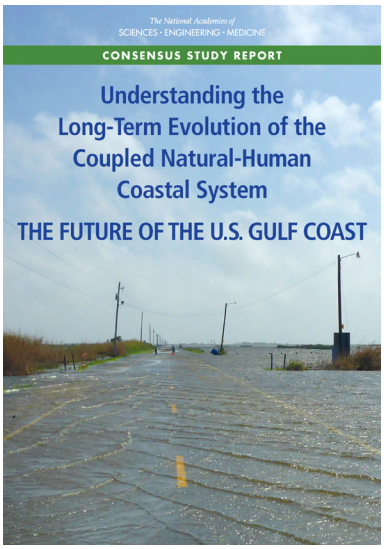
Consensus Study Report
HIGHLIGHTS
September 2018

Understanding the Long-Term Evolution of the Coupled Natural-Human Coastal System: The Future of the U.S. Gulf Coast



The United States coastline is a dynamic and important region that hosts a large percentage of the population, has a critical role in the economy, and is composed of diverse environments. With the number of people living in coastal areas increasing every year, long-term planning to sustain coastline communities depends on a better understanding of the natural and human activities that shape and change the coastal zone, as well as their interactions and feedbacks. Effective sharing of this understanding in support of decision-making and policies is also needed.

The U.S. Gulf of Mexico provides a particularly relevant setting to study deeply connected natural and human interactions of coastal environments. The region's historical and continuing concentration of coastal development, human population, and infrastructure are especially vulnerable to hurricanes and sea-level rise. The ability to promote the resilience and maintain the habitability of the Gulf Coast into the future depends on a better understanding of the physical, ecological, and human aspects of this complex, coupled natural-human system and how these components interact under rapidly changing conditions.

Produced at the request of the Gulf Research Program of the National Academies of Sciences, Engineering, and Medicine (NASEM), this report identifies three critical areas of research and 12 research gaps needed to improve understanding of the interactions and feedbacks among the Gulf Coast coupled natural-human system. The report also identifies barriers to and opportunities for effective communication among scientists and stakeholders.

CRITICAL RESEARCH AREAS

While the interconnected and complex nature of the system makes it difficult to discuss any one aspect of the Gulf Coast region, the system can be thought of as three related areas: the physical system, the ecological system, and the human system.

To better understand and predict the feedbacks and interactions among these areas and the resulting evolution of the coupled system along the Gulf Coast, the report identified three critical areas of research:

Critical Area 1: How will coastal landforms and coastal ecosystems along the Gulf Coast respond to rapidly changing conditions (both natural and human-induced), especially given the expectation for continued relative sea level rise acceleration?

Critical Area 2: How will human settlement and economic activity along the Gulf Coast respond to evolving coastal landforms and ecosystems under rapidly changing conditions?

Critical Area 3: How can improved understanding of both near- and long-term evolution of the Gulf Coast coupled natural-human system be applied to inform stakeholder decisions made at local, state, and regional scales? How does the coupled system evolve when decision-making is updated as scientific understanding advances?

RESEARCH GAPS

For each of the critical areas, the report identifies some major research gaps in the current scientific understanding of the coupled natural-human coastal system. All of the research gaps are interrelated and intended to be thought of as integral to the Gulf Coast coupled natural-human system.

THE NATURAL SYSTEM: PHYSICAL PROCESSES

Physical processes that drive changes in the natural coastal system occur over varying time scales, ranging from episodic (e.g., hurricanes) to longer-term processes (e.g., rising sea level). These processes also act on the landscape across a range of spatial scales, causing short-term disturbances, such as flooding or shoreline erosion, as well as longer-term changes, such as wetland loss and migration of barrier islands and tidal inlets. The following gaps in understanding are associated with Critical Area 1:

Wetlands in Breton Sound. The sinuous channels (bottom of image) are natural creeks that evolved through a combination of river and tidal processes. The two parallel straight channels (center) were created by people, likely for the energy industry. The expanse of open water (top) reveals the impacts of nearly a century of wetland loss in the region.

Source: Alexander Kolker and Southwings

Research Gap 1: Current data sets, monitoring systems, and approaches are insufficient to track and understand how the oceanic component of sea level is changing along the Gulf Coast.

Research Gap 2: The causes, rates, and patterns of subsidence along the Gulf Coast are not sufficiently understood to allow for accurate prediction.

