

Preface

The ocean fascinates people all over the world, including, of course, undergraduate marine biology students. For many students, taking marine biology is the natural expression of an interest in marine life that began by visiting the shore, scuba diving, recreational fishing, aquarium keeping, or viewing one of the many television documentaries about the ocean. Many students are also concerned about the increasing impacts of humans on the marine environment. *Marine Biology, eleventh edition*, was written to reinforce and enhance our readers' enchantment with marine life while providing a rigorous introduction to marine biology as a science.

Marine Biology is used by undergraduate, graduate, high school, and adult-education students, as well as by interested laypersons not enrolled in formal courses. We are gratified that many professional marine biologists use the book. The book is used in many countries outside the United States, and has been or is being translated into six other languages. While keeping this range of users in mind, the text is primarily written to meet the needs of lower-division, non-science majors at colleges and universities. For many of these students, marine biology will be their only tertiary science course, often taken to satisfy a general education requirement. We have therefore been careful to provide solid basic science coverage, including principles of the scientific method, the physical sciences, and basic biology. Our aim has been to integrate this basic science content with a stimulating, up-to-date overview of marine biology. We hope this approach demonstrates the relevance of the physical sciences to biology and makes all sciences less intimidating. To this end, we use an informal writing style that emphasizes an understanding of concepts over rigorous detail and terminology.

Not all marine biology courses, of course, are intended to fulfill a basic science requirement, and in many the students already have a science background. To balance the needs of instructors teaching courses with and without prerequisites in biology or other sciences, we have designed the book to provide as much flexibility as possible in the use of the basic science material, the order in which topics are presented, and overall emphasis and approach. We have tried to meet the needs and expectations of a wide variety of students, from the scuba-diving philosophy major to the biology major considering a marine science career. We hope a variety of readers other than university students also find the book useful and enjoyable.

Four major themes run through *Marine Biology*. One is the above mentioned coverage of basic science applied to the marine environment. Another is an emphasis on the organisms themselves, and their vast diversity not only in taxonomic terms but also in structure, function, and ecology. A third theme is an ecosystem approach that integrates this organismal diversity with the challenges imposed by the surrounding environment, both physical and biological. A

final theme that, unfortunately, becomes more urgent with each passing year is the impact of humans on the marine environment.

Marine Biology, eleventh edition, adopts a global perspective to emphasize that the world's oceans and seas are an integrated system that cannot be understood by looking in any one person's own backyard. For many students this is a new perspective. One aspect of our global approach is the deliberate inclusion of examples from many different regions and ecosystems so that as many students as possible, not just in North America but around the world, will find something relevant to their local areas or places they have visited. We hope this will stimulate them to think about the many relationships between their own shores and the one world ocean that so greatly influences all our lives.

CHANGES IN THE ELEVENTH EDITION

Like all new editions of *Marine Biology*, we have made extensive revisions to the eleventh edition to correct errors, incorporate new information, and improve readability. In many cases our revisions reflect comments by reviewers, whose suggestions we greatly appreciate. Much of the data presented in the eleventh edition has been updated to the latest information available at the time of writing. Updates include, among others, numbers of known species in various taxonomic groups, conservation status and population sizes of many threatened species, shark-attack frequency, data on global and regional climate, sea level, CO₂, hypoxic zones, paralytic shellfish poisoning, and the Antarctic ozone hole. The latest available data are also used for fisheries catches, aquaculture production, and seafood demand and consumption, and the extent of Arctic sea ice.

Many chapters in the eleventh edition include more information on the effects of global change on species and ecosystems in addition to the *Special Report: Our Changing Planet*. The coverage also in many cases reflects increasing scientific certainty regarding global change and its effects on the ocean.

We have updated or added information on many other topics. There are too many such changes to fully list here, but examples include the following:

- Discussion of the importance of natural experiments and the use of models in the scientific method
- Additional information on the role of the sea in ancient human migration
- Updated information on ocean observing systems
- Replaced Figure 2.6 with the most recent representation of the global sea floor

- Updated information on the formation of the Hawaiian Islands and mantle plumes
- New information on the role of viruses in the ocean
- Extensively revised coverage of sexual reproduction in seaweeds and marine plants, with a revised Figure 6.11
- New or updated information on the biology and ecology of many groups of organisms, from mangroves to marine mammals
- Additional information on the ecology of chemosynthetic bacteria
- Updated phylogenetic relationships and classification in invertebrates, with Figure 7.1 and Table 7.1 revised
- More information on the restoration of seagrass, saltmarsh, mangrove, and coral reef communities
- New information on hunting behavior and the role of older females in orcas, captive cetaceans, interactions among dolphins, and the reproductive tract of dolphins
- Extensive new information on small cetaceans including the vaquita and Maui's dolphin, with a new figure for the vaquita
- New information on infections of the cat parasite *Toxoplasma* in marine mammals
- Information on the effects of melting polar ice on cetaceans, polar bears, and polar subtidal communities
- How recent natural experiments are changing our view of the role of *Pisaster* as a keystone predator and potential roles of other sea stars
- Coverage of mass coral bleaching globally during 2014–2017
- New findings on the existing effects of climate change on human health
- Reproductive and physiological adaptation in the vampire squid
- Updated information on the ocean as a source of energy for humans
- Updated information on Alaska's *Exxon Valdez* oil spill, invasive marine species, and marine protected areas

The "Eye on Science" boxes, which have proven to be very popular among students and instructors alike, have been extensively updated. We have also added new Eye on Science boxes on a symbiosis between a barnacle and cyanobacteria in the intertidal, sea star wasting disease, coral reef resilience, and microplastic pollution.

