

SAP-4.1

Prospectus for

Coastal Elevations and Sensitivity to Sea-Level Rise

U.S. Climate Change Science Program

Lead Agencies

Environmental Protection Agency
National Oceanic and Atmospheric Administration
U.S. Geological Survey

Contributing Agencies

Department of Transportation
U.S. Fish and Wildlife Service
U.S. Army Corps of Engineers

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This prospectus has been prepared according to the *Guidelines for Producing Climate Change Science Program (CCSP) Synthesis and Assessment Products*. The prospectus was reviewed and approved by the CCSP Interagency Committee. The document describes the focus of this synthesis and assessment product, and the process that will be used to prepare it. The document does not express any regulatory policies of the United States or any of its agencies, or make any findings of fact that could serve as predicates for regulatory action.

**Coastal Elevations and Sensitivity
to Sea-Level Rise**



**1. OVERVIEW: DESCRIPTION OF TOPIC, AUDIENCE,
INTENDED USE, AND QUESTIONS TO BE ADDRESSED**

Sea level is rising 2-3 mm yr⁻¹ along most of the U.S. coast (NOAA, 2001). Rising water levels are converting wetlands into open bodies of water, while allowing wetlands to take over low-lying forests and farms. Ocean beaches are eroding, leading most states to initiate beach restoration projects in which dredges or dump trucks replace the sand lost to erosion. Shoreline erosion along estuaries has led many property owners to defend their back yards by erecting shore protection structures such as bulkheads, which eliminate the intertidal wetlands and beaches that would otherwise be found between the water and the dry land. As sea level rises, coastal flooding is becoming more frequent. In some older low-lying communities, high tides during new and full moons flood streets that were above the tides when originally paved. Rising global temperatures are likely to increase the current rate of sea level rise by 1-7 mm yr⁻¹ in the next century (IPCC, 2001). The Federal Coastal Zone Management Act states: “Because global warming may result in a substantial sea-level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence.” 16 US Code § 1451(l).

Studies over the last 2 decades have identified numerous decisions that may be sensitive to sea-level rise (e.g., NRC, 1987; Williams *et al.*, 1995; Section 3.1 of Titus and Narayanan, 1996). To inform those decisions, better information about the implications of sea-level rise is needed at various scales. For analyzing national decisions (e.g., incorporating shoreline retreat into flood insurance or wetland protection programs), nationwide estimates are important, perhaps with a state-by-state breakdown. Shore-protection and land-use decisions, by contrast, are mostly made at the local level or on a parcel-specific basis; those decisions require maps that show site-specific implications. Researchers may require fine-scale maps for process-specific analysis and coarse-scale data for analyzing broader implications.

During the 1980s and 1990s, quantitative assessments of the implications of sea-level rise generally proceeded on two independent tracks to meet the very different needs of national (Park *et al.*, 1989; Leatherman, 1989; Weggel *et al.*, 1989; FEMA, 1991; Titus *et al.*, 1991; Gornitz and White, 1992; Yohe *et al.*, 1996) and state or local decisionmakers (Kana *et al.*, 1984; Leatherman, 1985; State of Maine, 1995, Kearney and Stevenson, 1985). The evolution of geographic information systems (GIS), however, now makes it more feasible to use the information developed in one study for another purpose later. GIS also make it easier to develop information that can be useful for a variety of scales (Kemelis *et al.*, 2003).

These recent advances do not, however, imply that all of the implications of a rising sea are well understood. The effects of sea-level rise include tidal inundation of low-lying areas; coastal erosion of wetlands, beaches, and other types of shores; vertical accretion of wetlands; barrier island migration; increased coastal flooding during storm surges and periods of extreme rainfall; and increased salinity of aquifers and estuaries, especially during droughts. Providing maps that predict effects other than tidal inundation is scientifically challenging at best, and in some cases, impossible. Scientific literature may provide the basis for a



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qualitative prediction, but not always with the precision—or in the form—that decisionmakers prefer.

Many agencies and individuals are developing data that can provide insights regarding the implications of sea-level rise. For example, the Federal Emergency Management Agency (FEMA), the Army Corps of Engineers, and several states are developing elevation data for floodplain management. The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) are developing Digital Elevation Models (DEMs) that use a common vertical reference frame for both topographic and bathymetric maps (NOAA, 2004). Local governments and major coastal land conservancies are developing GIS land-use data for managing ecosystems and economic growth. U.S. Fish and Wildlife Service (USFWS) develops wetland data. NOAA's coastal change analysis program periodically provides a comprehensive assessment of land-cover changes in the coastal zone of the United States. USGS collects high resolution LIDAR elevation data for coastal areas for use in producing assessments of shoreline erosion and other coastal processes through its National Assessment of Coastal Change Hazards (e.g., Morton *et al.*, 2004 ; Morton and Miller, 2005; Thieler and Hammar-Klose, 1999, 2000a,b); and FEMA has conducted similar analyses. USGS also evaluates the ability of wetlands to keep pace with rising relative sea level (Rybczyk and Cahoon, 2002). The Environmental Protection Agency (EPA) has been working with local governments to create county-scale maps that identify the areas likely to require shore protection as sea level rises (Titus, 2004). Except for FEMA, all of these agencies will contribute authors to this report.

Synthesis and Assessment Product 4.1 will synthesize information from the ongoing mapping efforts by Federal and non-Federal researchers related to the implications of rising sea level. It will overlay the various data layers to develop new results made possible by bringing together researchers that are otherwise working independently. Because of time, data, and resource limitations, the synthesis will focus on a contiguous portion of the U.S. coastal zone (New York to North Carolina). The report will

also develop a plan for sea-level rise research to answer the questions that are most urgent for near-term decisionmaking. This report will provide information that supports the specific goal in Chapter 9 of the *Strategic Plan for the Climate Change Science Program* (CCSP, 2003) to analyze how coastal environmental programs can be improved to adapt to sea-level rise while enhancing economic growth.

This report will address the implications of sea-level rise on three spatial scales by providing:

- An introductory section that puts the report within the nationwide context
- Data overlays and a state-of-the-art quantitative assessment concerning coastal elevations, shore erosion, wetland accretion, and the areas where shores are likely to be protected for a multi-state study area along the U.S. Atlantic coast (New York to North Carolina)
- Qualitative discussions that document in greater detail the impact of sea-level rise on smaller areas within the mid-Atlantic study area.

The report will focus on the mid-Atlantic region for two reasons. First, the EPA and NOAA studies listed in the *CCSP Strategic Plan* that gave rise to this assessment were already underway in the mid-Atlantic. Second, the most vulnerable regions in the United States appear to be Louisiana, Florida, and the Mid-Atlantic. Louisiana's vulnerability is very different from other parts of the U.S. coast, resulting from the management of the flow of the Mississippi River and very high rates of regional land subsidence. Florida's vulnerability results largely from hurricane flooding; the limited involvement of FEMA and the Corps of Engineers precludes a state-of-the-art flood vulnerability assessment. Although coastal flooding is also important in the mid-Atlantic, it is possible to evaluate the implications of erosion, inundation, shore protection, and habitat loss without a floodplain mapping effort. If data are readily available and time permits, an adjacent state may be added.

