Maritime Risk Assessment in the U.S. Army Corps of Engineers

Operational Practice and Research Advancements

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Outline

USACE Risk-Based Assessments for Navigation

1. USACE Responsibilities and Studies
2. State of Practice
   a. Operations & research
   b. Gaps & Limitations
3. Data Issues, Confidence, Near-Miss Assessments, Multi-Disciplinary Approaches
4. Risk Assessment Standards, Best Practices, Lessons Learned
5. New Approaches
6. Challenges for Consideration by Marine Board

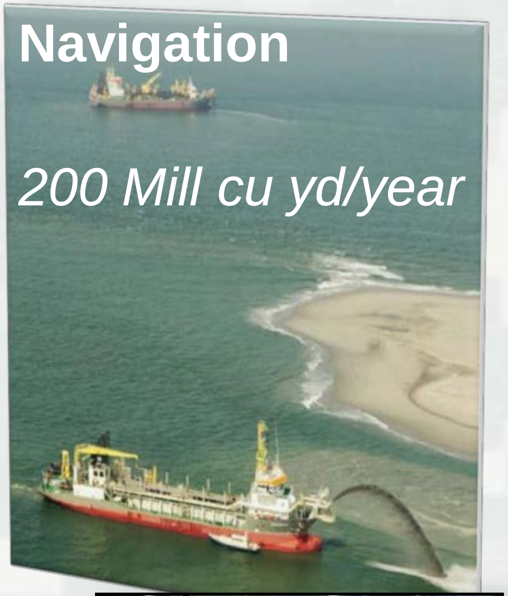
1. USACE Missions & Scope of Studies

Maritime Activities Involve Three USACE Missions:

Navigation, Environmental, and Flood Risk Management

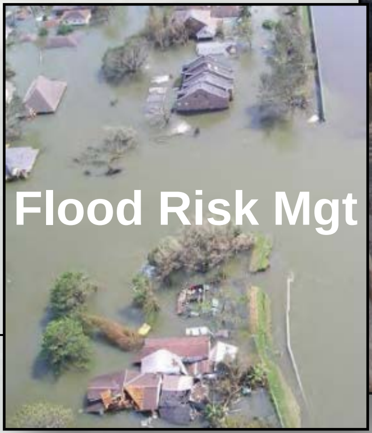
- *25,000 miles of federally authorized inland and coastal navigation channels*
- *200 Mill cu yd/year of dredged sediments*
- *926 coastal, Great Lakes and inland harbors*
- *30,000s+ acres wetlands restored* annually*

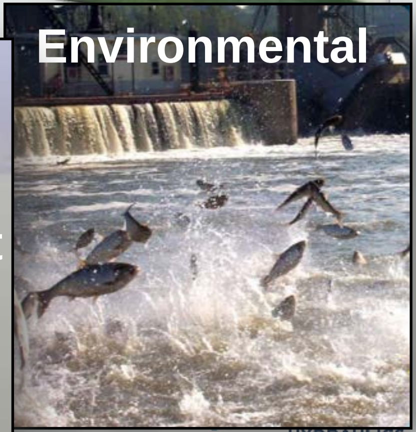
**Or created, enhanced, preserved*



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





2a. USACE Risk-Based Practice – Ocean to Nearshore (1 of 3)

- Environmental Forcing
  - ▸ CHS: Pre-calculated database for 1000s storms
  - ▸ WIS: hindcast & observed data
  - ▸ Tools: simple estimators to numerical models
- Vessel Operations
  - ▸ Cadet: numerical model for underkeel clearance
  - ▸ AIS data – analysis of vessel patterns
  - ▸ Ship simulator
  - ▸ Boussinesq numerical models

CHS: Coastal Hazards System

POCs: Massey, Melby

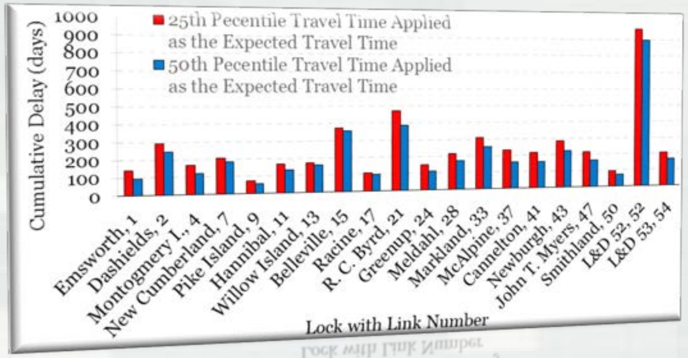
WIS: Wave Information Studies

POCs: Jensen, Hesser

> 100 Mill CPU hr; 3,450 storms; ~19K save points: https://chs.erdc.dren.mil

2a. USACE Risk-Based Practice – Coastal & Inland Infrastructure (2 of 3)

- Infrastructure Condition & Availability
  - ▸ Probability based models* for flooding & erosion to beaches, dunes, and infrastructure; economic implications
  - ▸ Asset Management: capacity to achieve intended purpose



