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Developed by the U.S. Geological Survey
at the Request of the U.S. Congress

A Plan for a Comprehensive National Coastal Program

U.S. Department of the Interior
U.S. Geological Survey

EXECUTIVE SUMMARY

ISSUES AND GOALS

The House Appropriations Committee (House Reports 106-646 and 107-103), recognizing the impacts of population growth along the Nation's coasts, directed the U.S. Geological Survey (USGS) ". . . to begin the process of developing a comprehensive multidisciplinary coastal program within the Survey." The Committee further instructed the USGS to ". . . develop a coastal pilot program within the Southeast Region with a research agenda designed to address the most critical issues facing this region" and to report how it would allocate resources ". . . among the growing list of coastal problems." This report describes a comprehensive National Coastal Program that responds to critical regional needs while addressing national issues associated with coastal change, including:

- Nutrient enrichment, oxygen depletion, harmful algal blooms, chemical contamination, diseases in marine organisms, and fish kills;

- Shoreline erosion, the increasing susceptibility of coastal communities to natural hazards and sea level rise, increasing demands on non-living resources (including groundwater, sand and gravel, and energy resources); and

- Declines in living marine resources, habitat loss, loss of biodiversity, and invasions of non-indigenous species.

These issues reflect the growing impact of human activities on coastal systems and the increasing vulnerability of expanding populations to coastal change. The interdependencies of these issues in complex coastal systems requires multidisciplinary and integrated science to provide the information and tools essential to:

- Sustain the environmental health of coastal communities and resources;

- Maintain and enhance the contribution of coastal systems to the Nation's economy and well-being; and

- Ensure the safety of coastal populations threatened by natural hazards and human-driven change.

The overall goal of this Program is to provide the scientific information, knowledge, and tools required to ensure that decisions about land and resource use, management practices, and future development in the coastal zone and adjacent watersheds can be evaluated with a complete understanding of the probable effects on coastal ecosystems and communities, and a full assessment of their vulnerability to natural and human-driven changes.

The Program plan contains, as recommended by Congress, ". . . goals and objectives consistent with the discussion of Future Program Emphasis contained in the recently released National Academy of Science (NAS) review of the Survey's Coastal and Marine Geology Program." In particular, it provides for a systems-science approach utilizing the multidisciplinary expertise of the USGS and its partners. As a broad natural science and information agency, the USGS is unique in its ability to ensure that geologic, geographic, biologic, and hydrologic research and information are effectively coordinated

and integrated. The USGS has a fundamental role, as a Federal agency, to ensure the standardization of information required for broad national application and to provide that information consistently across jurisdictional boundaries. Providing the science base needed by managers and policymakers requires efforts that are consistent across the wide range of spatial and temporal scales that characterize coastal variability. The USGS has a proven capacity to provide research and information that is integrated, consistent, and persistent over time.

House Report 106-646, Department of the Interior and Related Agencies Appropriations Bill, 2001

The Committee has provided an increase of $1,000,000 above the enacted level for the Coastal and Marine Geology program to begin the process of developing a comprehensive multi-disciplinary coastal program within the Survey. As population growth expands along U.S. coasts, coastal ecosystems are impacted by urban, industrial, and agricultural development. These impacts have resulted in the degradation of Everglades coastal wetlands and Florida Bay, coral die-off, hypoxia and fish kills in the Gulf of Mexico, and imperiled marine mammals and sea turtle populations to name a few. The Committee directs that the Survey develop a coastal pilot program beginning with the Southeast region with a research agenda designed to address the most critical issues facing this region. The Committee recommends that this work be conducted towards the goals and objectives consistent with the discussion of `Future Program Emphasis' contained in the recently released National Academy review of the Survey's Coastal and Marine Geology program. The Survey should report back to the Committee as soon as possible detailing how it would allocate these funds among the growing list of coastal problems. In addition, the Committee also directs the Survey to develop a comprehensive national coastal program as part of the fiscal year 2002 budget.

House Report 107-103, Department of the Interior and Related Agencies Appropriations Bill, 2002

The Committee reiterates its position relative to the need to enhance and expand the Survey's Coastal and Marine Geology program, and therefore has provided an increase of $1,000,000 above the enacted level for the Coastal and Marine Geology program to continue the process of developing a comprehensive multi-disciplinary coastal program within the Survey. The Committee directs the Survey to continue in the development of a coastal program beginning with the Southeast region with a research agenda designed to address the most critical issues facing this region. The Committee recommends that this work be conducted with goals and objectives consistent with the discussion of `Future Program Emphasis' contained in the National Academy review of the Survey's Coastal and Marine Geology program. The Committee further directs the Survey to develop a comprehensive national coastal program as part of the fiscal year 2003 budget request.

PROGRAM STRATEGY

Developing effective solutions to coastal problems requires a thorough understanding of coastal settings and processes. The USGS, as the Nation's principal natural science and information agency and provider of science information for the U.S. Department of the Interior and other Federal agencies, is uniquely suited to address coastal problems that require:

- A comprehensive characterization of the geologic, hydrologic, biologic, geographic, and human elements that define coastal systems and drive coastal change.

- Long-term research and monitoring to document and understand natural and human-driven coastal change on the important time scales encompassing climate change; changes in human development, land use and influence; and sudden and extreme events.

- Regional 'system-scale' studies to provide an appropriate context for understanding coastal change across the linked elements of coastal systems and for evaluating local problems and solutions.

- Fundamental studies of coastal processes and the response of complex systems leading to improved predictive capabilities.

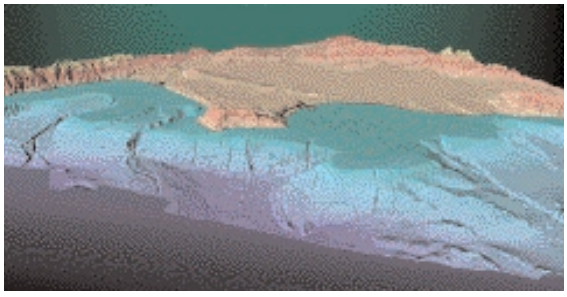


FIGURE 1: Perspective view looking northeast from the Pacific Ocean Angeles and Palos Verdes, California. The view was constructed from mapping data collected in 1996, 1998, and 1999 by the USGS and its greater Los Angeles area is home to more than 10 million people, wh the adjacent offshore continental shelf and margin with activities suc disposal for dredged spoils, explosive disposal, wastewater discharge fishing that must be balanced against the demand for clean water, he and recreational uses. The data collected in 1996-1999 have been us first highly accurate maps of the continental shelf and slope to serve multidisciplinary research on the coastal environment.

The USGS has an unmatched capacity to integrate research and information across the scientific disciplines to address interdependent issues, to provide the regional context required to develop and assess local solutions and national priorities, and to maintain long-term research and monitoring efforts needed to identify and respond to critical and emerging issues. USGS efforts in South Florida, San Francisco Bay, Chesapeake Bay, and Tampa Bay have proven the value and impact of integrated system studies. The USGS alone has the ability to ensure that wise stewardship and development is based on sound scientific understanding of sufficient scope, scale, and breadth.

The proposed National Coastal Program will apply the multidisciplinary capabilities of the USGS to increase our understanding of coastal problems that are national in scope and to develop predictive capabilities needed to wisely manage and utilize the Nation's coasts. New and expanded efforts will build on the rich history of USGS programs providing the science foundation to address national issues within and beyond the coastal zone. Every region in the Nation suffers problems related to coastal erosion, climate change, and the increasing impacts of human development, land use, and alteration of natural systems. The proposed Program strategy is intended to provide the basic understanding of coastal systems required to address coastal issues broadly, while focusing on those issues and processes which are critical within specific coastal regions and systems. An effective program will provide science-based tools responsive to specific management needs while making needed information and understanding broadly available. To meet this challenge, the USGS proposes development of an integrated coastal program that effectively applies the breadth of USGS expertise towards the

objective of providing national and regional capabilities to characterize coastal systems and to measure, analyze, understand, and forecast coastal changes (natural and anthropogenic) that affect coastal economies, resource availability, recreational quality, and the integrity and sustainability of the Nation's coastal ecosystems.

The USGS will meet this objective through complementary and linked activities that include:

- Mapping, inventory, and monitoring to provide the essential characterization of coastal systems and documentation of change required to identify current and developing issues, support informed decisionmaking, and develop and validate predictive models of coastal change; and

- Research to provide the understanding of natural and human processes and coastal change required to develop predictive models and science-based management tools.

Coordinated mapping, inventory, monitoring, and research efforts will lead to:

- Consistent and comprehensive information resources providing access to information critical to coastal managers, policymakers, and researchers;

- Integrated assessments at national and regional scales of coastal character, vulnerability, and change for the development and assessment of policy and management decisions; and

- Predictive systems-scale models and decision-support tools to identify future stresses and design effective programs for the protection and restoration of coastal resources.

These products will provide coastal managers and policymakers the information, understanding, and tools required to ensure the environmental health of coastal communities and resources is sustained, the contribution of coastal systems to the Nation's economy is maintained and enhanced, and the safety of coastal populations is assured.

Program implementation to achieve these outcomes will include expansion of existing USGS efforts through five Centerpiece Activities (see final section for Timelines).

1) Establish a National Coastal Information Infrastructure to provide consistent and reliable information to support research and decisionmaking;

2) Establish an integrated monitoring network to document and understand change in complex coastal systems across all important time scales;

3) Expand and coordinate efforts to provide the environmental characterization essential to understanding, modeling, and managing all coastal systems;

4) Expand process studies to provide the science foundation for the development of broadly applicable tools and models; and

5) Expand regional 'system-scale' studies to integrate research and the Centerpiece Activities to address critical regional issues.

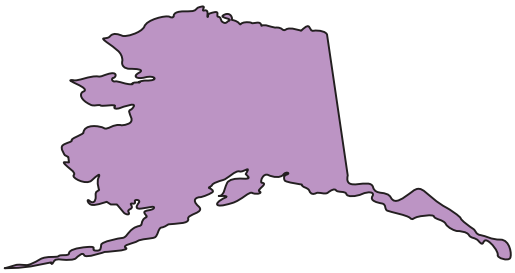
The activities of the proposed National Coastal Program will be prioritized to ensure they:

- Address critical and immediate regional needs and Federal obligations;
- Contribute to the overall objectives to provide broadly applicable information and understanding; and
- Result in the optimal use of resources through coordinated application of the capabilities of the USGS and cooperators, and fully exploit existing and new information.

Continued program planning will include active stakeholder and partner engagement to define critical concerns and needs and to maximize effectiveness through coordinated efforts. To ensure that these priorities are reflected in program planning and implementation, the National Coastal Program is structured to optimize responsiveness at a regional level.

A NATIONAL PROGRAM RESPONDING TO REGIONAL NEEDS

While the issues critical to coastal systems and the factors driving coastal change are national in scope, there are significant regional differences in coastal setting, climate, habitat, resources, and human impacts. Every region of the Nation faces a unique suite of issues and related societal costs. The assessment of critical issues and the development of appropriate responses requires engagement at the State and regional levels where problems are identified and solutions developed. The proposed Program will develop coordinated efforts in 10 coastal regions defined on the basis of oceanographic, geologic, political, and climatic boundaries. Program activities in each region will reflect the priority concerns and needs defined through stakeholder engagement. Figure 2 lists critical issues and priority studies for each of these regions. Throughout this report, brief examples are given illustrating some of the critical issues and science needs facing coastal regions. Program implementation will be designed to meet these regional needs while building the information and understanding required for broad application and policy development on a national scale.



ALASKA

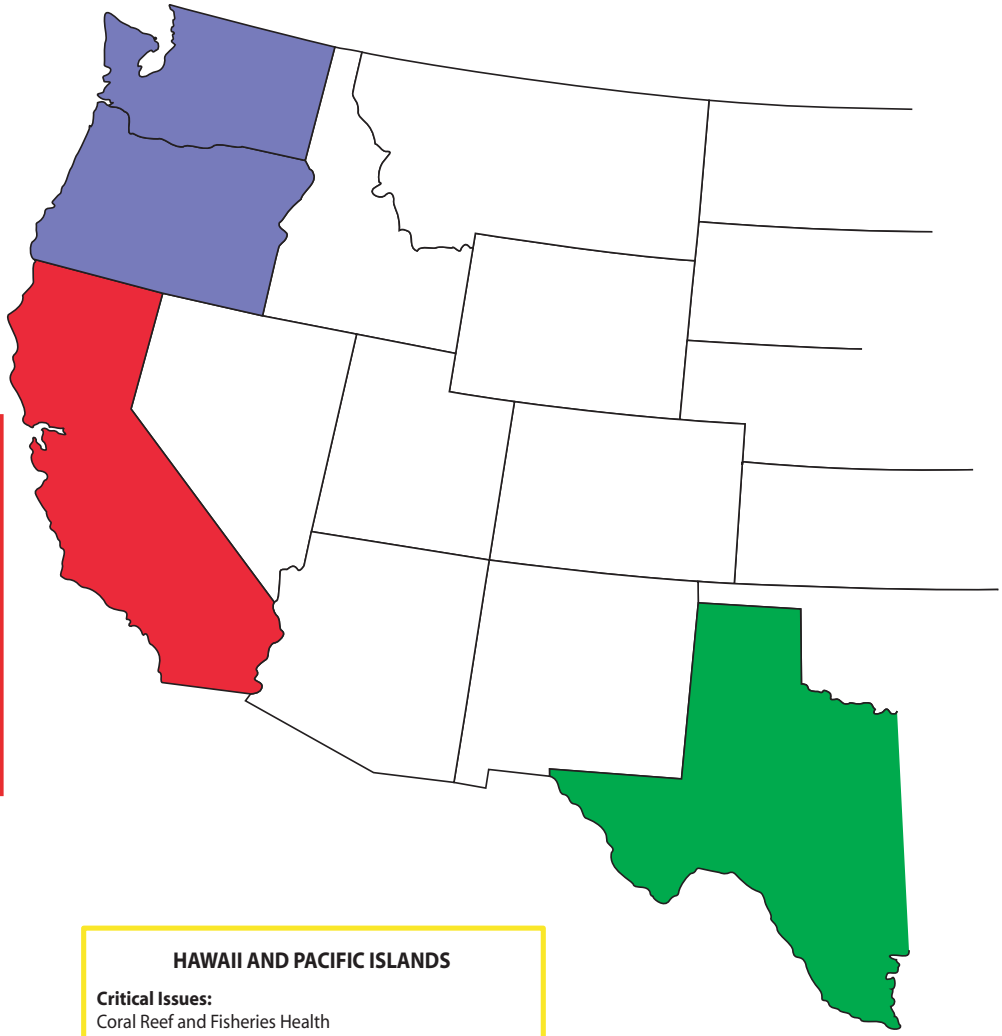
Critical Issues:
Fish and Wildlife Habitat
Earthquakes and Tsunamis
Threatened Wildlife (Seabirds, Marine Mammals, Salmon)
Wetlands Loss and Restoration
Erosion and Sand Resources
Climate Change Impacts