Within the multi-state study area, the synthesis product will examine four key questions that address four of the most commonly cited factors contributing to the sensitivity of

coastal lands to rising sea level: low elevations, coastal erosion, wetland accretion, and human modifications of the coastal zone. The four key questions follow:

- 1) Which lands are currently at an elevation that could lead them to be inundated by the tides without shore-protection measures?
- 2) How does sea-level rise change the coastline? Among those lands with sufficient elevation to avoid inundation, which land could potentially erode in the next century? Which lands could be transformed by related coastal processes?
- 3) What is a plausible range for the ability of wetlands to vertically accrete, and how does this range depend on whether shores are developed and protected, if at all? That is, will sea-level rise cause the area of wetlands to increase or decrease?
- 4) Which lands have been set aside for conservation uses so that wetlands will have the opportunity to migrate inland; which lands have been designated for uses requiring shore protection; and which lands could realistically be available for either wetland migration or coastal development requiring shore protection?

The product will answer as many of those questions as possible with a state-of-the-art quantitative analysis for the range of uncertainty regarding current coastal elevations and how much sea level may rise along the mid-Atlantic coast. Where such an analysis is not feasible, the product will rely on older quantitative assessments if possible, or provide a qualitative evaluation. The quantitative assessment may exclude estuarine shores in the case of question 2, and Long Island Sound and North Carolina in the case of question 3.

To ensure comparability with other assessments, the magnitude of sea-level rise considered will be expressed in round numbers such as 25, 50, and 100 cm. Although this product will focus on the impacts of a rise between 25 cm and 1 m, it will also consider the implications of a 2-m rise in sea level, for two reasons. First, in much of the United States, the lowest contour on available topographic maps is 10 feet above the National Geodetic vertical datum of 1929—that is, roughly 2 m above the upper edge of tidal

wetlands. Therefore, the area inundated by a 2-m rise can be more accurately estimated than the area inundated by a rise of 25-100 cm. Second, a 2-m rise in sea level is possible over the next 2 centuries (see, e.g., Section 11.5.4 of IPCC, 2001). To the extent that impacts depend on the timing of sea-level rise, the product will focus primarily on the implications for the 21st century, but it will also consider land potentially vulnerable during the next 2 centuries.

Questions 1-4 are not the only important questions about coastal elevations and sensitivity to sea-level rise. EPA, NOAA, and USGS have solicited contributing authors to help address several additional questions:

- 5) What are the potential impacts of sea-level rise on coastal floodplains? What issues would FEMA, coastal floodplain managers, and coastal communities face as sea level rises?¹
- 6) What are the population, infrastructure, economic activity, and value of property within the area potentially inundated by rising sea level given alternative levels of shore protection?²
- 7) How does sea-level rise affect the public's access to—and use of—the shore?³
- 8) Which species depend on habitat that may be lost due to sea-level rise given various levels of shore protection and other response options?⁴
- 9) Which decisions and activities (if any) have outcomes sufficiently sensitive to sea-level rise so as to justify doing things differently, depending on how much the sea is expected to rise?⁵

¹ Based on Question 9.2 from the *CCSP Strategic Plan*: “What are the ... potential future impacts of [climate change] on human welfare ... and how can resilience be increased and vulnerability reduced?”

² Based on Question 9.2 from the *CCSP Strategic Plan*.

³ Based on Question 9.2 from the *CCSP Strategic Plan*: “What are the current and potential future impacts of [climate change] on human welfare...?”

⁴ Based on Illustrative Research Questions for both *CCSP Strategic Plan* Chapters 8 (“What are the effects of ... increased rates of sea-level rise ... on ... functioning of coastal ecosystems?”) and 9 (“What factors determine the vulnerability of natural systems to the adaptive measures that people may implement in response to global change?”).

⁵ A continuing mission of the *CCSP Strategic Plan* is “Decision Support” which is not possible without a consideration of the decisions that may actually depend on the information produced.



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10) What adaptation options are being considered by specific organizations that manage land or regulate land use for environmental purposes?⁶ What other adaptation options are being considered by Federal, state, or local governments? What are the specific implications of each option?⁷ What are the institutional barriers to preparing for sea-level rise?

Our answers to these supplemental questions will not be as thorough or as quantitative as the answers to the key questions. In some cases, we will rely on a review of the best available information. Most of the answers will be qualitative rather than quantitative or map-based. The report will not necessarily have a separate section to address each of these questions. Although we will address the key questions for the entire mid-Atlantic study area, our answers to most of the supplemental questions will be based on site-specific examples, direct observations, stakeholder input, case studies, or complete results for an area smaller than the entire mid-Atlantic.

2. CONTACT INFORMATION AND ROLE OF PARTICIPATING AGENCIES

EPA, NOAA, and USGS are the key participating agencies, each of which will contribute authors and be involved in the management of this product. DOT, USFWS, and the Corps of Engineers also plan to support this effort.

2.1. Contact Information

The designated contact person for each agency supporting this effort is provided below.

Key Participating CCSP Agencies

EPA	James G. Titus Titus.jim@epa.gov
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⁶ Based on Question 9.2 from the *CCSP Strategic Plan*: "...and how can resilience be increased and vulnerability reduced?"

⁷ Based on Milestone #6 under *CCSP Strategic Plan* Section 9.2.

NOAA	Mike Szabados Mike.Szabados@noaa.gov
USGS	Eric Anderson Eric.K.Anderson@noaa.gov

Other Supporting Agencies

DOT	Robert Kafalenos Robert.Kafalenos@dot.gov
USFWS	Brian Czech brian_czech@fws.gov
Corps of Engineers	Charles Chesnutt Charles.b.Chesnutt@usace.army.mil

2.2. Agency Roles and Responsibilities

EPA is solely responsible the final CCSP deliverable and will perform, or ensure that others perform, the necessary work to ensure project completion. EPA's responsibilities include development of the draft report, as well as the nomination and obtaining of authors and expert reviewers. EPA is responsible for overall project coordination. In addition to these overall responsibilities, the three key participating agencies have specific responsibilities:

- EPA is responsible for compliance with the Information Quality Act (IQA) and Federal Advisory Committee Act (FACA):
 - EPA is the overall project lead agency for project management and as such has responsibility for official reporting purposes for IQA requirements.
 - EPA is responsible for FACA compliance.
 - EPA is responsible for managing the formal literature review portion of the project.
 - EPA is responsible for coordinating the acquisition of the authors' time as needed for this project, except for those authors that are employed by contributing agencies and their grantees.
- NOAA is responsible for logistics:
 - NOAA is responsible for setting up and hosting four meetings for the authors, with the first meeting to be held in Silver Spring, MD, and the other three to be held at suitable locations in the mid-Atlantic region to provide stakeholder input to the authors. NOAA



will manage the invitational travel for the authors as required.