- Travel Time Analysis via AIS – implications of lock closures

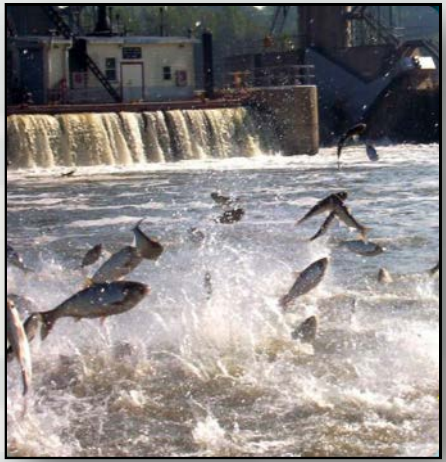
Cumulative delays due to Lock Closures in 2014, Ohio River *(POC: P. DiJoseph)*

- StormSim – life-cycle & reliability tool for coastal structures (POC: J. Melby)

** Beaches & dunes - Beach-fx; Coastal regions - G2CRM, 2nd Generation Coastal Risk Model; POC: M. Gravens*

2a. USACE Risk-Based Practice – Environmental Consequences (3 of 3)

- Track sediment transport:
  - ► Particle Tracking Model – PTM
  - ► Fate of Dredged Sediment Placements – Short-term, Multiple placement, and Long-term numerical models (STFATE, MDFATE, LTFATE)
- Analysis of environmental conditions:
  - ► PTM – oil spill modeling
  - ► Environmental DNA (Asian Carp)



2b. Gaps & Limitations in Risk-Based Maritime Assessments

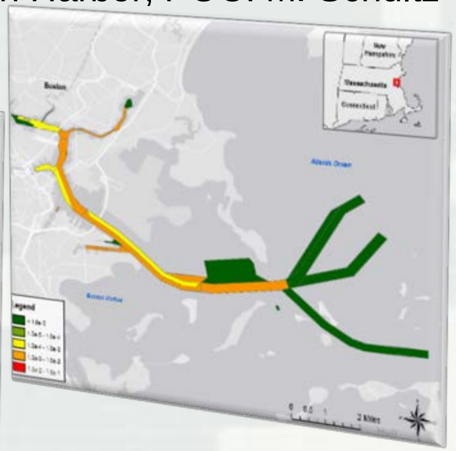
- Need risk-based design guidance; majority deterministic
  - Research studies bring risk-based analysis to practice for some applications
- Planning studies require rapid pre-calculated data
- Many assessments are project-centric (local); need planning-level watershed-scale tools (regional)
- Uncertainty in data, forcing, and state-of-knowledge affect long-term (decadal-century) forecasting
- Some model applications are not seamless
- Models must be validated and certified for USACE

3. Data Issues, Confidence, Near-Misses, Multi-Disciplinary Approaches

- Data Issues & Confidence: Forecasting Future
  - ► Lack of historical data; uncertainty in measurements
  - ► Uncertainty in future environmental forcing
  - ► State-of-knowledge for long-term morphologic change
  - ► Discovering and accessing authoritative data challenging (formats, metadata, uncertainties)
- Near-Miss Assessments & Multi-Disciplinary Approaches
  - ► AIS analyses
  - ► Ship-Tow Simulator

Ship-Tow Simulator

Ship Domain Violations via AIS Analysis, Boston Harbor; POC: M. Schultz



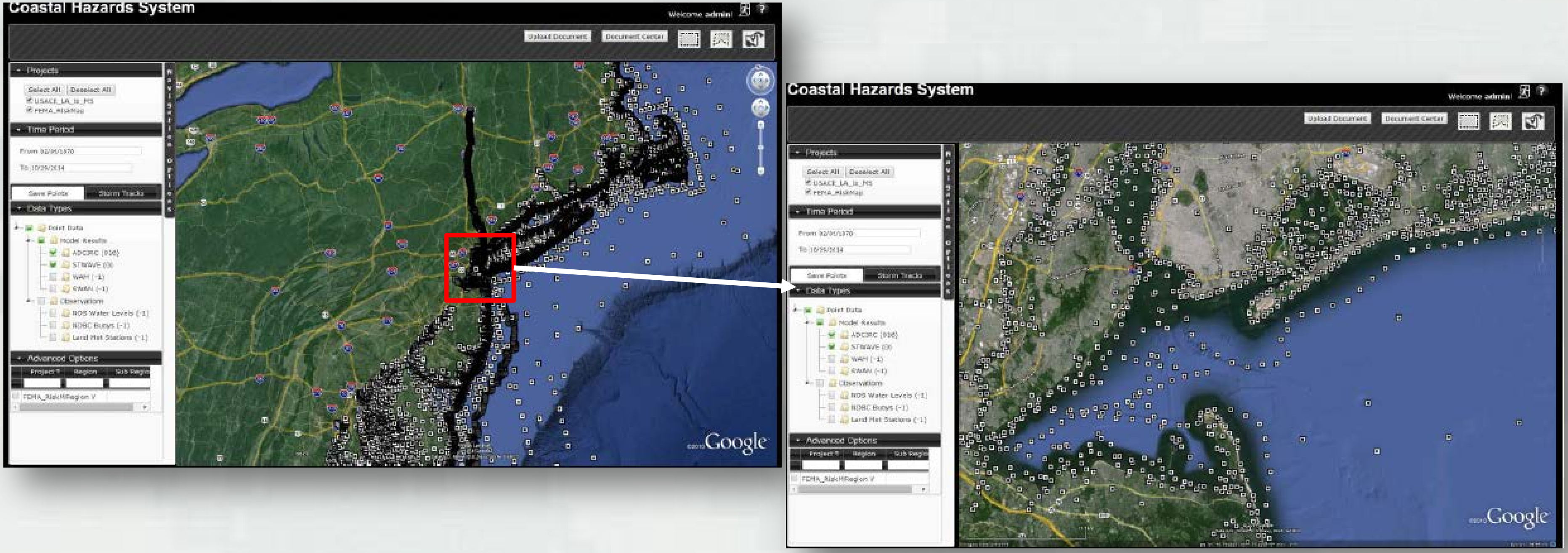
http://www.erdc.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/476712/erdc-shiptow-simulator/

