REPORT TO THE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION OF THE SENATE

AND

THE COMMITTEE ON NATURAL RESOURCES OF THE HOUSE OF REPRESENTATIVES

2010 Report to Congress on NOAA's Integrated Ocean and Coastal Mapping Initiative

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The National Oceanic and Atmospheric Administration
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2010 Report to Congress on NOAA's Integrated Ocean and Coastal Mapping Initiative

This report responds to requirements in the *Omnibus Public Land Management Act of 2009* (P.L. 111-11), and specifically the *Ocean and Coastal Mapping Integration Act* (P.L. 111-11, Title XII, Subtitle B). The *Ocean and Coastal Mapping Integration Act* (hereafter, "Act") directs the Administrator of the National Oceanic and Atmospheric Administration (NOAA) to "…develop and submit to the Congress a plan for an integrated ocean and coastal mapping initiative within the National Oceanic and Atmospheric Administration" (See *Appendix 1* for the full text of the reporting requirements as contained in Section 12205 of the Act).

Executive Summary

Accurate mapping of the Nation's coastal watersheds, adjacent oceans, and Great Lakes is critical to meeting economic, security, environmental, and social needs. With more than 50 percent of the U.S. population and economic activity occurring along the coast, accurate maps and charts are vital to protect life and property, support healthy and resilient coastal communities, provide for safe and efficient marine transportation, and inform smart economic decisions regarding public and private infrastructure. In order to fulfill its stewardship and economic missions, such as to responsibly manage our ocean and coastal resources and to provide information that helps us to better understand and adapt to the effects of climate change, NOAA has a suite of programs that acquire, manage, and distribute robust geospatial data for the ocean and coastal zone.

NOAA recognizes the importance and value of integrating these various mapping activities, both within the agency and with its Federal, State, local, and non-governmental partners. In accordance with the Act, NOAA is enhancing its coordination of ocean and coastal mapping in order to provide stakeholders and the public with comprehensive geospatial information more effectively and efficiently. This external community includes those who acquire ocean and coastal geospatial data, use this data, and/or depend on derivative mapping products and services developed from this data.

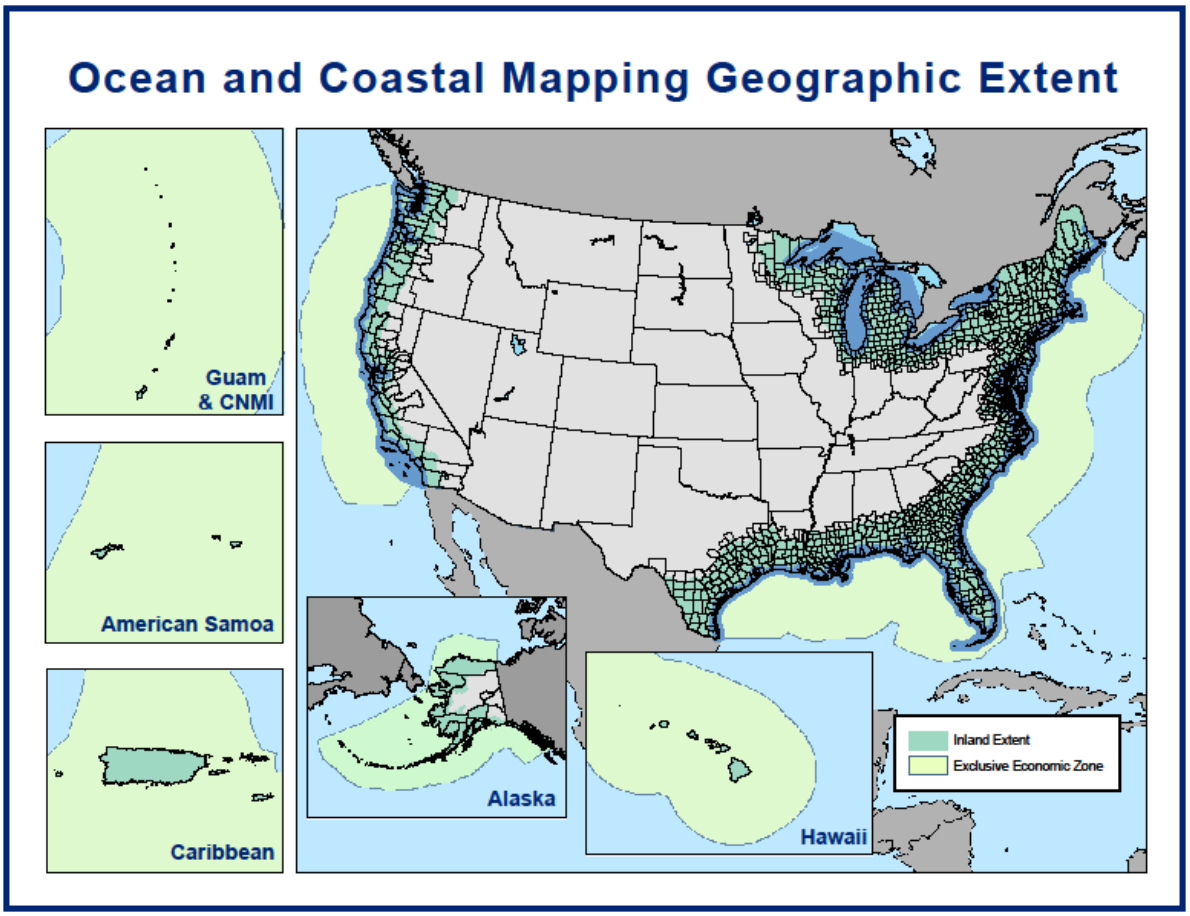
This report describes NOAA's diverse ocean and coastal mapping programs and explains NOAA's efforts to ensure effective intra- and interagency mapping coordination, support efficient management and dissemination of data, improve mapping technologies, and pursue other efforts to improve NOAA's ability to meets its ocean and coastal mandates. Furthermore, this report outlines a multi-year effort to enhance the integration and more comprehensively coordinate NOAA's ocean and coastal mapping programs.

Sections 1-7 of this report address each of the seven plan requirements specified in Section 12205 of the Act; short excerpts from the Act introduce each section of this report.

Introduction

As defined in the Act, ocean and coastal mapping is the acquisition, processing, and management of physical, biological, geological, chemical, and archeological characteristics and boundaries of ocean and coastal areas, resources, and sea beds using a variety of mapping technologies. The NOAA Integrated Ocean and Coastal Mapping (IOCM) program implements the practice of planning, acquiring, managing, integrating, and disseminating this data and derivative products in a manner that permits easy access to and use by the greatest range of users. NOAA is adopting these practices throughout its mapping programs with the philosophy of "map once, use many times."

In general, the ocean and coastal zone extends from the seaward limits of the Nation's Exclusive Economic Zone (EEZ) inland to include all coastal counties, all official state coastal zone boundaries, all estuarine and coastal drainage areas, and all coastal mapping zones for the National Land Cover Database (see figure below). This area will extend seaward to the limits of the U.S. extended continental shelf (ECS), once the ECS has been established.



