STORMSIM: RUBBLE MOUND HINDCASTING

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COASTAL INLETS RESEARCH PROGRAM
FY24 IN PROGRESS REVIEW

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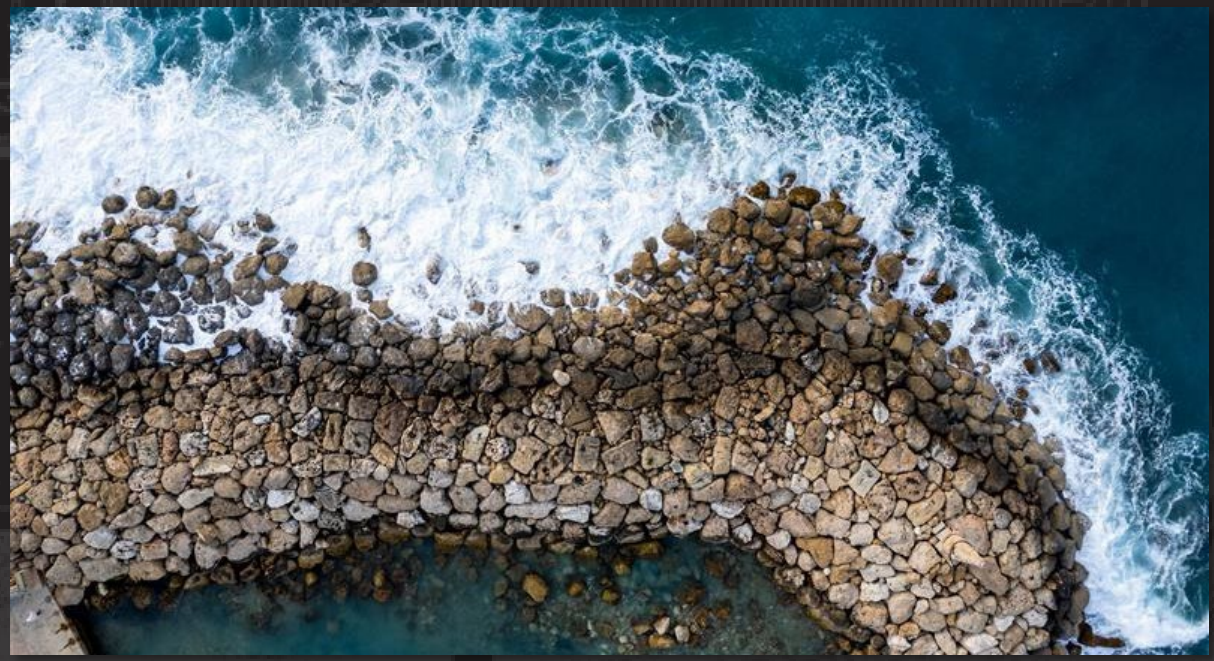
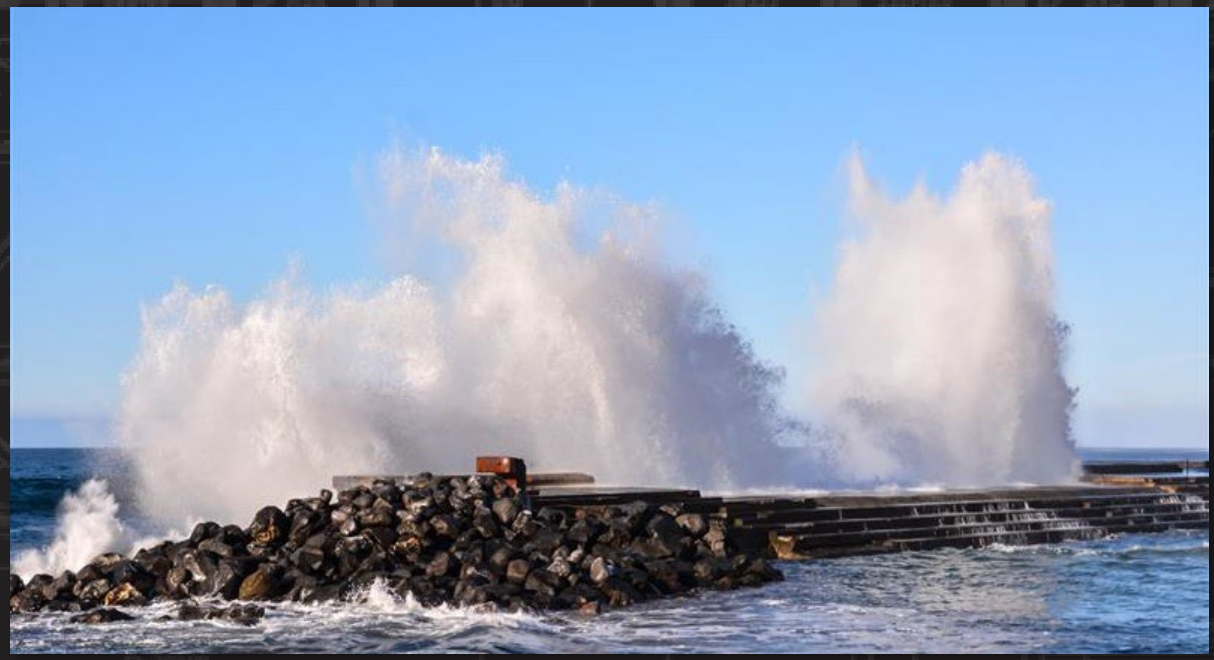




