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TECHICAL NOTE

FORECASTING WAVE CONDITIONS AFFECTED BY CURRENTS AND BOTTOM TOPOGRAPHY

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OPC Contribution No. 10

OPC CONTRIBUTIONS

No. 1. Burroughs, L. D., 1986: Development of Forecast Guidance for Santa Ana Conditions. National Weather Digest. (in press).

No. 2. Richardson, W. S., D. J. Schwab, Y. Y. Chao, and D. M. Wright, 1986: Lake Erie Wave Height Forecasts Generated by Empirical and Dynamical Methods -- Comparison and Verification. Ocean Products Center Technical Note, 23pp.

No. 3. Auer, S. J., 1986. Determination of Errors in LFM Forecasts of Surface Lows Over the Northwest Atlantic Ocean. Ocean Products Center Technical Note/NMC Office Note No. 313, 17pp.

No. 4. Rao, D. B., S. D. Steinrod, and B. V. Sanchez, 1986: A Method of Calculating the Total Flow from a Given Sea Surface Topography. NASA Technical Memorandum. (in press).

No. 5. Feit, D. M., 1986 Compendium of Marine Meteorological and Oceanographic Products Center. NOAA Technical Memorandum NWS NMC 68, 98pp.

No. 6. Auer, S. J., 1986: A Comparison of the LFM, Spectral, and ECMWF Numerical Model Forecasts of Deepening Oceanic Cyclones During One Cool Season. Ocean Products Center Technical Note/NMC Office Note No. 312, 20pp.

No. 7. Burroughs, L. D., 1986: Development of Open Fog Forecasting Regions. Ocean Products Center Technical Note/NMC Office Note No. 323. (in press).

No. 8. Yu, T., 1986: A Technique of Deducing Wind Direction from Altimeter Wind Speed Measurements. Mon. Wea. Rev. (Submitted).

No. 9. Auer, S. J., 1986: A 5-Year Climatological Survey of the Gulf Stream and Its Associated Ring Movements. Journal of Geophysical Research. (Submitted).

No. 10. Chao, Y. Y., 1987: Forecasting Wave Conditions Affected by Currents and Bottom Topography. Ocean Products Center Technical Note, 11pp.

No. 11. Esteva, D. C., 1987: The Editing and Averaging of Altimeter Wave and Wind Data. Ocean Products Center Technical Note, 4pp.

1. Introduction

A marked change in the characteristics of wind-generated surface waves occurs due to the presence of prevailing surface current and major bottom topographic features. A well known region characterized by intense and dramatic interactions of waves, currents and shoals is the Columbia River entrance on the west coast of the United States. It is recognized as one of the most dangerous coastal inlets in the world, where hundreds of search and rescue missions are conducted yearly by the Coast Guard and tragic losses of life continue to occur.

The National Oceanic and Atmospheric Administration (NOAA) is responsible for forecasting sea state conditions at the Columbia River entrance, as well as a number of other potentially dangerous sites on the United States coasts. In order to assist marine forecasters in these efforts, Gonzalez (1984) developed a one-dimensional wave-current-bathymetry interaction model under the assumptions of: monochromatic waves, straight depth contours parallel to the shoreline, and unidirectional tidal currents without lateral shear. The results of this simple model compare reasonably well with a limited set of field measurements but a major problem remains. For large incident wave angles there is a significant discrepancy between predicted values and measured data. This discrepancy may result from ignoring the two-dimensionality of the actual current and depth fields. Near a typical coastal inlet, the bottom configuration and current conditions are generally characterized by the presence of submarine shoals and tidal jet. This highly irregular bottom and nonuniform currents would cause significant difference in the wave condition over a relatively small coastal area. Thus, it is not always adequate to approximate the coastal region with parallel bottom contours and one-dimensional currents. It is also an accepted opinion that spectral consideration of ocean surface waves provides more realistic, and perhaps more accurate description of wave conditions than a monochromatic wave assumption.

Aiming toward providing forecast guidance for various coastal regions whose bottom bathymetry and current conditions vary in a general manner, a two-dimensional numerical model was developed. This paper outlines the model and presents some comparison of numerical results with analytical solutions and field data.

2. The Model

The theory of wave refraction by current and bathymetry has been comprehensively presented by Phillips (1977). The theory applies the kinematic and dynamic conservation laws, and the dispersion relation. The dynamic conservation law can be expressed in terms of an energy balance equation involving the radiation stress or a wave action conservation equation. The conservation equation of wave action is certainly preferable given its greater computational simplicity. Two numerical methods are commonly used. One is the ray tracing method and the other the finite difference method. As with bathymetric refraction, when only a few forecast points are of interest, it is computationally