Priority Study:
Human and Climate Change Impacts on Coastal Habitats and Living Resources

PACIFIC NORTHWEST

Critical Issues:
Erosion and Landslides
Earthquakes and Tsunamis
Pollution
River and Watershed Modification
Fish and Wildlife Habitat (Coastal Salmon)
Invasive and Nuisance Species

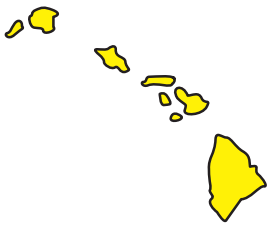
Priority Studies:
Columbia River Sand Resources: Impacts of Sand Supply on Shoreline and Habitats
Puget Sound: Ecosystem Health and Human Safety in an Urban Setting



CALIFORNIA

Critical Issues:
Groundwater Resources
River and Watershed Modification
Earthquakes and Tsunamis
Pollution
Erosion and Landslides
Threatened Wildlife (Sea Otters, Sea Birds)
Invasive and Nusiance Species

Priority Studies:
Southern California Water and Waste: Sustaining the Economy and Environment
San Francisco Bay Integrated Study

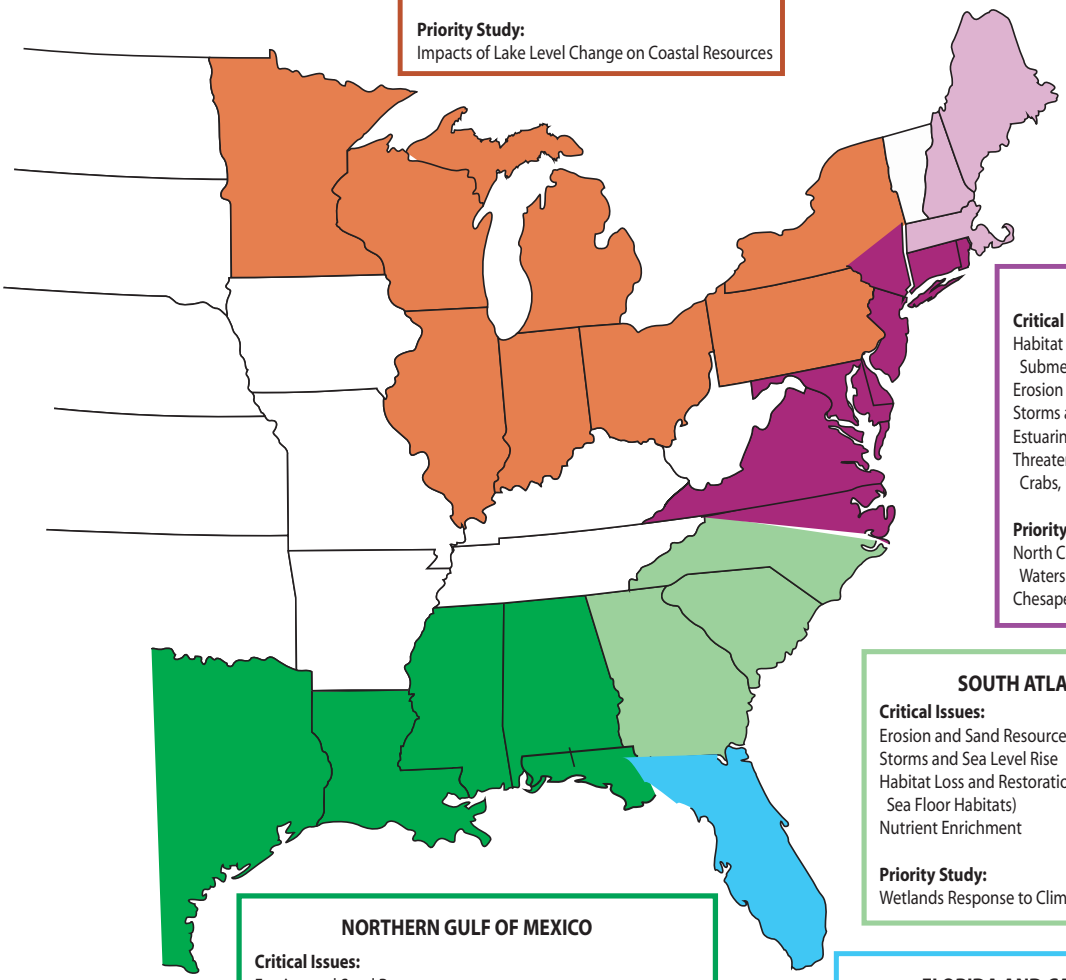


HAWAII AND PACIFIC ISLANDS

Critical Issues:
Coral Reef and Fisheries Health
Erosion and Resources
Pollution
Invasive and Nuisance Species
Coastal Hazards

Priority Study:
Climate and Development Impacts on Coral Reef Systems

FIGURE 2



GREAT LAKES

Critical Issues:
Pollution (Industrial Compounds)
Lake Level Changes
Erosion and Sand Resources
Habitat Loss and Restoration (Wetlands, Fisheries)
Invasive and Nuisance Species
Threatened Wildlife (Fish, Migratory Birds)

Priority Study:
Impacts of Lake Level Change on Coastal Resources

GULF OF MAINE

Critical Issues:
Fish and Wildlife Habitat
River and Watershed Modifications
Pollution
Atlantic Salmon Populations and Habitats

Priority Study:
Ecosystem Requirements for Healthy Fisheries

MID ATLANTIC

Critical Issues:
Habitat Loss and Restoration (Sea Floor Habitats, Submerged Aquatic Vegetation)
Erosion and Sand Resources
Storms and Sea Level Rise
Estuarine Eutrophication and Pollution
Threatened Wildlife (Fish Health, Horseshoe Crabs, Migratory Birds)

Priority Studies:
North Carolina Sounds and Barriers: Watershed/Ocean Interactions
Chesapeake Bay Integrated Study

SOUTH ATLANTIC

Critical Issues:
Erosion and Sand Resources
Storms and Sea Level Rise
Habitat Loss and Restoration (Wetlands, Sea Grass, Sea Floor Habitats)
Nutrient Enrichment

Priority Study:
Wetlands Response to Climate Change

NORTHERN GULF OF MEXICO

Critical Issues:
Erosion and Sand Resources
Habitat Loss and Restoration (Wetlands, Brown Marsh, Sea Grass)
Threatened Wildlife (Sea Turtles, Migratory Sea Birds)
Storms and Sea Level Rise (Subsidence)
Nutrient Loading and Hypoxia
Offshore Resources and Habitats
Transport, Fate, and Impact of Pollutants
Invasive and Nuisance Species

Priority Study:
Regional Influence of River Systems: Mississippi River to Mobile Bay

FLORIDA AND CARIBBEAN

Critical Issues:
Erosion and Sand Resources
Habitat Loss and Restoration (Sea Grass, Wetlands, Corals)
Threatened Wildlife (Manatees, Reef Fish, Migratory Birds)
Groundwater Resources
Storms and Sea Level Rise
Invasive and Nuisance Species

Priority Studies:
Climate and Development Impacts on Coral Reefs, Mangroves, and Sea Grasses
Tampa Bay Integrated Study

CONTENTS

INTRODUCTION

The Nation's coastal land and water resources provide enormous natural, economic, and public benefits. Coastal regions encompass the watersheds, beaches, habitats, and communities bordering the oceans and Great Lakes, as well as the adjacent waters and ecosystems of bays, estuaries, and the U.S. Exclusive Economic Zone (EEZ). The Nation's coastal fringe comprises only about 17 percent of the area of the contiguous United States, but includes more than 53 percent of our population. This coastal population is increasing by 3,600 people each day. The projected increase between now and the year 2015 is 27 million people. The EEZ is the largest in the world, establishing Federal jurisdiction over the natural resources of an area 1.3 times the size of the onshore U.S. territory.

Coastal regions are the most highly developed part of the country, reflecting their economic and aesthetic value. The coasts attract about 180 million recreational visitors each year. Many of these recreational visits occur on the lands and waters managed by bureaus of the U.S. Department of the Interior (DOI). Large and small Fish and Wildlife Service (FWS) refuges are situated along every U.S. coastline and the Great Lakes. Roughly 30 percent of the 538 national wildlife refuges protect marine, estuarine, Great Lakes, or coastal habitats. The National Park Service (NPS) manages an estimated 7,310 miles of coastline in 66 national park units containing coastal lands and waters. The Minerals Management Service has responsibilities for leasing and environmental protection related to resource extraction throughout Federal waters. The Bureau of Indian Affairs and FWS interact with numerous tribes that depend on coastal and marine resources for subsistence fishing, hunting, and cultural activities. The importance of coastal lands and waters within DOI is reflected in research investment. The Interagency Subcommittee on U.S. Coastal Ocean Science tabulated direct Federal research investment in the coastal ocean.

The largest contribution was by the DOI, with an annual budget ranging from $92 to $102 million during fiscal years (FY) 1992-1993. The U.S. Geological Survey (USGS) provides the science and information required on land, across the coast, and throughout the EEZ to assess and manage resources, minimize loss of life and property from natural disasters, and enhance and protect the quality of life.

Coastal systems, as seen in both natural settings and human use and interaction, are diverse. From highly urbanized estuarine systems to pristine and isolated shores, from Arctic shorelines to tropical coral reefs, our coastal resources are varied in character, value, and vulnerability. These resources face a similarly varied set of issues that are national in scope and include:

- Nutrient enrichment, oxygen depletion, harmful algal blooms, chemical contamination, diseases in marine organisms, and fish kills;

- Shoreline erosion, the increasing susceptibility of coastal communities to natural hazards and sea level rise, increasing demands on non-living resources (including groundwater, sand and gravel, and energy resources);

- Declines in living marine resources, habitat loss, loss of biodiversity, and invasions of non-indigenous species; and

- Development of offshore and coastal zone mineral, energy, and water resources.

These issues associated with coastal change threaten the very resources that make coasts valuable and desirable. Increasing coastal populations are resulting in increased exposure to coastal hazards and exacerbating the impact of changing or declining systems, whether caused by natural processes or by human influences. Studies indicate that increasingly, costly damages associated with hurricanes are largely atttibutable to the continued concentration of people and property in coastal regions. Human

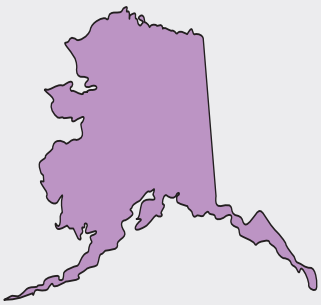
DISTINCT SYSTEMS, COMMON NEEDS: THE CASE FOR INTEGRATED SCIENCE

The complexity of coastal systems necessitates a "systems-science" approach aimed at understanding the response of linked elements of coastal systems to multiple stressors and influences. An effective approach must address critical regional issues while developing the information and understanding relevant to the entire system of concern and applicable to those processes and issues of national importance.

The following examples demonstrate the need for system-level understanding, identify critical regional issues and needs, describe program products and outcomes, and point to some of the common elements required to characterize coastal systems and understand coastal change throughout the Nation. In each case, the drivers of change include significant natural and human elements that must be addressed. Examples also demonstrate how system-scale studies build on the mapping, inventory, monitoring, and focused research efforts that are essential elements of the proposed National Coastal Program.

Coastal Change in Alaska

The impacts of coastal change are becoming increasingly apparent in even our most pristine coastal regions. The health and sustainability of Alaska's living marine resources, including marine mammals and sea birds, as well as commercially and culturally valuable fisheries, are increasingly threatened by human activities. More than one in ten Alaskans make a living from fisheries; and healthy fish and shellfish populations are also critical to marine mammals and sea birds. According to a 1991 study, 76 percent of Alaska's seafood harvest comes from inshore and wetland dependent species. Most of Alaska's population growth has been adjacent to coastal waters, placing extreme development pressures on coastal wetlands and waters.



ALASKA

Critical Issues:
Fish and Wildlife Habitat
Earthquakes and Tsunamis
Threatened Wildlife (Sea birds, Marine Mammals, Salmon)
Wetlands Loss and Restoration
Erosion and Sand Resources
Climate Change Impacts

Priority Study:
Human and Climate Change Impacts on Coastal Habitats and Living Resources

The sensitivity of this system to potential climatic changes is underscored by recent events. Highly unusual climatic conditions in the Bering Sea during the summers of 1997 and 1998 are suspected of playing a major role in the failure of western Alaskan salmon runs over these 2 years. Throughout these two summers, researchers documented extensive die offs of sea birds, unprecedented blooms of plankton, high sea surface temperatures, extremely low streamflows in Bristol Bay lake systems, and altered ocean currents and atmospheric conditions throughout the Bering Sea. The unprecedented low returns of salmon caused economic disaster throughout western Alaska and have resulted in over $50 million in emergency aid relief to fishermen and communities dependent on salmon for 1998 alone. Although no evidence links these unusual conditions to global climate change, there is little doubt that these run failures are linked to the observed climate extremes.

Continuing and expanded research in Alaska would lead to an improved understanding of the habitat requirements for healthy and sustainable coastal and marine ecosystems. For example, over 90 percent of the migratory shore bird species in the Western Hemisphere have breeding populations in Alaska. Almost all shore bird species are critically dependent on coastal habitats. USGS programs monitor the status and trends of shore bird populations and identify critical sites and habitat requirements. USGS research results have been instrumental in the development of the North American Shore bird Management Plan and provide State and Federal management agencies information upon which to base informed decisions concerning the welfare of shore birds and their habitats. Future integrated USGS programs, focused on population centers, important fishery areas, and managed areas such as Glacier Bay National Park, will lead to models for predicting system response to both climatic variability and changing patterns of land and resource use.

impacts are a significant and growing factor determining the rate and direction of coastal change. These impacts include increased loads of nutrients, toxic chemical, and pathogens. The resulting degradations and loss of critical coastal habitats threaten the healthy and diverse living resources which coastal communities and economies depend upon.

