1. Preface
The U.S. Integrated Ocean Observing System (IOOS) includes the development of 11 regional coastal ocean observing systems (RCOOSs) by Regional Associations (RAs) that have knowledge of the unique, regional requirements for observations and associated products. The Gulf of Mexico Coastal Ocean Observing System (GCOOS) is the RCOOS for the U.S. waters of the Gulf of Mexico from the boundary of the U.S. Exclusive Economic Zone inshore to the end of the tidal effects in estuaries. The GCOOS Regional Association (GCOOS-RA) is the body charged with development of the GCOOS. To build the GCOOS requires the partnership of many organizations—from governments to industry to academia to educators to the public—to integrate the measurements already being made and to fill gaps where necessary to meet the requirements of the region as well as the nation.

1.1 What is the purpose of this document?
First, this document identifies the five core activities or modules needed to develop the RCOOS for the Gulf of Mexico. These modules and their associated elements were identified by the GCOOS-RA Board of Directors based on assessment of regional stakeholder requirements coupled with the requirements to meet national criteria for data management and RA/RCOOS organizational structures.

Second, it announces the priority observing system elements for the five-year period 2011-2016 to potential operators who might wish to propose them as part of the GCOOS Regional Association funding efforts. There is a procedure for selecting and preparing letters of intent and proposals for GCOOS development. Anyone wishing to submit a letter of intent (LoI) to propose to carry out one of the GCOOS priority observing system activities should reference the procedure; it is on the GCOOS web site (http://gcoos.org/proposalprocess.html).

1.2 What is contained in various sections of this document?
The following sections of this document give the GCOOS-RA strategy, including how GCOOS fits within the U.S. IOOS and the main themes of GCOOS, as well as more detailed discussion of the activities to be developed in support of the GCOOS themes. Section 2 gives an overview of the five core modules, including the priority observing system elements. Section 3 begins with a summary of serious issues facing the Gulf coastal region and states the major socioeconomic themes GCOOS is addressing to mitigate the effects of these environmental threats. This makes clear the fact that GCOOS is designed as a part of the U.S. Integrated Ocean Observing System (IOOS). The relationships between GCOOS, the Gulf of Mexico Alliance (GOMA) and the Southeast Coastal Ocean Observing System and its RA, SECOORA, also are noted in Section 3. In Section 4 the main GCOOS themes are described in terms of the socioeconomic issues they support. For each theme the observing system activities needed to support that theme are presented so that a clear link is made between the socioeconomic themes of GCOOS and the required observing system elements. Section 5 gives a brief description of the subsystems envisioned at this time as part of the GCOOS. The organization is by observing system element.
2. **Priority GCOOS-RA operating system activities for the near term (five years)**
The observing system activities of highest priority to developing the GCOOS are summarized in
this section to make clear our near-term objectives. These are organized into four modules
dealing with data management and communication, operating systems, modeling and analyses,
and education and outreach.

Of course, there also is the priority need to maintain and strengthen the GCOOS Regional
Association that provides guidance and integration to the GCOOS itself. However, external
proposals are not solicited for this module, so it is summarized only in very broad terms.

2.1 **Regional Association: Support and Enhancement**
This module includes support for: full-time Regional, Education and Outreach, and DMAC
Coordinators; a GCOOS Office that maintains the web site, disseminates information through the
monthly news notes, flyers, brochures, and other routine materials, as well as through the
GCOOS list serve; arranges plans and logistics of RA meetings and workshops; coordinates
GCOOS activities with those of other observing system entities; represents GCOOS at various
IOOS, NFRA, and other meetings and conferences; provides staff support for the GCOOS-RA
organizational bodies; and prepares progress and other reports for funding entities.

2.2 **Data Management and Communications Module**
- Integration and delivery of DMAC-compliant data (Data Portal/Regional Operation
  Center)
- Identification and entrainment of new data providers
- Provision of support for new data providers
- Preparation and delivery of model output and other products

2.3 **Observing System Elements Module**
- Surface currents (High Frequency Radar (HFR) network)
- Surface waves (HFR network plus direct measurements)
- Water level; tide measurements
- Time series stations (physical, biological, chemical and geological oceanographic
  and meteorological)
- Sentinel station
- Others (e.g., gliders, AUVs, repeat surveys, VOS, drifters, floats)

2.4 **Modeling and Analyses Module**
- Develop improved 3-D circulation model for the Gulf of Mexico
- Integrated production of satellite data products
- Develop improved ecosystem models
- Dissemination of model output

2.5 **Education and Outreach Module**
- Develop education and outreach activities that support the GCOOS mission
  and raise public awareness of the U.S. IOOS
- Develop activities that enhance ocean and climate literacy initiatives
- Facilitate dialogue between GCOOS information users and data providers
• Provide technology workforce development opportunities
• Provide professional development opportunities
• Incorporate GCOOS data into STEM (Science, Technology, Engineering and Math) education in the Gulf of Mexico

