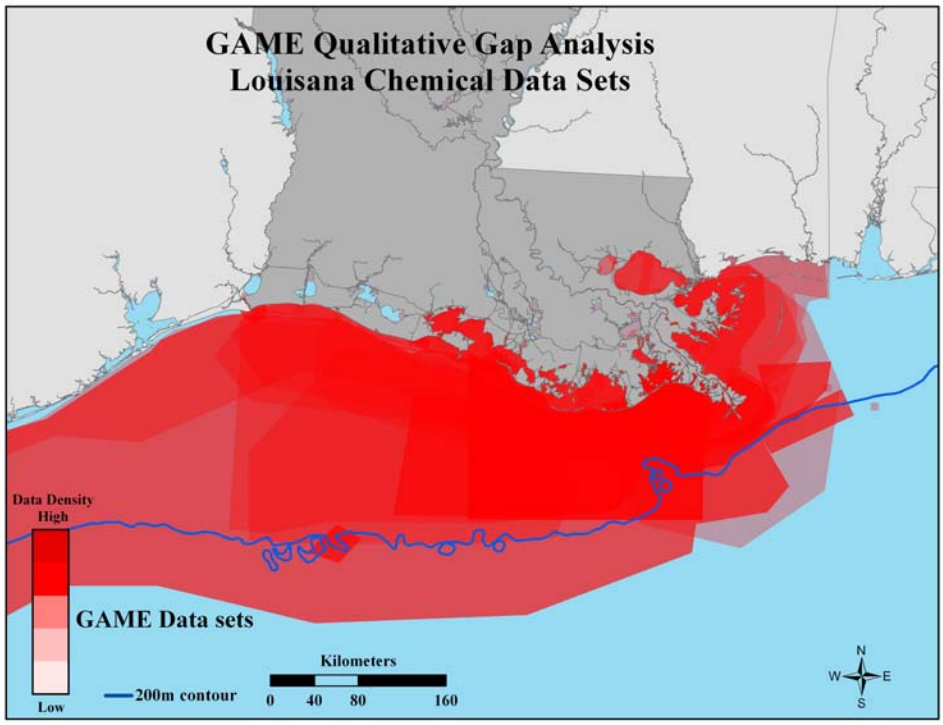
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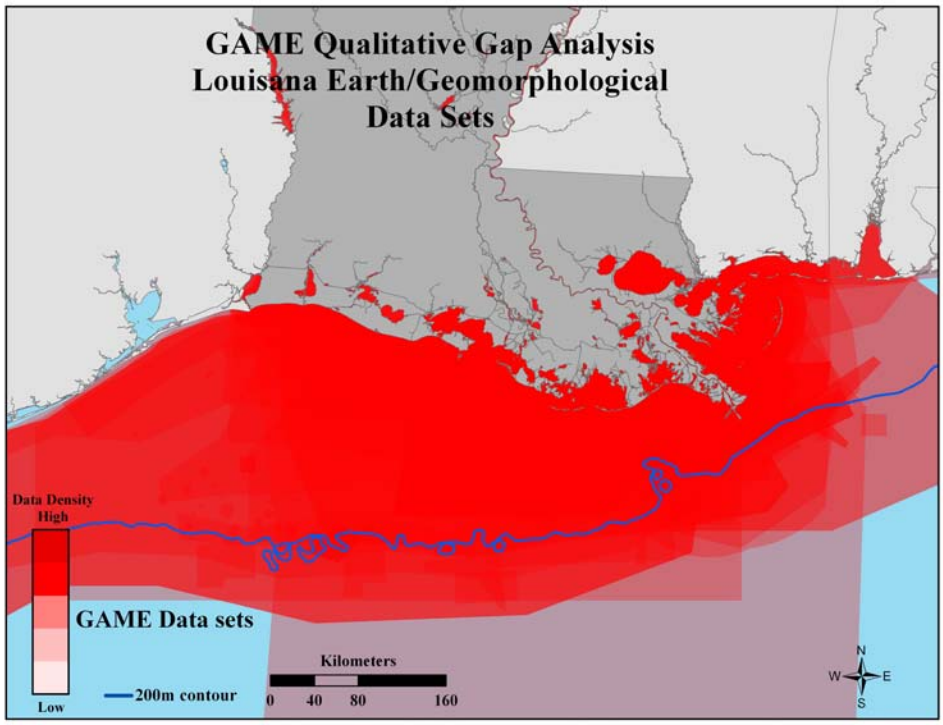
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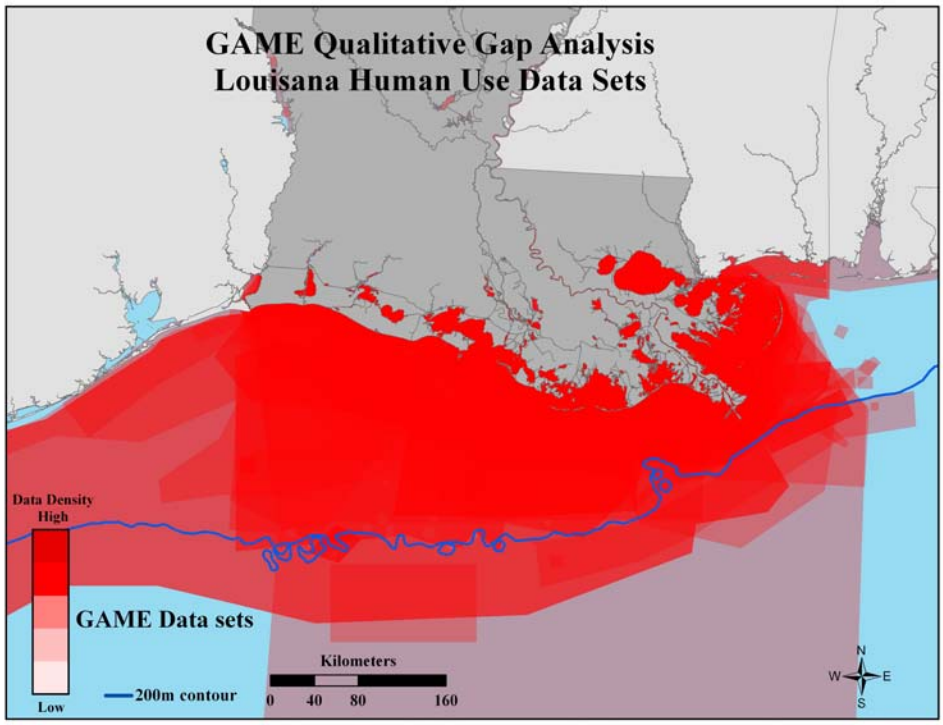
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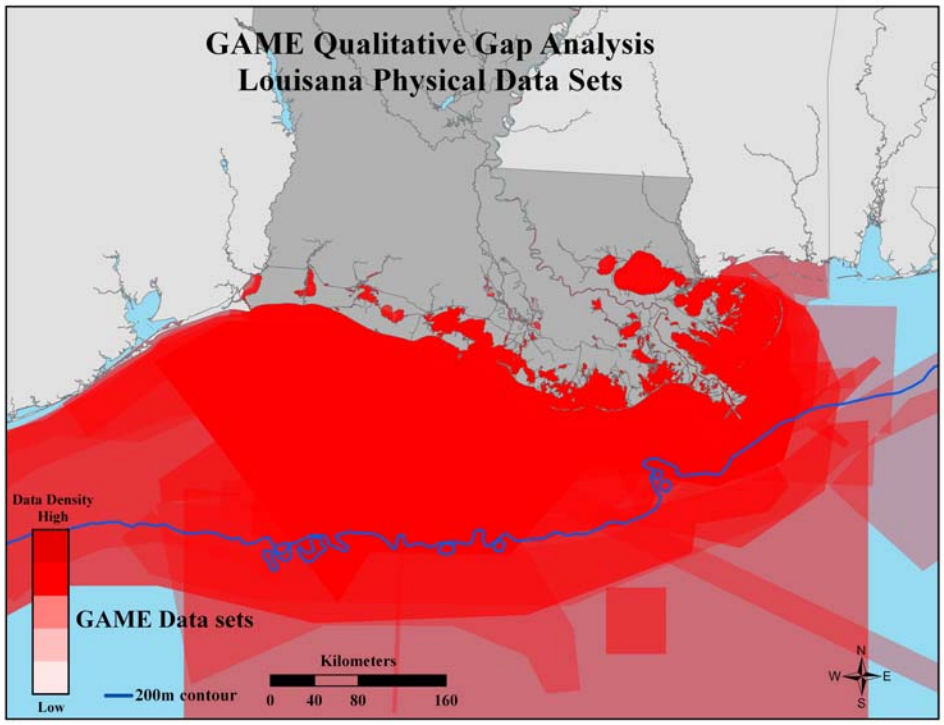