The health and welfare of the entire Nation depends on our ability to wisely use and sustain coastal resources, to ensure public safety, and to protect the economic health of coastal regions. The resources on which a large number of Americans rely for their livelihood, food, recreation, and enjoyment are at risk. For example, more than 1.7 billion pounds of fish and shellfish are harvested from the Gulf of Mexico each year; this catch has a dockside value of $3.6 billion. Along the southern shore of Long Island, approximately $2.8 billion worth of real estate, coupled with a $1.5 billion annual tourist industry, is dependent on the region's recreational beaches, which are undergoing rapid erosion. Other costs are more difficult to assess. It is estimated that North Carolina has already lost 34 percent of its coastal wetlands, including habitats critical to a fishery industry that contributes in excess of $1 billion a year to the State's economy.

The processes driving change in coastal systems are varied, including both natural and human processes working across a range of temporal and spatial scales. Natural processes range from the long time scales of sea level rise and climatic variability to the sudden impacts of coastal storms and riverine flooding. Human influences range from watershed scale impacts of changing land use and alteration of river systems, to local impacts of development and harvesting of living resources. These processes are not unique to any one region, but the resulting change is critically dependent on the physical and ecological structure of the particular system and the details of the interactions between the environment, biota, and people. Providing the tools required to forecast future change requires characterizing the essential elements of the system, documenting both system change and driving forces, and understanding how processes lead to the observed response across all the components of the system. An integrated approach to understanding coastal systems is essential to the development of models for future change locally, and to the development of tools for wide application to diverse coastal settings.

Ensuring the long-term health of coastal ecosystems and communities requires addressing the conflicting challenges of:

- Sustaining the environmental health of coastal communities and resources;
- Maintaining and enhancing the contribution of coastal systems to the Nation's economy and well-being; and
- Ensuring the safety of coastal populations threatened by natural hazards and human-driven change.

To meet these challenges, the USGS proposes an integrated coastal program that effectively applies the unique breadth of USGS expertise to provide national and regional capabilities to characterize coastal systems and to measure, analyze, understand, and forecast coastal changes (natural and anthropogenic) that affect coastal economies, public safety, resource availability, and the integrity and sustainability of the Nation's coastal ecosystems. The USGS will ensure that national information needs are met for characterizing coastal systems, identifying critical and emerging issues, documenting coastal change, and supporting policy and management decisions nationally, regionally, and locally.

Human Impacts in San Francisco Bay

Coastal bays and estuaries are strongly influenced by the exchange of water and materials at their boundaries with the coastal ocean and watersheds. Human development, resource extraction, and natural processes across watersheds and coastal margins increasingly impact productive estuarine systems. USGS research and observational programs in San Francisco Bay, Chesapeake Bay, and Tampa Bay demonstrates the value of sustained integrated approaches to understand coastal systems and guide the design of the comprehensive national effort proposed here.

CALIFORNIA

Critical Issues:
Groundwater Resources
River and Watershed Modification
Earthquakes and Tsunamis
Pollution
Erosion and Landslides
Threatened Wildlife (Sea Otters, Sea Birds)
Invasive and Nuisance Species

Priority Studies:
Southern California Water and Waste:
Sustaining the Economy and Environment
San Francisco Bay Integrated Study

In San Francisco Bay, over 95 percent of the historic tidal marshes have been leveed and filled, with attendant losses in fish and wildlife habitat. The flow of freshwater into the estuary has been greatly reduced by water diversion, largely to support irrigated agriculture. Harbor and channel dredging has changed both the dredged and disposal sites and altered water flow patterns and salinity. Contaminants enter the estuary in municipal and industrial sewage and urban and agricultural runoff. Introduced exotic species continue to change the Bay's biota by altering its food webs. All of these changes have had marked effects on the estuary's biological resources, particularly by well-documented declines in abundance of fish species.

The impacts on San Francisco Bay, and the conflicts among the many uses of the Bay system, have resulted in a consensus among the public, resource managers and regulators, and elected officials of the need for credible, unbiased scientific information on the significance of river flow diversion, contaminant inputs, dredging, and habitat alteration (San Francisco Estuary Project Management Committee, 1994). The USGS has provided much of the interdisciplinary knowledge of the interrelated hydrology, geology, chemistry, and ecology of this complex estuarine system. For example, the USGS has documented changes in the estuary's shoreline; changes in patterns of water and sediment movement; the contamination of its water, sediments and organisms; and alterations of its biological communities. These changes occur across all time scales, in response to changes in climatic and hydrologic forces, urbanization, land use, and management practices.

In San Francisco Bay, like Tampa Bay, Chesapeake Bay and estuaries around the Nation, water quality and habitat distributions are controlled by the quantity of river flow discharging into the bays. Historically, accurate measurement of river flows in the presence of strong tides has been impossible. New technologies, developed by the USGS in San Francisco Bay, provide for accurate monitoring of river inflow suitable for tidally-influenced coastal bays around the Nation. USGS monitoring in San Francisco Bay has resulted in specification of seasonal criteria for development of standards for freshwater inflows; allowing the State of California to respond to U.S. Environmental Protection Agency (EPA) requirements that flow standards protect multiple species of living resources such as striped bass, shrimp, smelt, and flounder. The Sacramento-San Joaquin River Delta supplies drinking water to over 20 million Californians. However, withdrawals can be a cause of mortality to endangered species of fishes, such as the chinook salmon. USGS hydrodynamic and biological studies have led to operational schemes that minimize the conflicts between municipal water withdrawal and protection of endangered species.

USGS studies of San Francisco Bay have demonstrated the critical importance of efforts to monitor coastal systems comprehensively at all relevant time scales, documenting changes in forces that drive the system, and in the attendant system response. Continuing efforts are focused on developing tools that allow managers to assess: (1) the effects of freshwater flow on the estuary's chemistry and biology, (2) the distribution and influence of contaminants on estuarine invertebrates, and (3) the processes influencing the character and stability of remaining and created wetlands. The integrated ecosystem perspective provided by USGS efforts in the San Francisco Bay has proven essential to providing the information for documenting, understanding and managing this changing system. Efforts within the proposed Program will enhance continuing work in the San Francisco Bay by providing more comprehensive characterization of resources and change, and by expanding research on the physical, biological, and geochemical requirements for healthy ecosystems. USGS efforts will provide the science and understanding required to manage regional water-use to support economic vitality while sustaining the overall health of the Bay ecosystem.

The proposed National Coastal Program will ensure that the resulting information base serves the broadest needs through coordinated efforts that:

- Increase our understanding of the regional and local response of complex coastal systems to natural processes and human influences;

- Develop improved ways to collect, store, integrate, and distribute information; and

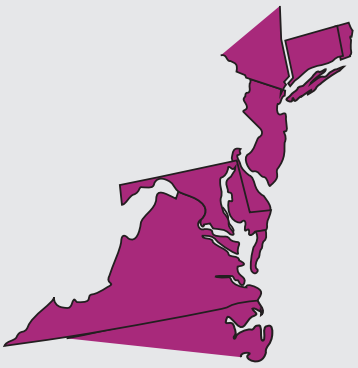
- Develop science-based management tools for effective assessment, management, protection, restoration, and prediction of changes in coastal systems.

The resulting comprehensive coastal program will meet identified needs for information that is consistent, integrated, and national in scope. A responsive and effective program will focus efforts on issues of critical concern both nationally and regionally. The inherent complexity of coastal systems argues for an approach that is consistent and integrated. The value of individual data and information pieces will be enhanced by application to a broad range of issues facing diverse and widespread coastal settings.

The encompassing goal of this Program is to provide the scientific information, knowledge, and tools required to ensure that decisions about land and resource use, management practices, and future development in the coastal zone and adjacent watersheds can be evaluated with a complete understanding of the probable effects on coastal ecosystems and communities, and a full assessment of their vulnerability to natural and human-driven changes. This goal will only be met through a coordinated effort spanning many of the traditional programs of the USGS and through partnership with stakeholders and other Federal agencies.

Restoring Chesapeake Bay, the Nation's Largest Estuary

Chesapeake Bay, like San Francisco Bay and estuarine systems across the country, has experienced serious environmental degradation during the past century. Symptoms of degradation include large declines in sea grass acreage and in finfish and shellfish populations, seasonal depletions in dissolved oxygen, and increases in sedimentation. Most research attributes these changes, at least indirectly, to ecological stresses due to human activities, especially land-use changes in the bay watershed related to deforestation, agriculture, use of fertilizers, and more recently, urbanization, pollution, and sewage. Since the early 1980's, the Chesapeake Bay Program (CBP), a partnership of agencies in Maryland, Virginia, Pennsylvania, the District of Columbia, the Federal government, and the Chesapeake Bay Commission, have been formulating and implementing restoration goals to restore living resources, minimize habitat loss, and reduce the amounts of nutrients, sediments, and contaminants entering the Bay. The current paradigm for bay ecosystem management, recognizing the need for a systems approach, emphasizes the links among land, sea, and biota that result in changes in the watershed affecting the Bay.



MID ATLANTIC

Critical Issues:
Habitat Loss and Restoration (Sea Floor Habitats, Submerged Aquatic Vegetation)
Erosion and Sand Resources
Storms and Sea Level Rise
Estuarine Eutrophication and Pollution
Threatened Wildlife (Fish Health, Horseshoe Crabs, Migratory Birds)

Priority Studies:
North Carolina Sounds and Barriers: Watershed/Ocean Interactions
Chesapeake Bay Integrated Study

Land-use and population changes have increased the amount of agricultural fertilizers and urban sewage plants, causing increased nutrient loading in surface and groundwaters. Excess nutrients lead to increases in algal blooms, reduced oxygen levels, habitat degradation and depleted living resources. Algal blooms can reduce water clarity, preventing sunlight from penetrating to the bottom and inhibiting the growth of sea grasses and submerged aquatic vegetation (SAV). Water clarity is also impacted by excessive sedimentation. USGS studies show that sedimentation has increased four-to-five fold since the 1800's in response to timber harvesting and increases in agriculture and urban lands. SAV is important because it adds oxygen to the water and provides food and habitat for organisms, particularly juvenile blue crabs and waterfowl in the Atlantic Flyway. USGS research on the factors influencing water clarity and on the habitat value of SAV are being used by the CBP and the FWS to set water clarity standards and to restore habitat for migratory waterfowl.

There is less awareness that the rising sea level is having dramatic and wide-ranging effects. Islands populated in colonial times and during the past century have disappeared due to submergence and related shore erosion. Expanding wetlands, responding to sea level rise, are claiming low-lying communities on Smith and Tangier Islands. Established coastal communities are increasingly surrounded by rising water during periods of extreme high tides -- a prologue to rising sea level. The Blackwater National Wildlife Refuge, unique in its coastal marshland waterfowl habitat, is being widely affected as steadily rising sea level converts vegetated marshlands into shallow ponds and changes important shallow water marsh habitat into deeper water plant and animal communities. In short, the Bay is changing and changing rapidly, even in human timeframes.

Sea level within the Chesapeake Bay is rising at twice the worldwide average rate. This rise has been variously attributed to changing climate, sediment compaction resulting from increased extraction of groundwater, and regional subsidence associated with post-glacial adjustment. Predicting the future of the Bay, and developing appropriate restoration goals and strategies, requires understanding the complex response of the system to changes in nutrient inputs, sedimentation, and sea level rise. Enhanced USGS efforts will provide complete characterization of the watershed-scale impacts of human activities and document the continuing change in the physical and biological components of the system. Ultimately, efforts will lead to the development of predictive models of the response of biological communities to changes in the input, transport, and fate of sediment and nutrients. With this science base, strategies can be developed and assessed to effectively mitigate the impacts of development throughout the watershed; providing for continued economic growth while sustaining the health of Bay resources and associated economic benefits.

EXTERNAL GUIDANCE

The National Research Council (NRC) recently completed a review of the USGS addressing "Future Roles and Opportunities for the U.S. Geological Survey" (NRC, 2001). This review, addressing the full breadth of USGS programs, echoes many of the recommendations of an earlier NRC review of the USGS's Coastal and Marine Geology Program ("Science for Decisionmaking", NRC, 1999). In particular, both reviews focused on the vital role of the USGS in developing and carrying out the integrated approaches required to provide and coordinate information related to critical issues in the natural sciences. Nowhere are the recommendations of the NRC more compelling than in addressing the issues facing the Nation's coastal lands and waters. In the design of a comprehensive coastal program, the USGS has responded to the recommendations of the NRC review committees. Two recommendations in particular are reflected in the coordinated approach proposed.

First, the NRC acknowledged that USGS responsibilities include the overlapping categories of surveys, monitoring, data analysis, research, information dissemination, and product generation. The committee further stated, "Subject to the overriding requirement that the USGS fulfill its primary and high priority mission responsibilities, the committee believes that the USGS should continue to conduct each of these activities, but that the balance of activities should shift toward the value-added activities of data analysis, problem solving, and information dissemination." A shift of balance does not mean that the USGS should reduce data gathering or long-term data collections, but that it should do more to interpret what the data mean and to make the data useful and accessible." The challenge is to ensure that data and information are exploited
to achieve maximum value. Providing an integrative framework for information that is responsive to priority needs, along with the tools to access and apply information, is critical to ensuring that results from this Program are broadly and effectively applied.

Second, the NRC stated, "The USGS should emphasize system modeling as a powerful tool for integrative science." The committee believes that the development of an enhanced capability in integrative system modeling can contribute to the future effectiveness of the USGS. Modeling and integration capabilities have to operate across divisions and feed into administration of research programs." Establishing an explicit objective to develop system models requires coordinated efforts prioritized and assessed on the basis of their contribution to development of this enhanced capability.
Development of system models drives integrated science and enhances the value of the component efforts of the comprehensive program proposed.

The proposed Program also reflects a variety of independent assessments of information needs and availability. There is a consensus recognition, expressed by the Committee on Environment and Natural Resources of the National Science and Technology Council, the interagency National Ocean Partnership Program (NOPP), the John Heinz III Center for Science, Economics and the Environment, and numerous NRC studies, that the Nation's capacity to deal with issues in coastal settings is increasingly hampered by a lack of comprehensive and consistent information. The information needs identified through these efforts are consistent with those identified by agencies of the Departments of the Interior and Commerce. Recent workshops hosted by the USGS have addressed the science needs of the NPS, FWS, and the National Oceanic and Atmospheric Administration (NOAA) National Marine Sanctuaries for geologic and habitat characterization. Despite the diversity of missions and interests, there is a consistent recognition of the fundamental information requirements for developing assessments and applying science-based management tools. This plan reflects that community consensus.

External guidance for the development of the proposed Program has also been provided through the solicitation of stakeholder input at the state and regional level.