3. Designing the Gulf of Mexico Coastal Ocean Observing System within the U.S. Integrated Ocean Observing System

Numerous serious issues threaten the quality of life that residents and visitors to the Gulf Coast currently enjoy. Based on focused stakeholder workshops held by the GCOOS RA (see Appendix) or included in national observing system plans, the prioritized requirements for data and data products to address these have been integrated into a set of priority activities that require measurements and activities. Details are given in the GCOOS-RA Conceptual Design, Version 2 (see http://gcoos.tamu.edu/conceptualdesign.html). Ranging from vulnerability of community infrastructure to risks to life and property, we believe at this time the major themes of the GCOOS-RA should be:

• Safe and Efficient Marine Operations
  o Within the GCOOR-RA are seven of the top 10 U.S. ports in terms of tonnage or cargo value, with two in the top global seven. These require real-time knowledge of water depth and currents for safe passage through coastal waters.
  o Industrial activity, including shipping and oil and gas operations, in and near the coastal waters could result in spills of pollutants that will need to be tracked effectively to improve opportunities for clean up and protection of ecosystems and beaches.

• Mitigation of Effects of Coastal Hazards
  o Extensive urban development will require knowledge of the currents, waves, and coastal flooding probabilities for sustainable development and knowledge of the vulnerabilities and monitoring of the affected coastal ecosystems so that mitigation measures can be implemented to protect important natural resources.
  o Extensive low lying coastal landscapes in an area of the world frequented by hurricanes, tropical storms, and winter cyclones, are vulnerable to storm surge and inundation.
  o The Gulf of Mexico oil and gas industry produces about 44% of the crude oil, 43% of the dry natural gas, and over 50% of the liquid natural gas of the U.S. Vulnerability to strong currents and hurricanes can impact Gulf ecosystems and the national economy.

• Public Health and Safety
  o Harmful Algal Blooms affect human and animal health
  o Currents, including rip currents, and waves pose risks to a myriad of activities including recreational boating, surfing, diving, and swimming at the beach.
  o Search and Rescue activities rely on accurate, real-time current and wave data.

• Healthy Ecosystems and Water Quality
  o The Gulf of Mexico fishing industry yields 69% of the shrimp and 70% of the
oyster catches in the U.S., as well as many fish varieties. A healthy coastal ecosystem is required for these to prosper.

- The watersheds of 33 states drain into the Gulf from over 150 individual rivers, of which 20 are major river systems including the Mississippi River; this river discharge brings high nutrient loads, pollutants, and sediments into the coastal waters.
- Hypoxia affects animal health and human activities such as fishing.

- Gulf-wide ocean literacy and climate change literacy initiatives
  - The Mason-Dixon poll conducted as part of the 2009 National Hurricane Survival Initiative (NHSI), revealed that of the Gulf Coast citizens surveyed, 70% did not know that storm surge represents the greatest potential for a large loss of life from a hurricane. Many are not sure if they reside in a flood zone. As a result, poor evacuation decisions are made.
  - An informed citizenry will be empowered to make decisions that promote sustainable use of resources, and protect life and property in the face of natural and human-induced threats.

For comparison, the seven societal goals of the U.S. IOOS are:
1. Improve predictions of climate change and weather and their effects on coastal communities and the nation;
2. Protect and restore healthy coastal ecosystems more effectively;
3. Reduce public health risks;
4. Enable the sustained use of ocean and coastal resources;
5. Improve the safety and efficiency of maritime operations;
6. Improve national and homeland security; and
7. Mitigate the effects of natural hazards more effectively.

Thus it is clear that the major themes of GCOOS are included in the goals of the U.S. IOOS.

In addition to being a part of the U.S. IOOS, the GCOOS-RA is closely coordinated with SECOORA, GOMA, and the Caribbean Regional Association (CaRA). The priority areas of our neighboring (and to some extent overlapping) Regional Association, the Southeast Coastal Ocean Observing Regional Association (SECOORA), are approximately aligned with our major themes. These areas are: ecosystems, living marine resources and water quality; coastal hazards; marine operations; and climate change (see the working document at http://secoora.org/documents/Strategic%20Priorities-Draft-20100204.pdf/view). Both the GCOOS-RA and SECOORA priorities are consistent with the five consensus priority theme areas of the National Federation of Regional Associations (NFRA): marine operations; climate variability and change; ecosystems, fisheries and water quality; coastal hazards; and coastal and marine spatial planning (NFRA planning document available at http://doc.aoos.org/nfra/03.10_RCBooklet_lo-res.pdf).

The Gulf of Mexico Alliance (GOMA) has identified six priority issues of concern to the governments of the Gulf coast states. These are:
- Water quality for healthy beaches and seafood
- Habitat conservation and restoration
The GCOOS-RA activities also are coordinated with the Gulf of Mexico Large Marine Ecosystem collaboration between Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) and the U.S.’ NOAA Southeast Fisheries Science Center (SEFSC).