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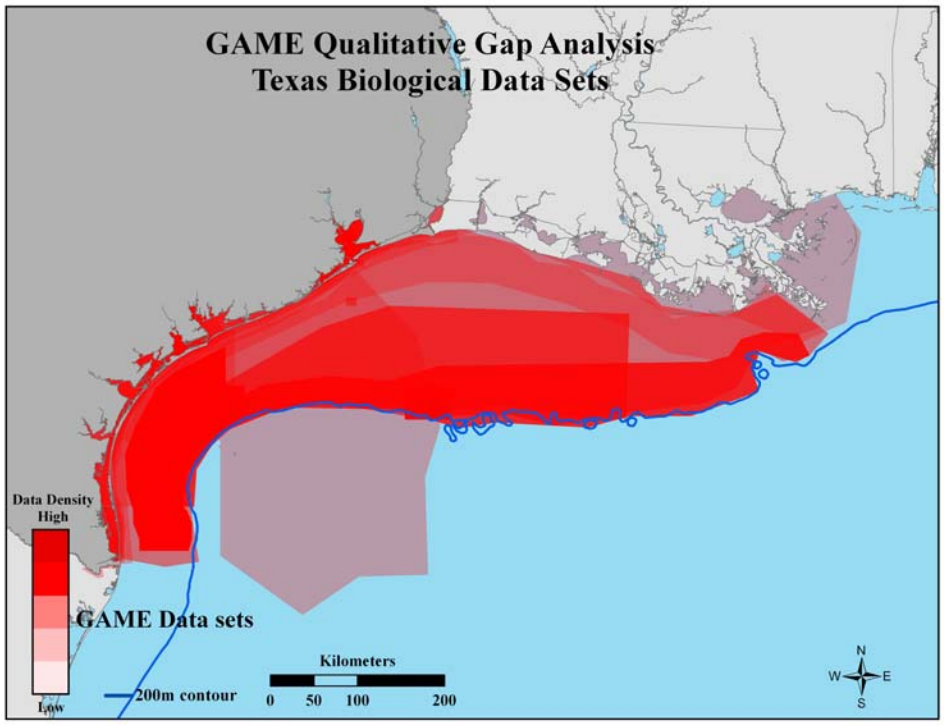
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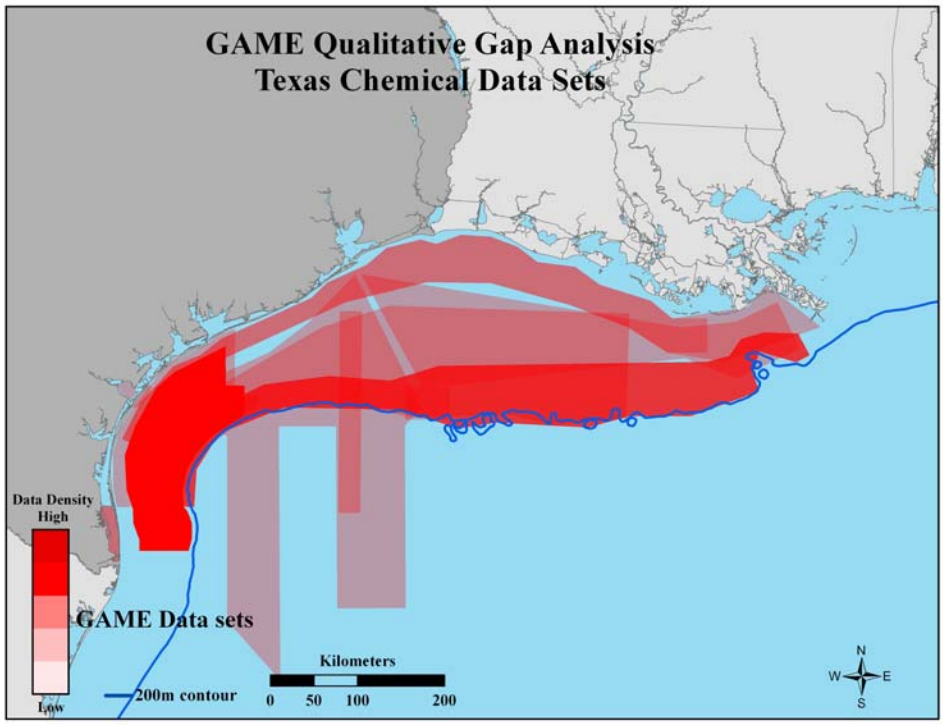
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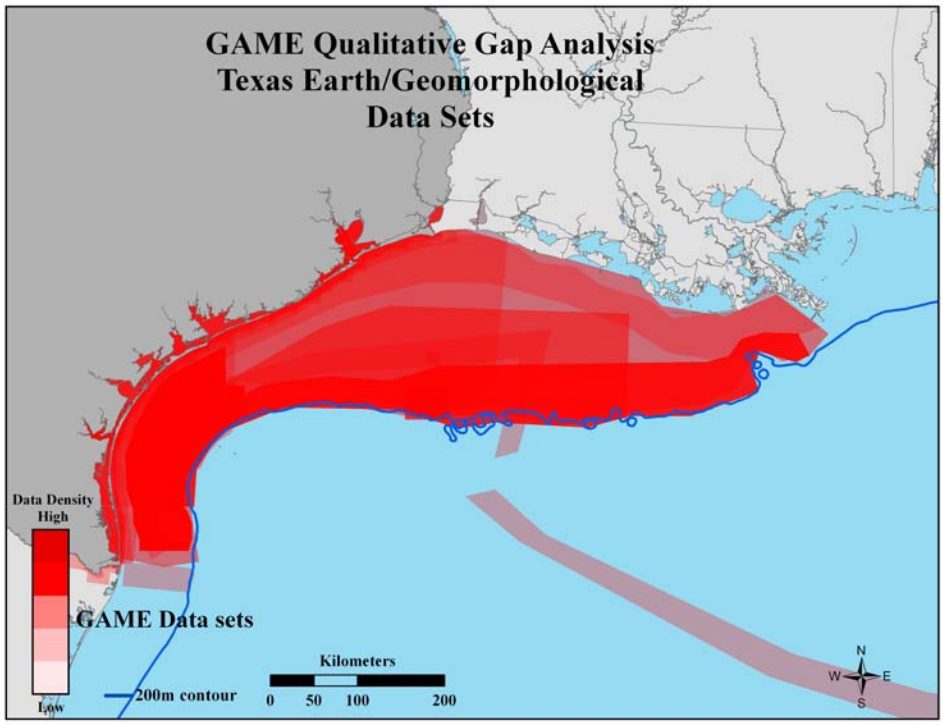