Partnerships Providing Science for Tampa Bay

FLORIDA

Critical Issues:
Erosion and Sand Resources
Habitat Loss and Restoration (Sea Grass, Wetlands, Corals)
Threatened Wildlife (Manatees, Reef Fish, Migratory Birds)
Groundwater Resources
Storms and Sea Level Rise
Invasive and Nuisance Species

Priority Studies:
Climate and Development Impacts on Coral Reefs, Mangroves, and Sea Grasses
Tampa Bay Integrated Study

The lessons learned in San Francisco and Chesapeake Bay of how similar systems function, how they respond to human and natural influence, and of the need for development of management tools founded on complete and objective science have been applied in the development of an integrated study of Tampa Bay.

The House Appropriations Committee (House Report 106-646) directed the USGS to develop a coastal pilot program in the southeast region designed to address the most critical issues facing this region. The resulting Tampa Bay Pilot Study builds on past studies and is a model for the development of future research programs. Tampa Bay, one of the Gulf of Mexico's largest estuaries, exemplifies the environmental stresses that our Nation's estuaries face in general. More than 2 million people live in the Tampa Bay watershed, and the population continues to grow. Increased development demands more freshwater and creates greater air and water pollution. Despite the changing quality and quantity of water entering the Bay and the dramatic alteration of sensitive coastal ecosystems, the scientific baseline controls documenting these changes have not yet been established. In addressing issues in Tampa Bay, the USGS found a wealth of engaged agencies and individuals, providing a breadth of knowledge about the issues of concern and the information available. The pilot study design is responsive to this community of concern, and USGS scientists are working with partners from 10 Federal agencies, 11 State agencies and academic institutions, and 11 local organizations. This level of partnership ensures that the resulting Program is responsive to local needs.

Four major pilot components, demonstrating the power of integrated science and the value of integrated information, are providing:

1. Essential maps of bathymetry, land-use and land cover. Historical maps are providing digital records of the history of land use and wetlands growth and loss for the entire Bay. Joint NOAA/USGS programs are demonstrating the value of creating consistent elevation maps from topographic and bathymetric sources. More comprehensive mapping, including characterization of geology and submerged habitats, addresses areas identified as critical by USGS partners.

2. Understanding of the delivery of freshwater to Tampa Bay. Freshwater discharge is critical to maintaining the salinity and water quality required for healthy habitats. Existing information from the USGS and others that characterizes river inputs and surface runoff is providing a record of freshwater inflow, salinity and nutrient patterns to aid in understanding the historical changes in wetlands and sea grasses. Hydrologists, geologists, and geochemists are working together to assess the quality and quantity of groundwater entering the Bay.

3. An understanding of the evolution of Tampa Bay. The coastal wetlands around Tampa Bay are a critical interface between land and sea, providing habitat and nursery for a wide variety of plants and animals. Therefore, the wetlands reflect the health of the estuary and the quality of the water that flows into it. Geologic and historic records are providing an understanding of wetlands evolution that will provide the basis for predicting the future of wetlands in Tampa Bay.

4. Scientific information that is easily accessed by researchers and managers. All of the scientific information that is being acquired in these projects, as well as the decades of data that have been collected by partners, will be made centrally accessible. This is the first step towards building a prototype Tampa Bay Decision Support and Query System.

The Tampa Bay Pilot Study is demonstrating the importance of partnerships, the value of existing data and continued long-term monitoring, and the compelling need for integrated science and information. After less than 1 year, results are already influencing resource management decisions. For example, a $10 million wetland restoration project by the Southwest Florida Water Management District and the Florida Department of Environmental Protection has been substantially modified. USGS maps of subsurface salinity, along with assessments of species diversity and sea level history, have been used to ensure that efforts are effectively targeted at critical habitats and that long-term system maintenance efforts are minimized. As this Study continues, State and local agencies will have improved tools to assess and mitigate the impacts of continuing population growth. The lessons learned from the Tampa Bay Study are carried forward in the development and implementation of this comprehensive program.

The activities proposed, particularly those addressing site-specific and regional problems, reflect priorities expressed by those stakeholders. Continued stakeholder engagement will be reflected in the setting of future priorities, continued development of study plans and products, and the review and assessment of Program accomplishments.

A comprehensive coastal program must include science and information elements that are coordinated for maximum effect. In the following proposed framework, science and information efforts are intimately linked in a single integrated framework, ensuring a coordinated approach to identifying needs, developing products, tools and understanding, and disseminating information.

The findings of the NRC review of USGS programs, "Future Roles and Opportunities for the U.S. Geological Survey" (NRC, 2001), include:

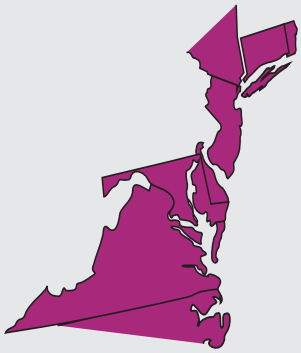
"The agency's current mission is to supply information that contributes to the effective management of a variety of natural resources and that promotes the health, safety, and well-being of the Nation's citizens. This mission is fully appropriate for a Federal science agency."

The USGS is a *vitally important provider and coordinator of information related to critical issues in the natural sciences.* As a result of changes in its external and internal environments, the USGS is evolving from an agency that was organized primarily to discover *what is out there*, to one that tries to understand *what is out there* to one that tries to understand how *what is out there* works (i.e., process understanding). The questions posed to the agency increasingly call for multifaceted, analytical, and integrative investigations of complex processes and systems. By evolving into a natural science and information agency, the USGS will be able to play a leadership role in the elucidation of the geological, hydrological, geographical, and biological processes that are important to the Nation, and in the use of modern technology for the effective and efficient dissemination of this information.

In upcoming decades, many of the relevant societal needs and emerging scientific opportunities that the USGS should address will involve interactions among the natural environment, its biota, and people. The USGS is well positioned, in terms of its information resources, technological capabilities, and range of professional expertise, to provided well-coordinated, comprehensive responses to priorities of society and science. Interactions between the environment, its biota and people are highly complex and unpredictable, and solutions will require integrative, multidisciplinary approaches. "The USGS should place more emphasis on multiscale, multidisciplinary, integrative projects that address priorities of national scale." (NRC, 2001, page 3)

"Effective information management will be critical to the future performance of the USGS. For the USGS, information management has two essential aspects. The first is the ability to assess the information needs of its customers and partners and to focus its resources on meeting those needs. The second is to effectively deliver and facilitate the use of reliable, high-quality data and information. "In the future, the information management at the USGS should shift from a more passive role of study and analysis to one that seeks to convey information actively in ways that are responsive to social, political, and economic needs." (NRC, 2001, page 4)

Mitigating Change, Maintaining Coastal Resources: The Sounds and Barriers of North Carolina



MID ATLANTIC

Critical Issues:
Habitat Loss and Restoration (Sea Floor Habitats, Submerged Aquatic Vegetation)
Erosion and Sand Resources
Storms and Sea Level Rise
Estuarine Eutrophication and Pollution
Threatened Wildlife (Fish Health, Horseshoe Crabs, Migratory Birds)

Priority Studies:
North Carolina Sounds and Barriers: Watershed/Ocean Interactions
Chesapeake Bay Integrated Study

North Carolina's coastal plain is a labyrinth of rivers, streams, brackish and freshwater wetlands, and upland flats. More than 40 percent of North Carolina and 10 percent of Virginia ultimately drain to the Albemarle-Pamlico Sound estuarine complex, the second largest estuary in the Nation. Water exchange between the estuary and the ocean is restricted to three narrow and shallow inlets through the barrier island system known as the Outer Banks. The resulting shallow lagoonal system provides habitat for waterfowl and shellfish, and provides critical nursery and foraging areas for the surrounding mid-Atlantic fishery. As in the estuarine systems previously discussed watershed, influences are great, but here oceanic influences are modified by the narrow barrier island fringe. The Outer Banks protect shallow estuarine waters from the harsher ocean conditions, and provide a long residence time allowing for assimilation of nutrient inputs and resulting in high productivity. However, the long residence time also makes the sounds sensitive to excessive loadings of nutrients and other contaminants.

Accelerated changes in the North Carolina coastal region are a late 20th-century phenomenon. Recent conversion of watersheds to agricultural crops, intensive livestock operations, silviculture, and urban landscapes has greatly increased nutrient loading to North Carolina estuaries resulting in algal blooms, increasing eutrophication, massive fish kills, and outbreaks of the toxic algae Pfiesteria piscicida. Loadings of chemical contaminants, such as pesticides and, more recently, veterinary pharmaceuticals, have resulted in exposures to chemical mixtures with unknown toxicological consequences. The USGS and partners documented massive nutrient inputs to the system resulting from the passage of Hurricanes Fran (1996) and Floyd (1999). These inputs have had dramatic short-term impacts, may have long-lasting consequences, and could be an indication of future conditions if Atlantic coastal storms increase as predicted.

Natural barrier islands are highly mobile, migrating landward in response to winter storms, hurricanes, and rising sea level. USGS researchers have documented as much as 300 feet of landward migration along the Outer Banks following a single hurricane. Storm overwash provides sand critical to the maintenance of island ecosystems including sound-side wetlands. These extreme events, and the prevalent erosion of most of North Carolina's beaches, are at odds with society's desire to protect valuable coastal properties and stabilize economically important beaches. Artificial dunes built to protect property along much of the Outer Banks form a barrier to storm overwash, affecting the habitat structure of the entire barrier island system. Barrier islands also evolve in response to the along-island transport of sand and the associated opening, closing, and migration of tidal inlets. Inlet stabilization to maintain navigation and protect private property affects estuarine circulation and exchange with the ocean and can restrict the movement of ocean-spawned larval fish into the estuary's critical nursery areas. Efforts to inhibit the movement of sand impact the barrier island and estuarine ecosystems may worsen the offshore loss of sand from beaches. Responding to the conflicting demands in this dynamic system requires a science-based understanding of riverine inputs of sediments, inlet and island dynamics, sea level rise and coastal storms, and the far-reaching impacts of efforts to mitigate natural change.

Enhanced monitoring and research by the USGS would provide understanding of the effects of increased nutrient loading from land use conversion and the long-term impacts of coastal storms on the ecological health of North Carolina's sounds. USGS contributions to understanding the relation between estuarine circulation and upland inputs on the development and persistence of harmful algal blooms have important implications for human health, as well as the fishing and tourism industries. Development of predictive tools derived from sound data and an integrated understanding of the system will guide coastal resource managers in making the important decisions that will affect the economic viability of North Carolina's coastal area, where tourism is the largest industry, as well as the health of much of the mid-Atlantic fishery. Understanding the processes and responses of the barrier island, wetland, and estuarine systems in North Carolina will provide the science base for managing similar systems around the Atlantic and Gulf of Mexico Coasts.

PROGRAM DESCRIPTION

The Program includes coordinated mapping, inventory, monitoring, and research efforts. These efforts will provide the information required to characterize coastal resources, document coastal change, and support the development and application of predictive models and decision-support tools. Research efforts will provide the understanding of how coastal systems function and respond that is required to effectively and broadly apply information. These coordinated efforts will result in products including:

- A National Coastal Information Infrastructure (NCII) providing access to information critical to coastal managers, policymakers, and researchers. Consistent and standardized data and interpretive products from mapping, inventory, monitoring, and research efforts will be provided along with tools for information access and application. The NCII will support the development of, and incorporate the results of:

- Integrated Assessments, at national and regional scales, of coastal character, vulnerability, and change useful for developing and assessing policy and management actions. Development of integrated assessment products, such as status and trends of coastal systems responding to changing nutrient inputs associated with watershed use, will contribute to identification of critical needs and program priorities.

Credible and meaningful assessments require research to understand coastal processes and the response of coastal systems to human and natural stresses. Research will provide the fundamental understanding necessary to develop broadly applicable:

- Predictive system-scale models and decision-support tools. The ultimate measure of program success will be the ability to anticipate the impact of future stresses to coastal systems, design effective programs for the protection and restoration of coastal resources, and predict the future evolution of coastal systems in response to natural and human processes.

The fundamental information requirements to be met by the NCII for developing assessments and applying predictive models and decision-support tools include:

- Quantifying inputs of sediments, nutrients, contaminants and water;
- Characterizing the geomorphology, geology, topography, and bathymetry that determines the physical and ecosystem response to external factors;
- Quantifying and monitoring the areal extent and fragmentation of salt marshes, sea grasses, coral reefs, and other important habitats;
- Monitoring changes in species, species mix, and rates of invasion by exotic and nuisance species;
- Monitoring the frequency and distribution of harmful algal blooms, fish diseases, and pathogens;
- Monitoring contaminant impacts and conditions leading to eutrophication and oxygen depletion;
- Monitoring the physical processes and energy inputs that drive coastal systems (waves, storm characteristics, currents, water levels, earthquakes, and weather);
- Monitoring of resource development, land use changes, and other human activities that affect the coastal area; and
- Mapping shoreline change, subsidence, and changing patterns in land use and land cover.

Currently these information needs are not consistently met and existing information resides in disparate Federal and State agency systems that vary in format, content, and accessibility. Existing USGS programs provide data on biologic and geologic characterization, geologic hazards, and water resources. The USGS will focus efforts on those information elements the Survey is uniquely qualified to provide, while ensuring that broader information sources are recognized and consistently available.

Information and research will support integrated assessments that (1) document the status and trends of coastal conditions; (2) evaluate the causes and consequences of coastal change; and (3) analyze the environmental and economic impacts of alternative policies for utilizing, protecting, and restoring coastal resources. Assessments will include:

- Status and trends of the distribution and fragmentation of critical coastal habitats;
- Status and trends of key species populations, including trust, threatened, endangered, and invasive species;
- Status and trends of human and ecosystem vulnerability to natural hazards, particularly storms and sea level rise;
- Status and trends of the delivery and impact on coastal systems of nutrients, freshwater, sediment, and contaminants leading to assessments of the impacts on coastal systems and water resources due to development, landuse, and nutrient enrichment; and
- Assessments of overall ecosystem health and vulnerability to changes in climate and human influences (resource extraction, hazard mitigation, and development.)