Plan Requirements

1. NOAA's Ocean and Coastal Mapping Programs:

"…identify and describe all ocean and coastal mapping programs within the agency [NOAA]..."

NOAA envisions an informed society that comprehensibly understands the role of the oceans, coasts, and atmosphere in the global ecosystem and uses that understanding to make the best social and economic decisions. The agency is pursuing four interrelated and mutually supportive long-term goals, of which three require a coordinated and integrated approach to ocean and coastal mapping.

1. Climate adaptation and mitigation – an informed society anticipating and responding to a changing climate and its impacts

2. Sustainable and resilient fisheries, habitats, and species – natural habitats and biodiversity protected and restored and fisheries sustained within healthy and productive ecosystems

3. Sustainable coastal communities and economies – environmentally and economically sustainable oceans, coasts, and Great Lakes communities and ecosystems

In addition, the Interagency Ocean Policy Task Force has identified high-priority objectives for the Nation to pursue in implementing a National Ocean Policy. These objectives include: 1) strengthening and integrating Federal and non-Federal ocean observing systems, data collection platforms, data management, and mapping capabilities into a national system, 2) adopting ecosystem-based management as a foundational principle, 3) implementing integrated coastal and marine spatial planning and management, and 4) strengthening resiliency of coastal communities to climate change impacts.

The following programs describe NOAA's primary ocean and coastal mapping activities in support of NOAA goals and National objectives:

Marine Resource Management

Coral Reef Mapping – NOAA's Coral Reef Conservation Program strategy includes creating digital maps and characterizations of all U.S. coral reef habitats using best available data to support coral reef monitoring and assessment; natural and socioeconomic research and modeling; outreach and education; and management and stewardship. Benthic (ocean bottom) habitat mapping is a fundamental component of ecosystem-based coral reef management. NOAA's Coral Reef Information System provides access to products from NOAA coral reef research, monitoring, and management activities, with an emphasis on U.S. states, territories, and remote island areas.

Deep-Sea Coral Mapping – Extensive deep-sea coral communities are believed to exist off many of the Nation's marine coasts and may be a key to the recovery and sustainability of economically-important species and the well-being of ocean systems. The NOAA Deep Sea

Coral Research and Technology Program, established by the *Magnuson-Stevens Fishery Conservation and Management Reauthorization Act*, has begun to map and characterize these habitats in the U.S. EEZ and submit this information to regional fishery management councils. Conducted under the auspices of the Coral Reef Conservation Program, deep-sea coral mapping is designed to build on and complement existing mapping efforts and to provide information to improve the management of these biologically diverse ecosystems.

Essential Fish Habitat Mapping – The *Magnuson-Stevens Fishery Conservation and Management Act* requires that NOAA: 1) designate Essential Fish Habitat (EFH; i.e., areas that are necessary to fish for their basic life functions) for managed species in fisheries management plans, 2) minimize fishing impacts on EFH to the extent practicable, and 3) consult with Federal action agencies (including NOAA) for actions that may adversely affect EFH. Each of these actions requires high-quality maps of the benthic environment coupled with accurate habitat classifications and detailed knowledge of the species and life history stages that make use of the environments. Regulations require that EFH designations be updated at least every five years. Benthic mapping and associated biological observations are carried out in response to needs articulated by eight Regional Fishery Management Councils and six regional Fisheries Science Centers. Mapping activities typically involve collaboration and partnerships. At present, many projects are implemented because of specific needs or opportunistically as resources are identified. Surveys generally are carried out by NOAA vessels, but when opportunities allow (e.g., California Seafloor Mapping Project), NOAA collaborates with sister Federal and State agencies to update EFH information.

Chesapeake Bay Assessments – NOAA performs habitat assessments throughout a range of Chesapeake Bay habitats including historic oyster bottom and sturgeon spawning grounds. The approach entails acoustic seafloor mapping of benthic habitats coupled with biological assessments, including identification of the spatial and temporal distributions of target species and associated species-habitat interactions. Resulting acoustic seafloor mapping products are based on high-resolution spatial datasets of bathymetry and backscatter amplitudes. Underwater video and sediment grab samples ground-truth this data. Survey efforts support native oyster restoration mapping in Maryland and Virginia and have grown to include sturgeon and coral habitat mapping inside and outside of the Chesapeake region.

Coastal Change Analysis Program – NOAA's Coastal Change Analysis Program (C-CAP) produces a nationally standardized database of land cover and land change information for U.S. coastal regions. These products provide inventories of coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. C-CAP products highlight what changes have occurred in the coastal landscape, providing data used for land use planning and habitat assessment. C-CAP provides the coastal component to the U.S. Geological Survey's (USGS) National Land Cover Database.

Marine Debris Mapping – NOAA supports a national and international effort to prevent, identify, and reduce the occurrence of marine debris and to protect and conserve the Nation's natural resources, oceans, and coastal waterways from the impacts of marine debris. To that end, NOAA develops best practices for locating derelict fishing gear, assesses the impacts of derelict fishing gear on habitat and species, monitors the amount of marine debris in the environment,

and investigates the use of remote sensing technologies for detecting marine debris. From 2005-2009, NOAA worked in the Gulf of Mexico to address the debris left behind by Hurricanes Katrina and Rita. NOAA conducted seafloor surveys in fishing grounds to identify and map debris using side scan sonar and other technologies, coordinated with and provided survey information to U.S. Coast Guard, Federal Emergency Management Agency (FEMA), and states, and disseminated information to inform the public and assist with debris removal. Side scan sonar has been used in detecting derelict crab and fishing traps in Juneau Bay, Alaska; Chesapeake Bay; Oregon; and North Carolina with excellent results.

Environmental Sensitivity Index Mapping – NOAA produces Environmental Sensitivity Index (ESI) maps of coastal resources at risk from spilled oil or other hazardous materials releases. ESI systematically compiles local information for coastal shoreline sensitivity, biological, and human-use resources. The maps identify sensitive resources before a spill occurs so that protection priorities can be established and cleanup strategies designed in advance.

Exploration

Ocean Exploration Program – NOAA explores the Earth's oceans for the purpose of discovery and the advancement of knowledge, using state-of-the-art technologies including multibeam mapping systems, autonomous underwater vehicles and remotely-operated vehicles. Ocean exploration core activities include global interdisciplinary exploration, systematic research, underwater technology, and education and outreach. Exploration projects leverage government and non-government resources to focus the best undersea assets and scientific minds on ocean exploration through mapping expeditions to unknown or poorly known ocean areas, features, and habitats. To establish ocean exploration priorities, NOAA relies on recommendations from its Exploration Advisory Group and proposals from the scientific community. The mapping NOAA supports is focused on unknown and poorly known areas, and the objective is to provide a foundation of information to support research and management.

