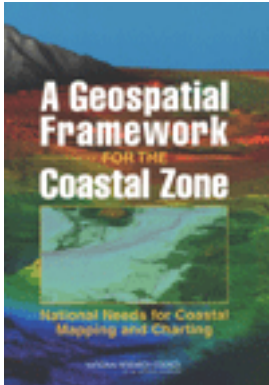


Free Executive Summary



A Geospatial Framework for the Coastal Zone: National Needs for Coastal Mapping and Charting

Committee on National Needs for Coastal Mapping and Charting, Mapping Science Committee, National Research Council

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The coastal zone is of enormous importance to the well-being of the nation, as our lives and economy are inextricably linked to the features and activities that occur within this dynamic region. In order to understand and address the effects of natural and anthropogenic forces in the coastal zone, a holistic multidisciplinary framework is required to account for the interconnectivity of processes within the system. The foundation of this framework is accurate geospatial information—information that is depicted on maps and charts.

A Geospatial Framework for the Coastal Zone National Needs identifies and suggests mechanisms for addressing national needs for spatial information in the coastal zone. It identifies high priority needs, evaluates the potential for meeting those needs based on the current level of effort, and suggests steps to increase collaboration and ensure that the nation's need for spatial information in the coastal zone is met in an efficient and timely manner.

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Executive Summary

The coastal zone is of enormous importance to the well-being of the nation, as our lives and economy are inextricably linked to the features and activities that occur within this dynamic region. Fourteen of the country's 20 largest urban corridors occur along the nation's coast; a major portion of the U.S. economic infrastructure is located near or on the ocean, and yet the coastal zone also encompasses forests, rivers and streams, wetlands, estuaries, beaches, barrier islands, and ocean habitats. The enormous importance of the economic, environmental, and recreational components of this complex area places tremendous demands and responsibilities on those charged with its management and maintenance. In order to understand and address the effects of natural and anthropogenic forces in the coastal zone, a holistic multidisciplinary framework is required to account for the interconnectivity of processes within the system. The foundation of this framework is accurate geospatial information—information that is depicted on maps and charts.

Science, education, commerce, planning, and resource management have relied for centuries on the availability of accurate maps. In coastal regions, high-quality maps are essential for safe navigation, resolving jurisdictional boundaries, understanding processes, mitigating hazards, tracking environmental changes, establishing inventories of resources and habitats, and developing new programs and policies. Historically, the fundamental geospatial data needed in the coastal zone have been captured and portrayed onshore as "maps" and offshore as "charts." Unfortunately, differences in scale, resolution, cartographic conventions and projections, and particularly reference datums currently inhibit the seamless combi-

nation of existing onshore and offshore data. The result is a lack of standardized, uniform geospatial products that span the coastal zone. This inability to produce a seamless map (or chart) across the land-water interface is a severe impediment to understanding the many processes that are continuous across the shoreline. The lack of standardization has also led government agencies, the research community, and the private sector to undertake the expensive and time-consuming task of separately generating new data and maps to accompany almost all new studies and initiatives. The lack of coordination of coastal zone mapping efforts inevitably leads to the potential for redundancy of surveys or products.

At least 15 federal agencies are involved in the primary collection or use of coastal geospatial data, often with responsibilities shared among multiple divisions within the same agency. In addition, a plethora of state and local agencies, academic institutions, and other organizations also gather and use coastal zone information. This has resulted in a chaotic collection of potentially overlapping, and often uncoordinated, coastal mapping and charting products that can frustrate the efforts of users to take advantage of existing datasets and build on past studies.

In response to this situation, and believing that an independent external evaluation could provide valuable new ideas, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the U.S. Environmental Protection Agency (EPA) requested that the National Academies undertake a study of national needs for coastal mapping and charting. The study committee was charged to identify and suggest mechanisms for addressing national needs for spatial information in the coastal zone, incorporating an analysis of the major spatial information requirements of federal agencies as well as the principal user groups they support. The committee was tasked to identify high-priority needs, evaluate the potential for meeting those needs based on the current level of effort, and suggest steps to increase collaboration and ensure that the nation's need for spatial information in the coastal zone is met in an efficient and timely manner.

