Impacts of Extreme Events on Marine Transportation Infrastructure:

A U.S. Army Corps of Engineers Perspective

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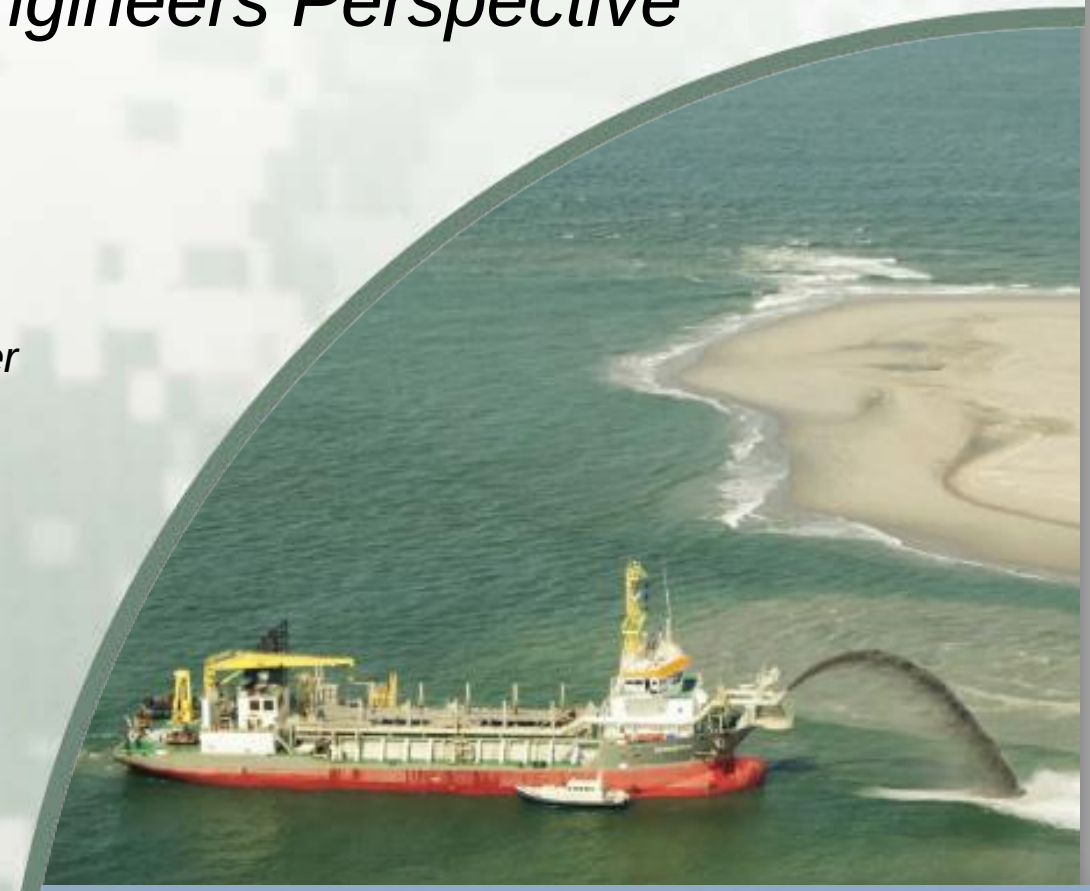


Marine Transportation Board
7 November 2017

USACE Mission

To provide vital public engineering services in peace time and war to strengthen our Nation's security, energize the economy, and reduce risk from disaster

NACCS Modeling & Statistics

Efficient Storm Sampling

Characterization of Storm Climate (Forcing)