4. The Main GCOOS Themes

GCOOS is organized into themes that illustrate the broad beneficial uses of the observing system activities. In this section the main GCOOS themes are described in terms of the socioeconomic issues they support. For each theme, the observing system activities needed for its support are presented so that a clear link is made between the socioeconomic themes of GCOOS and the required observing system elements.

4.1 Safe and Efficient Marine Operations

Observing system activities included under this theme provide support for recreational boating, fishing and diving; search and rescue; marine transportation and shipping; extraction of offshore mineral and energy resources, including wind farms and other emerging energy extraction processes.

These observing system activities include observations of water depths in harbors, ports and transit areas, accurate locations of shorelines, water level elevation, surface waves, surface currents, surface winds, visibility; and forecasts of weather (with particular emphasis on storms), water level, waves, currents and visibility.

4.2 Mitigation of Effects of Coastal Hazards

Observing system activities included under this theme provide support for prediction and mitigation of the effects of storm surge, coastal inundation, flooding, rip currents, rising relative sea level, and erosion.

These observing system activities include observations of bathymetry and topography in the coastal zone, accurate location of shorelines and boundaries of navigable waterways, river discharge, precipitation, surface waves, surface currents, sea level, winds; forecasts of weather (particularly storm track and intensity and precipitation), storm surge, river levels, inundation, flooding; updated flood plain maps, post-storm forensic studies.

4.3 Public Health and Safety

Observing system activities included under this theme provide support for prediction, detection, tracking/monitoring, and forecast of HAB events and associated impacts, Coast Guard search and rescue operations, monitoring and prediction of rip currents, shellfish/seafood safety, and monitoring of beach quality to help ensure safe beach usage.

These observing system activities include observations of discharge of water and pollutants from...
rivers, point-source and non-point-source outflow of pollutants, spills of petroleum and other pollutants, near-shore algal concentrations, air and sea surface temperatures, surface waves and currents, winds; satellite derived distributions of sea surface temperature, chlorophyll concentrations, .

### 4.4 Healthy Ecosystems and Water Quality

Observing system activities included under this theme provide support for healthy fisheries; protection of living marine resources; monitoring of hypoxia; prediction and mitigation of HABs; and monitoring and mitigation of the effects of pollution.

These observing system activities include observations of river discharge and its nutrient and pollutant loading, surface and subsurface distributions of dissolved nutrients and oxygen, surface currents, surface waves, surface wind, subsurface currents, , habitat types, selected algal concentrations, selected sea surface temperature and chlorophyll; satellite-derived products including sea surface temperature and surface chlorophyll distributions; forecasts of surface winds, surface currents, surface temperatures, surface waves, and subsurface currents.

Three overarching facts emerge from consideration of the foregoing information. First, many observations, forecasts or other products serve several user groups in more than one theme. Second, it is not feasible at this time to carry out some of these activities on an operational basis. Third, it is unreasonable to attempt to develop the capability to carry out all of the feasible observing system activities simultaneously.

Therefore, the GCOOS-RA has selected for implementation a subset of feasible activities that serve multiple purposes.

### 5. The GCOOS Observing System Modules

In this section we describe briefly the subsystems envisioned at this time as part of GCOOS. Planning for some of these subsystems is complete, while for others it is incomplete. Yet other subsystems not mentioned here are being considered but are not to the stage that they can be rationally discussed. Finally, we are aware that yet additional subsystems eventually will be needed to satisfy the requirements of our stakeholders for data and products. The rationale for these subsystems is presented in Section 4 where these activities are related with products, outcomes and societal benefits.

Organization of this section is by observing system module as first given in Section 2.

#### 5.1 Regional Association: Maintenance and Enhancement

The GCOOS Regional Association is responsible for the development, operation, and improvement of the GCOOS as a regional coastal ocean observing system (RCOOS) in the U.S. sector of the Gulf of Mexico, including bordering estuaries. Priority activities to maintain and enhance the GCOOS-RA so that it can meet those responsibilities are two-fold. The first priority activity is to provide office staff sufficient to conduct the day-to-day business, coordinate the activities of the diverse data providers, support the activities of the GCOOS-RA governing bodies, and prepare and submit necessary fiscal and progress reports to funding entities. Second is to facilitate meetings and workshops to allow the GCOOS governing bodies to conduct their
business, engage stakeholders from different sectors, and prepare and disseminate information on
the GCOOS and its Regional Association for diverse audiences.

The GCOOS Office functions as the official day-to-day representative of the GCOOS and its
Regional Association. It provides staff support for the activities of the Board and the various
GCOOS Councils, Committees, Task Teams, and other working groups. The GCOOS Office
also supports the GCOOS governing groups in the preparation of GCOOS observing, policy, and
business plans, associated budgets and their dissemination to others. It is responsible for
reporting functions to the Board and funding entities. It maintains and improves the GCOOS web
site for dissemination of information. The GCOOS Office staff is responsible for the ongoing
coordination and tracking of the elements that make up the GCOOS and for coordination of
activities to further develop the GCOOS. The GCOOS Office provides oversight to the GCOOS
Data Portal/Regional Operations Center that will manage the daily GCOOS data operations and
linkages between users and providers. The staff consists of a Regional Coordinator with overall
responsibility for GCOOS Office duties, a Data Management and Communications Coordinator
who will assist with development of common data management standards and other information
technology issues, an Education and Outreach Coordinator who will assist with development of
educational and outreach activities, and a modest support staff, including IT and administrative
support.