Extended Continental Shelf Mapping – Since 2003, the U.S. has been engaged in gathering and analyzing data to determine the outer limits of its ECS, following criteria contained in Article 76 of the United Nations Convention on the Law of the Sea. Beginning in 2007, the effort to delimit the U.S. ECS became the Extended Continental Shelf Project, directed by the U.S. Extended Continental Shelf Task Force, an interagency coordinating body headed by the U.S. Department of State. Participants in this Task Force include: NOAA, USGS, Executive Office of the President, Joint Chiefs of Staff, U.S. Navy, U.S. Coast Guard, Department of Energy, National Science Foundation, Environmental Protection Agency, Minerals Management Service, and the Arctic Research Commission.

The process to determine the outer limits of our ECS requires the collection and analysis of data that describes the depth, shape, and geophysical characteristics of the seabed and sub-sea floor and thickness of the underlying sediments. This data includes bathymetry, seismic profiles, bottom cores, and magnetic and gravity data. NOAA leads the bathymetric data acquisition and processing activities of the Task Force, archives and manages all geophysical data and information, and provides leadership and support to the analysis of data required to determine the

extent of the ECS. To date, this multi-agency effort has mapped approximately 350,000 square nautical miles of seafloor in the Atlantic, Pacific, Gulf of Mexico, and Arctic.

Nautical Charting

Nautical Charting Program - NOAA is responsible for producing nautical charts (traditional paper charts, raster charts, and electronic navigational charts) for most of the Nation, with a suite of over 1,000 charts encompassing the U.S. coasts, Great Lakes, and territories. Nautical charts provide detailed information on water depth, natural features of the seabed, surface and sub-surface navigational hazards such as wrecks and obstructions, aids to navigation, information on tides and currents, and man-made structures such as harbors, buildings, and bridges, all of which are critical for the safe and efficient navigation of surface vessels. The nautical chart is a working document used to plan voyage transits and plot courses for navigators to follow. The coastal waters of the United States are in a constant state of change: channels are dredged and sometimes re-routed, new aids to navigation are established or removed, new wrecks and obstructions are discovered, natural shoaling occurs in many areas, and new berthing facilities are constructed in the Nation's ports and harbors. In order for all mariners to transit safely, it is imperative that these changes be reflected on NOAA's nautical charts as soon as practicable.

Hydrographic Survey Program – Hydrographic surveys support nautical charting, dredging, beach erosion and replenishment studies, coastal zone management, and offshore resource development. While surveys primarily measure and record water depth, they can also determine the nature of sea floor material. These determinations have implications for anchoring, dredging, pipeline and cable routing, and benthic habitat characterization. NOAA is the Nation's nautical chart maker, helping to ensure safe navigation in U.S. coastal waters and the EEZ.

Shoreline Mapping and Shoreline Change Analysis Program – NOAA's Coastal Mapping Program surveys coastal regions to provide the Nation with accurate, consistent, up-to-date shoreline. This national shoreline serves many purposes including nautical chart production, official U.S. boundary determination, and shoreline change analysis. NOAA's mapping activities are conducted using high resolution satellite imagery, aerial photography, and light detection and ranging (LIDAR) using both NOAA and contracted private sector assets. NOAA's Coast and Shoreline Change Analysis Program analyzes shoreline feature changes in the major 175 U.S. port cities by comparing recent high-resolution satellite imagery or aerial photography with existing NOAA raster and electronic nautical charts. Shoreline changes are noted and used to aid in updating nautical charts. Shoreline mapping priorities are driven by nautical chart production and national shoreline update schedules.

Mapping Support Infrastructure

National Spatial Reference System - The National Spatial Reference System (NSRS) is the consistent national coordinate system in use by Federal civil mapping agencies. It specifies latitude, longitude, a variety of heights, gravity, and scale/orientation relative to international reference frames. NOAA has the authority to define, maintain, and provide access to the NSRS. The NSRS consists of a variety of elements, including: a consistent, accurate, up-to-date National Shoreline; the Continuously Operating GPS Reference Stations (CORS) network; and a

model of the gravity field over the U.S. The CORS network is the primary method by which users access up-to-date coordinates, as each station collects GPS data continuously, is monitored for movement, and NOAA provides tools for accurate positioning within the United States relative to CORS. NOAA is embarking on the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project which will improve access to the vertical datum. The gravity-based vertical datum resulting from this project will improve surveying and mapping accuracies from current errors of 40 cm to 2 m, to an accuracy of 1-2 cm relative to the NSRS.

National Water Level Observation Network - The National Water Level Observation Network (NWLON) is a national network of water-level stations and data management infrastructure that serves as a water-level datum reference system for the Nation. It is the backbone of the Integrated Sustained Ocean Observing System. Managed by NOAA, NWLON is a network of 210 long-term, continuously operating water-level stations throughout the U.S. and its territories. It is the foundation for reference stations for NOAA's tide prediction products, and provides the controls in determining tidal datums for all short-term water-level stations. NWLON data and products support the NOAA Tsunami Warning System, hydrographic surveys, shoreline mapping, the NOAA Storm Surge Warning System, and the Physical Oceanographic Real-Time Systems (PORTS®). NWLON data is used in coastal planning, wetland monitoring, marsh restoration, storm surge modeling, evacuation route planning, emergency preparedness, and hazardous materials response.

National Current Observation Program – NOAA collects tidal current information at over 70 locations each year to provide the basis for predictions in the U.S. Tidal Current Tables. Tidal current data is used by spatial modelers to both run and validate their circulation models. Knowledge of currents is important for building coastal structures, determining the fate of oil spills, and determining larval transport.

CoastWatch Program – Two significant environmental events, a harmful algal bloom (HAB) off the coast of North Carolina and a severe mammal die-off of more than 700 bottlenose dolphins in the mid-Atlantic coast, prompted Federal and State officials to explore near real-time satellite data sources for monitoring the coastal waters. In 1987, NOAA CoastWatch was formed to provide access to multiple satellite remote sensing data and products, including ocean color, sea surface temperature, and surface winds. These products support a variety of ocean and coastal mapping efforts. Biologists utilize ocean color radiometry data as well as derived chlorophyll-a and total suspended matter/turbidity products to identify runoff plumes and blooms and also to predict HABs. Mariners use ocean surface vector winds to help ensure safe navigation.

Ship and Aircraft Operations – NOAA ships and aircraft, civilian crew, and commissioned NOAA Corps officers support ocean and coastal mapping programs including hydrographic surveying in support of nautical charting, EFH mapping, ocean exploration, tsunami and storm-surge inundation modeling, and shoreline mapping. The platforms and mapping sensors enable NOAA to maintain government expertise in the knowledge, skills, and abilities necessary to both conduct and evaluate the performance of ocean and coastal mapping functional elements such as installation and operation of water level equipment, horizontal positioning, and improvements in data acquisition and processing methods.

Ocean and Coastal Mapping Contracting – The NOAA Ocean and Coastal Mapping Contracting Policy was promulgated in December 2009 and describes a strategy for expanding contracting with non-governmental entities in order to take advantage of private-sector mapping capabilities. NOAA recognizes that qualified commercial sources can provide competent, professional and cost-effective mapping services and expertise to NOAA in support of its diverse mapping missions. In the interest of public and environmental safety and the furtherance of scientific knowledge, NOAA's responsibility for executing its ocean and coastal mapping missions is manifest and non-delegable, and it is incumbent upon NOAA to maintain operational mapping core capabilities. Subject to appropriations, NOAA supplements its operational capacity by contracting for ocean and coastal mapping services when such contracts are determined to be a cost-effective method of obtaining these services.