In order to understand the needs and activities of the very large and diverse community involved with spatial information in the coastal zone, the committee and staff sought information and perspectives from agencies and individuals involved in numerous aspects of coastal zone mapping. Despite the complexities of the numerous issues raised by the many providers and users of coastal zone data, the consistency of needs and concerns raised permitted the committee to quickly converge on a vision for the future of coastal mapping and charting. This vision requires the development of an integrated and coordinated coastal mapping strategy for the nation, based on a foundation—a reference frame—upon which all data collection, analyses, and products can be built. To establish this foun-

dition, there must be a national effort to collect the information and develop the tools necessary to seamlessly blend topographic (onshore) and bathymetric (offshore) data. These data and tools will permit the establishment of a nationally coordinated digital database across the land-sea interface consisting of seamless elevation and depth data that can be referenced or transformed to common vertical and horizontal datums. This database will provide the basic geospatial framework for all subsequent data products, much like the USGS topographic sheet basemaps have formed the onshore foundation for a multitude of subsequent studies. Unlike the USGS topographic sheets, however, a coastal zone database must be “tide aware” and be able to reconcile the differences between onshore and offshore datums.

Our vision for the future of coastal zone mapping and charting also includes mechanisms to ensure communication among all the agencies and entities involved in order to minimize redundancy of efforts and maximize operational efficiencies. There will be national and perhaps international standards and protocols for data collection and metadata creation and readily available tools for data transformation and integration. With these tools the user community will be able to evaluate the accuracy and timeliness of data, change scales and projections, and seamlessly merge disparate datasets. The database and data integration tools will be easily accessible to all users, public and private, from a single digital portal accessible through the Internet.

This is a bold vision but at the same time an obvious one. Who would argue with a system that is efficient and produces easily accessible, fully interchangeable, accurate, and timely data? The vision may be simple to define, but its implementation will be anything but simple. The recommendations that follow are intended to address the root causes of the existing problems, help overcome the barriers to their solution, and begin to turn this vision into reality.

A SEAMLESS BATHYMETRIC/TOPOGRAPHIC DATASET FOR ALL U.S. COASTAL REGIONS

One of the most serious impediments to coastal zone management is the inability to produce accurate maps and charts so that objects and processes can be seamlessly tracked across the land-water interface. Differences between agency missions, onshore topographic versus offshore bathymetric mapping techniques, differing vertical reference frames, and the inherent difficulty of collecting source data in the surf and intertidal zones have combined to produce this fundamental incompatibility. It will be nearly impossible to properly understand processes, undertake planning, and establish boundaries in the coastal zone while two sets of

disparate and nonconvergent maps and charts are being separately maintained.

The barrier to the production of continuous integrated mapping products across the land-sea interface is the inherent difference in the horizontal and vertical reference surfaces (datums) and projections used for maps and charts. Horizontal datum and projection issues can be readily resolved with existing transformation tools, although these tools must be made more readily available to the user community. However, vertical datum issues present a serious challenge. In order to seamlessly combine offshore and onshore data, vertical datum transformation models must be developed. These models depend on the establishment and maintenance of a series of real-time tidal-measuring stations, the development of hydrodynamic models for coastal areas around the nation, and the development of protocols and tools for merging bathymetric and topographic datasets.

The Tampa Bay Bathy/Topo/Shoreline Demonstration Project, a collaborative effort between NOAA and the USGS, has developed a suite of such tools (called Vdatum) and has demonstrated the feasibility of generating a seamless bathymetric/topographic dataset for the Tampa Bay area. This project has also demonstrated both the inherent complexity of such an undertaking and the substantial benefits that arise from interagency collaboration and coordination.

Recommendation 1: In order to combine onshore and offshore data in a seamless geodetic framework, a national project to apply Vdatum tools should be initiated. This will involve the collection of real-time tide data and the development of more sophisticated hydrodynamic models for the entire U.S. coastline, as well as the establishment of protocols and tools for merging bathymetric and topographic datasets.

This dataset must be documented and disseminated in such a way that it can become the base for a wide range of applications, including the definition of local, regional, and national shorelines. As a result of this effort, it will be possible to merge data collected either on land or offshore into a common geodetic reference frame while at the same time allowing application-specific maps and charts to be generated that maintain traditional tidal-based datums (e.g., for navigational charts) or orthometrically based datums (e.g., for topographical maps).