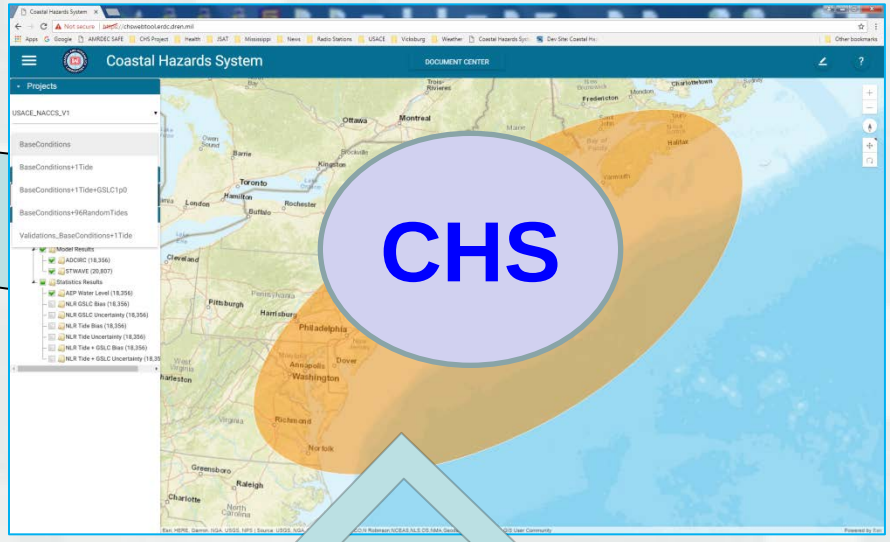
StormSim

Tropical Cyclones (Synthetic)

Extratropical Cyclones (Historical)

Development of JPM Storm Set

Development of Composite Storm Set



Climate and Hydro Modeling

PBL Cyclone Model (Wind and Pressure Fields)

WAM (Regional)

ADCIRC

Coupler

STWAVE (Nearshore)

- Water level (storm surge, astronomical tide, SLC)
- Wind speed, direction, currents
- Wave height, period, direction

CSTORM

Response Statistics

Combined Joint Probability

Annual Exceedance Probability
Average Recurrence Interval
Confidence Levels

StormSim

USACE Missions & Scope of Studies

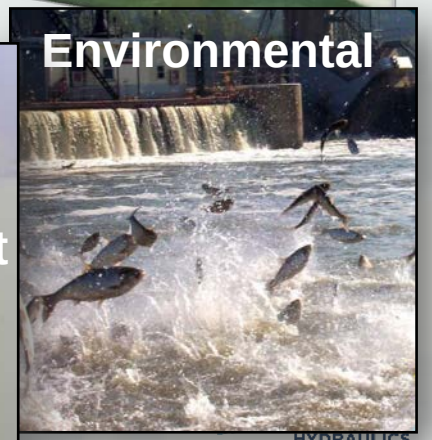
Maritime Activities Involve Three USACE Missions:
Navigation, Environmental, and Flood Risk Management

- *25,000 miles of federally authorized inland and coastal navigation channels*
- *200 Mill cu yd/year of dredged sediments*
- *926 coastal, Great Lakes and inland harbors*
- *30,000s+ acres wetlands restored* annually*

**Or created, enhanced, preserved*

Scope of Maritime Studies:

- Planning – 3x3x3 - Rapid; 2-18 mos
- Engineering Design – Detailed & rigorous; multiple months to several years
- Operations & Maintenance
  - Dredging & placement
  - Rehabilitation of infrastructure
  - Scope of analyses varies



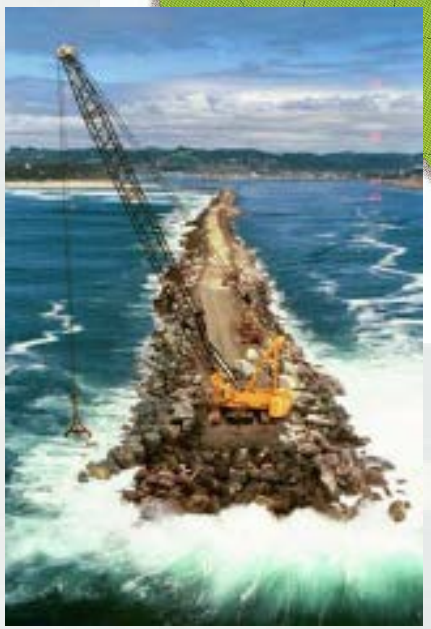
USACE Navigation Assets

COASTAL NAVIGATION

1067 Navigation Projects
19 lock chambers
13,000 miles of channels
929 navigation structures
844 bridges

INLAND NAVIGATION

27 Inland River Systems
207 lock chambers @ 171 lock sites
12,000 miles of inland river channels



Navigation RD&T Strategic Needs & Priorities

- **Extend the useful life** of existing navigation infrastructure
- Improve Navigation operations and **Multimodal Freight Flow** through systems optimization
- Optimize design & management of **resilient navigation systems**
- Develop and Deploy **eNavigation** capabilities

Cross-cutting:

- *Provide tools to enhance ecosystems, processes, benefits & services*
- *Collaborate & leverage via multidisciplinary teams*
- *Deliver sound engineering & scientific solutions that meet Planning Modernization guidelines*

Navigation Initiatives & Challenges

Infrastructure RD&T

USBR

Innovative Materials

Infrastructure

Remote Ops

UAS Infrastructure Assessments

Structural Health Monitoring

Regional Sediment Management

Travel Times

Engineering With Nature

Systems

Systems Optimization

SWG Regional Partnerships

Nav-DIF

Marine Transportation System

AIS & AISAP

River Information Services

Nearshore Placement

USACE Leadership

DOT

PIANC

Nearshore Processes Research

ASBPA

CMTS

NAS/ TRB

How do extreme weather, storm surge, and sea level rise with associated flooding effect USACE's mission?

