1 Introduction

Background

The movement of a barge train through a body of water produces a complex pattern of currents and waves. A general description of the waves and current patterns generated by a moving vessel is given by Maynord (1996). Quantification of these currents has relied on physical models and analytical descriptions. These analytical tools are primarily empirical one-dimensional models (e.g., Maynord 1996; Maynord and Siemsen 1991; and Jansen and Schijf 1953). Although empirical methods are practical for many situations, detailed analyses of specific areas are desirable. These empirical relations do not provide time-varying solutions necessary for predicting the duration of vessel-induced events. Also, spatial variations in rivers having backwaters and side channels are not modeled by these one-dimensional expressions. A two-dimensional (2-D) representation of the equations of motion provides temporal variation of the depth-averaged velocity distribution and the water-surface elevation.

Purpose and Scope

Researchers concerned with engineering consequences and biological response to barge traffic need to know ambient flow conditions and flow field changes that are a result of vessel passage. In particular, analysis of the physical forces generated by barges navigating along a waterway requires predicting not only the changes in velocity magnitudes and directions and water-surface elevation, but also the duration of these changes. Acquisition of this information requires a time-accurate 2-D model.

The objective of this study is to develop a numerical model to quantify vessel-generated currents. Included in this report are the governing equations and assumptions made in their derivation and a brief description of the numerical model. This report also summarizes a series of numerical experiments. Finally, conclusions are made as to how the 2-D model may be used to simulate vessel-generated currents and long-period waves.

Approach

Much attention has been given to a mathematical description of vessel-generated waves. An overview of many of the contributing researchers is presented by Stoker (1957). Stoker models vessel-generated waves as a series of impulses representing a moving pressure point. The waves generated by a moving vessel are modeled as the sum of the responses to the applied impulses. However, the application of this model to a particular vessel shape is limited by the idealized approach. Also, a method of computing not only vessel-generated waves, but also the currents resulting from vessel passage is needed. Therefore, a general method of determining spatial and temporal variations in the waves and currents generated by vessels is developed.

Flow fields containing a moving vessel are modeled by specifying a pressure field, representing a vessel hull, that is spatially varying in time. The movement of the pressure field in time is specified to represent a vessel navigating along a channel. A 2-D shallow-water model was modified to account for the effects of the imposed pressure field. The model is an extension of the finite element model HIVEL2D (Berger and Stockstill 1995; Stockstill and Berger 1994). Although HIVEL2D was developed specifically for simulation of high-velocity channels, the model was used for this study because of its numerical stability in regions of steep solution gradients.