National Oceanic
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Administration
(NOAA)

United States Army
Engineer Research
and Development
Center (ERDC)

United States
Army Corps
of Engineers
(USACE)

Proceedings from the U.S. Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA)

Natural and Nature-Based Features Workshop in Galveston District

February 23, 2017
Galveston, Texas

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Proceedings from the U.S. Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA)

Engineering With Nature Workshop

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Abstract

This proceedings report summarizes the activities of a collaborative workshop conducted on the topic of Natural and Nature-Based Features (NNBF) by the U.S. Army Engineer Research and Development Center (ERDC), the US Army Corps of Engineers' Galveston District (SWG), and the National Oceanic Atmospheric Administration's (NOAA) National Ocean Service's (NOS) National Centers for Coastal Ocean Science (NCCOS) and the Office for Coastal Management (OCM). The workshop was held on February 23, 2017, in Galveston, Texas. NNBF can be differentiated into two unique classifications: *natural features* and *nature-based features*. Natural features (e.g., reefs, barrier islands, dunes, beaches, wetlands, and maritime forest) are comparatively long-standing and are created over time as a result of physical, biological, and chemical processes. Nature-based features, however, are created by human design, engineering, and construction to mimic natural features and to provide similar — if not identical — services.

Twenty-six workshop participants represented USACE and NOAA. The objectives of the workshop were to (1) strengthen and broaden collaboration between the two represented organizations; (2) assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders and technical staff to identify opportunities for leveraging each agency's investments and capabilities with respect to design, development, implementation, monitoring, and adaptive management of NNBF and associated ecosystem services; (3) identify high-priority NNBF projects of common interest through use of plenary and breakout sessions; (4) categorize and prioritize projects that are identified for future collaboration; and (5) identify other opportunities for crossover working relationships in coastal science and engineering. The workshop included a plenary session that afforded USACE and NOAA leaders an opportunity to present their respective organizational overviews and legislative mandates with an emphasis on NNBF implementation along the Texas coast. An interactive breakout session was also convened to gather input on priority opportunities for collaborative projects in conjunction with initial steps, concerns, and challenges. At the end of the one-day workshop, participants selected a combined total of 19 short- and long-term NNBF-related project opportunities to further explore and refine.

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Preface

This report summarizes the activities of a collaborative workshop conducted on the topic of Natural and Nature-Based Features (NNBF) by the U.S. Army Engineer Research and Development Center (ERDC), the US Army Corps of Engineers' Galveston District (SWG), and the National Oceanic Atmospheric Administration's (NOAA) National Ocean Service's (NOS) National Centers for Coastal Ocean Science (NCCOS) and the Office for Coastal Management (OCM). The workshop was held February 23, 2017, in Galveston, Texas.

Dr. Todd Bridges (ERDC), Dr. Edmond Russo (SWG), Dr. Steven Thur (NCCOS) and Dr. Jeff Paine (OCM) served as workshop chairs. Additionally, Dr. Jeff King (ERDC), Mr. Rob Thomas (SWG), Mr. Coraggio Maglio (SWG), Ms. Michelle Harmon (NCCOS), and Ms. Elaine Vaudreuil (OCM) provided organizational and logistic support. Dr. Russo, Dr. King, Ms. Harmon, and Ms. Vaudreuil also served as facilitators during the breakout sessions. The workshop organizers would like to acknowledge the many individuals at SWG who provided on-site computer and facility support. Additionally, the organizers wish to thank all of the workshop participants who shared their knowledge and experience to identify potential collaborative opportunities for USACE and NOAA so these two organizations may advance their mutual interest in NNBF.

At the time of publication of this report, Dr. Beth Fleming was Director of the ERDC Environmental Laboratory.

COL Bryan S. Green was Commander of ERDC, and Dr. David W. Pittman was Director of ERDC.

Citation: USACE and NOAA. [DATE HERE]. Proceedings from the U.S. Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) Natural and Nature-Based Features (NNBF) Workshop in Galveston District. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Executive Summary

This meeting was the third USACE/NOAA collaboration workshop on Natural and Nature-Based Features (NNBF) in the last 12 months. It was attended by 24 participants representing USACE (from the Galveston District and the US Army Engineer Research and Development Center); NOAA's National Ocean Service (Office for Coastal Management and National Centers for Coastal Ocean Science), and NOAA's National Marine Fisheries Service (Restoration Center). Participants included organizational leadership from various levels, personnel representing diverse roles in USACE and NOAA, and those from a range of disciplines and programmatic backgrounds. During the one-day workshop, participants gained a greater understanding of how missions are executed and of ongoing/future-anticipated, NNBF-related work within the respective agencies. The workshop included plenary and breakout group (comprised of a mixture of USACE and NOAA participants) discussions. These discussions resulted in the identification of areas where the two organizations could collaborate along the Texas coast to address information gaps and advance NNBF practices.

The deep level of engagement among USACE and NOAA participants was evidenced by the array of focused and energetic presentations delivered at the workshop. These presentations inspired productive dialogue and ultimately resulted in the identification of high-priority NNBF opportunities along the Texas coast. NNBF project ideas were identified — including several that integrated science, engineering, management, and evaluation practices. Decreasing uncertainty gaps and increasing confidence in the design, construction, performance, and ecosystem services produced by NNBF were key themes of the one-day workshop. NNBF-related projects and activities within USACE's Galveston District were identified as potential opportunities for coordinated action to address the gaps. Workshop participants developed for consideration an initial list of specific, collaborative opportunities within a portfolio that included a mix of more than 25 near- to long-term efforts. Specific examples of NNBF project collaboration opportunities in Galveston District included, but were not limited to

1. Matagorda Bay west foreshore island and wetland creation;
2. Galveston Bay subaquatic ecosystem restoration;
3. South Padre Island sand engine and placement;

4. Large-scale restoration of Jefferson County shore-line and marsh areas;
5. Creation of breakwaters along the Galveston Intracoastal Waterway;
6. Studies of Mission-Aransas National Estuarine Research Reserve beneficial use site(s) and associated NNBF;
7. Identification of data gaps across agencies, such as modeling and evaluation of ecosystem benefits, with implementation of methods to improve data sharing; and
8. Expansion of our knowledge and understanding of NNBF solutions that are derived through assessment/management activities and that also satisfy environmental compliance requirements.

The immediate next steps that will be taken following the workshop include:

1. Preparation of a joint, one-page executive summary of the workshop (present document);
2. Distribution of a draft workshop proceedings report, which will be followed by report finalization and joint publication;
3. A senior leadership team follow-up teleconference to track progress; and
4. Engagement of the USACE-NOAA NNBF Collaboration Strategy Leadership and Coordination Groups to solicit their input on the identified project opportunities.

1 Introduction and Collaborative History

The US Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) are two federal agencies pursuing collaboration on projects with Engineering With Nature (EWN) applications or that prioritize construction of Natural and Nature-Based Features (NNBF). To accomplish their mutually desired goal of identifying collaborative projects, the two agencies have met in workshop settings a total of three times. From 1 March through 3 March 2016, the USACE and NOAA's National Ocean Service (NOS) participated in a collaboration workshop on Natural and Nature-Based Features (NNBF) in Charleston, South Carolina (Bridges et al. 2016a). This event was the first in a series of three workshops (to date) that afforded leadership and technical staff from both agencies an opportunity to engage in formal introductions and allotted time to discuss very broad, collaborative ideas focused on NNBF. This first meeting facilitated greater connectivity between the two organizations' leadership and produced several project ideas that required additional clarification and specificity (Bridges et al. 2016a).

NNBF can be differentiated into two unique classifications, natural features and nature-based features. Natural features (e.g., reefs, barrier islands, dunes, beaches, wetlands and maritime forest) are comparatively long-standing in terms of age and created through the action of physical, biological, and chemical processes over time. Nature-based features are created by human design and engineering and construction efforts to mimic natural features with the ultimate goal of providing similar, if not identical, services (Bridges et. al., 2015). Figure 1 illustrates different types of NNBF that can be found in coastal environments. Using, constructing, and/or restoring NNBF for the purpose of providing ecosystem services, reducing storm risks, and enhancing coastal resilience is a prime example of adopting an Engineering With Nature (EWN) solution that can achieve multiple benefits. EWN offers many opportunities to combine advances in the fields of engineering and ecology into a single collaborative and cost-effective approach for infrastructure development and environmental management (Bridges et al. 2016b; Bridges et. al. 2014). It is this intentional alignment of natural and engineering processes that efficiently and sustainably delivers economic, environmental, and social benefits through collaborative processes (Figure 2). The website

www.engineeringwithnature.org provides more information concerning the EWN initiative.

Following the first workshop, communications among the leaders in both organizations were maintained and ultimately resulted in a second event. The USACE and NOAA's National Marine Fisheries Service (NMFS) organized a joint EWN workshop that occurred October 5-6, 2016, at the Greater Atlantic Regional Fisheries Office (GARFO) in Gloucester, Massachusetts (Bridges et al. 2017). This workshop focused on developing/applying EWN alternatives that integrate design and construction considerations that are compliant with Section 7 consultations under the Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultations as part of the Magnuson-Stevens Fisheries and Conservation Management Act. (Bridges et al. 2017).

Figure 1. NNBF examples from USACE 2013.

NATURAL AND NATURE-BASED FEATURES AT A GLANCE				
Dunes and Beaches	Vegetated Features (e.g., Marshes)	Oyster and Coral Reefs	Barrier Islands	Maritime Forests/Shrub Communities
Benefits/Processes Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer Increased infiltration	**Benefits/Processes** Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	**Benefits/Processes** Wave attenuation and/or dissipation Sediment stabilization	**Benefits/Processes** Wave attenuation and/or dissipation Shoreline erosion stabilization Soil retention
Performance Factors Berm height and width Beach slope Sediment grain size and supply Dune height, crest, and width Presence of vegetation	**Performance Factors** Marsh, wetland, or SAV elevation and continuity Vegetation type and density Spatial extent	**Performance Factors** Reef width, elevation, and roughness	**Performance Factors** Island elevation, length, and width Land cover Breach susceptibility Proximity to mainland shore	**Performance Factors** Vegetation height and density Forest dimension Sediment composition Platform elevation
General coastal risk reduction performance factors include: Storm surge and wave height/period, and water levels				

Figure 2. The EWN approach provides overlapping benefits resulting in more sustainable projects.

A third USACE/NOAA collaborative workshop occurred at USACE's Galveston District (SWG) office in Galveston, Texas, on February 23, 2017. The rationale for hosting the meeting at SWG was derived from two principal factors: (1) During the first NNBF workshop, USACE and NOAA participants identified the Texas Coastal Study as a priority opportunity for collaboration on NNBF projects (Bridges et al. 2016a); and (2) SWG is recognized as one of three EWN "Proving Grounds." It should be noted that USACE's Galveston, Buffalo, and Philadelphia Districts have all agreed to serve as "proving grounds" for district-wide implementation of EWN principles and practices. As such, these districts prioritize the review/implementation of EWN alternatives for district-wide projects that are proposed within the Corps' business lines (i.e., navigation, flood control, water operations and ecosystem restoration).

Likewise, SWG's ongoing efforts along the Texas coast are multidimensional in nature with numerous opportunities to design and implement NNBF-based projects that also align with the NOAA-NOS mission to advance the following priorities in coastal and marine environments: (1) safe and efficient transportation and commerce; (2) preparedness and risk reduction; and (3) stewardship, recreation and tourism (http://oceanservice.noaa.gov/about/). Moreover, NOAA-NOS's roadmap also prioritizes use of natural and nature-based infrastructure as an approach for coastal communities to become more resilient to coastal hazards; this approach also aligns very well with the priorities identified in

SWG's comprehensive Texas Coastal Texas Protection and Restoration Feasibility Study (NOS Roadmap 2016 and USACE 2013).

The subsequent sections of this proceedings document provide details and results from the third USACE/NOAA workshop that was held in Galveston, Texas.

2 Workshop Objectives and Process

2.1 Objectives

The objectives of the collaborative workshop were to:

- Strengthen and broaden collaboration among represented organizations;
- Assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders and technical staff to identify opportunities to leverage each agency's investments and capabilities with respect to design, development, implementation, monitoring, and adaptive management of NNBF and associated ecosystem services;
- Identify high-priority NNBF projects of common interest through use of plenary and breakout sessions;
- Categorize and prioritize projects that are identified for future collaboration; and
- Identify other opportunities for crossover, working relationships in coastal science and engineering.

2.2 Participants

Twenty-six participants from USACE and NOAA attended the EWN Workshop. The group of attendees was comprised of individuals representing USACE (Galveston District and the US Army's Engineer Research and Development Center) and NOAA (National Ocean Service's National Centers for Coastal Ocean Science and the Office for Coastal Management and National Marine Fisheries Service's Office of Habitat Conservation). Please see Appendix I for a listing of workshop participants and their respective organizations and positions.

2.3 Agenda and Workshop Structure

The one-day workshop was structured with both plenary and breakout group sessions (as indicated in the workshop agenda, Appendix II). The morning plenary session began with opening remarks and presentations that allowed USACE and NOAA-NOS leadership to provide overviews of their respective mission areas, and SWG provided considerable details about ongoing, mission-related activities along the Texas coast (Figure 3, 4 and 5). During the morning plenary session, participants were also provided background information pertaining to EWN and NNBF (Figure

6). Agency leadership also provided updates and thoughts related to the earlier action items and/or outcomes that were derived from the previous USACE/NOAA workshops. The morning plenary presentations can be found in Appendix III.

Figure 3. Workshop participants in the morning plenary session.

Figure 4. Dr. Edmond Russo provides an overview of the SWG mission and priorities during the morning plenary session.

Figure 5. Dr. Steve Thur provides an overview of the NOS and NCCOS missions and priorities during morning plenary session.

Figure 6. Dr. Todd Bridges provides an overview of the EWN initiative during the morning plenary session.

The afternoon plenary session included SWG presentations that emphasized ongoing collaborations, environmental restoration opportunities, and data collection needs along the Texas coast. The afternoon plenary presentations can be found in Appendix IV.

Following the afternoon plenary session, participants were assigned to one of four pre-determined breakout groups. Group 1 consisted of four senior leaders from ERDC, SWG, NCCOS, and OCM that participated in the plenary sessions. Groups 2, 3, and 4 were comprised of seven individuals. Groups 2, 3, and 4 were evenly distributed across the participating organizations, consisting primarily of technical staff with diverse skill sets and expertise. Please see Appendix V for a listing of individuals that participated in the respective breakout groups. Participants were provided an "NNBF Collaborative Opportunity/Discovery" workbook for use during the breakout session. Questions located in the workbook were reviewed and subsequently answered by each of the participants. In turn, individuals shared their responses with their respective teams, which resulted in considerable discussion among members. Next, each of the four teams identified a spokesperson who presented his/her respective group's thoughts/ideas when the teams reconvened in plenary session at the end of the one-day workshop. The following describes the approach taken by each breakout group to stimulate and focus discussion during the breakout session:

Initially, each participant within each of the four breakout groups was asked to consider the following questions independently: (1) Knowing what you do about NOAA-NOS, SWG, and ERDC, what are three possible NNBF-related opportunities along the Texas coast that we should consider for future collaboration? (2) Leveraging existing SWG projects is one approach to consider. However, creative ideas focused on innovative, "yet-to-be-seen" demo projects are highly encouraged. We also request that you describe your project ideas and how it captures the four "EWN Elements of Success"; (3) What are the key steps required to initiate your project opportunity? And (4) What resources are required to initiate your project opportunity?

When each individual answered the initial questions, the breakout group participant was then asked to rate their three opportunities as high, medium, or low potential; provide a rationale for giving that priority; and finally, define the timeframe for the respective opportunity (i.e.,

Immediate: now-3 years; Short-term: 3-5 years; Long-term: 5-10 years). Upon completion of these actions, each participant shared his or her ideas with the additional members of their breakout group. For projects identified as a high priority, the facilitators also prompted the individual to provide a rationale for prioritization and the timeframe for implementation.

The results of this exercise were recorded by each of the facilitators in the four breakout groups. In turn, each breakout group nominated a speaker that presented results during the final plenary session of the workshop.

3 Key Outcomes

3.1 Breakout Session

The breakout session offered the participants a chance to identify and share ideas specific to NNBF-focused demo (new) projects or current projects that would allow for collaboration and incorporation of NNBF elements. More than 25 total project ideas for NNBF-based projects emerged from the initial discussions in Breakout Groups 1-4 (Please see Appendices VI-VIV for listing of project ideas from each team). Table 1 and Table 2 illustrate only the high-potential project ideas (19 total) identified and reported by each group.

3.2 Breakout Session Results

Review of the high-potential project ideas resulted in the emergence of common themes. Although some liberty was offered when comparing/contrasting ideas, five project categories became apparent. For example, four of the identified projects included collaboration on NNBF-related restoration research that focused on beaches, dunes, and shorelines. Ideas that prioritized island-related initiatives, which include various habitat restoration initiatives (i.e., marshes, sea grasses, mangroves, crane habitat, etc.), also emerged as a priority category.

Alternatively, two projects were grouped into a collaborative research category that included elements of future breakwater deployment and/or enhancement. Finally, collaborative modeling-based initiatives/tools were a noticeable priority that emerged in Group 4's discussion. For example, ecological forecast models and marsh evolution models are specifically identified as priority collaborative efforts that SWG, ERDC, and NOAA-NOS should pursue. While many of the linkages between project ideas are easily discernible, the authors of this document acknowledge that other relationships among ideas likely exist, which would result in alternative categories that are easily created. However, the initial identification of these collaborative project ideas remains the overall goal of the workshop. Follow-up efforts by workshop participants will include refinement and elucidation of existing project ideas, and these future actions are anticipated to improve connectivity or help with differentiation.

4 Closing Session and Workshop Conclusion

The closing session allowed Dr. Russo, Dr. Bridges, Dr. Thur, and Dr. Paine to provide their perspectives regarding the workshop and final thoughts to the participants. Dr. Bridges also commented that the workshop prioritized several good ideas that should be further refined, evaluated, and pursued in the short-term. After describing anticipated workshop products and next steps, the workshop concluded with Dr. Russo and Dr. Bridges thanking the USACE staff and NOAA guests for attending.

5 Workshop Products, Recommendations and Next Steps

At the conclusion of the workshop, there were a number of products, recommendations, and next steps for USACE and NOAA to pursue, including:

- Preparing and disseminating a joint executive summary of the workshop;
- Preparing and jointly publishing a workshop proceedings report;
- Holding a senior leadership team follow-up teleconference to track progress; and
- Engaging the USACE-NOAA NNBF Collaboration Strategy Leadership and Coordination Groups to solicit their input on the identified project opportunities.

Table 1. High priority project ideas from each breakout group (Ideas 1-11).

Project #	Priority Project Ideas	Priority Rationale	Breakout Group 1	Breakout Group 2	Breakout Group 3	Breakout Group 4	Comparison
1	Jefferson County Clay Core Dune Construction and Shoreline Restoration Project	Retard Coastal Resource Losses Strategy: Coordinate interests on existing project to characterize NNBF project performance in retarding shoreline retreat Intended Outcome: Publish best practices in EWN design, construction, and maintenance, Ecosystem Goods and Services (EGS) (e.g., beach access, recreation, eco-tourism), inform future USACE and non-federal interest (NFI) project development guidance.	X				Similar to Idea #2, #5, #15, and #19
2	South Padre Island (SPI) Sand Engine	Work with resource agencies to set conditions for industry use of SPI shoreline as "sand motor" dredged materials placement site with intent to characterize NNBF performance. Publish best practices and inform future channel maintenance project dredge materials management practices.	X				Similar to Idea #1, #5, #15, and #19
3	Galveston Bay Subaquatic Ecosystem Restoration	Work with resource agencies to set conditions for industry use of degraded bay bottoms (historical oyster shell mining) as dredged material placement sites (e.g., thin layer placement for new work clays and sands) for subaquatic ecosystem restoration with intent to characterize NNBF performance (oyster bed cultch, sea grass beds, fish habitat).	X				
4	Matagorda Bay West Foreshore Island and Wetland Creation	Mine existing bay (open water) dredged materials placement areas for sand/shell to create features and relocate placement areas to west of channel to sustain created features with intent to characterize NNBF performance.	X				Similar to Idea #1, #5, #7, #8, #12, #15 and #16
5	Galveston Island Beach and Dune Restoration	Work with project owner and regulatory agencies to set conditions for creating variations on beach/dune restoration test section with intent to characterize NNBF performance.	X				Similar to Idea #1, #2, #15 and #19
6	Vegetation of Mud Dikes – Tool to Determine Density Needs	Utilize/modify siting tool from living shorelines work to predict and forecast where more/less vegetation is needed on dikes. Transfer, expansion and replicability of existing tool		X			
7	Create Breakwaters Along GIWW and Include NNBF Wetlands (Behind Breakwaters)	SWG and ERDC focus on design, construction and assessment of engineering benefits. NOAA-NOS provides ecosystem analysis, monitoring, etc. 8-12 miles proposed in next few years; 14 miles right now.		X			Similar to Idea #12
8	Data Gap Analysis Between ERDC, SWG and NOAA	Inventory data needs across organizations and determine availability of data with NOAA, SWG and ERDC. Develop inventory/repository of data and ensure ease of accessibility. Where there are gaps, NOS can collect data.		X			
9	Restoring GIWW Barrier Island	Barrier islands have eroded and there is a need to reestablish. Conduct investigations for restoration and include NNBF with wetlands, sea grasses, corals, etc.		X			Similar to Ideas #4 and #10
10	Island and NNBF Creation and Protection within the Mission Aransas NERRS	Use dredged material to strategically construct islands and other nature-based features in an effort to protect MA habitat susceptible to erosion and degradation (i.e., mangroves, whooping crane habitat, marshes, etc.)		X			Similar to Idea #4 and #9
11	Focused Studies on Thin-Layer Placement	Numerous opportunities within SWG to pursue TLP projects. Direct studies at marsh and outcompeting SLR and determining improvements in marsh health.		X			

Table 2. Continuation of high priority project ideas from each breakout group (Ideas 12-19).

Project #	Priority Project Ideas	Priority Rationale	Breakout Group 1	Breakout Group 2	Breakout Group 3	Breakout Group 4	Comparison
12	Construction of Living Breakwater	Numerous opportunities to pursue the construction of living breakwaters within SWG. Offers SWG and ERDC to design/engineer structures and model/monitor engineering benefits. Similarly, NOAA-NOS to develop approach for studying/monitoring ecosystem services. Collaborations across areas as well.		X			Similar to Idea #7
13	Shoreline Restoration Projects	Agencies identify shoreline restoration project(s) to pursue. Investigate/determine how to maximize benefits with minimal investment (i.e., highest return on investment).			X		Similar to Idea #14
14	Establish/Quantify Multiple Benefits Derived from NNBF Projects	Emphasis is placed firmly on establishing/quantifying the ecosystem services benefits derived from shoreline, marsh restoration and oyster breakwater projects. Consider using Mission Aransas NERRS as project location.			X		Similar to Idea #10 and #13
15	Jefferson County, Large-Scale Shoreline and Marsh Restoration Project	Ongoing project that offers immediate opportunity for ERDC, SWG, and NOAA-NOS to collaborate on mutually agreeable research endpoints including wave attenuation, storm surge reduction and ecosystem services			X		Similar to Idea #1, #2, #5 and #19
16	Collaborations on Marsh Evolution Model	SWG, ERDC and NOAA-NOS staff continue to expand capabilities of existing marsh evolution model.			X		Similar to Idea #17 and #18
17	Ecological modeling that builds in interdisciplinary approaches – look at one or suite of modeling platforms; Ecological Forecast Models (Example: HABs, water quality, etc.)	There is a critical need for building/validating models that have utility. Easily transferable from R&D to operations.				X	Similar to Idea #16 and #18
18	Beneficial Re-Use of Dredged Material. Tool for optimizing/matching re-use sites to dredge material sources	Houston ship channel already has a tool. Would like to expand to other places. Ecological side is missing most info...would correct for that. Also, focus on creating models with more vegetation composition (e.g., marsh model with fewer variables (LiDAR or things that could be collected regularly to screen).				X	Similar to Idea #16 and #17
19	Dune/Beach re-nourishment project: coastal ecosystem restoration, Jefferson County muddy sand motor	Identify/develop most efficient sand motor systems and options for bypass techniques. Review jetty influence on sand motor to determined magnitude of sediment flow obstruction and potential for pumping past groins				X	Similar to Idea #1, #2, #5 and #15

References

Bridges, T. S., C. J. Banks, and J. K. King. 2016a. Proceedings of the U.S. Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) Natural and Nature-Based Features Workshop (NNBF). Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Bridges, T. S., C. J. Banks, and M. A. Chasten. Engineering with Nature. Advancing System Resilience and Sustainable Development. 2016b. The Military Engineer (January/February 2016) 699: 52-54

Bridges, T. S., J. K. King, C. J., Banks, C. Tortorici, M. Murray-Brown, and D. Marrone. 2017 Proceedings from the U.S. Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric (NOAA) Engineering With Nature (EWN) Workshop. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Bridges, T. S., P. W. Wagner, , K. A. Burks-Copes, , M. E. Bates, , Z. Collier, C. J. Fischenich, J. Z. Gailani, L. D. Leuck, C. D. Piercy, J. D. Rosati, E. J. Russo, D. J. Shafer, B. C. Suedel, , E. A. Vuxton, and T. V. Wamsley. Use of Natural and Nature-Based Features (NNBF) for coastal resilience. 2015. ERDC SR-15-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Bridges, T.S., J. Lillycrop, J.R. Wilson, T.J. Fredette, B. Suedel, C.J. Banks, and E.J. Russo. "Engineering With Nature" Promotes Triple Win Outcomes. Tera et Aqua (June 2014) 135:17-23.

National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS). October 2016. NOS Roadmap. http://oceanservice.noaa.gov/about/NOSRoadmap.pdf

U.S. Army Corps of Engineers. 2013. Coastal Risk Reduction and Resilience. CWTS 2013-3. Washington, DC: Directorate of Civil Works, US Army Corps of Engineers.

Appendix I: Participants List

USACE and NOAA-NOS Workshop: Natural and Nature Based Features
February 23
2017
Galveston Texas
Total Registered: 26

Last Name	First Name	Badge Name	Agency/Organization	Expertise	Contact Number	Email
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White	Thomas	Tom White	USACE-SWG	Coastal Engineering	409-766-3109	Thomas.E.White@usace.army.mil
Maglio	Coraggio	Coraggio Maglio	USACE-SWG	Design, Dredging, and Coastal engineering	409-941-8517	coraggio.maglio@usace.army.mil
Hamilton	Paul	Paul Hamilton	USACE-SWG	Geomorphology	(409) 766-3102	Paul.B.Hamilton@usace.army.mil
Clarkin	Timothy	Tim Clarkin	USACE-SWG	H&H	(409) 766-3854	Timothy.J.Clarkin@usace.army.mil
Burks-Copes	Kelly	Kelly Burks-Copes	USACE-SWF	Ecosystem Services	601-618-5565	Kelly.A.Burks-Copes@usace.army.mil
Irigoyen	Eddie	Eddie Irigoyen	USACE-SWG	Project Manager	409-766-3130	Eduardo.Irigoyen@usace.army.mil
Agbley	Senanu	Sena Aghley	USACE-SWG	SME H&H	(409) 766-6383	Senanu.Agbley@usace.army.mil
Jones	Seth	Seth Jones	USACE-SWG	Operations Manager	(409) 766-3068	Seth.W.Jones@usace.army.mil
Campbell	Tricia		USACE-SWG	Operations Manager	(409) 766-3153	Tricia.C.Campbell@usace.army.mil
Solomon	David		USACE-SWG	Construction Management	(409) 766-3942	David.A.Solomon@usace.army.mil
Thur	Steve	Steve Thur	NOS-NCCOS	NCCOS Acting Director	240-533-0146	steve.thur@noaa.gov
Harmon	Michelle	Michelle Harmon	NOAA/NOS/NCCOS	Coastal Resilience/Climate Vunerability Team Lead NCCOS; coastal ecology/program planning	240-533-0158	michelle.harmon@noaa.gov
Payne	Jeff	Jeff Payne	NOS-OCM	Director of OCM; Ecosystem Services	843-740-1207	Jeff.Payne@noaa.gov
Penn	Kim	Kim Penn	NOS - OCM	Other coastal management and policy, climate adaptation, natural and nature-based infrastructure	240.533.0727	kim.penn@noaa.gov
Davis	Jenny	Jenny Davis	NOS-NCCOS	coastal wetland ecology - natural and nature based infrastructure	252-838-0804	jenny.davis@noaa.gov
Kidwell	David	David Kidwell	NOS-NCCOS	coastal ecology, sea level rise and storm surge modeling; natural and nature-based features	240-533-0286	david.kidwell@noaa.gov
Vaudreuil	Elaine	Elaine Vaudreuil	NOS-OCM	coastal management, natural and nature-based infrastructure, coastal land conservation	240-533-0821	elaine.vaudreuil@noaa.gov
Schubert	Jamie	William Schubert	NOAA-OHC-RC	coastal ecology, coastal restoration	409-621-1248	jamie.schubert@noaa.gov

Appendix II: Workshop Agenda

US Army Corps of Engineers

EWN

NNBF

National Ocean Service

Agenda

SWG, ERDC, and NOAA-NOS
Natural and Nature-Based Features Workshop

23 Feb 2017

Galveston District HQ, 2000 Fort Point Road, Galveston, Texas 77550

Conference Room 175

Dialin: 1-877-411-9748; Access Code: 7671981; Security Code: 1234; (USA Caller Paid/International Toll: 636-651-3128);
https://www.teleconference.att.com/servlet/AWMlogin

Purpose: Explore and establish common interests for partnering on Natural and Nature Based Features (NNBF), which lead to the timely infusion of innovative technical products that support lifecycle coastal infrastructure systems, promote coastal preparedness and risk reduction, and enhance management decisions, in practice.

Objectives:

- Strengthen and broaden collaboration among represented organizations;
- Assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders and technical staff to identify opportunities to leverage each agency's investments and capabilities with respect to design, development, implementation, monitoring, adaptive management of NNBF and associated ecosystem services;
- Identify high-priority NNBF projects of common interest through use of plenary and breakout sessions. Categorize and prioritize projects that are identified for future collaboration;
- Identify other opportunities for crossover, working relationships in coastal science and engineering

Morning:

0800 – 0830 Arrive at SWG

0830 Welcome, Introduction and SWG Overview, Edmond Russo

0930 EWN, NNBF and Update on USACE/NOAA Collaborations, Todd Bridges

1030 Break (15 minutes)

1

1045 NOS Overview: Emphasis on OCM and NCCOS; Steve Thur and Jeff Payne

1130 Coastal Texas Restoration/Protection Project; Sharon Tirpak

Lunch:

1200 Break with Lunch Instructions, Todd Bridges

1215 Working Plenary Lunch: "Around-the-Room" Discussion, Statement Clarifications, Q/A, and Additional Thoughts; "Parking Lot" Ideas for Breakout Group Discussions.

Afternoon:

1300 Coastal Science and Engineering Collaborative (CSEC); Rob Thomas

1320 Coastal Texas Environmental Restoration & Coastal Storm Risk Management measures; Kelly Burks-Copes

1340 Galveston Bay: Environmental Restoration Opportunities; Tom White

1400 Texas Gulf Coast Data Collection Needs; Coraggio Maglio

1420 - 1545 Breakout Session (Instructions: Todd Bridges)

1545 Plenary Report: Breakout Groups Report on Results/Outcomes; Group Leaders

1615 Plenary Discussion: Common Themes / High-Priority Outcomes; Todd Bridges

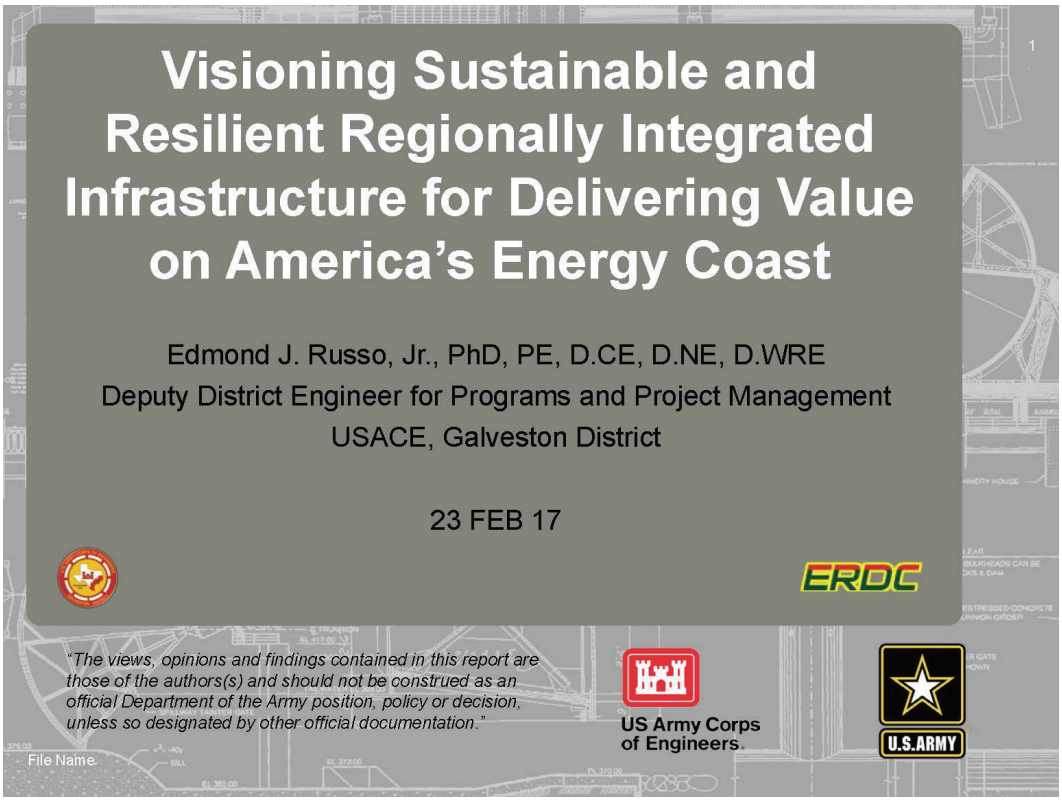
1645 Next Steps/Action Items; Edmond Russo, Todd Bridges, Jeff Payne, Steve Thur

1700 Adjourn

1800 - 2000 Dinner Social at The Spot, Seawall Blvd, Galveston, TX 78597

Appendix III: Day 1 – Morning Plenary Slides

Introduction to SWG



Overview
USACE, Galveston District (SWG)

2

- Chief of Engineer's Philosophy
- Civil works mission, geographic area of responsibility, and significance
- Strategy for delivering Value to the Nation (V2N)
- Coastal infrastructure system stressors and drivers
- Shared visioning for Sustainable and Resilient Regionally Integrated Infrastructure (SRRII)
- Leading change initiatives for organizational excellence to realize SRRII
- Value proposition for stakeholder partnering

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Chiefs' Vision: Building Our House in the "Federal / National" Community

3

"Strengthen the Foundation" . . . . "What" + "How"

"Doing the routine things to an exceptionally high standard, routinely."

"Deliver the Program" . . . . "What" ⇨ "How"

"The most strategic thing we can do is deliver our mission . . . . keep our promises."

"Achieve our Vision" . . . . "How" ⇨ "What"

Troop leading ourselves into an unknowable future . . . . together.

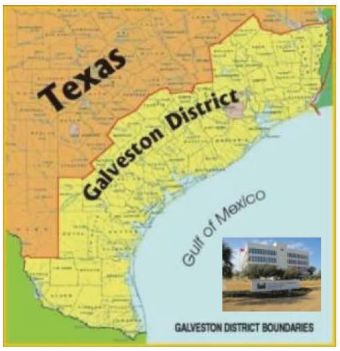
Vision . . . . Why + Who + Where

Our "compelling, better tomorrow."