Regional Sediment Issues in the Pacific Northwest

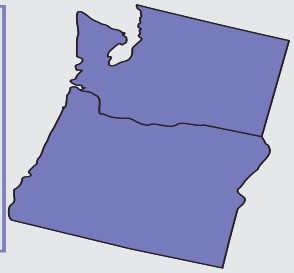
The Pacific Northwest is geologically, climatically, and ecologically distinct from the regions previously discussed. Nonetheless, many of the issues and impacts of critical concern are shared. Northern Oregon and Southwest Washington coastal systems are dominated by the influence of the Columbia River. There is no comparable system on the Atlantic Coast in terms of the potential delivery of water and sediments. Sediment derived from the Columbia watershed is vital to the maintenance of 100 miles of beaches as well as riverine, estuarine, coastal, and marine habitats. Human modifications of the Columbia River system include dams for hydroelectric generation and water supply as well as dredging and inlet stabilization for navigation. These, along with changing land-use throughout the watershed, have altered the quantity and timing of sediment inputs to riverine and coastal systems.

PACIFIC NORTHWEST

Critical Issues:
Erosion and Landslides
Earthquakes and Tsunamis
Pollution
River and Watershed Modification
Fish and Wildlife Habitat (Coastal Salmon)
Invasive and Nuisance Species

Priority Studies:
Columbia River Sand Resources:
Impacts of Sand Supply on Shoreline and Habitats

Puget Sound:
Ecosystem Health and Human Safety in an Urban Setting



For some 5,000 years, the beaches along the southwest coast of Washington and the northwest coast of Oregon accumulated Columbia River sediment, creating broad coastal barrier plains and dune fields. Questions regarding the permanence and safety of development along the rapidly accreting barrier plains were rarely if ever raised as a management concern. However, within the past few decades the growth of coastal communities has accelerated while accretion rates have generally slowed and several areas have begun to erode. Since the early 1990's, erosion at several sites has threatened or destroyed community infrastructure, resource-based industries, public parks and access, and public and private property. In response to recent erosion problems, over $70 million has been invested in coastal stabilization projects since 1993.

Analysis of historical surveys by USGS and cooperative researchers has shown that high rates of beach accretion followed the construction of the Columbia River jetties in the early 1900's. Over several decades, sand from the Columbia River ebb-tidal deltas fed shoreline accretion along an increasingly large segment of the coast. As the ebb-tidal delta source was exhausted, accretion slowed or reversed, resulting in erosion near the jetties. In addition, riverflow regulation associated with dam and reservoir construction has diminished the sediment carrying capacity of the Columbia River by approximately two-thirds over the historical period. It is anticipated that the shoreline will continue to evolve for several decades in response to the declining sediment budget, and shoreline sections that advance will tend to do so as a result of shoreline retreat elsewhere. USGS research results have been used by Washington state agencies to evaluate permit requests for the $100 million Columbia River Channel Deepening Project, to develop a regional sediment management plan with Oregon, the EPA, and the U.S. Army Corps of Engineers for the Columbia River estuary and adjacent beaches, and to respond to erosion problems impacting State, tribal, and private lands.

The results of USGS studies clearly suggest that sediment is a regional resource and must be managed as such. Strategic use of dredged material from the estuary entrances will be increasingly important to coastal communities. However, the removal and placement of sediment, whether by natural or human processes, also impacts the health of critical natural resources. Riverine habitat, particularly for salmon, and estuarine and coastal habitats for finfish and shellfish are extremely sensitive to sediment cover. Sediment management must reflect an understanding of the physical and ecological links to sand movement throughout the lower Columbia River, estuary and adjacent coastal waters. Regional and comprehensive understanding is required to resolve conflicts between, for example, a proposed channel deepening project with $34 million in annual economic benefits and the crab fishery that provides in excess of $30 million in annual income.

Providing the science base for management of the resources of the Columbia River system will inform our understanding of coastal systems nationwide. The processes of sediment supply and transport and the physical and ecological links to sediment accumulation and movement are fundamental to coastal systems everywhere. At the same time, activities must recognize the unique aspects of the Pacific Northwest. Human alteration and use of coastal resources varies greatly, as do natural processes. In the Pacific Northwest, resource and human vulnerability assessments must include the potential for catastrophic change associated with regional earthquake events. The Pacific Northwest is exemplary of the need for integrated system-scale research and information. The USGS is uniquely capable of providing the understanding of geologic, hydrologic, geographic, and ecological factors and processes that is required. Federal, State, and local partnerships are critical to identifying needs, balancing conflicting requirements, and developing adaptive management strategies.

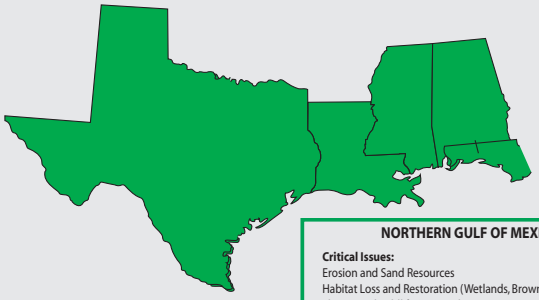
The proposed Program explicitly recognizes that integrated and consistent information, properly managed, accessible, and coupled with user-friendly tools and science-based understanding, has greatly enhanced value. Program implementation further ensures that Program activities respond to immediate regional needs and Federal obligations while addressing long-term national needs; reflect the unique capabilities and responsibilities of the USGS; and build upon and enhance the value of the wealth of information currently available. Program planning, implementation, and evaluation of performance will entail regular and responsive engagement of stakeholders and partners regionally and nationally. Interagency working groups will provide coordination across Federal agencies.

Ultimately, the test of our knowledge will be our ability to anticipate future stressors to coastal systems, design effective programs for ecosystem protection and restoration, and predict the future evolution of coastal systems. Decision-support tools will integrate results of data collection and research activities, with feedbacks so that predictive models and data collection programs evolve. Decision-support tools and predictive models will include:

- Tools for managing, integrating, analyzing, interpreting, and visualizing information;
- Models of the transport and accumulation of sediment and contaminants;
- Tools for comparing and explaining the differences among and within coastal systems in their susceptibility to change induced by nutrient enrichment;
- Models for evaluating the outcomes of different scenarios of land-use or climate change on the inputs of sediments, nutrients, or contaminants to coastal waters;
- Tools for evaluating the potential effectiveness of alternative approaches to the protection or restoration of coastal ecosystems;
- Models of the geomorphic and ecosystem response to coastal storms, sea level rise, and human and natural process that mobilize and transport sediment.

Extreme Coastal Change in the Northern Gulf of Mexico

Nowhere in the United States is the complexity of societal and natural pressures more apparent than in the Northern Gulf of Mexico. The result is a landscape that changes at rates unmatched nationwide. The Northern Gulf of Mexico contains some of the world's most diverse and productive ecosystems, including a large percentage of the Nation's estuaries, barrier islands, and salt and brackish marshes. The safety, health, economy, and culture of the rapidly expanding population in this region are increasingly threatened.



NORTHERN GULF OF MEXICO

Critical Issues:
Erosion and Sand Resources
Habitat Loss and Restoration (Wetlands, Brown Marsh, Sea Grass)
Threatened Wildlife (Sea Turtles, Migratory Sea Birds)
Storms and Sea Level Rise (Subsidence)
Nutrient Loading and Hypoxia
Offshore Resources and Habitat
Tramsport, Fate, and Impact of Pollutants
Invasive and Nuisance Species

Priority Study:
Regional Influence of River Systems:
Mississippi River to Mobile Bay

Natural resources in the region are under intense pressure from extractive activities, navigation and flood control projects, and large-scale land-use change associated with industrial, agricultural, and municipal development. The Mississippi River deltaic plain is experiencing the most extreme rates of coastal erosion, subsidence, and land loss on the continent. Rapidly rising relative sea level is increasing the already substantial impacts of coastal storms and hurricanes. The large and growing pressures of development are responsible for many of the current stresses to coastal resources, which include water quality and sediment pollution, increased flooding, loss of barrier islands and wetlands, and declining fisheries. In addition, this region is impacted by the development of oil, gas, and mineral resources. The Gulf accounts for over 95 percent of the U.S's outer continental shelf oil and gas production, and the region processes over two-thirds of the Nation's oil imports. Invasive species are a serious threat to native biota in many Gulf coast ecosystems, and aquatic nuisance species pose serious economic problems; interfering with transportation, energy production, reservoir capacity, and recreational uses.

About 25 percent of the Gulf Coast's shellfish-growing areas are closed due to pollution, increased nutrient loading of the Mississippi River causes hypoxia in a 7,000 square mile region of the Gulf each summer, and chronic algal blooms occur in many of the region's inshore waters. Over 80 percent of U.S. coastal wetland losses have occurred in the Gulf Coast region since 1940, and predictions of future population growth, coupled with accelerated sea level rise, portend increasing pressure on Gulf Coast communities and their environment. Despite these pressures, the Gulf coastal margin remains important to the Nation in terms of both renewable and non-renewable resources. Gulf coast ecosystems support most of the Nation's wintering waterfowl and account for about half of the fisheries production of the lower 48 states.

USGS collaborative research with the Louisiana Department of Wildlife and Fisheries led to a coast wide vegetative survey for 1997 and 2001. The resulting information is being used in implementation of the Coastal Wetlands Planning, Protection, and Restoration Act to evaluate the effectiveness of large-scale restoration projects ($200 million). The data are also being used to assess nutria damage to wetlands and to monitor a 10-year, $5 million a year effort to eradicate nutria and alleviate wetland loss.

Issues in the Northern Gulf of Mexico require a comprehensive regional approach. Coastal change, in all its aspects, is fundamentally dependent on the delivery of sediment, nutrients, water, and contaminants from the Mississippi River and other major river systems. The impacts of modifications to the Mississippi River and watershed are regional in scope, as are the impacts of subsidence, sea level rise, and hurricanes. The USGS proposes a comprehensive approach to the Northern Gulf of Mexico to include resource characterization and assessment, research on coastal change dynamics and hazards, studies of the ecology of wetland, estuarine, and nearshore habitats, and improved understanding of the geochemical cycles of nutrients within benthic habitats and wetlands. The proposed regional science effort will provide decisionmakers information and products that are needed to address many current problems in the region and to plan for the intensive growth that is anticipated over the next 25 years. With an integrated and regional science base, Gulf Coast managers can design effective projects to manage freshwater and sediments to mitigate hazards and maintain commerce while sustaining and restoring natural resources.

PROGRAM IMPLEMENTATION

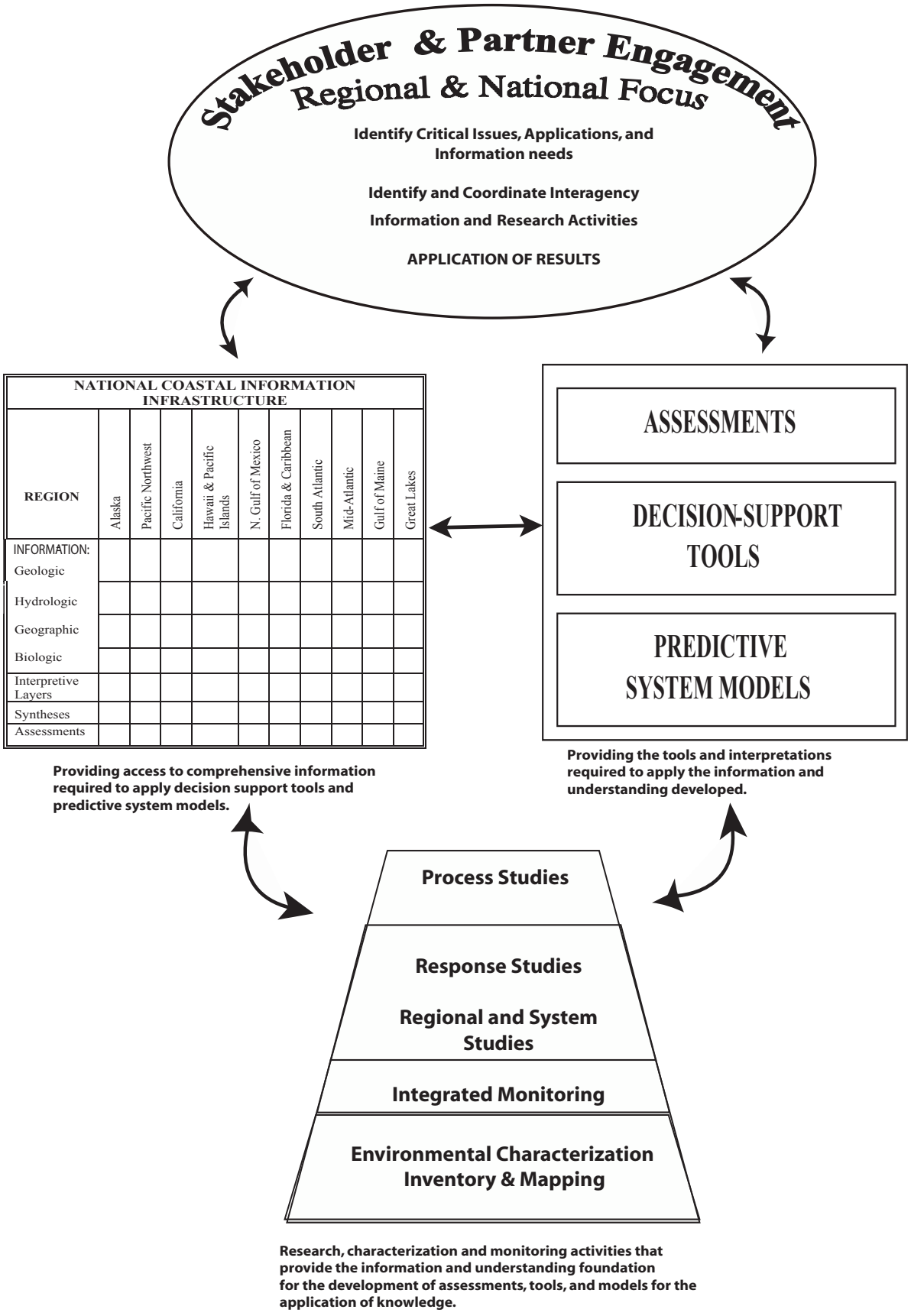
Initial program implementation includes expansion of existing USGS efforts through five centerpiece activities:

1. Establishment of a National Coastal Information Infrastructure for coastal systems, populated initially with existing information and leading to a source of consistent and reliable information with the appropriate science-based tools to support research and decisionmaking. The NCII will be developed as a focal element of the broader National Spatial Data Infrastructure, a major focus of USGS activities for the next decade. The National Biological Information Infrastructure has shown the effectiveness of partnership efforts to build seamless information systems. The USGS will provide leadership in the creation of an information infrastructure for cooperative development. Initial focus: Regional and interagency forums will be established to identify critical information needs and to develop standards and protocols for consistent information management and dissemination. The NCII will be initially populated with critical, existing information (for example, merged topography/bathymetry and historic nutrient inputs), enhancing availability and consistency. Activities will focus on providing multidisciplinary information resources to support integrated assessments, research addressing priority regional and system-scale environments, and identification of information gaps.