- NOAA is responsible for managing the compilation and production of the final report. This includes editing, report layout, and printing.
- USGS is responsible for the research plan:
 - USGS is responsible for managing the development of a supporting research plan that identifies key areas of applied and basic research that supports and provides a scientific context for this deliverable.

In addition to the three key agencies, DOT, USFWS, and the Corps of Engineers will each provide a contributing author.

3. LEAD AUTHORS AND EXPERT REVIEWERS: REQUIRED EXPERTISE AND BIOGRAPHICAL INFORMATION

EPA, NOAA, and USGS have prepared a list of authors, based on availability to contribute to this product and record of accomplishments in the relevant fields of expertise. Biographical information for the lead authors and most contributing authors is included in Appendix A.

3.1. Authors

The team generating the product (hereinafter “synthesis team”) will have at least five lead authors. The lead authors will be jointly responsible for the entire product, including the text itself and any analysis required to synthesize the underlying studies on which the product is based. The lead authors will decide how best to manage the team, including division of responsibility, time requirements, and whether to designate a managing author.

The team will also have as many contributing authors as necessary. Contributing authors will either be responsible for preparing a case study, contributing analysis of a specific issue, or drafting a portion of the research plan that will constitute the final chapter of the product. Contributing authors will be responsible solely for their own contributions.

3.2. Required Expertise of Authors and Expert Reviewers

Lead authors should be accomplished writers and have technical backgrounds in at least one field relevant to the implications of sea-level rise. Regardless of discipline, each lead author must have produced, or managed production of, a product that informs our understanding of the implications of sea-level rise, or have extensive experience using such products while developing responses to coastal erosion, flooding, or wetland loss.

Contributing authors should have the expertise required to complete proposed contributions that answer one or more of the supplemental questions, or provide essential text for the report. Contributing authors for the research plan must have a general familiarity with key uncertainties regarding the implications of sea-level rise, familiarity with at least one Federal research agency, and an understanding of the general principles of how to set priorities for information collection.

Expert reviewers should have well-established and documented education, experience, and credentials in at least one of the topics that this product will examine (e.g., coastal geomorphology, tidal wetlands, land-use planning, coastal zone management). In addition, several of the reviewers will have a broad level of experience with the issue of sea-level rise. To ensure independence and avoid conflicts of interest, reviewers will not be employees or recent contractors of the Environmental Protection Agency.

3.3. Authors and Reviewers

Lead Authors

James G. Titus, EPA
(Coordinating Lead Author)
Stephen Gill, NOAA
Donald R. Cahoon, USGS
E. Robert Thieler, USGS
S. Jeffress Williams, USGS

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Contributing Authors

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Mark M. Brinson, East Carolina University
Peter Conrad, City of Baltimore
Michael Craghan, Middle Atlantic Center for Geography
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Brian Czech, USFWS
Jeff DeBlieu, The Nature Conservancy
Ducan FitzGerald, Boston University
Benjamin Gutierrez, USGS
Daniel Hudgens, Industrial Economics Incorporated
Nancy Jackson, New Jersey Institute of Technology
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Robert Kafalenos, USDOT
Michael S. Kearney, University of Maryland
Danielle Kreeger, Partnership for the Delaware Estuary
Alexander S. Kolker, State University of New York
Curt Larsen, USGS
Christopher Linn, Delaware Valley Regional
Planning Commission
Doug C. Marcy, NOAA
Laura J. Moore, Oberlin College
Andrew Morang, U.S. Army Corps of Engineers
Denise Reed, University of New Orleans
Ann Shellenbarger Jones, Industrial Economics Inc.
Elizabeth Strange, Stratus Consulting
Jay Tanski, New York Sea Grant Program
E. Robert Thieler, USGS
Michael Weinstein, New Jersey Marine Sciences Consortium
Robb Wright, NOAA
Jue Wang, Pyramid Systems Incorporated

Expert Reviewer Nominees

EPA will assemble a panel of at least 10 expert reviewers representing state and local governments in the multi-state study area, as well as experts on the various issues that the report examines. Reviewers may also include Federal government employees (from agencies other than EPA) and local stakeholders. The public is invited to nominate authors and experts to participate in the peer review of the draft product. Nominations should be sent to <4.1-Sea_Level@usgcrp.gov> by February 1, 2007. Nominations must include CVs and publications listing.

The Environmental Protection Agency has designated a “peer review leader” who will be responsible for ensuring the creation of a balanced and qualified set of expert reviewers. Under the close scrutiny of the peer review leader, an EPA contractor will propose a list of reviewers, based on the public nomination process and other qualified individuals identified by the contractor. The peer review leader will revise the list based on three considerations. First, the peer review leader will ensure that the nominees are technically qualified, based on documented education, experience, publications, and other credentials in their areas of expertise. Second, the peer review leader will screen for real or perceived conflict of interest and independence from the lead and contributing agencies. Finally, the peer review leader will ensure that all nominees comply with the CCSP peer review nomination process. The peer review leader will provide the contractor with the revised list, and the contractor will make the final selection of expert reviewers.

4. STAKEHOLDER INTERACTIONS

Numerous individuals—as well as Federal, state, and local governments and agencies, together with non-governmental organizations (NGOs)—are involved in managing lands that may be affected by rising sea levels. Coastal decisionmakers include coastal planners, engineers, policy analysts, investors, homebuyers, public officials, and citizens who provide input to coastal decisions within the study area.

This report will be primarily written and produced by a subset of stakeholders. The Army Corps of Engineers, USFWS, NOAA, USDOT, and EPA make decisions that affect the coast and produce data needed by decisionmakers. Each of these agencies (with the possible exception of the Corps) will contribute writers to this product; the participation of the Corps will depend on the availability of resources. In addition, at least two state coastal programs will contribute writers. The Nature Conservancy will contribute an author.

State and local governments that will not participate directly in this assessment have participated in the creation of the underlying products. NOAA’s Coastal Zone Management

Program will obtain reviews of the product outline, and each of the underlying products, from all of the state coastal zone management and state wetland regulatory programs within the study area. The Army Corps of Engineers may assist by seeking comments from district wetland regulatory and shore-protection offices. USFWS may seek comments from the coastal refuges and national parks. Sixty city and county planning departments have reviewed the sea-level rise/shore-protection maps of the EPA planning study; EPA will seek comments on the synthesis product from all localities highlighted by the synthesis product.

EPA, NOAA, and USGS have solicited case study contributions in a variety of forums, including the draft prospectus. The contributing agencies will make available the data being developed to answer the key questions (discussed in the next section) for use in developing case studies that need such data. NOAA will coordinate a stakeholder review of the draft report, which will include meetings in three communities vulnerable to a rise in sea level of 2 feet or less, and the lead authors will incorporate stakeholder concerns before the “first draft” for expert review is produced. Public input will also be solicited on a draft of the product following the expert review period.