2. Establishing Mapping Priorities and Partnerships:
"…establish priority mapping programs … across all missions of [NOAA]…"

Pursuant to various statutory mandates, NOAA has the authority and responsibility to establish national priorities and promote multi-sector management of coastal resources at local, state, regional and national scales. NOAA's unique responsibilities and management mandates include:

1. Nautical charting and related hydrographic and geospatial services for safe and efficient marine commerce
2. Stewardship and protection of trust resources
3. Systematic observation and monitoring
4. Protection and restoration of critical coastal and marine habitats
5. Mitigation of impacts of coastal hazards on life and property
6. Research to address priority issues
7. Delivery of and decision-maker access to relevant science, tools, products, and services to manage multiple and often competing ocean and coastal resource uses.

NOAA and other Federal and State agencies historically have established individual mapping priorities and data acquisition plans based in large part on their specific mandates, responsibilities, available technologies, and resource levels. In 2004, a National Research Council (NRC) report, *A Geospatial Framework for the Coastal Zone – National Needs for Coastal Mapping and Charting*, concluded that

> "any activity that involves multiple Federal, State, and local agencies, academic researchers, and the private sector has the potential for redundancy and overlap of effort…In the areas of coastal zone mapping and charting, the large number of agencies involved, their differing histories, the breadth of their mandates, and the complexity of the task offer ample opportunities for redundancy and inefficiency."

Although the individual program and agency approach to establishing mapping priorities remains largely in place today, NOAA has made considerable progress over the past several years to coordinate mapping activities with those of other Federal, State, and regional interests. Ensuring

that all relevant agencies are aware of existing data through accurate web-map inventories and of each other's planned data acquisition activities is an important aspect of improved coordination.

Intra- and interagency coordination takes place through the efforts of the NOAA IOCM Coordination Team (see Section 6) and the Joint Subcommittee on Ocean Science and Technology Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM), which NOAA co-chairs with USGS and the U.S. Army Corps of Engineers (USACE). In partnership with the Federal Geographic Data Committee's (FGDC) Geospatial One-Stop (GOS), a geo-portal that provides public access to geospatial information, the IWG-OCM has made great strides in increasing the registration of ocean and coastal mapping metadata that facilitates the discovery of available data, thus preventing additional resources from being expended to acquire data that is readily available. The IWG-OCM has made considerable progress in increasing the number of federally-funded data acquisition activities (ongoing, planned, and proposed) registered in the GOS Marketplace. The Marketplace was developed to serve as a national focal point for coordination of geospatial data collection.

The development of partnerships and the leveraging of Federal, State and non-governmental mapping resources are imperative to meeting the ocean and coastal geospatial data needs of the Nation. Appendix 2 describes several mapping partnerships that are addressing multiple Federal, State, and regional needs.

The Act requires Federal mapping agencies, in coordination with affected coastal states, to establish a program to develop a National ocean and coastal mapping plan for the Great Lakes and coastal state waters, the territorial sea, the EEZ, and the continental shelf of the U.S (Section 12202 of the Act). This plan will require considerable cooperation among Federal agencies, coastal states, regional ocean governance councils, and other mapping interests. As a first step in developing this plan, representatives of these groups met for a three-day NOAA-sponsored National Ocean and Coastal Mapping Plan workshop in November 2009. Participants agreed on the priority National themes that will benefit from an integrated approach to mapping, and identified and validated requirements the will benefit from an integrated mapping plan.

3. Cooperative Technological Research and Development Activities:

"…encourage the development of innovative ocean and coastal mapping technologies and applications …"

NOAA has benefited greatly from research and development partnerships with Federal agencies, universities, and non-governmental organizations. To fill identified gaps in its ocean and coastal mapping capabilities, NOAA will continue to explore opportunities to establish additional partnerships.

Existing research and development partnerships:

NOAA-University of New Hampshire Joint Hydrographic Center – The academic partnership concept of the Center for Coastal and Ocean Mapping/Joint Hydrographic Center (JHC) offers a valuable mechanism for effective, albeit indirect NOAA liaison with private industry. The

university partner is able to enter into agreements with industry to collaborate on research and development, to use the latest industry-provided equipment and software, and to license commercial application of new technological developments. These partnerships ensure that the private sector ocean mapping community is contributing to, as well as benefiting from, new technology developed through JHC.

Joint Airborne LIDAR Bathymetry Technical Center of Expertise – The Joint Airborne LIDAR Bathymetry Technical Center of Expertise (JALBTCX) conducts operations, research, and development in airborne LIDAR bathymetry and complementary technologies. These activities support the coastal mapping and charting requirements of the USACE, the U.S. Naval Meteorology and Oceanography Command, and NOAA. JALBTCX staff includes engineers, scientists, hydrographers, and technicians from all three organizations. JALBTCX research and development supports and leverages work in government, industry, and academia to advance airborne LIDAR for coastal mapping and charting technology and applications.

Cooperative Institute for Ocean Exploration, Research, and Technology – The Cooperative Institute for Ocean Exploration, Research, and Technology (CIOERT) is a consortium led by the Harbor Branch Oceanographic Institute at Florida Atlantic University. The University of North Carolina-Wilmington is the co-managing partner. Limited partners are SRI International and the University of Miami. NOAA's Office of Ocean Exploration and Research is CIOERT's primary NOAA partner. CIOERT conducts research and activities under four main themes: 1) development of advanced underwater technologies, 2) exploration and research of frontier regions of the eastern continental shelf and beyond, 3) improved understanding of deep- and shallow-water coral, and 4) outreach and education.

NOAA-Navy Unmanned Surface Vehicle Development – NOAA, in partnership with the Naval Surface Warfare Center (NSWC), is exploring the feasibility of developing unmanned surface vehicles (USVs) to support hydrographic survey and other seafloor mapping operations. This is an important component of NOAA's goal to further develop technology and the operational capabilities of USVs and use them as a "force multiplier" for acquiring hydrographic data. NOAA is developing a USV concept of operations (CONOPS) and detailed technical requirement for integrating USVs into NOAA's existing hydrographic survey operations. Once the CONOPS and technical requirements are developed, NOAA, through an agreement with NSWC, will develop and demonstrate a prototype USV system based on the proposed CONOPS and technical requirements. NSWC's extensive experience with USV technology development and design and NOAA's expertise in hydrographic data acquisition lend themselves to this cooperative partnership.

In addition to facilitating the innovation at cooperative and joint research institutes, NOAA has a vibrant internal research and innovation capability. Examples of technologies and applications being developed by NOAA mapping programs are described in Appendix 3.

