Preface

What is ‘rotating hydraulics’ and why would anyone wish to read a book on the subject? Over the past three decades, the term has come to describe the physics of overflows and other choked flows of the ocean and atmosphere that are broad enough to be influenced by Earth’s rotation. The currents and winds in question typically have high speeds, subcritical-to-supercritical transitions, shocks, and other objects familiar to open-channel or aeronautical engineers. Bores, intrusions, steepening waveforms and separation phenomena are considered part of the subject because they tend to arise within these flows. Mixing with neighboring fluid often occurs as the result of wave breaking or of instabilities associated with the high velocities. Interest in the field is often excited by the dramatic and strongly nonlinear character of the features in question and by the mixing and its downstream consequences. The subject is also important for the study of Earth’s climate because of the special opportunities for observation and long term monitoring made possible as a result of the choking effect.

This book is concerned primarily with the theory of rotating hydraulics. However, the Introduction contains an overview of the observations that have motivated much of the theoretical development, and more detailed case studies appear later in the book. Though both the atmosphere and ocean are covered, the latter is the source of the most numerous examples. Laboratory experiments have also played a key role in the development of the field and many of these are described. Our intent is to provide the reader with the material necessary to develop a solid grasp of the fundamental ideas and physical processes as well as a general familiarity with geophysical applications. We will also introduce the reader to a range of mathematical techniques that have proved useful in dealing with the types of nonlinear problems that arise the field.

An introduction and review of classical hydraulics appears in Chapter 1. The prospective reader should have a good understanding of basic fluid dynamics and be familiar with the shallow water equations and the approximations behind them. A grasp of the basics of linear wave propagation in fluids, including the concepts of phase speed and group speed, is also desirable. Beginning with Chapter 2, where the effects of rotation are first discussed, the reader will need to know about Coriolis acceleration and geostrophic flow. Thorough discussions of all of these topics appear in the texts of Gill (1982), Pedlosky (1987), Cushman-Roisin (1994) and Salmon (1998).

The notation and conventions used in this book are largely standard for geophysical fluid dynamics. However there are two departures worth mentioning. The first is the use of y, in place of the more common x, to denote the predominant direction of flow. This convention stems from early models of currents in deep ocean straits and along coasts, which are often aligned in the north-south (y-) direction. The second matter concerns the representation of dimensional vs. dimensionless variables. Most of the book (Chapters 2-6) makes use of a common convention in which a star (*) superscript signifies a dimensional quantity, at least where an ambiguity might arise. Stars are used to indicate the dimensional form of common variables such as y^* that also have nondimensional counterparts (y). Stars are omitted, however, for well-known dimensional parameters such as the gravitational acceleration g and the Coriolis parameter f. Stars are also omitted for dimensional scales, indicated by capital letters, that do not have a nondimensional counterpart. Examples include the generic depth scale D and length scale L. There is one exception to this scheme: nearly all the variable used in Chapter 1 are dimensional and it would have been cumbersome to place stars on every one. The star notation is therefore not used at all there. We have tried to avoid any confusion by placing reminders where ambiguities might arise.

Finally, to avoid exotic notation, we sometimes use the same symbol to denote different quantities in different places. One example is the symbol α, which is given a thorough workout. The context usually makes the meaning clear, but a list of variables (Appendix A) can be consulted should a questions arise concerning the meaning of a certain symbol in a certain section.

A number of texts explore the hydraulics of nonrotating fluids in much more depth than is present here. At the time of this printing, the most scientific and up-to-date book is Baines' *Topographic Effects in Stratified Flows*. Treatments of linear and nonlinear waves in shallow water systems can also be found in Stoker's *Water Waves* and Whitham's *Linear and Nonlinear Waves*. Engineering texts such as Chow's *Open Channel Hydraulics* and Henderson's *Open Channel Flow* present the traditional engineering perspective.