Public input was also solicited on this prospectus through a notice in the December 14, 2005, edition of the Federal Register. The draft of this prospectus was available for public comment from December 14, 2005, until February 13, 2006. Commenters included representatives from the coastal zone management agencies of Massachusetts, Rhode Island, New York, Maryland, Virginia, Texas, and California; a county manager in North Carolina; a regional planner in Florida; four professors; a coastal consultant; an oil company researcher; and a climate scientist representing an NGO.

5. DRAFTING, INCLUDING MATERIALS TO BE USED IN THE PRODUCT

The product will provide two types of information. First, for the coastal practitioner, this product will provide GIS

files that provide site-specific estimates and assessments of all the quantitative analysis undertaken to address the key questions. Electronic versions of the data will be distributed on CDs or DVDs, with smaller files also available on lead agency web sites. Second, for the general public, CCSP will provide maps and a report that answers the questions. The report will avoid jargon and be written for a general audience. The maps and reports will be placed on the web sites of EPA, NOAA, and USGS.

This product will use GIS databases from a variety of sources. The best data for answering the four key questions will be developed specifically for this product. NOAA and EPA are both producing the specific elevation and shore-protection maps enunciated in the *CCSP Strategic Plan*, which announced this synthesis product. Those studies are essential for answering key questions 1 and 4 identified in Section 1 of this prospectus. For other questions, the product will rely on best available information.

USGS also has ongoing efforts that could support this product—most significantly the ongoing national assessment of coastal change hazards (see key question 2).

The lead agencies will make all of the underlying products available for reviewers so that they can examine the data and assumptions. They will also make the data available to those researchers interested in contributing case studies to the synthesis.

As the principal agency for “The National Map”⁸, USGS may also take on the task of facilitating the exchange of GIS data that may be used in any case studies that might be conducted. In cooperation with other parts of Department of the Interior (DOI), USGS will also investigate the feasibility of contributing GIS layers for subsidence, wetland erosion and accretion, and beach erosion and accretion (key questions 3 and 4), and provide GIS layers

⁸ The National Map is a data set developed by a consortium of federal, state, and local partners who provide geospatial data to enhance America’s ability to access, integrate, and apply geospatial data at global, national, and local scales.



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for as much of the study area as possible. USGS may also provide user-friendly data files that explicitly define those tidal wetlands that tend to be above mean sea level, and those that may be technically inter-tidal but below mean sea level.

EPA, NOAA, DOI, and Department of Defense (DOD) may collaborate to improve EPA's GIS layer responsive to key question 4.

6. REVIEW

This product will include a stakeholder review, an expert peer review, and a review by a Federal Advisory Committee. During the stakeholder review, the lead and contributing agencies will solicit comments on a stakeholder review draft, from state and local governments, and other stakeholders who express an interest. USGS will solicit comments on the research plan from users and producers of the information the plan proposes. The lead authors will modify the product to incorporate the stakeholder concerns and prepare a complete first draft version of the synthesis and assessment product.

EPA will then submit the product to a peer-review panel of experts selected from those nominated in the process described in Section 3.3. To ensure that the peer review panel has the required expertise to review this report, the peer review leader will ensure that at least three reviewers are qualified to review each answer to the key and supplemental questions. Nevertheless, each reviewer will read the entire report and review the document as a whole. Given that few people have expertise in all of these issues, the panel is likely to have more than 10 people, but the precise number of reviewers can only be established as the reviewers are identified and selected.

A contractor, under the guidance of the EPA peer review leader, will be responsible for organizing the peer review, conducting and facilitating panel meetings, and documenting the review process, findings, and resulting responses. Typical meeting logistics, including travel arrangements,

will also be coordinated and facilitated by the contractor, when appropriate.

Reviewers will be asked to address the following questions in formulating their comments:

- 1) Is the charge, outlined in the prospectus, clearly described in the product? Are all aspects of the charge fully addressed? Do the authors stay within their charge and expertise? If not, are such departures reasonable?
- 2) Are the conclusions and recommendations adequately supported by evidence, analysis, and argument? Are uncertainties or incompleteness in the evidence explicitly recognized? If any recommendations are based on value judgments or the collective opinions of the authors, is this acknowledged and are scientifically defensible reasons given for reaching those judgments?
- 3) Are the data and analyses handled competently? Are statistical methods applied appropriately?
- 4) Are the product's exposition and organization effective? Is the title appropriate?
- 5) Is the report fair? Is its tone impartial?
- 6) Does the executive summary concisely and accurately describe the key findings and recommendations? Is it consistent with other sections of the product?
- 7) Are supporting papers or appendices, if any, relevant to the charge? If the product relies on supporting papers to support consensus findings or recommendations, do the papers meet criterion 3 above?
- 8) What other significant improvements, if any, might be made to the product?

Following this review, the lead authors will revise the document and present the second draft for public comment. The lead authors will prepare a third draft of the product, taking into consideration the comments submitted during the public comment period. The scientific judgment of the lead authors will determine responses to the comments.

Once the revisions are complete, the Environmental Protection Agency will certify compliance with IQA and submit the third draft of the product to the CCSP Interagency Committee. If the CCSP Interagency Committee review determines that no further revisions are

needed and that the product has been prepared in conformance with the *Guidelines for Producing CCSP Synthesis and Assessment Products*, they will submit the product to the National Science and Technology Council (NSTC) for clearance. Clearance will require the concurrence of all members of the Committee on Environment and Natural Resources. NSTC review comments will be addressed by the CCSP Interagency Committee in consultation with the lead and contributing agencies and the lead authors.

EPA has established the Coastal Elevations and Sea-Level Rise Advisory Committee (CESLAC) to advise on the specific issues this synthesis and assessment product should address, appropriate technical approaches, the nature of information relevant to decisionmakers, the content of the final report, IQA compliance, and other matters important to the successful achievement of the objectives of the study. All meetings will be open to the public unless otherwise specified, in accordance with FACA, which will afford the public with the opportunity to provide input to the advisory committee's advice. The committee will have separate meetings to (i) provide advice relevant to the initiation of the study; (ii) review and comment on a substantive draft intermediate product; and (iii) review and comment on the draft final product. A fourth meeting will be held if the advisory committee considers such a meeting necessary.

After the public review, the authors will revise the report. The lead agencies will forward the product to the CCSP Interagency Committee and the NSTC for final approval and dissemination.

7. RELATED ACTIVITIES

The product will complement and reinforce assessment efforts of the National Academy of Sciences (NAS) and congressionally mandated studies. In the fall of 2007, NAS will release an independent assessment of ways to mitigate the environmental consequences of responses to shoreline erosion. Portions of that report will contribute to Synthesis

and Assessment Product 4.1. The Clean Water Act requires the Federal wetland program to avoid any cumulative environmental impacts when issuing general wetland permits, and the National Environmental Policy Act requires Federal agencies to assess environmental impacts of major Federal actions. Synthesis and Assessment Product 4.1 will help to define the research necessary for legally required assessments to correctly estimate environmental impacts of Federal actions if sea level continues to rise.