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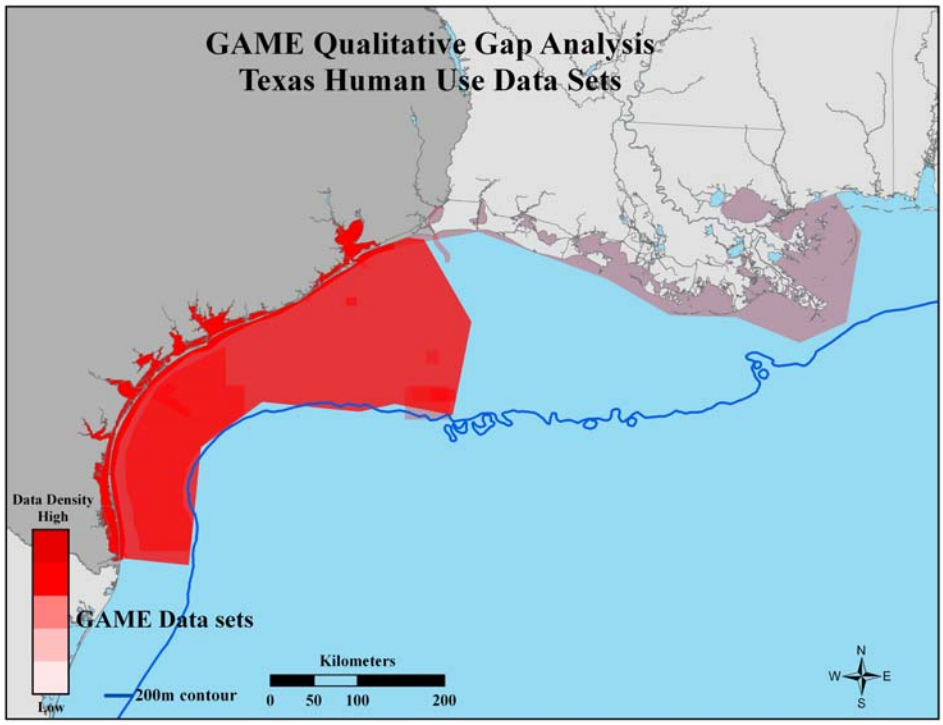
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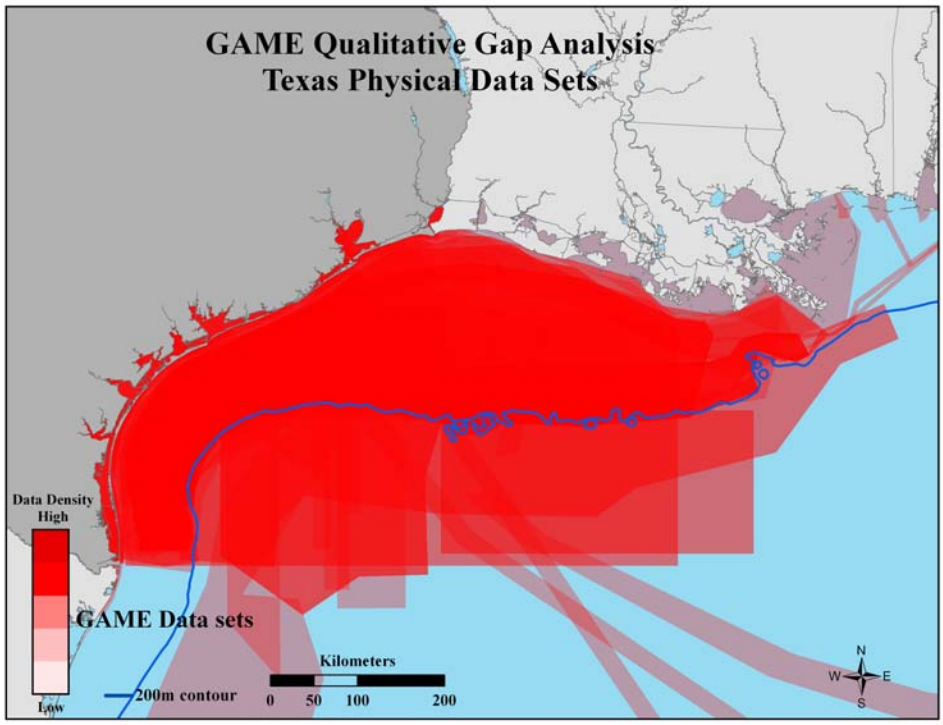
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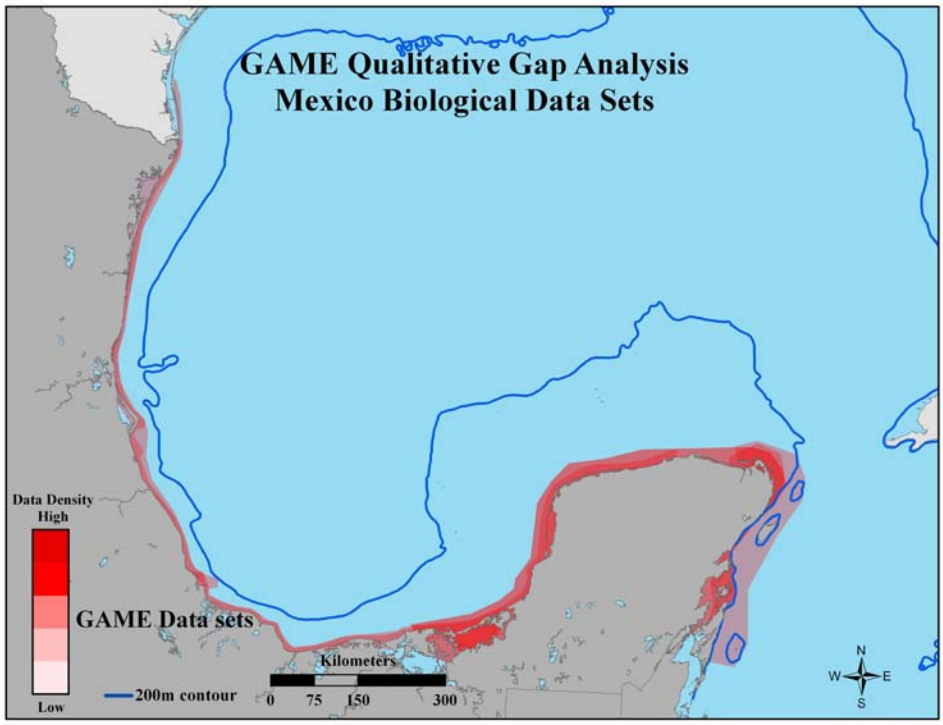