2. Establishment of an integrated monitoring network that provides comprehensive information describing representative coastal systems, human influences, and system response to both human and natural processes. These efforts will support intensive system studies and provide the persistent monitoring to document and understand coastal change on all relevant time scales. Initial focus: For priority watershed-scale systems, establish permanent and temporary monitoring of inputs of nutrients, freshwater, sediments, and selected contaminants. Mapping and inventory activities will address information gaps in environmental characterization and documentation of change for these monitored systems.

3. Initiation of efforts to provide environmental characterization essential to all coastal systems. Data characterizing, for example, elevation, surface geology, habitat distribution, and land use are critical to assessing health and vulnerability and applying decision-support and modeling tools in any setting. New technology provides the means to effectively, efficiently, and widely provide information characterizing the critical physical and ecological components of coastal systems. Initial focus: Initiate a systematic approach to mapping elevation, surface geology, habitat distribution and land use with emphasis on DOI and other Federally managed lands and waters and priority environments. Develop protocols for inventory and monitoring of critical populations and communities.

4. Expansion of research activities that focus on particular processes that drive coastal change, link elements of coastal systems, and illuminate the cause-and-effect nature of system response. Response studies will focus on the response of coastal systems to short-lived and extreme events. Process research will provide the understanding that supports development of broadly relevant applications, decision-support tools, and predictive models. Process research will be coordinated with integrated monitoring and system study activities to increase effectiveness. Initial focus: Research and model development will address sediment transport processes; the uptake, cycling, and impact of changing nutrient loads; the structure and function of coastal habitats; the relation between coastal habitats and biological communities; and the societal and ecological impacts of coastal storms and sea level rise.


Stakeholder & Partner Engagement
Regional & National Focus
Identify Critical Issues, Applications, and Information needs
Identify and Coordinate Interagency Information and Research Activities
APPLICATION OF RESULTS
NATIONAL COASTAL INFORMATION INFRASTRUCTURE
REGION
Alaska
Pacific Northwest
California
Hawaii & Pacific Islands
N. Gulf of Mexico
Florida & Caribbean
South Atlantic
Mid-Atlantic
Gulf of Maine
Great Lakes
INFORMATION:
Geologic
Hydrologic
Geographic
Biologic
Interpretive Layers
Syntheses
Assessments
ASSESSMENTS
DECISION-SUPPORT TOOLS
PREDICTIVE SYSTEM MODELS
Providing access to comprehensive information required to apply decision support tools and predictive system models.
Providing the tools and interpretations required to apply the information and understanding developed.
Process Studies
Response Studies
Regional and System Studies
Integrated Monitoring
Environmental Characterization Inventory & Mapping
Research, characterization and monitoring activities that provide the information and understanding foundation for the development of assessments, tools, and models for the application of knowledge.

5. Expansion of research activities that address critical regional issues through a system-scale and integrated approach. Regional/system studies, approximately 5 years in duration, will address chronic issues at regional and watershed scales. Initial focus: Supported by activities under 1, 2, 3, and 4 above, expand efforts to understand the complex response to human and natural processes of the Chesapeake Bay, San Francisco Bay, Tampa Bay, Northern Gulf of Mexico, and Pacific Northwest systems. Begin planning, with stakeholder input, for intensive studies of Great Lakes, California, and North Carolina systems.

The five centerpiece activities are intimately linked. For example, significant Program resources will be applied to system-scale or regional studies to address critical regional issues. These studies will build on integrated monitoring and environmental characterization efforts, as well as existing information incorporated in the NCII. The information infrastructure developed will support the system-scale research and provide a regional context for effective process research studies. Similarly, results will be incorporated in the NCII to contribute to the development of each of the products described in the previous section. The resulting Program will consist of elements that are linked and coordinated to achieve mission effectiveness. USGS activities will be leveraged with those of other Federal and State agencies. Available expertise will be enhanced through funding of cooperative research with external researchers, including the academic community.

Research activities will provide the understanding of coastal processes and human impacts that are required to effectively identify information needs, develop decision-support tools, assess coastal condition and vulnerability, and develop system models. Research activities will include:

- Hydrologic, geographic, and geologic research to address the surface and subsurface processes that control the delivery of freshwater, sediment, nutrients, and contaminants from the watershed to the coast,
- Hydrologic, geologic, geochemical, and biological research to address the accumulation, transport, and impact of these materials within coastal systems,
- Multidisciplinary research to define the structure and function of coastal habitats, substrates, and biological communities. A research priority will be the biogeochemical and geochemical processes controlling the cycling of nutrients and contaminants within benthic habitats and biota, and the relationship of these processes to the health of animal and plant communities,
- Studies of the physical, hydrologic, and ecological response of coastal systems to storms, earthquakes, and extreme inputs of sediments, nutrients, and contaminants, and
- Studies of the response of coastal landforms and ecosystems to climate change and sea level rise.
- Studies of responses of coastal systems to human activities including energy, mineral, and water resources development; interruption of sediment supply and transport; and land-use changes.

Enhanced Mapping, Inventory, and Monitoring: Providing Critical Data, Supporting Integrated Science

Within the proposed Coastal Program mapping, inventory, and monitoring efforts are essential components providing the basis for development of integrated assessments and science-based predictive models and decision-support tools. They also provide the essential characterization of coastal systems and coastal change required by the USGS and others to support effective research programs and to identify critical and emerging issues. Expanded mapping, inventory, and monitoring programs are essential to providing the fundamental data needed for a variety of federal, state, and local efforts to manage coastal resources within the existing regulatory framework. In short, the proposed data collection efforts are essential to developing the science-based understanding required to better manage coastal systems in the future while providing immediate benefits in the development and assessment of solutions to coastal issues.

The need for enhanced mapping, inventory, and monitoring is reflected in the joint effort by federal and academic partners to define and establish an Integrated Ocean Observing System (IOOS). USGS efforts will contribute to and be coordinated with this broad interagency partnership effort. The critical need for persistent and long-term monitoring efforts was emphasized in the National Research Council's (NRC) review "Clean Coastal Waters: Understanding and reducing the effects of nutrient pollution" completed in 2000.

"The duration of any monitoring program is particularly important. Since the purpose of monitoring involves, among other things, the detection of trends, the length of monitoring must be sufficiently long to allow separation of naturally occurring trends from anthropogenically-induced changes. Unfortunately, the political will to maintain long-term funding for monitoring programs is often lacking because such programs rarely (and were never intended) to produce major breakthroughs in understanding. The U. S. Geological Survey (USGS) stream monitoring program has provided excellent data on stream flow and nutrient content for many years. These long data sets allow monitoring of changes in runoff characteristics on decadal time scales and development of statistical models of discharge and load. But the gradual reduction of this network over recent years, primarily because of budget pressures, has had dramatic effects, reducing our capability to estimate flow. The data collected by the USGS are invaluable, and continuation of this monitoring is essential. However, USGS monitoring network was not designed specifically to assess inputs to coastal regions. The committee concludes that there are major missing pieces in the resultant data set that are needed to support the management of healthy ecosystems; for instance, monitoring sites "below the fall line" (the transition point between lowland and upland portions of rivers, marked by waterfalls and other rocky stretches that limit navigability) are few and far between. Since many of our older, eastern cities arose at these transition points, the network is failing to cover areas down river containing significant population centers. An important aspect of any discussion of national monitoring should be expansion of the USGS monitoring program so that it better assesses nutrient inputs to estuaries and tracks how these change over time." (Page 207)

The proposed Coastal Program includes support for monitoring efforts following the recommendations of the NRC. Expanded monitoring of coastal fluxes would be developed in an integrated context with other USGS efforts and those of the IOOS. While ensuring the development of long-term records, an integrated approach will enhance the immediate value of monitoring data while providing the framework for "breakthroughs in understanding."

SETTING PROGRAM PRIORITIES

The activities and objectives outlined in the preceding sections describe a Program that is national in scope. The long-term objectives of the Program provide a context for each proposed activity. Effective program implementation requires that program activities contribute to short- and long-term objectives and provide information that is exploited to provide maximum value. In setting priorities, program studies will be evaluated in terms of three criteria.

1. Activities must address critical and immediate regional needs and Federal obligations.

   The USGS has a Federal role to provide information for setting national policy and identifying national issues, but most applic ations will be at regional or smaller scales. Coastal information is critically required to address regional and local issues, and to address Federal land management and regulatory obligations. The National Coastal Program will engage regional and Federal stakeholders in the identification of critical issues and needs, the development of Program plans, and the assessment of Program products and performance.

   In every coastal region of the Nation there is a common need for basic characterization of coastal resources and processes. Nonetheless, each region faces a unique suite of issues and related social costs. For example, offshore mapping to identify sand resources is most critical to those regions faced with severe shoreline erosion. In those areas, identification of sand resources suitable for beach nourishment is critical to assessing the cost of mitigation strategies. In order to ensure responsiveness to regional needs, the Program will plan, implement, and assess activities collaboratively with stakeholders within 10 separate regions. These regions, defined on the basis of oceanographic, geologic, political, and climatic boundaries include:

   - Alaska
   - Pacific Northwest (Oregon, Washington)
   - California
   - Hawaii and Pacific Islands
   - Northern Gulf of Mexico (Texas to Florida Panhandle)
   - Florida and Caribbean Islands
   - South Atlantic (Georgia to Cape Hatteras)
   - Mid-Atlantic (Cape Hatteras to Cape Cod)
   - Gulf of Maine (Cape Cod to Canadian Border)
   - Great Lakes

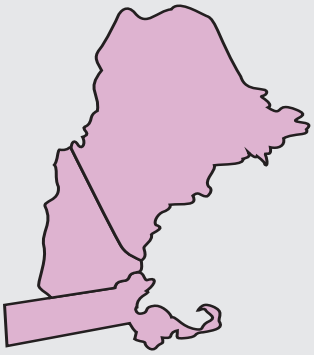
   This regional focus will also be reflected in the development of studies that address issues on the "system-scale" that defines the response of coastal systems. The USGS, as a Federal agency, has a unique ability to address coastal issues at scales that span political or jurisdictional boundaries.

   As the Nation's principal natural science and information agency, the USGS must also be responsive to other Federal agencies. Effective management of Federal lands in national parks and seashores and wildlife refuges, as well as meeting the obligations associated with trust and endangered species and a variety of Federal regulatory missions, requires consistent and reliable information. Meeting these needs is a priority of this Program, building on the existing strong relationship of the USGS with the land management agencies.

2. Activities must contribute to the overall objectives of the National Coastal Program to provide broadly applicable information and understanding.

   While responding to critical regional issues and meeting specific information needs, Program activities must contribute to a broader understanding of coastal systems that supports the development of predictive models that are generally applicable. The proposed Program explicitly recognizes that consistent and integrated information has application far

Sustaining Healthy Ecosystems in the Gulf of Maine



GULF OF MAINE

Critical Issues:
Fish and Wildlife Habitat
River and Watershed Modifications
Pollution
Atlantic Salmon Populations and Habitats

Priority Study:
Ecosystem Requirements for Healthy Fisheries

Understanding the requirements for healthy and sustainable ecosystems within naturally dynamic systems increasingly impacted by human activities is essential to the development of management strategies across the Nation. The Gulf of Maine region, characterized by a diversity of geologic conditions ranging from sandy barrier island and dune ecosystems along Cape Cod to the glacially scoured bedrock coast extending from Boston to the Maine border with Canada, has been densely populated for the past 200 years; as a result, many coastal and marine habitats are damaged or threatened. Boston, one of the Nation's first urban centers, has expanded at the expense of coastal wetlands that were systematically dredged and filled, and are heavily polluted. Boston Harbor and Massachusetts Bay are only now being cleaned up as a result of a major Federal-State restoration program. The commercial fishing industry of cod and other important stocks has been decimated due to a combination of over fishing, suspected climate change effects, and alterations of seafloor habitats from use of mechanical fishing gear. Many of the rivers of New England that are used by Atlantic salmon for spawning have been blocked by dams for electric generation and waterpower--an unintended consequence has been near extinction of the Atlantic salmon. Long-term coastal erosion is affecting more than three-quarters of the Massachusetts shore and many sandy beaches in New Hampshire and Maine. Forecasts of accelerating rise in relative sea level and more storm activity, along with increasing coastal development and population, have ominous implications for the next 50 years.

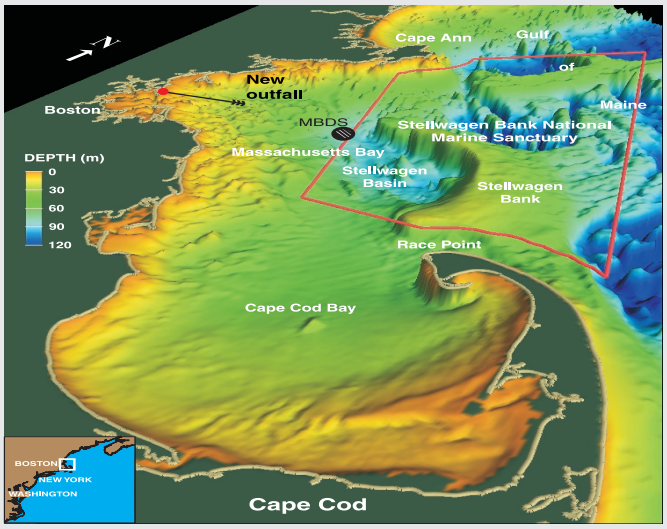


FIGURE 3: Perspective map of Massachusetts Bay and Cape Cod Bay showing the complex underwater topography. The discharge of treated sewage effluent from the Boston metropolitan area is being relocated from Boston Harbor to a new site 15 kilometers offshore in Massachusetts Bay. Detailed geologic maps and circulation modeling provided by the USGS were used in selecting the new outfall location.