The U.S. Army Corps of Engineers is conducting a multi-year National Shoreline Study, which will examine inundation, erosion, flooding, shore protection, and other coastal processes throughout the United States. Synthesis and Assessment Product 4.1 will examine a subset of the National Shoreline Study's issues, for a portion of the Nation, and be completed sooner. Therefore, this synthesis product may serve as an initial pilot effort for the longer term National Shoreline Study.

8. COMMUNICATIONS

EPA and NOAA will release the completed product using a standard format for all CCSP synthesis and assessment products. The final product and the comments received during the Expert Review will be posted without attribution on NOAA and EPA web sites, and mirrored on the CCSP web site. A response to the expert review comments will also be posted. The comments received during the Public Comment Period will be posted with attribution. Final report production and layout will be managed by professional technical editors and writers. The CCSP Interagency Committee will be responsible for seeing that comments generated during the NSTC review are addressed. They will consult with the lead agency and the authors to develop an appropriate response. If required, product revisions will be written by the SAP Coordinating Team and/or chapter authors and then routed back through the lead agency and the CCSP Interagency Committee to the NSTC.

The draft report, prior to the CCSP Interagency Committee and NSTC clearance, and its revised version after said



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clearance, will both be posted on the CCSP web site and made available to the public.

9. TIMELINE

The following schedule is proposed for completion of this product. The final deadline is contingent on completion of review deadlines following completion of the draft products.

December 2005	Prospectus posted on CCSP web site for public comment
December 2006	Final prospectus posted on the CCSP web site
January 2007	Rough draft of entire report
February 2007	Stakeholder review draft finalized
April 2007	Stakeholder review complete
May 2007	Expert Review (first) draft finalized
June 2007	Expert Review complete
June 2007	Public Comment Period (second) draft finalized
July 2007	Public Comment Period complete
August 2007	Third draft submitted to CCSP Interagency Committee
September 2007	Final product posted on CCSP web site

REFERENCES

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Appendix A. Biographical Information for Authors

K. Eric Anderson

B.S. Purdue University (Economics)

M.S., Ph.D. Northwestern University (Geography)

Eric Anderson is a senior research geographer with the US Geological Survey (USGS). His research focuses on the development of tools and techniques involving integrated multidisciplinary data sets and their application across a range of scales from global to local. Current projects have particular emphasis upon techniques for mapping and communicating coastal hazards including seismic risk, coastal flooding, and storm surge. At the USGS, he has worked in digital cartography, geographic research, and the development and applications of geographical information systems. He served as Chief of the Eastern Region of the National Mapping Division until 2000. He is a Past President of the American Congress on Surveying and Mapping and was one of the founding editors of the International Journal of Geographical Information Systems. He served as the Director of Auto-Carto 9 and co-Director of Auto-Carto 2005.

Mark M. Brinson

B.S. 1965, Heidelberg College, Tiffin, Ohio, Biology

M.S. 1967, University of Michigan, Ann Arbor, Michigan, Botany

Ph.D. 1973, University of Florida, Gainesville, Florida, Botany

Mark Brinson is a Professor of the Biology Department, East Carolina University. He and his colleagues study the relationship of hydrology and hydroperiod to wetland ecosystem structure and function, classification and assessment of wetlands, and the effects of rising sea level on coastal wetlands. He participates in research at the Virginia Coast Reserve site of the Long Term Ecological Research program and was a Fulbright Fellow in Argentina. Current projects include the ecological effects of rising sea level and the development of reference-based condition assessments for estuarine and riparian ecosystems in the North Carolina coastal plain. He serves on several committees in North Carolina advisory to the Division of Marine Fisheries and the Division of Coastal Management. He served as president of the Society of Wetland Scientists and received the society's Merit Award in 1998. He chaired the Public Policy Review committee of the American Institute of Biological Science, was a member of the National Research Council committee on Wetland Characterization, and chaired the NRC committee on Riparian Zones. He has provided testimony before U.S. Senate and House committees on the identification of wetlands.

Donald R. Cahoon

B. A., Botany, with Honors, Drew University, 1972

M.S., Plant Ecology, University of Maryland, 1975

Ph.D., Plant Ecology, University of Maryland, 1982

Don Cahoon, a senior research ecologist with the U. S. Geological Survey, has more than 25 years experience investigating wetland plant ecology, wetland accretionary processes, and wetland restoration and management; and has published his findings in more than 100 research papers and reports. With his colleagues, he has developed a research approach for measuring wetland elevation dynamics (surface elevation tables (SET) used in conjunction with artificial soil marker horizons), which is being used in 18 countries by 65 coastal scientists. He and his colleagues have developed: 1) a global network of elevation monitoring sites using standard measurement protocols (SET and marker horizons) on coastal wetlands to give an advance warning of change, 2) new predictive models to determine the long-term potential for submergence of coastal wetlands, and 3) new elevation monitoring technology to improve our understanding of subsurface process influences on elevation. These developments are being used to determine: 1) the vulnerability of coastal wetlands to global change (e.g., sea-level rise and storms), 2) the critical driving forces and subsurface processes controlling elevation for a wide range of wetland types,

and 3) the impact of current wetland management and restoration practices on elevation dynamics and wetland stability. The SET-marker horizon methodology is described on the USGS website

Michael Craghan

B.S. Rutgers University (Civil Engineering) 1989

M.S. Geography, Rutgers University (1995).

Ph.D. Rutgers University, New Brunswick, N.J. (Geography). 1999

Michael Craghan has expertise in floodplain modeling, estuarine sedimentation processes, coastal zone land use planning, and civil engineering. He was an engineer and GIS floodplain modeler for the Federal Emergency Management Agency's regional office in Philadelphia until the middle of 2006. His Ph.D. Dissertation was entitled "An Investigation of Sediment Delivery and Accumulation on a Developed Estuarine Shore." He has also prepared a report analyzing land use planning for sea level rise in New Jersey, and serves on the Environmental Conservation Board of the Town of Manasquan, New Jersey.

Brian Czech

B.S. University of Wisconsin (Wildlife Ecology) 1982

M.S. University of Washington (Wildlife Science) 1988

Ph.D., University of Arizona (Renewable Natural Resources) 1997

Brian Czech is a conservation biologist in the national office of the U.S. Fish and Wildlife Service, National Wildlife Refuge System, Arlington, VA. His major duties include planning and policy development for maintaining the biological integrity, diversity, and environmental health of the Refuge System. He has served as a Refuge System lead for interagency sustainability initiatives pertaining to forests, rangelands, and climate change. Dr. Czech is also an adjunct professor at Virginia Polytechnic Institute and State University, National Capitol Region, Alexandria, where he has taught ecological economics, sustainability science, and endangered species policy and management. Between 1988 and 1993, he was a conservation biologist and Director of Recreation and Wildlife for the Apache Tribe in San Carlos, Arizona.