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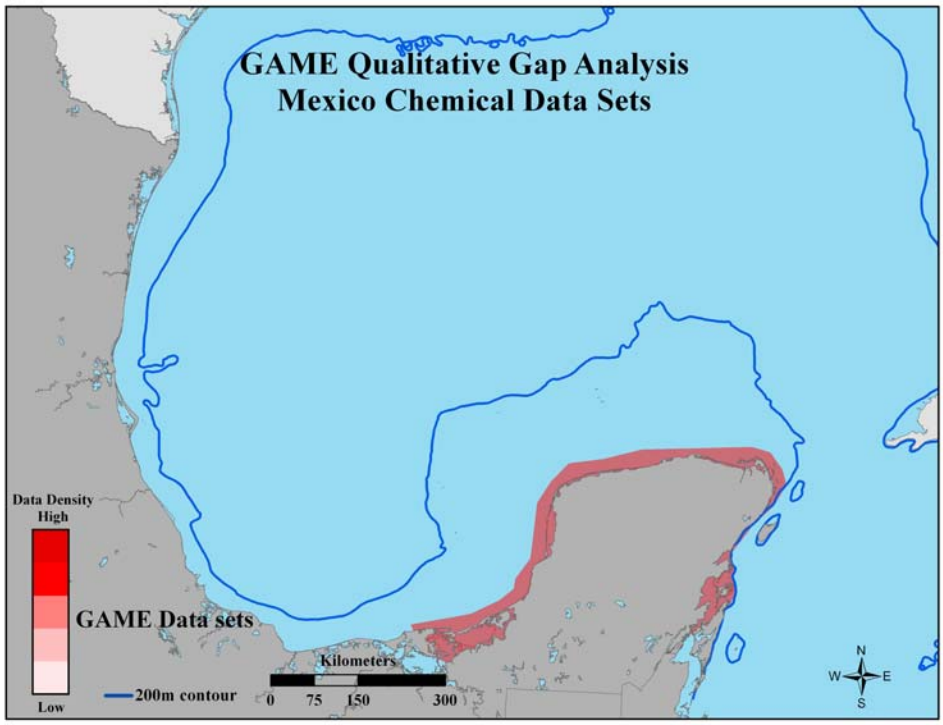
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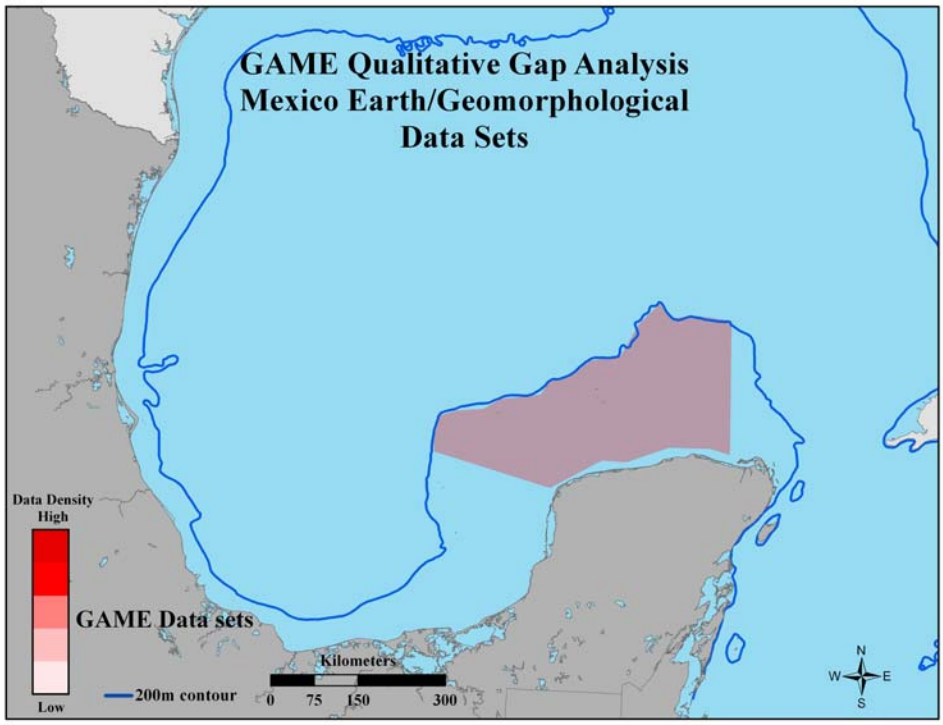
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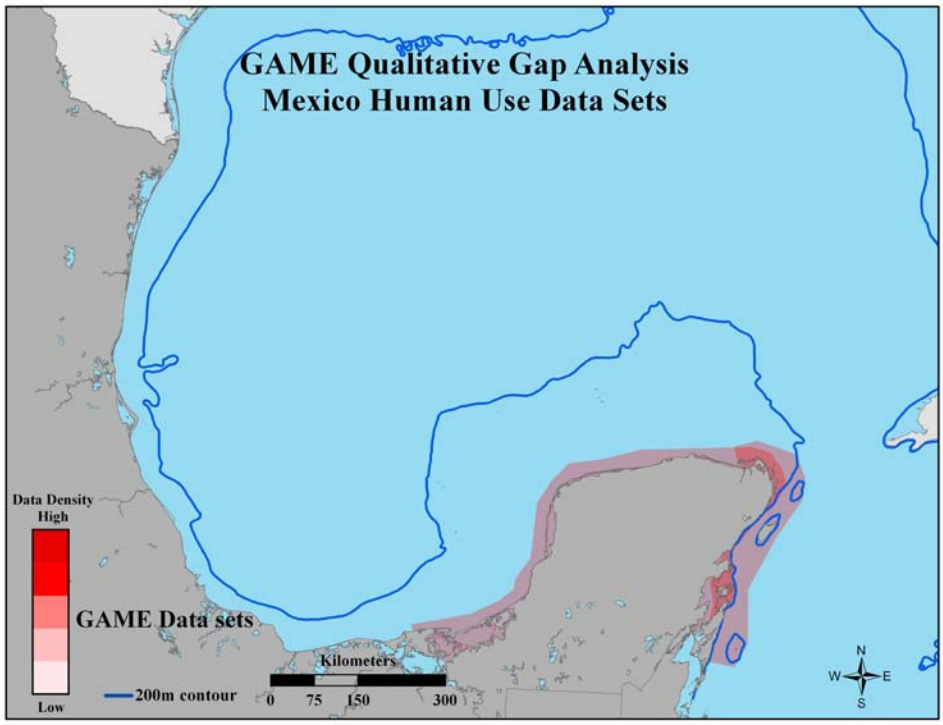
