OCE408: Introduction to Engineering Wave Mechanics and Littoral Processes: Final Project Assignment

For this project, an analysis of the storm conditions impacting Narragansett Beach will be conducted. Narragansett Beach is an important economic resource for the town of Narragansett providing an average net income of approximately $270,000 each season and increasing seasonal business for the surrounding restaurants, shops, and rentals. Understanding the natural forces contributing to beach erosion is important to inform expensive re-nourishment projects that keep the beach healthy for vacationers. You will conduct an estimate of the local wave conditions in Narragansett, including wave propagation/transformation up to the breaking point near the Narragansett beach in order to estimate wave properties that may be used for studies of surf zone dynamics, induced currents in the area, and sediment transport. The project will be conducted in groups of 4 (one group of 3). The findings of the project will be summarized in a written report presented in the usual homework format and will include a 12 minute presentation that will be given on the second to last day of class.

Important Dates

- **Project Assigned: April 3rd 2014**
- **Project Presentations: April 24th 2014**
- **Project Written Reports Due: April 29th 2014 by 5:00 pm**

The project will consist of two tasks outlined below:

1. Conduct a statistical analysis of historical wave conditions offshore of Rhode Island (hindcast analysis).
2. Use a wave ray tracing program to evaluate what the offshore wave conditions look like at the beach and calculate the breaker line.

It is recommended that you choose one member of your group to act as the gourd leader/coordinator to manage time and tasks associated with the project. Each group should subdivide into two groups of 2 in order to handle each assigned task.

TASK 1 - Determine design deep water wave heights and periods for dominant directions relative to Narragansett Beach.

To determine the wave conditions that impact a coastline or structure a statistical analysis of historical wave conditions is often used. Conduct an analysis of the waves off of the Rhode Island coastline. Appropriate Matlab scripts/functions described below will be provided to aid in the statistical analysis of waves.

To begin, obtain a copy of 20 years of hind-cast wave height data from the U.S. Army Core of Engineers Wave Information Studies (WIS) project. Visit `https://maps.google.com/?q=http://wis.usace.army.mil/WIS.kmz` and locate the Rhode Island coastline. Select a WIS station off the coast of RI that is most directly offshore of the area of interest and select “more products,” then download the time series zip file.

Next determine the dominant wave directions at the WIS node location using wavedir.m to create a wave rose plot counting the number of waves in 30 degree sectors to define each direction.

As a minimum, select the three major wave directions and determine the 20 and 50 year return period extreme waves in each direction using statistical extrapolation based on fitting a Gumbel probability distribution to extreme values in the data using extremeDist2_new.m. Monthly extrema of wave height in a specific directional sector should be determined using monthmax.m and used as the basis for the extrapolation. The corresponding period can be derived assuming fully developed or fetch limited conditions, as applicable for the chosen direction.

Results of this analysis should be in the form of a table with, for each of the dominant wave directions and corresponding storm return periodicity (20 and 50 years), a significant wave height and corresponding period. Additional tables/plots should be provided to demonstrate the statistical extrapolation.

From the Sakai Resources section, download the .zip file labeled as ”wavestats.” This file will contain the following Matlab scripts to use for this task of the project:

- monthmax.m
- wavedir.m
- yearlyDist.m
- monthextrema_new.m
- extremeDist2_new.m

Note: Once the storm wave characteristic heights, H_s are found, the corresponding peak spectral periods T_p, should be found as a function of the latter, assuming fully developed sea conditions. The findings from this task will be used directly for the wave propagation analysis.

TASK 2 - Propagate storm waves through wave ray tracing

2) Differing bottom topography causes wave refraction which concentrates or disperses the wave energy as it travels towards shore. Wave ray tracing using bathymetric data can simulate how storm waves refract and provide information about the wave properties at the beach. This tasks involves propagating the storm waves determined from TASK 1 using a wave ray tracing algorithm and the local bathymetry information for Narragansett Bay. You will utilize bathymetry information from online databases which will be provided.

Download the wave ray tracing program from the class Sakai site (file name is "raytracing.zip" in the Resources section) and follow the included instructions to setup and run ray-tracing simulations. The instructions show sample simulations of several rays produced using the Matlab script. Make sure you download all necessary functions and libraries in order to properly run the script. The TA will be available to assist with these tasks and will provide a tutorial on using the ray tracing software.

Conduct simulations for the 20 and 50 year storms from each of your dominant directions. Arrange to have at least 8 rays intersect along the shoreline of Narragansett Beach. For the 20 year storm simulations, use the ray spacing on the beach to calculate a refraction coefficient for each section of beach. Then, using bathymetry data from a chart near the beach, estimate the beach slope and use it along with the deep water wave properties and refraction coefficient to estimate the shoaling coefficient, breaking depth, and breaker height.

Present your results as images of the simulation output along with tables with calculated values for each beach section. Label the beach sections appropriately on any graphs/tables. Finally, plot the approximate breaker line on the bathymetric chart near the beach. Your table of relevant breaking criteria should include m, K_r, K_s, H_b, h_b, H_b/h_b, θ_b for each beach section (between wave rays). Note: The breaking angle θ_b is measured between the wave crest and the local shoreline direction.

Questions to include in report

In addition to discussion of the tasks above, please discuss or answer the following questions in the discussion section of your report:

1. How might the results of this study be used for estimating sediment transport at Narragansett beach? What additional information may be necessary to do a proper sediment transport analysis?
2. If one were interested in doing a wave energy resource assessment for the

Rhode Island coastline, how might this type of study be used for estimating wave resources near the shoreline or siting a wave energy facility? What aspects of hind casting and ray tracing may be important for siting a wave energy converter facility on the coastline? What additional information may be necessary to do such a study? How might you deal with assessing the regular wave conditions, rather than extreme wave conditions for assessing the energy resource?

3. How do you think the inclusion of diffraction models would alter your ray tracing analysis? Discuss in terms of the particular wave directions determined from TASK 1.