The stresses on the coastal and marine environments of the Gulf of Maine result from a complex combination of natural processes, climate extremes and changes that are likely to increase in the next few decades, and the accumulated effects of human activities on the ecosystem over the past 200 years. A clear scientific understanding of the nature of these changes and the discrimination of natural vs. manmade causes is lacking. The USGS has contributed to understanding several of the important issues such as the restoration of Boston Harbor, movement of groundwater pollutants on the Massachusetts Military Base on Cape Cod, and effects of storms and long-term erosion on Cape Cod's barrier beaches; but many other coastal issues remain to be addressed, and systematic mapping of sea floor habitats is needed but lacking. Timely provision of research results have already had a substantial impact. USGS mapping, monitoring, and modeling have been critical to the successful efforts to clean up Boston Harbor. Seafloor maps were used to site Boston's new sewage outfall and contributed to the design of a more efficient and cost effective monitoring program required under Federal law. USGS models of the transport of sewage were used by the Massachusetts Water Resources Authority to evaluate and gain approval for downsizing the planned sewage treatment plant, saving Boston area ratepayers an estimated $160 million. Future USGS research in the Northeast would build upon existing data and gather new information so as to be able to assemble information systems that would be used by Federal, State, and local managers and planners to protect and restore coastal resources and meet the needs of the public for recreation, marine resources, and a healthy environment.

beyond the immediate issue of concern. For example, characterization of coastal geology and geologic change to address issues related to erosion provides information that is fundamental to understanding the distribution and response of coastal habitats. The design of issue-specific approaches must provide information that is appropriate to broader objectives. Information management, establishment of standards and protocols, and the development of appropriate tools for application are critical.

System-scale and process research contributes to long-term Program goals when there is an effective transfer of the understanding that results. For example, the Pacific Northwest includes long stretches of coastal cliffs subject to failure and erosion. The coastline responds, in part, to the inter-annual and decadal scale variation in sea level associated with climatic events such as El Nino. The coastal cliffs of the Great Lakes are similar in form, and water levels vary significantly on similar time scales. Understanding coastal response to water level fluctuations in one region is relevant to the other. Again, the design of site-specific studies, and the subsequent dissemination of results, should promote this broader application.

Program activities must ensure that this transfer of knowledge is completed. National assessments, broadly applicable predictive models, and an integrated information framework are elements of the Program that actively seek to synthesize and integrate information from individual studies. Program activities will be evaluated in light of immediate benefits and as they contribute to long-term and broader objectives. The development of fully realized predictive models for coastal systems will require a persistent effort over many years. While addressing time-critical issues, the USGS must continue to invest resources in understanding those fundamental processes that represent the incremental advancements toward long-term objectives.

3. Activities must result in the optimal use of resources through coordinated application of the capabilities of the USGS and cooperators and full exploitation of existing and new information.

   The USGS does not have the capabilities, the resources, or the responsibility to provide all the information, knowledge, and tools that are required to meet the challenges described here. The objectives described will only be met through coordinated efforts with State, other Federal, academic, and private sector cooperators.

   Significant Program resources will be provided to ensure that data and knowledge integration are facilitated. Exploiting the full value of information requires a consistent and integrated approach to data management and dissemination. New tools for management and analysis of digital data (Geographic Information System and relational databases) promise to greatly enhance the value of information. There is a wealth of existing information, from a diversity of sources, that has untapped value. Incorporating this information in an integrated information infrastructure will have immediate benefits. Compiling existing information will enable identification of information gaps, an important first step in setting priorities. Existing information will also provide a historic perspective critical to identifying issues and extending the range of monitoring efforts.

   The comprehensive National Coastal Program described here aims to meet the science needs of regional stakeholders; to develop broadly applicable tools and models relevant to coastal systems nationwide; and to provide baseline information and the fundamental understanding required to apply that information. Program activities must be coordinated to ensure that efforts effectively address each of these aims. For example, mapping and monitoring are not separable from regional and fundamental research activities. Each Program element depends upon and supports other activities required to meet Program objectives.

Climate and Lake Level Variability in the Great Lakes

Some of the Nation's most highly developed shoreline is found along the Great Lakes. In 1990, over 31 million people lived in the U.S. portion of the Great Lakes. Great Lakes coastal areas support extensive recreation, tourism, and fish and wildlife habitat, and are dependent on the Lakes for shipping and water supply. Commerce, navigation, water-use, and land-use pressures have resulted in a need to manage Great Lakes water levels and to better understand the impact of water levels on coastal resources and development. Water level management activities have the potential to profoundly alter coastal areas, the quality of life for people, and the habitat needed to support fish and wildlife. The USGS maintains a longstanding program to assess the abundance of prey fish, the food source for commercial fish species, throughout the Great Lakes. Results of this assessment, along with the documentation of variability in populations that has developed over time, are used by State and Provincial fisheries management councils to define fisheries goals to ensure sustainable commercial and recreational fisheries.

Natural water level variations in the Great Lakes can far exceed those of open ocean shorelines and can be as much as 18 inches per year and 5-6 feet on decadal time scales. Since late 1997, in response to below-average rainfall and above-average temperatures, lake levels have dropped dramatically. Levels in Lakes Michigan and Huron have dropped at the fastest pace ever recorded, resulting in a 5-8 percent decrease in the value of commercial shipping on the Lakes. Millions of dollars have been spent to maintain harbors, marinas, and navigation channels. In contrast, in periods of high water levels, coastal erosion and the resultant loss of property and wetlands are of great concern.

Natural fluctuations in water level are essential to maintaining coastal habitats, but the sensitivity of habitats to extremes is poorly understood. In this respect, the Great Lakes are a valuable laboratory for studies of the potential impacts of future sea level rise.

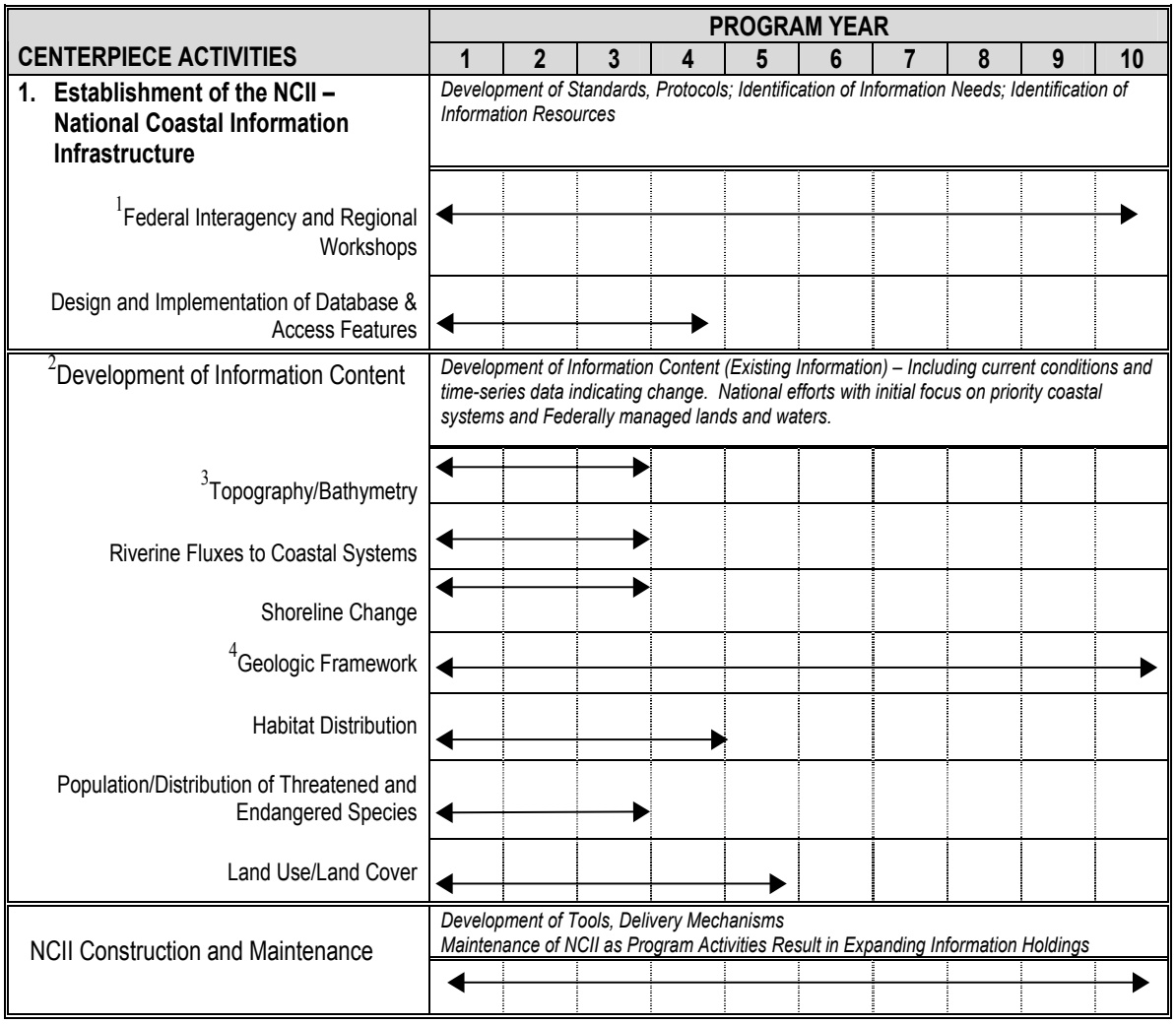
The widespread impacts of water level variations in the Great Lakes demand an integrated system-science approach. USGS research will provide characterization of resources sensitive to water level variations and understanding of the vulnerability of shoreline development and habitat quality, quantity, and biodiversity to managed and natural changes in water level. Studies will also address the impacts of changing exposure to concentrations of persistent chemical contaminants associated with variable water levels. Ultimately, USGS research will allow managers to consider the impacts of regional climatic changes, including changes in temperature and precipitation as well as lake level on coastal systems. Providing useful tools to support decisionmaking will require integration of USGS information with economic and infrastructure evaluations. For example, the costs of upgrading aging sewage treatment infrastructure and regulating non-point pollution sources should be measured against the potential economic losses associated with overflows resulting from more intense precipitation. USGS efforts will provide the basis for predicting the impacts on coastal ecosystems and resources of climate and human-driven change.

National Coastal Program
Proposed Timelines

The timelines are organized to highlight the five centerpiece activities described in the preceding text. Each activity, while contributing to national objectives, supports those priority regional studies that are the primary building blocks of the proposed program. Regional studies include both larger-scale efforts and efforts that build on existing USGS integrated ecosystem programs in San Francisco Bay, Chesapeake Bay, and Tampa Bay.

Ongoing efforts and advanced planning provide the basis for immediate expansion of activities in San Francisco Bay, Chesapeake Bay, and Tampa Bay, as well as implementation of comprehensive and coordinated efforts in the Gulf of Mexico and the Pacific Northwest regions. Regional studies, exclusive of planning and synthesis efforts, are planned as 5-year efforts. USGS programs are currently active in each of these regions.

National Coastal Program
Proposed Timelines



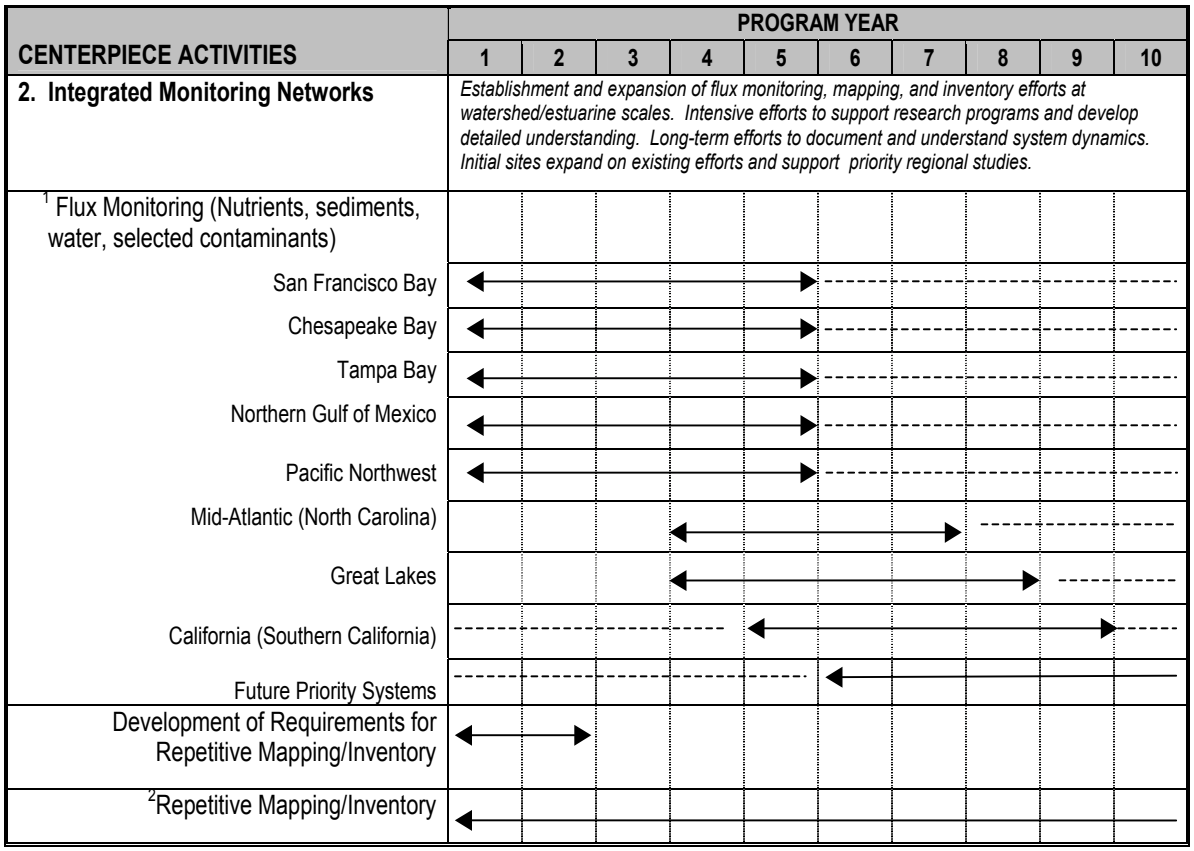
[1]Includes regional planning activities prior to implementation of regional studies. Subsequent planning, coordination, and outreach activities are provided for in the region-specific line items that follow.

[2]Systematic efforts to compile, develop quality assurance and control, and standardize existing USGS and externally generated information. These national efforts will initially focus on the priority coastal systems identified for program focus, and on Federally managed lands and waters.

[3]Process existing topographic data to provide datum control required for merging of topography and bathymetry. Complete development of consistent elevation data (topography and bathymetry) will require enhanced efforts by NOAA to address issues related to bathymetric data.

[4]Supports efforts to establish the regional framework of the United States coastal and marine realms. This addresses two of the Future Science Directions identified in the NRC review of the USGS Coastal and Marine Geology Program and referenced in the congressional directive to the USGS for the development of this Plan: (1) Establish the geologic framework of U.S. Coastal and Marine regions; and (2) develop a national knowledge bank on the geologic framework of these regions.