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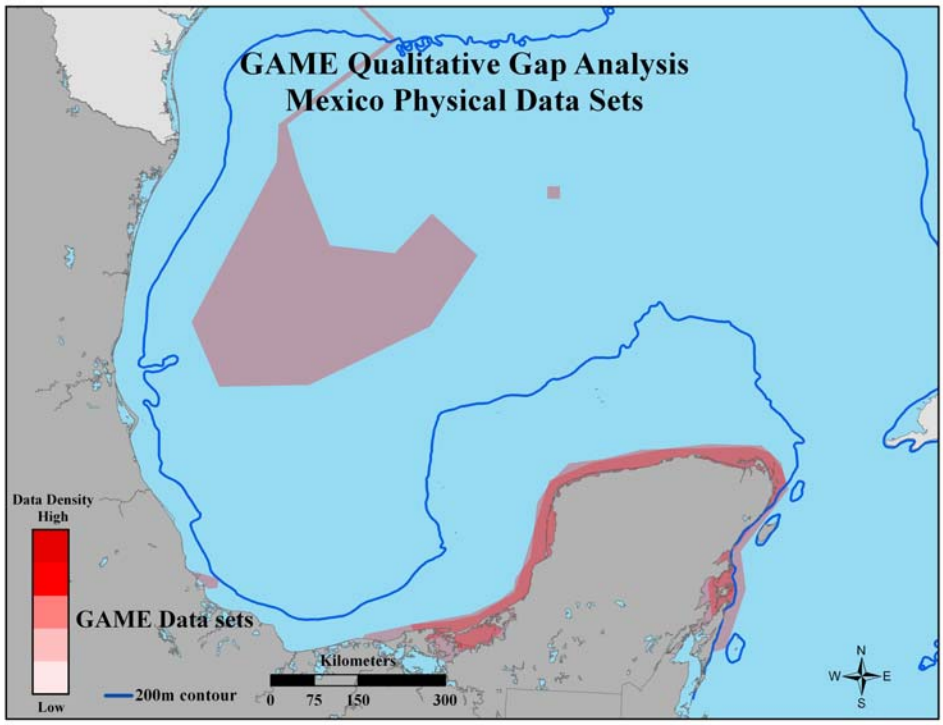
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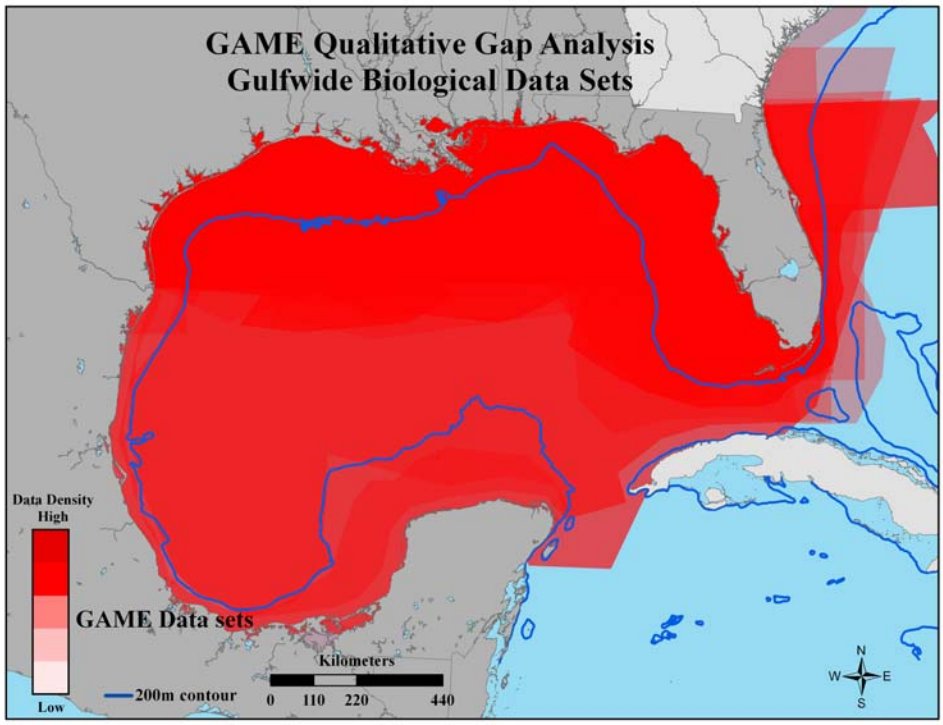
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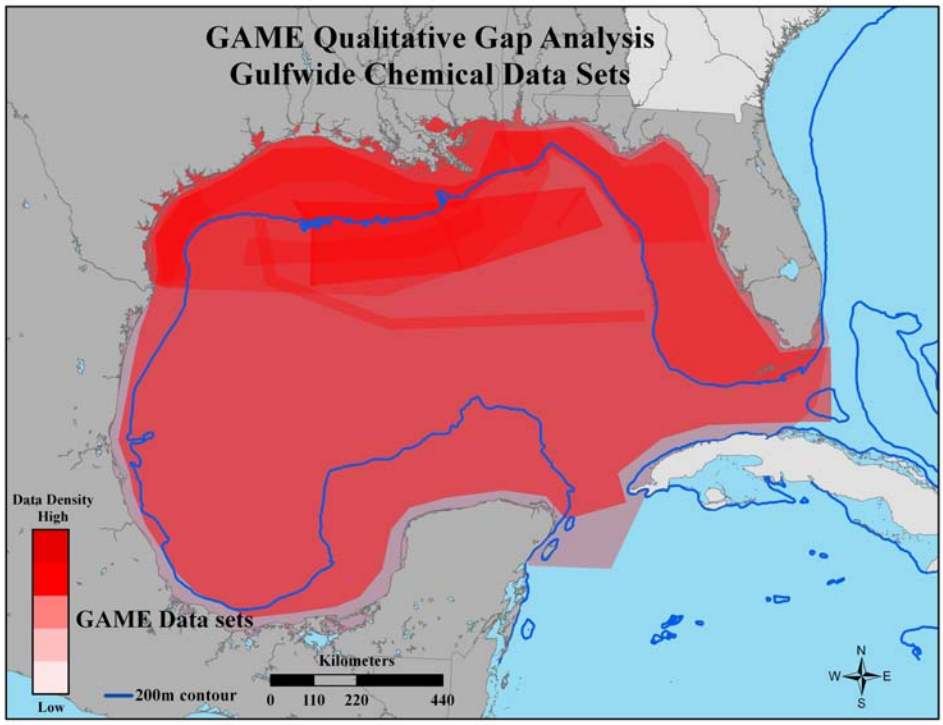