Jeff DeBlieu

B.A. Millsaps College (Political Science) 1971.

Jeff DeBlieu is a project manager in The Nature Conservancy's Global Climate Change Initiative, overseeing the development of a climate change adaptation program on the Albemarle-Pamlico Peninsula in North Carolina. His responsibilities include building partnerships with major landowners on the peninsula and working with them to test adaptation strategies. He is also working with scientists to implement a coordinated research and monitoring program on long-term climate-driven changes and the effectiveness of various adaptation strategies. He previously directed The Nature Conservancy's Pamlico Sound Oyster Reef Restoration Project and served as director of the Conservancy's Nags Head Woods Preserve.

Stephen Gill

B.S. New York University School of Engineering and Science. 1970 (Meteorology and Oceanography)

M.S. New York University School of Engineering and Science. 1975. (Physical Oceanography)

Stephen Gill is Senior Oceanographer for the NOAA/NOS Center for Operational Oceanographic Products and Services (CO-OPS). Mr. Gill has been with NOAA's tides and water levels program in various capacities since 1975 and has operational experience in water level measurement, data processing, analyses and tidal datums, and product development for tides and sea level applications. Most recently, he has been working to develop various training programs in the application of tides and sea level measurement to surveying and mapping as well as to coastal zone management and habitat restoration, and is working to develop the Federal backbone for the Integrated Ocean Observing System (IOOS). Prior to coming to NOAA, Mr. Gill was an oceanographer for three years at the New York Ocean Science

Laboratory in Montauk, NY. His educational background also includes one-year of applied research in tides and tidal theory at Scripps Institution of Oceanography under the tutorship of Bernard Zetler.

Daniel E. Hudgens

B.S. Cornell University (Natural Resources) 1996

M.S. University of Massachusetts (Environmental, Coastal, and Ocean Sciences) 1999

Dan Hudgens is an environmental consultant with Industrial Economics Incorporated. His masters research article “Adapting the National Flood Insurance Program to Relative Sea Level Rise,” was published in *Coastal Management*. Since joining Industrial Economics in 1999, Mr. Hudgens has continued to work on projects associated with sea level rise, such as EPA's project to create GIS maps depicting local planner expectations on how communities will respond to sea level rise. He also undertook a GIS-based study for the Electric Power Research Institute estimating the cost of sea level rise along the California coast. Other projects include contracts with National Marine Fisheries Service (Draft Atlantic Large Whale Take Reduction Plan Environmental Impact Statement, as well as a GIS model to assess the change in fishing line usage), EPA's Office of Emergency and Remedial Response (evaluating impacts of extreme weather events on subaqueous contaminated sediment sites) and EPA's Office of Policy (draft benefits report for the revised Concentrated Animal Feeding Operations rule).

Nancy Jackson

B.A. Clark University (Geography) 1978.

M.S. Antioch/New England Graduate School (Natural Resource Management and Administration) 1986.

Ph.D. Rutgers University. (Geography) 1992.

Nancy Jackson is a physical geographer and coastal geomorphologist. She is an Associate Professor in the Department of Chemistry and Environmental Science at New Jersey Institute of Technology and Director of the Graduate Program in Environmental Policy. Her research focuses on coastal processes on beaches and dunes with particular emphasis on foreshore processes and sediment transport in estuarine and low wave energy environments. Specific research projects have examined wave activation and sediment mixing, longshore sediment transport, swash - beach water table interactions, and geomorphic-biotic interactions on sandy foreshores in estuaries. Applied research she has undertaken focuses on humans as an agent of coastal landform change and specifically how physical – biological –social processes increase or decrease resilience of coastal environments. Dr. Jackson has published over 40 journal articles on coastal processes and management. She is an Associate Editor of *Estuaries: An International Journal of Coastal Science* and serves on the Editorial Board of *Journal of Coastal Research*. She was awarded the 2004-2005 *Fulbright Distinguished Chair in Environmental Policy and Legislation* at the Politecnico di Torino, Italia.

Zoë P. Johnson

B.A. Western Washington University (Urban and Regional Planning) 1992

M.M.A. University of Washington (Marine Affairs) 1998

Zoë Johnson is an in-house coastal planning consultant for the Maryland Department of Natural Resources, Coastal Zone Management Division and the Maryland Eastern Shore Resource Conservation & Development Council. Current projects include: oversight of Maryland's sea level rise planning and research activities; development of assessment tools for shore protection; and, assistance to local governments for coastal hazard planning and sea level rise response. As a NOAA Coastal Management Fellow for the State of Maryland, she prepared the sea level rise response strategy for the State of Maryland. From 1992-1996, she was an associate planner and shoreline administrator for the Skagit County (Washington) Planning Department.

Michael S. Kearney

B.A. University of Illinois, 1973, History/Geology

MA, Western Illinois University, 1976, Geography

PhD, University of Western Ontario, 1981 (Geography, specializing in geomorphology and paleoenvironmental reconstruction)

Michael S. Kearney is a Professor in the Department of Geography, University of Maryland, College Park. Since joining the faculty at College Park, Dr. Kearney has focused on coastal processes and environments, particularly problems of marsh loss and sea level rise, reconstructing of recent sea level trends, changes in historical shoreline erosion, and Bay sedimentary processes. He has also worked extensively on barrier islands, focusing barrier island evolution, the impact of storms on beach processes, and aeolian transport. In recent years, he focused on using remote sensing to assess the response of coastal marshes to sea level rise and changes in nutrient concentration in US middle Atlantic estuaries. Dr. Kearney has published over 60 refereed journal articles, book chapters, and proceeding papers and reports, and is co-author of the recent books, *Sea Level Rise: History and Consequences*, published by Academic Press, and *North American Coasts*, published by Kendall Hunt.

Alexander S. Kolker

B.A. University of California, Santa Cruz (1995)

M.A. Stony Brook University (2000)

Ph.D. Stony Brook University (2005) Marine and Atmospheric Science.

Alexander Kolker is interested in the influence of climate variability and human activities on coastal ecosystems. This work pulls from a variety of disciplines, including sedimentary geology, isotope and biogeochemistry, climatology and plant ecology. His Ph.D. thesis focused on environmental changes in Long Island salt marshes and he has been particularly interested in the causes and consequences of salt marsh loss. Additionally, Alexander Kolker seeks to understand how local and global climatic processes drive sea level changes. His current post-doctoral work involves monitoring salt marsh restoration efforts in Jamaica Bay.

