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BOOK REVIEW

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'Introduction to Physical Oceanography' by Mirko Orlić

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The development of physical oceanography over the last fifty years since the last Croatian textbook was published (Buljan and Zore-Armanda, 1971) has been enormous. New advanced measurement techniques and data analyses have been used, leading to better understanding and improved knowledge of marine processes. Although courses in physical oceanography, or closely related ones with topics from physical oceanography, are offered at Croatian universities from undergraduate to postgraduate levels, new modern textbook encompassing new achievements and written in Croatian was missing. The book 'Introduction to Physical Oceanography' by academician and professor at the University of Zagreb Mirko Orlić (2022) clearly fills the gap (Fig. 1).

The book is based on the courses that Professor Orlić has given for many years at the Department of Geophysics of the University of Zagreb to undergraduate, graduate and postgraduate students, to undergraduate students of biology and geology at the universities in Zagreb and Split and to postgraduate students of oceanology, doctoral study jointly organized by the University of Zagreb, the Ruđer Bošković Institute in Zagreb and Rovinj, the Institute of Oceanography and Fisheries in Split and the University of Dubrovnik. The book has undergone a rigorous review and is approved as a university textbook.

The textbook is divided into two parts, the first considers descriptive oceanography, while the second is based on dynamical approach. Having such unique concept, the book can be used by students of geophysics but also by students of other disciplines, such as biology, geology, geography etc., for whom physical oceanography is important but not the main subject of study. Students of geophysics are advised to read the entire book, whereas others should concentrate on the first part of the book. Thus, the book can be used in two different ways. Students with advanced background in mathematics will study the whole book (the author advises to group the chapters according to formula 1, 2+7, 3+8, 4+9, 5+10, 6+11), while those with only basic knowledge of mathematics will focus on the first part of the book (chapters 1, 2, 3, 4, 5 and 6).

The first chapter of the book describes the origin of the discipline's name, lists parameters and processes studied by physical oceanographers and explains the relationships between physical oceanography and other scientific disciplines. The optimal research method, which includes an empirical and a theoretical approach, is illustrated with the historical development in some fundamental topics of physical oceanography: ocean surface circulation, wind waves and tides. Finally, the practical significance of the findings of physical oceanography in addressing threats of natural and anthropogenic origin and in exploiting marine resources is presented.

After the introductory chapter, the next five chapters are devoted to descriptive physical oceanography, a discipline that encompasses data collection, analysis and interpretation of results using simple conceptual models. Chapter 2 presents the methods of data collection and the instruments used in the field work. The methods of data collection and determination of physical properties (salinity, temperature, pressure, density, and water

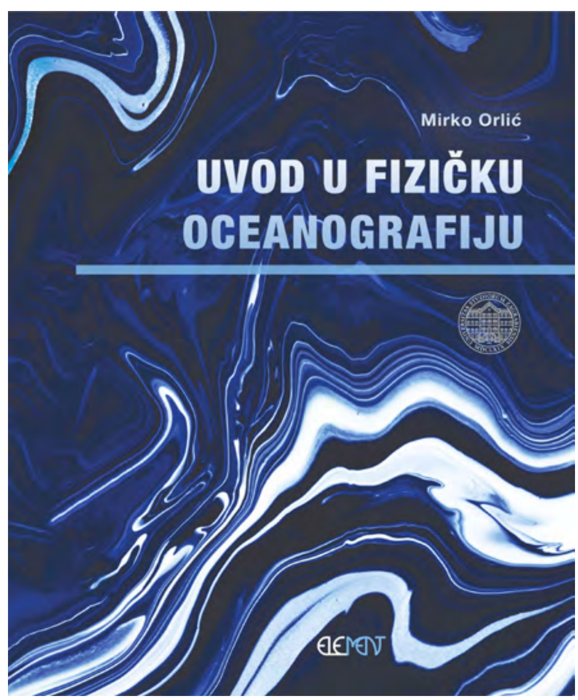

Fig. 1. Cover of the textbook 'Introduction on Physical Oceanography' by Mirko Orlić (2022) (reproduced from Orlić, 2022).