The GCOOS is being developed to serve data and products of many types, being freely shared by
diverse providers, in an interoperable way. This requires that the GCOOS-RA be responsible for
coordination of observing system activities supported by the GCOOS-RA with those of the (1)
U.S. federal government (aka the "National Backbone"), (2) Gulf state and local governments,
including the Gulf of Mexico Alliance, (3) southeastern U.S. RCOOS (governed by SECOORA),
(4) private industry, (5) non-governmental organizations, and (6) Mexico and Cuba, as
appropriate and lawful, in the Gulf of Mexico waters. The GCOOS-RA represents GCOOS
within the National Federation of Regional Associations (NFRA). Resources to coordinate
observing elements, engage new data providers, and attend activities to develop the GCOOS are
provided by the GCOOS Office through personnel, travel support, textual materials, information
flyers on GCOOS, support for joint workshops/meetings, or other appropriate resources.

The 15-member Board of Directors meets twice a year, nominally in winter and summer, with
the GCOOS Office staff and selected invitees. It also conducts telephone conference calls every
other month and whenever needed. The Stakeholder Council has approximately a dozen
members representing diverse sectors that use or provide data and products. The Education and
Outreach Council has approximately 25 members representing formal (K-gray) and informal
(e.g., museums, aquariums) education and outreach entities and including representatives from
the five Gulf states. Both Councils meet annually and conduct other business by email and
teleconference. The Data Management and Communications Committee, Observing Systems
Committee, and Products and Services Committee meet approximately annually, either jointly or
separately according to need. The Membership Committee consists of three members. Most of
their work is conducted by email or teleconference.

The Parties to the GCOOS-RA meet annually, in winter, with the Board of Directors. They also
elect the Board members each year, with results announced at the Annual Parties Meeting. The
GCOOS Office staff assists the Membership Committee in the conduct of the election by preparing and distributing the ballots with candidate credentials. The GCOOS Office also provides staff support for the Membership Committee and the Board of Directors in their efforts to recruit new Parties (signatories to the governing Memorandum of agreement) and thus build the membership of the GCOOS-RA.

Members of the GCOOS Board, Councils, Committees, Task Teams, Office staff, and other working groups represent GCOOS and the GCOOS-RA at various professional, stakeholder, GCOOS, NFRA, governmental, and other meetings. Further, the GCOOS Office arranges 1-4 workshops each year to (1) engage specific stakeholder sectors to determine or refine requirements and/or (2) provide training to the E/O community that will improve the utility to it of the data and products from the integrated observing system in the Gulf. GCOOS Office staff arrange for meetings and workshops. Travel of the members of GCOOS groups, invitees, or GCOOS representatives to meetings, conferences, and workshops, are supported through the GCOOS Office.

5.2 Data Management Module
The GCOOS Data Management system exists to facilitate the use of data, model output and other products by a broad range of consumers including public and private sectors; state, federal and local agencies; non-governmental organizations; and all tiers of the academic community from kindergarten through university. While focused primarily on supporting regional stakeholder needs we also support the Integrated Ocean Observing System (IOOS) Data Management and Communication (DMAC) Plan’s vision of an automated and largely-unattended interoperable System of Systems that serves the national and global ocean observing system’s needs.

5.2.1 IOOS DMAC Compliance
Adherence to IOOS DMAC interoperability requirements means that core elements of our data subsystems (catalogs, data content models, metadata, transport etc.) must adhere to IOOS community standards. Guidance on community standards is still in development and currently comes from the NOAA IOOS Program Office although this may change in the future. This guidance is captured in the document titled “Guidance for Implementation of the Integrated Ocean Observing System (IOOS) Data Management and Communications (DMAC) Subsystem. NOAA IOOS Program Office White Paper (V1.0) March 12, 2010”. Any group considering proposing to do data system development should consult this or subsequent documents. Our approach to IOOS DMAC compliance has three major elements.