Danielle Kreeger

B.S., Pennsylvania State University (Biology/Marine Biology, Honors), 1984

M. S., University of Delaware (Marine Biology/Biochemistry), 1986

Ph.D., Oregon State University (Fisheries Science) 1992

Danielle Kreeger is Science Coordinator for the Partnership for the Delaware Estuary, which administers the National Estuary Program for the Delaware Estuary. Although the Partnership is headquartered in Wilmington, DE, she also maintains an office at the Delaware River Basin Commission in West Trenton NJ. Dr. Kreeger leads science and technical teams that address the goals of the Comprehensive Conservation and Management Program for the Delaware Estuary and watershed. Example responsibilities include organizing the bi-annual Delaware Estuary Science Conference, charting science and management needs for the Estuary, and working with science and technical committees to address these needs. Trained as a shellfish ecologist and wetland ecologist, she previously worked as a scientist at the Plymouth Marine Laboratory, U.K. (1992-1994) and the Academy of Natural Sciences, Philadelphia (1994-2004). She has authored dozens of papers, mainly on the physiological ecology of filter-feeding animals such as bivalve mollusks. She is also an Associate Research Professor at Drexel University.

Curt Larsen

B.S., Geology, University of Illinois Urbana-Champaign, 1964

M.A., Sociology, Western Washington University, Bellingham, WA, 1971

Phd., Anthropology, The University of Chicago, 1980

Curtis Larsen is a senior research geologist with the U.S. Geological Survey in Reston, VA. He is a coastal geologist and geomorphologist with more than 35 years of experience investigating sea level change along the U.S. east and west coasts as well as the Persian Gulf region. He has also studied lake

level change and postglacial isostatic crustal adjustments in the Great Lakes region. His current focus is on discerning the sea level history of the Mid Atlantic coast with respect to geologic and historic time scales. Most recently he has been deeply involved with modeling the impacts of prospective relative sea level rise on coastal wetlands and wetland habitats in conjunction with the U.S. Fish and Wildlife Service at the Blackwater National Wildlife Refuge. Apart from his active interest in reconstructing relative sea level history he is interested in assessing the role of wetlands as contributors of sediment to adjacent water bodies like the Chesapeake Bay. Similarly, he is interested in comparing the responses of marine coastal wetlands to current rates of relative sea level rise to those of fresh water wetlands in the Upper Great Lakes in similar water level rise situations.

Christopher Linn

B.S. Pennsylvania State University (Earth Sciences) 1994.

M.S. University of Delaware (Environmental and Energy Policy) 2000.

Chris Linn has been an Environmental Planner with the Delaware Valley Regional Planning Commission (DVRPC) since 2000. In that position, he manages Pennsylvania's Coastal Zone Management (CZM) program in portion of the state vulnerable to sea level rise (as distinct from the Great Lakes), and has undertaken several studies of impacts of sea level rise on the developed communities and natural resources of the Delaware Estuary. He chairs the Urban Waterfront Action Group, a multi-agency task force set up to review permitting decisions for waterfront projects, and was a major contributor to the land use component of Destination 2030, the Delaware Valley's comprehensive long-range plan. Recently, he prepared the Pennsylvania Coastal and Estuarine Land Conservation Program (CELCP) Plan for land acquisition and conservation. Currently, he serves on the Schuylkill River Development Council's Environmental Committee, the Pennsylvania Sea Grant Advisory Committee, and the Philadelphia Open Space Plan Advisory Committee. Before pursuing his master's degree, he worked as a client services manager and staff scientist for a Pennsylvania firm developing hazardous materials emergency response software.

Doug C. Marcy

B.S. Geology, College of Charleston, 1994.

M.S. Geology, University of North Carolina at Wilmington, 1997

Doug C. Marcy is a Physical Scientist at the NOAA National Ocean Service / Coastal Services Center (CSC) in Charleston, SC. He has been with the CSC since January of 2002 as a NOAA National Weather Service (NWS) employee working on enhancing NWS flooding forecast products and GIS capability, NOAA storm surge assessments, hydrologic modeling to support inland flood forecasting, and coastal hazards assessment projects designed to make communities more resilient to disasters. Before joining NOAA, he was a hydraulic engineer with the U.S. Army Corps of Engineers, Charleston District from 1999 to 2002. His work at the Corps focused on flood control projects, hydrologic and hydraulic modeling, flood inundation mapping, shoreline change analysis, and coastal engineering. From 1997 to 1999 he worked at the South Carolina Office of Ocean and Coastal Resource Management as a CSC Coastal Management Fellow.

Laura J. Moore

B.A. Colgate University (Geology), 1993

Ph.D. University of California Santa Cruz (Earth Sciences), 1998

Laura Moore is an Assistant Professor of Geology at Oberlin College. Dr. Moore has conducted research in a variety of coastal settings on topics including coastal cliff retreat, shoreline change, nearshore sand bar evolution, coastal barrier development and hurricane overwash deposition. Her most recent research focuses on improving our understanding of linkages between coastal evolution, climate variability and sea-level rise. Before arriving at Oberlin in 2002, she held an appointment as postdoctoral scholar at the Woods Hole Oceanographic Institution, followed by a joint appointment as a research associate at the University of South Florida and the USGS Center for Coastal Geology in St. Petersburg, FL. In addition

to authoring over 20 scholarly articles and reports, Dr. Moore has been an invited participant in the Cutting Edge series of pedagogical workshops and she is a member of the Project Kaleidoscope Faculty for the 21st Century.

Denise J. Reed

B.S. Cambridge University (1980).

Ph.D. Cambridge University (Geography) 1986.

Denise Reed is a Professor at the University of New Orleans. Dr. Reed's research focuses on various aspects of sediment dynamics in coastal wetlands, with emphasis on sediment mobilization and marsh hydrology, both natural and altered, as factors controlling sediment deposition. She has participated in numerous research projects concerning marsh and estuarine sediment dynamics on the Gulf and Pacific coasts of the US as well as in Europe and South America. Dr. Reed has also worked closely with the development of restoration plans in for coastal Louisiana for the last 15 years being involved in incorporating science into efforts under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and more recently the Louisiana Coastal Area study. Dr. Reed has recently completed publications on altered hydrology effects on Louisiana salt marsh function and restoration of tidal wetlands in the Sacramento-San Joaquin delta. She currently serves on scientific advisory boards for ecosystem restoration in San Francisco Bay and Jamaica Bay NY, as well as the CALFED program and the US Army Corps of Engineers.

Ann Shellenbarger Jones

B.A. Washington University in St. Louis (Chemistry) 1995

Ph.D. Massachusetts Institute of Technology (Inorganic Chemistry) 2000

Ann Shellenbarger Jones is a Senior Associate with Industrial Economics, Incorporated, an economic and environmental consulting firm in Cambridge, MA. Her primary area of expertise is natural resource damage assessment and restoration, with a focus on developing methodologies for evaluating impacts to biological resources. Major areas of focus include habitat equivalency analysis and evaluation of ecological impacts of natural resource damage. She has developed and overseen multi-matrix ecological studies, including analyses for the Montrose Settlements Restoration Program. Her work has involved a variety of urban and rural river and estuary systems, including the Delaware River and Bay and the Passaic River. Dr. Shellenbarger Jones has also participated in oceanographic research, including analyzing impacts of sewage outfall on water column properties in Southern California and porewater iron chemistry in a southern Delaware salt marsh.