National Coastal Program
Proposed Timelines



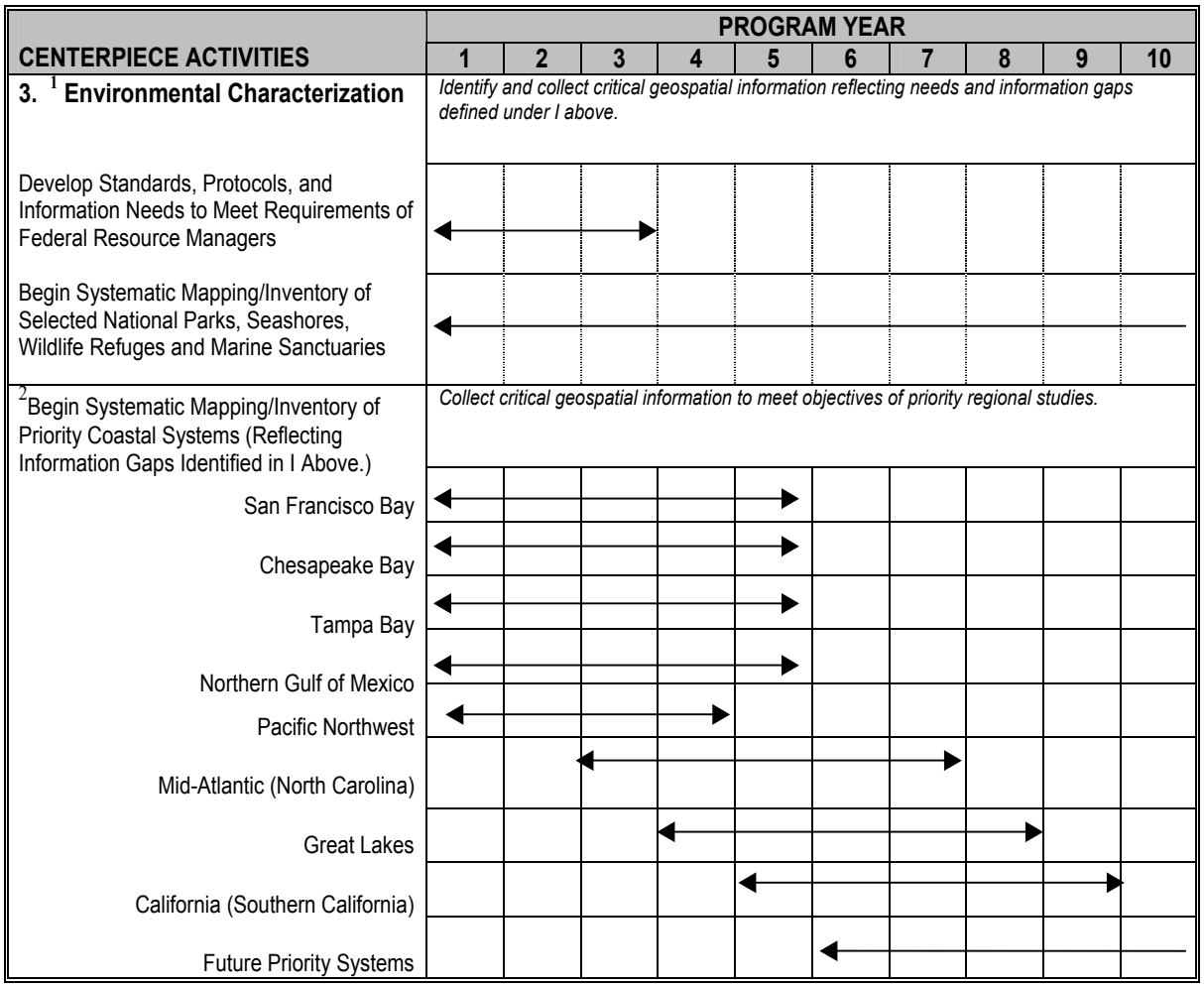
Intensive Phase

---------- Long-Term Monitoring

[1] Supports the establishment of a national network for monitoring fluxes of nutrients, sediments, fresh water, and selected contaminants from rivers and watersheds impacting significant coastal resources. Initial deployment, in priority systems, will include intensive multiple-site monitoring required to characterize regional fluxes and sub-regional spatial variability. Analyses of intensive phase monitoring will provide the basis for selection of permanent sites of reduced spatial distribution and sampling intensity.

[2] Repetitive mapping and inventory requirements will be determined to document significant changes in shorelines, land-use, land-cover, habitat and distribution of threatened, endangered, and indicator species. Focus on integrated monitoring sites will supplement regional/systems scale efforts and provide persistent long-term monitoring on sub-regional scales. Repetitive efforts will ensure that decision-support systems are based on up-to-date and accurate information. Results will also support the development and validation of models of system evolution in response to natural and human processes. Repetitive mapping will be focused on those systems that are subject to integrated monitoring efforts crucial to documenting and understanding the processes that drive coastal systems.

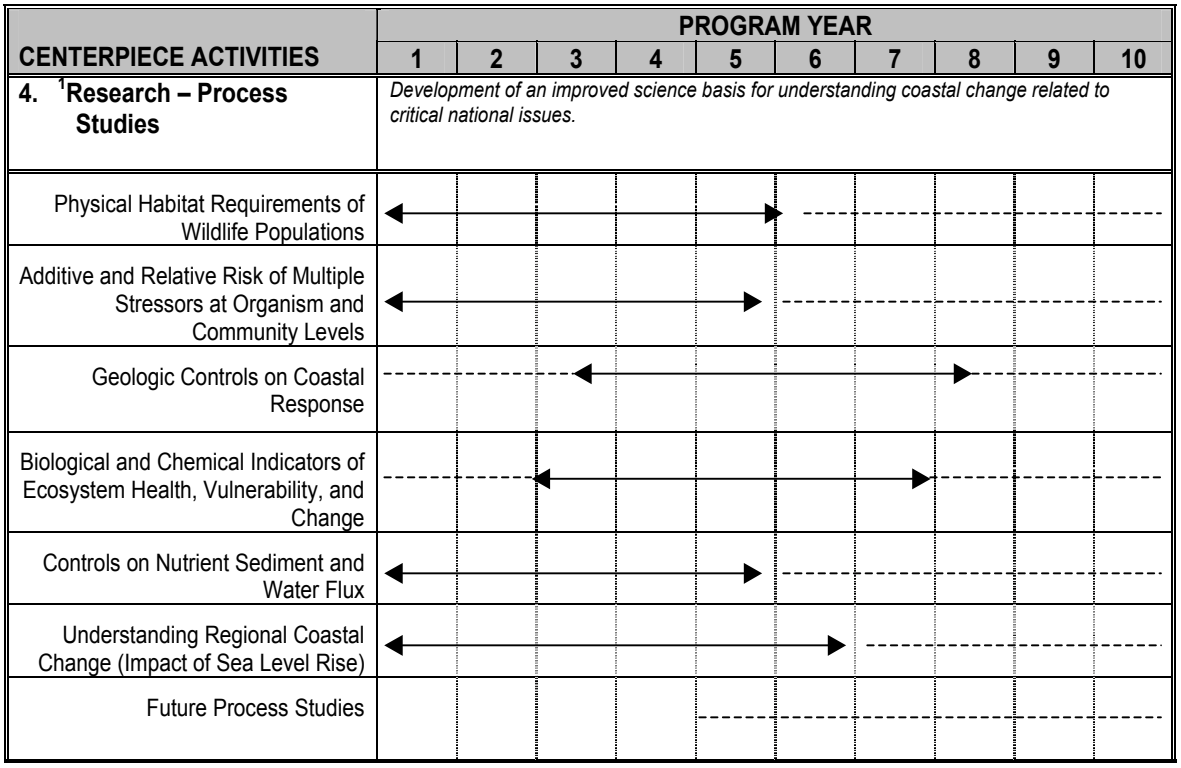
National Coastal Program
Proposed Timelines



[1] Standards, protocols, and information needs will reflect guidance provided by the recently initiated NRC Coastal Mapping and Charting Study funded by the USGS, NOAA and EPA. This study will be particularly relevant for identifying the national needs for improved topographic and bathymetric data. Topographic data collection efforts within this proposal will support priority regional studies as well as DOI managed resources. Expanded efforts to provide more complete regional coverages will require development of cost-sharing approaches with external partners.

[2] Based on information gaps identified through completed planning efforts and activities under Centerpiece Activity I (see previous), efforts will provide up-to-date characterization of topography, shoreline position, geology, land-use, land-cover, habitat, and the distribution of threatened, endangered, and indicator species. Data collection for mapping activities will be accomplished primarily through competitive procurement from private sector providers in accordance with established Federal data standards. Funding will provide for a systematic development of the regional geologic framework of the regional systems identified, addressing one of the Future Science Directions identified in the NRC review of the USGS Coastal and Marine Geology Program and referenced in the congressional directive to the USGS for the development of this plan.

National Coastal Program
Proposed Timelines

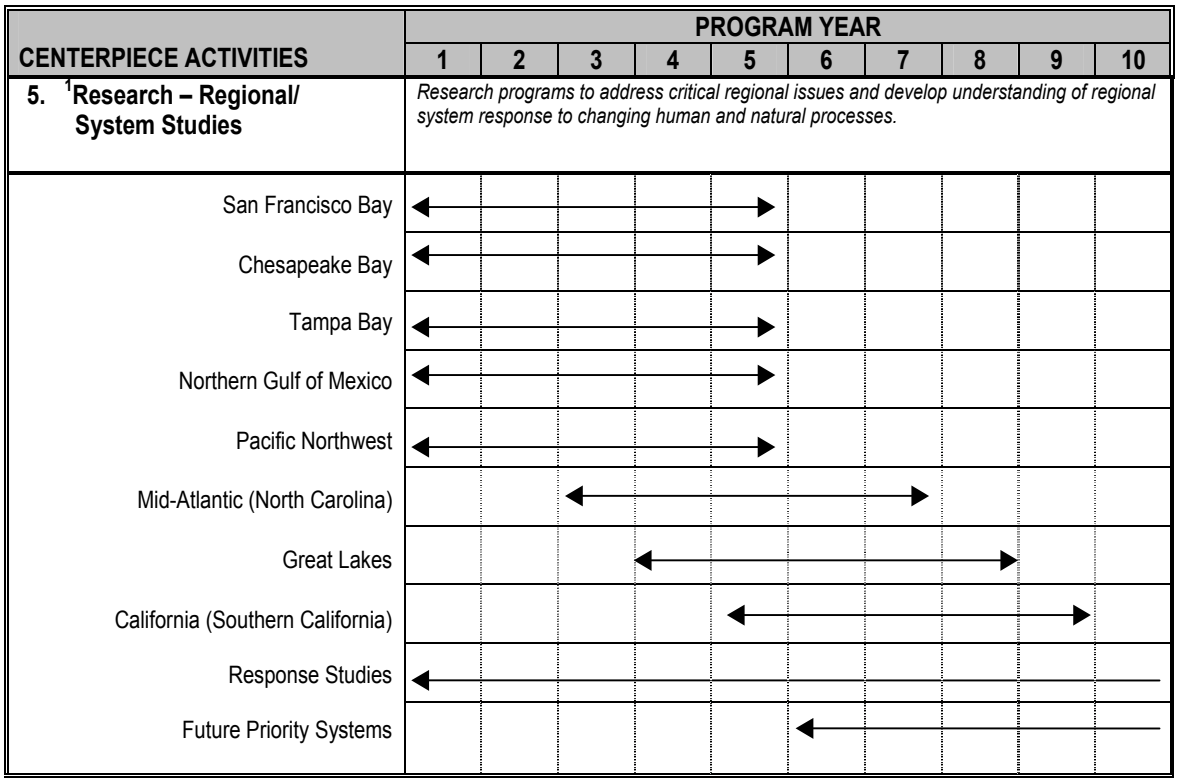


Intensive Efforts

Developmental efforts and activities that build on results of intensive phase investigations.

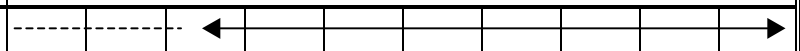
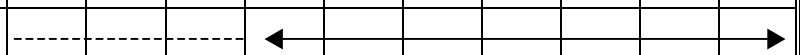
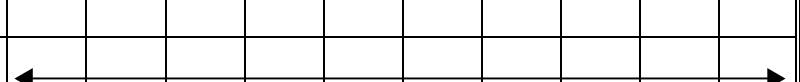
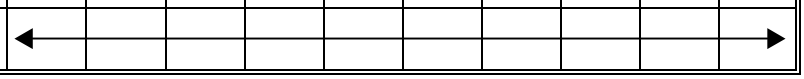
[1] Research activities will contribute to an improved science-basis for understanding coastal change related to critical national issues. Research projects will be developed through a proposal review process designed to identify optimal science projects, leveraged where appropriate to meet regional needs. Process research studies will also support investigation into critical issues, for example Coral Reef Health, that are outside the scope of ongoing regional studies. Substantial funds (35-50 percent of total) will be provided through grants and cooperative agreements to academic researchers and cooperating State agencies. Where appropriate, funding will be provided through existing interagency coordinating mechanisms such as the NOPP to leverage multi-agency resources, to meet multiagency mission objectives, and to insure interagency cooperation.

National Coastal Program
Proposed Timelines



[1] Research activities will contribute to an improved science-basis for decisionmaking with respect to critical regional and national issues. Substantial funds (35-50 percent of total) will be provided through grants and cooperative agreements to academic researchers and cooperating State agencies.

National Coastal Program
Proposed Timelines

PRODUCTS	PROGRAM YEAR									
	1	2	3	4	5	6	7	8	9	10
6. [1]Products/Outcomes	*Syntheses and Analyses Products/Outcomes supported by Centerpiece activities.*									
Regional and National Assessments										
Predictive Models (Process and System Models)										
Decision-Support Tools (Watershed Scale)										
Communication of Results										

[1] Budget category supports the synthesis and development of broadly applicable assessments, models, and tools. Efforts will be based on products of regional studies and processes research. Product definition and development will be a community effort to ensure that a) USGS information and expertise is coordinated and leveraged with activities across the Federal research and academic community, and that b) products reflect the priority needs of the research and resource management communities. Synthesis of results from research activities will build toward predictive models as recommended by the NRC review of the USGS Coastal and Marine Geology Program. Research activities will be supported in the development of predictive models and funding will be provided to incorporate economic and other social scientists in the development of assessments and decision-support tools.