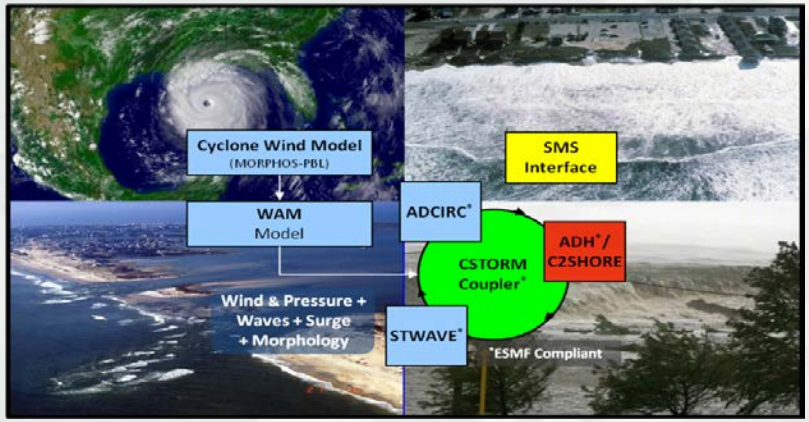
IMPACTS/CHALLENGES

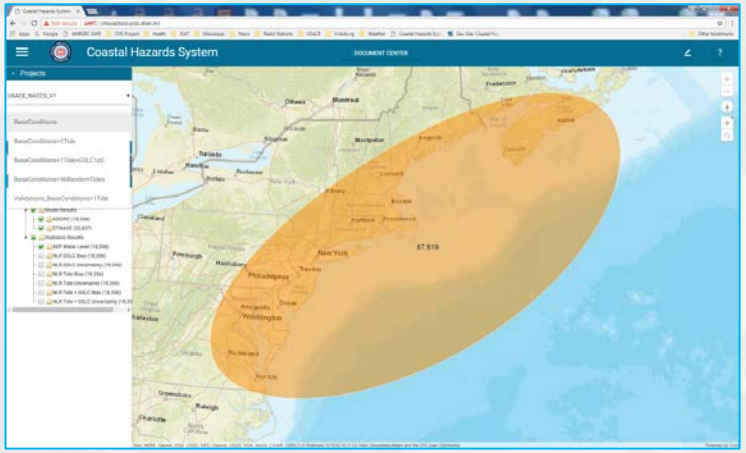
- Our systems are aging/stressed so increased storms:
  - Adds MORE stress to a stressed system
  - Increases sedimentation
  - Increases dredging
  - Where do we PLACE the dredged sediment in a sustainable way?
- Aging infrastructure – more damage from extreme events
  - Navigation issues
- USACE Districts must incorporate SLR into study plans

How do extreme weather, storm surge, and sea level rise with associated flooding effect USACE's mission?

MEASURES for REDUCING RISK/INCREASING SUSTAINABILITY

- Better probabilistic/statistical estimates of inundation
- Reduction in uncertainty
  - NACCS Study
    - High fidelity Modeling
    - JPM-OS Statistical Analysis
    - 1000s of Simulations
    - Incorporating into Coastal Hazards System for rapid [illegible] future events

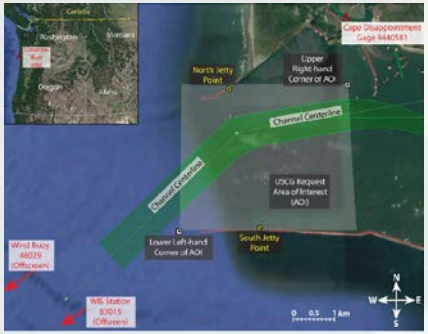


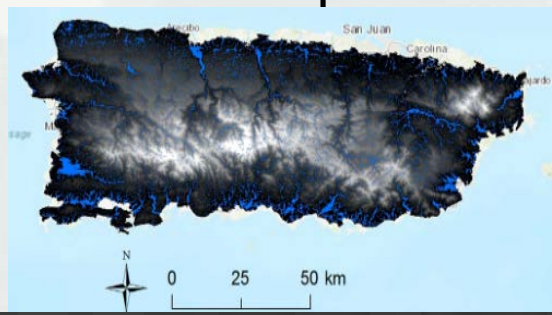


How do extreme weather, storm surge, and sea level rise with associated flooding effect USACE's mission?

