[Review of: T. Kiørboe (2008) A mechanistic approach to plankton ecology]

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BOOK REVIEWS

THOMAS KIØRBOE. 2008. **A Mechanistic Approach to Plankton Ecology**. Princeton University Press. ISBN: 978-0-691-13422-2. 228 p. US$39.50.

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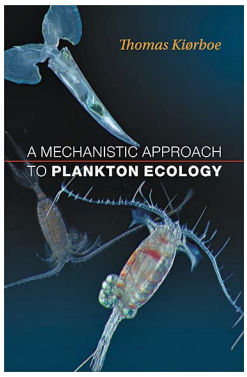
Kiørboe's book offers an exciting tour through biological-physical interactions in the plankton. The book successfully demonstrates how basic knowledge of small-scale physical and chemical processes contributes to a better understanding of plankton ecology at the individual level. Expanding on these individual-level processes, the book produces new insights in community dynamics, and the structure and functioning of pelagic food webs. It is an outstanding overview of ongoing research on plankton encounter rates, and will be highly suitable for seminars and advanced student courses.



The first chapters present an invitation to think about notions at the core of plankton ecology. Kiørboe leads the reader through a variety of ideas and fundamental questions to develop an intuitive understanding of the everyday life of individual plankters. At the individual level, the life of planktonic organisms is all about encounters. They have to find food, they have to find mates, and they should stay away from predators. These might seem simple and familiar tasks. After all, human beings also enjoy a good dinner, like to find a good mate, and prefer to avoid any undesired encounters. Yet imagine yourself as a tiny little plankter in the middle of the endless ocean, mostly blind-folded. The surrounding fluid is three-dimensional, concentrations of food are extremely low, and the nearest mate can be thousands of body lengths away. In addition, the surrounding fluid feels like dense syrup as the viscosity of water dominates over inertial forces at these small scales. Swimming is demanding. Got the picture? How are you ever going to arrive at dinner in time, let alone find yourself a suitable mate in this unstructured, viscous and vast environment? The ocean environment as experienced from the perspective of a small plankter isn't quite the same as our own world after all.

Natural selection has favored a multitude of adaptations in the individual behavior, morphology, and ecology of planktonic organisms to cope with these challenges. Take the copepods, which make up about 80% of the mesozooplankton in the oceans. As nicely illustrated on the front cover of the book, copepods have two huge antennules packed with sensory hairs sticking out in the water, aimed at chemical and hydromechanical signals in the environment. They put this sensory machinery into use to explore their surroundings. For instance, female copepods can leave a long trail of pheromones behind as they slowly swim through the endless ocean. Male copepods crossing this trail pick up the scent, and track the convoluted trail. During tracking, the male constantly checks the borders of the trail by chemoreceptive sensors on its antennules, and adjusts its chase accordingly, until he finally makes it to the female. Kiørboe discusses these spectacular stories in a very lucid style, and then moves on to derive equations that allow a quantitative evaluation of the implications. For instance, based on simple calculus, he shows that pheromone tracking increases the encounter rates of males and females substantially. Girls shouldn't leave without a trace.

These analyses point to the issue of spatial scale. Do we observe plankton dynamics at scales relevant to the organisms? Much of our knowledge of aquatic ecosystems is based on "blind sampling," where we simply scoop up a few liters of water, several meters apart along the vertical, and enumerate the organisms in our samples. However, these coarse methods only sample bulk properties of aquatic ecosystems. Kiørboe argues, convincingly, that these sampling methods exceed the spatial scale of individual plankters by orders of magnitude. The whole book builds up on this logic. It starts from descriptions of the spatial and temporal scales at which chemical signals and food particles are dispersed by diffusion and advection, and shows how these important transport processes affect the feeding rates and motility of individual organisms. Subsequently, Kiørboe discusses the emergence of global properties at larger scales, extrapolating the individual-based processes from preceding chapters to the population level. For instance, according to the coagulation theory developed with his colleague George Jackson, encounters between sticky particles can ultimately lead to the formation of large aggregates in the form of marine snow. Such aggregate formation has important implications for the dynamics of phytoplankton populations, which suffer large sedimentation losses by coagulation, and for the downward flux of organic carbon from surface waters into the deep ocean. Finally, in the last chapter of the book, the individual- and population-level processes are integrated to gain a more comprehensive understanding of the dynamics of entire pelagic food webs.

Emphasis is clearly set on processes at the organism scale. Hence, the chapters on community processes and ecosystem dynamics are relatively brief, and the book does not cover all aspects of plankton ecology. In particular, the title of the book may suggest that it covers mechanistic approaches to competition theory, which is textbook material in many undergraduate ecology courses, and has been extensively tested in plankton competition studies (e.g., papers by Tilman, Sommer, Grover, Rothhaupt, Lampert, and several others). However, although the book contains many useful references to competition studies, the book does not review resource competition theory, and also doesn't tackle several other hot topics in plankton ecology such as ecological stoichiometry, inducible defenses, biogeochemical processes, and regime shifts in aquatic ecosystems. The book is more limited in scope than the title suggests. Clearly, dealing with all these topics would have been a tremendous task, and would have diluted the original message of the book in a mass of information. The book may thus present a starting point for plankton ecologists, to inspire further research linking the small-scale physical processes that are so important in the everyday life of the plankton with other important themes in plankton ecology. The intended audience of the book consists of graduate students and postdocs as well as senior researchers. Some understanding of biological oceanography and/or aquatic ecology, at the undergraduate level, is recommended. Many of the conceptual ideas build on earlier books on physical-biological interactions by Denny (1993), Berg (1993), and Vogel (1994). However, none of these earlier books focused specifically on the plankton. The author makes extensive use of simple fluid dynamics and diffusion theory to understand and evaluate the adaptations of planktonic organisms to their physical and chemical surroundings. Hence, mathematical equations are presented throughout the book. Yet, the math never becomes really complicated. A basic knowledge of high school calculus is required, and is often (but not always) sufficient to follow the arguments. It is clear from the careful explanations that much of the material has been developed as teaching material for courses. The writing style is very pleasant and reveals a passionate author, who offers his thoughts, and shares his experience, in a very didactic synthesis. Last but not least, the book is affordable (only US$ 39.50!). If you are interested in the state of the art on life at the scale of the individual plankter, then this book is definitely something for you!

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