Research Gap 3: The combined effects of freshwater input from Gulf Coast watersheds, storm surge, sea level rise, and human development on coastal flood hazards are not well understood, which limits the capacity to include and model those effects in predictions.

Research Gap 4: The relative contributions of naturally-occurring and artificially-managed riverine sediment delivery, diversion and management activities, and how they impact the evolution of coastal landforms and ecosystems is poorly understood.

Research Gap 5: Limited understanding of sediment transport processes and uncertainties in predicting future hydrodynamic conditions hampers the ability to project long-term coastal evolution.

Research Gap 6: There is a critical need to understand and project the future response of coastal landforms and embayments to changing climate, and the conditions under which they will no longer be able to keep pace with relative sea level rise.

THE NATURAL SYSTEM: ECOLOGICAL PROCESSES

Gulf Coast ecosystems evolve continuously over decadal (10-50 years) to centennial scales (50-200 years). Meanwhile, people affect ecosystems through coastal development, industrial activities, and climate change. Addressing the ecological component within the Gulf Coast's coupled natural-human system means first understanding how ecosystems function under natural conditions, and then how human interactions affect those functions. The following are gaps in the understanding of ecosystem function and management under current and future conditions, also tied to Critical Area 1:

Research Gap 7: There is limited understanding of the individual and combined effects of current environmental gradients, physical forcing, climate change, and coastal development on Gulf Coast ecosystems.

Research Gap 8: The understanding of strategic natural resource conservation and restoration activities for effective coastal management is limited.

THE HUMAN SYSTEM

Understanding the evolution of the coupled natural-human coastal system requires better knowledge of the aspects of the human system that interact and feed back with the natural system. The following research gaps fall within Critical Area 2:

Research Gap 9: There is a need to understand how decisions about the built environment will be affected by coastal change, and how these decisions create feedbacks between the natural and human systems.

Research Gap 10: There is a need for better understanding of how coastal changes affect the built environment and which aspects of the built environment are most vulnerable to coastal changes.

Research Gap 11: There is an incomplete understanding of the vulnerability of different Gulf communities to coastal dynamics, how coastal dynamics trigger migration and relocation decisions, and how these decisions create feedbacks between the natural coastal processes and migration.

DECISION-MAKING IN THE GULF

As noted above, the impacts of human development on coastal ecosystem function or physical processes can generate feedbacks for coastal communities. However, the understanding of these feedbacks for the coupled natural-human system in the Gulf Coast is limited The following research gap is linked to Critical Area 3:

Research Gap 12: Understanding how decisions about the built environment and human migration will affect the coupled natural and human coastal system is limited and can be furthered through integrated modeling.

A RESEARCH AGENDA FOR THE FUTURE

The Gulf Research Program of the NASEM could leverage its scope and autonomy to create an integrated research program that addresses critical research areas and gaps in a sustained way that federal and state funding agencies would be challenged to support. **This research program can be most successful it if includes:**

- A focus on interactions and feedbacks critical to the evolution of the coupled coastal system
- Support collaborative, multidisciplinary research teams
- Encouragement of comprehensive, Gulf Coast-wide, integrated observational and modeling efforts
- Research opportunities that are longitudinal and multi-decadal
- Delivery of easily accessible, regularly updated observational data and model results
- Coordination at a high level

BARRIERS AND OPPORTUNITIES FOR COMMUNICATION

Implementation of research products into actionable policies for a more resilient Gulf necessitates effective communication and collaboration between stakeholders and scientists. The following are barriers and opportunities for each of these groups:

STAKEHOLDER PERSPECTIVE

Barrier 1. Financial constraints, information availability, time, and expertise.

> **Opportunity 1.** Targeted funding opportunities to allow practitioners to obtain data and hire staff with science expertise would facilitate the use and application of available scientific information by other stakeholders.

Barrier 2. Many scientific products intended to inform decision-making are not tailored for and applicable to stakeholders' specific needs.

> **Opportunity 2.** When developing products that are intended to inform decision-making, scientists should be encouraged to engage substantively with stakeholders from the development to delivery stage. To encourage stakeholder involvement, solicitations for research programs could make this a requirement.

Barrier 3. The size and complexity of the energy industry and apparent limitations to information sharing present a barrier between the energy industry and other stakeholders.