UNMET R&D Needs

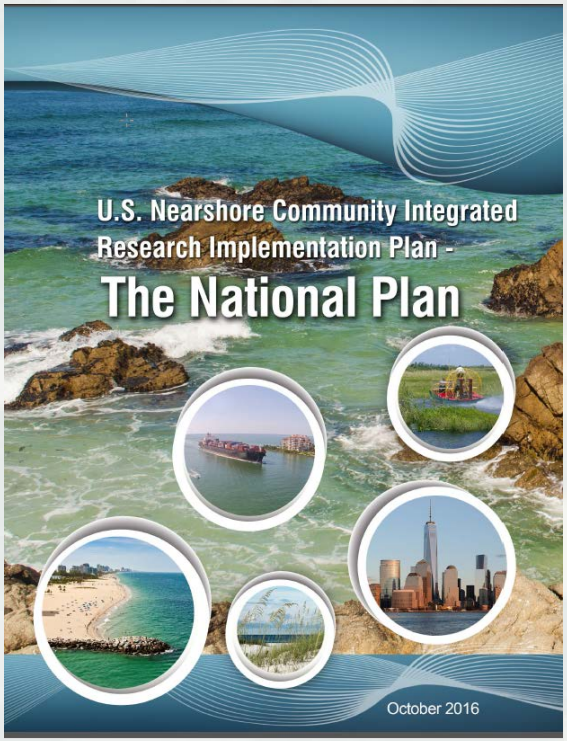
- What can we not fully address with our present technologies?
  - The combined effect of surge and rainfall in our models
    - Examples Hurricane Harvey, Hurricane Maria
    - DC Metro
  - Better numerical model coupling
  - Condition of our infrastructure
    - Assessing Jetty Sheltering via Statistical Analysis of AIS Data
    - Unmanned Aerial System – developmental
  - Challenge of where to place dredged material
    - USACE considers it an asset versus "disposable" or "spoil"
    - Keep in littoral zone, wetland, other?
  - Converting science to actionable item
    - Which IPCC curve should we use?





Short-Term and Long-Term Actions

- Short-Term (1-3 yr)
  - Better coupling of inland flooding and coastal surge models
  - National Nearshore Processes Plan
    - Storm Process and Impacts Initiative



Long-Term (5-10 yr)….see next page….

Challenges for Consideration by Marine Board (1 of 2)

a. **Future Forcing & Uncertainty.** What range(s) in long-term environmental conditions are most representative (sea level, precipitation, drought, frequency and severity of storms)? What are their associated uncertainties?

b. **Port Infrastructure & Operations.** Develop database on port infrastructure (elevation, composition, vulnerability) and port operations (e.g., base level operations (e.g., Point Judith Harbor, RI only allows vessel transit if waves less than 10-ft) and constraints (e.g., environmental windows) utilized at each port).

c. **Optimizing Risk Reduction & Performance.** Define a balance between risk reduction and maximizing the performance of our MTS infrastructure.

d. **Post-Disaster Data.** Data collection to assess damage/risk following major events that impact maritime facilities (e.g., storm/tsunami induced structure damage, environmental impacts, operational impacts).

e. **Adaptation Data.** How are ports adapting infrastructure and operations to better prepare for future short- and long-term hazards?

Challenges for Consideration by Marine Board (2 of 2)

f. **Community System-Wide Modeling of Port Operations.** Develop community frameworks for system-wide modeling of hydrologic, hydraulic, and coastal hydrodynamics and sediment processes that impact navigability. This could include flow conditions around structures (locks, gates, breakwaters), sedimentation of channels, and extreme wave conditions that could impact operations.

g. **Include Maritime within National Systems-scale Multimodal Freight Policy.** Recommend how maritime can be incorporated into an intermodal freight assessment. Maritime is largely considered separately from road, rail, and other modes when budgeting at the federal level; budgets are not coordinated. The lack of coordination increases risk to the overall intermodal freight system, since network bottlenecks are more difficult to identify and mitigate.

h. **Recommend approaches to expand asset condition assessments from project- to watershed-scales.** Methods are needed to incorporate available data, uncertainties, condition of asset relative to capacity to achieve mission, and performance on regional scale.