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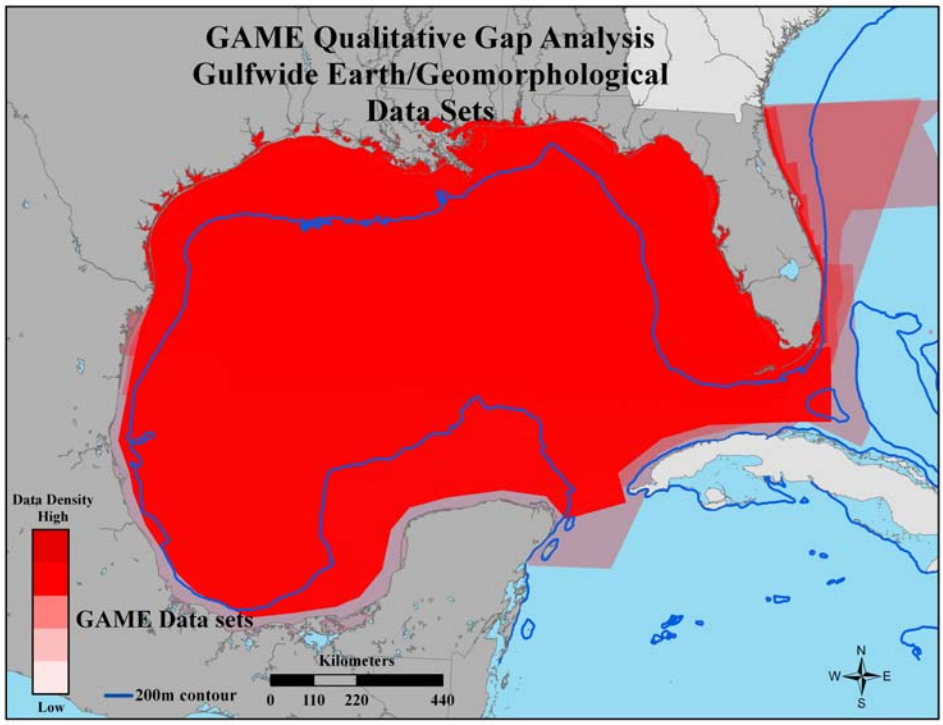
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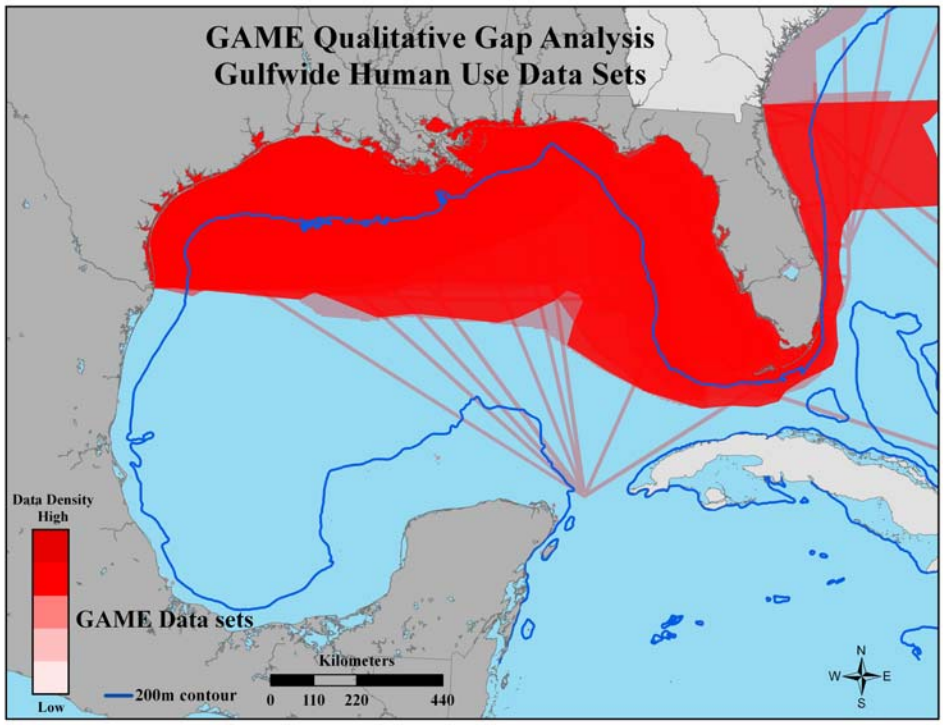
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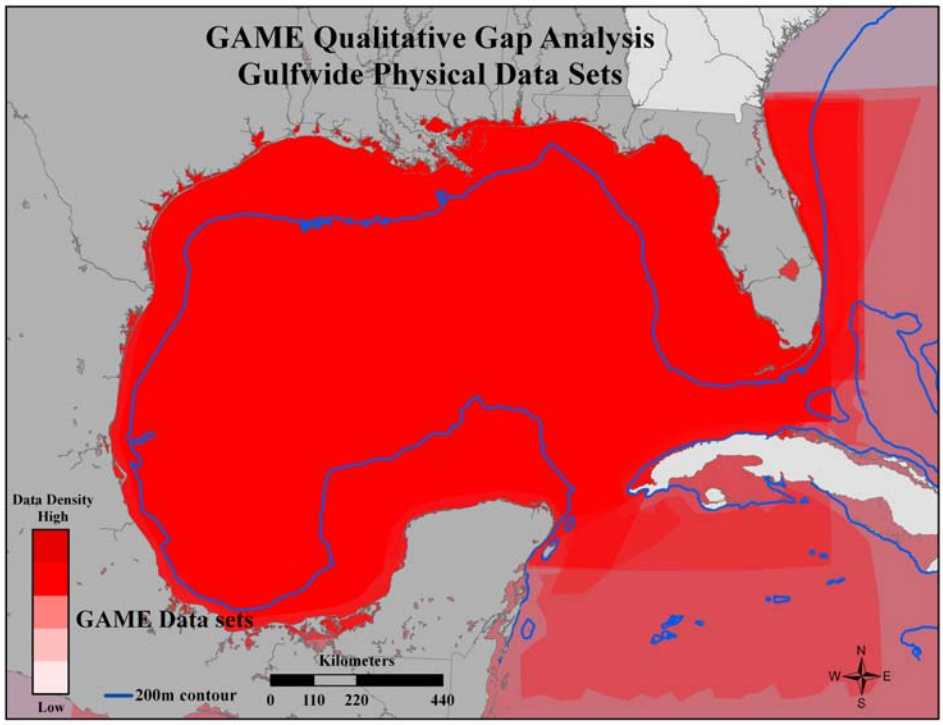
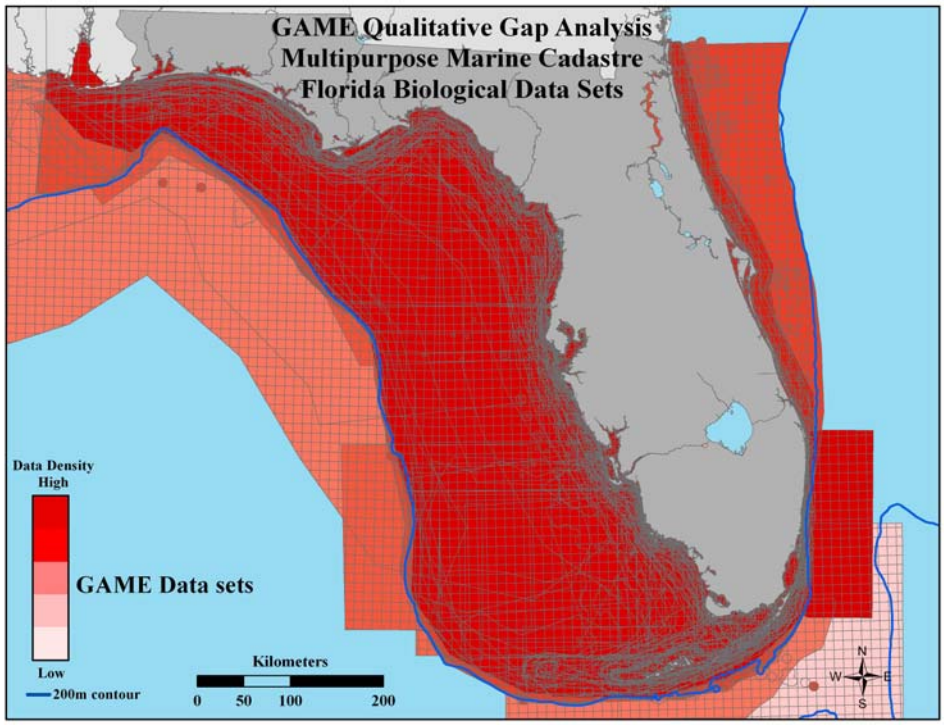
S