First, because Information Technology (IT) aspects of the IOOS vision evolve and change rapidly, to keep abreast, members of the GCOOS DMAC group must participate in a variety of steering teams, meetings, workshops, teleconferences, and national conferences. To keep informed on current status and future trends we continually monitor email, project wikis, newsletters, white papers, project reports, announcements and related programs (e.g. Ocean Observatories Initiative). We frequently engage in related unfunded and funded projects such as the NOAA IOOS Data Integration Framework (DIF) Pilot Project and the SURA-led model test bed. The needed DMAC skill sets span those of domain scientist, computer programmer, information architect and data manager.
Second, we established and currently maintain a close working relationship with our region’s non-federal data providers and their IT staff to promote enhanced data sharing. In some Regional Associations this type of relationship is formalized through an “Ocean Data Partnership” which is an unfunded non-binding memorandum of understanding on data sharing. In the GCOOS-RA this relationship was formalized and made binding through 3-year funded subcontracts made with each of our 10 principal non-federal local data providers. These subcontracts require that the data providers serve their data through a Sensor Observation Service (SOS) using a commonly-controlled vocabulary and participate in the IOOS Observation Registry Program. The resulting relationships foster enhanced cooperation in the form of a timely response on issues of data availability, data quality, and observing system status. These subcontracts expire at the end of 2010. We would like to continue to provide support to local data providers to maintain and modify their systems to be compatible with the evolving and changing IOOS DMAC requirements.

Third, we designed, constructed, and now maintain and enhance, a centralized web-based regional data portal. The portal aggregates and serves data from a variety of federal and non-federal data sources. These data are primarily near real-time data streams of physical and marine meteorological data including in situ and remotely-sensed parameters. The portal also hosts historical data sets of physical parameters; climatologies of temperature, salinity and their variability; elevation-bathymetry-shoreline sets; digital photos of phytoplankton from near real-time camera; satellite images; numerical model output from ocean circulation and weather models; and other products of potential interest to stakeholders. These data and products are made available to the public through several IOOS DMAC approved service end points (SOS, OPeNDAP, WCS/WMS, THREDDS) in XML for machines, netCDF for models and software tool and in graphical and tabular outputs for humans.

5.2.2 Facilitating Use of Data and Products

Our purpose is to facilitate the use of data and product output. Our primary way of doing this is though the operation and maintenance of a web-based data portal. We “facilitate use” by designing the portal interfaces to meet the following requirements. Data and products must be to easy to discover, access, understand, and use. They should be of high-quality and be available to the user as soon after collection or production as possible and many years beyond. The requirement “easy to discover” means a user, either human or networked computer, can determine easily what parameters are available through the portal and what are their temporal and spatial coverages. By “easy to access” we mean data and model output will be delivered to their desktop or portable device via the network using community-approved transport protocols. By “easy to understand” we mean that sufficient metadata will be available to ensure users have all the information they need to understand what the data are. “Easy to use” means all data will be served in similar ways in common structures and formats. “High-quality” means the data will be passed through appropriate quality-control and quality-assurance steps. Data should be made available as soon as possible, in near real-time if available, because certain applications (e.g. search and rescue) are only useful with recent data. Data should be preserved both locally at the data portal and at secure long-term trusted digital repositories such as the National Oceanographic Data Center.

Increasingly, the Regional Associations are being judged by the number of web site hits received
and bytes transferred. Although some users only want numeric values and can make their own products, a larger group wants access to pre-made basic and tailored products. Thus, the GCOOS data portal activity must include delivery of selected products. Current products include maps showing the location of observing system equipment, images displaying current environmental conditions, and other products given in Section 5.2.1. Many additional products need to be delivered; their development should be in consultation with specific user groups.

5.2.3 Future Work

For the next decade, we envision the GCOOS data management activity will exist as a regional aggregation node in a global System-of-Systems. We will undertake activities to ensure that valid data and products are produced and to guard against data loss. We will work with regional providers to standardize their data delivery systems and with regional and national efforts to deploy and test interoperable software implementations.

We envision staffing a central data management facility and providing for paid collaborative programming and metadata producing efforts at the major data provider nodes in the region over a four-year period. The work will involve maintaining a data portal which incorporates the back-end interoperable elements coupled with a robust and easy to navigate front-end web presence with product generating capability, a centralized data management activity to handle the traditional data management activities, and an effort that builds toward a regional Operations Center to monitor and report on the availability of data for time sensitive uses. We do not envision a 24/7/365 operations in the immediate future, but we expect to provide for higher than usual staff availability during extreme weather, spills and drills, or other events requiring guaranteed high-availability.

The following are some areas outlined in the NOAA guide referenced in section 5.2 which need resources and engagement by the GCOOS DMAC effort in the near future.

1) The GCOOS-RA must be certified and accredited and reach as high a maturity level as is appropriate for a regional enterprise.

2) The GCOOS-RA must monitor our data portal’s service availability, response time, and summary web site usage statistics on a monthly basis. There are a number of ways to measure and present the results—a community agreement is needed so comparisons can be made between regions.

3) IOOS leadership is currently researching issues regarding vocabularies for parameters, units, and standardized identifiers for sensors, platforms and other areas where controlled naming will enhance machine-to-machine interoperability. We anticipate the need for effort in incorporating their decisions in our data management systems. There is a need for semantic reasoning software tools to cross-walk vocabularies.