4. Best Practices in Data Acquisition Standards, Processing and Delivery:
"Document available and developing technologies, best practices in data processing and distribution …"

The 2004 NRC report, *A Geospatial Framework for the Coastal Zone,* recommended that all thematic and other value-added products adhere to predetermined standards to make them universally accessible and transferable, and that all sources should supply digital data accompanied by appropriate metadata. An aspect of this recommendation requires the development of minimum data acquisition and metadata standards to ensure that data acquired in support of particular requirement can be used to support a range of additional requirements.

Data Standards - Interagency efforts are underway to develop common specifications for airborne coastal mapping and charting data. A multi-year NOAA-led effort to develop a national habitat classification standard is progressing. New efforts will be required to develop common acoustic bathymetry data specifications that will ensure that bathymetry data acquired by one program or agency can be used to support a multiple of Federal, State and regional applications.

Common Specifications for Airborne Coastal Mapping and Charting Data – Federal agencies are building consensus on and agreeing to use a set of common LIDAR specifications for coastal mapping. NOAA and its partners at JALBTCX hosted a pair of summits: one was organized for the five Federal agencies with mandates for coastal mapping and charting (USACE, USGS, FEMA, NOAA, and Navy), and the other included members of academia and the private sector with a focus on application-driven requirements for coastal LIDAR mapping. These summits allowed agencies to understand their counterpart's requirements, identify areas for developing common survey specifications, and build consensus on priorities.

Habitat Classification Standard – An essential companion to habitat mapping efforts is a classification standard that faithfully describes the nature of biological and geological features. Utilizing commonly understood and accepted terms to delineate "what's out there" is a prerequisite for coastal and ocean governance activities such as planning for climate change, dealing with hazards, and sustainably managing coastal and ocean resources. Over the past decade, NOAA has worked with individual scientists and managers from a host of Federal, State and regional agencies, academia, industry, and non-governmental organizations to develop and test the Coastal and Marine Ecological Classification Standard (CMECS). In 2008, CMECS was submitted to the FGDC as a candidate national standard for classifying coastal and marine ecosystems. In 2010, a revised version will undergo internal FGDC technical review in preparation for the standard's release for public comment.

Data Acquisition and Metadata Standards – Through the IOCM efforts, NOAA initiated a review of its marine data acquisition procedures. NOAA is evaluating the Ocean Exploration Program's data acquisition and on-board data description model for potential fleet-wide application. NOAA is also developing and identifying metadata best practices including the applications of consistent vocabularies for a variety of marine data. NOAA is the national archive and integration center for marine geophysical data. In support of the interagency U.S. Extended Continental Shelf project, NOAA, in partnership with the USGS, the Minerals Management Service, and the University-National Oceanographic Laboratory System (UNOLS),

developed common metadata templates for cruise-level, seismic, and bathymetric data description. NOAA will continue to develop common templates in order to improve the discovery, sharing, and use of geophysical data collected at sea.

Ensuring the Preservation of Data – To ensure stewardship and access to marine geophysical data, NOAA is laying the foundation for an enterprise-wide "rolling deck to repository" (R2R) data system to transfer data from the ships to the NOAA Data Centers, via the IOCM Data Processing Center, for eventual long-term archive and distribution. This secure process is similar to the R2R system recently approved by the National Science Foundation for the UNOLS fleet. NOAA's National Geophysical Data Center and National Oceanographic Data Center are two of the final repositories for the NOAA and the UNOLS R2R data.

Inventory of Ocean and Coastal Data – The NOAA Data Centers, through standards-based web services built on robust archives, support dynamic integrated inventories of ocean and coastal mapping data, providing information on the location, date, type, and source of data as well as access to the data. These inventories can be augmented with additional data sources and incorporated into management tools to improve prioritization of areas requiring surveys. NOAA is leading one such effort for the Hawaiian Islands and will incorporate dynamic archive-based inventories in the Northern Gulf of Mexico pilot-mapping project.

Integrated Digital Maps of the Ocean and Coast – Dynamic inventories of existing and planned surveys also improve planning and development of integrated digital elevation models (DEMs) of the U.S. coastal regions. These DEMs are a common base-layer for many integrated mapping activities and requirements for better resolution continue to emerge to support planning for sea level rise impacts and coastal and marine spatial planning. NOAA, working through the NOAA Tsunami Program, the National Tsunami Hazard Mitigation Program, and other programs, is improving digital relief maps at regional (U.S. territorial waters) and higher-resolution community scales. NOAA will complete more than ninety 10-meter resolution coastal DEMs, covering numerous communities, by the end of 2012. In addition, NOAA will have four regional-scale coastal DEMs (covering areas in southern Alaska, southern California and the Gulf of Mexico) completed by the end of 2010. Supporting broad access to these digital ocean and coastal maps, NOAA and Google signed a Cooperative Research and Development Agreement (CRADA) in 2009, to create visual images for scholars and for the public. As a part of this CRADA, NOAA will deliver its digital elevation models through a common portal, and is working with Google to develop and test delivery mechanisms. NOAA is building this capability on top of an existing multi-agency ocean and coastal DEM web portal.

Products Resulting From Improved Coordination – As a result of coordination and *American Recovery and Reinvestment* Act (ARRA) funding in 2009, NOAA acquired additional hydrographic data and generated new products from existing data, supporting uses beyond navigation and charting. One beneficiary is a multi-agency habitat assessment and risk reduction effort in Louisiana. By coordinating efforts and requirements, NOAA rapidly delivered products and services that significantly improved the storm surge modeling for the eastern Gulf of Mexico, including New Orleans. These products also supported sea-level rise studies, habitat restoration, and tsunami inundation efforts underway in the region.

Digital Coast - A best practice in product delivery, the Digital Coast is a constituent-driven delivery mechanism of geospatial data, tools, training, and information for the coastal resource management community. The Digital Coast supports both highly technical and management level audiences through an integrated approach, allowing users to download data and also see and learn how the data are used in analysis tools and in decision-making across the country. National organizations such as the Association of State Floodplain Managers, Coastal States Organization, National Association of Counties, National States Geographic Information Council, and The Nature Conservancy provide guidance on effective web delivery, contribute content, conduct outreach to their memberships, and track return on investment outcomes. This customer engagement approach is a best practice that ensures success.

New Approaches to Ocean Mapping Data Processing - The research and development themes of the University of New Hampshire/NOAA JHC include the development of new approaches to ocean mapping data processing and to data visualization, presentation, and management. The Center's efforts have improved hydrographic and ocean mapping data processing efficiency and quality. The Combined Uncertainty and Bathymetry Estimation (CUBE) data processing algorithm, which reduces manual multibeam data processing time by orders of magnitude, has been incorporated into most commercial ocean mapping data processing software. Hydrographic organizations around the world have also adopted the algorithm. Similarly, the GEOCODER seafloor backscatter processing technology has been commercialized in multiple software packages and is now widely used to produce seafloor character maps. Ongoing development is aimed at achieving additional improvements in NOAA's ability to derive multiple mapping products from its ocean mapping data and its ability to disseminate IOCM data to a wider variety of end users.