SWD Commanding General's Philosophy: Be Humble, Be Kind, Be Optimistic

USACE SWG Mission and Area of Responsibility

4



- 50,000 square mile district boundary
- 28 ports handling 500+ M tons of commerce annually
- 1,000+ miles of channels
  - 750 miles shallow draft
  - 270 miles of deep draft
- 367 miles of Gulf coastline
- 30-40 M cubic yards/yr material dredged
- 16 Congressional districts
- 48 Texas counties
- 18 Coastal counties - bays / estuaries
- 9 watersheds
- 4 Louisiana parishes

- Navigation
- Flood Risk Management
- Regulatory
- Ecosystem Restoration
- Emergency Management
- Interagency & International Support

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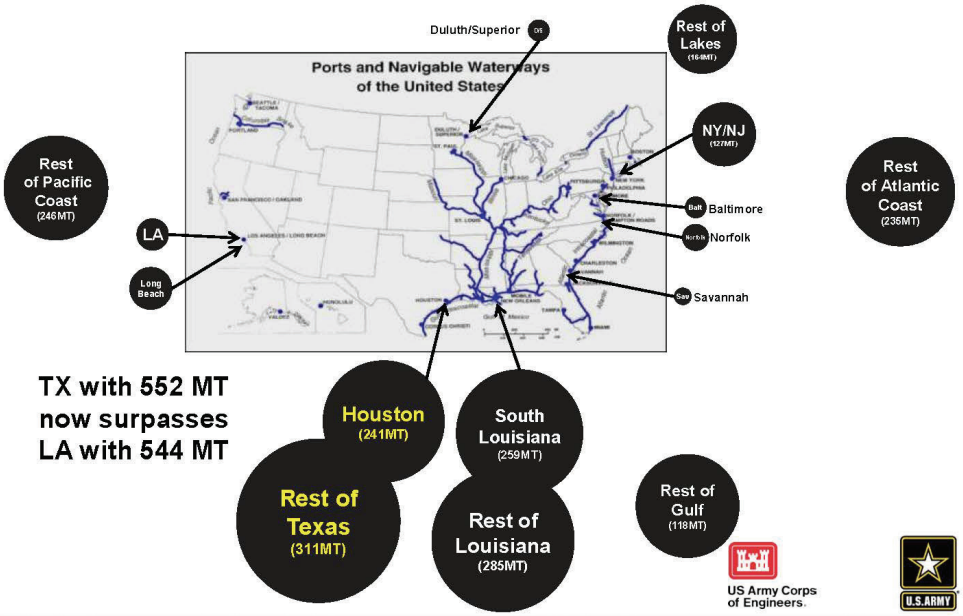
Significance of Navigation Commerce as a National Economic Driver

5

Data Source: USACE, Waterborne Commerce Statistics Center – 2015



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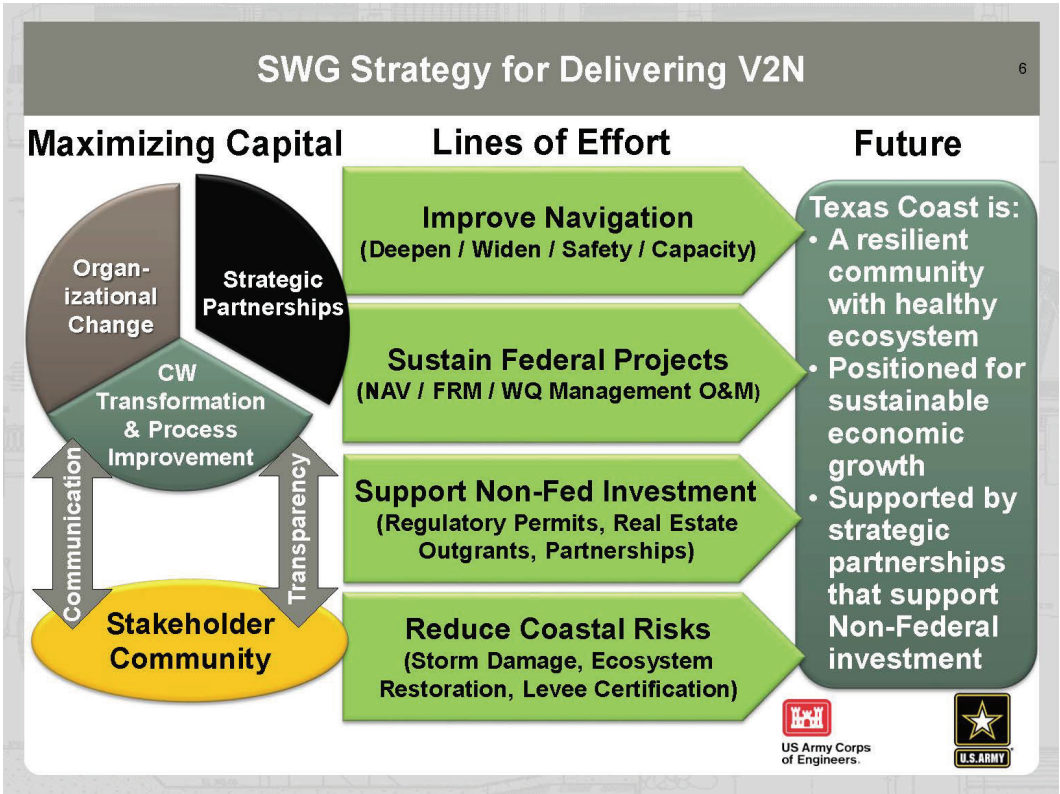
SWG Strategy for Delivering V2N
6
Maximizing Capital
Lines of Effort
Future
Organ-izational Change
Strategic Partnerships
CW Transformation & Process Improvement
Communication
Transparency
Stakeholder Community
Improve Navigation
(Deepen / Widen / Safety / Capacity)
Sustain Federal Projects
(NAV / FRM / WQ Management O&M)
Support Non-Fed Investment
(Regulatory Permits, Real Estate Outgrants, Partnerships)
Reduce Coastal Risks
(Storm Damage, Ecosystem Restoration, Levee Certification)
Texas Coast is:
• A resilient community with healthy ecosystem
• Positioned for sustainable economic growth
• Supported by strategic partnerships that support Non-Federal investment
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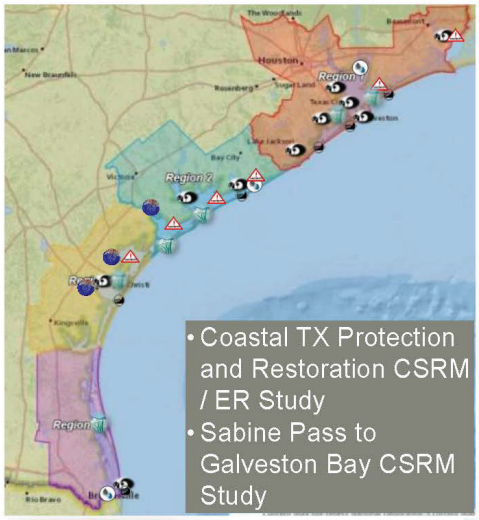
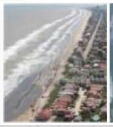
Coastal Navigation: Value to the Nation
USACE Southwestern Division Regional Priority
7
SNWW LRR
HSC EIP Mega Study
GHCE Sec 216
Chocolate Bayou Const
FHCIP GRR
MSC Sec 216 Study
CCSC MC / BLConst
CRL-BRFG Sec 216 Study
BIH Const
Port of Beaumont
Port of Port Arthur
Port of Houston
Port of Texas City
Port of Galveston
Port Freeport
Matagorda
Port of Victoria
Port of Corpus Christi
Port of Brownsville
Mexico
Gulf Intracoastal Waterway
40' 48' Sabine-Neches Waterway
46' 46' Houston-Galveston-Texas City Navigation Complex
46' 55' Freeport Harbor
38' 45' Matagorda Ship Channel
47' 52' Corpus Christi Ship Channel
42' 52' Brazos Island Harbor
Texas is the number two state in the nation for waterborne commerce. Texas ports generate over $5 billion in local and state tax revenue, and over $9 billion in federal import tax revenue each year.
With the Panama Canal Expansion opening in 2017, ports must expand their capacity via land-and-waterside improvements to accept these ships. The Texas navigation system has post-Panamax projects ready for construction and studies are completed for deepening Port Freeport, Corpus Christi Ship Channel and the Sabine-Neches Waterway to depths that would allow post-Panamax ships to call.
Constructed Depth
40' 48'
Authorized; not funded to date
38' 45'
Pending Authorization
Constructed Depth
LEADING U.S. PORTS
(2015 Tonnage)
Houston #2 - 240.9 million tons
#1 Foreign Tonnage & #2 Total Tonnage
Beaumont #5 - 87.2 m.tons
#1 Military Port in World
Gulf Intracoastal Waterway (79 million tons - Texas portion)
#3 Inland Waterway
Corpus Christi #6 - 85.7 m.tons
America's Energy Gateway
Texas City #15 - 42.9 m.tons
Services Largest Petrochemical Complex
Port Arthur #19 - 35.9 m.tons
Vital Break-Bulk Port
Freeport #32 - 21.1 m.tons
Connecting Global Services Via Caribbean Relay Port
Matagorda to include Port of Port Lavaca and Port of Point Comfort #46 - 11.8 m. tons
Generates Annual Business Revenues of Nearly $2 Billion
Galveston #51 - 10.4 m.tons
#4 Cruise Ship Port
Brownsville #66 - 7.7 m.tons
#1 Ship Recycling Port
Victoria (#70 - 6.7 m.tons)
#2 Shallow-Draft Port for Domestic Crude Petroleum
U.S. Army Corps of Engineers Galveston District
CONNECT WITH US! Web: www.swg.usace.army.mil Facebook: www.facebook.com/GalvestonDistrict Twitter: www.twitter.com/USACEgalveston

Addressing Problems and Opportunities in the Coastal Protection and Restoration Program

8



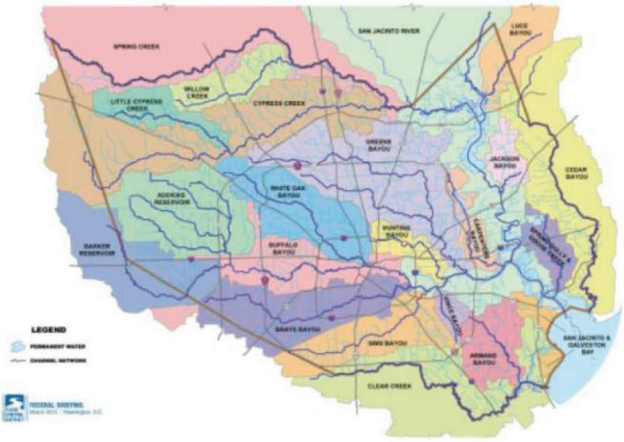
- Economic damage from coastal storm surge
- Inland shoreline erosion
- Gulf shoreline erosion
- Loss of T&E Critical Habitats (migratory bird habitat, critical T&E habitat, shellfish habitat)
- Loss of Natural Delta Processes
- Disrupted Hydrology



Identifying Problems and Opportunities in the Watershed Flood Risk Management Program

9

- Metro Houston Regional Watershed Assessment
- Addicks & Barker Reservoirs System Study
- SE Texas Regional Watershed Assessment
- Metro Brownsville Regional Watershed Assessment



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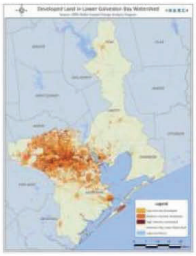
Contributors to Civil Works Program Risks and Uncertainties

10

Stressors:

- Extreme storm water levels (rivers, coast)
- Dynamics of coastal shorelines, islands, wetlands, sediments, and debris
- Drought effects on water availability and quality
- Aging, outmoded, and/or exhausted infrastructure & equipment (e.g., locks, PAs, dredges)
- Program funding levels



Drivers:

- Relative sea level change
- Changing legislation/policies
- Resource availability (e.g., energy, land)
- Development patterns/rates and modifications to natural systems

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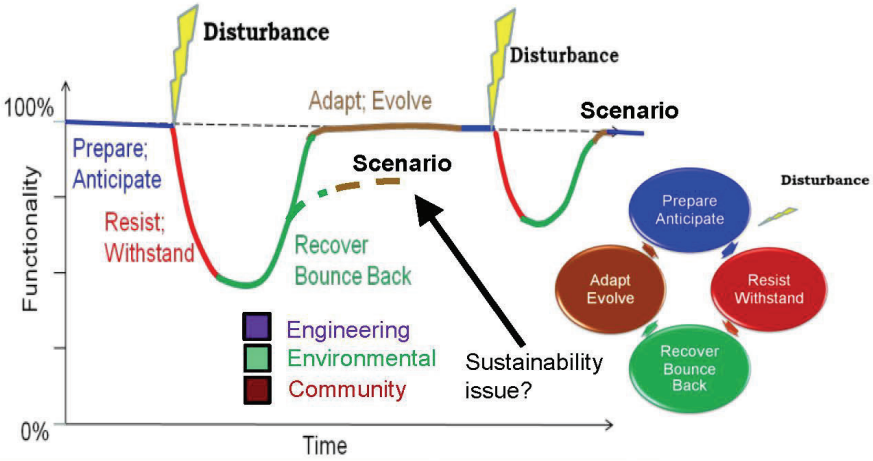
Concepts of Resilience against Disturbances and System Sustainability

11



Goal is for Texas Coast to be:

- **A resilient community with healthy ecosystem**
- **Positioned for sustainable economic growth**
- **Supported by strategic partnerships that support Non-Federal investment**

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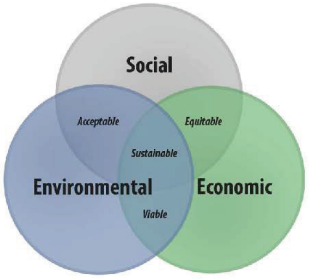
Engineering with Nature (EWN)

12

…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

Key Elements:

- Science and engineering that produces operational efficiencies
- Use of natural processes to maximum benefit
- Broadening and extending benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners



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Natural and Nature Based Features (NNBFs) in Water Infrastructure Improvements for the Nation (WIIN) Act

13

SEC. 1184. CONSIDERATION OF MEASURES.

(a) DEFINITIONS.—In this section, the following definitions apply:

(1) NATURAL FEATURE.—The term "natural feature" means a feature that is created through the action of physical, geological, biological, and chemical processes over time.

(2) NATURE-BASED FEATURE.—The term "nature-based feature" means a feature that is created by human design, engineering, and construction to provide risk reduction in coastal areas by acting in concert with natural processes.

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Integration of NNBFs with Traditional Engineered Features
Water Infrastructure Improvements for the Nation (WIIN) Act

14

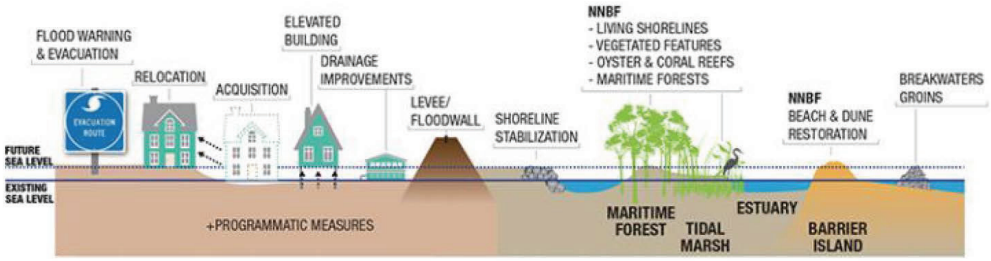
SEC. 1184. CONSIDERATION OF MEASURES. (continued)

(b) REQUIREMENT.—In studying the feasibility of projects for flood risk management, hurricane and storm damage reduction, and ecosystem restoration the Secretary shall, with the consent of the non-Federal sponsor of the feasibility study, consider, as appropriate—

(1) natural features; (2) nature-based features;

(3) nonstructural measures; and (4) structural measures.

(c) REPORT TO CONGRESS.— Excerpted



Multiple Lines of Defense (MLD)

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Integration of NNBFs with Traditional Engineered Features
Water Infrastructure Improvements for the Nation (WIIN) Act

14

SEC. 1184. CONSIDERATION OF MEASURES. (continued)

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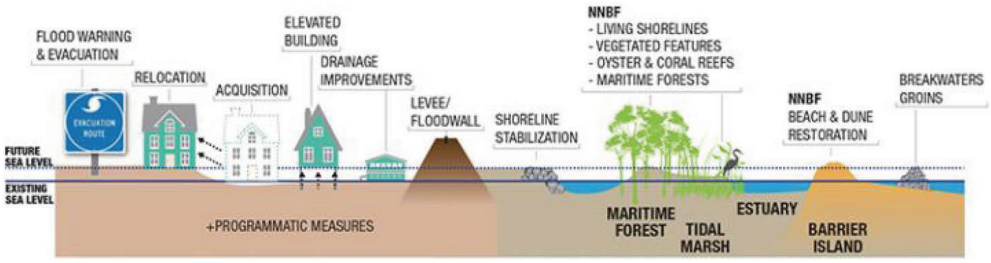

Multiple Lines of Defense (MLD)

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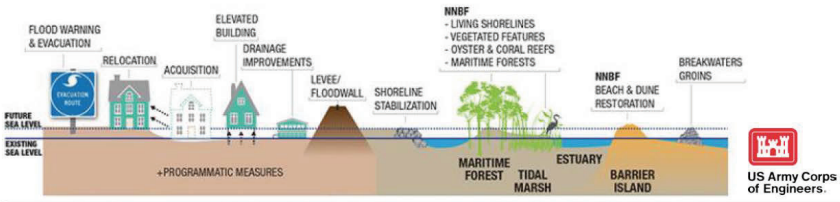
SRRII Shared Visioning

15

- Interconnected portfolio of partnered projects across business lines.
- Incorporates Regional Sediment Management (RSM), Engineering with Nature (EWN), Natural and Nature Based Features (NNBF), and Multiple Lines of Defense (MLD).
- Nested/networked infrastructure interoperating regionally to deliver broad spectrum of enduring economic, environmental, and social values.
- Value proposition for pursuit via inter-operational synergies:
  - –Transformed organizational technical, business, and management processes,
  - –High performing workforce culture, and
  - –Parties who understand, contribute to, and value the concepts and support infusion into practice.



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Leading Change Initiatives for Organizational Excellence to Realize SRRII

16

- ***SRRII*** shared visioning is the focal point
- ***Enhanced stakeholder engagement*** for closer V2N working relationships that support non-Federal investment
- ***Active Project Management (APM) and Workload / Workforce (WL/WF) Management*** for confident delivery on commitments
- ***Evolved governance and Vertical Team (VT) integration*** for increased organizational efficiency in mission execution
- ***Knowledge management and continuous process improvement*** for complete/efficient records continuity/recall, discovery learning, and improving competencies/capabilities
- ***Energizing the workforce*** for improved career satisfaction and productivity

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Enhancing Strategic Partnerships for Delivering V2N

17

- Texas coast shared visioning for alignment of agency values toward mutually desired outcomes
  - Vibrant regional and national economy
  - Resilient and sustainable communities
  - Healthy, diverse, and functional ecosystems
- Driving progress through regularly-engaged partnering and governance
  - Multi-agency participation (Local, State, Federal)
  - Shared vision steering
  - Identifying / resolving barriers to progress
- Team building, collaboration, and unified communications
  - Articulating challenges and successes
  - Building stakeholder awareness and support for action
  - Supporting elected officials with needed information

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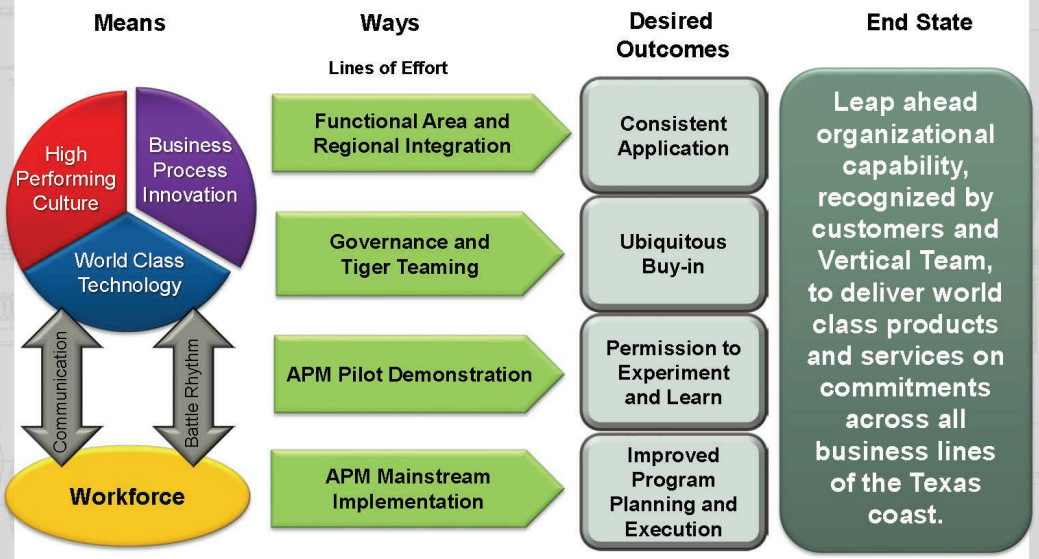
APM and WL/WF Management Strategy

18



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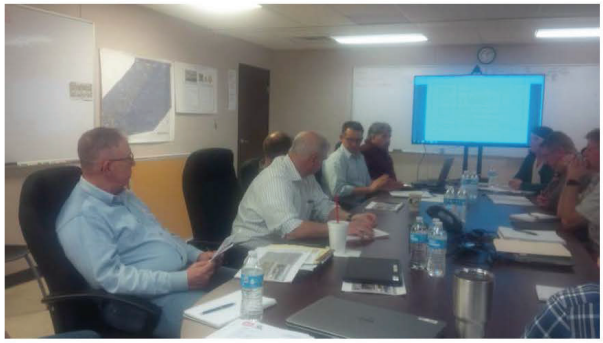
Evolved Governance and VT Integration

19

- District governance of strategic direction, functional integration, program execution, business management, resource management, and workforce management
- Bi-weekly VT synchronization meetings
- Mega Study and Mega Project tiered governance organizational model



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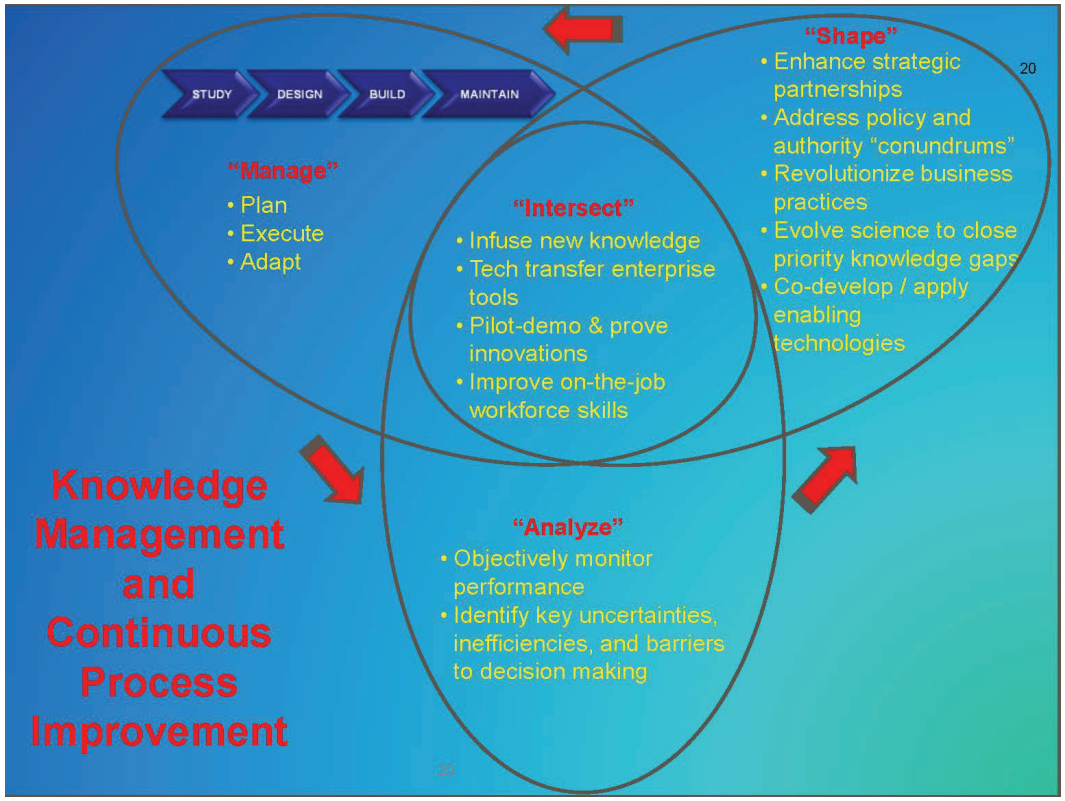

Coastal Science and Engineering Collaborative (CSEC) Objectives

21

- Transfer new science into practice faster
  - Deliver science and engineering to improve coastal project life cycle systems performance and cost
- Develop business collaboratively
  - Bring together capabilities, resources, and funding from multiple partners
  - Derive overall greater value than could be achieved separately
- Link academics to practice
  - Student learning experiences
  - Cultivate recruiting opportunities

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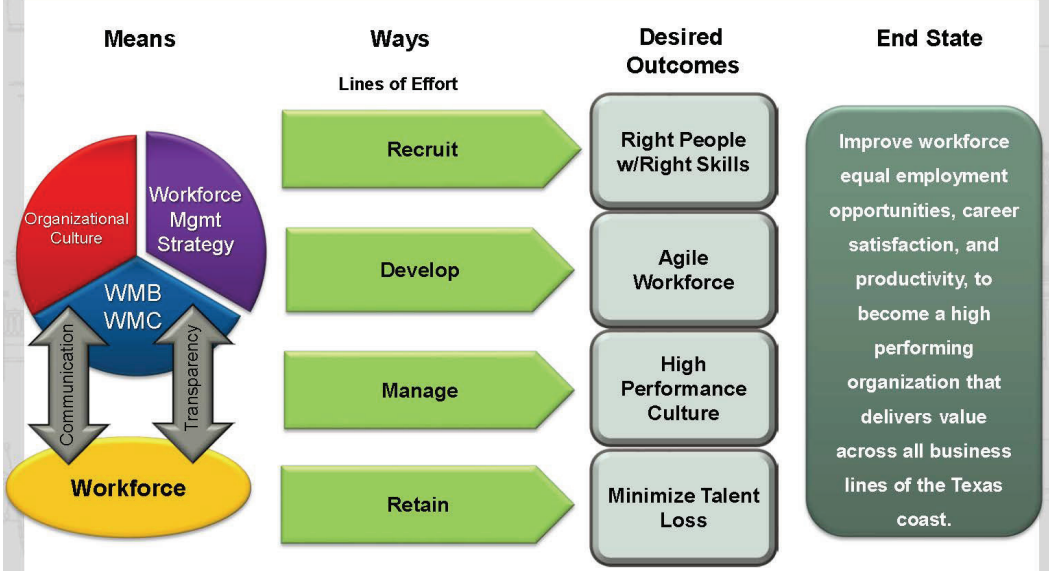
Workforce Management Strategy

22



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SWG Value Proposition for Stakeholder Partnering

23

- ***Vibrant regional economy*** driving need for ***resilient coastal communities*** and ***healthy ecosystem*** on America's Energy Coast
- ***Increasing partnerships*** across navigation, coastal storm and flood risk management, and ecosystem restoration business lines
- Addressing authority, policy, resourcing, and business process challenges with focus on ***Strengthening the Foundation***
- Existing and new authorities for studies and projects to derive V2N through ***Delivering the Program***
- Compelling, sustainable budgets and partnering to ***Achieve the Vision***

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ONLINE
www.swg.usace.army.mil

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EWN Overview

Engineering with Nature for Natural Infrastructure

Dr. Todd S. Bridges
Senior Research Scientist, Environmental Science
U.S. Army Engineer Research and Development Center, USACE
todd.s.bridges@usace.army.mil

SWG-ERDC-NOAA/NOS
Galveston, TX
February 23, 2017

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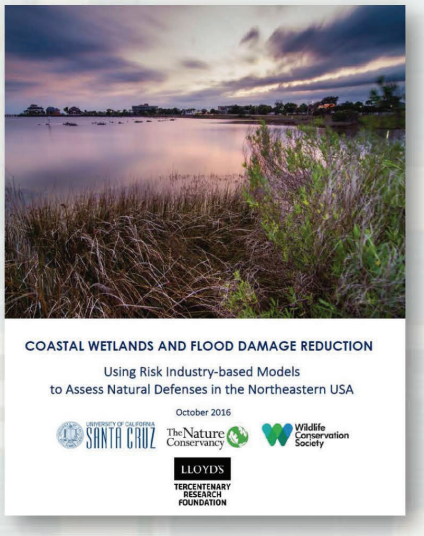
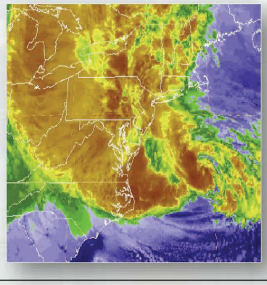
ERDC Engineer Research and Development Center

Value and Use of Natural Systems

Following Hurricane Sandy:

- Risk industry-based tools used to quantify the economic benefits of coastal wetlands
  - Temperate coastal wetlands saved more than $625 million in flood damages.
  - In Ocean County, New Jersey, salt marsh conservation can significantly reduce average annual flood losses by more than 20%.





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ERDC

BUILDING STRONG®

Innovative solutions for a safer, better world

2

Creating Value through Alignment…

- What opportunities are there for achieving better alignment of natural and engineered systems?
  - Can improved alignment reduce risks to life, property and ecosystems?
  - What range of services can be produced through such alignment?
  - What are the science and engineering needs in order to achieve better alignment?

Sustainable Solutions Vision: "Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation's water resources challenges."

ERDC

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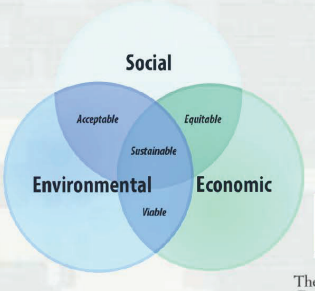
Innovative solutions for a safer, better world

Engineering With Nature…

…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes.

Key Elements:

- Science and engineering that produces operational efficiencies
- Using natural process to maximum benefit
- Broaden and extend the benefits provided by projects
- Science-based collaborative processes to organize and focus interests, stakeholders, and partners



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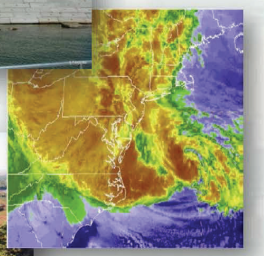
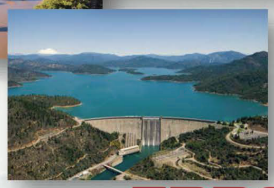
EWN Across USACE Mission Space

- Navigation
  - Strategic placement of dredged material supporting habitat development
  - Habitat integrated into structures
  - Enhanced Natural Recovery
- Flood Risk Management
  - Natural and Nature-Based Features to support coastal resilience
  - Levee setbacks
- Ecosystem Restoration
  - Ecosystem services supporting engineering function
  - "Natural" development of designed features
- Water Operations
  - Shoreline stabilization using native plants
  - Environmental flows and connectivity





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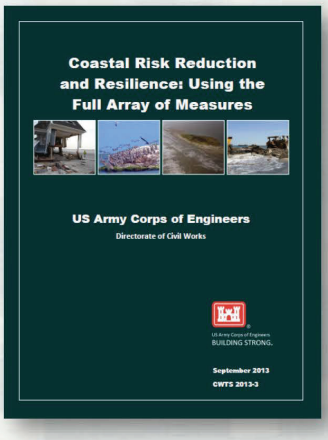
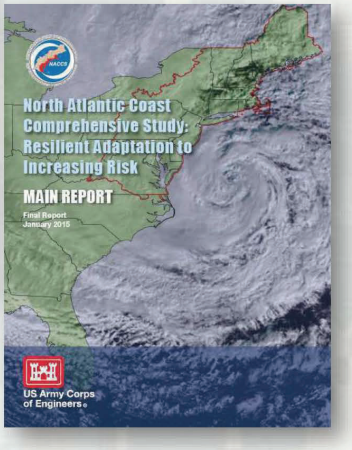
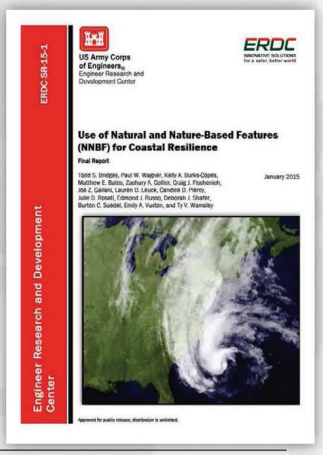
The North Atlantic Coast Comprehensive Study







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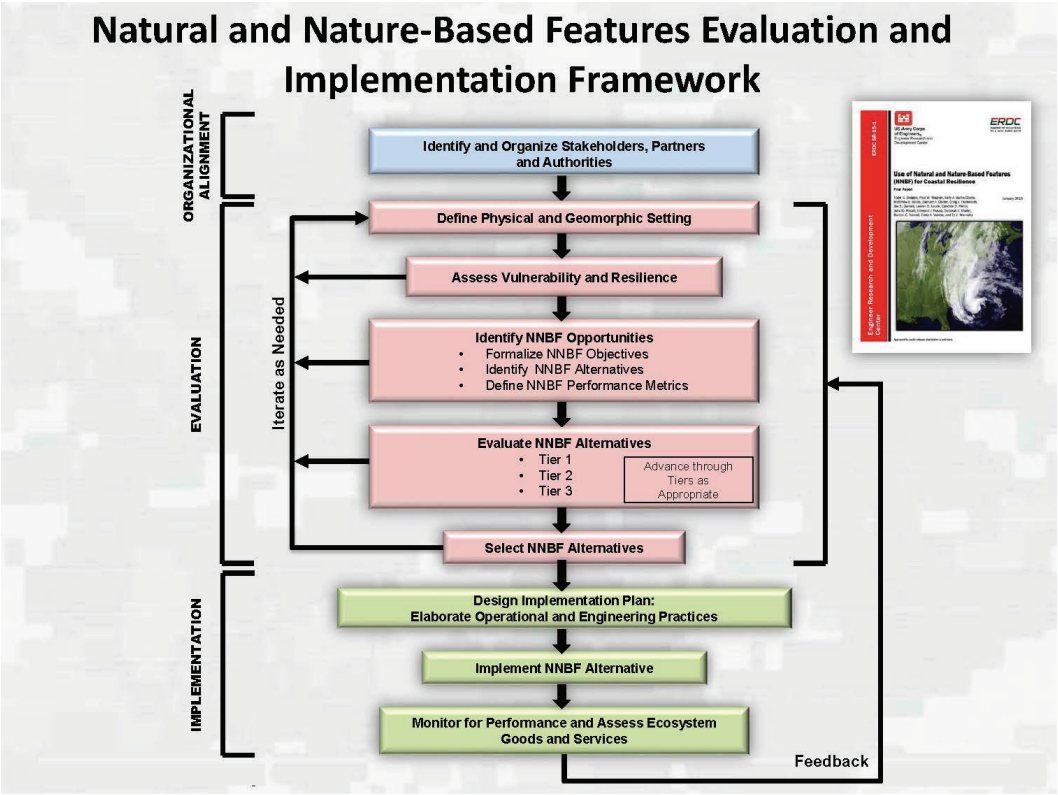
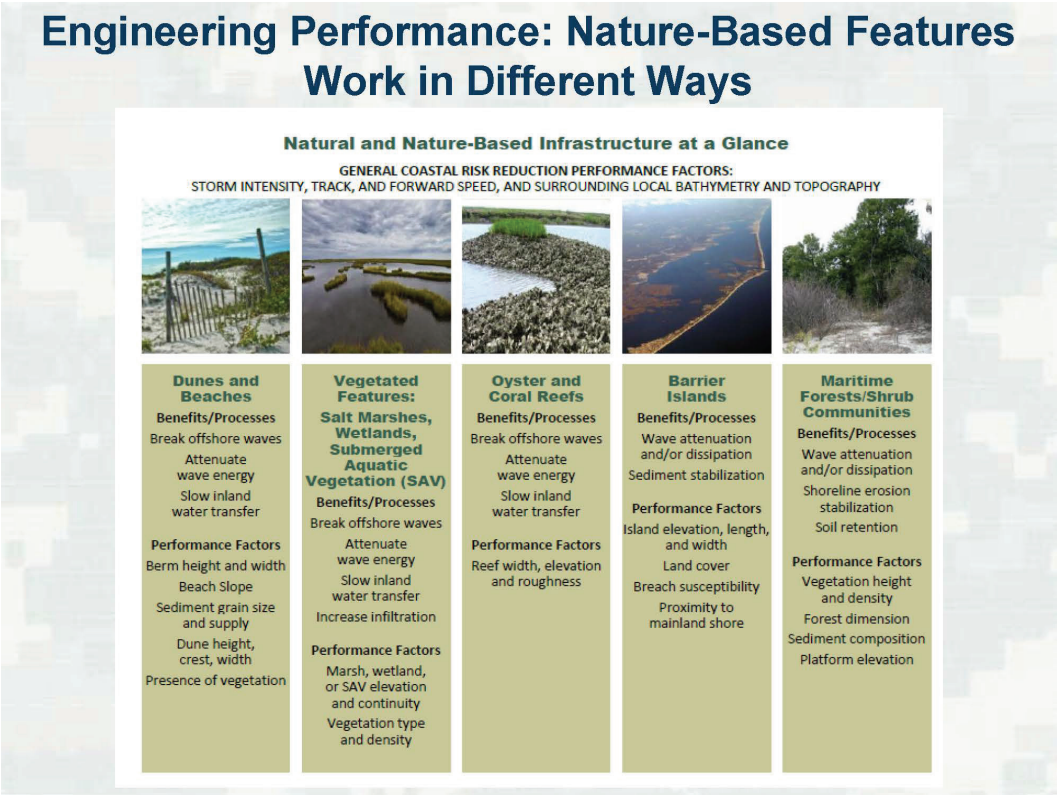
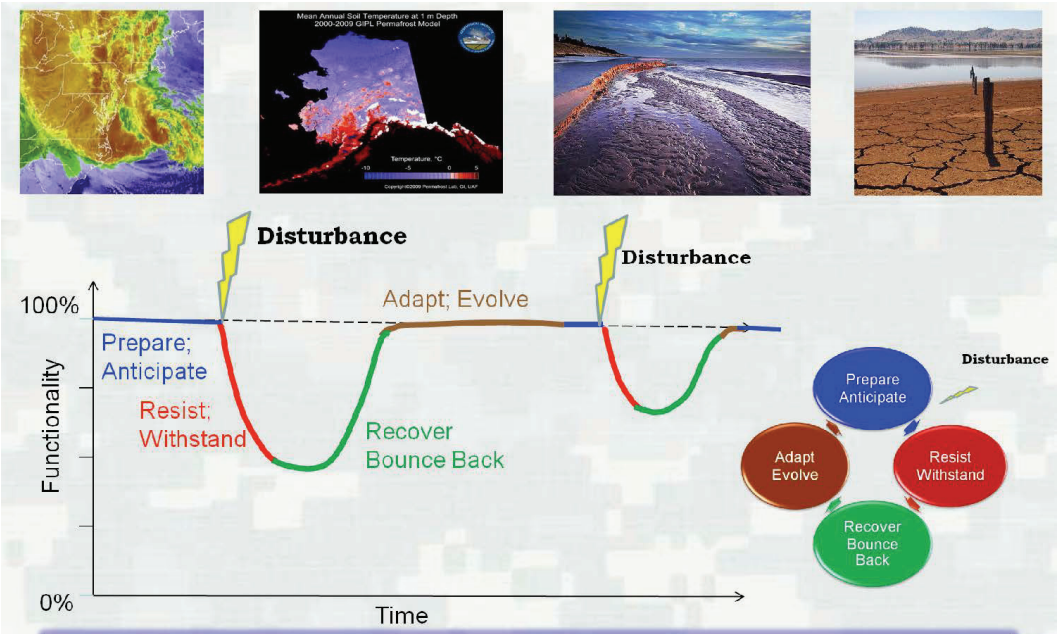
http://www.nad.usace.army.mil/CompStudy


Natural and Nature-Based Features Evaluation and Implementation Framework
ORGANIZATIONAL ALIGNMENT
EVALUATION
IMPLEMENTATION
Iterate as Needed
Identify and Organize Stakeholders, Partners and Authorities
Define Physical and Geomorphic Setting
Assess Vulnerability and Resilience
Identify NNBF Opportunities
• Formalize NNBF Objectives
• Identify NNBF Alternatives
• Define NNBF Performance Metrics
Evaluate NNBF Alternatives
• Tier 1
• Tier 2
• Tier 3
Advance through Tiers as Appropriate
Select NNBF Alternatives
Design Implementation Plan: Elaborate Operational and Engineering Practices
Implement NNBF Alternative
Monitor for Performance and Assess Ecosystem Goods and Services
Feedback
ERDC
Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience

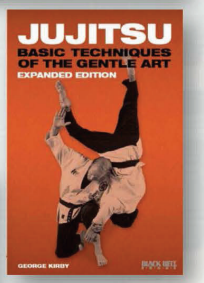

Engineering Performance: Nature-Based Features Work in Different Ways
Natural and Nature-Based Infrastructure at a Glance
GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED, AND SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY
Dunes and Beaches
Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer
Performance Factors
Berm height and width
Beach Slope
Sediment grain size and supply
Dune height, crest, width
Presence of vegetation
Vegetated Features:
Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)
Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer
Increase infiltration
Performance Factors
Marsh, wetland, or SAV elevation and continuity
Vegetation type and density
Oyster and Coral Reefs
Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer
Performance Factors
Reef width, elevation and roughness
Barrier Islands
Benefits/Processes
Wave attenuation and/or dissipation
Sediment stabilization
Performance Factors
Island elevation, length, and width
Land cover
Breach susceptibility
Proximity to mainland shore
Maritime Forests/Shrub Communities
Benefits/Processes
Wave attenuation and/or dissipation
Shoreline erosion stabilization
Soil retention
Performance Factors
Vegetation height and density
Forest dimension
Sediment composition
Platform elevation

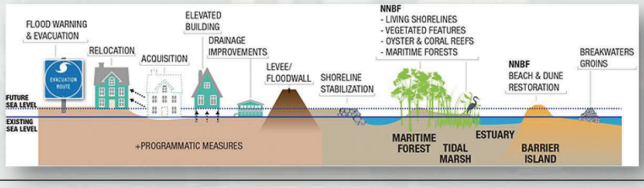


Resilience: the ability of a ***system*** to **Prepare for**, **Resist**, **Recover**, and **Adapt** to achieve functional performance under the stress of disturbances through time.