4) Metadata need to be produced and published in standardized interchange formats. Metadata have always proven to be a labor intensive activity even with the help of computerized metadata tools. There will be opportunities to participate in the specification of metadata standards.
5) Our regional data need to be archived at NODC. In some cases this is a relatively simple task. In others cases there is the complicating issue of near real-time data vs. delayed-mode data and associated levels of quality control and assurance processing. Duplicate and near-duplicate versions of data may exist due to their acquisition from different feeds. Data versioning needs to be established and used in our data system. This will require human supervision.

The following are some areas of near-term need which do not flow from the guidance document but are central to producing a useful, frequently-visited data portal.

6) There is a continuing need to add additional data streams. These include, but are not limited to water-quality, remote sensing, beach quality, biological data of all types (plankton, fisheries, etc), seabed characterization, and biogeochemical data sets. Also additional numerical model output is desired (e.g., wave model outputs).

7) Additional basic and tailored products are needed. Tailored products are products that support a particular stakeholder group. A tailored product might be composed of several basic products grouped on a page for particular stakeholders such as recreational boaters or fishers, hazards emergency managers, or ecosystem managers. Products also are needed for smart phones (e.g., iPhone or Droid) and other small screen devices such as the iPad.

8) Decision support tools are designed for a particular user group; examples are a tool designed to support oil-spill monitoring and mitigation, or a tool that ingests all relevant sources of information on surface currents and winds and predicts drift trajectories for search and rescue. There is a clear lack of decision support tools capable of ingesting IOOS DMAC compliant data streams such as the Sensor Observation Service (SOS) feeds and providing useful applications.

Some of these needs will be developed best through new projects.

5.3 Observing System Elements Module

One goal of the GCOOS-RA focuses on the development of the capacity to monitor the state of the Gulf of Mexico from its estuaries to the limit of the U.S. EEZ. At present there are seven sub-systems planned to be built. These systems will consist of existing observational elements supported by a various GCOOS-RA partners and the addition of new observational elements to fill gaps. The DMAC module will be used to integrate these elements into a cohesive single system. The seven sub-systems are briefly described below.

I. HF Radar Observing System for Surface Currents and Waves.

Planned is a comprehensive High-Frequency Radar (HFR) network of observations of surface currents and waves that is consistent with the National Surface Current Mapping Plan (http://ioos.gov/hfradar/) and the National Waves Plan (http://ioos.gov/program WAVESplan.html). The initial network will focus on siting HFRs around the U.S. Gulf coast to enable observation of currents and waves in the offshore environment. We will use a combination of CODAR and Wellen Radars. The system will be build over a period of about six years, funding permitting. Plans are to direct all data through the National Data Buoy Center for quality control. However, products will be served via the GCOOS Data Portal. Future network enhancements will target near-coast environments.
The initial network will consist of

(1) continuation of operations of the existing High Frequency Radar (HFR) network in the GCOOS region:
   (a) three 5-MHz CODARs on the coasts of MS, AL, and the FL panhandle,
   (b) three 5-MHz CODARs on the West Florida Shelf, to be maintained and funded through SECOORA (Note if this funding fails, then these are priorities for GCOOS-RA funding), and
   (c) two 16-MHz WERA units in the Florida Straits to be maintained and funded as part of SECOORA (Note if this funding fails, then these are priorities for GCOOS-RA funding);

(2) development of a complete understanding of the quality control and quality assurance issues for different HFR systems and how to ensure interoperability between different HFR systems;

(3) development of a plan for choosing particular HFR station types, operating frequencies, locations, and infrastructure plans for particular site types;

(4) expansion of the network to ~36 sites (tentative locations are shown in Figure 1); Note: SECOORA will maintain and fund the HF Radars along the Florida coast from Port Richey, FL, south through the Keys and Florida Straits (Note if this funding fails, then these are priorities for GCOOS-RA funding), and

(5) expansion of the HFR contributions from oil and gas platforms in the Gulf.

II. Water Level Observing Network for the Gulf of Mexico.

Planned is an expansion of the existing sea level data observing network to bring the density of sea level stations along the entire Gulf coast to the dense sea level data observing system that is in Texas under the Texas Coastal Ocean Observing System (TCOON). The data from this network will enable evaluation of changes in relative sea level elevation through time, aid in remediation activities in the event of storms, and, for offshore stations, aid the National Weather Service and the Hurricane Center for use in network model forecasting of tropical storm surge. The Water Level Observing Network will consist of

(1) Continuation of the existing system of __ stations;

(2) Upgrade of __ systems for more accurate elevations and/or severe storm surge resistance;

(3) Addition of approximately 30 new stations;

(4) Addition of 5 to 10 sea level and meteorological data collection stations on oil platforms, with the logistical cooperation of the oil companies and their service contractors.