This approach to data processing is critical to NOAA's IOCM efforts as well as to coastal and marine spatial planning and ecosystems-based management. The NOAA IOCM effort has the potential to provide a solid base for acquiring and delivering geospatial data to support integrated management approaches and efficient use and re-use of data. With a successful IOCM program, the Nation will realize the full benefits of the substantial data collection investment made at Federal, State, university, and local levels.

5. Training, Technology, and Other Critical Resources:

"…identify training, technology, and other resource requirements … to support a coordinated ocean and coastal mapping program"

With intra- and interagency planning and coordination, overlapping agency mission requirements can be better integrated, prioritized, and managed in order to maximize the Federal investments in ocean and coastal mapping. Many Federal, State and private-sector customers rely on coastal, seafloor, and water column mapping data, and demand for this data is growing exponentially. Resourcing the *Ocean and Coastal Mapping Integration Act's* mandates will allow NOAA to execute the needed coordination, provide the necessary technical support, reduce the potential for duplication of effort, ensure easy access to accurate and real-time data, and directly target currently unrealized efficiencies.

Training - One of the primary challenges with IOCM is the shortage of trained personnel to support data acquisition and processing, particularly in programs other than nautical charting and hydrography. An IOCM training center, co-located with JHC, would provide a much-needed mechanism for training NOAA and other agency staff on the theory and operation of advanced seafloor and water column mapping sensors. The addition to the NOAA fleet of new fisheries survey vessels equipped with state-of-the-art multibeam mapping systems requires that shipboard personnel be trained in survey planning, at-sea data acquisition and processing practices, and post-processing techniques in order to fully realize the maximum benefits from these systems. Training in consistent data acquisition, processing, and data/metadata management practices is critical in order to utilize and generate useful and reliable products. The training center would work closely with NOAA's ocean and coastal mapping programs to ensure delivery of generalized ocean and coastal mapping skills and knowledge, as well as program-specific curricula. The center would also utilize NOAA metadata experts and trainers to facilitate a comprehensive training program.

While the objective of data acquisition, processing, and management training is to improve NOAA's in-house capabilities, training to support the end-users' application of this data is equally important. Expanded geospatial training is needed to enable the ocean and coastal decision makers to integrate new data into their decision-support tools.

Technology – Ocean and coastal mapping technologies continue to evolve, enabling acquisition of more high-resolution data describing the coast, seafloor, and water column. These advancing technologies can provide an initial data management challenge but also offer the potential to better enable accurate and automated data descriptions. NOAA's Ocean Exploration Program is testing technology to automatically harvest information about data directly from the on-board observing systems, providing essential documentation to enable immediate and long-term use of the data. This effort is being tested on one of NOAA's newest and most technologically advanced ships, but has potential to be implemented fleet-wide given the ability to upgrade ship-board systems. If successful, this system could save many hours of manual labor and significantly improve the metadata. Also, NOAA's involvement in programs such as R2R and Integrated Ocean Observing Systems has further advanced capabilities for capturing and transporting sensor and platform characteristics and data processing and quality information along with the data. JHC continues to advance new technologies in data collection and data processing.

Autonomous underwater vehicles (AUV), which are unmanned, self-propelled marine vehicles that operate without any physical connections to a ship or operator, show significant promise for providing new survey and mapping capabilities. AUVs have been a part of NOAA's hydrographic survey technology development testing program since 2003. There is considerable potential in AUVs for hydrographic surveying and emergency response, as well as benthic habitat mapping and sea bottom characterization. NOAA has successfully demonstrated the use of an AUV equipped with side scan sonar to conduct operational surveys to detect submerged obstructions and hazards to navigation. In 2008, NOAA utilized AUVs to survey navigation channels in Galveston Bay in the aftermath of Hurricane Ike, rapidly verifying that the waterways were free of obstructions prior to the Coast Guard reopening them to commerce. NOAA has tested an AUV as a means to map underwater unexploded ordnance and munitions

debris in support of coastal restoration efforts. In 2010, NOAA will take delivery of a bathymetric mapping AUV equipped with multibeam sonar and will evaluate if AUV-based depth measurements can meet stringent nautical charting standards. However, much is still needed to successfully transition AUVs to a fully operational technology, including safe and efficient launch and recovery systems aboard NOAA ships and small craft, training, and a support infrastructure.

Data Management Infrastructure - NOAA currently lacks aspects of the data and data management foundation needed to ensure long-term access to mapping data and products. Key among these are expanded capacity to integrate and deliver data via common or standard formats, build and sustain integrated dynamic inventories of ocean and coastal mapping data, and improve or implement rigorous metadata for archive data. Under current capabilities, significant data collection investments are at risk due to lack of archive or are processed for single purpose use only.

However, using one-time ARRA funding, NOAA began addressing foundation gaps in the critical data and data management capability in 2010. Additional data acquisition, processing of data for non-hydrographic uses and increased data center capacity for storage and delivery are among the benefits of the ARRA funding. Additional resources are required to ensure all data are collected by trained experts, processed to appropriate standards, described to enable long-term understanding, and archived and delivered in a secure and integrated environment that supports easy access and planning.

Data acquisition – There are significant, documented, yet unmet, national ocean and coastal mapping data requirements. These requirements range from high-resolution LIDAR topography and shallow-water bathymetry – both of which are needed for sea level rise mapping and improved storm surge modeling – to seafloor habitat mapping for EFH analyses, coral reef mapping, and coastal and marine spatial planning. Since no single Federal agency's resources can meet these needs, a coordinated national ocean and coastal mapping program is required.

Addressing challenges such as those described in the text above will improve the efficiency and cost-effectiveness of NOAA's mapping efforts; however, a significant need remains for more extensive program-related, fundamental mapping activities required to carry out NOAA missions. The need for basic data collection far exceeds that which can be accomplished using savings associated with greater operational coordination and more efficient processing, interpretation, and distribution of collected information. In order for NOAA's mapping programs to meet present and future mandates, resources for basic mapping, coordination, and infrastructure all must be addressed.

6. Centralized Coordination of Data Acquisition and Management:
"…identify a centralized mechanism or office for coordinating data collection, processing, archiving, and dissemination…"

NOAA has a coordination team to implement IOCM. In addition to this team, NOAA has established data processing, archival, and dissemination processes and centers to ensure

maximum use of NOAA data assets. As part of the process to improve collection and management of mapping data, NOAA initiated a new fleet directive defining the roles and responsibilities under the R2R data system for all non-nautical charting survey vessels (charting vessels already adhere to R2R principles). Implementing this new directive, along with existing NOAA Administrative Orders describing collection and management of geospatial data, will significantly strengthen NOAA's capability to coordinate, process, preserve, and disseminate ocean and coastal mapping data. The approaches to improved coordination and re-use of data are described below in greater detail.