Opportunities to *Engineer With Nature* for Resilience

- **Strategies and Tactics**
  - ▸ Hold the Line
    - Use of NNBF in combination with conventional measures
  - ▸ Retreat
    - Managed realignment
    - "Coastal Engineering Jujitsu"
  - ▸ Advance / Attack
    - Adding elevation and features to landscapes through large-scale construction





U.S. ARMY

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Cat Island
Green Bay, Wisconsin

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Noordwaard

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Fort Pierce City Marina, Florida

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Caterpillar Corporation's
Restoring Natural Infrastructure Summit
4 November 2015, New York City

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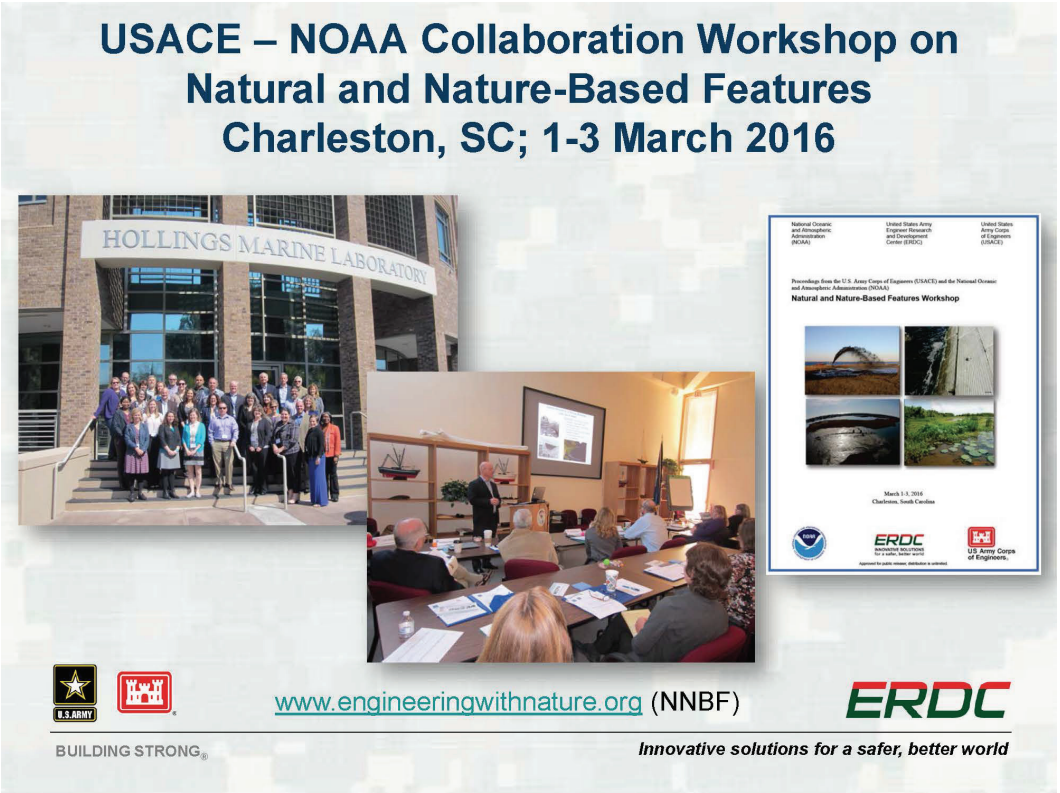
USACE – NOAA Collaboration Workshop on
Natural and Nature-Based Features
Charleston, SC; 1-3 March 2016
HOLLINGS MARINE LABORATORY
Natural and Nature-Based Features Workshop
www.engineeringwithnature.org (NNBF)
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USACE/NOAA-NMFS Collaboration Workshop on
Engineering with Nature
Gloucester, MA; October 5-6, 2016
www.engineeringwithnature.org
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Philadelphia District, ERDC, NOAA Collaboration

Mordecai Island

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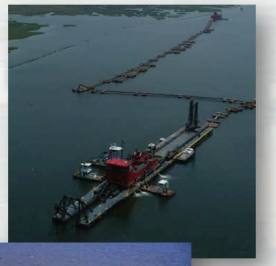
International Guidelines for Use of Natural and Nature-Based Features for Sustainable Systems



- Publish coastal guidelines by 2019:
  - Multi-author: government, academia, NGOs, engineering firms, construction companies, etc.
  - Addressing the full project life cycle: planning, design, engineering, construction, and maintenance
- Use experience and momentum to initiate inland international guidelines
- Engagement with Silver Jackets?
  - Key needs? How and Who to engage?

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EWN-Dutch Collaborations

- Rijkswaterstaat
  - Case studies report and project twinning
- Deltares
  - Collaboration on performance processes
- EcoShape's Building with Nature program
  - Multiple levels
- Academia
  - TU Delft
  - University of Applied Science/HZ

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Other EWN Collaborations

- The Nature Conservancy
  - Several topics involving both coastal, estuarine, and inland EWN
- World Bank and UN Development Program
  - Guidelines for international investment in NNBF, developing world
- TAMU EWN Curriculum

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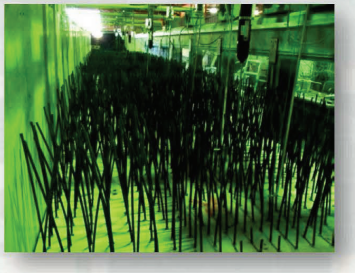
Next Steps for Science and Engineering…

- What processes and engineering requirements are critical to engineering performance and resilience?
- How will integrated solutions and systems evolve over time in dynamic environments?
- How can integrated systems be assembled to reduce long-term O&M costs in order to sustainably deliver resilience?
- How can field-scale demonstration projects be used to accelerate progress?



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Science, Engineering, Technology Research Targets

- Fundamental processes
  - Sediment transport through and around NNBF
  - Long-term engineering and environmental performance of features
  - Ecosystem Services provided by engineered features and structures
  - Processes contributing to system-scale resilience
- Modeling systems that support broad-scale application
  - Planners, stakeholders and decision-makers
  - Engineering design
  - Operations and maintenance
- Reliable, cost-efficient monitoring technologies
  - Measuring system evolution
  - Infrastructure/feature performance
- Demonstration/pilot projects to innovate, evaluate, and learn at relevant field scales
  - Facilitate necessary collaboration
  - Evolve organizational culture and practice
  - Produce credible evidence of success
  - Fuel the "power of the story"

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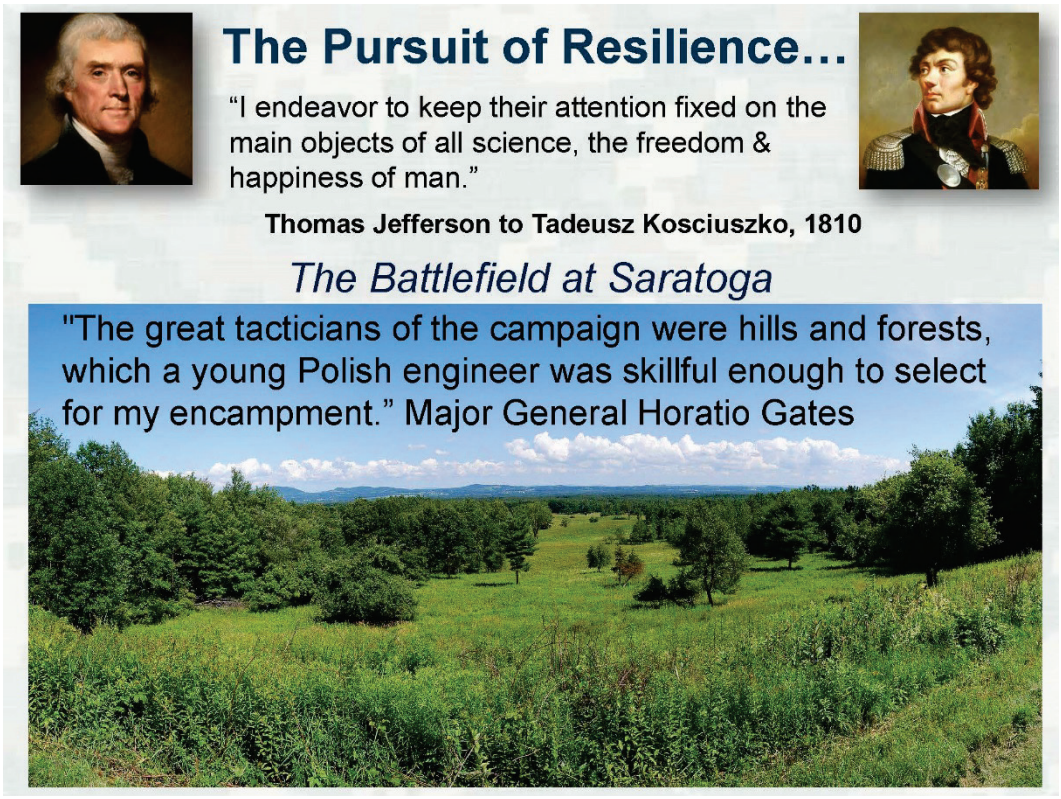
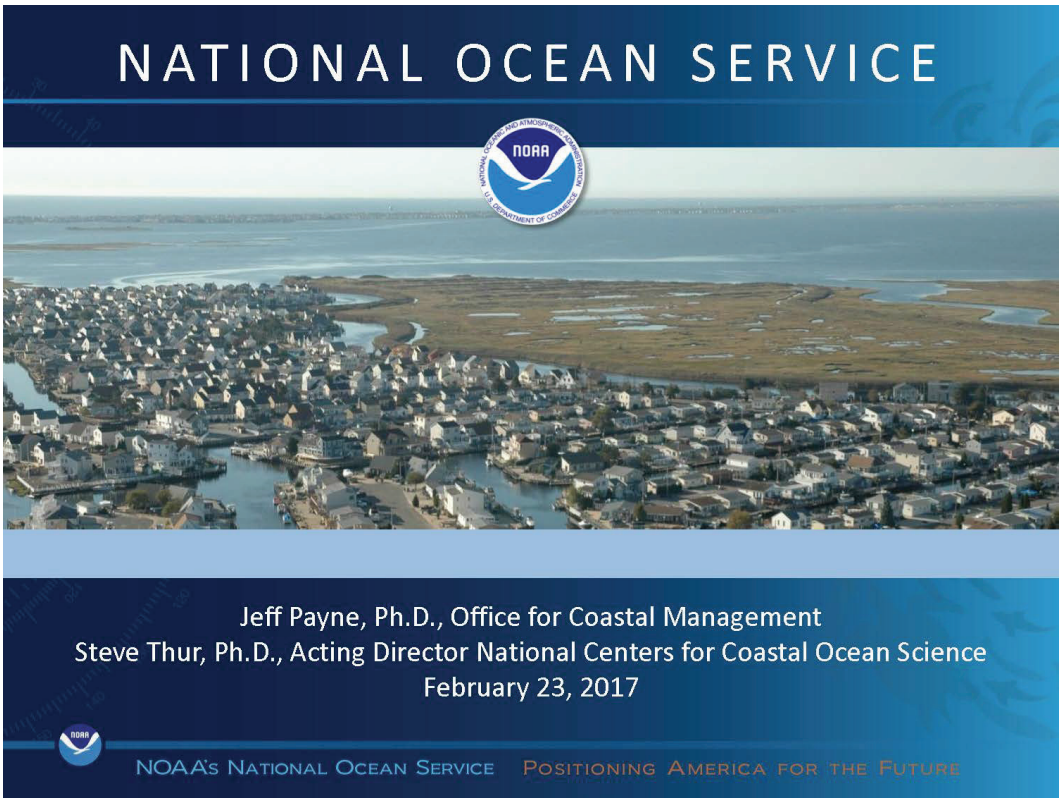
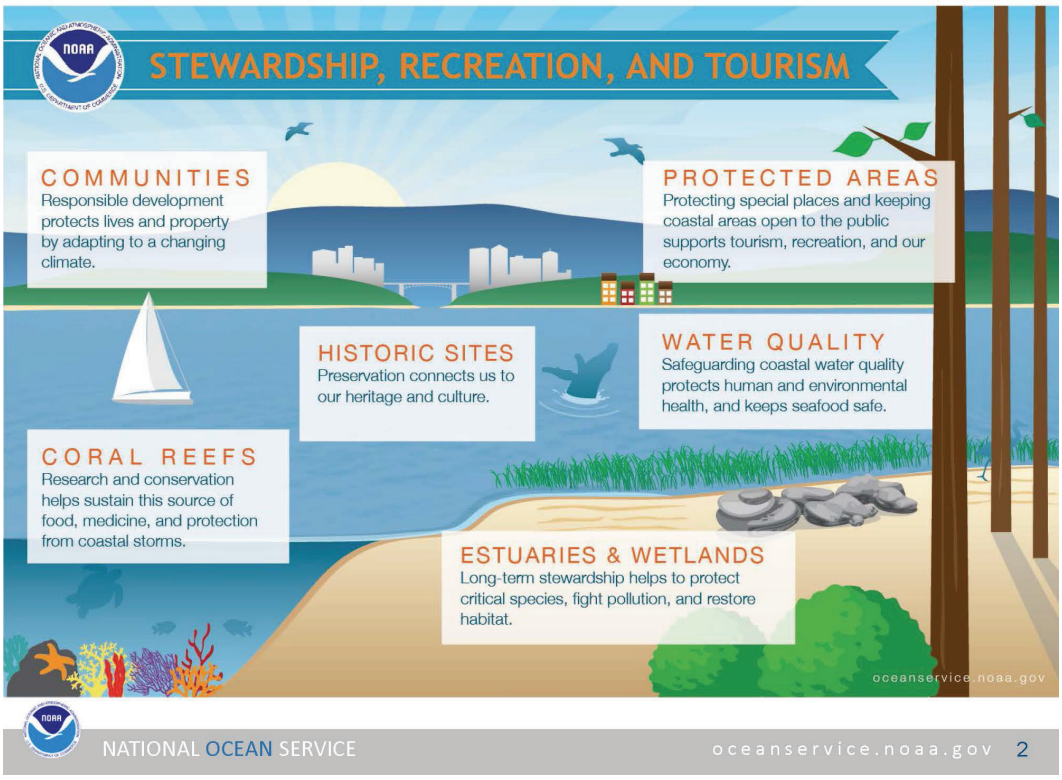
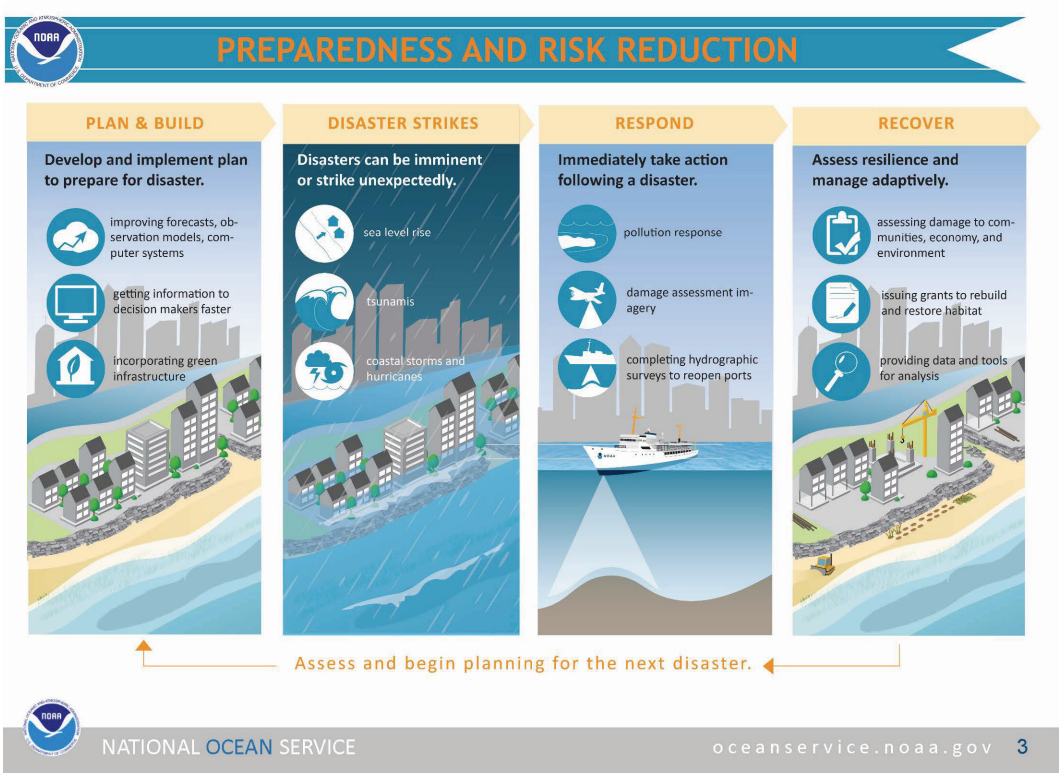
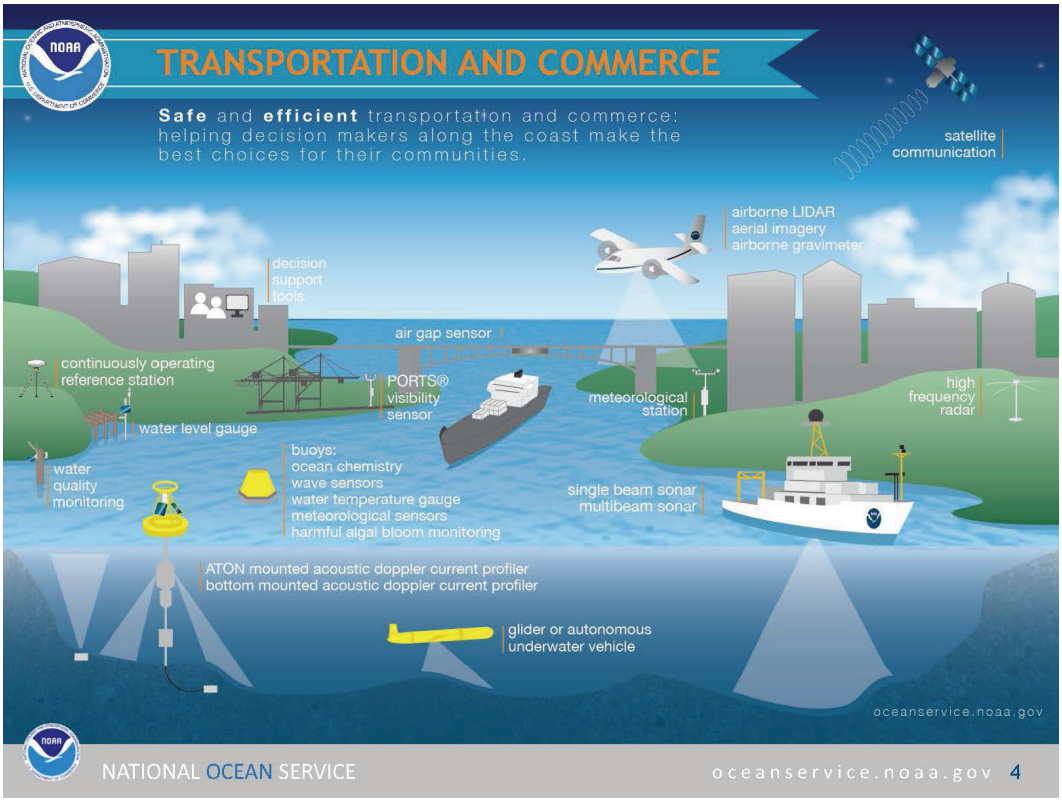

The Pursuit of Resilience…
"I endeavor to keep their attention fixed on the main objects of all science, the freedom & happiness of man."
Thomas Jefferson to Tadeusz Kosciuszko, 1810
The Battlefield at Saratoga
"The great tacticians of the campaign were hills and forests, which a young Polish engineer was skillful enough to select for my encampment." Major General Horatio Gates

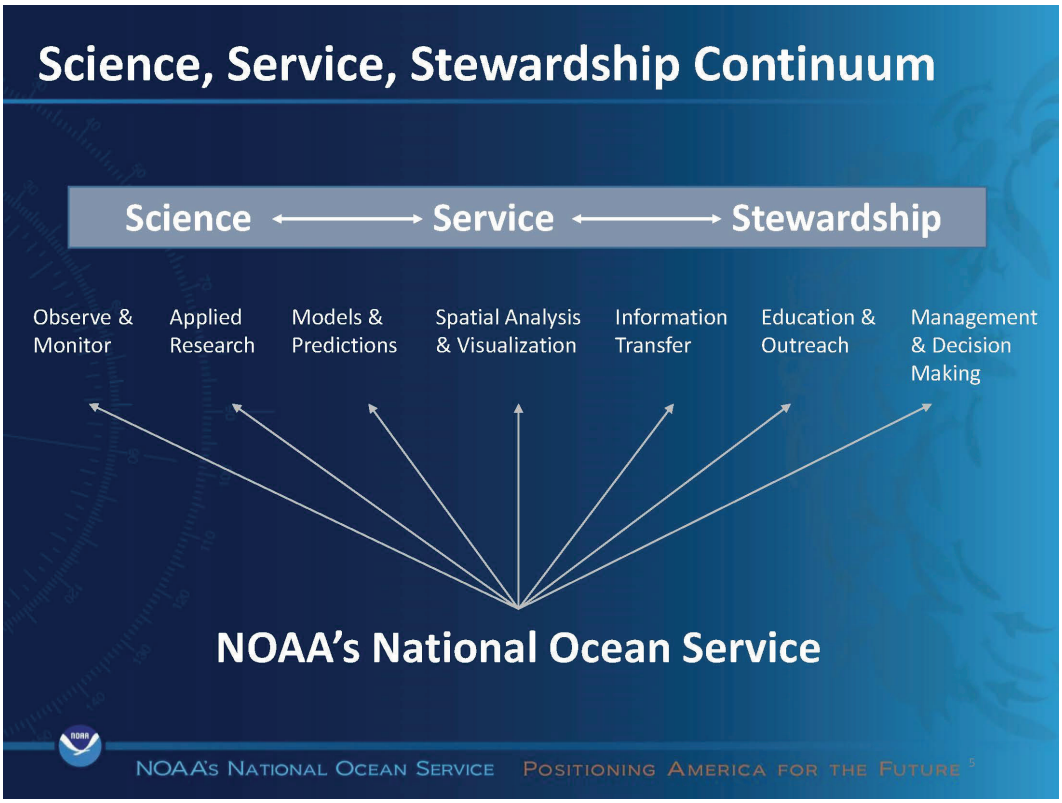
Introduction to NOAA






PREPAREDNESS AND RISK REDUCTION
PLAN & BUILD
Develop and implement plan to prepare for disaster.
improving forecasts, observation models, computer systems
getting information to decision makers faster
incorporating green infrastructure
DISASTER STRIKES
Disasters can be imminent or strike unexpectedly.
sea level rise
tsunamis
coastal storms and hurricanes
RESPOND
Immediately take action following a disaster.
pollution response
damage assessment imagery
completing hydrographic surveys to reopen ports
RECOVER
Assess resilience and manage adaptively.
assessing damage to communities, economy, and environment
issuing grants to rebuild and restore habitat
providing data and tools for analysis
Assess and begin planning for the next disaster.
NATIONAL OCEAN SERVICE
oceanservice.noaa.gov 3

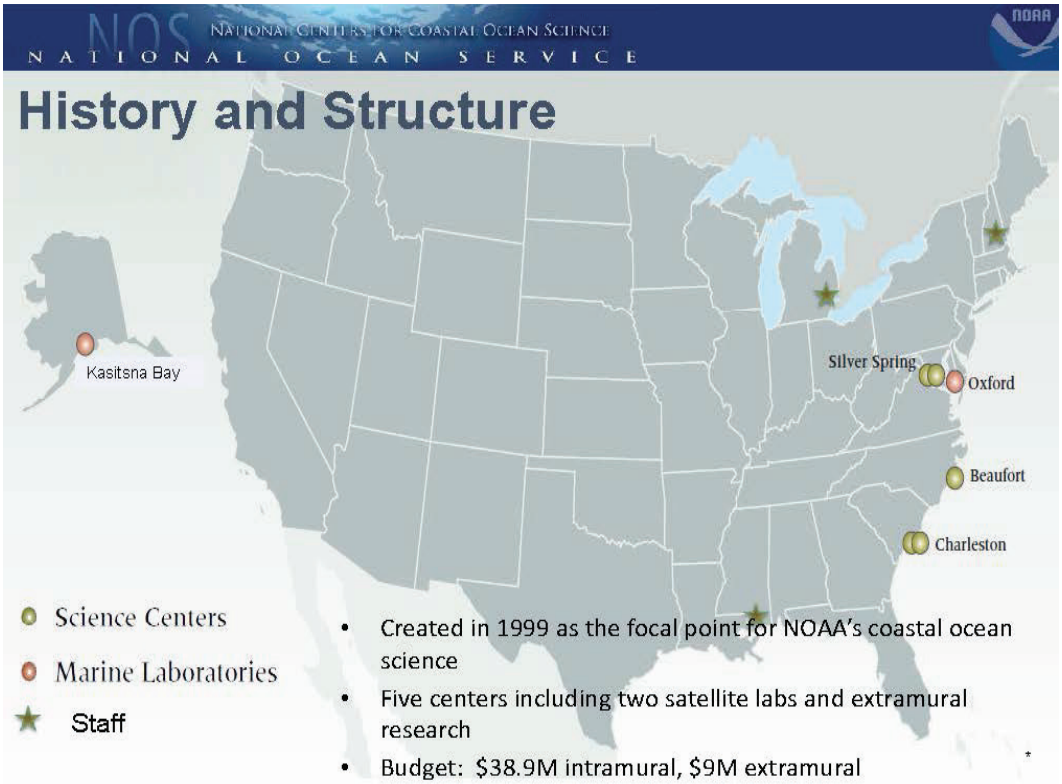

TRANSPORTATION AND COMMERCE
Safe and efficient transportation and commerce: helping decision makers along the coast make the best choices for their communities.
satellite communication
airborne LIDAR
aerial imagery
airborne gravimeter
decision support tools
air gap sensor
continuously operating reference station
PORTS® visibility sensor
meteorological station
high frequency radar
water level gauge
water quality monitoring
buoys:
ocean chemistry
wave sensors
water temperature gauge
meteorological sensors
harmful algal bloom monitoring
single beam sonar
multibeam sonar
ATON mounted acoustic doppler current profiler
bottom mounted acoustic doppler current profiler
glider or autonomous underwater vehicle
oceanservice.noaa.gov
NATIONAL OCEAN SERVICE
oceanservice.noaa.gov 4



National Centers for Coastal Ocean Science

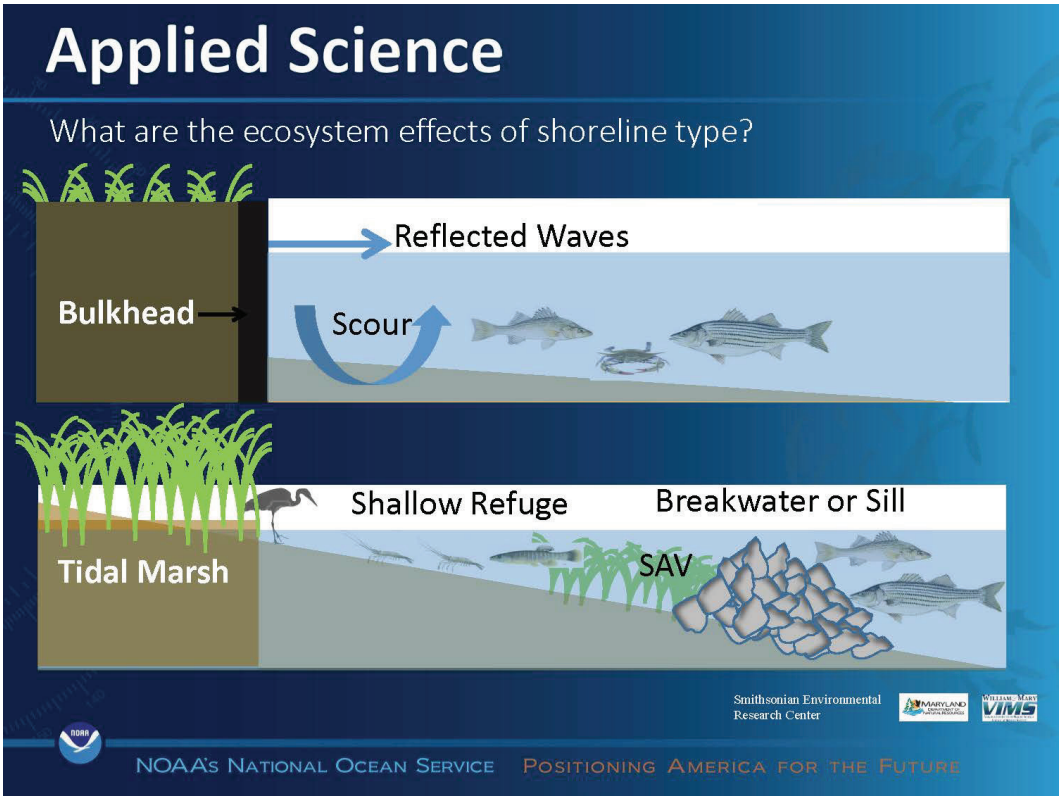
Delivering ecosystem science solutions

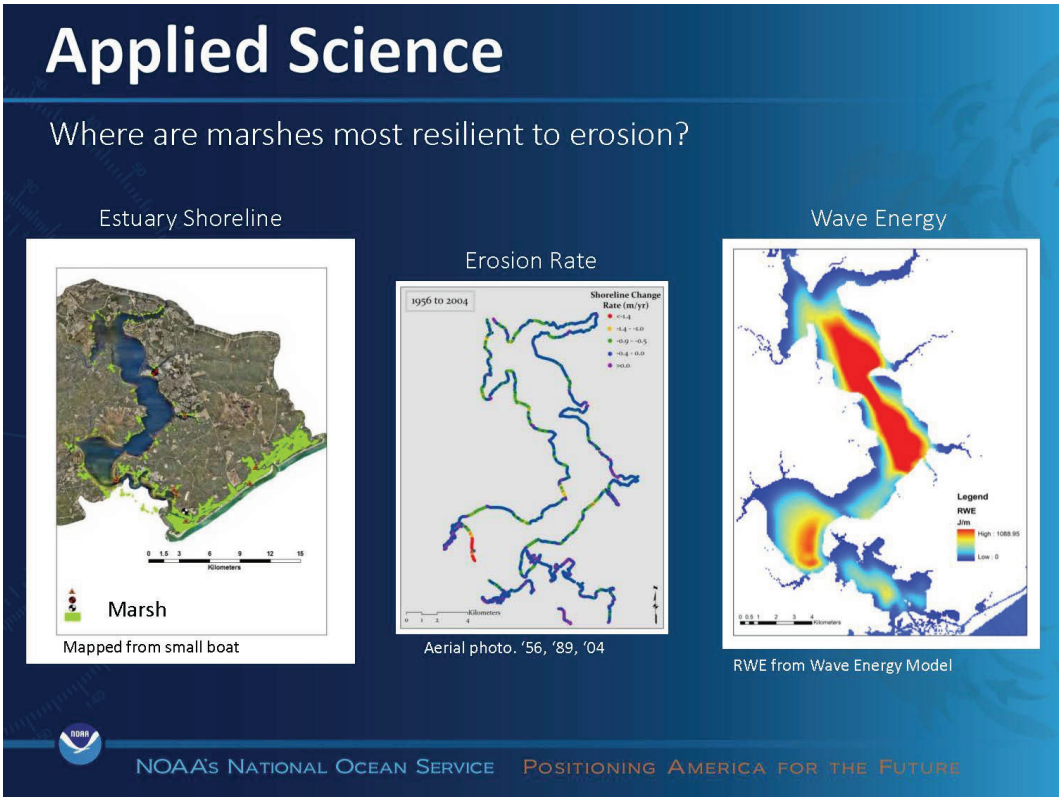
- for stewardship of the nation's ocean and coastal resources
- in direct support of NOS priorities, offices and customers
- to sustain thriving coastal communities and economies



Priorities
NOAA's National Centers for Coastal and Ocean Science

- Marine spatial ecology
- Coastal resilience and climate vulnerability
- Stressor impacts, mitigation and restoration
- Social science
- Monitoring and change detection


Applied Science
What are the ecosystem effects of shoreline type?
Reflected Waves
Bulkhead
Scour
Shallow Refuge
Breakwater or Sill
Tidal Marsh
SAV
Smithsonian Environmental Research Center
NOAA's National Ocean Service
Positioning America for the Future


Applied Science
Where are marshes most resilient to erosion?
Estuary Shoreline
Marsh
Mapped from small boat
Erosion Rate
1956 to 2004
Shoreline Change Rate (m/yr)
Aerial photo. '56, '89, '04
Wave Energy
Legend
RWE
Jim
RWE from Wave Energy Model
NOAA's National Ocean Service
Positioning America for the Future

Applied Science

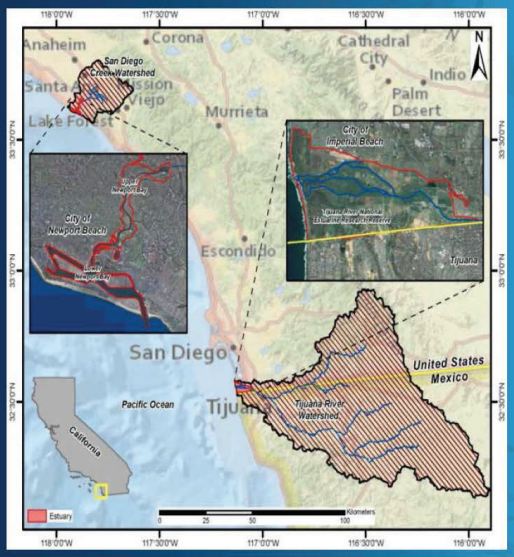
Sediment management effects on NNBF and flood vulnerability?

Newport Beach

- Urban beach community with pleasure boat harbor and tidal salt marsh/estuary

Tijuana River Valley

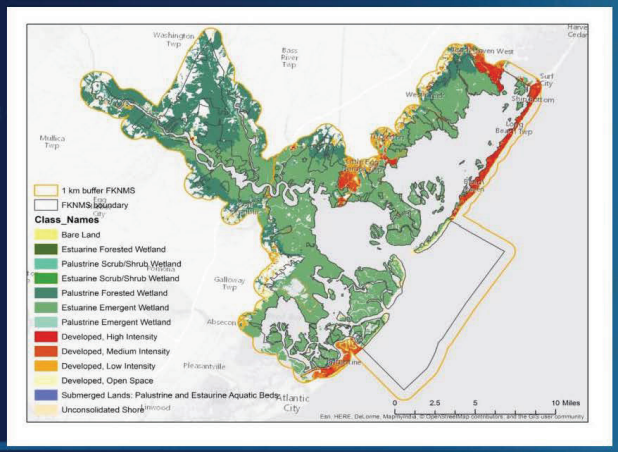
- Rural community with natural floodplain and tidal salt marsh/estuary
- Rapidly growing urban community (MX)



Applied Science

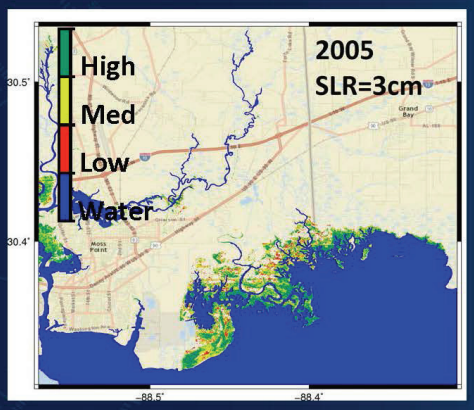
What is the value of marshes for flood protection?

- Value ($$) of damages avoided by having natural habitats
- Value saved from reduced flood insurance costs
- Economic stimulus to the community

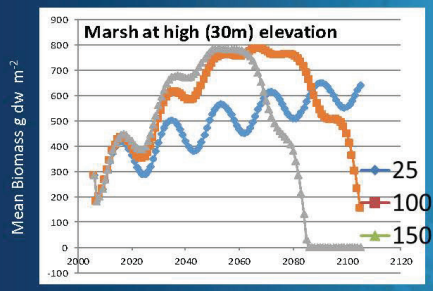


Models and Tools

Solutions to mitigate marsh vulnerability?



Vulnerability and migration potential
(Hydro-MEM model)

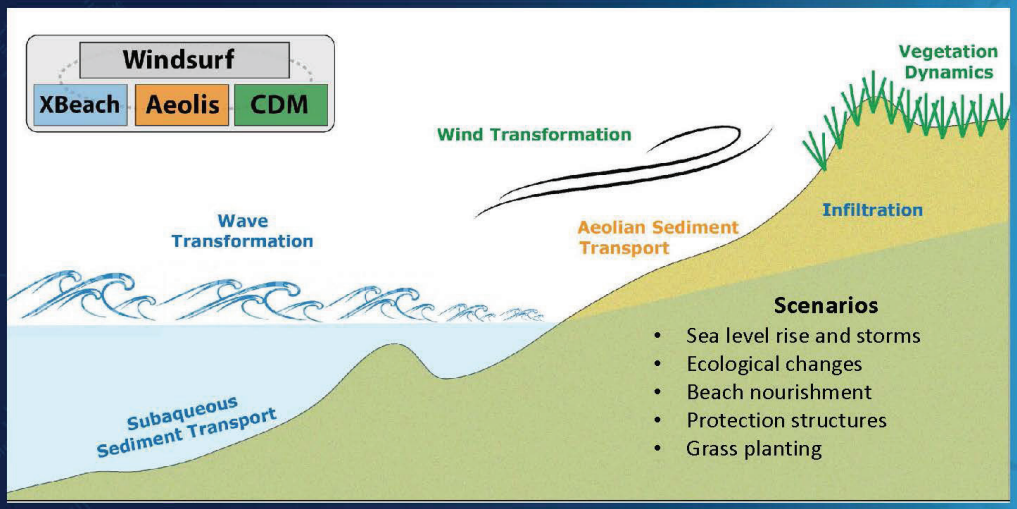


Sea level rise and marsh elevation scenarios (MEM model)

NOAA's National Ocean Service Positioning America for the Future

Models and Tools

Beach/dune recovery after storms – climate and policy scenarios?



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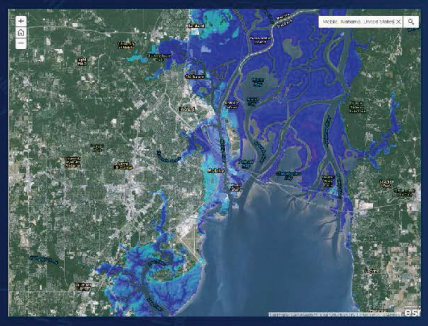
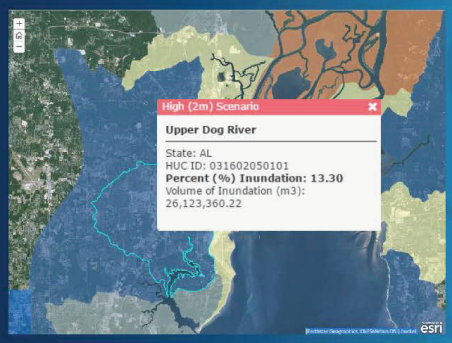
Models and Tools

Geospatial Analytics – Impact of 2 m sea level rise on storm surge?



Product development for storm surge model outputs



Watershed-level flood analytics

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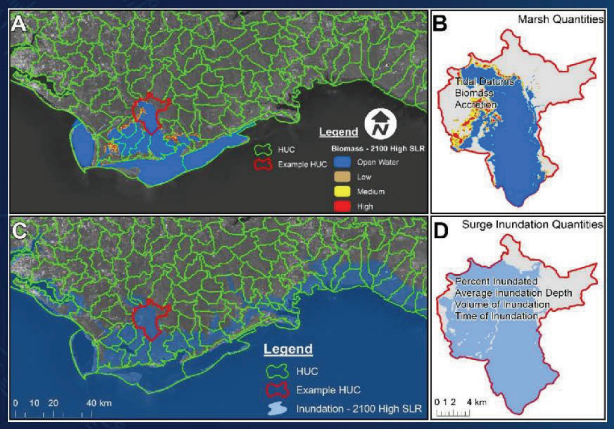
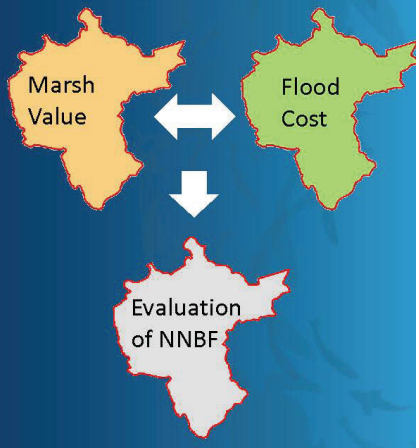
Models and Tools

What is the value of marsh services under scenarios of future conditions?



