AN OVERVIEW OF THE DEVELOPMENT, EXPANSION, AND APPLICATION OF THE ENGINEERING WITH NATURE® MODELING TOOLKIT

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BACKGROUND

Nature-based Solutions (NbS) are increasingly being considered for implementation in coastal engineering projects around the world as a means of enhancing coastal protection, resiliency, and sustainability. With this increased emphasis on nature-based features, the need to evaluate the efficacy of NbS project designs has never been greater. Numerical models are powerful tools that can be leveraged to assess and quantify the hydrodynamic impact and protective capacity of nature-based features. However, numerical modeling of NbS is often difficult due to the amount of time and expertise required, as well as the lack of standardized approaches within the modeling community of practice for characterizing these features. In order to address this need, the U.S. Army Corps of Engineers' (USACE) Engineering With Nature® (EWN) program has funded researchers from USACE's Engineer Research and Development Center (ERDC) to develop a tool called the Engineering With Nature® Modeling Toolkit to streamline and standardize the incorporation of Nature-based Solutions in numerical model frameworks.

INITIAL EWN MODELING TOOLKIT DEVELOPMENT AND CAPABILITIES

USACE-ERDC partnered with Aquaveo, a leading hydrodynamic modeling software company, to develop the EWN Modeling Toolkit in the form of open-source Python tools and a user-friendly GUI (Figure 1) contained within Aquaveo's Surface-water Modeling System (SMS) software. The program's interface allows the user to input a shapefile or polyline defining the geometry of a nature-based feature, and to specify the resolution at which the feature is to be incorporated into a model. The GUI then asks the user to specify the feature type (e.g. a dune, marsh, or mangrove forest), and then supplies recommended values for various model parameters, such as the Manning's roughness coefficient, associated with that feature type. The user can interactively set the mesh element growth rate allowed when the feature is incorporated into the model. When the tool is applied, the feature is incorporated into the mesh at the desired resolution and smoothly integrated into the pre-existing model geometry as seamlessly as possible. As initially developed and tested, the EWN Modeling Toolkit could solely be applied for use with the Advanced Circulation (ADCIRC) model (Westerink et al. 1992).

EXPANSION OF THE EWN MODELING TOOLKIT

The EWN Modeling Toolkit is currently being expanded for use with additional community-based numerical models (Crisanti 2023). These include water level and circulation models (the Adaptive Hydraulics (AdH) model (CHL 2023) and CMS-Flow (Militello et al. 2004)), wave models (the Steady-State Spectral Wave (STWAVE) model (Massey et al. 2011), CMS-Wave (Lin et al. 2008), and WaveWatch III (WW3DG 2016)), and an overland flow model (the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model (Downer et al. 2004)). A variety of approaches are being explored and implemented to optimize the characterization of NbS based on the specifications and best use practices of each model. This effort expands the application of the Toolkit to include modeling of phenomena such as waves and hydrologic processes that are critical to understanding the impacts of NbS on natural systems. This will also enable a more significant portion of the modeling community of practice to validate NbS designs for a broader range of project scenarios and natural environments faster and more efficiently.

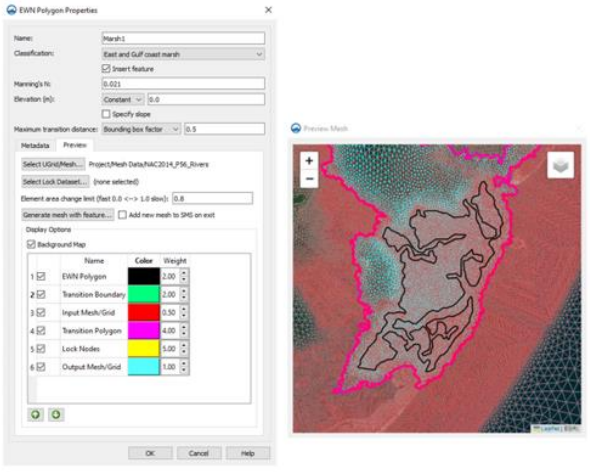

Figure 1 - The EWN Modeling Toolkit GUI used to specify parameters associated with the representation of a marsh feature in an ADCIRC model mesh within the Surface-water Modeling System (SMS) interface.

APPLICATIONS

To date, the Engineering With Nature® Modeling Toolkit has been utilized as part of a number of coastal storm risk

management (CSRM) studies conducted by the USACE and its agency and industry partners, including the New Jersey Back Bays CSRM Study, the Deer Island Restoration Study (Tritinger 2023), and the Aberdeen Proving Ground Resiliency Study. These studies each included a numerical modeling component that quantified the impacts of specific Nature-based Solutions on coastal hydrodynamics during extreme storm events. The studies illustrate how the EWN Modeling Toolkit is improving the ability of coastal modelers and engineers to evaluate the efficacy of various designs and provide crucial information to decision makers, thus leading to more successful application of NbS and increased innovation in coastal management and resiliency practices.

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