III. Network of Autonomous Meteorological Monitoring Packages.

This network will consist of the deployment of multiple portable meteorological observation packages to provide real time data from oil industry production platforms located in data sparse regions of the Gulf. The projected benefits of this network will be to: improve hurricane and weather forecasts by the addition of new meteorological data; extend farther offshore the overall and climatological data bases of the National Climatic Data Center; and provide underlying data to answer questions regarding hurricane intensification and the strength of mesoscale vortices and downdrafts. The packages will be autonomous so that they will continue to operate even when platforms are shut down and evacuated during severe storms. They will meet strenuous safety standards imposed by the industry for all equipment on their platforms. Data will be transmitted via satellite to the NDBC, which has agreed to accept the data
sets for quality control and further distribution. The network will consist of
(1) Addition of 7-20 autonomous meteorological monitoring packages to supplement the
those deployed by the FAA and the NOAA NWS.

IV.  Harmful Algal Bloom Integrated Observing System

An implementation plan for a HAB Integrated Observing System (HABIOS) is under
development. It will include all aspects of the system: monitoring, detection, confirmation,
tracking, forecasting, data management, production and dissemination of information
(advisories, warnings, closures, etc.), and outreach.

V.  Hypoxia Monitoring System for the Gulf

The GCOOS-RA intends to assist primarily with the deployment of the real-time data
collection aspects of NOAA’s plan for an integrated hypoxia observing system for the Gulf of
Mexico (see Figure 2). Meanwhile, several research efforts are underway to study the
mechanisms responsible for hypoxia, its temporal and spatial scales, and its occurrences. These
should be supplemented with additional observations, both moored stations and ship-borne surveys.

A successful monitoring program must be designed with knowledge of the dominant
spatial and temporal scales of the phenomena of interest. Because of the wide range of temporal
and spatial scales of processes that influence hypoxia on the shelf, a cost-effective monitoring
system must use a combination of moored systems, to provide necessary temporal resolution,
and shipboard monitoring, to provide necessary spatial coverage. New technologies such as
gliders should also be included in the design. The proposed monitoring system should continue
existing monitoring efforts of the region to extend time-series and statistically establish long-
term trends (see Figure 2). A mooring program should be phased in over multiple years and span
the entire hypoxic zone from the Southwest Pass delta to the Texas-Louisiana border. At a
minimum, the systems should report in real-time and measure conductivity, temperature,
dissolved oxygen and nitrate concentration above and below the pycnocline and current profiles.
Additional measurements of meteorological parameters, near-surface fluorescence, near-bottom
dissolved oxygen concentration, pH, turbidity, and fluorescence are also recommended. The
monitoring cruise plan builds upon the groundwork begun with previous efforts by extending the
previous time-series and establishing additional repeated lines. The full shelf survey should be
continued adding time for along-shelf stations and continuing westward into Texas coastal
waters and eastward into Mississippi and Alabama waters. Monthly and bimonthly cross-shelf
transects should be conducted and additional bi-monthly transects performed.
VI. Monitoring of effects of Mississippi-Atchafalaya River discharge on the Gulf

This is of very high priority because these rivers exert a major impact on Gulf ecosystems. Many of the needed pieces are included in this strategic design, but a complete design will require additional time and effort. Sought is the ability to track outflow, spreading, stratification, and effects of river water and constituents. This likely will include:

1. Major densification of present levels of measurements, both spatially and temporally.
2. Additional biogeochemical measurements
3. A concerted modeling effort
4. Better integration of all data sets
5. Development of new products

VII. Development of a deep-ocean, advanced capability sentinel station.

Envisioned are one or more moored stations with a measurement suite capable of characterizing the environment from the sea floor to the troposphere (-3000 m to +3000 m). It would serve both as a sentinel station in the U.S. EEZ as well as a test bed for advanced technology. Technology development is needed for future enhancements to the GCOOS.

5.4 Modeling and Analyses Module

Develop improved 3-D circulation model for the Gulf of Mexico.

Results of a pilot project will be used to determine whether a 3-D current model can supply forecasts, nowcasts, and hindcasts of currents and hydrography with sufficient accuracy to be useful to a sizeable constituency around the Gulf of Mexico. Secondary goals include laying the foundation for a permanent operational forecast model in the Gulf, better identifying and meeting the needs of the various beneficiaries, increasing our understanding of Gulf of Mexico oceanography, and advancing modeling technology.

The next stage in the development of this subsystem will be to establish a Gulf of Mexico Forecast Center (GMFC). This will begin with setting in place an operational circulation model.
That model will assimilate and interpolate the measurement streams from the GCOOS observing system. We will then begin wave and storm surge forecast model testing and testing of an ecosystem forecast model. When testing and evaluation is complete, operational wave forecast and storm surge models will be added to the GMFC. Then we will begin testing of a sediment transport model. Within seven years we hope to have operational ecosystem and sediment transport models within the Center.

This capability will enable the development and subsequent delivery to stakeholders of a wide variety of model output and model derived products.

Integrated Production of Satellite Data Products.

Various laboratories prepare products for the Gulf using data remotely sensed from satellites. These include, but are not limited to: University of South Florida, Louisiana State University, University of Colorado, University of Texas, The Johns Hopkins University, University of Miami, NOAA, and Navy, as well as private firms. The GCOOS-RA is encouraging these laboratories to jointly plan for the production of integrated satellite data products for the Gulf. We believe such cooperation would clarify which laboratories have responsibilities for which products. This should reduce redundancy, result in more and better products for stakeholders, and improve delivery of those products. It seems likely that financial incentives will be needed to bring about such cooperation. At this time we have no good estimates of the costs.