NOAA IOCM Coordination Team – The key to coordinating NOAA's diverse ocean and coastal mapping activities, including data acquisition, processing, archiving and dissemination, is a robust dialogue between NOAA mapping programs and external stakeholders. To facilitate internal coordination activities, NOAA established the NOAA IOCM Coordination Team under the governance of the NOAA Ocean Council (NOC). The NOC established the Team to promote an integrated approach to ocean and coastal mapping, to facilitate communications and coordination within NOAA's diverse mapping community, and to develop IOCM-related policies for review and endorsement by the NOC. NOAA offices and programs that participate on the Team are:

National Ocean Service
- Office of Coast Survey
- Center for Operational Oceanographic Products and Services
- National Geodetic Survey
- Center for Coastal and Ocean Mapping/Joint Hydrographic Center
- National Centers for Coastal and Ocean Science
- Office of National Marine Sanctuaries
- Office of Ocean and Coastal Resource Management
- Office of Response and Restoration
- Coastal Services Center
- Special Projects Office
- Coral Reef Conservation Program
- Marine Debris Program
- Integrated Ocean Observing System Program

National Marine Fisheries Service
- Office of Science and Technology
- Office of Habitat Conservation

Office of Oceanic and Atmospheric Research
- Office of Ocean Exploration and Research
- Climate Program

National Environmental Satellite, Data, and Information Service
- National Geophysical Data Center
- National Oceanographic Data Center/National Coastal Data Development Center

NOAA Office of Marine and Aviation Operations

National Weather Service
- Tsunami Program

NOAA IOCM Data Management – Essential aspects of the NOAA IOCM program include establishing an IOCM Data Processing Center and developing a 21st century data management infrastructure. Modern data management supports dynamic inventories of existing data, ensures effective long-term stewardship, enables coordinated planning, and delivers data and products for multiple requirements.

IOCM Data Processing Center **–** As envisioned by the IOCM Data Processing Center concept of operations, seafloor and water column mapping data acquired by NOAA, other Federal and State agencies and academic institutions would be sent to the data processing center. The Center would be co-located with the NOAA/University of New Hampshire JHC. It will develop and maintain IOCM standards, specifications, and metadata standards for mapping data. It will utilize JHC's strengths to develop new technology and techniques for improved data processing and analysis. The Center would accept mapping data from a variety of sources; manage this data with advanced data systems; and produce quality-assured products that support both navigation and non-navigation uses. The data would be archived and distributed by NOAA's Data Centers.

NOAA Data Centers – NOAA has three National Data Centers and several centers of scientific data expertise. The primary ocean and coastal data centers are the National Oceanographic Data Center (responsible for data describing the water column), and the National Geophysical Data Center (responsible for data describing the physical shape and composition of the seafloor and lakebeds). Processed data and products would go from the IOCM Data Processing Center to the appropriate national repository for long-term archive and distribution. Centralizing archive and distribution through the data centers takes advantage of the investment in archive infrastructure and ensures complete inventories of NOAA ocean and coastal mapping data for planning purposes. Importantly, it would provide the broader research and resource management communities with greater public access to data that would otherwise be lost.

The aforementioned activities are initial examples of the potential benefits that can be realized with an adequately resourced and functional NOAA IOCM program. Strengthened IOCM coordination, investments in data acquisition, product development, management, and delivery will yield overall cost savings as the benefits of "map once, use many times" are realized. Essential next steps include a fully staffed IOCM Data Processing Center; data centers able to ingest, archive, and deliver data and products based on common web services and standards; and development of tools to support planning, research, and management.

7. Implementing the NOAA Integrated Ocean and Coastal Mapping Initiative: "…set forth a timetable for implementation and completion of the plan…"

Resourcing the *Ocean and Coastal Mapping Act's* mandates will enable NOAA to execute the actions needed to enhance integration and move to a more fully coordinated environment of ocean and coastal mapping programs. While the timeframe may change depending on available resources, NOAA is committed to the following actions:

Action	< 2Years	2-5 Years	> 5 Years
Planning and Coordination:			
1. Conduct annual NOAA OCM planning and coordination workshops.	✓	✓	✓
2. In partnership with the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM), conduct annual interagency OCM planning and coordination workshops.	✓	✓	✓
3. Develop integrated inventories of existing data.		✓	✓
4. With coastal states and regional ocean governance councils, conduct regional mapping requirements workshops to ensure the capture of Federal, State and regional requirements.	✓	✓	✓
5. With the IWG-OCM and the Federal Geographic Data Committee, improve the Geospatial One-Stop Marketplace tool, or equivalent, to allow more robust interagency coordination of data acquisition activities.	✓		
6. Develop standard operating procedures for documenting and providing for discovery of planned survey activities.	✓		
Data Acquisition:			
1. Define new standard operating procedures for NOAA Rolling Deck Repository (R2R).	✓		
2. Implement NOAA R2R.		✓	

3. Develop a plan for supporting the acquisition of shallow-water bathymetry	✓		
4. Complete the development of a common specification for airborne LIDAR coastal mapping and charting.	✓		
5. Develop or adopt a common specification for the acquisition of acoustic bathymetry.	✓		
Data Management:			
1. Identify and adopt standards and practices applicable to IOCM data.	✓	✓	✓
2. Develop consistent practices and guidance for applying metadata standards to ocean and coastal mapping data.	✓	✓	✓
3. Develop new technologies and techniques for improved data processing and analysis.	✓	✓	✓
4. Provide guidance and implement standard operating procedures for end-to-end data management.		✓	
Data Integration:			
1. Develop integrated web-map inventories of existing OCM data.	✓		
2. Develop or adopt common data delivery formats.		✓	
Data Dissemination:			
1. Increase capacity for "near-line" access to data.	✓	✓	
2. Improve discovery and delivery of data.	✓	✓	
3. Implement approved practices and standards for IOCM data and metadata.	✓	✓	

The Act calls for NOAA to provide a schedule for submission to the Congress of periodic progress reports on plan implementation. NOAA will provide these written reports on a biennial basis, with the first to be delivered by April 1, 2012.

Appendix 1

Omnibus Public Land Management Act of 2009 (P.L. 111-11)
Title XII, Subtitle B – *Ocean and Coastal Mapping Integration Act,* Section 12205: PLAN.

(a) IN GENERAL.—Not later than 6 months after the date of enactment of this Act, the Administrator, in consultation with the Committee, shall develop and submit to Congress a plan for an integrated ocean and coastal mapping initiative within the National Oceanic and Atmospheric Administration.

(b) PLAN REQUIREMENTS.—The plan shall—

(1) identify and describe all ocean and coastal mapping programs within the agency, including those that conduct mapping or related activities in the course of existing missions, such as hydrographic surveys, ocean exploration projects, living marine resource conservation and management programs, coastal zone management projects, and ocean and coastal observations and science projects;

(2) establish priority mapping programs and establish and periodically update priorities for geographic areas in surveying and mapping across all missions of the National Oceanic and Atmospheric Administration, as well as minimum data acquisition and metadata standards for those programs;

(3) encourage the development of innovative ocean and coastal mapping technologies and applications, through research and development through cooperative or other agreements with joint or cooperative research institutes or centers and with other non-governmental entities;

(4) document available and developing technologies, best practices in data processing and distribution, and leveraging opportunities with other Federal agencies, coastal states, and non-governmental entities;

(5) identify training, technology, and other resource requirements for enabling the National Oceanic and Atmospheric Administration's programs, vessels, and aircraft to support a coordinated ocean and coastal mapping program;

(6) identify a centralized mechanism or office for coordinating data collection, processing, archiving, and dissemination activities of all such mapping programs within the National Oceanic and Atmospheric Administration that meets Federal mandates for data accuracy and accessibility and designate a repository that is responsible for archiving and managing the distribution of all ocean and coastal mapping data to simplify the provision of services to benefit Federal and coastal state programs; and

(7) set forth a timetable for implementation and completion of the plan, including a schedule for submission to the Congress of periodic progress reports and recommendations for integrating approaches developed under the initiative into the interagency program.