SHORELINE DEFINITION PROTOCOLS

Numerous agencies have identified the lack of a consistently defined national shoreline as a major barrier to informed decision making in the

coastal zone. While a consistent shoreline is certainly desirable, many different definitions of the shoreline remain embedded in local, state, and federal laws, making it impractical to call for a single “National Shoreline.” Rather, the key to achieving a consistent shoreline is the seamless geodetic framework referred to in Recommendation 1. With a seamless bathymetric/topographic dataset across the land-water interface, appropriate difference or tidal models, and consistent horizontal and vertical reference frames, any shoreline definition can be transformed and integrated within the common framework. The Vdatum tool kit and associated Web sites will be the key to establishing internally consistent shorelines between and among disparate surveys and studies.

Recommendation 2: To achieve national consistency, all parties should define their shorelines in terms of a tidal datum, allowing vertical shifts to be calculated between and among the various shoreline definitions, while at the same time permitting different agencies and users to maintain their existing legal shoreline definitions. In situations where legislation or usage does not preclude it, the committee recommends that the internationally recognized shoreline established by NOAA’s National Geodetic Survey be adopted.

The committee encourages the Marine and Coastal Spatial Data Subcommittee of the Federal Geographic Data Committee (FGDC) to pursue implementation of this recommendation.

EASY ACCESS TO TIMELY DATA

Easy access to timely data is an essential component of effective coastal zone management. Many agencies have created Web sites that offer access to data in a variety of forms, as well as data manipulation tools. However, these sites still represent only a small percentage of existing coastal zone data.

Recommendation 3: A single Web portal should be established to facilitate access to all coastal mapping and charting data and derived products. The site should be well advertised within federal and state agencies, state and local governments, academic institutions, nongovernmental organizations and conservation groups, and to other potential users. The portal should work well with all Web browsers and on all computer platforms, to make it easily accessible to all users.

The single portal is not intended to host all coastal data. Rather, it should serve as a focal point that links to many distributed databases maintained by individual agencies or organizations. This site would

represent the one place where users, particularly new users, could begin their search for coastal data and derived products. A single, easily accessible data portal with appropriate data manipulation tools should also promote timely entry and retrieval of data. Coordination of such a site logically falls under the purview of the FGDC and is fully consistent with the Geospatial One-Stop concept.

DATA INTEGRATION, INTERCHANGEABILITY, AND ACCURACY

Providing easy access to data through a single Web portal is a critical starting point for addressing the needs of the coastal zone community. However, users must also be able to combine and integrate data collected by different agencies using a range of sensors and often based on different datums or projections. Users must also be able to assess the attributes and accuracy of the data provided. Integration of data and assessment of data quality are made possible by the establishment of data and metadata standards and the application of tools for data transformation.

Recommendation 4: All thematic data and other value-added products should adhere to predetermined standards to make them universally accessible and transferable through a central Web portal. All sources should supply digital data accompanied by appropriate metadata.

The FGDC is in the process of establishing a series of standards for the National Spatial Data Infrastructure (NSDI) that will be applicable to all coastal zone data. Unfortunately, implementation of the NSDI continues to be problematic for the coastal/marine community due to highly variable levels of commitment by different agencies and insufficient incentives to fully implement its principles. This may, in part, be due to structural and budgetary barriers, the inability of a single set of standards to serve all applications, and disconnects between those developing the standards and the user community. One approach to addressing this issue is for additional involvement of the private sector.

Recommendation 5: The private sector should be more involved in developing and applying data standards and products. Agency procurement requirements can be used to encourage the private sector to deliver needed products in a timely fashion.

The committee is aware of numerous examples where private-sector initiatives established well-accepted and easily used data protocols—in effect *de facto* standards—that significantly enhance the effectiveness of data products. The private sector is often capable of greater speed and efficiency in the adoption of standards and tools than its government

agency counterparts. Access to data, metadata, and data standards must be complemented by readily available tools to easily convert between and among different data formats, scales, and projections.

Recommendation 6: Government agencies and the private sector should continue to develop tool kits for coastal data transformation and integration. This will facilitate data analysis and the production of a range of value-added products. The tools should be accessible through the Web portal.

Documentation of the tools and techniques used to process data must also be provided to help the user community understand the limitations and appropriate uses of various datasets. A variety of training courses and workshops will be essential to provide end-users with the knowledge and tools necessary for intelligent application of the available data.