Develop improved ecosystem models.

Provide product using existing beach and water quality measurements from all Gulf states beaches.

5.5 Education and Outreach Module

The Gulf of Mexico Coastal Ocean Observing System (GCOOS) Education and Outreach Council (EOC) has developed a Strategic Plan to guide education and outreach activities within the GCOOS-RA. The plan builds upon the GCOOS Mission to develop a self-sustaining, collaborative, real-time ocean observation system for the Gulf of Mexico region. The EOC Vision is for all residents within the Gulf of Mexico region to be aware of and effectively use GCOOS products and services when making decisions concerning their work and life in ocean and coastal waters, estuaries, and their watersheds. The EOC Mission is to provide guidance and assistance to GCOOS in the development of education, outreach, public awareness, and understanding of programs and materials that are applicable to residents of the Gulf of Mexico region. There are five goals associated with the EOC Strategic Plan.

The first goal toward achieving this vision and mission is to establish a GCOOS education and outreach network within the Gulf of Mexico region. This includes establishment of a sustained central education and outreach (E/O) office. Diversity and inclusiveness in the EOC membership will be pursued actively. Collaboration, coordination, and communication efforts within the broader Gulf of Mexico E/O communities will be enhanced by increasing and maintaining effective partnerships that reach diverse audiences. We will enhance the GCOOS E/O community by supporting and developing professional development programs and practices of formal and informal educators. Key messages will be developed and reinforced in the daily work
The second goal is to communicate within GCOOS to ensure all committees' efforts guide education and outreach efforts and all GCOOS partners deliver a consistent message. This will include facilitation of two-way communication between data providers and users to maximize relevancy and usefulness of products. The EOC will collaborate with appropriate committees to create relevant products and materials.

The third goal is to work toward the use and application of GCOOS observations, products, and services throughout the region. To this end we will develop GCOOS E/O relevant programs and materials for diverse stakeholder audiences (such as the general public, formal and informal educators, coastal decision makers and resource managers). We will increase the awareness and understanding of GCOOS products and services by various audiences. We will target E/O efforts at a diversity of stakeholder groups.

The fourth goal is to encourage and enhance workforce development in the ocean observing system field. We will ensure K-16 teachers are aware of GCOOS as a platform for teaching and learning science, mathematics, and technology as well as an opportunity for a professional or vocational career. We will work to increase knowledge and skills of students in the K-16 community who will improve ocean, coastal, and science literacy through their use of GCOOS products, services, projects, and activities.

The fifth goal is to evaluate effectiveness and accountability of outreach and education activities. This involves establishing a baseline to gauge future success. We will identify and implement mechanisms that can be used to measure effects of specific education and outreach activities (e.g., pre/post tests, website hits, feedback form/email, questionnaires, needs assessment instruments, Likert-scale evaluations, and other related evaluation tools).

Appendix: GCOOS-RA Stakeholder Sector Workshops

The focused stakeholder sector workshops held by the GCOOS-RA are listed below. The report from each workshop can be found at the URL <http://gcoos.tamu.edu/meetingreports.html>.

<table>
<thead>
<tr>
<th>Workshop Name</th>
<th>Dates</th>
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<tr>
<td>NVODS Workshop for Managers of Coastal Observing System Activities in the Gulf of Mexico</td>
<td>14-15 Jan. 2003</td>
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<tr>
<td>GCOOS Education and Outreach Council Formation Meeting</td>
<td>29-30 Nov. 2004</td>
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<tr>
<td>HABOSOS-GCOOS Workshop</td>
<td>13-15 April 2004</td>
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<tr>
<td>A Workshop to Explore Private Sector Interests and Roles in the U.S. Integrated Ocean Observing System: Focus on the Southeastern U.S. and Gulf of Mexico</td>
<td>2-4 March 2004</td>
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<tr>
<td>GCOOS and the Private Sector: Oil and Gas and Related Industry</td>
<td>2-4 Nov. 2005</td>
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<tr>
<td>GCOOS-SECOORA-NOAA CSC Storm Surge &amp; Inundation Workshop</td>
<td>24-26 Jan. 2007</td>
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<tr>
<td>First GCOOS-GOMA Harmful Algal Bloom Observing System Plan for the Gulf of Mexico Workshop</td>
<td>14-16 Nov. 2007</td>
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<tr>
<td>Eastern Gulf of Mexico Recreational Boaters Workshop</td>
<td>4-5 Feb. 2009</td>
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<tr>
<td>Global Positioning Workshop for Educators: Eastern Gulf</td>
<td>30 Apr. - 1 May 2009</td>
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<tr>
<td>Second GCOOS/GOMA HABIOS Workshop</td>
<td>21-23 Apr. 2009</td>
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