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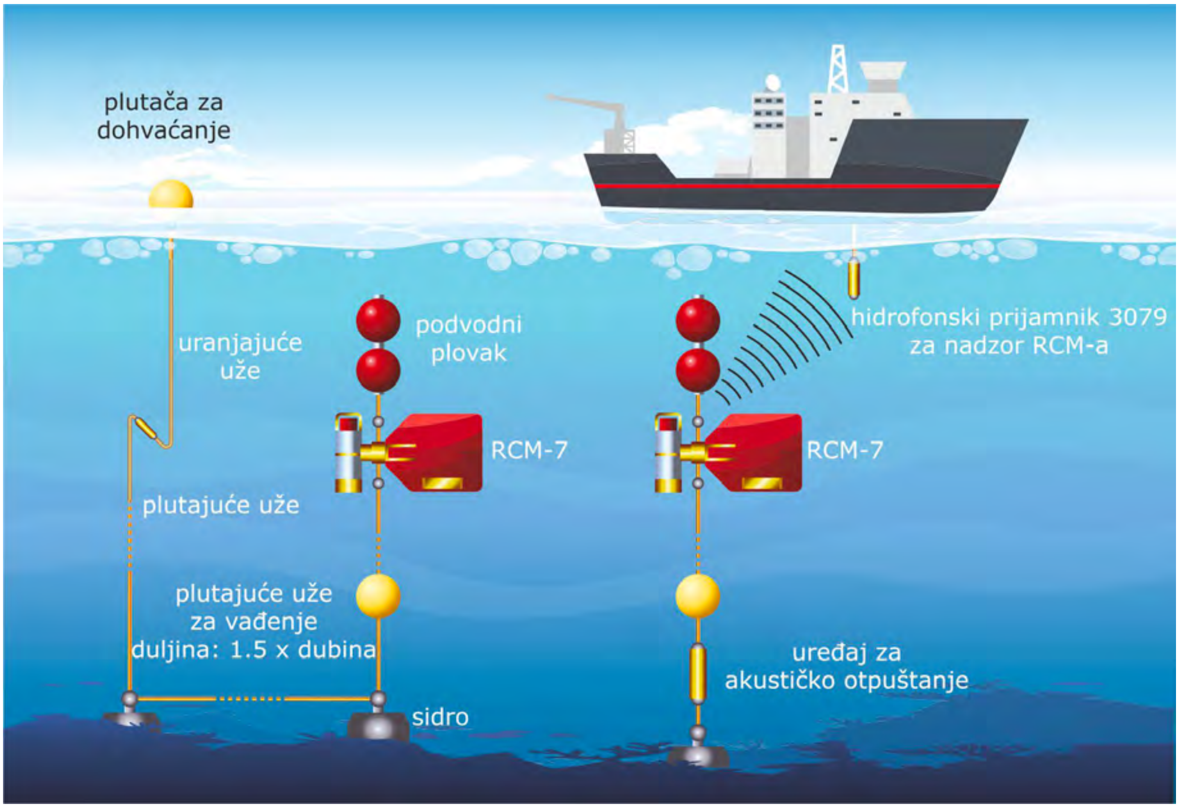

Fig. 2. Two types of current meter moorings: U-mooring (left) and I-mooring (right) (reproduced from Orlić, 2022).

masses) are described and followed by measurements of currents (Fig. 2), short- and long-period oscillations of sea level. An overview of measuring platforms, remote sensing techniques, and a list of famous oceanographic expeditions and experiments complete this chapter. In describing the measurement methods, Professor Orlić begins with the classical methods used before massive implementation of the electronics in oceanographic instruments. The designers of the early instruments were forced to find ingenuous solutions for recording the results, like for example in the reversing thermometer or the Ekman current meter. After a brief overview of the historical development, more recent methods and up-to-date instruments are presented.

Chapter 3 addresses internal and external factors that determine the spatial and temporal variability of oceanographic parameters in the global ocean, the Mediterranean Sea and the Adriatic Sea. Numerous illustrations give insight into the three-dimensional distribution of salinity, temperature, pressure, density and water masses in the three areas mentioned (e.g. Fig. 3). The description of the mean fields is followed by the presentation of their interannual and seasonal variations.

Chapter 4 is devoted to the general circulation, i.e. quasi-steady currents, again using a zooming approach, from the global ocean, to the Mediterranean and the Adriatic Sea. Simple models that can explain most of the general circulation: hydrostatic and geostrophic, are briefly discussed. After kinematic illustration of the quasi-steady currents obtained from measurements, the main circulation drivers are considered: wind and surface heat and water fluxes. The basics of analytical models related to wind forcing – Ekman models for drift currents, slope currents and relative currents – are presented and used to explain the main features of the surface ocean flow. The basic mechanisms of thermohaline circulation are explained and applied to the general circulation in the deep ocean layers, the Mediterranean Sea and the Adriatic Sea.

Time-variable processes are described in Chapters 5 and 6. Several types of free waves (gravity, inertial, and Rossby or planetary waves) are considered in Chapter 5. Short-period gravity waves are usually divided into two classes using the ratio between depth and wave length: deep-water waves and shallow-water waves. Long-period waves with periods over one day are divided into two classes based on the relationship between local and Coriolis accelerations. Examples of waves in the first-class are seiches and inertial oscillations, while Rossby or planetary waves belong to the second class. A number of illustrations facilitates the understanding of free waves. Forced motions are examined in Chapter 6, focusing on the most important ones – those under the gravitational influence of the Moon and Sun, atmospheric forcing (air pressure and winds), and surface heat and water fluxes.