HUC by HUC Assessment



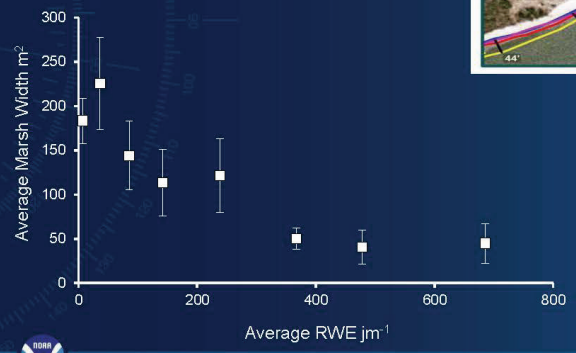
Policy Decisions

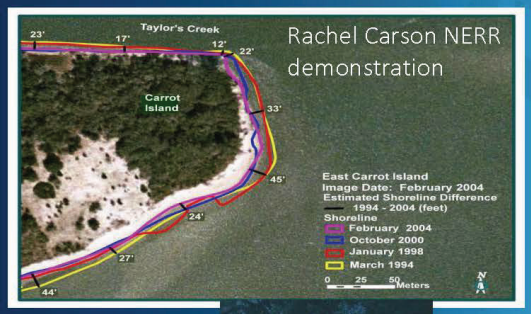
NOAA's National Ocean Service Positioning America for the Future

Guidance and Metrics

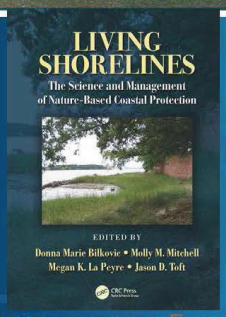
How much wave energy can living shorelines sustain?

Fringing marsh distribution versus wave energy





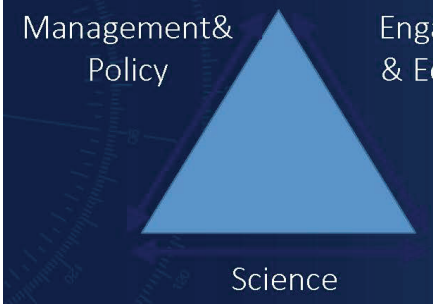
Rachel Carson NERR demonstration

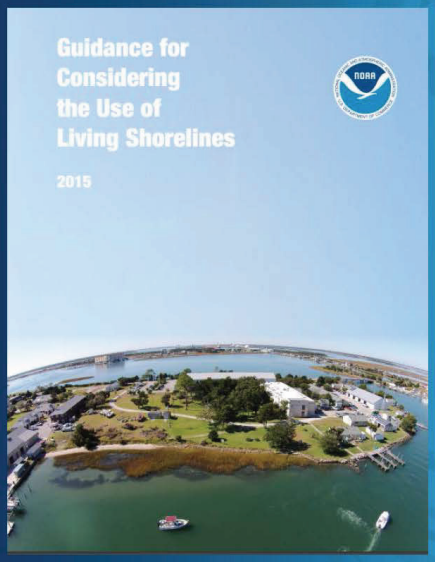


NOAA's National Ocean Service Positioning America for the Future

Guidance and Metrics

Guidance for installing a living shoreline?

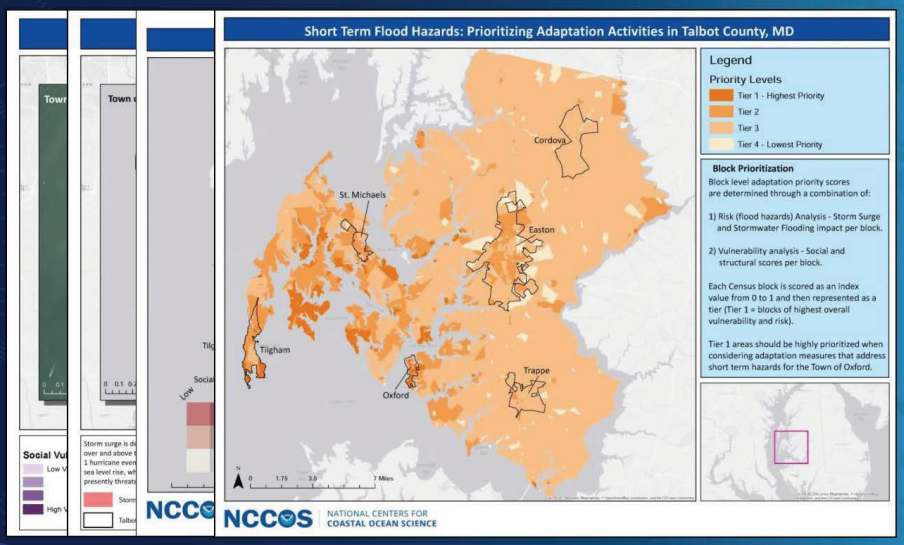




NOAA's National Ocean Service Positioning America for the Future

Guidance and Metrics

How can our science inform adaptation?



NOAA's National Ocean Service Positioning America for the Future

Emerging Partnerships with USACE

Can thin-layer application of dredged material improve marsh resiliency?

Marine Corps Base Camp Lejeune
NCCOS Beaufort Lab
USACE Wilmington District

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Emerging Partnerships with USACE

Can the use of dredged sediment improve ecosystem services?

Mordecai Island, NJ
NCCOS- USACE collaboration
USACE Philadelphia District

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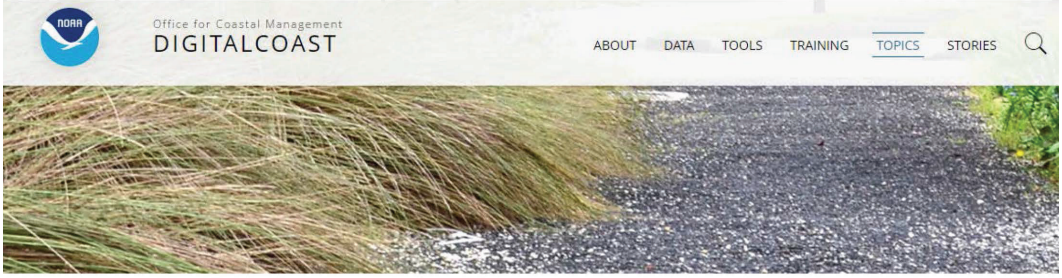
Office for Coastal Management

Catalyze and influence a broad base of leaders, community residents, and coastal practitioners to ensure:

- Healthy coastal ecosystems
- Resilient coastal communities
- Vibrant and sustainable coastal economies

NATIONAL OCEAN SERVICE oceanservice.noaa.gov

Advancing Green Infrastructure



Key tools, training, and resources through the Digital Coast:

- Coastal Flood Exposure Mapper
- *A Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction*
- Living shoreline guidance
- Introducing Green Infrastructure for Coastal Resilience training
- Climate Adaptation for Coastal Communities training

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Coastal Management Program

- Coastal Zone Management Act
- Voluntary state and federal partnership
- 34 federally approved programs
- Comprehensive approach to critical coastal issues

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Texas Coastal Management Program

The Texas General Land Office

- Reviews federal actions in the coastal zone to ensure consistency with the program
- Supports protection of natural habitats and wildlife
- Awards approximately $2.2 million annually in grants
  - Example: South Padre Island and Goose Island Marsh Restoration

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Texas Coastal Management Program

2016-2020 Strategies

- Increase use of living shorelines
- Update and improve topographic and bathymetry models
- Develop regional sediment management plans to identify potential restoration sites in the vicinity of navigation projects.
- Develop sediment supply studies and source identification mapping

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Texas Resiliency Master Plan

- Community, socio-economic, ecological, and infrastructure protection from coastal hazards
- Restoration for multiple types of habitat
- Led by Texas General Land Office, supported by coastal zone management funding
- NOAA on the technical advisory committee

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Great Lakes Resilience Study

- Promoting resilience within human and natural coastal systems
- Modeled after Mid-Atlantic Hurricane Sandy study
- Study framework
  - Identify problems and opportunities
  - Assess vulnerability and determine response
  - Complete a "programmatic coastal resiliency plan"
- Themes of interest: green and port infrastructure; sand management and littoral drift study; coastal habitat conservation; erosion; flooding; bluff recession; dune restoration; beach nourishment; shoreline protection; and nearshore water quality

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NOAA Coastal Resilience Grants Program

- Nature-based solutions
- Geospatial data and tool development
- Economic research

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National Estuarine Research Reserves

- 29 sites in national system
- Over 1.3 million acres protected
- Research, education, stewardship
- "Living laboratories"
- Locally relevant, nationally significant research

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Mission-Aransas Research Reserve

University of Texas, Marine Science Institute

- Protects 186,189 acres
- Located 30 miles northeast of Corpus Christi
- Habitat includes tidal flats, seagrass beds, mangroves, and oyster reefs. Serves as the winter home to the critically endangered Whooping Crane.

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Mission-Aransas Research Reserve

Aransas County Coastal Resiliency Initiative

Focus: environment, economy, and community

Example Project

- Live Oak Peninsula – Promoting coastal resiliency by protecting important infrastructure

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Weeks Bay Research Reserve

Swift Tract
Living Shoreline Project

Focus: Shoreline erosion control, salt marsh habitat protection, and restoration of ecosystem diversity and benthic productivity

- 1.6 miles of breakwaters constructed with oyster shell in Mobile Bay

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Coral Reef Conservation

- Coral Reef Conservation Act
- Preserve, sustain, and restore
- National and international leadership
- U.S. Coral Reef Task Force

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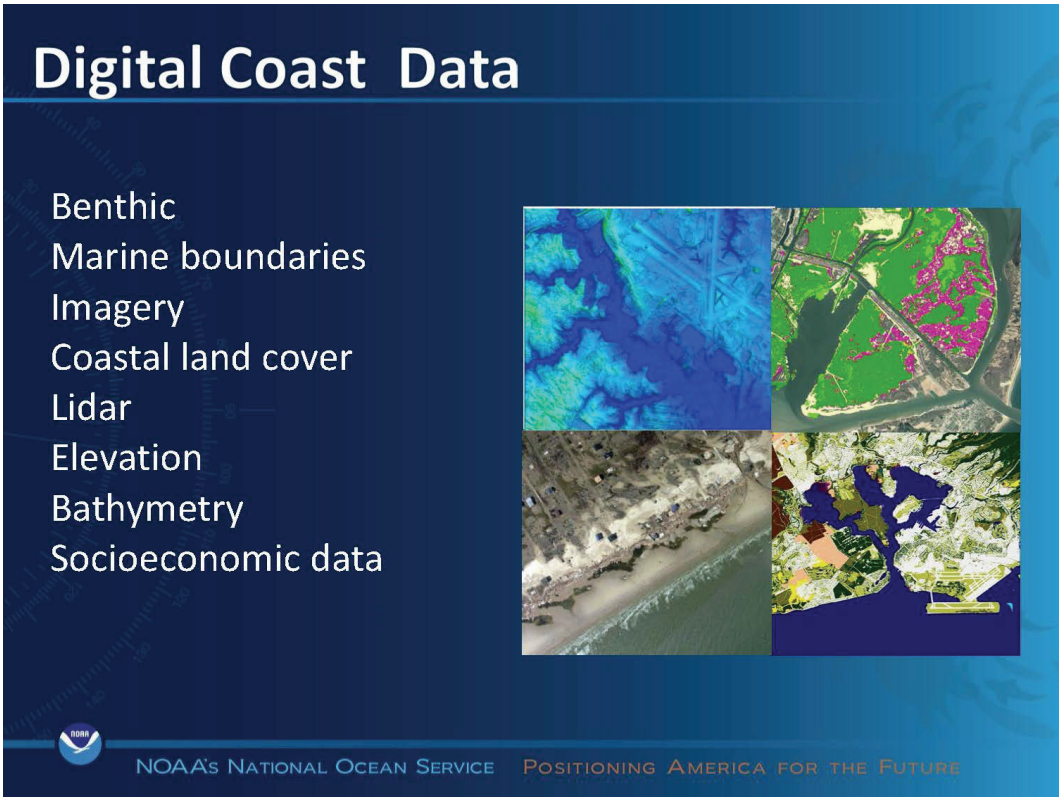
OFFICE FOR COASTAL MANAGEMENT
Digital Coast Partnership
American Planning Association
Association of State Floodplain Managers
Coastal States Organization
National Association of Counties
National Estuarine Research Reserve Association
National States Geographic Information Council
NOAA Office for Coastal Management
The Nature Conservancy
Urban Land Institute


Digital Coast Data
Benthic
Marine boundaries
Imagery
Coastal land cover
Lidar
Elevation
Bathymetry
Socioeconomic data
NOAA's National Ocean Service
Positioning America for the Future

Digital Coast Data

FLOOD RISK POPULATIONS

Twenty-five percent, or 74,466 people, live in the floodplain in Galveston County, Texas.

COASTAL HAZARDS

84 Billion dollar disasters from 1980-2016

CHANGING LANDS

Texas experienced 5,677 square miles of change between 1996-2010, with the largest change being a 1,327-square-mile loss of forest.

OCEAN ECONOMICS

Offshore mineral extraction is the largest employer among Texas's ocean-dependent economic sectors.

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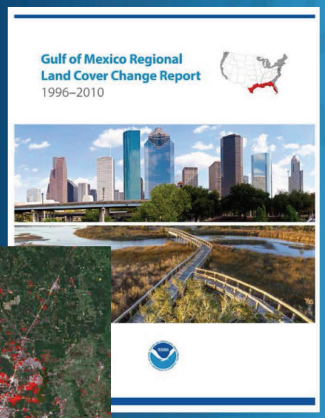
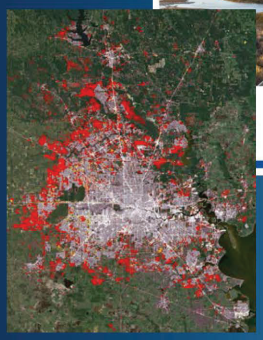
Coastal Land Cover and Land Change Data

- 17% increase in developed area
  = 580 square miles
  = football field every 26 minutes

- 11% decrease in tree cover
  = 1,325 square miles
  = football field every 12 minutes





Houston development changes (1996 to 2011)

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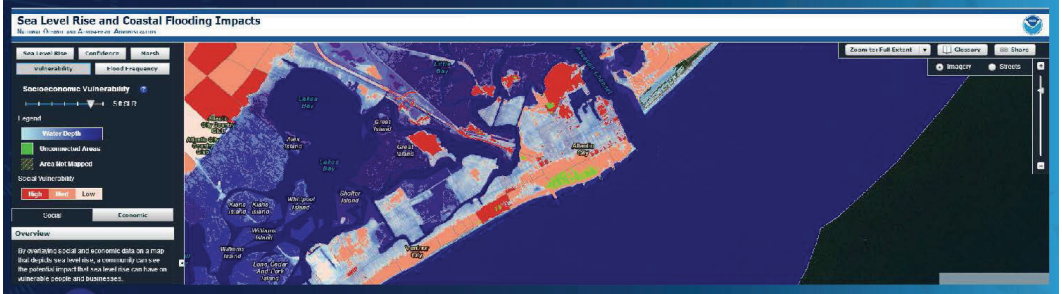
Digital Coast Tools

Types

- Analysis tools
- Data visualization and handler tools
- Simulation tools
- Informational tools

Top Products

- Sea Level Rise Viewer
- Lake Level Viewer
- Historical Hurricane Tracks
- Coastal Flood Exposure Mapper
- Coastal County Snapshots



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Conclusion

NOS capabilities to advance resilience and natural infrastructure

- Coastal management
- Coastal intelligence
- Coastal science

Strengthen application and facilitate implementation of natural infrastructure

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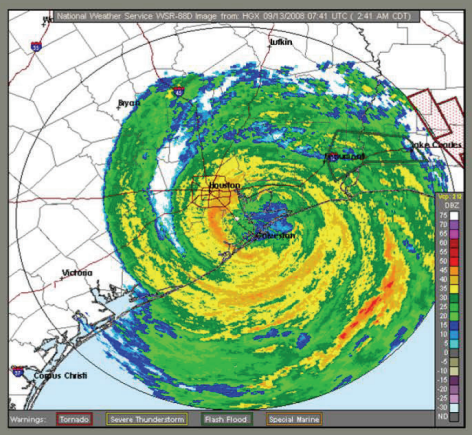
Texas Coastal Project

COASTAL TEXAS PROTECTION AND RESTORATION PROJECT



23 February 2017

"The views, opinions and findings contained in this report are those of the authors(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation."

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Coastal TX Study Authority

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Section 4091, Water Resources Development Act (WRDA) of 2007 Public Law (P.L.) 110-114

Sec. 4091. Coastal Texas Ecosystem Protection and Restoration, Texas.

(a) In General.—The Secretary shall develop a ***comprehensive plan*** *to determine the feasibility of carrying out projects for flood damage reduction,* ***hurricane and storm damage reduction****, and* ***ecosystem restoration*** *in the* ***coastal areas*** *of the State of Texas.*

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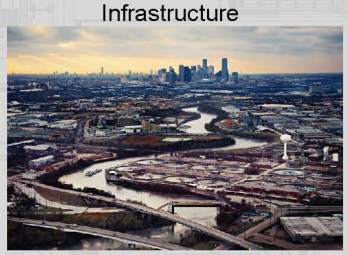
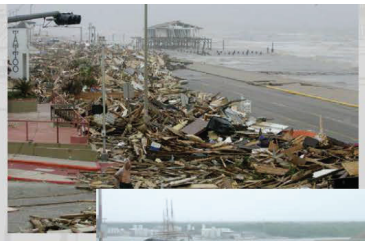
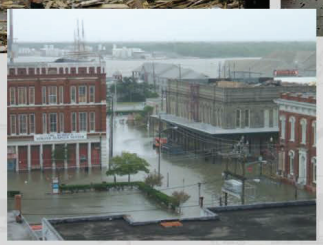
Important Houston Infrastructure

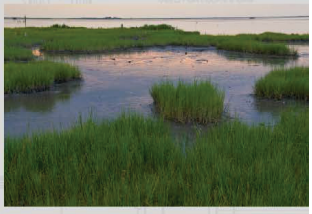






Images After Ike Galveston Island

Aquatic Resources and Endangered Species



USACE Planning Modernization

SMART Planning

- USACE established new policies in 2012 modernizing the Planning process to reduce costs and time to study product delivery
- 3x3x3 = complete studies in 3 years; cost $3M; 3 levels of review
- Studies that would not fit into this policy require an exemption from Headquarters USACE (HQUSACE)
- Sec 1001 of Water Resources Reform Development Act (WRRDA) 2014 codifies 3x3x3 into law
- Coastal TX received an exemption to the 3x3x3 law in October 2015
  - $19.8 Million for study costs and 5.5 years to complete

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Non-Federal Sponsor

- Texas General Land Office (GLO) study sponsor
- Feasibility Cost Sharing Agreement (FCSA) signed in November 2015
  - 50% Federal dollars / 50% Non-Federal
- Implementing Sponsor (design and construction) needs to be identified
  - Cost share varies pending final plan
  - Final project is turned over to NFS for operations and maintenance responsibilities

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Study Purpose

Coastal Storm Risk Management (CSRM)- Develop and evaluate coastal storm damage risk reduction measures for coastal Texas residents, industries and businesses which are critical to the nation's economy.

Ecosystem Restoration (ER) - Increase the net quantity and quality of coastal ecosystem resources by maintaining, protecting, and restoring coastal Texas ecosystems and fish and wildlife habitat

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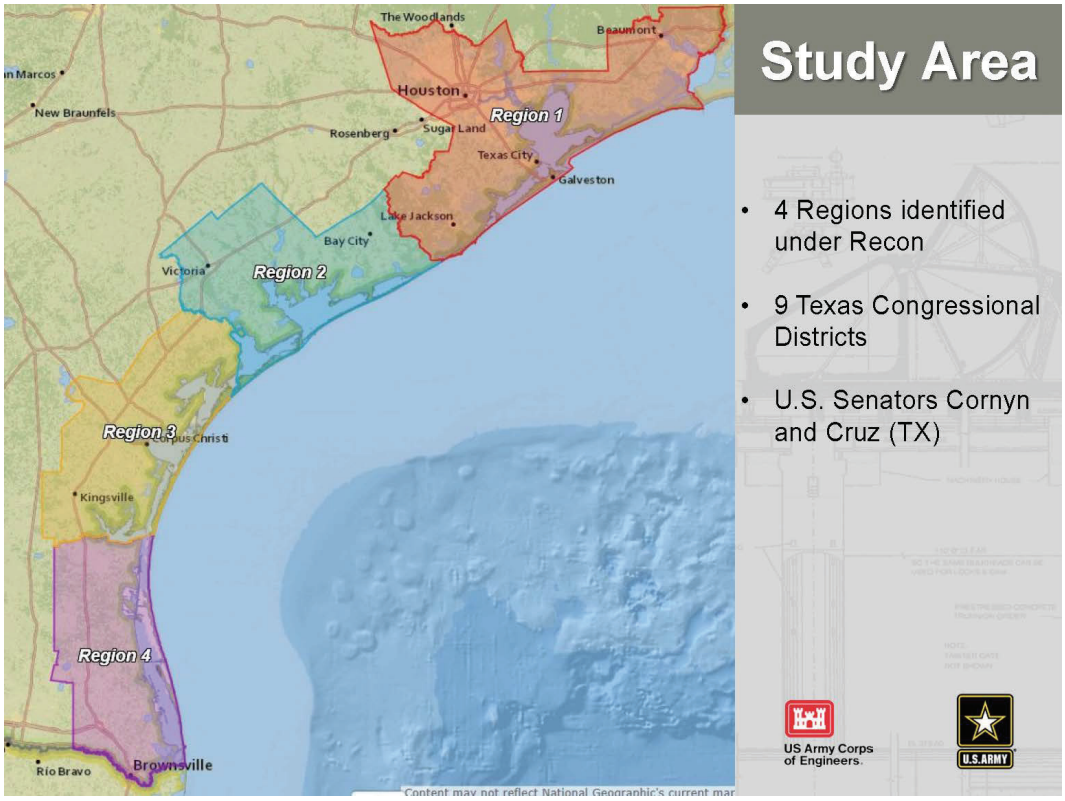
Study Area
The Woodlands
Beaumont
Houston
Region 1
New Braunfels
Rosenberg
Sugar Land
Texas City
Galveston
Lake Jackson
Bay City
Victoria
Region 2
Region 3
Corpus Christi
Kingsville
Region 4
Rio Bravo
Brownsville
• 4 Regions identified under Recon
• 9 Texas Congressional Districts
• U.S. Senators Cornyn and Cruz (TX)
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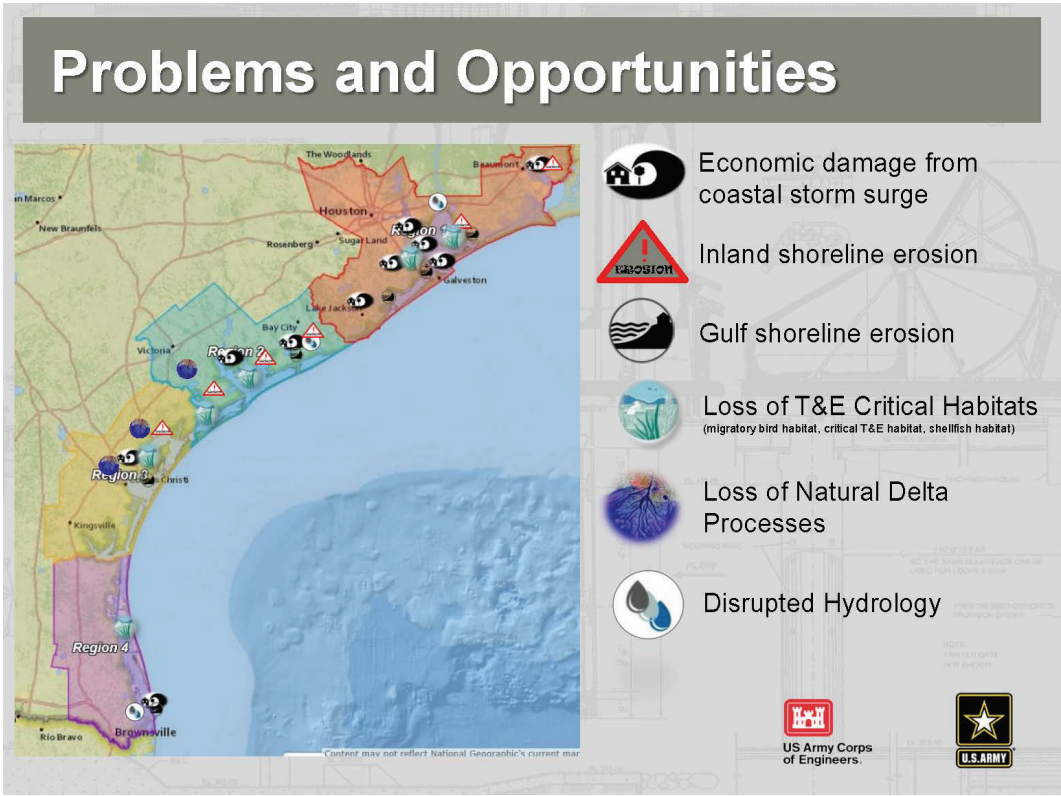
Problems and Opportunities
The Woodlands
Beaumont
Houston
New Braunfels
Rosenberg
Sugar Land
Galveston
Bay City
Victoria
Region 3
Kingsville
Region 4
Rio Bravo
Brownsville
Economic damage from coastal storm surge
Inland shoreline erosion
Gulf shoreline erosion
Loss of T&E Critical Habitats
(migratory bird habitat, critical T&E habitat, shellfish habitat)
Loss of Natural Delta Processes
Disrupted Hydrology
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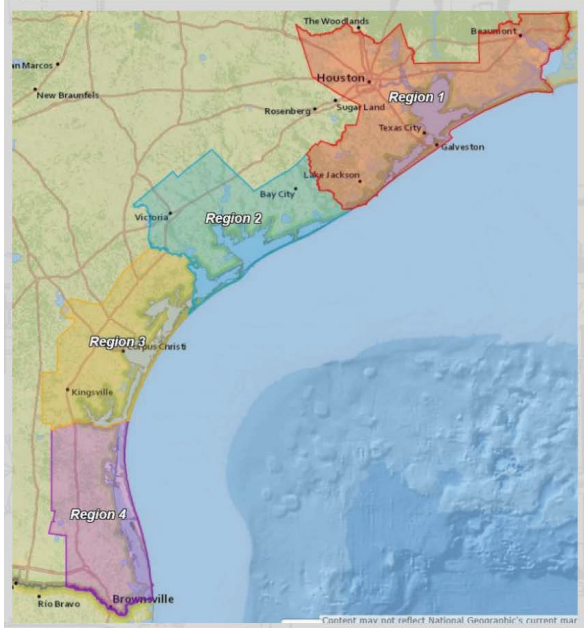
Constraints



- Avoid or minimize negative impacts:
  - to threatened and endangered species and protected species
  - to critical habitat, (e.g. Essential Fish Habitat.)
  - to commercial fisheries
  - that affect the ability of authorized navigation projects to continue to fulfill their purpose
  - that induce flooding

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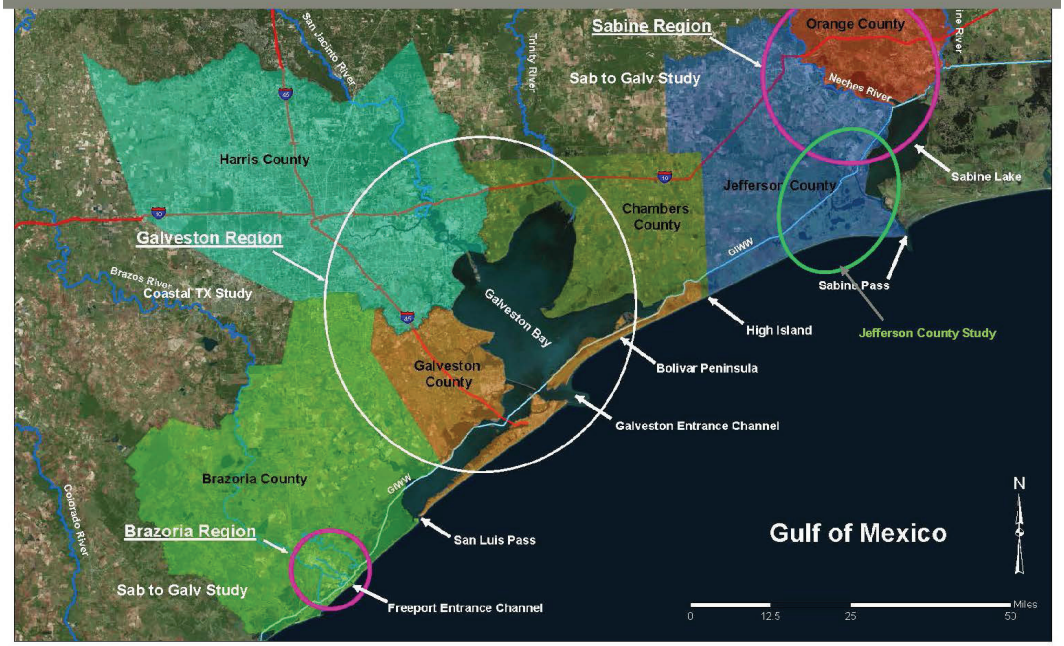
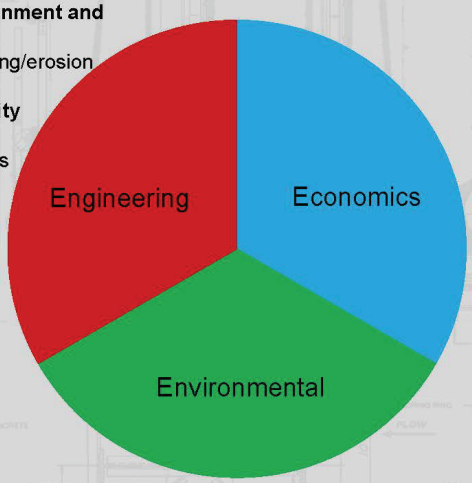
Other CSRM/ER Studies in Region 1



Feasibility Analyses

Impacts to physical environment and processes
- Circulation/salinity/flooding/erosion

Constructability / operability
- Engineering feasibility
- Real Estate requirements



Damages to property
- Personal and public damages from flooding

Project costs
- Study, design, construction and O&M

Benefit-to-cost ratio
- National Economic Development (NED)

Life/health
- Social impacts

NEPA compliance
Impacts to natural environment
Hazardous material spills
National Ecosystem Restoration (NER) Plan

Habitat
Fish and wildlife
Cultural Resources

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Goals and Objectives

COASTAL STORM DAMAGE RISK REDUCTION:
Promote a sustainable economy by reducing the risk of storm damage to residential structures, industries and businesses critical to the nation's economy.

- **Reduce economic damage from coastal storm surge** to business, residents and infrastructure
- **Reduce risk to human life from storm surge**
- Enhance energy security and **reduce economic impacts of petrochemical supply-related interruption due to storm surge**
- **Reduce risks to critical infrastructure** (medical centers, ship channels, schools transportation, etc.)
- **Manage regional sediment** so it contributes to storm surge attenuation where feasible
- **Increase the resilience** for existing HFPS from sea level rise and storm surge impacts

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Region 1 Alternatives

	Formulation strategies
• Alternative A - Coastal Barrier/Nonstructural System	• Multiple lines of Defense (MLOD) • Navigation Impacts • Resiliency • Focus on Significant Resources
• Alternative B – Coastal Barrier	• Multiple lines of Defense (MLOD) • Navigation Impacts • Resiliency • Focus on Significant Resources
• Alternative C – Mid Bay Barrier	• Navigation Impacts • Resiliency • Focus on Significant Resources
• Alternative D – Upper Bay Barrier/ Nonstructural System	• Navigation Impacts • Focus on Significant Resources

All alternatives would also look at maximizing Ecosystem Restoration (ER) Benefits

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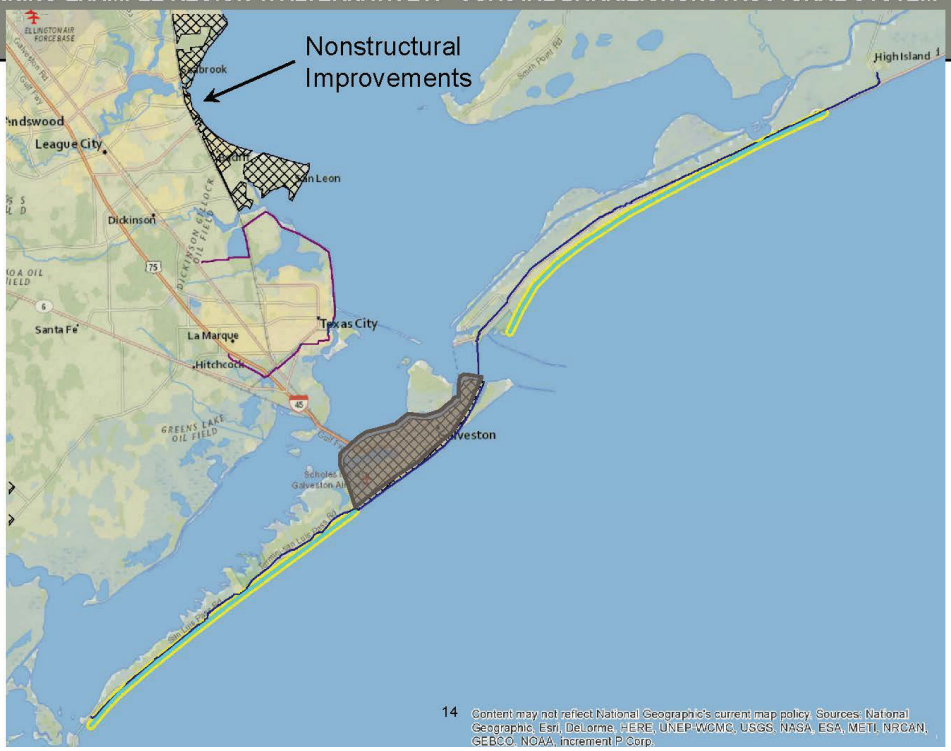
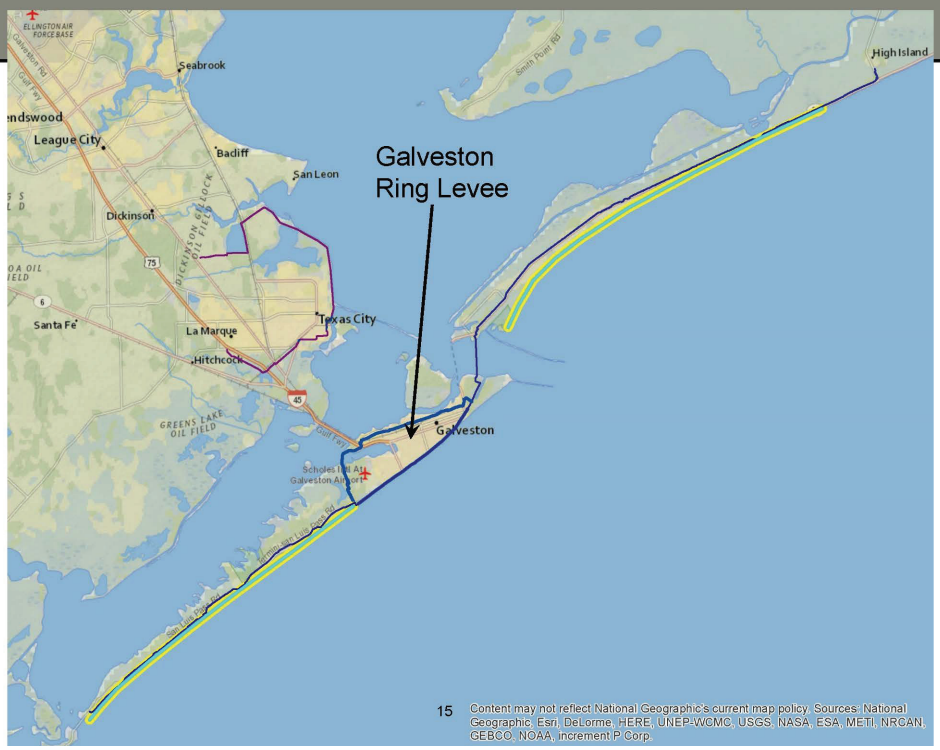
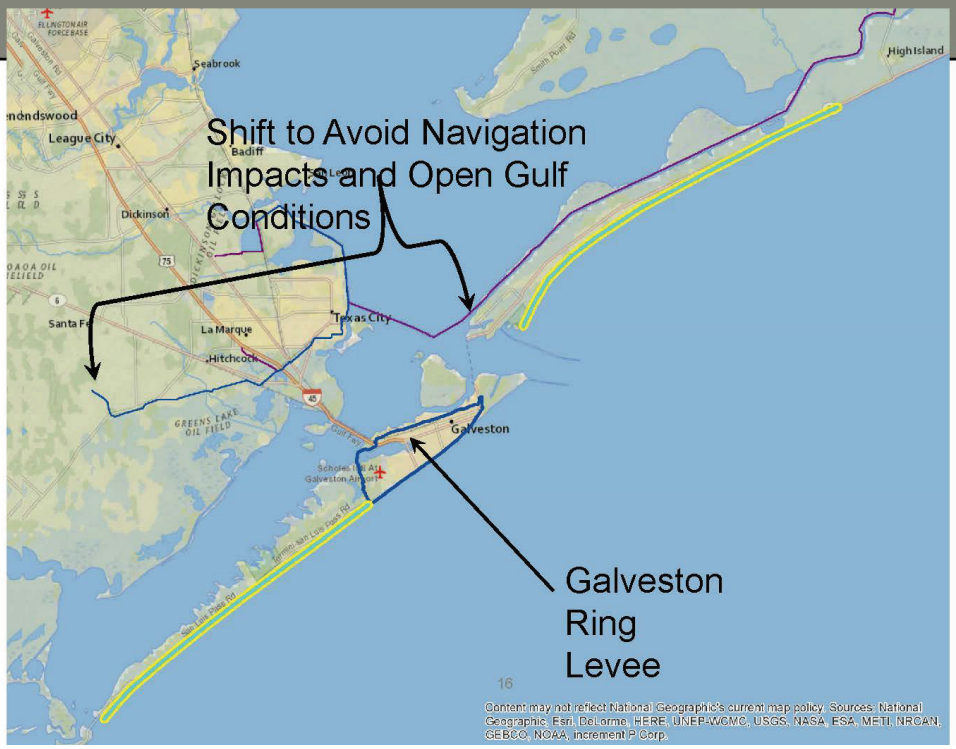
PLANNING EXAMPLE REGION 1: ALTERNATIVE A - COASTAL BARRIER/NONSTRUCTURAL SYSTEM



PLANNING EXAMPLE REGION 1: ALTERNATIVE B - COASTAL BARRIER

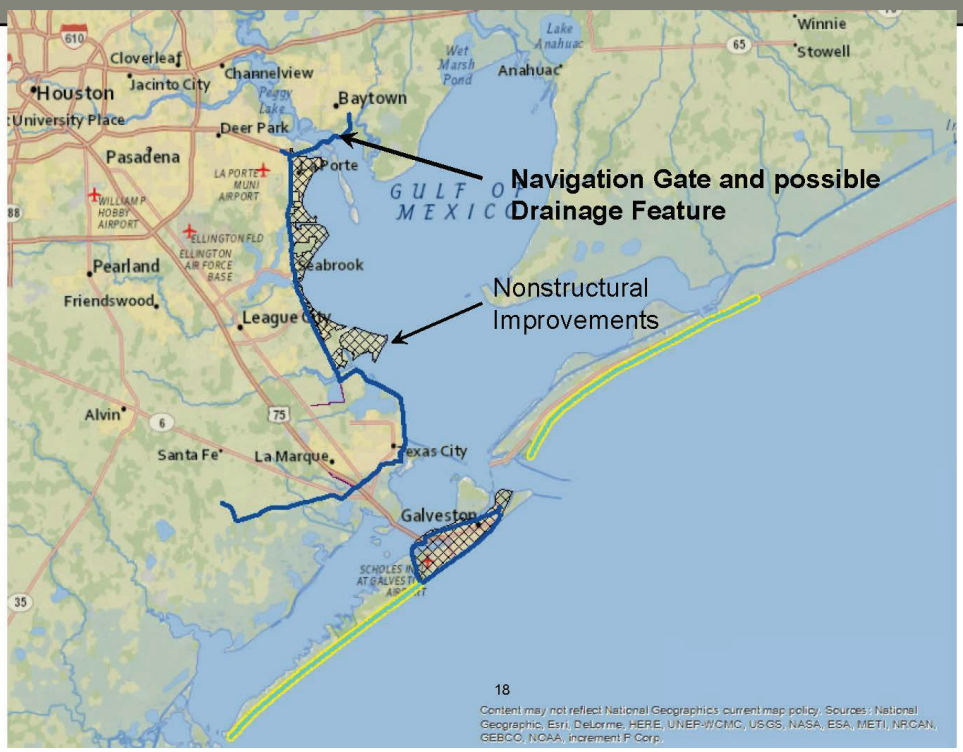


ALTERNATIVE B - COASTAL BARRIER (ENG. WORKSHOP DISCUSSIONS)

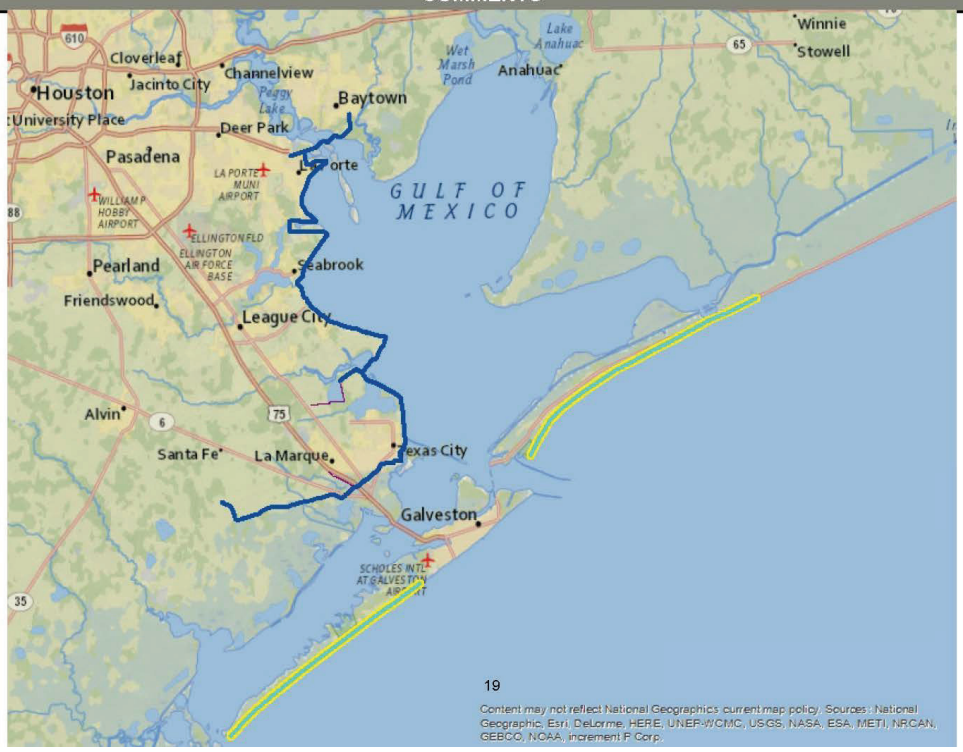


PLANNING EXAMPLE REGION 1: ALTERNATIVE C – MID BAY

PLANNING EXAMPLE REGION 1: ALTERNATIVE D UPPER BAY BARRIER/ NONSTRUCTURAL SYSTEM



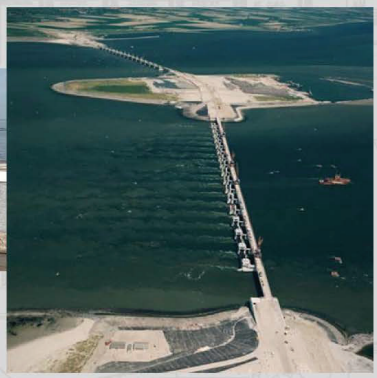
PLANNING EXAMPLE REGION 1: ALTERNATIVE D - OPTIONS REVIEWED BASED ON GCCPRD COMMENTS

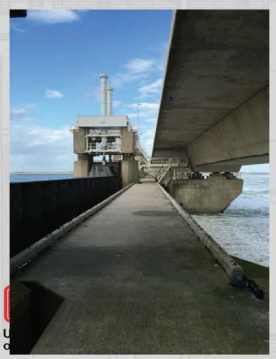


Potential Barrier Designs

Maeslant Barrier

Eastern Scheldt Barrier

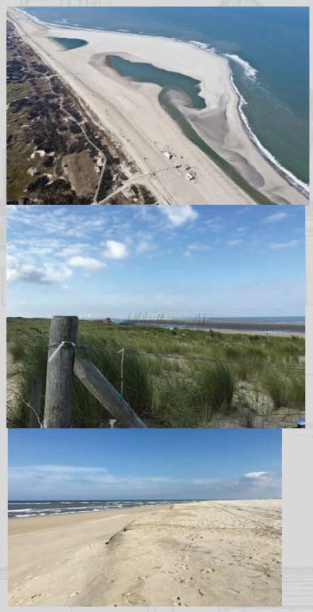




EWN Designs?