4. Risk Assessment Standards, Best Practices, Lessons Learned

- Projects are justified based on economic benefit to cost ratios
  - Risk is incorporated in probabilistic life-cycle approach
- Best practices and guidance are documented in engineering guidance, certified models and tools
- Lessons learned and research needs communicated through Communities of Practice

5. New Approaches

- Pre-calculated data to facilitate planning-level risk-based, lifecycle probabilistic assessments
  - e.g., Beach-fx, G2CRM, Coastal Hazards System
- Remote structural health monitoring via sensors



6. Challenges for Consideration by Marine Board (1 of 3)

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).

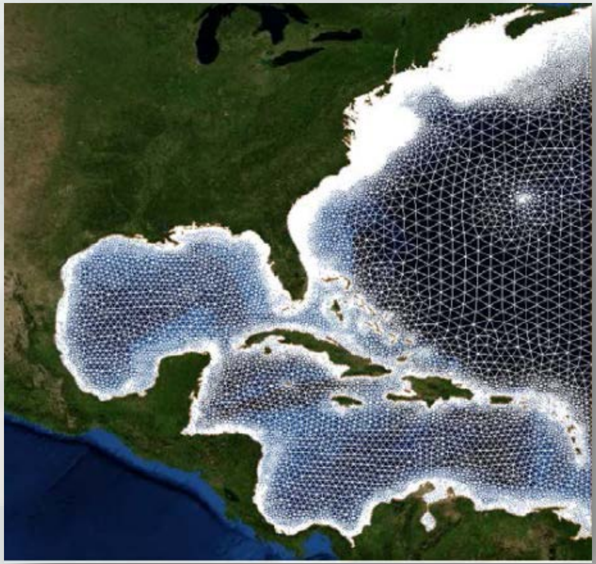
e. **Adaptation Data.** How are ports adapting infrastructure and operations to better prepare for future short- and long-term hazards?

6. Challenges for Consideration by Marine Board (2 of 3)

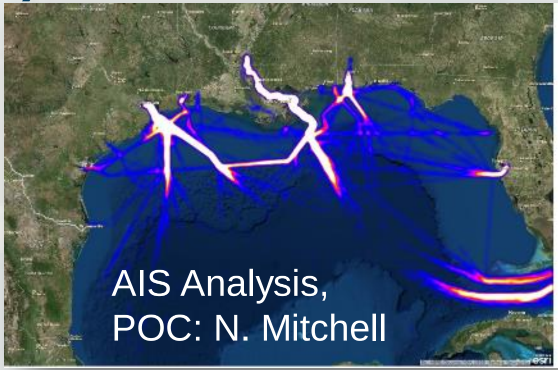
f. **Coordinate Long-Term Environmental Monitoring of MTS.** Coordinate field studies across academia, government, private sector to assess impacts of navigation channels (dredging, ship wakes) on coastal and estuarine processes (beach/shore erosion, salinity intrusion, constituent transport, channel and estuary currents, real-time navigable depth, long waves in harbors and ports, etc.).

g. **Assessment of Climate Change Impacts on Maritime Activities.** Evaluate long-term impacts of climate change (sea level rise, storm tracks, storm intensities) on maritime activities (navigation, ports, and environmental quality).

h. **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.



6. Challenges for Consideration by Marine Board (3 of 3)



i. **Data Science and Knowledge Management.** Recommend robust, computationally efficient means of processing large AIS and commodity flow data sets, and data standards and integration protocols to provide consistency and take full advantage of these data.

j. **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.

k. **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.

Conclusions: USACE Maritime Risk

- Assessments support
  - Navigation, Flood Risk Management, and Environmental Missions+
  - Planning, Operations, Maintenance & Engineering studies
- Research studies have incorporated risk assessments in a probabilistic life-cycle approach; guidance is deterministic
- Challenges include
  - Designing with National Economic Development benefits and sufficient risk reduction
  - Rigorous assessments for planning-level studies
  - Utilizing pertinent data with uncertainties
  - Representing project performance on regional scales
  - Considering decadal-to-century forcing
  - Developing risk-based guidance

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