The second part of the book deals with dynamical oceanography, a theoretical discipline in which the solutions of partial differential equations describe the properties and motions of the seas and oceans. The chapters are organized in a similar way as in the first part of the book. Chapter 7 introduces the main tool of dynamical

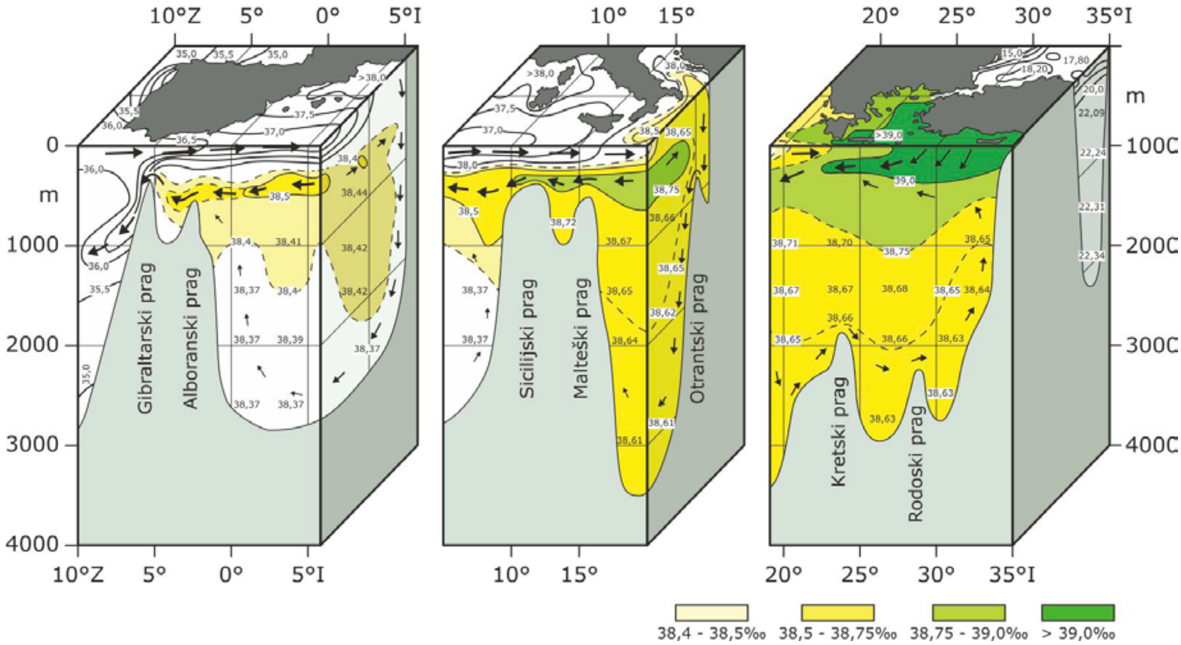

Fig. 3. Salinity and current distributions at three vertical transects in the Mediterranean Sea (reproduced from Orlić, 2022).

oceanography – seven partial differential equations with corresponding boundary conditions.

In Chapter 8, related to Chapter 3 in the first part of the book, three mathematical models dealing with the spatial distribution of temperature and salinity and annual variations in sea temperature are presented. The models are based on the simplified equations for the conservation of heat and salt and, like all other models presented in this book, result in explicit solutions.

The Reynold's equations of motion subjected to geostrophic and hydrostatic approximation are solved in Chapter 9. Obtained solution, mentioned also in Chapter 4, is given here with many more details important for the quasi-steady circulation. Mathematical models developed by Swedish oceanographer Vagn Walfrid Ekman for drift, slope and relative currents and their solutions are thoroughly explained. Forcing by surface heat and water fluxes is examined using simplified mathematical models. Thermal and haline circulations are first considered separately, and then, as both models are linear, their superposition is also presented.

The last two chapters deal with models for free and forced time-variable motions. The same classes of motion are considered here as in the first part of the book. Mathematical models of short- and long-period free waves are developed, as are models of tides, storm surge and sea level rise. Mathematical formulation of tide-generating force is presented together with the Newton's equilibrium theory of tides.

At the end of the book, Professor Orlić, gives a comprehensive list of primary and secondary sources used in the preparation of the book.

The textbook, written by Professor Mirko Orlić and published by Element d.o.o., is a valuable contribution for all students and teachers of physical oceanography in Croatia since before the publication of this textbook they were forced to use either English books or outdated texts in their native language. The division of the book into two parts, dealing with descriptive and dynamical oceanography, allows its wide use – by students of geophysics, but also by other students whose main subject is not physical oceanography. An additional advantage of the book for Croatian students is the overview of physical properties and processes (salinity, temperature, density, water masses and circulation) in the Adriatic Sea given in the first part of the book. Besides fundamental and advanced lectures, the author provides contributions to terminology and language used in Croatian physical oceanography, burdened by many inadequately used terms, mostly taken from English.

The clear text and numerous illustrations easily introduce the reader to the subject of physical oceanography, both to basic and traditional knowledge and to new theories and methods.

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