Katwijk Sea Defense

Sand Motor



Goals and Objectives

ECOSYSTEM RESTORATION:

Promote a sustainable coastal ecosystem by minimizing future land loss, enhancing wetland productivity, and providing and sustaining diverse fish and wildlife habitats.

- **Restore size and quality of fish and wildlife habitats** such as coastal wetlands, forested wetlands, rookery, oyster reefs, and beaches and dunes
- Improve **hydrologic connectivity** into sensitive estuarine systems;
- Reduce **erosion to barrier island**, mainland, interior bay and channel shorelines
- **Create, restore and nourish oyster reefs** to benefit coastal and marine resources
- Manage regional sediment so it contributes to improving and sustaining diverse fish and wildlife habitat

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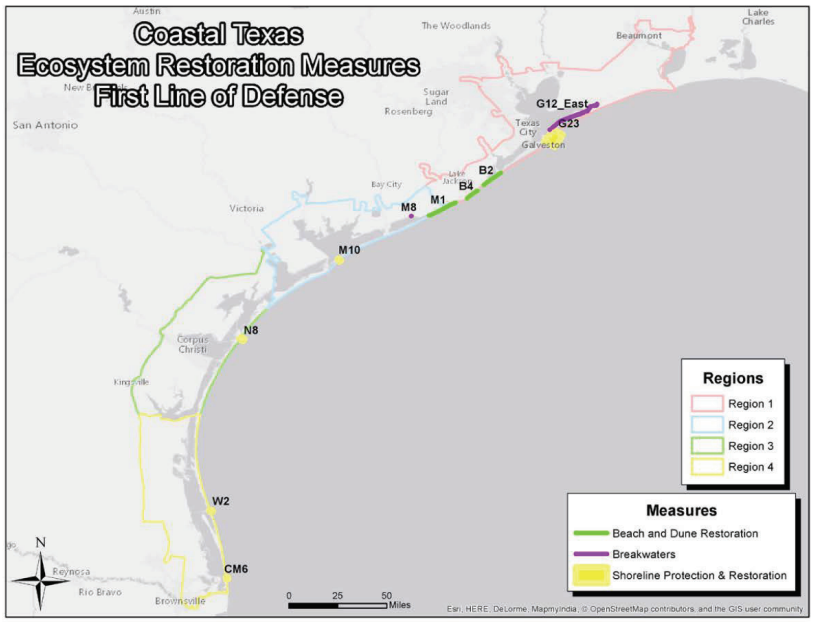
Coastal TX – First Line of Defense Map



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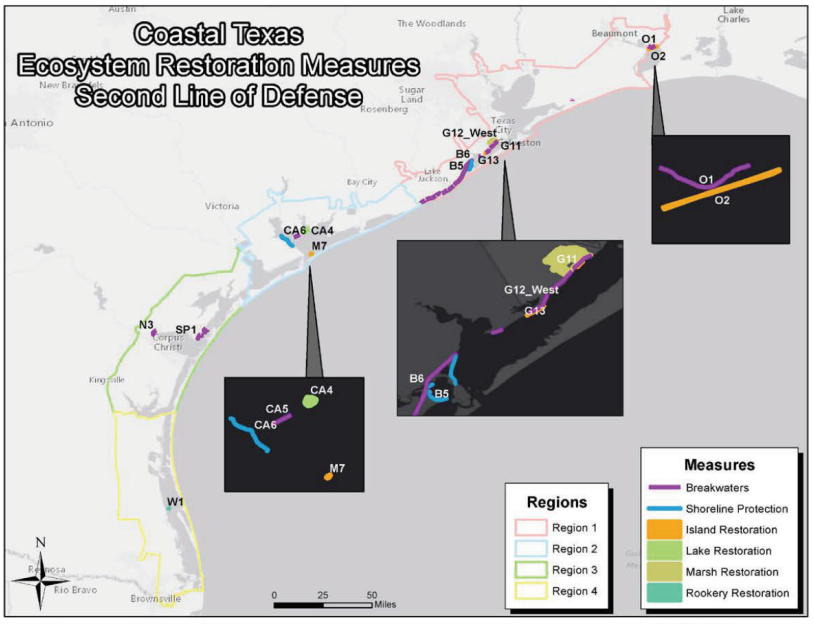
Coastal TX – Second Line of Defense Map



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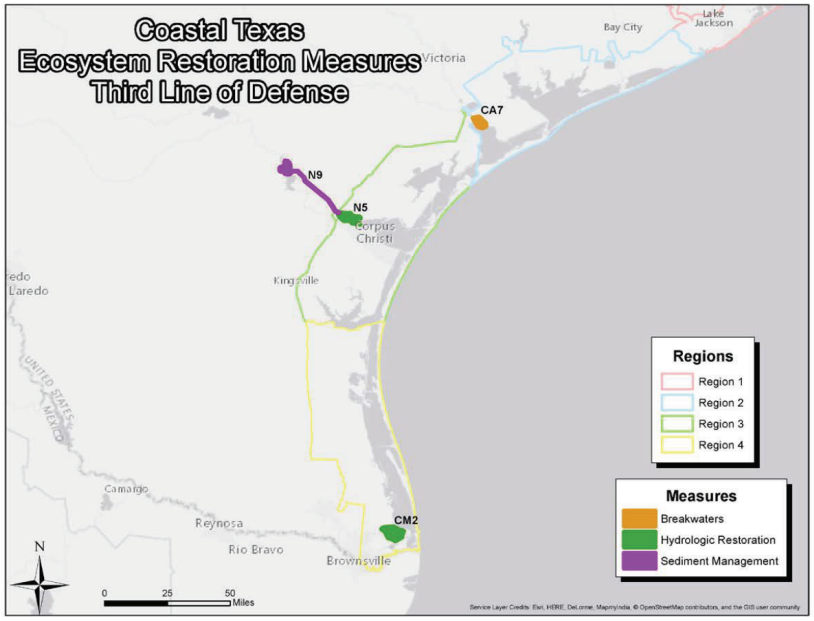
Coastal TX – Third Line of Defense Map



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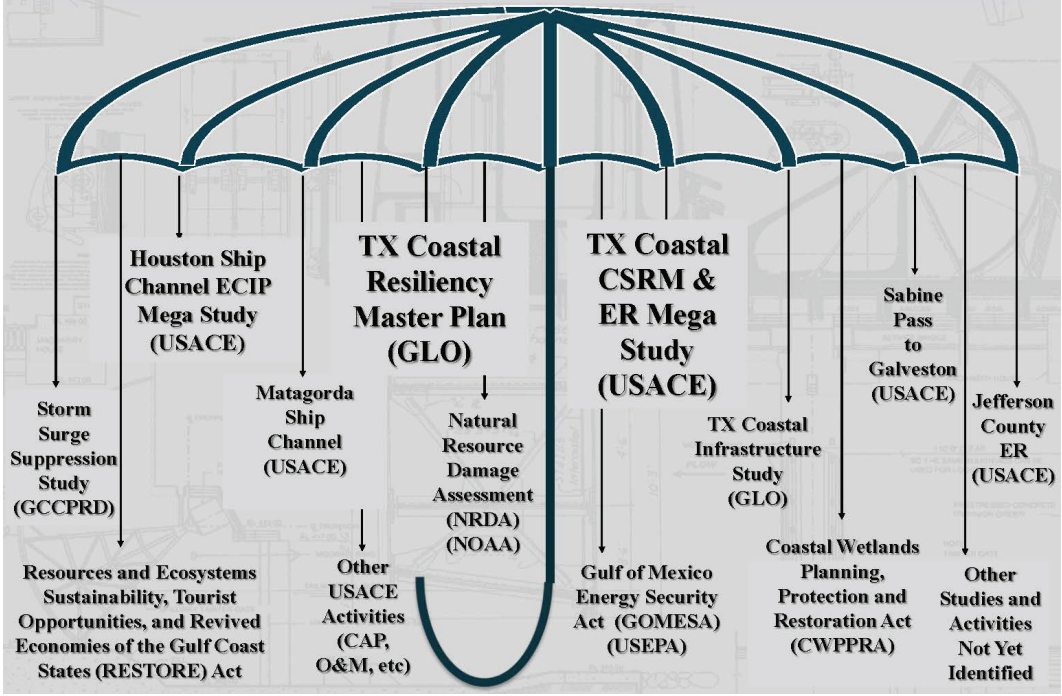
Comprehensive Plan: Overarching Vision



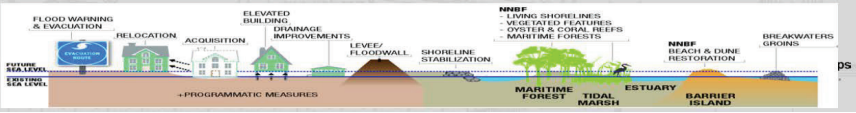
Comprehensive Plan:

Purpose

Provide an **overarching, long-term strategic vision** of a **resilient Texas coast** that supports, protects, and sustains the environment, economy and culture of the region, and that contributes greatly to the economy and well-being of the nation.

Goals

- Focus on the **long-term** (100+ years)
- Identify **threats** & future conditions (coastal storms, urbanization, changing climate/sea level rise, petrochemical/oil & transportation outlooks, etc.)
- Enhance **resilience** – e.g., improve our capabilities to **prepare** for, **resist**, **recover**, and **adapt** to significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment
- Take a **systems-based** approach and promote **ecosystem-based** management
- Adopt and communicate our "**multiple lines of defense**" strategy (structural, non-structural, natural and nature-based solutions)
- Highlight benefits and present these in terms of **ecosystem goods and services**
- Incorporate **ALL** ongoing and potential future activities (where possible)
  - USACE's TX Coastal Feasibility study
  - GLO's Master Plan
  - Other USACE studies
  - Other activities undertaken by other agencies & NGOs
- Lay the groundwork for **future authorizations & programs**
- Identify areas where **additional research** and development is warranted



TEXAS COASTAL RESILIENCY MASTER PLAN PHASE 1 OUTCOMES

- Identify current coastal issues of concern and create a database of projects to address regional vulnerabilities;
- Framework for GLO implementation to inform effective coastal management to enhance and protect the coast;
- Stakeholder engagement documents and website for education and outreach on the importance of the Texas coast and the significance of keeping it resilient;
- Data from this initiative will be available for other planning initiatives to use;
- Findings will be presented in 2017 to the Legislature.

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COASTWIDE RESILIENCY STRATEGIES

Study Milestones and Funding Needs

Milestone		Date
Scoping	Exemption Approval by Senior Leaders	Sep 2015
	Exemption Approval by ASA(CW)/OMB	Nov 2015
	Execute FCSA with GLO	Nov 2015
Alternative Evaluation and Analysis	Alternatives Milestone	June 2016
	Tentatively Selected Plan (TSP) Milestone	May 2018
Feasibility Level Analysis	Agency Decision Milestone (ADM)	Oct 2018
	Feasibility Report Complete	Oct 2020
	Civil Works Review Board (CWRB)	Jan 2021
	S&A Review	Feb 2021
	Chief's Report	Apr 2021

Fiscal Year*	Total Funding ($)	Federal Funding ($)	Non-Federal Funding*** ($)
2016	2,506,000	1,253,000	1,253,000
2017	3,650,000	1,825,000	1,825,000
2018	3,950,000	2,175,000**	1,775,000
2019	5,350,000	2,675,000	2,675,000
2020	4,244,000	2,122,000	2,122,000
2021	100,000	50,000	50,000
Total	19,800,000**	10,100,000	9,700,000

* USACE FY is 1 Oct thru 30 Sept
** Includes $400,000 for Independent External Peer Review (IEPR)
*** Includes cash and Work-In-Kind (WIK)

In partnership with the Texas General Land Office, the Corps of Engineers has a funding strategy to achieve project authorization

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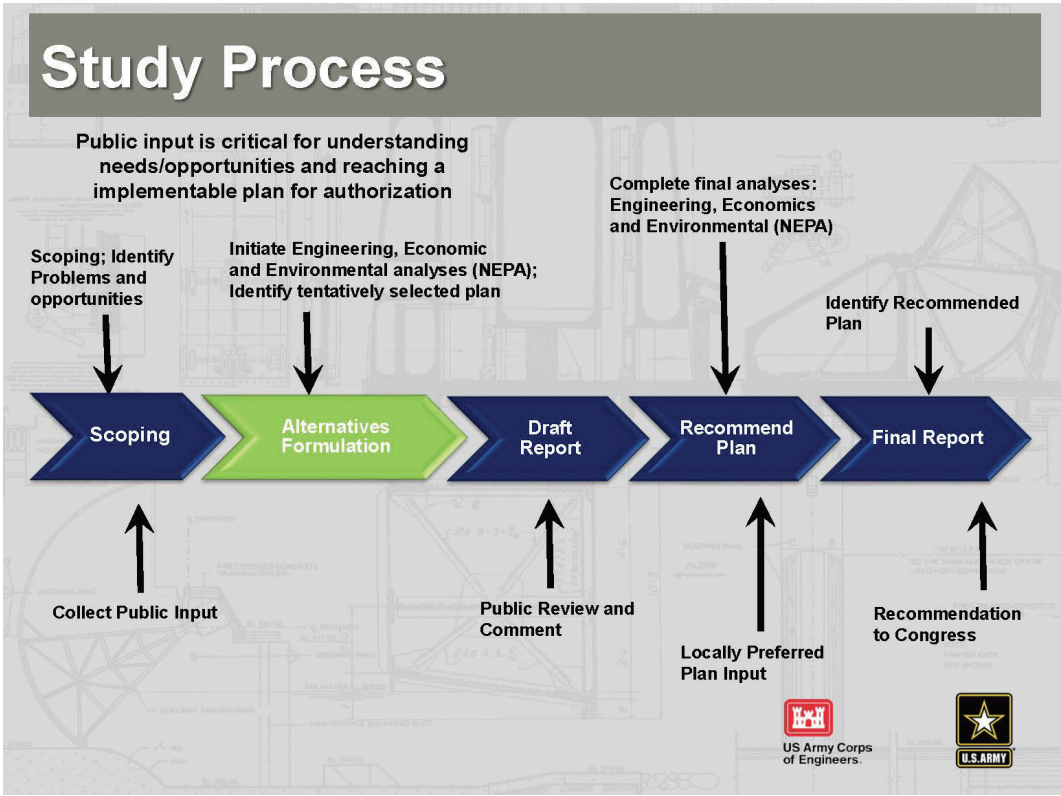
Study Process
Public input is critical for understanding needs/opportunities and reaching a implementable plan for authorization
Scoping; Identify Problems and opportunities
Initiate Engineering, Economic and Environmental analyses (NEPA); Identify tentatively selected plan
Complete final analyses: Engineering, Economics and Environmental (NEPA)
Identify Recommended Plan
Scoping
Alternatives Formulation
Draft Report
Recommend Plan
Final Report
Collect Public Input
Public Review and Comment
Locally Preferred Plan Input
Recommendation to Congress
US Army Corps of Engineers.
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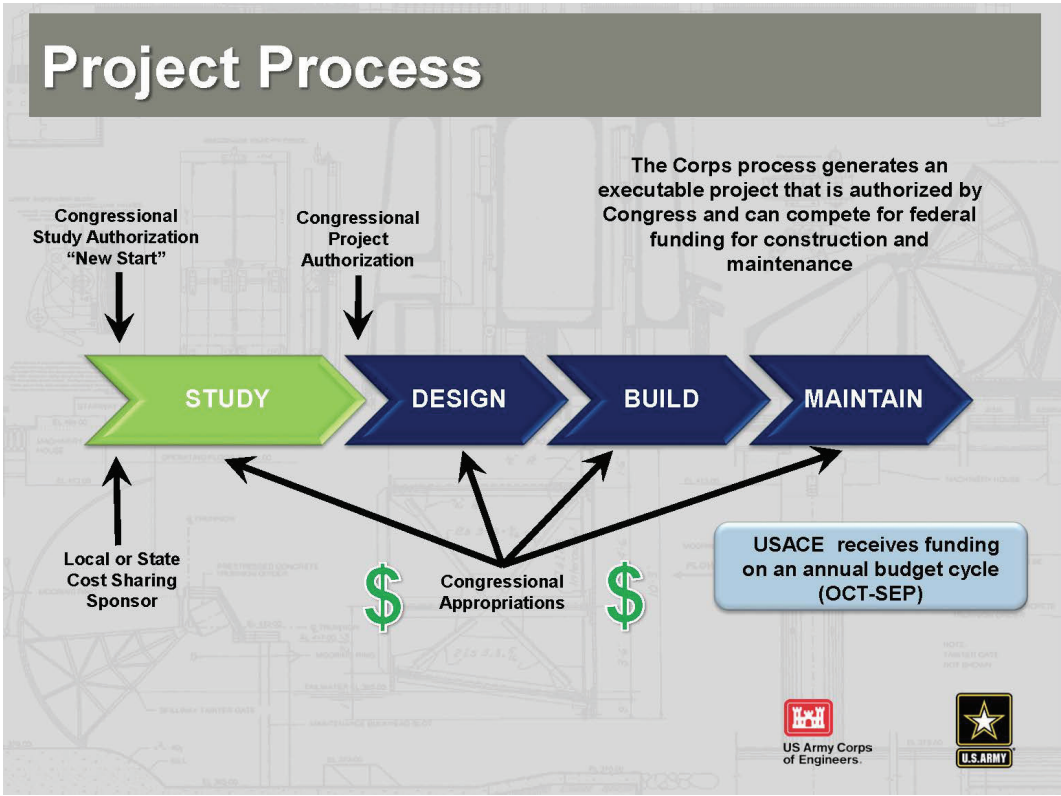
Project Process
Congressional Study Authorization "New Start"
Congressional Project Authorization
The Corps process generates an executable project that is authorized by Congress and can compete for federal funding for construction and maintenance
STUDY
DESIGN
BUILD
MAINTAIN
Local or State Cost Sharing Sponsor
$
Congressional Appropriations
$
USACE receives funding on an annual budget cycle (OCT-SEP)
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Collaboration With Others
Maximizing Capital
Organizational Change
Strategic Partnerships
Civil Works Transformation / Process Improvement
Communication
Transparency
Stakeholder Community
TCEQ
CBP & ICE
Port of Texas City
Port of Corpus Christi
Port of Harlingen
USDOT MARAD
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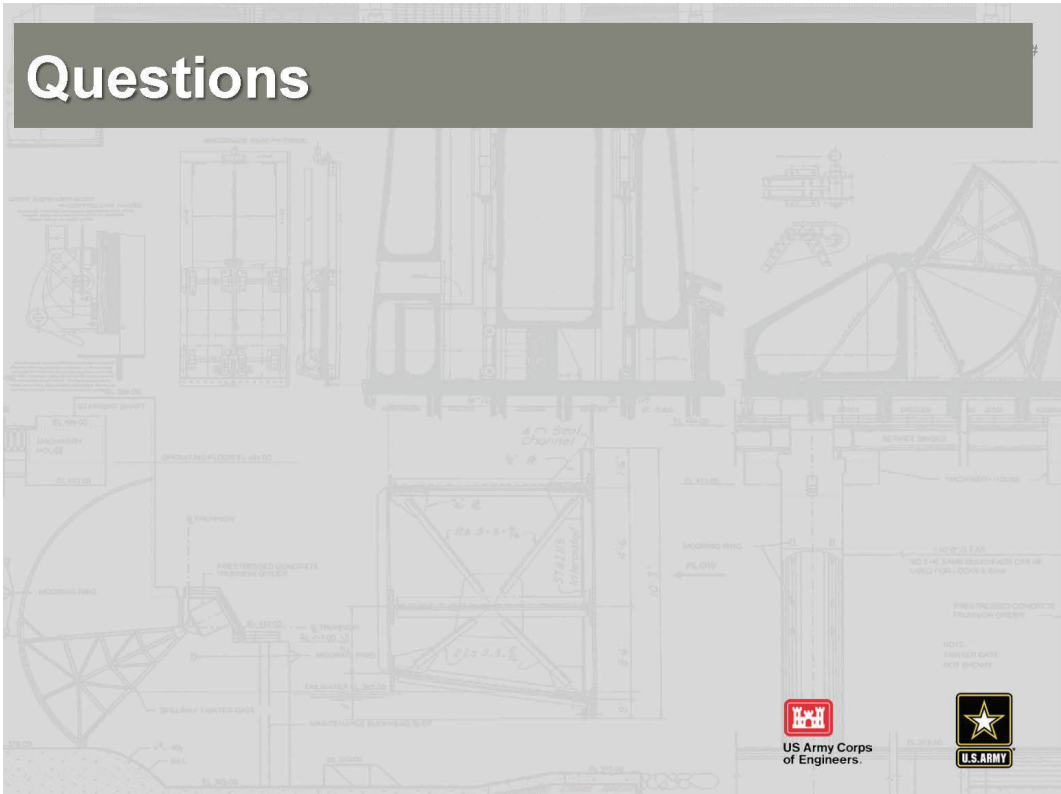
Questions
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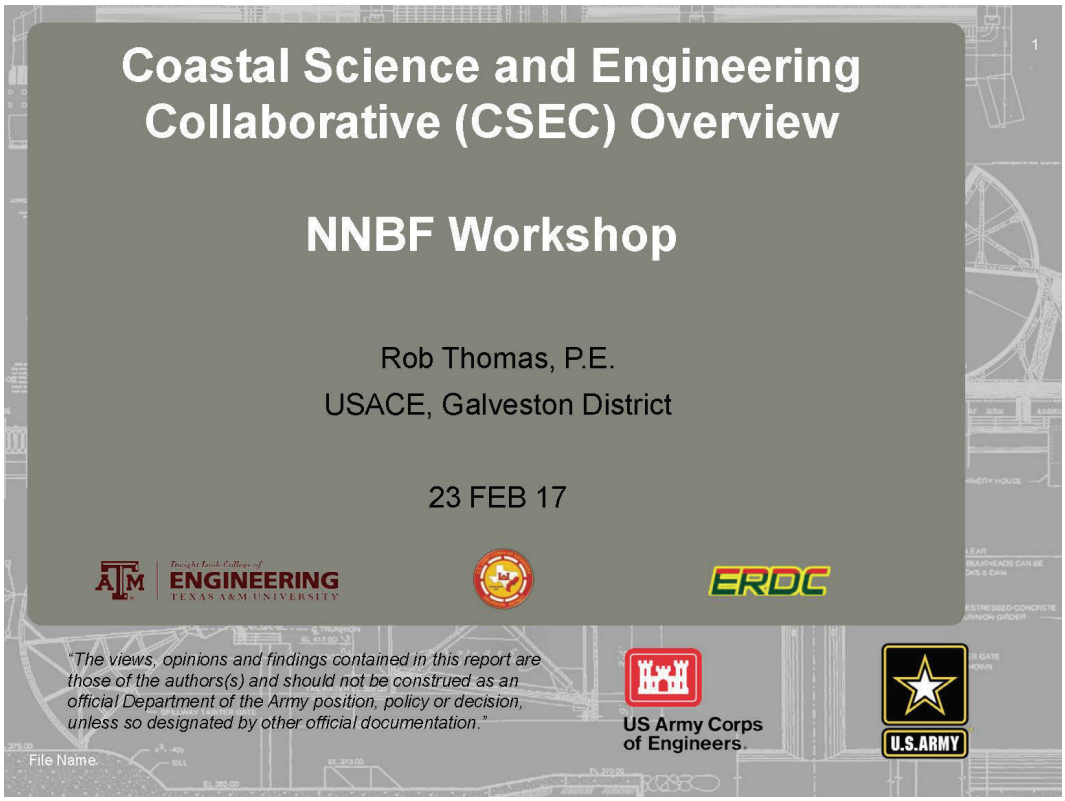
Appendix IV: Afternoon Plenary Slides

CSEC Overview



CSEC Objectives

- Transfer new science into practice faster
  - Deliver science and engineering to improve coastal project life cycle systems performance and cost
- Develop business collaboratively
  - Bring together capabilities, resources, and funding from multiple partners for an overall greater value than could be achieved separately
- Link academics to practice
  - Student learning experiences
  - Cultivate recruiting opportunities

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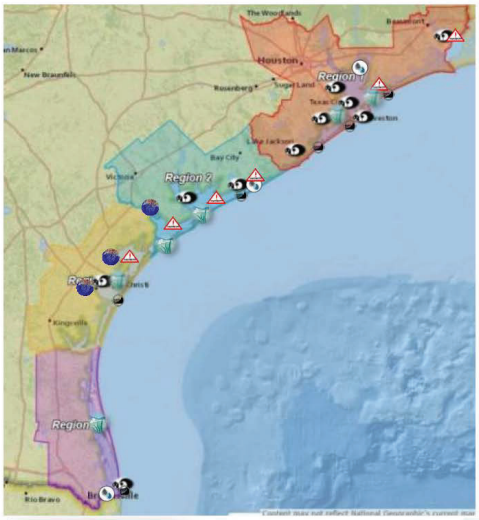
Addressing Problems and Opportunities in the Coastal Protection and Restoration Program

3



- Economic damage from coastal storm surge
- Inland shoreline erosion
- Gulf shoreline erosion
- Loss of T&E Critical Habitats (migratory bird habitat, critical T&E habitat, shellfish habitat)
- Loss of Natural Delta Processes
- Disrupted Hydrology

CSEC Workshop Series

Held workshops in AUG and NOV 2016 with next planned in APR 2017.

Purpose: Explore and establish common interests for partnering on coastal science and engineering academics, research and development, and practice, for timely infusion of innovative technical products to support lifecycle coastal infrastructure systems management decisions in practice.

Objectives:

- Become familiar with each others' organizations and their future directions
- Identify crossover working relationships in coastal science and engineering
- Develop a partnering value proposition for achieving mutually held objectives
- Identify action items for joint organization follow up with future event planning

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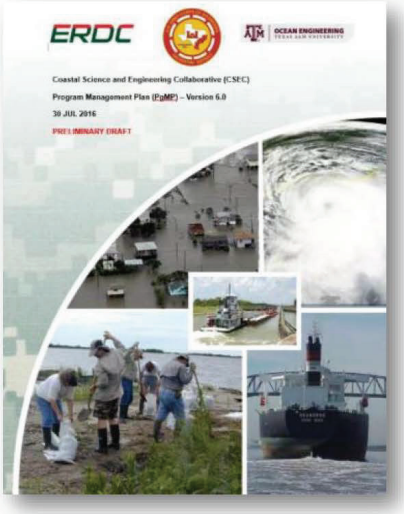
CSEC Program Management Plan Under Development

- Vision
- Intent
- Strategy
- Approach
- Goals
- Objectives
- Intended Capabilities and Products
- Path forward



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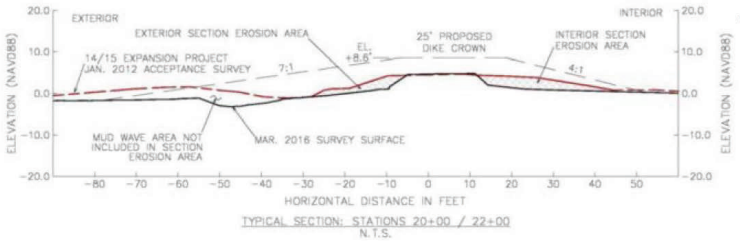
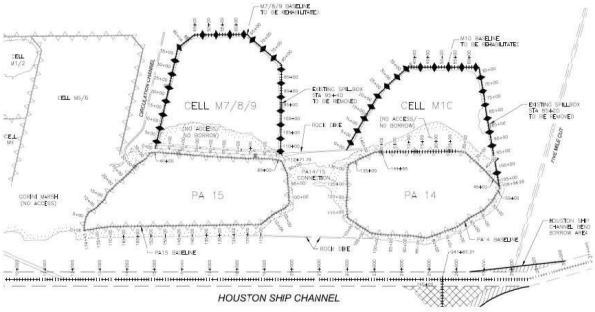
MUD DIKES



Construction:
Build a dike to protect a disposal area & make a new marsh

Research Questions:

1. Under what conditions does the dike erode?
2. How does a sandy beach form (erosion? winnowing?)
3. Are there critical thresholds (tipping points) of the forcing functions? (storm duration, wave height)
4. What is the impact of storm surge? (duration & height)



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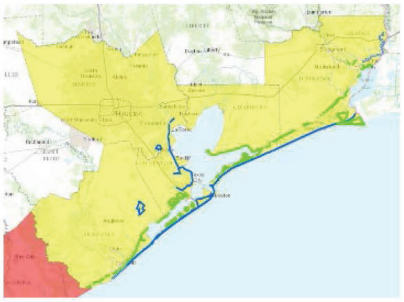
File Name

6

Coastal Texas Feasibility Study

- Background
  - Develop comprehensive plan for coastal storm risk mitigation and ecosystem restoration
  - 5.5 yr feasibility study
- Funded Activities
  - Regional storm climate & statistics
  - Regional storm surge & wave modeling
  - Galveston Bay 3D circulation & salinity model



- Research Needs
  - Depth-damage functions
  - Framework for climate change and sea level rise
  - Storm surge barriers: selection, operations, etc.

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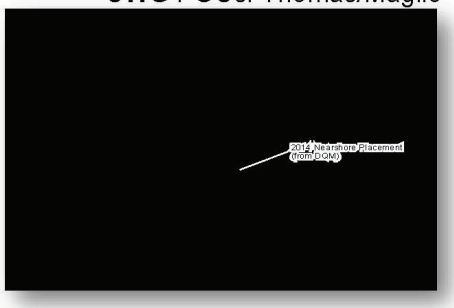
South Padre Island BU

SWG POCs: Thomas/Maglio



- Background
  - BIH Navigation Channel
  - Critical shoaling in the entrance channel
  - Critical erosion on South Padre Island
    - The most nourished beach in Texas!
- Funded Activities
  - Channel dredging
  - Incremental cost for beach placement
  - Monitoring completed navigation projects
  - SPI/GLO funded activities
- Research Needs
  - Improved methods to evaluate nearshore placement
  - Lower cost beach placement methods
  - More frequent, lower cost monitoring

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BENEFICIAL USE OF DREDGED MATERIAL – 2015 61ST GALVESTON

9

BENEFICIAL USE OF DREDGED MATERIAL – 2015
61ST GALVESTON

10

94 samples collected on the dredge Terrapin Island – over two loads

- 35 Inflow
- 59 overflow

330 samples collected at the beach over 3 months by GLDD

- Discharge slurry
- Carrier water
- Beach berm

Munsell Color
Cone Penetrometer

File Name

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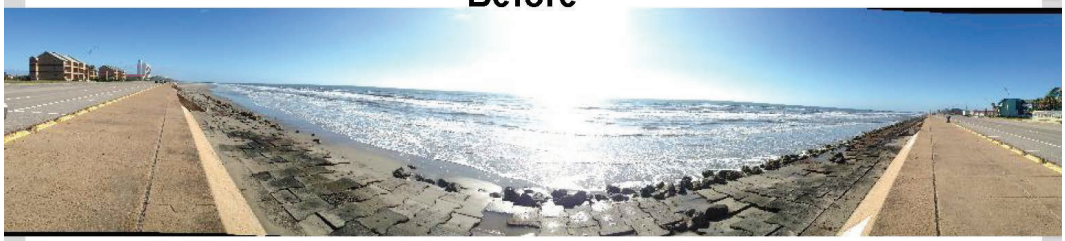
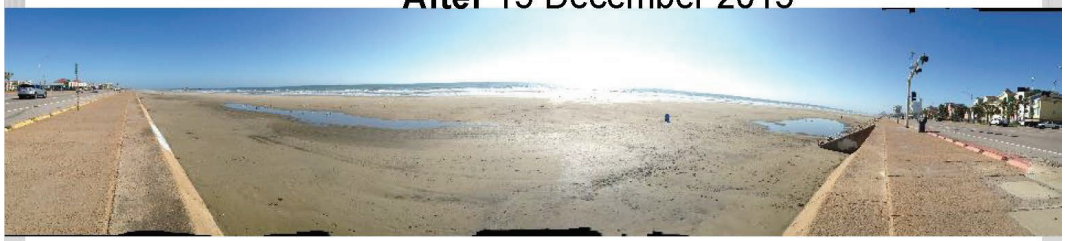
BENEFICIAL USE OF DREDGED MATERIAL – 2015
61ST GALVESTON

11

Before



After 15 December 2015



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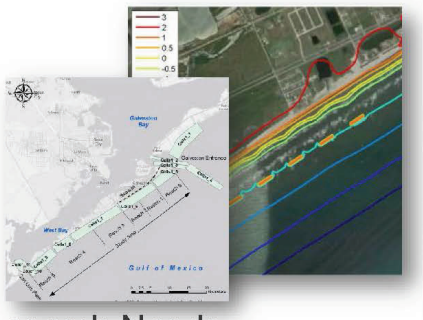
Galveston Park Board PAS

- Background
  - Needed nourishment has not been sustained
  - Critical erosion west end of the seawall
- Funded Activities
  - Sand Management Plan
  - Channel dredging
  - Incremental cost for beach placement
  - Monitoring completed navigation projects
  - County/USFWS/ATKINS assessment of shore protection



- Research Needs
  - East beach sediment source
  - Lower cost beach placement methods
  - By/Back passing systems
  - More frequent, lower cost monitoring

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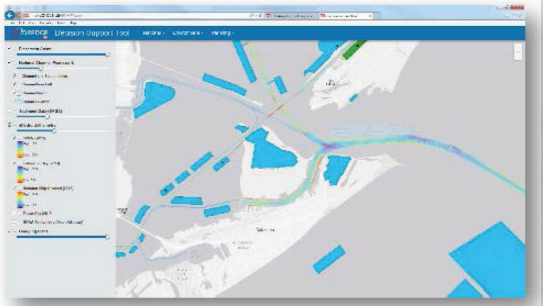
DMMP Modernization

- Background
  - Need to manage dredging and placement capacity
  - Opportunity to integrate data and systems with knowledge
- Funded Activities
  - Channel dredging and PA maintenance program
  - CE Dredge Decision Support Tool
  - Leveraging RSM and other ERDC programs



- Research Needs
  - Better monitoring
  - Visualization, Knowledge transfer
  - Systems optimization
  - Sediment management

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Submitted Statements of Need

1. Biophysical System Performance of Natural and Nature Based Features (NNBFs) for Coastal Storm Risk Management (CSRM)
2. Vegetated Stabilization of Erodible Clay Dike for Protection of Dredged-Material Placement Areas
3. Environmentally Acceptable Methods for Dredged-Material Disposal in Deep Holes
4. Decision tools for integration of dredged material management information and analyses
5. Modern dissemination, access, and approval methods for USACE Engineering Regulations and Manuals

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Engagement Opportunities

- Identifying critical knowledge gaps
- Sharing knowledge
- Participate in reviews
- Funding research
- Leading science to build the Texas Coast

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ON TWITTER
www.twitter.com/USACEgalveston

ON YOUTUBE
www.YouTube.com/Galveston District

ON DVIDS
www.dvidshub.net/units/USACE-GD

ONLINE
www.swg.usace.army.mil

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CSRM and ER Proposed Measures

A Road Map for Today

"A beginning is the time for taking the most delicate care that the balances are correct."
—Frank Herbert
Dune (1965)

1. Where we are in the study
2. Proposed Plans
3. Problems & Opportunities
   - Sea Level Rise - Sustainability
   - Hybrid Solutions – Will they work?
   - Ecosystem Goods & Services – Metrics (Non-monetized & Monetized)
   - Resilience Indices – Metrics Again
   - BU Mapping & Regional Sediment Mgmt

2

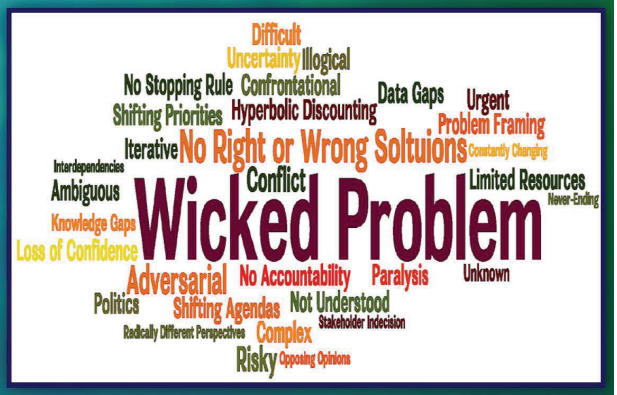
Research Questions Behind the Study

- **How to plan** and implement effective protection and restoration plans for hundreds of miles of TX coastline over the long-term (50-100+ years) when shifting, oftentimes conflicting political, social, and ecological agendas influence the decision outcomes?
- **How to measure success** when ecosystem integrity or system wholeness cannot be assured and **SUSTAINABILITY** is questioned in the face of urbanization and climate change (specifically SLR)
- **How to efficiently integrate** data, models and expert knowledge in a transparent manner that is prescriptive (sufficient, relevant, and reliable), visually engaging (promoting rapid communication), and adaptive (proactively responsive to uncertainty) in dynamic decision making environment over the long-term?
- **How to effectively engage** stakeholders and scientists alike in formulating sustainable and resilient solutions?