PROBLEM STATEMENT

- Coastal rubble mound structure design and assessment is made difficult by the myriad of empirical physics equations with little commonality.
- Little guidance on best suited equations leads to large differences in responses and design metrics across Districts and projects.
- Additionally, there is no prescriptive safety level guidance. Here safety level refers to both aleatory uncertainty (average annual exceedance probability) and epistemic uncertainty (level of confidence).

Statement of Need: SON-N-1987
FY24 was Year 1 of 4

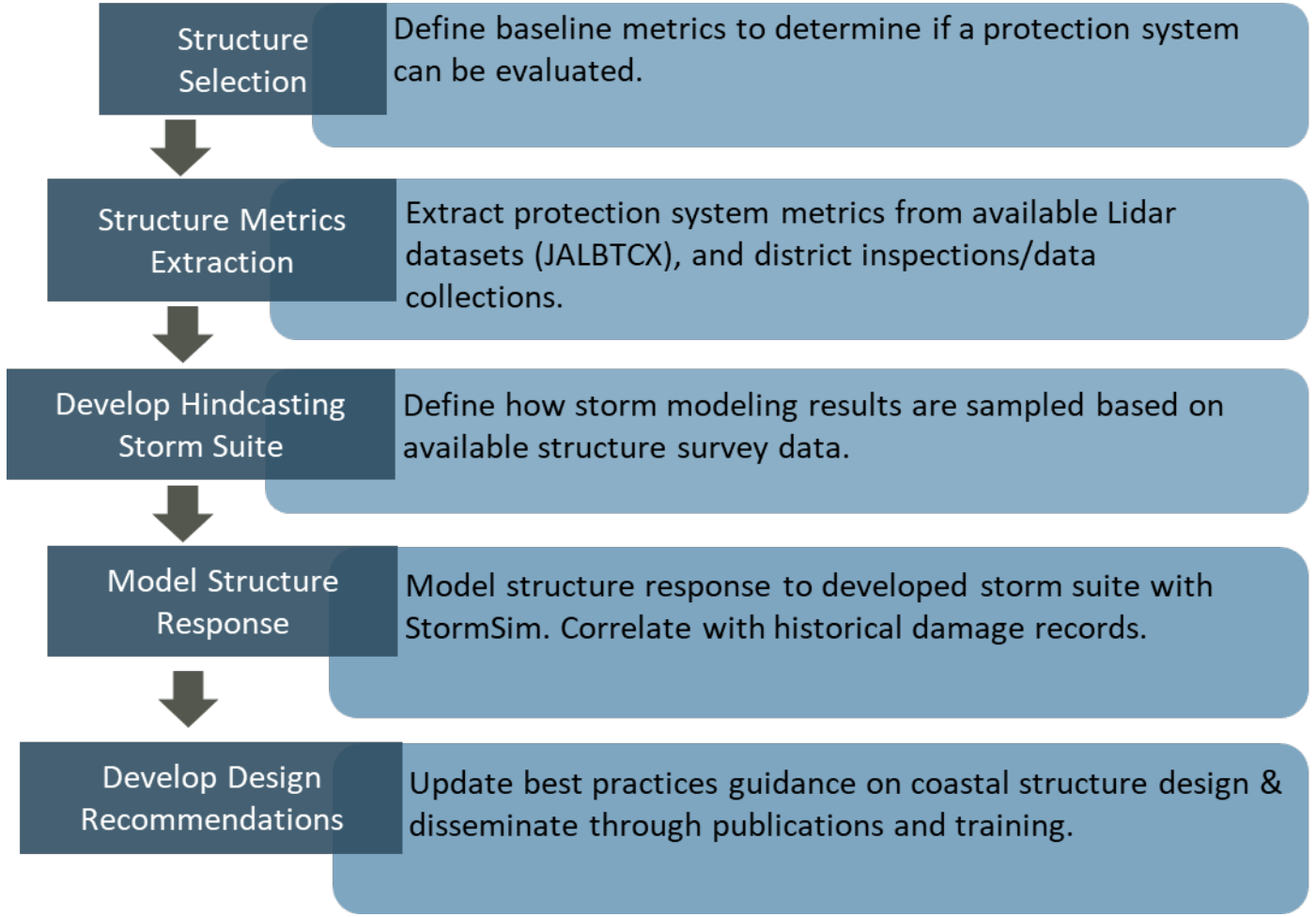
Year over year advancements to date

CAPABILITY AND STRATEGIC IMPACT

Additional functionality added to StormSim tools trough this work unit will:

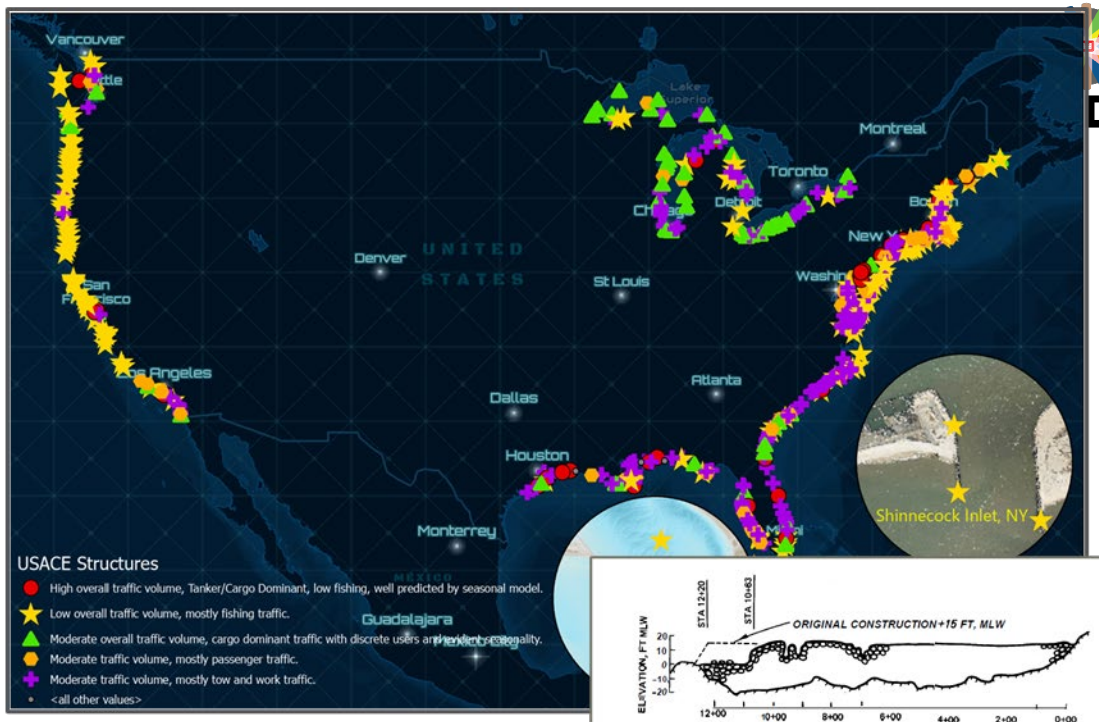
- Improve life-cycle analysis accuracy, consistency, and design for coastal rubble mound structures.
- Standardize approaches, generating uniformity of assessments and performance metrics across the USACE.