Jay Tanski

B.S. Pennsylvania State University (Geology) 1978.

M.S. State University of New York (SUNY) at Stony Brook. (Coastal Geology) 1981.

Jay Tanski has been the Coastal Processes Specialist with New York Sea Grant since 1983. The program is a marine research, education and technical assistance program run jointly by SUNY and Cornell University. In his position he provides technical information and advisory services to a variety of coastal audiences including federal, state and local officials and agencies, communities, businesses and the public. He was technical advisor to the State and the Long Island Regional Planning in the development of the Long Island South Shore Hazard Management Program. He has served on the Governor's Coastal Erosion Task Force, New York State's Barrier Island Scientific Advisory Committee, and the Atlantic Coast of New York Erosion Monitoring Study Team, a collaborative effort of the U.S. Army Corps of Engineers, New York State Coastal Management Program and New York Sea Grant. Following graduate school, he worked as a project supervisor with a South Carolina consulting firm before returning to Long Island as a research associate at SUNY Stony Brook.

E. Robert Thieler

B.A. Dickinson College (Political Science, Environmental Studies) 1987

M.S. Duke University (Environmental Science) 1993

Ph.D. Duke University (Geology) 1997

Rob Thieler is a research geologist with the U.S. Geological Survey. He conducts marine geologic research on the geologic framework and morphodynamics of the coastal zone. This includes understanding relationships between regional geology, sediment transport, and coastal erosion, as well as assessing potential sand and gravel resources. Thieler has worked with several state agencies (MA, MD) to develop long-term shoreline change data for coastal management. He also develops GIS software for measuring historical shoreline change using a variety of statistical techniques. He has completed preliminary assessments of coastal vulnerability to sea-level rise using simple criteria at both the national scale, and more recently for 25 National Park Service units worldwide. He is the author or co-author of over 70 technical publications. Dr. Thieler serves on the editorial boards of the *Journal of Coastal Research* and *Marine Geology*.

James G. Titus

B.A. University of Maryland (Economics and Applied Math) 1978

J.D. Georgetown University Law Center 1996

Since 1982, Jim Titus has managed EPA's Sea Level Rise Project, the first government project designed to identify opportunities to adapt to the consequences of global warming from greenhouse gases. His publications include the first probabilistic assessment of future sea level rise, the first assessment to estimate the nationwide impacts of sea level rise and cost of shore protection, and first set of state-specific maps depicting the lands vulnerable to projected sea level rise (posted at www.epa.gov/globalwarming/sealevelrise). He also undertook the first analysis of "rolling easements" and other legal and planning mechanisms that might allow public property rights to survive rising sea level. He has visited the shores of 90 percent of the counties within the case study area, and sailed in the majority of major bays, sounds, and rivers. Before coming to EPA, he developed macroeconomic models and wrote FORTRAN programs for University of Maryland and Congressional Budget Office. In 2004, Governor Robert Ehrlich appointed him to the Maryland Bicycle and Pedestrian Advisory Committee.

Jue Wang

B.S. Henan University (Geography) 1982

M.S. Fujian Teacher's University (Geography: Climate Change, Sea level Change) 1986

Ph.D. University of Kansas (Geography: GIS, Remote Sensing, Biological Geography) 2000

Jue Wang has studied physical geography for more than 20 years and remote sensing and Geographical Information Systems (GIS) for the past nine years. Before coming to the United States, he was an assistant professor in China, where he taught and conducted research in geography. From 1993 to 2000, he was a graduate research assistant in the GIS and Environmental Modeling Laboratory (GEMLab) of the Kansas Applied Remote Sensing Program (KARS) at the University of Kansas. He served as the GIS and remote sensing specialist for the Brunca conservation biology project sponsored by the Organization for Tropical Studies, the Flint Hills-Osage Plains ecoregion GIS project funded by the Nature Conservancy, and the Kansas Ecological Reserves GIS project funded by National Science Foundation. His dissertation research focused on relationship between climate, the normalized difference vegetation index, and net primary productivity. Before joining Pyramid Systems, he was a senior GIS analyst at ICF Consulting, Inc.

S. Jeffress Williams

B.S., Geology, Allegheny College, 1967

M.S., Geology/Oceanography, Lehigh University, 1969

S. Jeffress Williams, a senior research marine geologist with the U.S. Geological Survey at the Woods Hole Science Center, has more than 30 years of experience investigating topics such as the geologic

origins and evolution of coastal and estuarine and Great Lakes systems, late Quaternary sea-level history, and the geologic character of modern marine sand bodies. He has published more than 200 research papers, reports, abstracts, and chapters and been a member on more than a dozen high-level national and state science advisory committees. Prior to his current research position in Woods Hole, Williams managed the Coastal and Marine Geology Program from 1996 to 2000 at the USGS headquarters, Reston, VA. Prior to joining the USGS in 1983, he was a research marine geologist with the Corps of Engineers, Coastal Engineering Research Center and an invited visiting scientist (1980) at the Institute of Oceanographic Sciences, Taunton, UK, after receiving degrees in geology/oceanography from Allegheny College and Lehigh University. Williams' current research focus is on three main topics: carrying out a national synthesis and assessment of the state-of-knowledge about offshore marine sand and gravel aggregates, assessing the risk and vulnerability of U.S. coastal regions to coastal subsidence and future rise in relative sea level, and serving as a scientific advisor to system-scale coastal and wetland ecosystem restoration activities underway and in Louisiana.

Michael P. Weinstein

B.A., Biology, Hofstra University, 1966

M.S., Zoology, Rutgers University, 1969

Ph.D., Marine and Environmental Science, Florida State University, 1975

Michael P. Weinstein is President and CEO, New Jersey Marine Sciences Consortium (NJMSC) and Director, *New Jersey Sea Grant College Program*. With more than twenty-eight years experience in research and teaching, Dr. Weinstein's primary academic interests include the role of estuarine habitat in the production of marine recreational and commercial fishes and shellfish. He has conducted extensive research in the areas of coastal ecology, fisheries science, wetland ecology, and restoration ecology, primarily in salt marshes, sea grass meadows, and mangrove habitats. Dr. Weinstein is deeply committed to technology transfer and outreach based on his research, especially in melding the science and practice of habitat restoration, sustainable development, integrated coastal zone management, and the "bottom up" management of fisheries resources. He has served on several National Research Council Committees, an NCEAS Working Group, the US-Japan CEST Panel, the Governor's Dredged Material Task Force, and currently serves on the Governor's Tourism Advisory Council as New Jersey's Ecotourism Representative. He is a member of the National Working Group for preparing the Nationwide Strategy for Coastal Habitat Restoration. He also serves on many other advisory councils and scientific advisory panels. He has been an invited speaker on numerous occasions and has authored more than 175 journal articles, abstracts, books, chapters and monographs. His most recent text, *Concepts and Controversies in Tidal Marsh Ecology* is expected to have international impact on the direction of tidal marsh research and restoration science.