Appendix 2 – Interagency Ocean and Coastal Mapping Partnerships

California Seafloor Mapping Project (CSMP) – NOAA, in partnership with the State of California, the USGS, and private sector contractors, entered into a multi-year partnership to develop the first comprehensive and seamless maps of California's seafloor and marine resources. The data acquired in support of this project are enhancing efforts to manage marine ecosystems and coastal resources, identify obstructions to navigation, and better understand the California coast's unique natural hazards. The California State Coastal Conservancy oversees CSMP in partnership with the California State University at Monterey Bay, Moss Landing Marine Laboratory, and California Geological Survey. The USGS is developing the geologic and habitat base maps for coastal decision makers.

NOAA's contributions to this project are diverse. A hydrographic services contract, managed by NOAA, supported the acquisition and processing of high-resolution bathymetry and acoustic backscatter data. The data, which meets nautical charting standards, has a wide variety of uses. In addition to updating NOAA nautical charts along the California coast, it supports the designation and monitoring of marine reserves and marine protected areas; improves management of marine fisheries; informs potential regulation of coastal development; adds to our understanding of sediment transport and coastal erosion; improves coastal circulation models; improves assessments of earthquake and tsunami hazards; and helps communities prepare for sea-level rise impacts. NOAA also acquired biological and geological data to verify seafloor mapping data. NOAA provided extensive data archiving and dissemination services for unparalleled volumes of bathymetry data. Bathymetry data will be incorporated with coastal elevation data to produce seamless digital elevations models of vulnerable coastal communities.

Gulf of Mexico Alliance – During the past six years, 13 Federal agencies have partnered with the five Gulf States to form the Gulf of Mexico Alliance. The Alliance identifies collaboration opportunities to enhance the ecological and economic health of the Gulf of Mexico (GOM) region. Early on, the Alliance identified and prioritized five issues, including the identification and characterization of habitats, which were regionally significant to the GOM. As part of Action Plan II, the Gulf of Mexico Alliance has established a Data Management Advisory Committee and is working to integrate a Gulf-wide data system to provide access to physical, chemical, and environmental data. The committee has established requirements for a regional data management platform and portal, and a format to streamline metadata.

The Alliance formed an Ecosystems Integration and Assessment Team to develop a data management and mapping initiative that will provide public access to interactive web based habitat maps. Working with states and other Federal mapping partners, the team inventoried and assessed sea grass data and maps in priority coastal, estuarine, near shore and off shore habitats. As part of Action Plan II, the team will produce the Gulf of Mexico Master Mapping Plan, a comprehensive plan to collaboratively acquire data on the physical characteristics of the Gulf region, particularly elevation, shoreline, and surface data. The Alliance mapping effort is improving coordination of State and Federal data collection and has produced a complete inventory of existing habitat data and a gap analysis. In addition, the team will generate an Emergent Wetlands Status and Trends Report with the requisite supporting maps.

NOAA/USACE Shoreline Mapping Collaboration – NOAA and the USACE are charged with delineating the Nation's shorelines on a recurring basis. These shoreline mapping data support the USACE regional sediment management, construction, operations, and regulatory functions in the coastal zone. Further, NOAA uses the data to update nautical charts, as a baseline for cadastral (boundary) applications in matters of private, State, and Federal property ownership, waterway responsibilities, and mineral rights. Using in-house and contract assets, NOAA annually maps between two and three percent of the U.S. shoreline. The partnership between NOAA and USACE, especially in regards to data acquisition and processing methodologies, benefits both organizations.

Appendix 3 – NOAA Ocean and Coastal Mapping Innovations

Vertical Datum Transformation (VDatum) Tool – NOAA developed a tool to improve processing and integration of elevation data at the coast. VDatum enables the transformation of elevation data (heights and depths) from one vertical datum to another. Such transformations are necessary when someone needs to combine or compare elevation data from diverse sources. Vertical datum is a "coordinate system" of geospatial data, with some specified "zero height" surface. If maps and charts are built from inconsistent data, artificial steps or discontinuities can appear. This problem is particularly acute in coastal areas where terrestrial datums (created for specifying heights on land) and water level datums (created for nautical charting) often overlap and disagree. Under such circumstances, on a gently sloping beach for instance, datum differences will change the depiction of the shoreline. In the case of gently sloping beach, it can shift the shoreline and change its slope on the map. The VDatum tool resolves these issues.

Tidal Constituent And Residual Interpolation (TCARI) – NOAA developed TCARI as a quick, accurate method of providing tidal corrections to bathymetry data. Tidal corrections are essential to the hydrographic survey process so that water depths presented on the chart are referenced on the same vertical datum. NOAA's tidal experts, hydrographers, and aerial coastal remote sensing experts developed an easy to use tool that determines appropriate corrections more quickly. This new tool not only improves the accuracy and spatial detail of the correctors, but also reduces the time required to produce them from months to weeks.

GPS Water Level Buoy – NOAA is partnering with the Naval Oceanographic Office to develop and validate the use of a GPS water level buoy for hydrographic surveying and VDatum validation in a variety of tidal conditions and locations. While the Navy and NOAA developed the technical and scientific requirements for the buoy, NOAA is setting the standards for rigorous testing and approval of the observations in a variety of environments.

Interactive Mapping and Visualization Tools – NOAA builds interactive mapping and visualization tools that provide on-line spatial data access and cartographic products related to coastal and marine spatial planning, climate change adaptation, and other coastal and ocean issues. These tools provide geospatial mapping and visualizations that enable users to see potential impacts of various management scenarios should they be applied. NOAA is using the latest visualization technologies to deliver its products and services more efficiently.

Gravity for the Redefinition of the American Vertical Datum (GRAV-D) – One of the upcoming major improvements to the NSRS is vertical datum accessibility. New methods of accessing accurate heights will be provided. The cornerstone of this improvement is a new model of the gravimetric geoid, part of the gravity field of the Earth. In order to facilitate this improvement, NOAA is embarking on the GRAV-D project. The gravity-based vertical datum resulting from this project will improve surveying and mapping accuracies to the 1-2 cm level relative to the NSRS. Data products resulting from this project include national and regional airborne and terrestrial survey information, gravity data, gravity-based models, geoids and datums. The completion of GRAV-D is one of the cornerstones of updating the International Great Lakes Datum (IGLD). To that end, several NOAA programs have partnered to update IGLD, provided new tools for its use, and tested the agreements between ocean circulation models and GRAV-D based geoid heights.