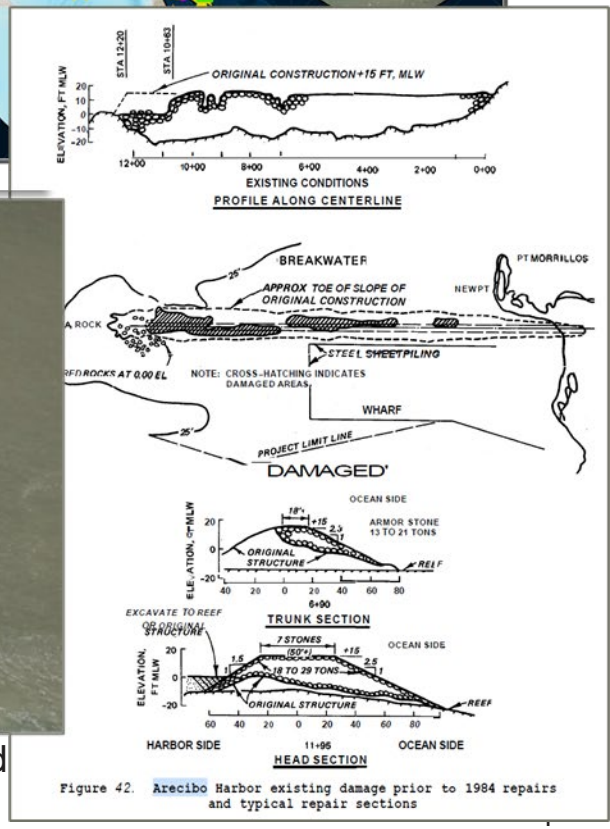
Hindcasting Framework



1.STRUCTURE SELECTION

- USACE manages over +1000 rubble mound structures (breakwaters/Jetty).
- Structures will be selected based on the available data in the following context:
  - **Lidar Surveys**
  - Field inspections
  - Published Reports (i.e., REMR* Reports)
- Analysis ability hinges upon frequency of damage information, quality, and quantification of damaged area.