Map 29.

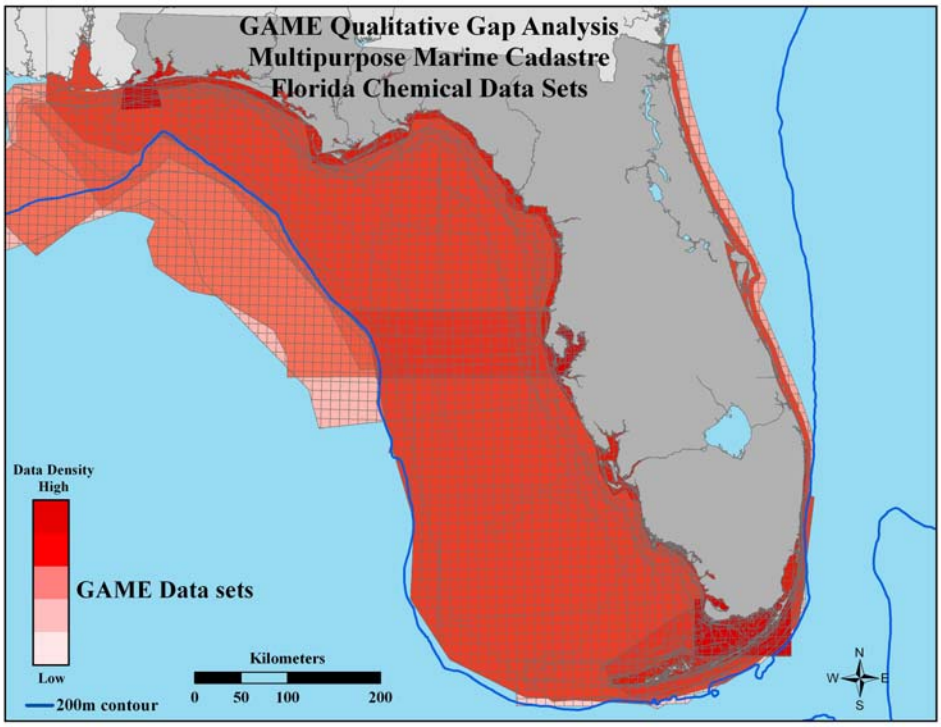

GAME Qualitative Gap Analysis
Gulfwide Physical Data Sets
Data Density
High
Low
GAME Data sets
200m contour
Kilometers
0 110 220 440
N
W
E
S

Map 30.