> **Opportunity 3.** Create an incentive structure that fosters information sharing between the energy industry and other stakeholders, as well as protocols for how to engage more effectively to facilitate information sharing.

Barrier 4. Limited financial and human resources, logistical complexity, difficulty in identifying all relevant stakeholders, and skepticism, lack of understanding, or lack of trust can make it difficult for stakeholders to communicate effectively with the generic public.

> **Opportunity 4.** Boundary organizations[1] can play a key role in facilitating trusting relationships among community members, practitioners, and scientists, allowing for more effective engagement.

Barrier 5. There can be difficulties in establishing two-way information flow between scientists and stakeholders. There are also challenges in coordinating diverse entities and individuals for any particular research effort, especially when there are numerous people or groups involved.

> **Opportunity 5.** Clear lines of communication, chain of command, and protocols, and the involvement of boundary spanners or boundary

1 Boundary organizations play an intermediary role between different disciplines, creating and sustaining meaningful links between knowledge producers and users, and seek to provide a neutral ground for science-based discussion.

organizations, may facilitate the coordination of stakeholders and scientists in efforts that will help participants feel involved.

SCIENTIST PERSPECTIVE

Barrier 6. Scientists' engagement with stakeholders can be limited by competing demands on time and on the relative importance placed on this engagement, in terms of promotion and professional recognition.

Opportunity 6. To facilitate the development of strong relationships between scientists and stakeholders, funding programs could provide funds for engagement and knowledge transfer activities, and consider ways to incentive collaborations via boundary organizations and other boundary spanners[2].

Barrier 7. Scientists working on or wanting to engage in research related to the Gulf Coast but who are not from or based there may feel limited by their "outsider" status when engaging with stakeholders.

Opportunity 7. Funding programs that focus on Gulf Coast-related research could encourage and facilitate collaborations among regional scientists and those from outside the region with complementary interests and expertise.

CONCLUSION

The physical and ecological systems, people, and economy in the Gulf Coast are inextricably linked. The research agenda presented here could lead to advances in understanding of the natural and human factors that combine, interact, and feed back to influence coastal evolution, as well as coastal communities and infrastructure. It also underlines the importance of effective communication among scientists and stakeholders in promoting informed decision-making in the coastal zone. While changing environmental conditions present challenges to coastal communities, there is a great opportunity for groundbreaking research and innovation, which may lead to a re-envisioning of what is means to live along the Gulf Coast.

2 Boundary spanners are individuals working at the edge of different groups who serve to connect these groups with each other.

COMMITTEE ON UNDERSTANDING THE LONG-TERM EVOLUTION OF THE COUPLED NATURAL-HUMAN COASTAL SYSTEM: THE FUTURE OF THE U.S. GULF COAST

Tuba Özkan-Haller (*Chair*), Oregon State University; **Gregory A. Carter,** University of Southern Mississippi; **Just Cebrian**, Dauphin Island Sea Lab and University of South Alabama; **Robert (Tony) A. Dalrymple** (NAE), Johns Hopkins University; **Jordan R. Fischbach**, Water and Climate Resilience Center and RAND Corporation; **Jennifer L. Irish**, Virginia Tech; **Alexander S. Kolker**, Louisiana Universities Marine Consortium and Tulane University; **Shubhra Misra**, Chevron Energy Technology Company (until May 2018); **Laura J. Moore**, University of North Carolina at Chapel Hill; **Martin D. Smith**, Duke University; **Torbjörn E. Törnqvist**, Tulane University; **Gabrielle Wong-Parodi,** Carnegie Mellon University; Staff from the National Academies of Sciences, Engineering, and Medicine: **Deborah Glickson** (*Senior Program Officer*), **Heather Kreidler** (*Associate Program Officer*), **Courtney DeVane** *(Administrative Coordinator),* **James Heiss** *(Postdoctoral Fellow)*

For More Information This Consensus Study Report Highlights was prepared by the Board on Earth Sciences and Resources based on the Consensus Study Report *Understanding the Long-Term Evolution of the Coupled Natural-Human Coastal System: the Future of the U.S. Gulf Coast* (2018). The study was sponsored by the Gulf Research Program. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Board on Earth Sciences and Resources web page at http://www.dels.nas.edu/besr.

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