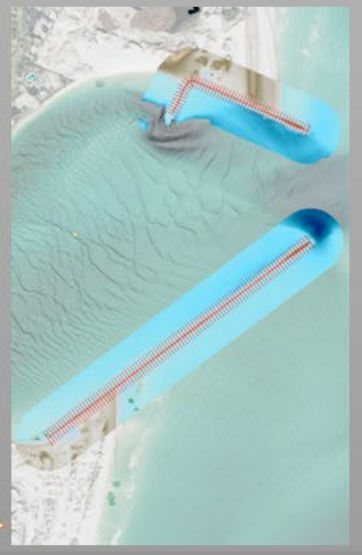


*REMR-Repair, Evaluation, Maintenance And Rehabilitation

2.STRUCTURE METRICS

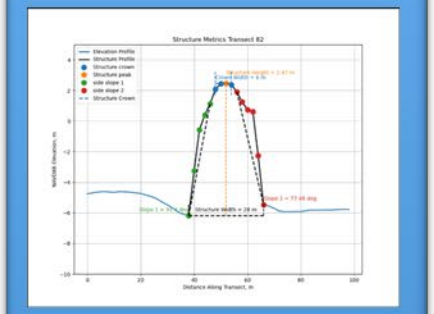
DEM Processing
- Extract
- QC
- Void Fill (if needed)

Transect Generation
- @ 10-m spacing along structure centerline

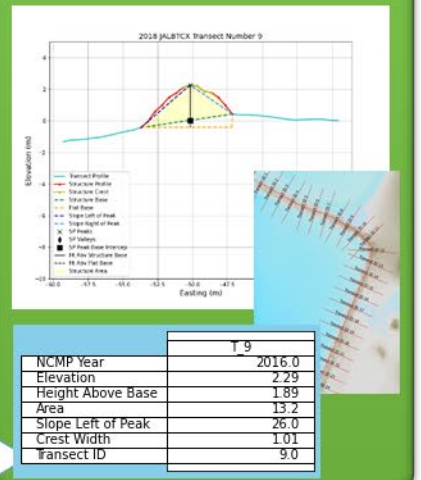


Point Generation
- @ 1-m spacing along structure transects

Structure Classification
- Structure Crown
- Side Slope 1
- Side Slope 2
- Berm



Metrics Computations
- Elevation
- Height
- Slope
- Width
- Volume
- Difference



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NCMP Year	2016.0
Elevation	2.29
Height Above Base	1.89
Area	13.2
Slope Left of Peak	26.0
Crest Width	1.01
Transect ID	9.0

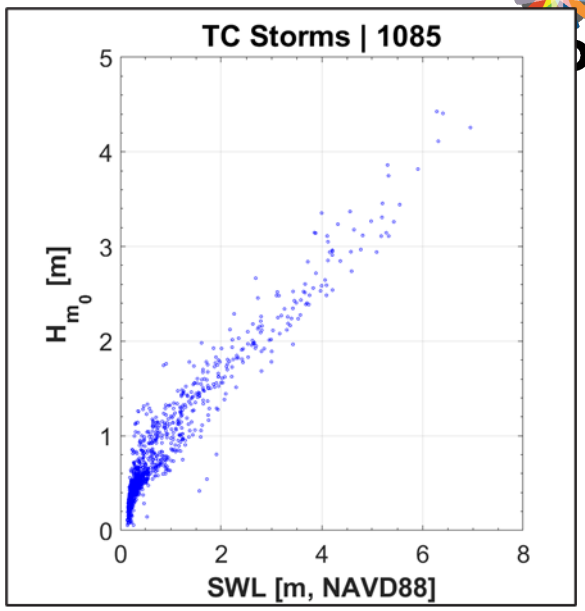
3. HINDCAST STORM SUITE

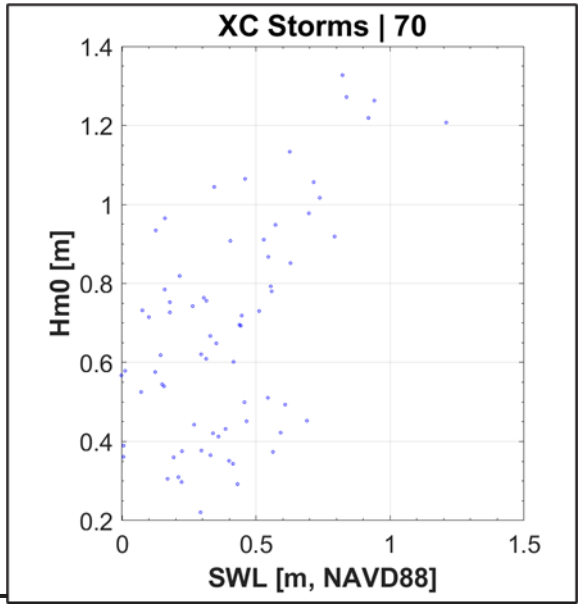
Hindcasting analysis will leverage the following data sources to characterize the forces acting upon the structures:

- Wave Information Study (WIS)
- Coastal Hazard System (CHS) -> surrogate models
- Local long-term observations:
  - National Oceanic and Atmospheric Administration (NOAA)
  - National Data Bouy Center (NDBC)

Hindcasting storm suite is built according to the analysis periods found for the system.

- Before/after extreme event
  - Data limited to specific extreme event. (historical)
- Routine inspections
  - Surveys cover a range of years of operation.





4.MODEL STRUCTURE RESPONSE

- Initial protection system evaluation will be done with the Stochastic Storm Simulation (StormSim) library.
- The StormSim: Life Cycle Simulation module will be used to estimate the following responses:
  - Run-up (R2%)
  - Overtopping Discharge Rate (q)
  - Armor Stone Damage Progression (S)
- Additional modeling external to StormSim will be considered if needed on a structure-to-structure basis.

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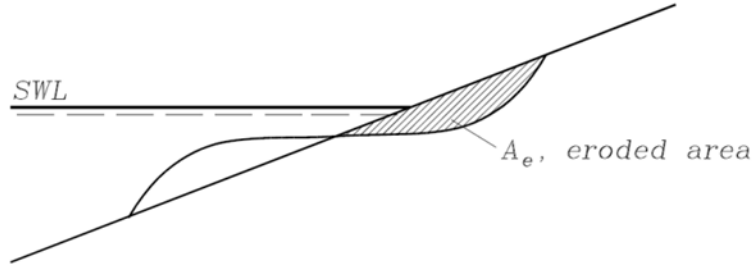

$$D = \frac{\text{number of displaced units}}{\text{total number of units in area}}$$

$$N_{od} = \frac{\text{number of units displaced}}{(\text{width of tested section})/D_n}$$

$$D = \frac{\text{average eroded area from profile}}{\text{area of average original profile}} \times 100\%$$

$$S = \frac{A_e}{D_{n50}^2}$$

WHAT IS STORMSIM?

- The Stochastic Storm Simulation (StormSim) is a coastal engineering software toolkit tailored to probabilistically:
  - Assess coastal hazards
  - Design & evaluate coastal protection systems

- Provides computational modules that facilitate the inclusion of modeling/response uncertainties and reduce the complexity associated with Probabilistic Coastal Hazard Analysis (PCHA).

- Has been used on projects such as:
  - Flood Risk Management
  - Coastal Structure Design
  - Beach Morphology
  - Levee Risk Assessment

SUMMARY

FY24 Major Advancements in Capability

- StormSim library physics update
  - Rubble mound response equations calibration (uncertainty & coeff.)
  - Sea level rise module
  - Tidal Module
  - Low crested break water response (Stone Size & Stability)
- StormSim guidance documents initiated:
  - User Manual
  - Implementation and Considerations Guidance

FY24 Major Products & Collaborations

- Stonybrook collaboration with Dr.Ali Farhadzadeh
  - Life Cycle Simulation module further development
- ICCE Presentation: “StormSim: A New Approach To Probabilistic Coastal Structure Design”
- Collaboration with Coastal Engineering Branch (CEB) at JALBTCX
  - Structure Metrics Extraction

FY25 Products & Advancements

- StormSim Guidance Documents (Drafts- Q2 FY25)
  - Coastal rubble mound design considerations (physics)
  - User manual

•StormSim Beta Access (Q2 FY25)

•PDT Kick-off Meeting (Nov FY25)