IMPROVED COORDINATION AND COLLABORATION

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. This is amplified when the activity requires expensive platforms, technologies, and sensors. In the area 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. Because data acquisition is unquestionably the most expensive aspect of coastal zone mapping, elimination of redundancy and overlap in this area is likely to yield large savings. Ensuring that all relevant agencies are aware of each other's activities will be an important first step toward improved coordination.

Recommendation 7: All federally funded coastal zone mapping and charting activities should be registered at a common, publicly available Web site. This combined registry should be accessible through the single Web portal for coastal zone information.

Each entry in the registry should include a description of the mapping activity, its location and purpose, the agency collecting the data, the tools to be used, the scales at which data will be collected, and other relevant details. Nonfederally funded agencies conducting coastal mapping activities should be encouraged to register their activities at the same site. A section of the registry should be dedicated to descriptions of planned but unfunded coastal mapping activities, as well as a "wish list" of coastal areas where surveying would be particularly helpful to state or local agencies. Technically, components of such registration may already

be required under Office of Management and Budget (OMB) Exhibit 300, but Recommendation 7 suggests a considerably expanded effort focused on making all federally funded coastal zone mapping efforts more widely known.

Once implemented, this registry could serve as the focal point for national coordination of geospatial data collection and analysis efforts. Individual agencies would continue to set their own priorities, but through the registry process, overlapping efforts could be quickly identified and avoided. The registry would also facilitate increased efficiency by highlighting opportunities for “incremental” surveys, where one agency takes advantage of the mapping activities of another agency in a region of common interest by providing a small amount of additional funding to achieve an additional objective. Such piggyback efforts would allow additional agencies to acquire data to meet their needs at minimal incremental cost.

Recommendation 8: To be effective, coordination should be carried out among all the primary agencies involved in coastal zone mapping, it should be mediated by a body that has the authority and means to monitor and ensure compliance, and it should involve people who are knowledgeable enough to identify the most critical issues.

Structurally, the FGDC appears to be an appropriate body to oversee such coordination, but many concerns remain about its effectiveness. Some restructuring of the FGDC, and perhaps an empowered Marine and Coastal Spatial Data Subcommittee, will be required to allay these concerns. In this light the committee endorses the recommendations of a recent design study team that calls for major structural and management changes for the FGDC (FGDC, 2000). A less appealing alternative might be either a new government office or an extragovernmental body charged with establishing oversight of all national coastal mapping and charting activities.

Recommendation 9: Whichever body is charged to carry out the needed coordination activities, dedicated staff personnel should be assigned to maintain the Web portal (Recommendation 3), the activities registry (Recommendation 7), and associated Web sites, and to proactively search for areas where efforts can be coordinated, supplemented, or combined to increase efficiency.

Specific areas where better coordination among federal agencies is urgently needed include high-resolution topographic and bathymetric data acquisition at the land-water interface, including aerial and satellite imagery, Light Detection and Ranging (LIDAR) surveys, bathymetric

surveys, seamless topographic/bathymetric Digital Elevation Models (DEMs)/Digital Depth Models (DDMs), and derived products for mapping shoreline change, habitat change, hazard vulnerability, and coastal erosion and inundation.

INCREASED DATA COLLECTION

There is a widespread need for more and better data to be collected in the coastal zone. The single most consistently cited need, among the agencies and the user community, is for enhanced bathymetric data, particularly in very shallow coastal waters. These data provide the basic geospatial framework for almost all other studies and are a key component for derived products such as offshore habitat maps.

Recommendation 10: The fundamental reference frame data for the entire coastal zone should be collected, processed, and made available. The dynamic nature of the coastal zone requires that there should be specific plans for repeat surveys over time. The important role of qualified private survey contractors in coastal zone mapping and charting should also be acknowledged. Much of the work done by this sector is contracted by government agencies, and accordingly the prioritization and tracking of surveys can be coordinated by the body called for in Recommendation 8.

Given the number of agencies and private-sector companies involved in coastal mapping and their disparate missions and budget directives, it is unrealistic to expect agreement on one unified and prioritized national mapping initiative. While each agency has responsibility for its own mapping priorities, a strong and enforceable mechanism for tracking and coordinating existing, ongoing, and planned mapping efforts (Recommendation 7) would increase efficiency to the point where considerably more survey work could be carried out for each dollar spent. Inconsistencies in scale and resolution for new data collection efforts could be resolved by the coastal zone coordinating body called for in Recommendation 8. After surveying agency needs, the coordinating body could determine whether the incremental value of collecting data over a larger area or in a slightly different form (e.g., at higher resolution) warrants modification of a planned surveying effort.

