

## **Development of Operational Guidance Criteria for Small Craft Operating in Dangerous Seas**

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The most dangerous seas to small craft operation are those which produce groups of extreme, steep waves (relative to the size of the vessel) and those that involve breaking waves impacting from the beam or astern quartering directions. Rogue waves of twice the significant wave height are certainly dangerous to vessel operation, but groups of steep waves which are large relative to the vessel size are far more likely to be encountered and are equally dangerous.

The paper presents additional analysis of the comprehensive model tests of fishing vessel capsizing carried out by the National Research Council of Canada in the 1980s. The analysis is focused on those dangerous elements of ship behavior in large, steep waves which indicate the possibility of ship capsize. The symptoms of danger of capsize can include: water shipping on deck, large amplitude of motions with hesitant return, riding on the wave crest, tendency to surfing, difficulty to maintain course control, bulwark immergence, and others. The occurrence of these phenomena is related to ship loading conditions, **wave parameters**, ship speed and course direction relative to waves.

Special attention is paid to the frequency of occurrence and intensity of the phenomena in the test runs in which the model eventually capsized. Certain parameters of these phenomena are considered as the pre-capsize symptoms. They should be an important part of the operational guidance in the future.

The paper will also address the problem of using the results of model tests in steep regular waves to predict the probability of encountering the same type of vessel motions in irregular waves. One correlation being investigated is to use the probability of encountering large amplitude wave groups with an equivalent regular wave height and mean period found in various irregular wave spectra formulations. This approach is based on work by Dawson and Kriebel using Markov theory for wave group statistics combined with Longuet-Higgins analysis for narrow band frequency spectra. In the case of the JONSWAP spectral formulation, fetch length, wind speed and duration will be systematically varied in order to find a range of significant wave heights, periods and resulting probabilities of encountering irregular wave groups roughly equivalent to the vessel motions found from regular wave tests. The goal of this analysis is to develop a performance-based approach to capsize risk assessment for various loadings of fishing vessels in typical operational sea states based on model tests in regular waves. Limited validation of this concept is available from the irregular wave tests done as part of the NRC model test series.