Preface

Virtual Plankton Ecology (VPE) creates complex mathematical simulations of the ocean plankton ecosystem. The simulations are called Virtual Ecosystems (VEs). A VE simulates the ecosystem in a mid-ocean mesoscosm. It includes the changing environment and the life histories of all the individual plankters in the mesocosm. The life histories are used to compute the demography of each population and its biofeedback to the environment. The simulated environment, plankton histories, demography and biofeedback are all free emergent properties of the VE.

Exploring a virtual ecosystem reveals ecological processes involving complex interactions between the environment and the plankton. The VE contains all the information needed to explain these processes in terms of the basic laws of physics, chemistry and biology contained in the model equations. The latter are called primitive equations because they are derived from reproducible experiments performed in a laboratory under controlled conditions. That applies as well to biology as to physics and chemistry. Biological primitive equations are phenotypic equations describing how a plankter responds to its local environment, either physiologically or by its behaviour. The existence of plankton life histories in virtual ecosystems is a prerequisite for explaining ecological processes in terms of phenotypic equations.

So a virtual ecosystem contains a comprehensive description capable of revealing both familiar and new ecological processes and explaining them in terms of the basic laws of nature. However, it is an artificial ecosystem that is much simpler than that in the ocean because it contains less than one percent of the species. Nevertheless, we commonly find that ecological processes identified in virtual ecosystems are similar to those identified in experimental data sets collected at sea. That encourages us to make two bold hypotheses.

1. Ecological processes found in virtual ecosystems are likely to occur in the ocean, even though they may not yet have been found in experimental data.
2. The scientific explanations of ecological processes diagnosed in virtual ecosystems will also apply to the ocean.

We expect that it will be possible to test the first hypothesis by suitable experiments at sea. But it will never be possible to test the second hypothesis directly because experimental data sets do not support the kind of diagnosis possible in virtual ecosystems. It is impossible to tag an individual plankter, and to construct an audit trail of its physiological and behavioural response to ambient environment.[2]

If the hypotheses are justified, virtual plankton ecology can make a useful contribution to biological oceanography, and eventually (when sufficiently powerful computers become available) to operational oceanography.

This book presents evidence to support the hypotheses.

Part One (chapters 1-9) focuses on the underpinning science.

Part Two (chapters 10-12) shows how to create and analyse a virtual ecosystem.

Part Three (chapters 13-24) addresses the second hypothesis; it compares a dozen classical paradigms of biological oceanography with the corresponding emergent phenomena in virtual ecosystems. In each case the paradigm is recognizable in the virtual ecosystem. However, in many cases there are interesting differences in detail. Analysing the environmental fields and the life histories of individual plankters reveals the causes of these differences in terms of the laws of marine physics, chemistry and biology contained in the model equations.

Part Four (chapters 25-29) considers applications in operational oceanography that will follow once we have established the credentials of virtual ecology.

Part Five (chapters 30-31) looks more generally at the future of mathematical simulation of the plankton ecosystem.

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[2] An audit trail quantifies the life history of a plankter. It comprises time series of the plankter's location and biological state, and of its ambient environment (the values of all environmental variables at its precise location). See Chapter 2.