Senior Design Project in Electrical & Computer Engineering

Woods Hole Oceanographic Institution

Acoustic Study of Shallow Water Surf Zones

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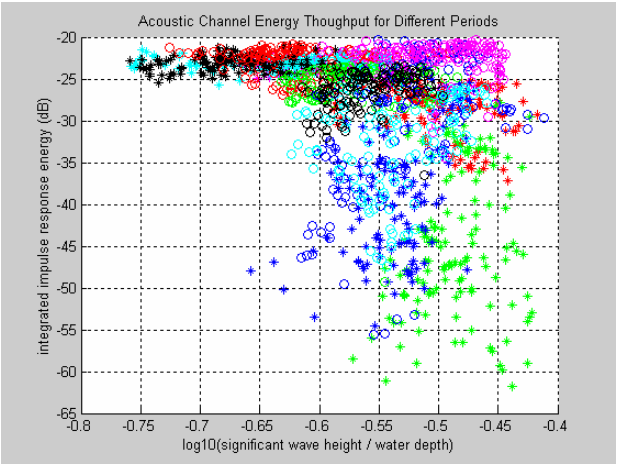
Project Background

Naval mine-clearing vessels have trouble working in shallow water surf zones because breaking waves introduce bubbles into the water. These bubbles can destroy the communications channel for minutes at a time, making it impossible for the vessel to communicate with the equipment deployed in the surf zone. The black line on the figure at right shows the total energy received at each time on the x-axis. A short outage can be seen on the figure between seconds 3 and 4 when the total signal strength falls to below -50 dB.

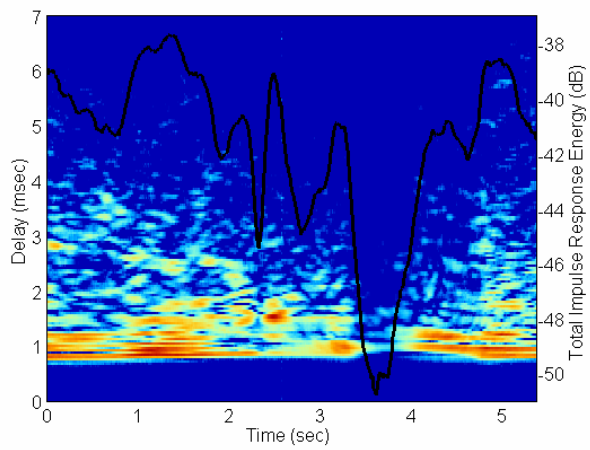
Project Goals

The long-term objective of this project is to create a general model predicting when communication signals will be lost in surf zones. Scientifically, the goal is to determine which environmental factors effect the signal's ability to travel through the surf zone in hopes of predicting when a signal will dissipate and how long it will stay out. Operationally, this model will allow Navy mine-clearing vessels to take a few readings from their environment and determine the probability of losing the communications channel to breaking waves. The readings needed to use the model will be similar to readings already taken by people on these ships, such as wind direction and speed, water depth and wave height.

Plot of energy received over several different 2 hour periods, showing a ratio of wave height to water depth below which the signal is never lost



Graph of total signal received (black line) over a 5 second period. The colormap shows when the signal arrives (red areas are showing the signal's strongest arrivals)



Project Plan

The model will be developed by comparing the statistics of environmental data to the statistics of the energy received. To date, the analysis has been based in communications theory techniques, using entropy and mutual information calculations to determine how knowledge of environmental conditions can be used to lower the uncertainty in energy received. Results show that the biggest wave in the last two minutes and significant wave height are the two environmental factors most closely linked to the amount of energy received. Another finding, depicted in the figure at left, shows that as long as the ratio of significant wave height to water depth stays below a threshold, the signal will not be lost, whereas above this threshold the signal may be lost. The graph plots energy received over different time periods (shown in different colors) versus the ratio of significant wave height to water depth and shows a threshold at about -.625.

The analysis is now shifting to an analysis of data variances and conditional variances and data will be studied in sets of several seconds instead of studied as individual data points. Once this analysis is complete, a model will be designed, combining all the results to date and determining which environmental factors have the most direct effect on the amount of energy received.