3

The Overarching Concern

- **Wicked problems** like this cannot be resolved in time solely with hard science or technical solutions – their complexity mandates rapid & prescriptive R&D to fill knowledge gaps and promote transparency and confidence in the proposed solutions.

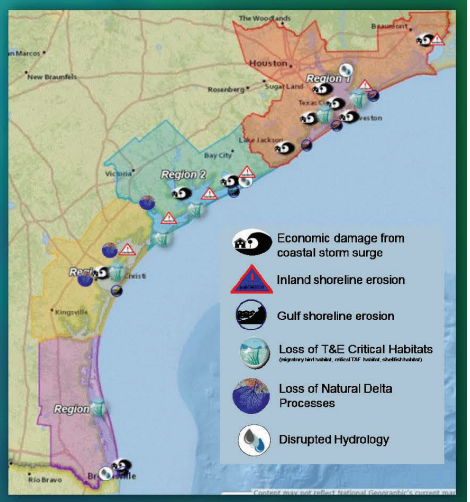


"Wicked problems have numerous intervention points, have consequences difficult to envision, and are surrounded by a dynamic uncertainty wrapped in a moving frontier of knowledge."
—Ioannis Petrus, 2009

4

Overarching Themes for the R&D Agenda

- **System-Based Approach** requires creative problem solving and critical thinking at both the strategic (future-oriented) and tactical (near-term) scales and encourages a systems-level characterization of ecosystem integrity based on scientifically-defensible performance metrics comparing/contrasting potential interventions and adaptively managing solutions
- **Spiraling framework** utilizes an interactive group approach that encourages stakeholders to identify problems, deliberate, propose solutions and respond to contextual changes in recursive reflection cycles (centered around information presented at each workshop/web meeting)
- **Transdisciplinary teams** draw knowledge not only from academic researchers coming from different unrelated disciplines, but also from experiential perspectives garnered from non-academics in applied disciplines (e.g., natural resource managers, end-user groups and the general public)



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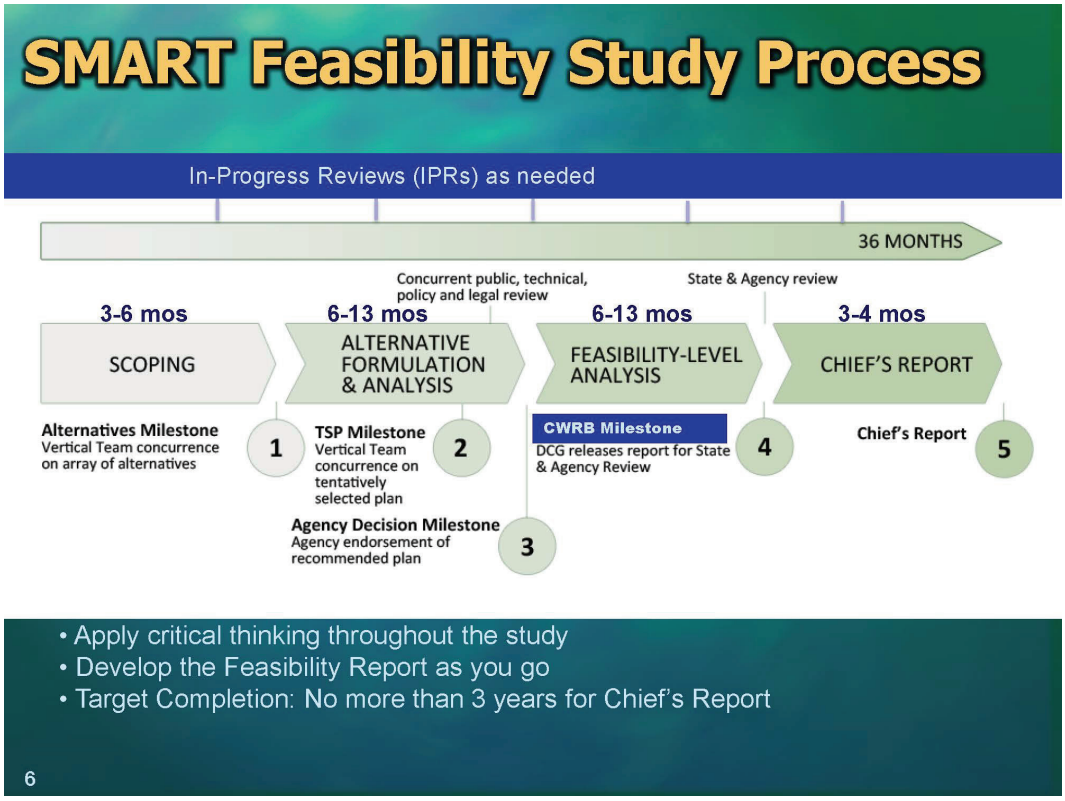
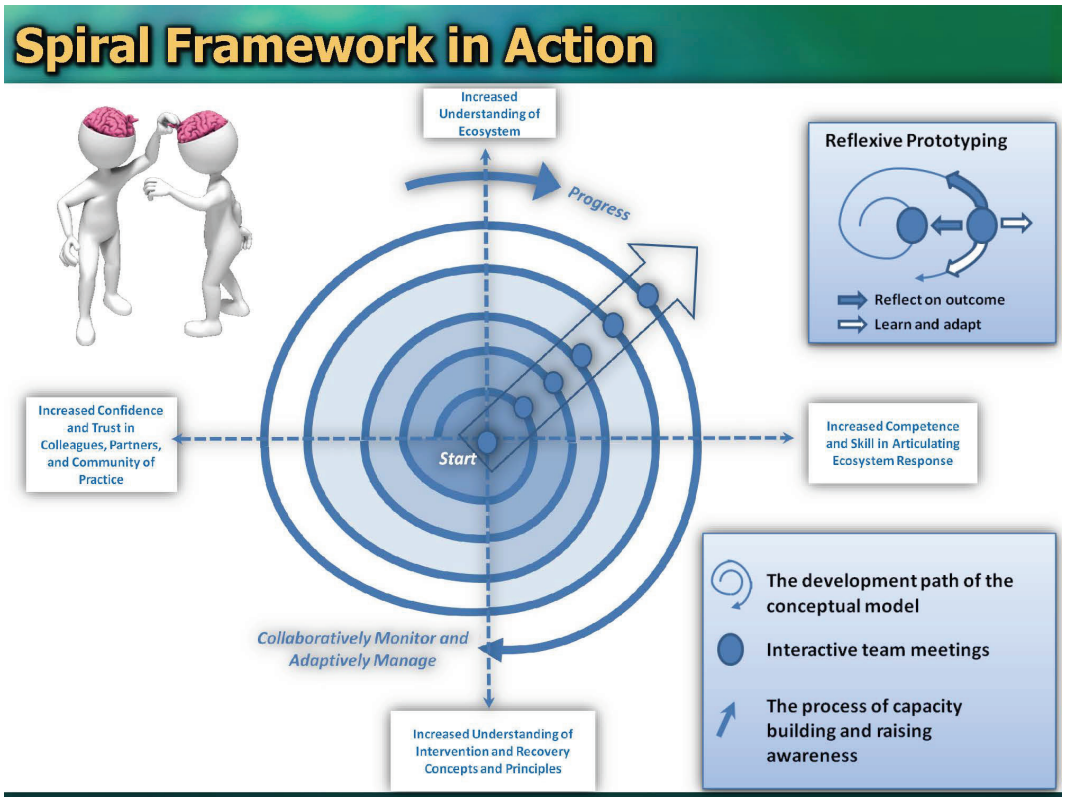
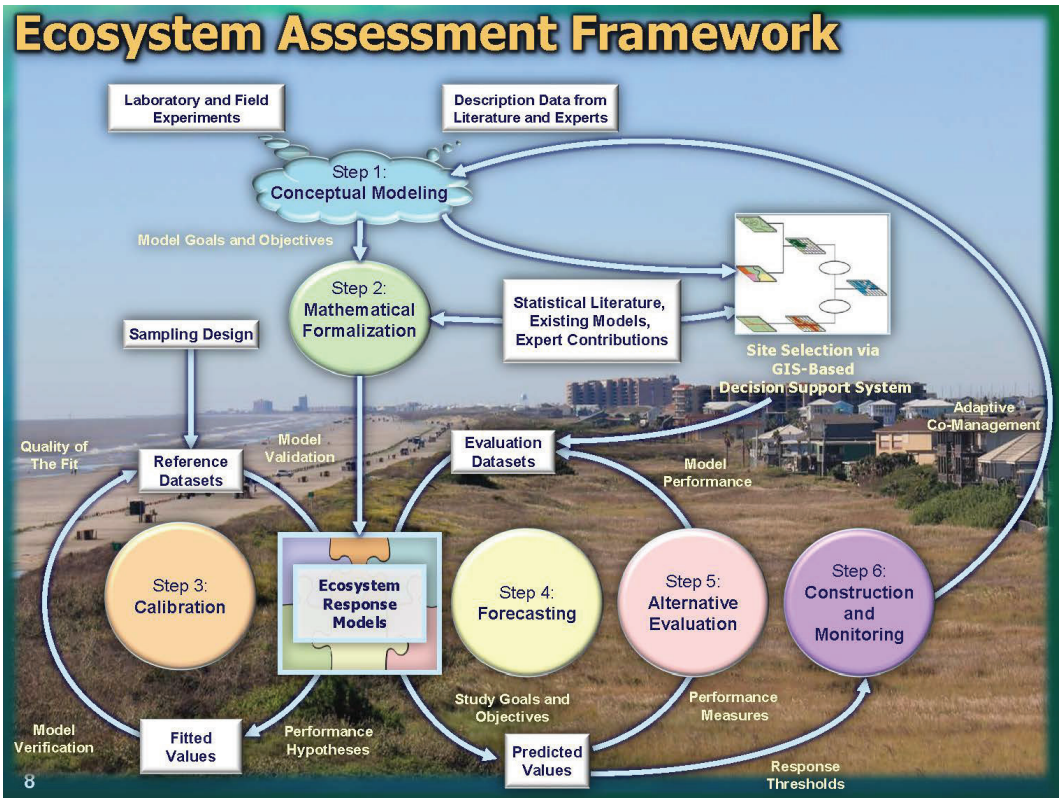
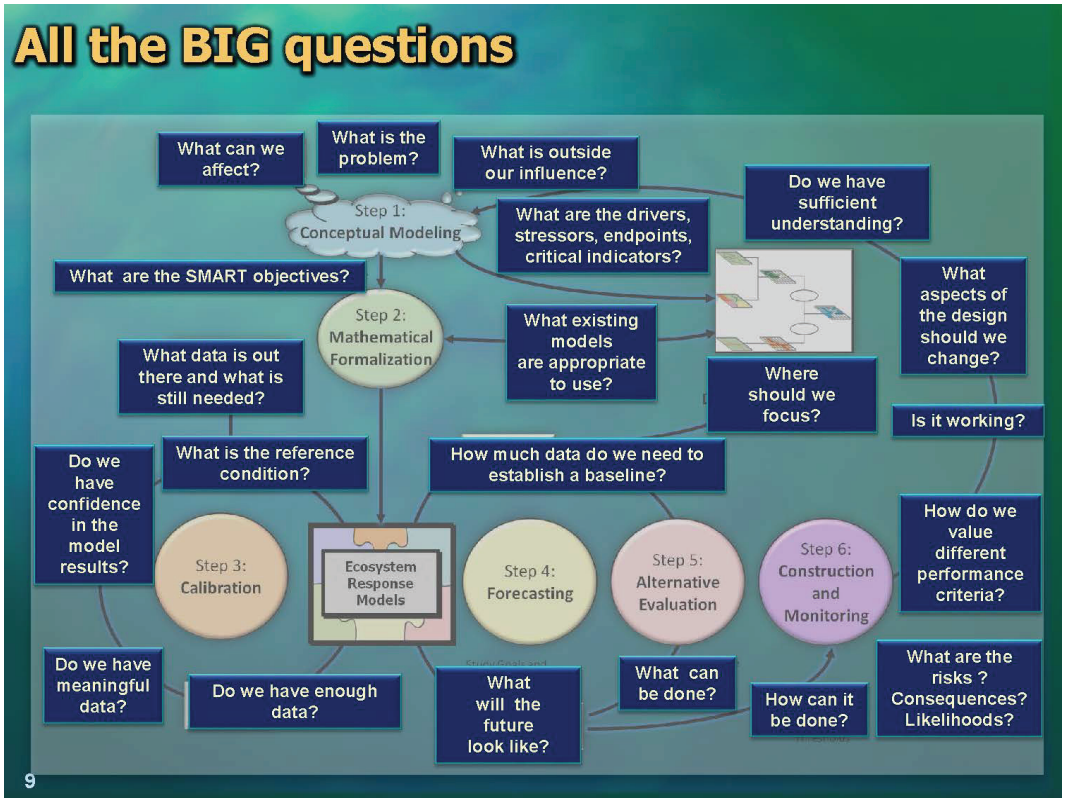
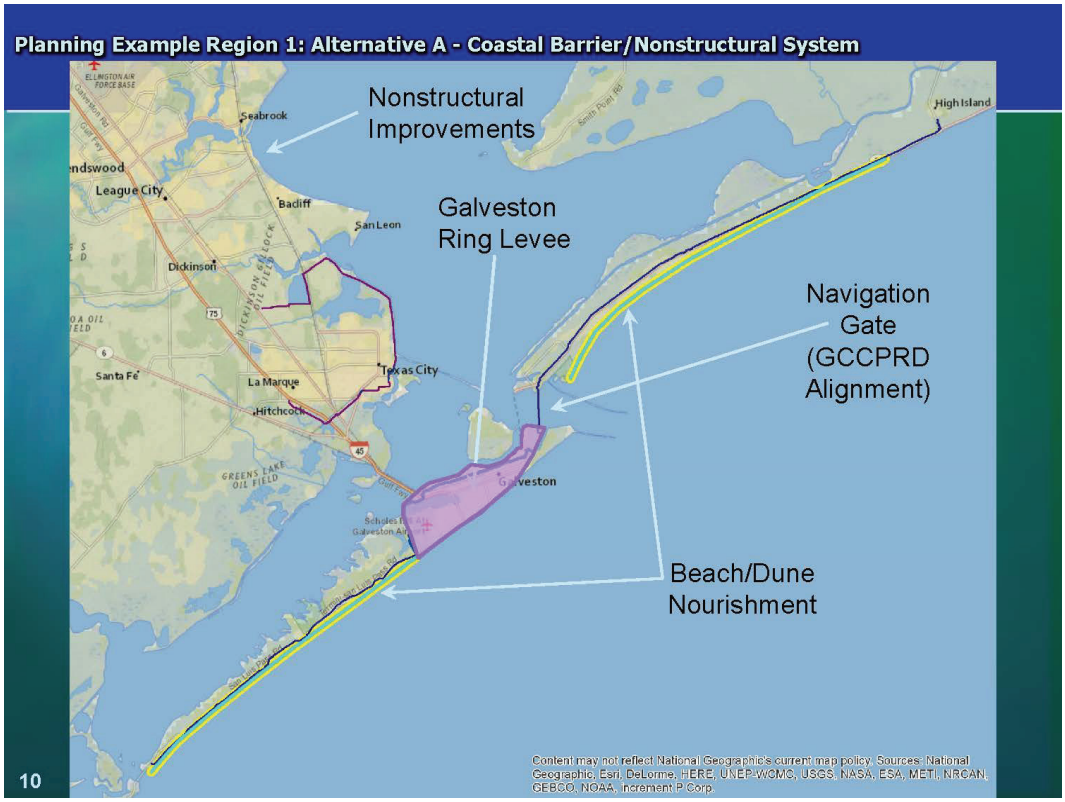
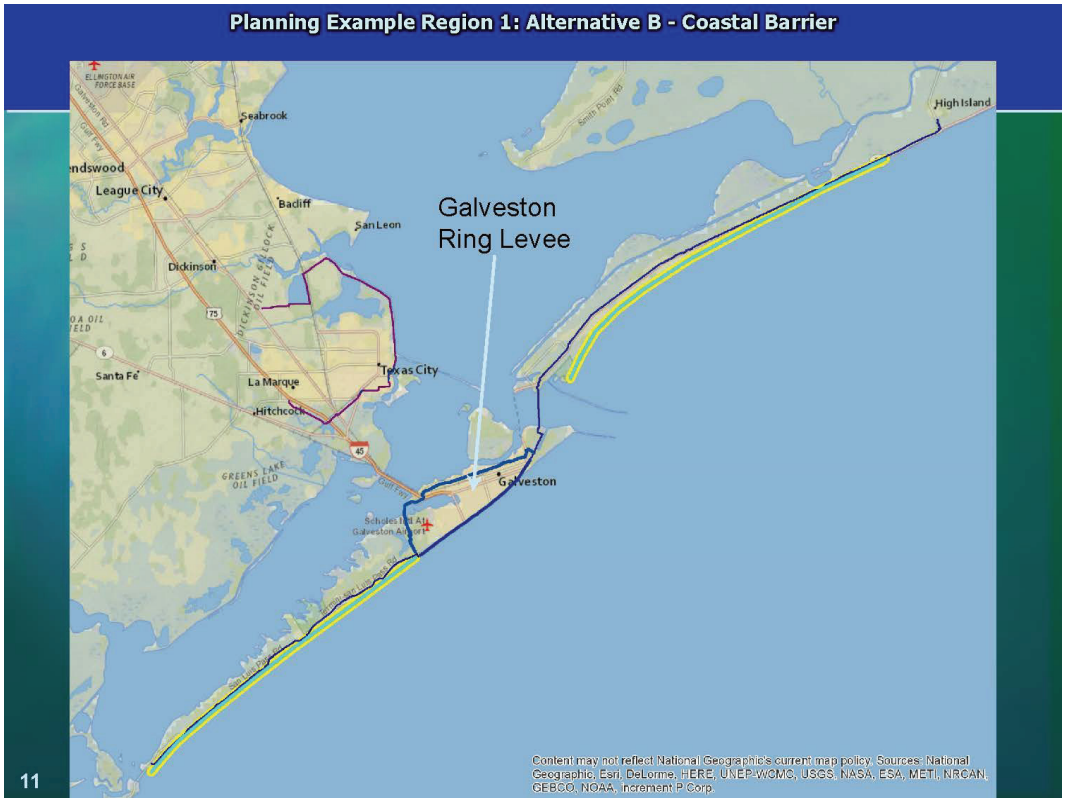

SMART Feasibility Study Process
In-Progress Reviews (IPRs) as needed
36 MONTHS
Concurrent public, technical, policy and legal review
State & Agency review
3-6 mos
6-13 mos
6-13 mos
3-4 mos
SCOPING
ALTERNATIVE FORMULATION & ANALYSIS
FEASIBILITY-LEVEL ANALYSIS
CHIEF'S REPORT
Alternatives Milestone
Vertical Team concurrence on array of alternatives
1
TSP Milestone
Vertical Team concurrence on tentatively selected plan
2
Agency Decision Milestone
Agency endorsement of recommended plan
3
CWRB Milestone
DCG releases report for State & Agency Review
4
Chief's Report
5
• Apply critical thinking throughout the study
• Develop the Feasibility Report as you go
• Target Completion: No more than 3 years for Chief's Report
6

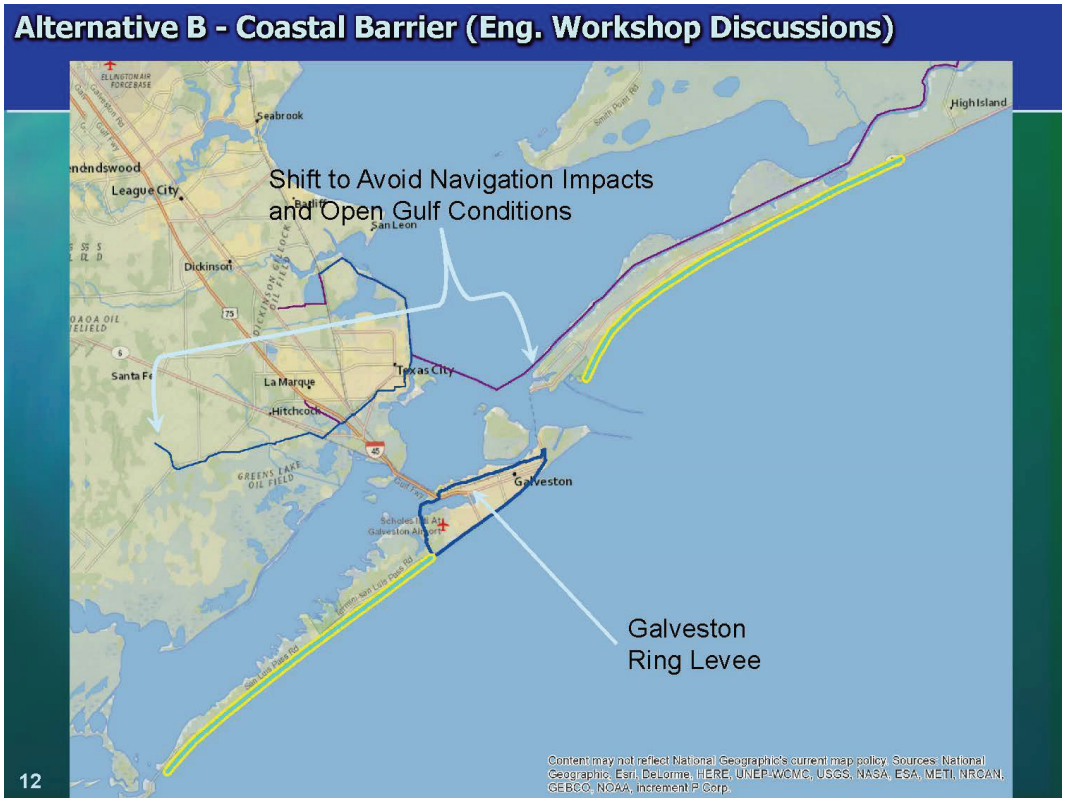

Spiral Framework in Action
Increased Understanding of Ecosystem
Progress
Reflexive Prototyping
Reflect on outcome
Learn and adapt
Increased Confidence and Trust in Colleagues, Partners, and Community of Practice
Start
Increased Competence and Skill in Articulating Ecosystem Response
Collaboratively Monitor and Adaptively Manage
Increased Understanding of Intervention and Recovery Concepts and Principles
The development path of the conceptual model
Interactive team meetings
The process of capacity building and raising awareness

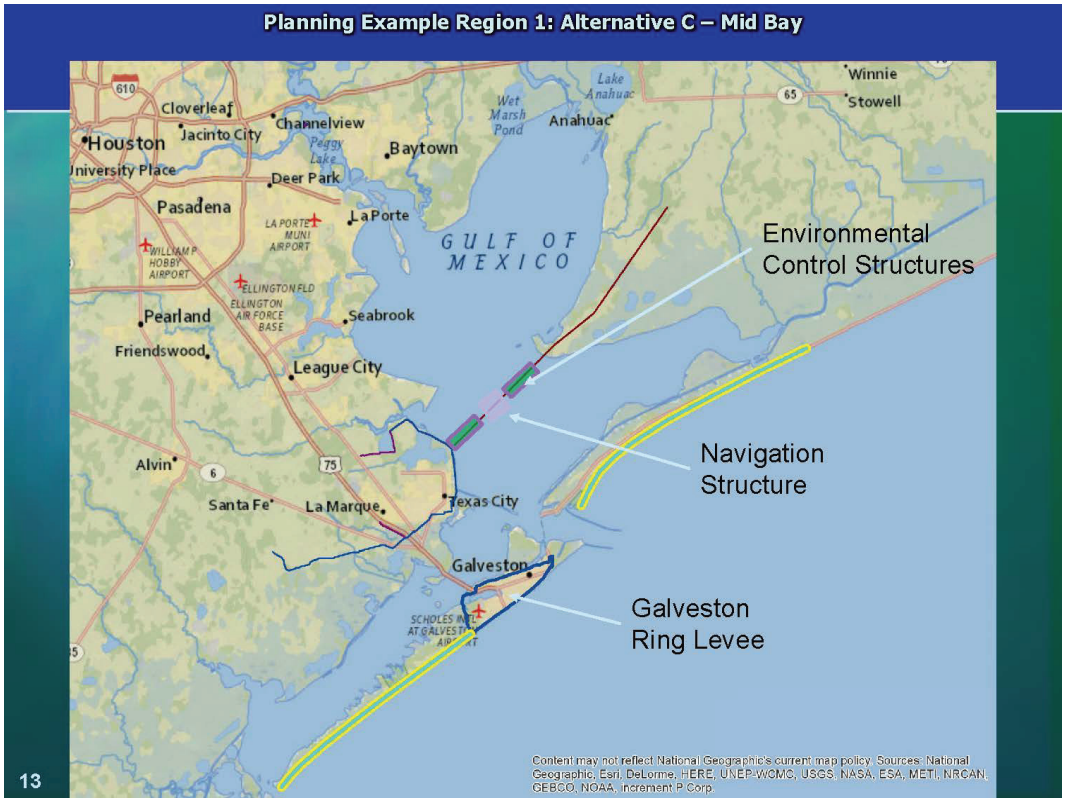

Ecosystem Assessment Framework
Laboratory and Field Experiments
Description Data from Literature and Experts
Step 1: Conceptual Modeling
Model Goals and Objectives
Step 2: Mathematical Formalization
Statistical Literature, Existing Models, Expert Contributions
Sampling Design
Site Selection via GIS-Based Decision Support System
Adaptive Co-Management
Quality of The Fit
Reference Datasets
Model Validation
Evaluation Datasets
Model Performance
Step 3: Calibration
Ecosystem Response Models
Step 4: Forecasting
Step 5: Alternative Evaluation
Step 6: Construction and Monitoring
Study Goals and Objectives
Performance Measures
Model Verification
Fitted Values
Performance Hypotheses
Predicted Values
Response Thresholds
8


All the BIG questions
What can we affect?
What is the problem?
What is outside our influence?
Do we have sufficient understanding?
Step 1: Conceptual Modeling
What are the drivers, stressors, endpoints, critical indicators?
What are the SMART objectives?
What aspects of the design should we change?
Step 2: Mathematical Formalization
What existing models are appropriate to use?
What data is out there and what is still needed?
Where should we focus?
Is it working?
Do we have confidence in the model results?
What is the reference condition?
How much data do we need to establish a baseline?
How do we value different performance criteria?
Step 3: Calibration
Ecosystem Response Models
Step 4: Forecasting
Step 5: Alternative Evaluation
Step 6: Construction and Monitoring
Do we have meaningful data?
Do we have enough data?
What will the future look like?
What can be done?
How can it be done?
What are the risks ? Consequences? Likelihoods?
9

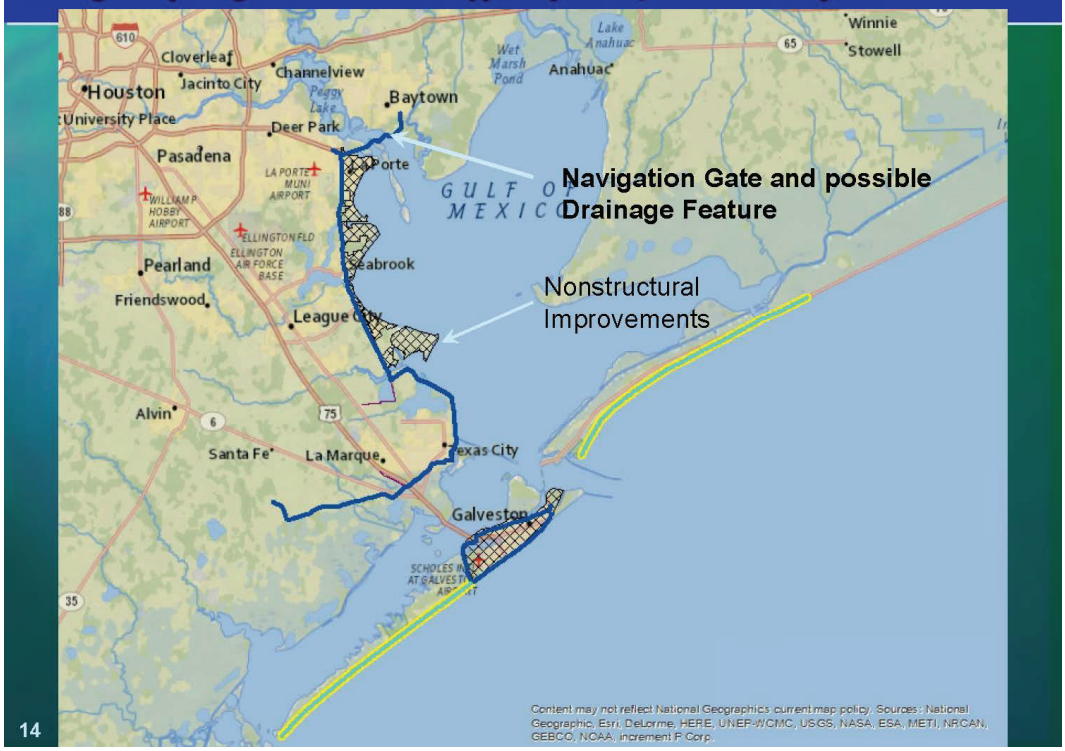

Planning Example Region 1: Alternative A - Coastal Barrier/Nonstructural System
Nonstructural Improvements
Galveston Ring Levee
Navigation Gate (GCCPRD Alignment)
Beach/Dune Nourishment
Seabrook
League City
Badiff
San Leon
Dickinson
Santa Fe
La Marque
Hitchcock
Texas City
Galveston
High Island
10
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.


Planning Example Region 1: Alternative B - Coastal Barrier
Galveston Ring Levee
Seabrook
League City
Badiff
San Leon
Dickinson
Santa Fe
La Marque
Hitchcock
Texas City
Galveston
High Island
11
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.


Alternative B - Coastal Barrier (Eng. Workshop Discussions)
Shift to Avoid Navigation Impacts
and Open Gulf Conditions
Galveston
Ring Levee
Seabrook
League City
Dickinson
San Leon
Texas City
La Marque
Hitchcock
Santa Fe
Galveston
High Island
12


Planning Example Region 1: Alternative C – Mid Bay
Environmental
Control Structures
Navigation
Structure
Galveston
Ring Levee
Houston
Cloverleaf
Jacinto City
Channelview
Baytown
Anahuac
Winnie
Stowell
Deer Park
Pasadena
La Porte
GULF OF
MEXICO
Pearland
Seabrook
Friendswood
League City
Alvin
Santa Fe
La Marque
Texas City
Galveston
13

Planning Example Region 1: Alternative D Upper Bay Barrier/ Nonstructural System



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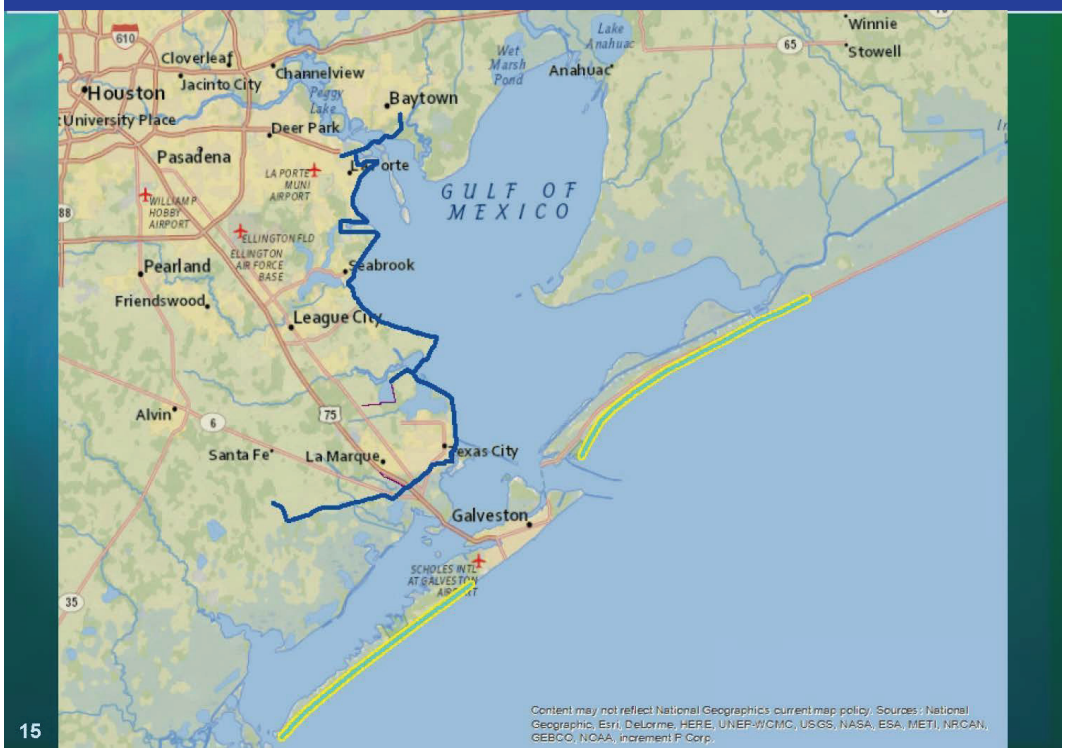
Planning Example Region 1: Alternative D - Options Reviewed based on GCCPRD Comments



15

Conceptual Ecological Model

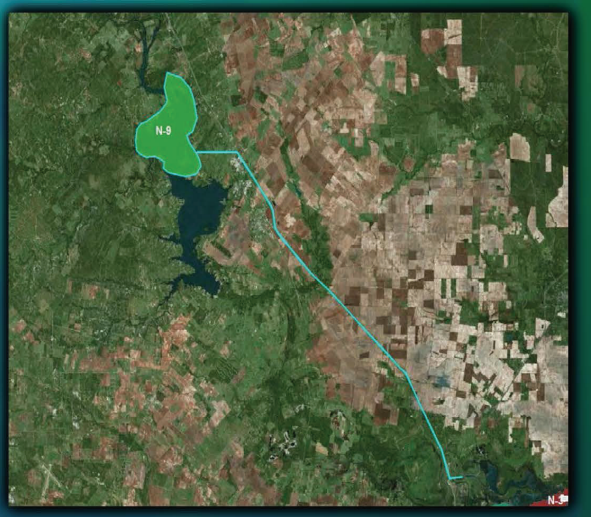
16

Coastal TX Plans to Date

Ecosystem Restoration Plans

Multiple Lines of Defense:

- Wetland Restoration
- Dunes and Beaches
- Hydrologic Restoration
- Island Restoration
- Revetment/Breakwaters
- Sediment Bypass & Sediment Management



17

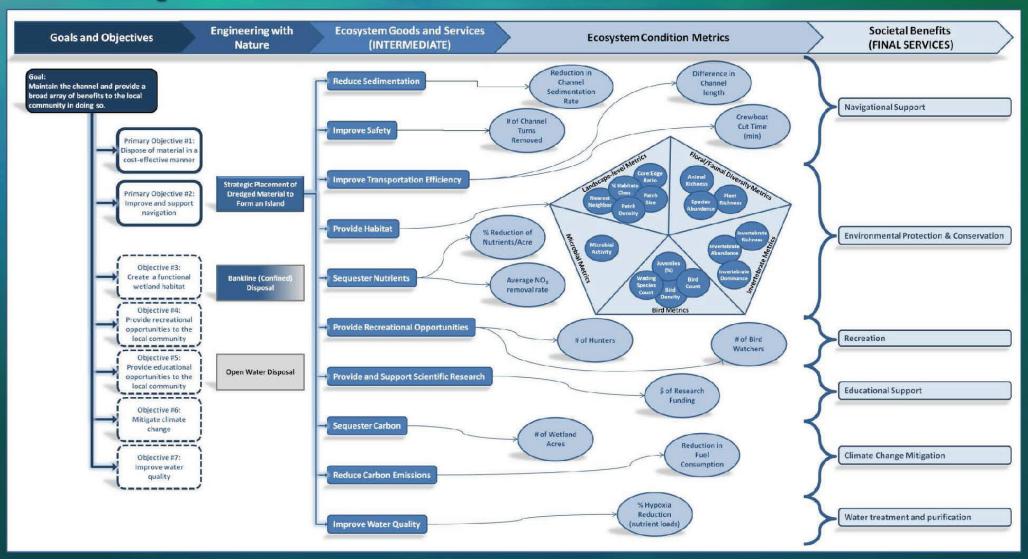
Sustainability in the face of threats?
G-11
18

Multiple Lines of Defense – Hybrid Success?
G-5 East
G-12 East
19

Benefit Quantification?