Severe challenges remain for those attempting to map the coastal zone. As well as the fundamental conceptual problem of reconciling terrestrial and tidal datums, there are also a number of logistical challenges, including shallow depths, waves, turbid waters, and longshore currents, all of which make it difficult to operate survey vessels and other equipment safely, accurately, and efficiently.

Recommendation 11: New remote sensing and in-situ technologies and techniques should be developed to help fill critical data gaps at the land-water interface.

There are a number of promising new technologies and techniques: integrated bathymetric/topographic LIDAR, multispectral, hyperspectral, and photographic imaging systems; sensors deployed on autonomous underwater vehicles; “opportunistic” mapping using volunteer recreational boats equipped with specialized mapping sensors approved by issuing agencies; autonomous bottom-crawling vehicles; improved satellite-imaging capabilities; and data fusion capabilities. Continued support from funding agencies for development of coastal remote sensing tools, combined with an increased emphasis on coastal needs, will greatly accelerate the development and implementation of these critically needed technologies. The private sector can play a major role in addressing this recommendation.

The recommendations and strategies outlined above call for the establishment of a consistent geospatial framework and the application of innovative new acquisition, integration, and data management technologies that should allow coastal zone scientists, engineers, and managers to efficiently produce easily accessible, fully interchangeable, accurate, timely, and useful geospatial data and mapping products that seamlessly extend across the coastal zone. The recommendations also suggest simple mechanisms to enhance collaboration and cooperation among those charged with acquiring data in this complex region. These mechanisms should facilitate efficiency gains that will allow most of the nation’s coastal zone to be mapped in a timely manner. While simple in concept, implementation of the suggested strategies will require a focused effort on the part of the coastal zone community. If implemented, however, the committee believes that a major step will have been taken toward assuring the long-term well-being of the coastal zone.

A Geospatial Framework for the Coastal Zone

National Needs for Coastal Mapping and Charting

Committee on National Needs for Coastal Mapping and Charting
Ocean Studies Board
Mapping Science Committee

Division of Earth and Life Studies

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Preface

While the academic community will long debate the relative roles of science and technology in fostering an understanding of the world around us, there can be little doubt that every so often there are concomitant technical developments that set the stage for a major leap in scientific understanding. This is indeed the case with respect to remote sensing, mapping, and data-handling technologies, where remarkable advances in the development of satellite-positioning systems, terrestrial and marine mapping sensors, and the digital manipulation of mapping data using geographic information systems have revolutionized our ability to collect, distribute, analyze, and visualize geospatial data. Along with these technological developments has come an evolution in our understanding of the fundamental importance of the coastal zone to the social, economic, and environmental well-being of the nation. With this increased understanding has also come a new appreciation for the complexity, sensitivity, and interconnectedness of the coastal zone system. This convergence of technology and scientific awareness heralds a new era of geospatial data handling and products that, for the first time, may allow us to address some of the key challenges faced by those charged with understanding and managing the coastal zone. Recognizing these technological advances, the critical importance of the coastal zone to the well-being of the nation, and the fundamental role that mapping and charting plays in understanding and managing the coastal zone, the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, and the U.S. Environmental Protection Agency asked the National

Academies to provide an independent assessment of national coastal zone mapping and charting activities and needs.

With at least 15 federal agencies, almost all coastal states, and innumerable local agencies, academic institutions, and private companies involved in coastal mapping and charting, this assessment has been a very large and difficult task. Through a series of information-gathering exercises and meetings, we attempted to understand the short- and long-term mapping needs of the coastal zone community and to determine how well current activities are meeting these needs. We explored roadblocks to generating the information needed in appropriate forms, and sought approaches for maximizing the efficiency of data collection and the value of data products. While we cannot be assured that we covered every need and activity, we are confident that we have addressed the major issues and hope that the recommendations we make will help establish an infrastructure for U.S. coastal zone mapping activities that will allow us to efficiently and effectively manage and preserve our wonderful coastal environments.

Larry Mayer
Chair

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

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