

WADHAMS, P. 2000. *Ice in the ocean*. Amsterdam, etc., Gordon and Breach Science Publishers. xi + 351 pp. ISBN 90-5699-296-1, cloth. US\$67/£44/€74.

THERE are several books on sea ice, but apart from article collections, a long time has passed since the appearance of a true textbook. That is, until now with the appearance of *Ice in the ocean* by Peter Wadhams. The most recent text was *Sea ice* by Yu. P. Doronin and D. Ye. Kheisin, dating back to 1975 (Doronin and Kheisin, 1977). Peter Wadhams is a well-known member of the polar science community with impressive field experience as well as an extensive list of published works to his name. For 30 years he has worked on sea ice, and has educated sea-ice scientists, at the Scott Polar Research Institute, Cambridge, U.K.

*Ice in the ocean* is an excellent introduction to sea-ice geophysics. The first chapter introduces freezing seas of the world, and the next three chapters review the classical themes: sea-ice structure, thermodynamics and dynamics. Then follow three more specific chapters dealing with pressure ridges and ice-thickness distribution, the marginal ice zone, and icebergs. The final chapter discusses the role of sea ice in climate and environment. In all, the book is well structured, and balanced representation is given to the different areas of the subject, except that the three specific chapters on pressure ridges, etc., lay more emphasis on those areas where the author has done his own research.

The book begins with a romantic polar citation from J. Zukriegel's *Cryologia Maris*. This theme recurs at the opening of each chapter, and is tied in with Wadhams' own polar experience, providing a thread that runs through the book in a beautiful way and which reflects the life and focus of the author.

Chapter 1 introduces the frozen oceans, or rather the two polar oceans; I would have also liked to read about the seas of the seasonal sea-ice zone such as the Baltic Sea, the Bering Sea and Hudson Bay. Chapter 2 presents sea-ice structure and then gives a thorough description of the development of both thermally and mechanically produced types of ice, including the formation of leads and polynyas. The sea-ice salinity question is also well covered. Chapter 3 deals with the thermodynamics of sea ice. Thermal properties of sea ice are first presented, then follows a brief section about analytical models, and finally the Maykut–Untersteiner model is shown in detail with analysis of its outcome. What I missed here was more of the physical background to the analytical models, as well as their solutions. It might also have been valuable to discuss quantitatively the thermodynamics of other ice types. Chapter 4 is about sea-ice drift. The physics is well presented, as is the free-drift solution, i.e. ice drift in the absence of internal friction. However, only a very brief verbal description and one figure illustrate numerical ice models. Although models are models, and not real Nature, complex numerical models are presently so widely used in sea-ice dynamics that a basic description of their background and solution methodology is desirable in a book like this.

Chapter 5 gives a comprehensive presentation of pressure-ridge statistics and ice-thickness distribution, and is a synthesis of the author's own extensive work with proper

review of other papers. Sections on measurement techniques and applications are included, though the omission of thermal infrared thickness mapping is puzzling. Nevertheless, this is a particularly enjoyable chapter, teaching how much is known, and why more should be known, about the sea-ice thickness field. Chapter 6, on marginal ice zones, deals with geography, wave–ice interaction, and ice-edge geometry-related processes such as ice bands and eddies. Again this chapter is excellent, largely based on the long-term experience of the author, who in fact wrote his Ph.D. thesis on ice–wave interactions in the marginal ice zone. Here, I missed seeing a little more on air–ice–ocean coupling phenomena in the marginal ice zone. Chapter 7 is a thorough presentation of the formation, drift and decay of icebergs, including discussion of their significance to man via scouring and fresh-water potential.

The final chapter discusses environmental and climatic aspects of sea ice. On the one hand, sea ice is a sensitive indicator of climate change, and on the other hand, the climate changes and impacts on the sea-ice environment. Sea-ice ecology, including life inside as well as below ice, is an exciting topic on which geophysicists and biologists are presently collaborating, and the strong two-way link between the disciplines is obvious here. The transport of pollutants by ice is also briefly discussed. The chapter ends with the important role of sea ice in the climate problem, concluding that there is still much to be investigated and many open problems to work on. Maybe “new” sea ice will be found elsewhere, such as on Jupiter's satellite Europa. At the end of the book there is a list of further reading, accompanied by comments providing an excellent guide for newcomers to the field who want to read the historical sea-ice literature.

My only substantial criticism of the book is its rather weak presentation of mathematical models. Simple analytical models would improve the reader's qualitative understanding of sea-ice geophysics, while presenting the background of numerical models would provide a measure of the quality and reliability of their outcomes.

Peter Wadhams is an excellent writer. The text is clean and easy to follow, it is logically consistent, and the style is pleasant. Also the author knows and cites the history of polar exploration. Knowledge grows out of the author's own experience, and a number of the photographs in the book are by the author. *Ice in the ocean* will serve as a very good textbook for an undergraduate-level first course in sea-ice science. Even more, this book belongs on the shelves of all students and scientists of polar oceans and sea ice.

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## REFERENCE

- Doronin, Yu. P. and D. Ye. Kheisin. 1977. *Sea ice*. New Delhi, Amerind Publishing Co. (Translation of *Morskoi Led*, Gidrometeoizdat, Leningrad, 1975.)