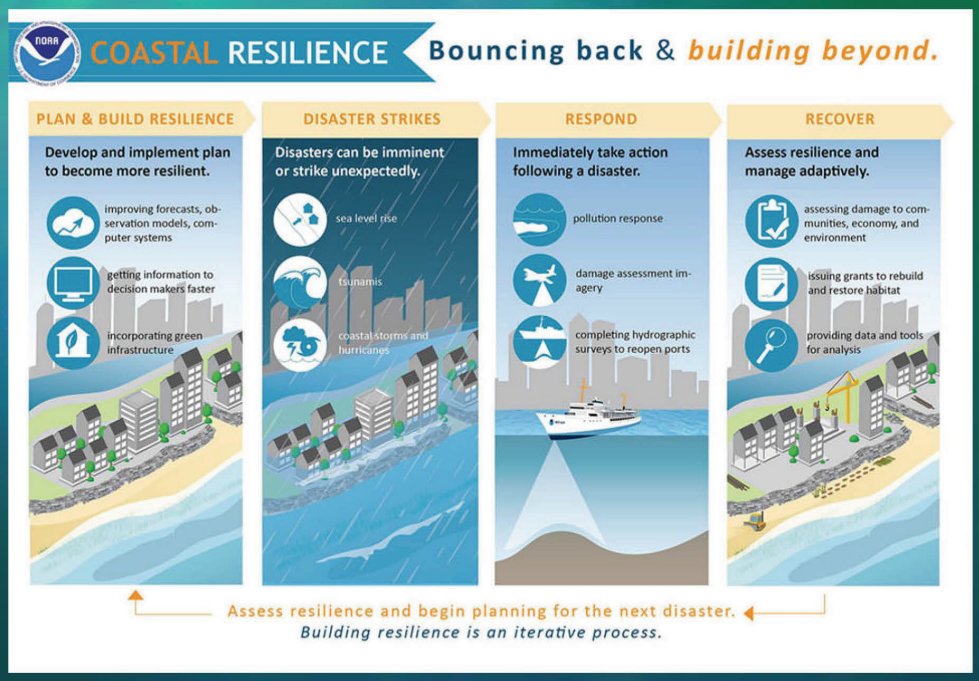
- Community-based index modeling
- Ecosystem goods & services
- Multiple account tradeoffs

Model Certification is Key



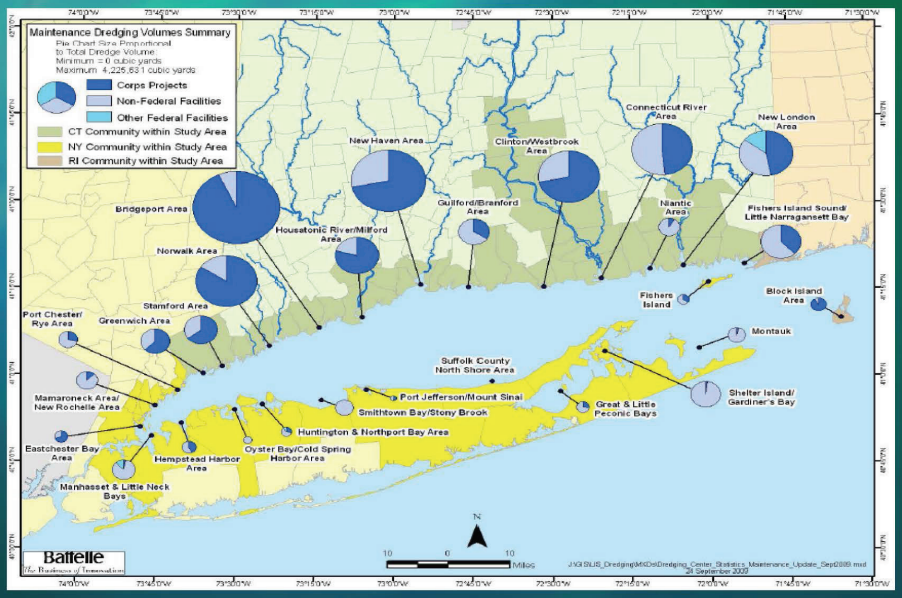
20

Resilience Indices?



21

Regional Sediment Management



22

Research Agenda

- **Metrics for Ecosystem Response:**
  - Community-based Models
  - Resilience
  - Goods & Services
- **Regional Sediment Management**
  - BU Maps
  - Particle Tracking
  - Stockpiling
- **Sustainability**
  - SLR & Urbanization
  - Hybrid Solutions Proving Grounds

	Milestone	Date
Scoping	Exemption Approval by Senior Leaders	Sep 2015
	Exemption Approval by ASA(CW)/OMB	Nov 2015
	Execute FCSA with GLO	Nov 2015
Alternative Evaluation and Analysis	Alternatives Milestone	June 2016
	Tentatively Selected Plan (TSP) Milestone	May 2018
Feasibility Level Analysis	Agency Decision Milestone (ADM)	Oct 2018
	Feasibility Report Complete	Oct 2020
	Civil Works Review Board (CWRB)	Jan 2021
	S&A Review	Feb 2021
	Chief's Report	Apr 2021

23

Questions?

24

Environmental Restoration Opportunities

Galveston Bay: Environmental Restoration Opportunities

1. Build containment dikes with clay (Tom White)
2. Use a variety of vegetation to stabilize dikes (Tosin Sekoni)
3. Try many combinations of substrates and oyster castles (Tim Clarkin)
4. Measure extent of "environmental deserts" created by mining oysters (Crawford/White/Maglio/ERDC)
5. Collect project methods used to fill deep bay holes from Jacksonville, Mobile, and Philadelphia Districts (White/Maglio)
6. How and where to stockpile sediment for later use (Coast of Texas)

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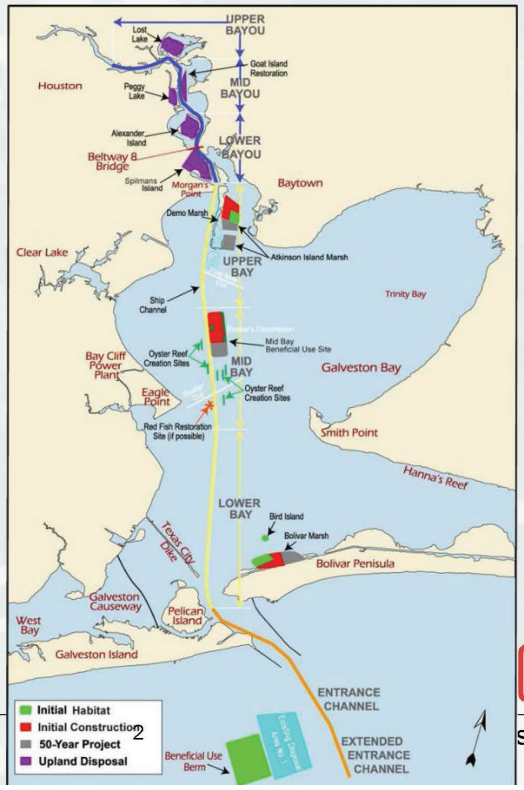
Galveston Bay Placement Areas



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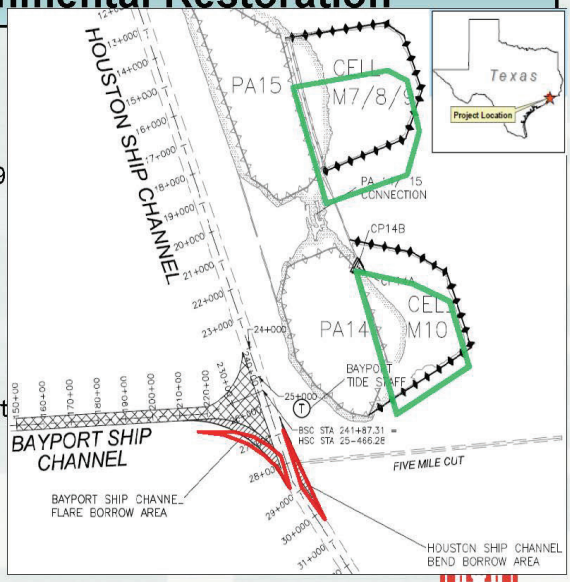
2

STRONG®

Houston Ship Channel
Deferred Environmental Restoration

- New-work material adjacent to Bayport Ship Channel (BSC) Flare and Houston Ship Channel (HSC) will be used to repair containment dikes at Atkinson Island beneficial use marsh cells M7/8/9 and M10
- Meets authorized project commitments to create marsh in Galveston Bay
- Provides additional placement capacity for HSC maintenance dredged material
- Provides necessary O&M of the Bayport Ship Channel and Flare
- Contract was awarded 27 Sep 2016



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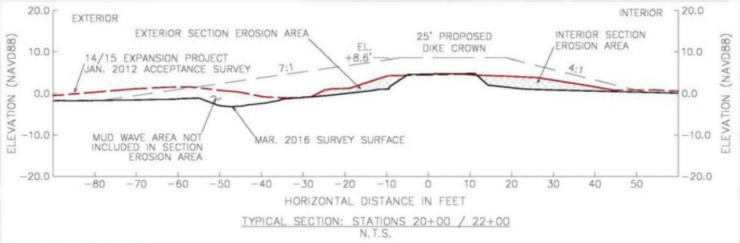
Mud dikes

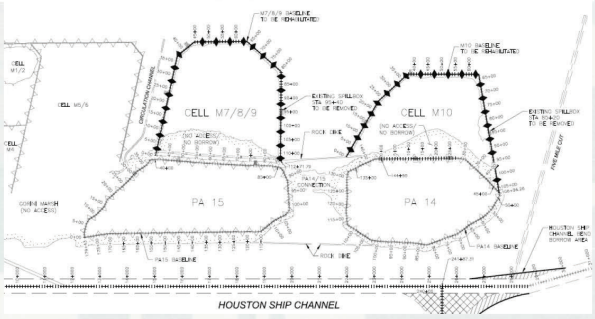


Construction:

Build a dike to protect a disposal area & make a new marsh

Research Questions:

1. Under what conditions does the dike erode?
2. How does a sandy beach form (erosion? winnowing?)
3. Are there critical thresholds (tipping points) of the forcing functions? (storm duration, wave height)
4. What is the impact of storm surge? (duration & height)



BUILDING STRONG®

R&D Opportunities
(thesis and dissertation topics)

Field 1. Monitor mud winnowing during beach nourishment (tides, waves, currents, grain size, elevation)

Field 2. Monitor mud dike erosion (elevations, quantities, grain size, settlement, waves, currents, storm surge)

Field 3. Monitor water displacement from a large ship (mud-wave formation, vertical mixing, side-slope erosion)

Computer 4. Model salinity changes in a large shallow bay

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5

BUILDING STRONG®

R&D Opportunities
(thesis and dissertation topics)

Lab & Field 5. Measure marsh grass (Spartina) rates of sediment accumulation as a function of tide, waves, grain size, subsidence, sea level

Lab & Field 6. Compare different methods of measuring sediment erodibility

Lab & Field 7. Try out recipes and methods for flocculating mud “fluff” in bay holes

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6

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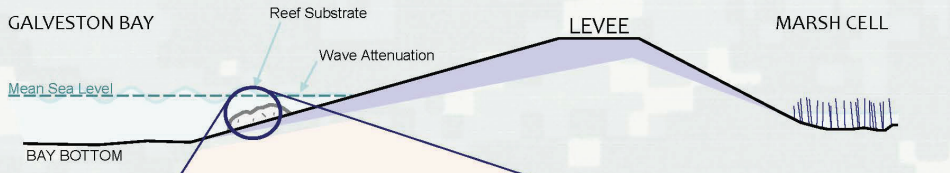
Proposed Oyster Demonstration Project

Design and deploy ten structures at Atkinson Island Marsh Cell 10.

Compare performance in erosion reduction and habitat formation.

Typical Reef Materials

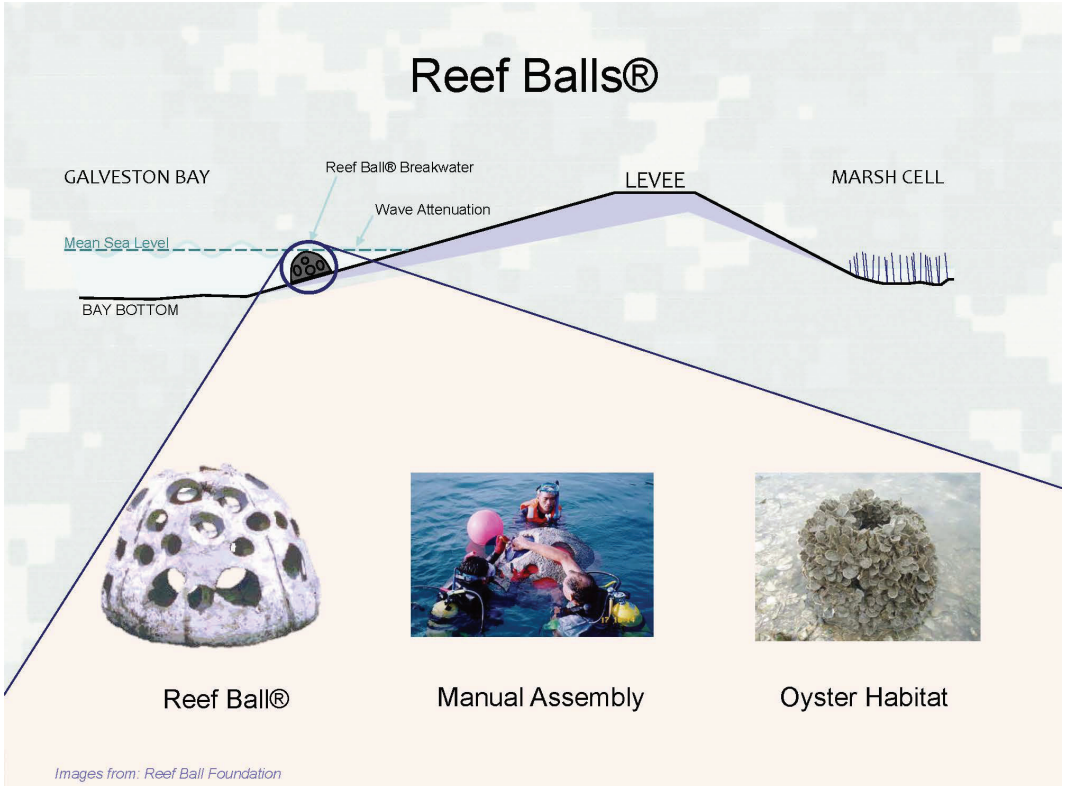


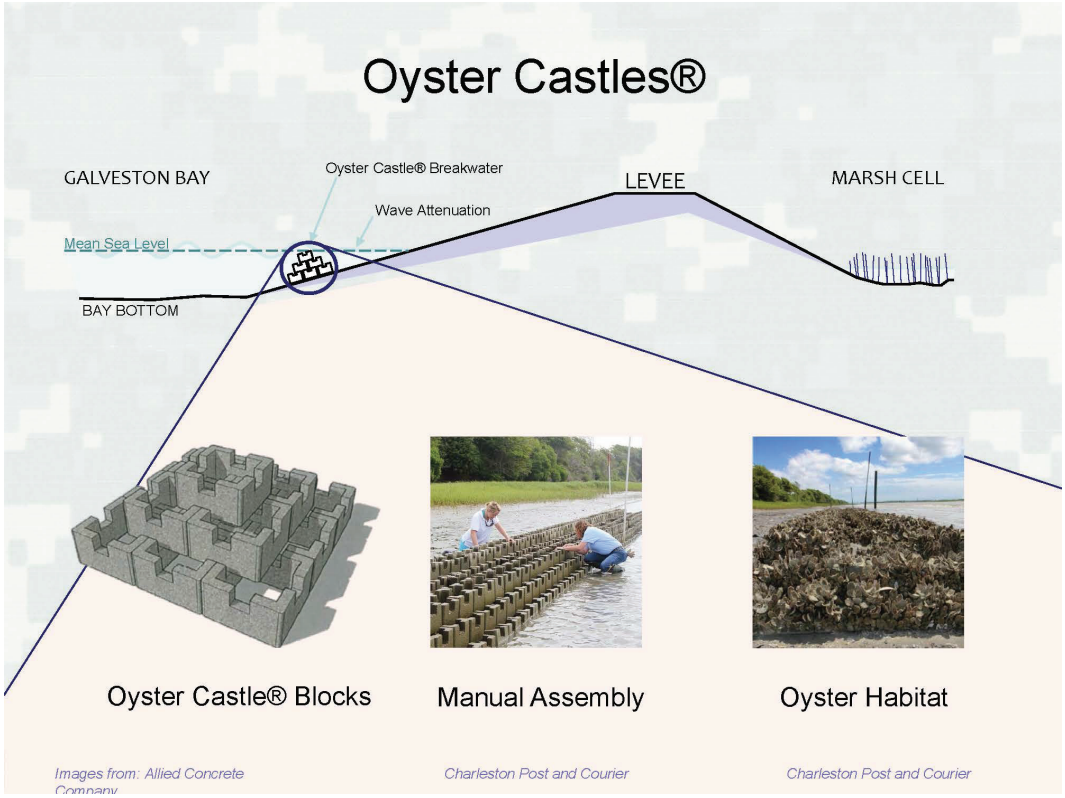
Limestone

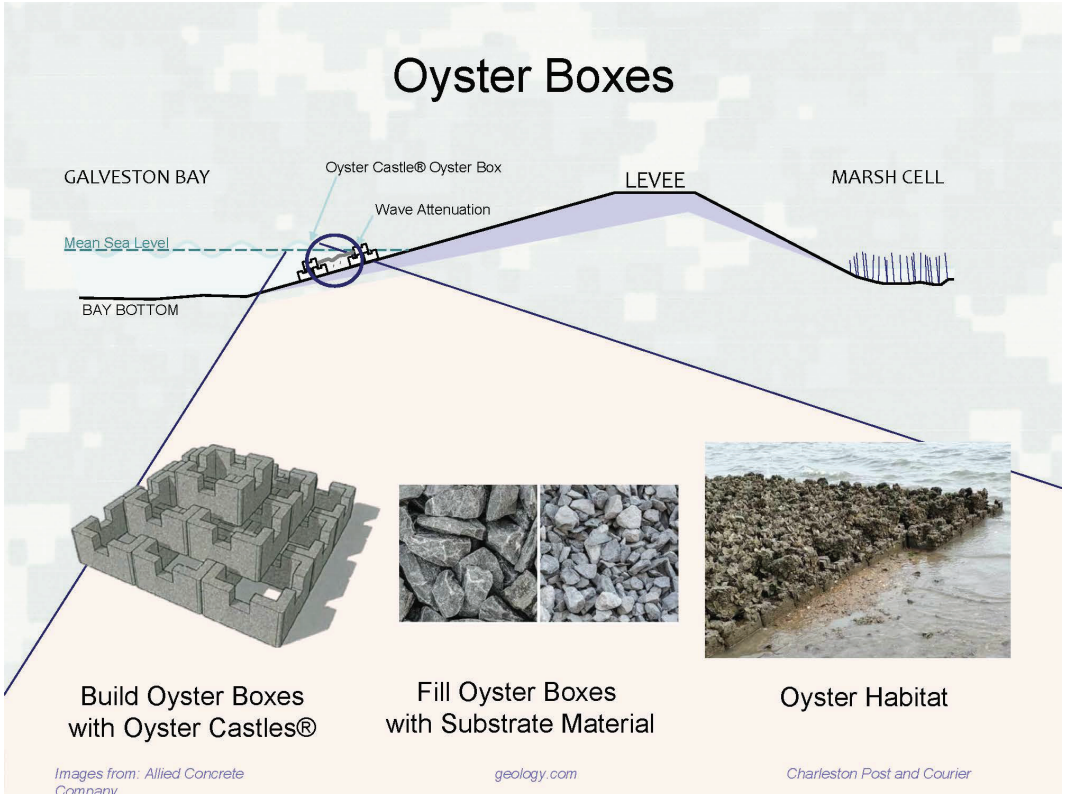
Crushed Concrete

Crushed Stone

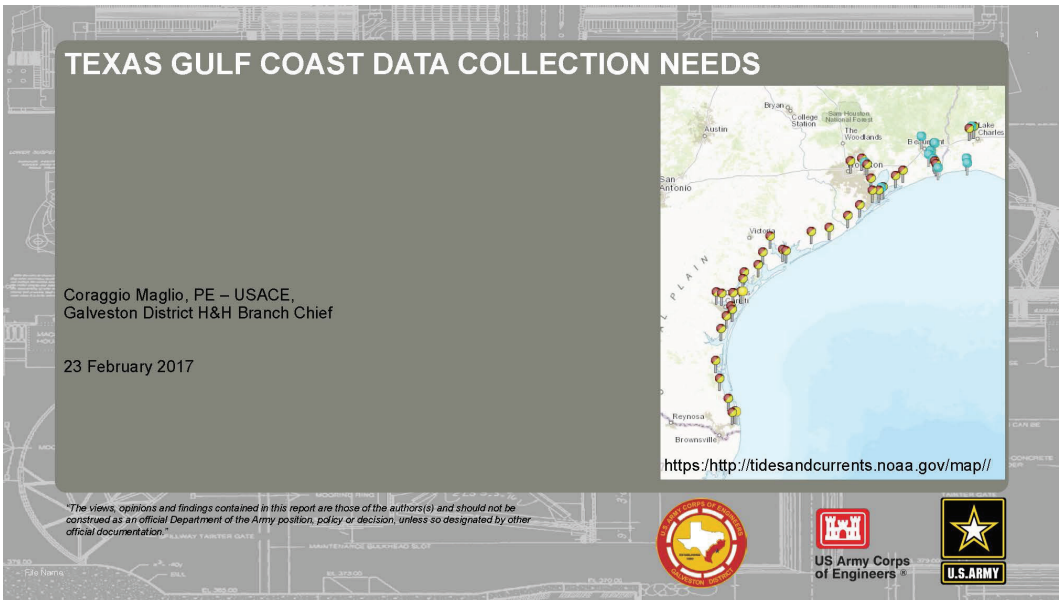
Images from: geology.com

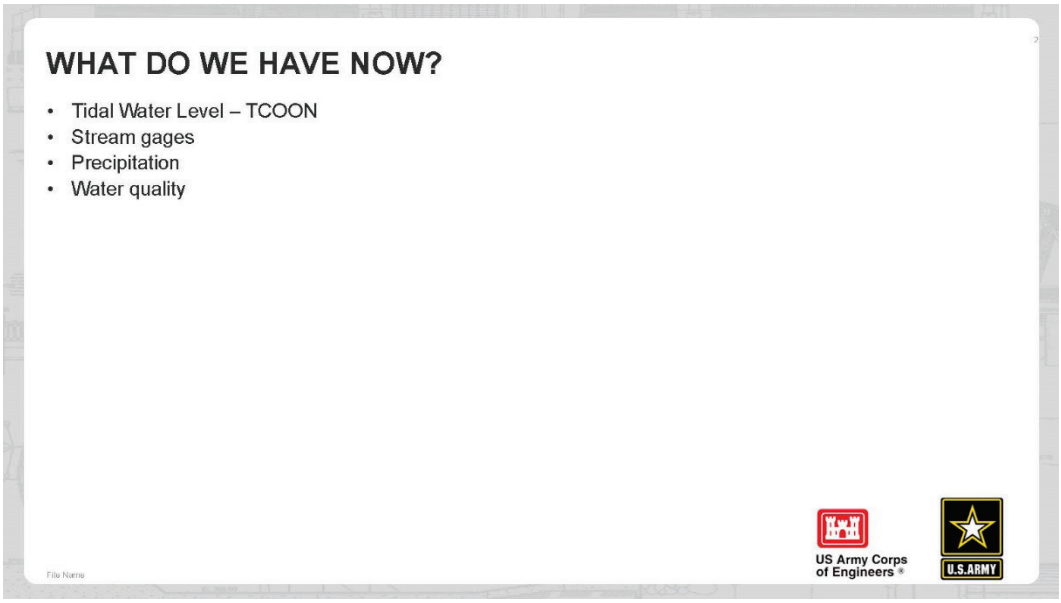

Reef Balls®
GALVESTON BAY
Reef Ball® Breakwater
LEVEE
MARSH CELL
Wave Attenuation
Mean Sea Level
BAY BOTTOM
Reef Ball®
Manual Assembly
Oyster Habitat
Images from: Reef Ball Foundation

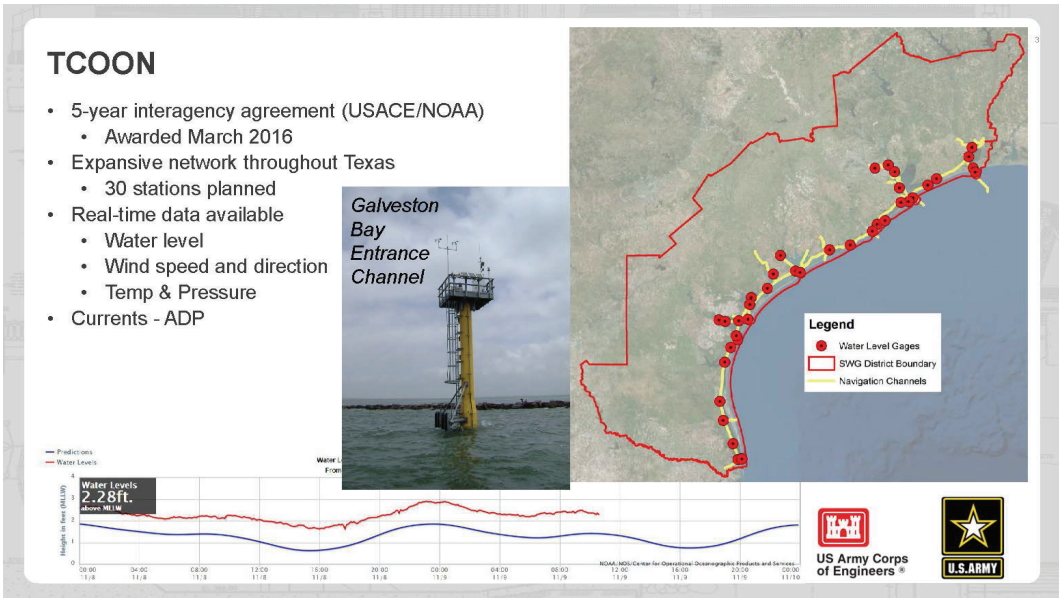

Oyster Castles®
GALVESTON BAY
Oyster Castle® Breakwater
LEVEE
MARSH CELL
Wave Attenuation
Mean Sea Level
BAY BOTTOM
Oyster Castle® Blocks
Manual Assembly
Oyster Habitat
Images from: Allied Concrete Company
Charleston Post and Courier
Charleston Post and Courier


Oyster Boxes
GALVESTON BAY
Oyster Castle® Oyster Box
LEVEE
MARSH CELL
Wave Attenuation
Mean Sea Level
BAY BOTTOM
Build Oyster Boxes with Oyster Castles®
Fill Oyster Boxes with Substrate Material
Oyster Habitat
Images from: Allied Concrete Company
geology.com
Charleston Post and Courier

SWG Data Needs






TCOON
5-year interagency agreement (USACE/NOAA)
Awarded March 2016
Expansive network throughout Texas
30 stations planned
Real-time data available
Water level
Wind speed and direction
Temp & Pressure
Currents - ADP
Galveston Bay Entrance Channel
Legend
Water Level Gages
SWG District Boundary
Navigation Channels
Predictions
Water Levels
Water Levels
2.28ft.
above MLLW
US Army Corps of Engineers
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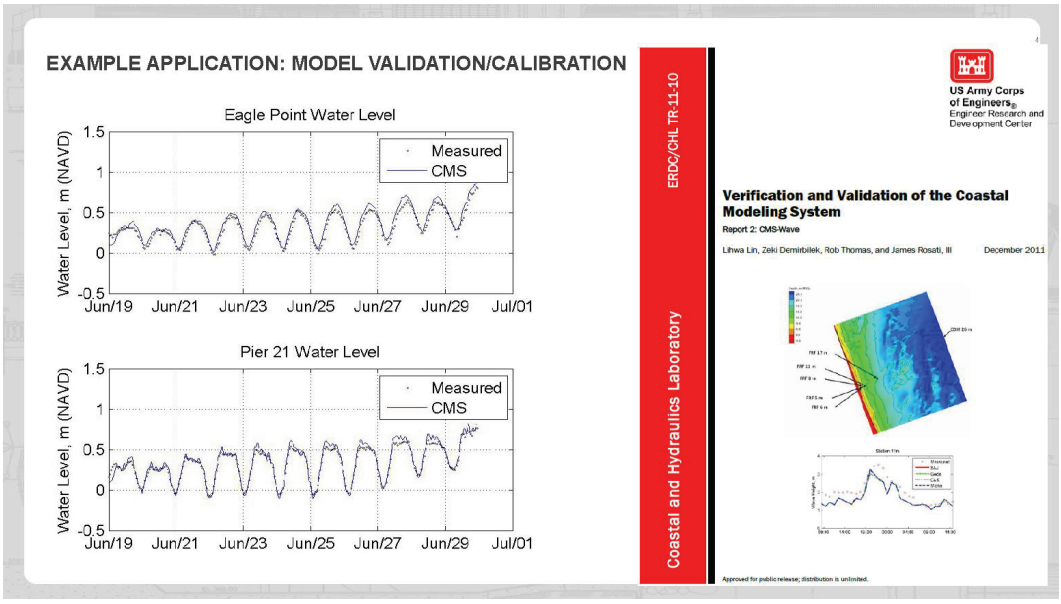
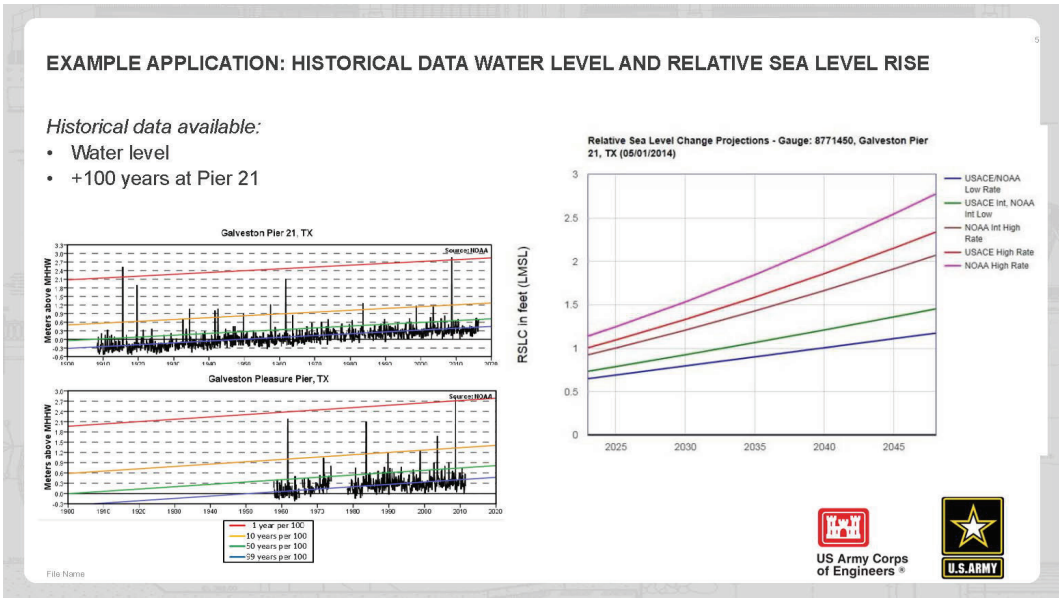
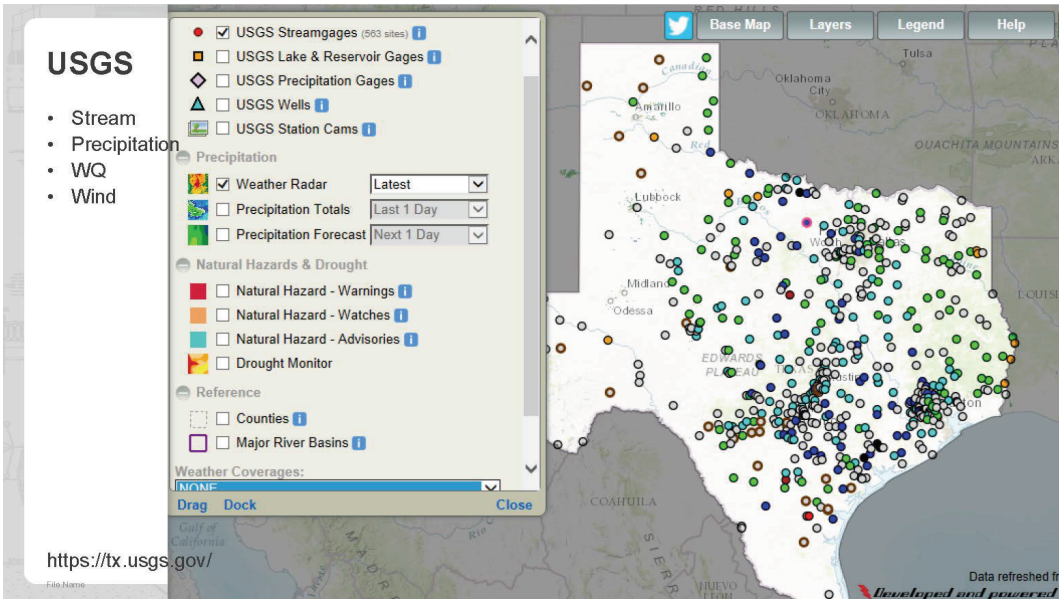

EXAMPLE APPLICATION: MODEL VALIDATION/CALIBRATION
Eagle Point Water Level
Measured
CMS
Water Level, m (NAVD)
1.5
1
0.5
0
-0.5
Jun/19
Jun/21
Jun/23
Jun/25
Jun/27
Jun/29
Jul/01
Pier 21 Water Level
Measured
CMS
Water Level, m (NAVD)
ERDC/CHL TR-11-10
Coastal and Hydraulics Laboratory
US Army Corps of Engineers
Engineer Research and Development Center
Verification and Validation of the Coastal Modeling System
Report 2: CMS-Wave
Lihwa Lin, Zeki Demirbilek, Rob Thomas, and James Rosati, III
December 2011
Approved for public release; distribution is unlimited.

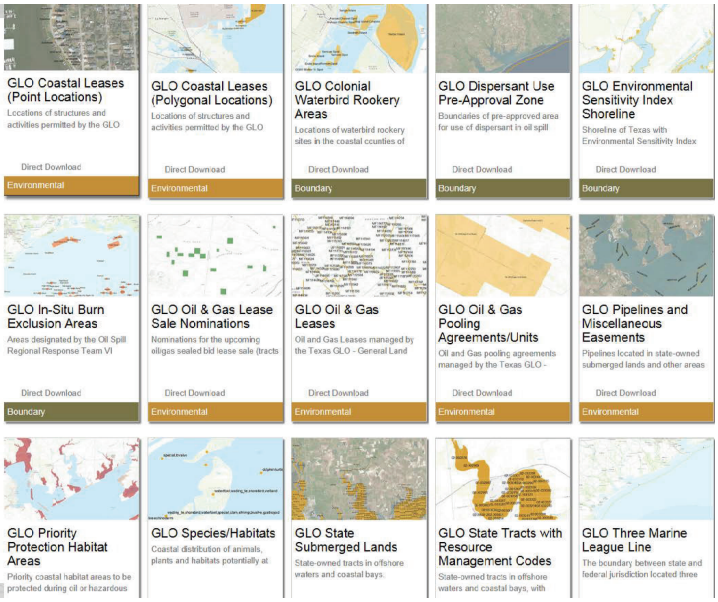

EXAMPLE APPLICATION: HISTORICAL DATA WATER LEVEL AND RELATIVE SEA LEVEL RISE
Historical data available:
• Water level
• +100 years at Pier 21
Galveston Pier 21, TX
Galveston Pleasure Pier, TX
Meters above MHHW
1 year per 100
10 years per 100
50 years per 100
99 years per 100
Relative Sea Level Change Projections - Gauge: 8771450, Galveston Pier 21, TX (05/01/2014)
RSLC in feet (LMSL)
USACE/NOAA Low Rate
USACE Int, NOAA Int Low
NOAA Int High Rate
USACE High Rate
NOAA High Rate
US Army Corps of Engineers
U.S.ARMY
File Name


USGS
• Stream
• Precipitation
• WQ
• Wind
https://tx.usgs.gov/
USGS Streamgages (563 sites)
USGS Lake & Reservoir Gages
USGS Precipitation Gages
USGS Wells
USGS Station Cams
Precipitation
Weather Radar
Latest
Precipitation Totals
Last 1 Day
Precipitation Forecast
Next 1 Day
Natural Hazards & Drought
Natural Hazard - Warnings
Natural Hazard - Watches
Natural Hazard - Advisories
Drought Monitor
Reference
Counties
Major River Basins
Weather Coverages:
NONE
Drag
Dock
Close
Base Map
Layers
Legend
Help
Tulsa
Oklahoma City
OKLAHOMA
Amarillo
Lubbock
Midland
Odessa
EDWARDS PLATEAU
COAHUILA
Data refreshed fr
Developed and powered

TNRIS

- Bathymetry
- LiDAR
- Imagery
- Land Cover
- Hydrography
- Soils
- Geology
- Environmental

Texas Natural Resources Information System

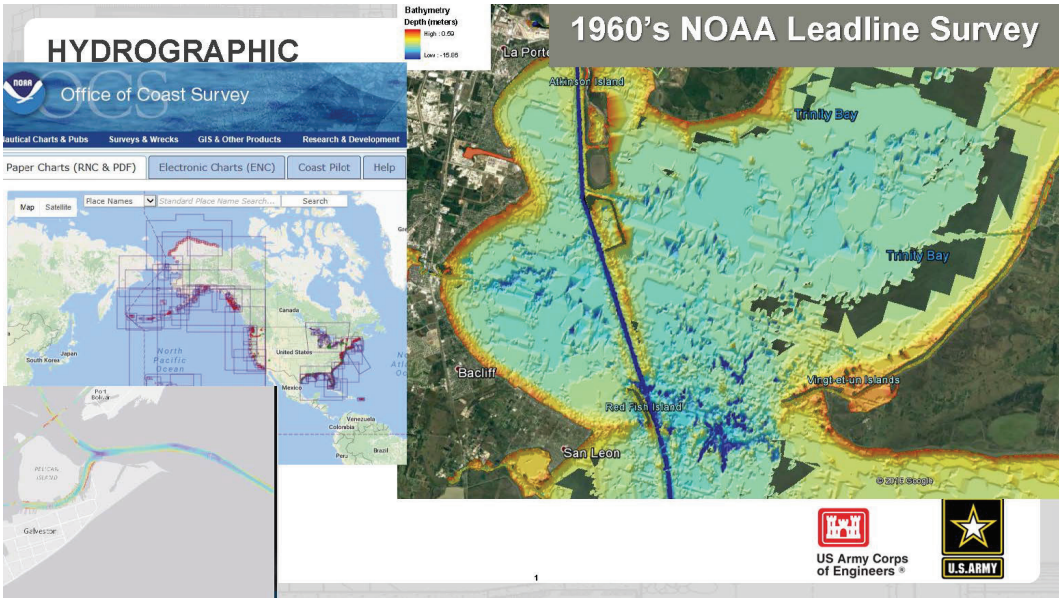


File Name

JABLTCX

- LiDAR – flights along the coast every 3 to 5 years
  - 10 cm vertical accuracy

https://tx.usgs.gov/


HYDROGRAPHIC
Office of Coast Survey
Nautical Charts & Pubs
Surveys & Wrecks
GIS & Other Products
Research & Development
Paper Charts (RNC & PDF)
Electronic Charts (ENC)
Coast Pilot
Help
Bathymetry
Depth (meters)
1960's NOAA Leadline Survey
Atkinson Island
Trinity Bay
Trinity Bay
Bacliff
Virginia Islands
Red Fish Island
San Leon
US Army Corps of Engineers
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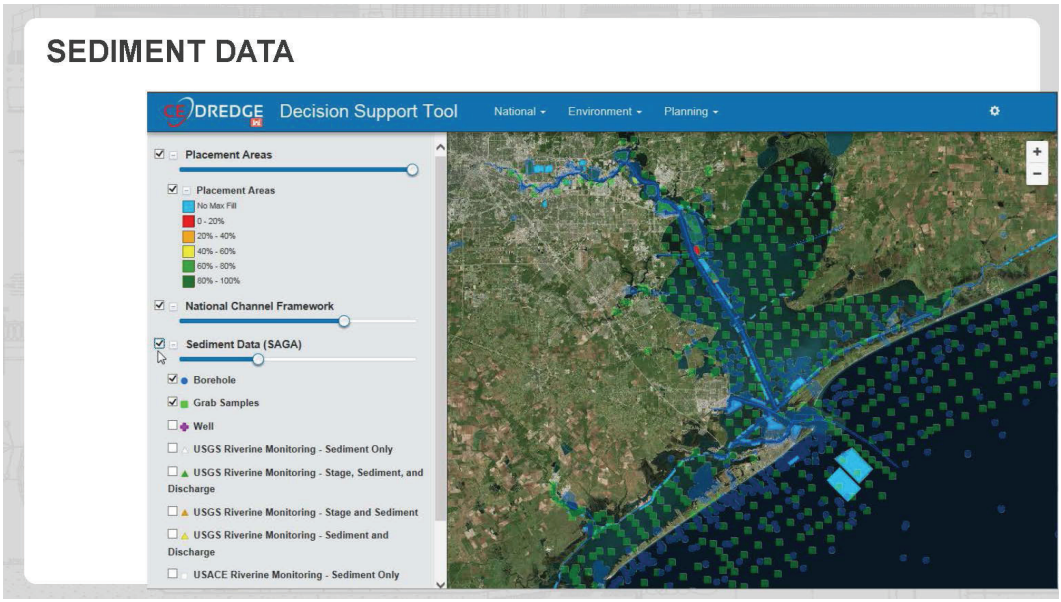
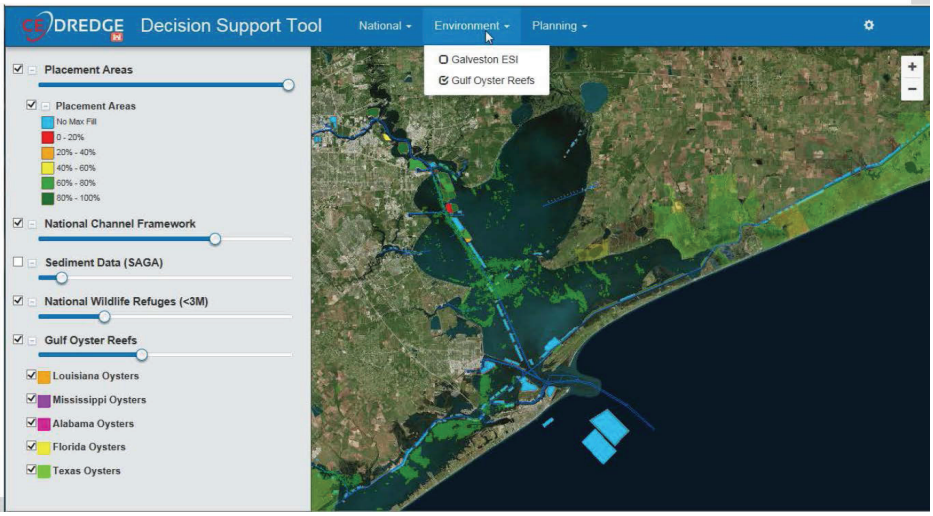
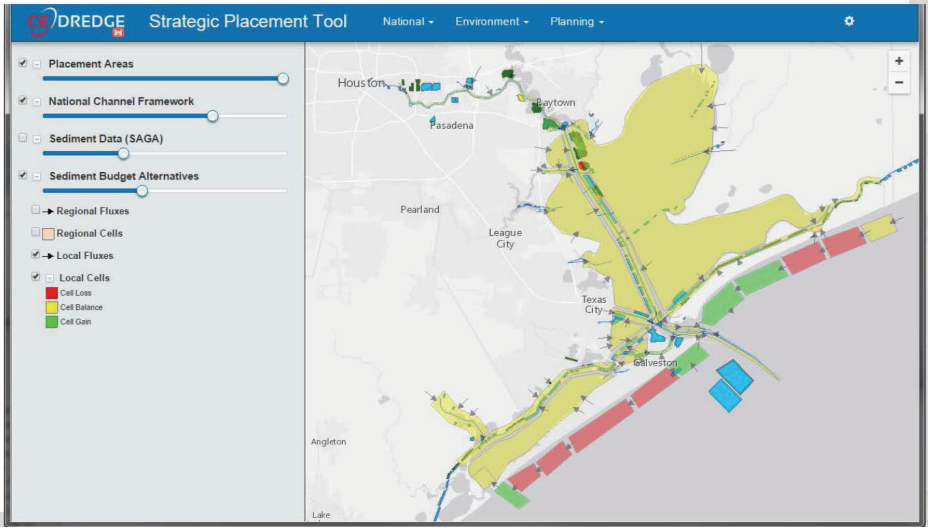

SEDIMENT DATA
DREDGE Decision Support Tool
National
Environment
Planning
Placement Areas
Placement Areas
No Max Fill
0 - 20%
20% - 40%
40% - 60%
60% - 80%
80% - 100%
National Channel Framework
Sediment Data (SAGA)
Borehole
Grab Samples
Well
USGS Riverine Monitoring - Sediment Only
USGS Riverine Monitoring - Stage, Sediment, and Discharge
USGS Riverine Monitoring - Stage and Sediment
USGS Riverine Monitoring - Sediment and Discharge
USACE Riverine Monitoring - Sediment Only

ENVIRONMENTAL LAYERS



SEDIMENT BUDGETS



WHAT DO WE WANT?