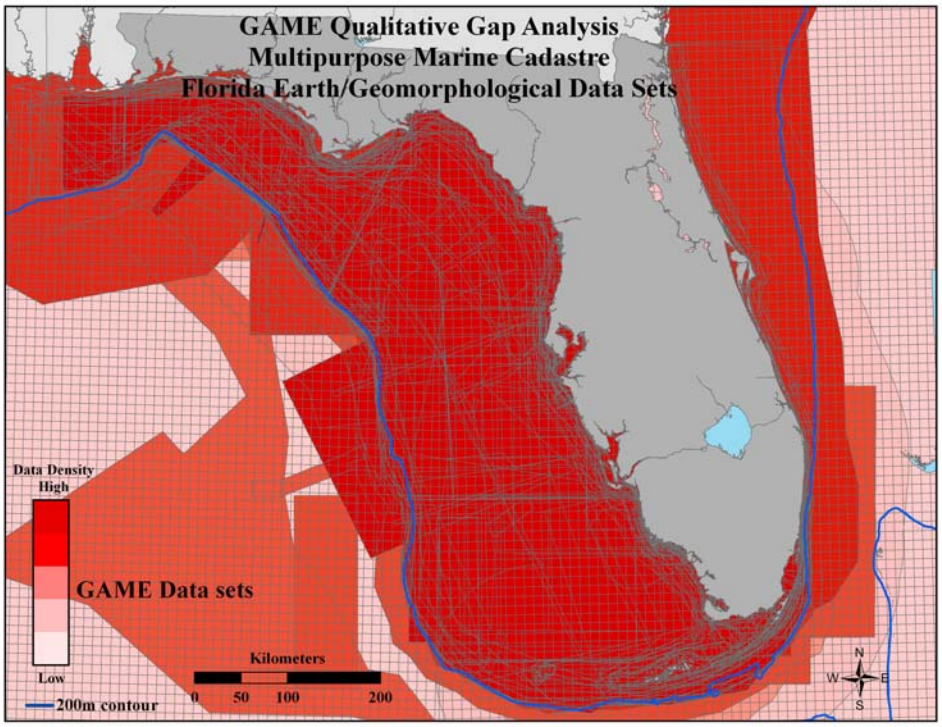
Appendix C


GAME Qualitative Gap Analysis
Multipurpose Marine Cadastre
Florida Biological Data Sets
Data Density
High
Low
GAME Data sets
200m contour
Kilometers
0 50 100 200
N
W
E
S

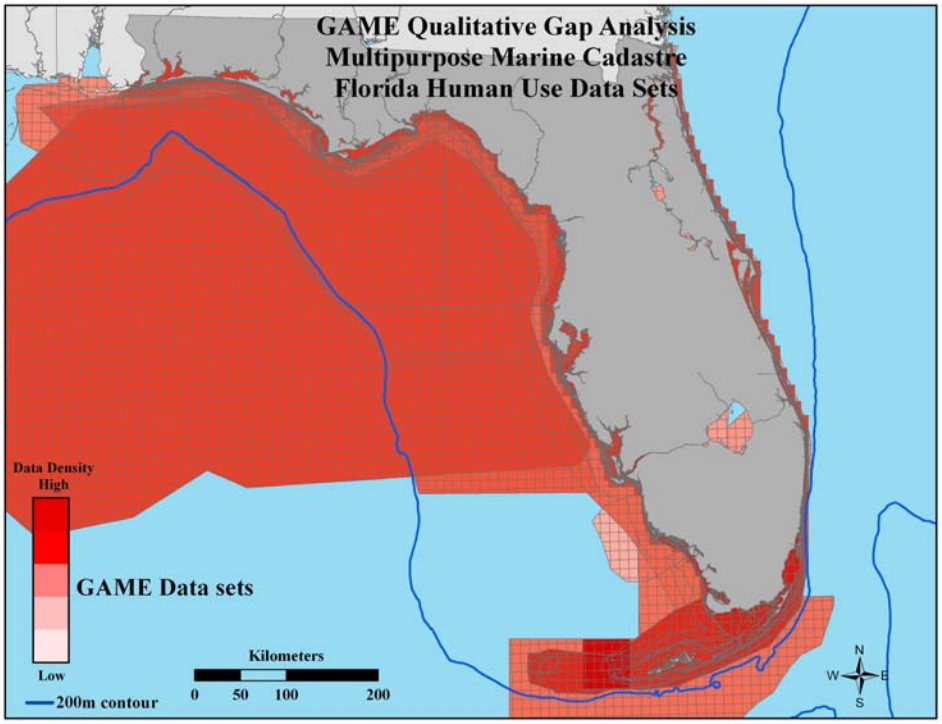
Map 1.


GAME Qualitative Gap Analysis
Multipurpose Marine Cadastre
Florida Chemical Data Sets
Data Density
High
Low
GAME Data sets
200m contour
Kilometers
0 50 100 200
N
W
E
S

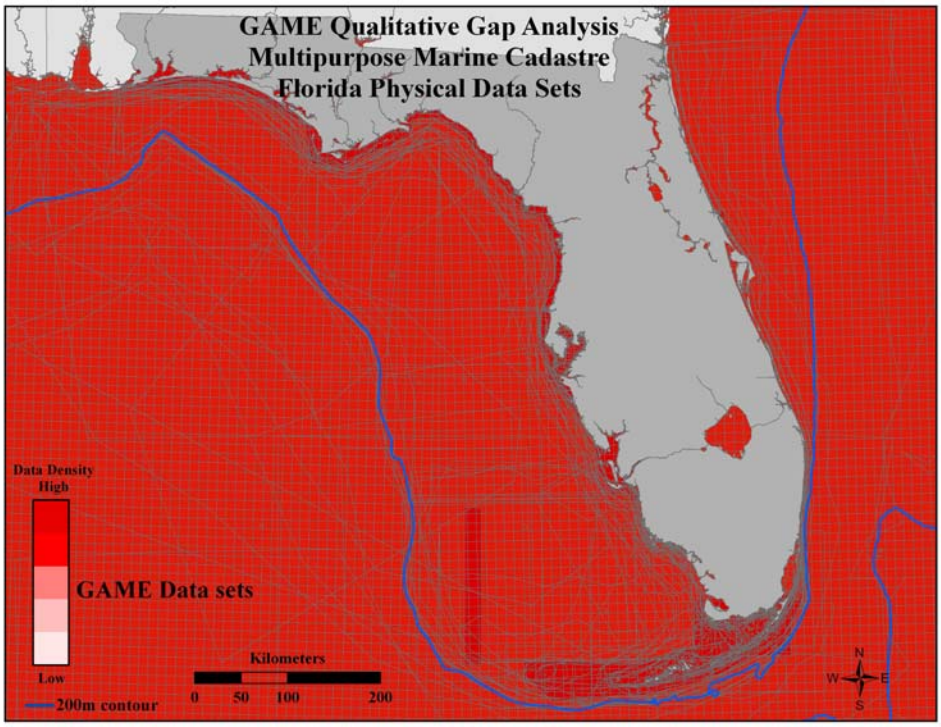
Map 2.


GAME Qualitative Gap Analysis
Multipurpose Marine Cadastre
Florida Earth/Geomorphological Data Sets
Data Density
High
Low
GAME Data sets
Kilometers
0 50 100 200
200m contour
N
W
E
S

Map 3.


GAME Qualitative Gap Analysis
Multipurpose Marine Cadastre
Florida Human Use Data Sets
Data Density
High
Low
GAME Data sets
Kilometers
0 50 100 200
200m contour
N
W
E
S

Map 4.


GAME Qualitative Gap Analysis
Multipurpose Marine Cadastre
Florida Physical Data Sets
Data Density
High
Low
GAME Data sets
Kilometers
0 50 100 200
200m contour
N
W
E
S

Map 5