- Water Level
  - Relative sea level rise response
    - Ecological
    - Geomorphic
- Sediment Budgets
  - Riverine sediment budgets – bedload and suspended load long-term measurements - USGS
  - Long and cross shore transport rate measurements
- Ecological
  - SAV or oyster frequent mapping
  - Vegetation species evolution
  - Density and diversity
  - Water quality
- Improved precipitation forecast accuracy
- Improved remote sensing technologies
- Data-Hub – geospatial and metadata searchable
- All of this will improve our models and decisions

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WHAT ARE WE DOING TO GET THERE?

- Meeting with you!
- CESC
- EwN proving ground
- CESU - In-Situ Measurements of Physical Forces and Biological Parameters in Coastal and Estuarine Systems, Galveston District
- Hiring well… maybe??

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Appendix V: Breakout Group Listing of Participants

USACE and NOAA-NOS Collaboration Workshop on Natural and Nature-Based Features (NNBF)

USACE Galveston District
February 23, 2017

BREAKOUT GROUPS

Team 1 Room 175

1	Todd Bridges*	USACE-ERDC	Environmental Lab ST; Dredging, Engineering With Nature
2	Edmond Russo	USACE-SWG	Deputy District Engineer; Programs and Project Management
3	Steve Thur	NOAA-NOS-NCCOS	NCCOS Acting Director
4	Jeff Payne	NOAA-NOS-OCM	OCM Director; Ecosystem Services

Team 2 Room 225

1	Jeff King*	USACE-ERDC-EL	Engineering With Nature; Environmental Engineering; USACE Regulatory; Ecosystem Restoration
2	Jenny Davis	NOAA-NOS-NCCOS	Coastal Wetland Ecology; Natural and Nature Based Infrastructure
3	Seth Jones	USACE-SWG	Operations Management
4	Jamie Schubert	NOAA-NMFS-OHC-RC	Coastal Ecology; Coastal Restoration
5	Thomas White	USACE-SWG	Coastal Engineering
6	Sharon Tirpak	USACE-SWG	Project Management
7	Sena Agbley	USACE-SWG	Hydraulics and Hydrology

Team 3 Room 120

1	Michelle Harmon*	NOAA-NOS-NCCOS	Team Lead for Climate Resilience/Climate Vulnerability; Coastal Ecology/Program Planning
2	Kim Penn	NOAA-NOS-OCM	Coastal Management and Policy; climate adaptation; Natur al and Nature-Based Infrastructure
3	Todd Swannack	USACE-ERDC-EL	Ecological Modeling; Natural and Nature-Based Features
4	Eddie Irigoyen	USACE-SWG	Project Manager
5	Paul Hamilton	USACE-SWG	Geomorphology
6	Tricia Campbell	USACE-SWG	Operations Management
7	David Solomon	USACE-SWG	Construction Management

Team 4 Room 180

1	Elaine Vaudreuil*	NOAA-NOS-OCM	Coastal Management, Natural and Nature-Based Infrastructure; Coastal Land Conservation
2	Rob Thomas	USACE-SWG	Chief of Engineering and Construction Division
3	David Kidwell	NOAA-NOS-NCCOS	Coastal Ecology; Sea-Level Rise Modeling; Natural and Nature-Based Features
4	Tosin Sekoni	USACE-ERDC-EL	Plant Ecology
5	Kelly Burkes-Copes	USACE-SWF	Ecosystem Services
6	Coraggio Maglio	USACE-SWG	Design, Dredging and Coastal Engineering
7	Timothy Clarkin	USACE-SWG	Hydraulics and Hydrology

* Serves as facilitator and note taker for breakout group.

Appendix VI: Facilitator Workbook for Breakout Team 1

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Collaborative Opportunity/Discovery Exercise **NAME: Team 1**

Recall the Following:

Workshop Purpose: Explore and establish common interests for partnering on Natural and Nature-Based Features (NNBF) projects, which lead to the timely infusion of innovative technical products that support lifecycle coastal infrastructure systems, promote coastal preparedness and risk reduction, and enhance management decisions, in practice.

Workshop Objectives:

- Strengthen and broaden collaboration among represented organizations;
- Assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders/technical staff to identify opportunities to leverage each agency's investments and capabilities with respect to design, development, implementation, monitoring, adaptive management of NNBF and associated ecosystem services;
- ***Identify high-priority NNBF projects of common interest through use of plenary and breakout sessions. Categorize and prioritize projects that are identified for future collaboration; and***
- ***Identify other opportunities for crossover, working relationships in coastal science and engineering***

SWG is an EWN Proving Ground: EWN Program supports more sustainable practices, projects, and outcomes by working to *intentionally align natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes* (www.engineeringwithnature.org). EWN's focus on developing practical methods provides an achievable path toward an ecosystem approach to infrastructure development and operations. Four elements critical to the success of EWN Projects:

Advancing sound science and engineering to improve operational efficiency

Using natural systems and processes to maximize the benefits

Broadening the benefits of the project – social, environmental, economic

Using collaborative processes to engage stakeholders throughout the project

Collaboration Meeting February 23, 2017 Page 1

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Participants Identify NNBF Opportunities for Collaboration along Texas Coast

Today, you are learning more about the organizations that are represented and their associated missions, expertise, priorities and/or project inventories. Knowing what you do about NOAA-NOS, SWG, and ERDC, what are 3 possible NNBF-related opportunities along the Texas Coast that we should consider for future collaboration?

(1) Leveraging existing SWG projects is one approach to consider. However, creative ideas focused on innovative, "yet-to-be-seen" demo projects are highly encouraged. **We request at least one of each type (i.e., leverage existing project or new demo) be provided from each of the participants in a breakout group.** We also request that you describe your project ideas and how it captures the four, "EWN Elements of Success".

(2) When describing a project opportunity, **please include information that highlights the crossover/working relationships that will be needed in coastal science and/or engineering along the Texas Coast.** Crossover can be defined as, "a combination of two elements that makes something more appealing (n)," or "having two pieces that cross especially one over the other (adj)."

(3) What are the key steps required to initiate your project opportunity?

(4) What resources are required to initiate your project opportunity?

Each participant will use the three tables below to describe their project ideas. In turn, project ideas will be shared with others in the breakout group.

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Identify Opportunities
Specific Project Opportunity #1 - Name of Project:
Leverage Existing SWG Project or New Demo Project: Jefferson County clay core dune construction and shoreline restoration
(1) Description of opportunity: **Objective: Retard Coastal Resource Losses** **Strategy: Coordinate with project interests on existing project to characterize project NNBF performance in retarding shoreline retreat** **Intended Outcome: Publish best practices in EWN design, construction, and maintenance, Ecosystem Goods and Services (EGS) (e.g., beach access, recreation, eco-tourism), inform future USACE and non-federal interest (NFI) project development guidance via Wetlands Regulatory Assistance Program (WRAP)** **(2) Crossover/working relationships needed:** **Jefferson County (project owner, grantee)** **TX GLO (granting agency)** **Regulatory Agencies** **ERDC, SWG, NOAA (CSEC collaborators)** **(3) Key steps to initiate opportunity:** **Assign a PM and watch the magic happen!** **(4) Resources required:**

Specific Project Opportunity #2 – Name of Project:

Leverage Existing SWG Project or New Demo Project: South Padre Island (SPI) sand engine

(1) Description of opportunity:
Objective: Sustain Coastal Resources

Strategy: Coordinate with Regulatory Agencies to set conditions for industry use of SPI shoreline as "sand motor" dredged materials placement site with intent to characterize NNBF performance

Intended Outcome: Publish best practices in RSM engineering, design, construction, and maintenance, inform future USACE Brazos Island Harbor channel maintenance project dredged materials management practices, as may be modified by the Coastal Texas Protection and Restoration Mega Study

(2) Crossover/working relationships needed:

City of SPI (project owner)

LNG Plant Developers (project developer, sand source)

Regulatory Agencies

ERDC RSM Program Manager (potential consideration of RSM proposal)

ERDC, SWG, NOAA (CSEC collaborators)

(3) Key steps to initiate opportunity:

Assign a PM and watch the magic happen!

(4) Resources required:

Specific Project Opportunity #3 – Name of Project:

Leverage Existing SWG Project or New Demo Project: Galveston Bay Subaquatic Ecosystem Restoration

(1) Description of opportunity:
Objective: Restore Coastal Resources

Strategy: Coordinate with Regulatory Agencies to set conditions for industry use of degraded bay bottoms (historical oyster shell mining) as dredged materials placement sites (e.g., thin layer placement of new work clays and sands) for subaquatic ecosystem restoration (i.e., oyster bed cultch, sea grass beds, relief patterns for fisheries habitat) with intent to characterize NNBF performance

Intended Outcome: Publish technical guidance on EWN/RSM, design, construction, and maintenance, inform Galveston Bay Subaquatic Ecosystem Restoration Master Plan via the Planning Assistance to States (PAS) Program

(2) Crossover/working relationships needed:

Port of Houston Authority (Houston Ship Channel non-federal sponsor to USACE, potential PAS non-federal sponsor)

Petrochemical Industries (project developer, sediment source)

Regulatory Agencies

ERDC, SWG, NOAA (CSEC collaborators)

(3) Key steps to initiate opportunity:

Assign a PM and watch the magic happen!

(4) Resources required:

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Specific Project Opportunity #4 – Name of Project:

Leverage Existing SWG Project or New Demo Project: Matagorda Bay west foreshore island and wetland creation

(1) Description of opportunity:
Objective: Create/Sustain Coastal Resources

Strategy: Mine existing bay open water dredged materials placement areas for sand/shell to create features and relocate placement areas to west of channel to sustain created features (Continuing Authorities Program (CAP) Sec 1135) with intent to characterize NNBF performance

Intended Outcome: Publish best practices in EWN/RSM, design, construction, and maintenance, inform future USACE and NFI project development guidance

(2) Crossover/working relationships needed:

Calhoun Port Authority (Matagorda Ship Channel non-federal sponsor, potential CAP project non-federal sponsor)

Bay shoreline community (stakeholders)

ERDC, SWG, NOAA (CSEC collaborators)

(3) Key steps to initiate opportunity:

Assign a PM and watch the magic happen!

(4) Resources required:

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Specific Project Opportunity #5 – Name of Project:

Leverage Existing SWG Project or New Demo Project: Galveston Island beach and dune restoration

(1) Description of opportunity:
Objective: Improve Coastal Resources Resilience

Strategy: Coordinate with project owner and Regulatory Agencies to set conditions for creating variations on beach/dune restoration test sections with intent to characterize NNBF performance

Intended Outcome: Publish best practices in EWN/RSM engineering, design, construction, and maintenance, EGS outputs (e.g., beach access, recreation, eco-tourism), inform future USACE and NFI project development guidance

(2) Crossover/working relationships needed:

Galveston Parks Board (project owner, potential PAS or International and Interagency Support (IIS) Program project sponsor to USACE for involvement)

TAMU OCEN (grantee)

NOAA? GLO? (granting agency)

ERDC, SWG, NOAA (CSEC collaborators)

(3) Key steps to initiate opportunity:

Assign a PM and watch the magic happen!

(4) Resources required:

Facilitated Discussion: NNBF Project Opportunities along the Texas Coast

- Group members go around the table and describe their 3 ideas for NNBF collaboration. Each participant will then be asked to rank their three opportunities: High, Medium, or Low and provide a rationale. Keep going around the table until you have elicited information from all participants. **All of the opportunities (and workbooks) will be collected and included in the Workshop Report.**
- Define the timeframe for the high-ranked opportunities (i.e., Immediate: now -3 years; Short Term: 3-5 years; Long-Term: 5-10 years). **For High Ranked Opportunities: Seek group concurrence on the timeframe and identify key steps for initiating project.**
- **For High Ranked Opportunities**: Identify individuals within the group that would like to serve as POCs, have an interest in refining the idea, and/or developing a preliminary project scope. Record the names of interested participants (At least one POC from USACE and NOAA).

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

Appendix VII: Facilitator Workbook for Breakout Team 2

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Collaborative Opportunity Discovery Exercise **NAME:**_____

Recall the Following:

Workshop Purpose: Explore and establish common interests for partnering on Natural and Nature-Based Features (NNBF) projects, which lead to the timely infusion of innovative technical products that support lifecycle coastal infrastructure systems, promote coastal preparedness and risk reduction, and enhance management decisions, in practice.

Workshop Objectives:

- Strengthen and broaden collaboration among represented organizations;
- Assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders/technical staff to identify opportunities to leverage each agency's investments and capabilities with respect to design, development, implementation, monitoring, adaptive management of NNBF and associated ecosystem services;
- ***Identify high-priority NNBF projects of common interest through use of plenary and breakout sessions. Categorize and prioritize projects that are identified for future collaboration; and***
- ***Identify other opportunities for crossover, working relationships in coastal science and engineering***

SWG is an EWN Proving Ground: EWN Program supports more sustainable practices, projects, and outcomes by working to *intentionally align natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes* (www.engineeringwithnature.org). EWN's focus on developing practical methods provides an achievable path toward an ecosystem approach to infrastructure development and operations. Four elements critical to the success of EWN Projects:

Advancing sound science and engineering to improve operational efficiency

Using natural systems and processes to maximize the benefits

Broadening the benefits of the project – social, environmental, economic

Using collaborative processes to engage stakeholders throughout the project

Collaboration Meeting February 23, 2017 Page 1

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Participants Identify NNBF Opportunities for Collaboration along Texas Coast

Today, you are learning more about the organizations that are represented and their associated missions, expertise, priorities and/or project inventories. Knowing what you do about NOAA-NOS, SWG, and ERDC, what are 3 possible NNBF-related opportunities along the Texas Coast that we should consider for future collaboration?

(1) Leveraging existing SWG projects is one approach to consider. However, creative ideas focused on innovative, "yet-to-be-seen" demo projects are highly encouraged. **We request at least one of each type (i.e., leverage existing project or new demo) be provided from each of the participants in a breakout group.** We also request that you describe your project ideas and how it captures the four, "EWN Elements of Success".

(2) When describing a project opportunity, **please include information that highlights the crossover/working relationships that will be needed in coastal science and/or engineering along the Texas Coast.** Crossover can be defined as, "a combination of two elements that makes something more appealing (n)," or "having two pieces that cross especially one over the other (adj)."

(3) What are the key steps required to initiate your project opportunity?

(4) What resources are required to initiate your project opportunity?

Each participant will use the three tables below to describe their project ideas. In turn, project ideas will be shared with others in the breakout group.

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Identify Opportunities

Specific Project Opportunity #1 - Name of Project: CSEC Collaboration Integration of NOAA

Leverage Existing SWG Project or New Demo Project:

(1) Description of opportunity: CSEC model already exists along TX coasts. Opportunity to integrate NOAA-NOS into the SWG, ERDC, TAMU, USGS, TGLO Network. Use this collaborative framework with all expertise to target the larger initiatives identified by the group.

(2) Crossover/working relationships needed: Crossover relationships already exist in this collaborative model.

(3) Key steps to initiate opportunity: Build upon existing relationship/partnering initiatives. Have NOAA-NOS participate in the next CSEC meeting.

(4) Resources required: Initially, would require NOAA-NOS personnel time and travel dollars to link into existing resources that bring together collaborative team. Future projects would be derived based on smaller working groups.

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Identify Opportunities

Specific Project Opportunity #2 – Name of Project: Living Breakwaters Study

Leverage Existing SWG Project or New Demo Project:

(1) Description of opportunity: SWG is preparing to develop a protective structure for disposal facilities, which would include a variety of living breakwaters measures. Oyster castles, reef balls, rock, etc. Need to better understand the health/productivity of such a system. What approaches work best; what is the best design approach; long-term monitoring, Determine what if any mitigation credits can be gleaned from such work?

(2) Crossover/working relationships needed: SWG and ERDC bring engineering and design concepts. Also can model/study the protective/engineering benefits associated with such a system. NOAA-NOS can study ecosystem associated science needs. Also, mapping interest and growth/productivity associated with oysters, fish populations, habitat, productivity, etc.

(3) Key steps to initiate opportunity: Continued dialogue and exchange of information. Integrate NOAA-NOS staff into project design phase. ERDC develops SON to obtain RD funds for match in pursuit of this work. NOAA-NCCOS includes this project in discretionary process to include long term monitoring and associated research.

(4) Resources required: R&D funding by ERDC and NOS; fed labor, travel, etc.

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Specific Project Opportunity #3 – Name of Project: DEEP Holes in Galveston Bay Project

Leverage Existing SWG Project or New Demo Project:

(1) Description of opportunity:

(2) Crossover/working relationships needed:

(3) Key steps to initiate opportunity:

(4) Resources required:

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Facilitated Discussion: NNBF Project Opportunities along the Texas Coast

- Group members go around the table and describe their 3 ideas for NNBF collaboration. Each participant will then be asked to rank their three opportunities: High, Medium, or Low and provide a rationale. Keep going around the table until you have elicited information from all participants. **All of the opportunities (and workbooks) will be collected and included in the Workshop Report.**

- Define the timeframe for the high-ranked opportunities (i.e., Immediate: now -3 years; Short Term: 3-5 years; Long-Term: 5-10 years). **For High Ranked Opportunities: Seek group concurrence on the timeframe and identify key steps for initiating project.**

- **For High Ranked Opportunities**: Identify individuals within the group that would like to serve as POCs, have an interest in refining the idea, and/or developing a preliminary project scope. Record the names of interested participants (At least one POC from USACE and NOAA).

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Justify Monetarily these Projects. Ecosystem Services Evaluations of the EWN and NNBF Projects	Existing Project	High	1-yr if requiring NCCOS Discretionary Funds	Jenny Davis

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Vegetation of the Mud Dikes; Siting tool to look at living shorelines. Where you need vegetation and where you need more; Apply and expand the existing tool to another system, which is applicable here. Transfer, expansion and replicability of existing tool.	Existing/New would align with existing vegetation studies on dikes	Medium	Requires a lot of data and running model ~ 1-year	Jenny Davis Tosin Sekoni; Jamie Schubert
Create breakwaters along GIWW; complete living shorelines behind breakwater. SWG and ERDC include design, construction and engineering benefits. NOAA-NOS provides ecosystem analysis, monitoring, etc. 8-12 miles online in next few years. 14 miles right now. Carbon accumulation rates in association with Ecosystem Services. Solution that is cost effective and still supports living shoreline initiatives.	Existing Project	Low Jenny; High Seth	Ongoing now; some permitted and waiting for funding	Jenny Davis; Seth Jones
NOS Data Collection: Digital Coast Data; Identify Data Gaps between USACE and NOAA and then transfer of that data.	Existing Project/Study-Used within Existing Study	High	Immediate; Data already exist.	Sharon Tirpak

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Marsh Restoration/Eroded Shoreline and work that can help with design and possible consulting of this. Refer to maps that illustrate problem areas.	Existing Project	Medium	Once we have project identified, then help is needed By May 2018	Sharon Tirpak
Beach Restoration; Coast is sand starved, Does NOAA-NOS have this kind of information? Beach or dune restoration…must find sand and maintain it. How do you continue to maintain it. Development of dunes and how to design, study timeline for colonization with plants, biota, etc.	New Demo Project	Low	Done at anytime; Start after May 18 to coincide with Coastal Texas	Sharon Tirpak
Restoring GIWW barrier island; eroded and need to be reestablished and shoring up these areas. Use and protect navigation and design to produce more marsh and sea grasses; Example: West Galveston Bay – design can be done with O&M. GO BIG OR GO HOME!	Existing/New-hasn't been done yet.	High	Need actual design; ready to go within 6 months.	Seth Jones

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Aransas NWR BU sites Mission Aransas NERRs – Beneficial Use sites for whooping crane habitat area. Rip-rap breakwaters and marsh cells behind. Are there alternatives to rock in this location? Linking Beneficial Use and EWN with Mission Aransas NEERs – Linking USACE benefits. Started construction of 3 or 4 of them. This FY another 3 miles of breakwater. Look at engineering and ecosystem services function.	Existing/New Pilot Project	High	Ongoing ; build as we get funding	Seth Jones; Jamie Schubert
Thin-Layer Placement – How does that facilitate adaption to SLR? Does it improve marsh health? How often do you have to return to add additional sediment placement?	Existing	High	Ongoing work in this area;	Jamie Schubert; Seth Jones
CSEC Integration Teaming	Existing	Medium	Immediate	Jeff King
Living Breakwater Study	Existing	High	Another 1 year NCCOS Discretionary	Tom White, Tim Clarkin

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

Appendix VIII: Facilitator Workbook for Breakout Team 3

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Collaborative Opportunity Discovery Exercise **NAME: Team 3**

Recall the Following:

Workshop Purpose: Explore and establish common interests for partnering on Natural and Nature-Based Features (NNBF) projects, which lead to the timely infusion of innovative technical products that support lifecycle coastal infrastructure systems, promote coastal preparedness and risk reduction, and enhance management decisions, in practice.

Workshop Objectives:

- Strengthen and broaden collaboration among represented organizations;
- Assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders/technical staff to identify opportunities to leverage each agency's investments and capabilities with respect to design, development, implementation, monitoring, adaptive management of NNBF and associated ecosystem services;
- ***Identify high-priority NNBF projects of common interest through use of plenary and breakout sessions. Categorize and prioritize projects that are identified for future collaboration; and***
- ***Identify other opportunities for crossover, working relationships in coastal science and engineering***

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USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Participants Identify NNBF Opportunities for Collaboration along Texas Coast

Today, you are learning more about the organizations that are represented and their associated missions, expertise, priorities and/or project inventories. Knowing what you do about NOAA-NOS, SWG, and ERDC, what are 3 possible NNBF-related opportunities along the Texas Coast that we should consider for future collaboration?

(1) Leveraging existing SWG projects is one approach to consider. However, creative ideas focused on innovative, "yet-to-be-seen" demo projects are highly encouraged. **We request at least one of each type (i.e., leverage existing project or new demo) be provided from each of the participants in a breakout group.** We also request that you describe your project ideas and how it captures the four, "EWN Elements of Success".

(2) When describing a project opportunity, **please include information that highlights the crossover/working relationships that will be needed in coastal science and/or engineering along the Texas Coast.** Crossover can be defined as, "a combination of two elements that makes something more appealing (n)," or "having two pieces that cross especially one over the other (adj)."

(3) What are the key steps required to initiate your project opportunity?

(4) What resources are required to initiate your project opportunity?

Each participant will use the three tables below to describe their project ideas. In turn, project ideas will be shared with others in the breakout group.

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Identify Opportunities
Specific Project Opportunity #1 - Name of Project:
Leverage Existing SWG Project or New Demo Project:
(1) Description of opportunity:
(2) Crossover/working relationships needed:
(3) Key steps to initiate opportunity:
(4) Resources required:

Specific Project Opportunity #2 – Name of Project:
Leverage Existing SWG Project or New Demo Project:
(1) Description of opportunity: **(2) Crossover/working relationships needed:** **(3) Key steps to initiate opportunity:** **(4) Resources required:**

Specific Project Opportunity #3 – Name of Project:
Leverage Existing SWG Project or New Demo Project:
(1) Description of opportunity: **(2) Crossover/working relationships needed:** **(3) Key steps to initiate opportunity:** **(4) Resources required:**

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Facilitated Discussion: NNBF Project Opportunities along the Texas Coast

- Group members go around the table and describe their 3 ideas for NNBF collaboration. Each participant will then be asked to rank their three opportunities: High, Medium, or Low and provide a rationale. Keep going around the table until you have elicited information from all participants. **All of the opportunities (and workbooks) will be collected and included in the Workshop Report.**

- Define the timeframe for the high-ranked opportunities (i.e., Immediate: now -3 years; Short Term: 3-5 years; Long-Term: 5-10 years). **For High Ranked Opportunities: Seek group concurrence on the timeframe and identify key steps for initiating project.**

- **For High Ranked Opportunities**: Identify individuals within the group that would like to serve as POCs, have an interest in refining the idea, and/or developing a preliminary project scope. Record the names of interested participants (At least one POC from USACE and NOAA).

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Coastal Texas – all three alternatives 1. Data collection 2. Develop guidance to approach restoration projects collectively in an area to better understand how choices interact with each other.	Existing	High	Immediate	Eddie, Michelle

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Shoreline restoration – what's the biggest bang for the buck? 1. How and when to place materials to get the highest return on investment.	Existing	High	Immediate	Eddie, Kidwell
Quantify the multiple benefits from a project. 1. Ecosystem services of shoreline and marsh restoration and oyster breakwater 2. Consider Mission Aransas NERR as a location	Both	Super High	short	Todd S., Kim
Jefferson County large scale shoreline and marsh restoration 1. Wave attenuation, storm surge reduction and ecosystem services	Existing	High	short	Paul, Kidwell

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Building another placement area near mid-bay. 1. Identification of a site that provides multiple benefits. Locate such that it attenuates waves.	new	Medium	Long term	David S., Michelle
Collaborations on the marsh evolution model 1. Workshop initially leading to longer term collaborations	new	High	immediate	Todd S., Kidwell
Sustainability and ecosystem services provided by hybrid approaches	new	medium	Short	Kelly, Kim
Engineered dunes – what's the performance and costs of these approaches. What are the best practices?	New	Medium	Short	Paul, Michelle

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors

Appendix VIV: Facilitator Workbook for Breakout Team 4

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Collaborative Opportunity Discovery Exercise **NAME: Team 4**

Recall the Following:

Workshop Purpose: Explore and establish common interests for partnering on Natural and Nature-Based Features (NNBF) projects, which lead to the timely infusion of innovative technical products that support lifecycle coastal infrastructure systems, promote coastal preparedness and risk reduction, and enhance management decisions, in practice.

Workshop Objectives:

- Strengthen and broaden collaboration among represented organizations;
- Assemble USACE-ERDC, USACE-SWG, and NOAA-NOS leaders/technical staff to identify opportunities to leverage each agency's investments and capabilities with respect to design, development, implementation, monitoring, adaptive management of NNBF and associated ecosystem services;
- ***Identify high-priority NNBF projects of common interest through use of plenary and breakout sessions. Categorize and prioritize projects that are identified for future collaboration; and***
- ***Identify other opportunities for crossover, working relationships in coastal science and engineering***

SWG is an EWN Proving Ground: EWN Program supports more sustainable practices, projects, and outcomes by working to *intentionally align natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes* (www.engineeringwithnature.org). EWN's focus on developing practical methods provides an achievable path toward an ecosystem approach to infrastructure development and operations. Four elements critical to the success of EWN Projects:

Advancing sound science and engineering to improve operational efficiency

Using natural systems and processes to maximize the benefits

Broadening the benefits of the project – social, environmental, economic

Using collaborative processes to engage stakeholders throughout the project

Collaboration Meeting February 23, 2017 Page 1

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Participants Identify NNBF Opportunities for Collaboration along Texas Coast

Today, you are learning more about the organizations that are represented and their associated missions, expertise, priorities and/or project inventories. Knowing what you do about NOAA-NOS, SWG, and ERDC, what are 3 possible NNBF-related opportunities along the Texas Coast that we should consider for future collaboration?

(1) Leveraging existing SWG projects is one approach to consider. However, creative ideas focused on innovative, "yet-to-be-seen" demo projects are highly encouraged. **We request at least one of each type (i.e., leverage existing project or new demo) be provided from each of the participants in a breakout group.** We also request that you describe your project ideas and how it captures the four, "EWN Elements of Success".

(2) When describing a project opportunity, **please include information that highlights the crossover/working relationships that will be needed in coastal science and/or engineering along the Texas Coast.** Crossover can be defined as, "a combination of two elements that makes something more appealing (n)," or "having two pieces that cross especially one over the other (adj)."

(3) What are the key steps required to initiate your project opportunity?

(4) What resources are required to initiate your project opportunity?

Each participant will use the three tables below to describe their project ideas. In turn, project ideas will be shared with others in the breakout group.

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Identify Opportunities
Specific Project Opportunity #1 - Name of Project:
Leverage Existing SWG Project or New Demo Project:
(1) Description of opportunity:
(2) Crossover/working relationships needed:
(3) Key steps to initiate opportunity:
(4) Resources required:

Specific Project Opportunity #2 – Name of Project:

Leverage Existing SWG Project or New Demo Project:

(1) Description of opportunity:

(2) Crossover/working relationships needed:

(3) Key steps to initiate opportunity:

(4) Resources required:

Specific Project Opportunity #3 – Name of Project:

Leverage Existing SWG Project or New Demo Project:

(1) Description of opportunity:

(2) Crossover/working relationships needed:

(3) Key steps to initiate opportunity:

(4) Resources required:

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Facilitated Discussion: NNBF Project Opportunities along the Texas Coast

- Group members go around the table and describe their 3 ideas for NNBF collaboration. Each participant will then be asked to rank their three opportunities: High, Medium, or Low and provide a rationale. Keep going around the table until you have elicited information from all participants. **All of the opportunities (and workbooks) will be collected and included in the Workshop Report.**

- Define the timeframe for the high-ranked opportunities (i.e., Immediate: now -3 years; Short Term: 3-5 years; Long-Term: 5-10 years). **For High Ranked Opportunities: Seek group concurrence on the timeframe and identify key steps for initiating project.**

- **For High Ranked Opportunities**: Identify individuals within the group that would like to serve as POCs, have an interest in refining the idea, and/or developing a preliminary project scope. Record the names of interested participants (At least one POC from USACE and NOAA).

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project (including needed resources)	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Monetizing goods and services – USACE can't do it, but they'd be happy to use it or review if we do this work. USACE could use CSEC to help bring $ to this – they need it and partners need it but they can't do it. (And recreational benefits) Expand existing project in Northern Gulf of Mexico	New			David K /Steve Thur (NOAA) Jenny (USACE)
Modeling to support prioritization of restoration / right-sizing culverts / road crossings to reduce flooding – USACE can't pay to "fix" it --- could the Corps help with the modeling (esp where stream & tidal/surge meet) and then seek other sources to pay for the restoration – NWS Water Center				
Data needs – Do they do LiDAR data corrections in marshes to improve DEMs in shallow habitats – apply correction techniques for vegetation (correction factors) that have been done in other places. Current correction techniques don't work well in marshes Also, would like automatic extraction of shoreline from LIDAR for marshes	New – fairly low cost or scaled up depending on amount of field validation desired	Would be very helpful, but medium / low – or have USACE ask Jabaltek to do that		David Kidwell, Chris and Jennifer Wozencraft (USACE / Jabaltek) David & NGS for NOAA

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project (including needed resources)	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Create a tool that can pull into to evaluate engineering alternatives – develop the framework – ID the structure and skelton, which drives where you go to fill in modeling or data acquisition.				
Ecological modeling that builds in interdisciplinary approaches – look at one or suite of modeling platforms to see if they can look at multiple benefits – Ecological forecasting models that could be applied – HABs, water quality, etc. that shift from R&D to operations Build and/or validate models that can be used as indictors of success (meaningful algorithms) – models for the whole coast	USACE would consider this a high need			
Design standards - - including fragility and damage curves that engineers can use.	USACE could do this for the Texas coast – would need to be adopted by Corps District			Kelly? Rob? (USACE) OCM (reach out to GLO) to help get buy-in among folks who would use it

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project (including needed resources)	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Flood Risk Management Project – Buffalo Bayou – channel that was never improved, doesn't have capacity to carry water it needs to and is constantly eroding. There are things that can be used to improve it – now nature, could incorporate nature-based features (e.g. utilization of wood debris for shoreline protection- - having a way to naturally arm shorelines as release rates increase – channel slumping b/c of quick water flows. Reservoirs do a good job of managing waters – USAC needs to release more w/out impacting the local communities (aka flooding them or causing erosion to their properties Help with modeling or communicating what a community can do to help address stormwater	Existing –have authorization to study it but don't have $ -- this would be a new solution tnat they haven't looked at to addressing an existing issue	Project is high – this task might be medium – need to figure out the mechanism Educatoin / pubic outreach, community buy-in : collaboration opportunity	Would need research done n different options within a year LID option could be any day	Coraggio Maglio OCM – TBD (Elaine)

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project (including needed resources)	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
Beneficial Re-use – If we had locations and optimization tool to target/match re-use sites to dredge sources – to do NEPA in advance -- efficiency. They have a tool for the Houston ship channel – would like to expand it to other places. Ecological side is missing the most info – models don't match well to what's available from USFSW – something more vegetative (e.g. Marsh model with fewer variables (e.g. LIDAR or things that could be collected regularly to screen) – connections to Fisheries modeling (for subtidal) or IEAs?				Kelly (USACE) and David Kidwell (NOAA)
Dune / Beach re-nourishment project – Coastal Ecosystem Restoration – Jefferson County Muddy Sand Motor Also, look at jetties to see if they're obstructing sediment flow and if so, figure out how to pump past groins (effectiveness of sand motors / bypass techniques)				

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project (including needed resources)	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
GIWW Erosion Problem – 750 miles of channel (1,500 miles of shoreline). Would be nice to find less expensive alternative to breakwaters to control erosion from barge wakes. Need to ID and study different options that could be used.	Existing – have continuous $ --	High impact opportunity	Any time	Rob Thomas and Tim
Oyster restoration in Galveston Bay – population is reduced by 90% - impact of shipping and Hurricane Ike – restoring the species while also providing resilience benefits -- Potential connections / lessons learned from Choptank River HFA work? Ties in w/ work on oyster holes – shows historical evidence of role of oysters in Bay	New for USACE	High priority would be relating it to beneficial re-use (e.g. fetch wake and ship wave attenuation) to connect to USACE role		Tim
Forecasting coastal population growth – could you forecast what that translate into land use change based on C-CAP trends?				
Prioritizing and/or cost-share acquisition of high-rez C-CAP data?				

USACE/NOAA-NOS NNBF Workbook
Opportunity Discovery

Name of Project Opportunity; Key Steps to Initiate Project (including needed resources)	Existing Project or New Demo Project	High (H), Medium (M), or Low (L) Priority-Reason for Priority	Estimated Timeframe	POCs and Interested Contributors
-				

- Mix of opportunities that reflect mix of business lines and TX coast geographies

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*
March 2017

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Proceedings from the U.S. Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) – Engineering With Nature Workshop

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Todd S. Bridges, Jeff K. King, Cynthia J. Banks, Cathy Tortorici, Mark Murray-Brown, and Daniel Marrone

5d. PROJECT NUMBER

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)
USACEHQ

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
N/A

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

.

15. SUBJECT TERMS
Environmental engineering – Congresses
Sustainable engineering – Congresses
Interagency coordination – United States

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Dr. Todd S. Bridges
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR		601-634-3626

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18