Many of the eleventh edition's figures have been extensively revised and redesigned by Bill Ober and Claire Garrison to their usual standard of excellence. A number of figures have been modified to include the new data described above. In some cases, for example, Figures 6.11 on reproduction in marine macrophytes and 7.1 showing invertebrate phylogenetic relationships, the changes reflect important new information. Many other figure revisions include updated or added content, or make the figures more understandable, accurate, and

eye-catching. We have also added a number of new photographs throughout the book.

ORGANIZATION

Marine Biology is organized into four parts. **Part one** (*Chapters 1 through 4*) introduces students to marine biology and the basic sciences that underpin it. *Chapter 1* describes the history of marine biology. It also explains the fundamentals of the scientific method. This feature emphasizes that science is a process, an ongoing human endeavor. We think it is critical that students understand how and why science works, that science has limitations, and that there is still much to be learned. *Chapters 2 and 3* are a basic introduction to marine geology, physics, and chemistry. *Marine Biology* includes more information on these subjects, and places greater stress on their importance to understanding marine ecosystems, than other texts but we have kept *Chapters 2 and 3* as short as possible and have covered many abiotic aspects of the marine environment in the chapters where they are most relevant to the biology. Wave refraction, for example, is described in conjunction with intertidal communities (*Chapter 11*) and estuarine circulation is discussed as part of the ecology of estuaries (*Chapter 12*). This approach emphasizes the importance of the physical and chemical environment to the organisms of the sea throughout the book. At the same time, it provides flexibility for instructors to make best use of the material in light of general education requirements, course prerequisites, and students' backgrounds. *Chapter 4*, "Fundamentals of Biology," briefly reviews some essential biological concepts. In covering basic biology we have tried to balance the needs of a spectrum of students ranging from those with no prior university-level instruction to those who have taken a number of biology courses. Depending on the level of their students, instructors may choose to cover *Chapter 4* in class, assign it as review reading, or omit it and rely on the in-text glossary entries in later chapters to remind students of the definitions of key terms.

Part Two (*Chapters 5 through 9*) surveys the diversity of marine life from the perspective of organismal biology. As in Part One, we provide introductory information that is reviewed and expanded upon in later chapters. In discussing the various taxa we emphasize functional morphology, ecological and physiological adaptations, and economic importance or other significance to humanity. Classification and phylogeny are not stressed, though we do present cladograms illustrating widely accepted phylogenetic schemes for invertebrates and vertebrates. As in the rest of the book we have selected organisms from around the world for photographs, line drawings, and color paintings, but organisms from the coasts of North America are emphasized. Organisms are referred to by their most widely accepted common names. One or two common or important genera are noted in parentheses the first time a group is mentioned in a chapter, but we have not attempted to provide comprehensive lists of genera.

Part Three of the book (*Chapters 10 through 16*) presents an ecological tour of the major environments of the world ocean, commencing with an introduction to some fundamental principles of marine ecology in *Chapter 10*. As in *Chapter 4*, important concepts presented here are reviewed elsewhere in the in-text glossary boxes.

The remaining six chapters of Part Three proceed from nearshore to offshore and from shallow to deep water, describing the physical characteristics of each environment and the adaptations and interactions of the organisms that live there. This admittedly arbitrary sequence follows the teaching sequence of the greatest number of our reviewers, but the chapters are designed so that they can be covered in any sequence according to instructors' preferences and needs. Most chapters include generalized food webs with standardized color coding to indicate the nature of the trophic relationships. Part Three also contains the *Special Report: Our Changing Planet*, a feature on anthropogenic global change that was introduced in the seventh edition.

Finally, **Part Four** looks at the many ways in which humans interact with the world ocean: our use of and impact on the marine environment and the influence of the ocean on the human experience. The section presents an up-to-date, comprehensive view of issues and concerns shared by many students. The chapter on resource utilization (*Chapter 17*) looks not only at traditional uses, such as fisheries, aquaculture, and oil and gas extraction but also at more modern aspects, such as the emerging technologies to generate energy from the sea, the pharmacological use of marine natural products, and the application of genetic engineering and other technologies in aquaculture. *Chapter 18* discusses human-induced degradation of the marine environment, balanced by an examination of marine conservation and habitat restoration.

The *Special Report: Our Changing Planet*, lying roughly in the middle of the book, presents some of the global-scale threats to the ocean resulting from human activities. Much of the material in the *Special Report* could appear in chapters where it is most relevant to specific ecosystems or species. In our opinion, bringing this material together in a single section emphasizes both the global nature of human-induced change in the ocean and the multiple stresses we are imposing. Placing the *Special Report* in the middle of the book results in important related material being covered in later chapters. We think the current placement gives prominence to

this critically important issue even if the *Special Report* has to look forward to later chapters.

ACKNOWLEDGMENTS

Bill Ober and Claire Garrison have again done a superb job of bringing new life to the illustrations, including new ones. We also thank the many contributors of photographs that add so much to the book. Most of all we thank the students, friends, colleagues, former teachers, and reviewers who answered questions, pointed out errors, and made suggestions that have greatly improved the book. We take full credit, however, for any errors or shortcomings that remain.

REVIEWERS

The following people reviewed the tenth edition and have provided useful valuable comments and suggestions for preparing the eleventh edition:

Elena D. Cainas, *Broward College, Central Campus, Davie, Florida*

Hector Douglas, *University of Alaska Fairbanks, Kuskokwim Campus*

Malcom S. Gordon, *University of California, Los Angeles*

Jennifer Harper, *Bainbridge State College, Bainbridge, Georgia*

Marianne McNamara, *Suffolk County Community College, Selden, New York*

Katherine Peach, *Broward College, Fort Lauderdale, Florida*

Amy Reber, *Georgia State University, Atlanta*

Anne Michelle Wood, *University of Oregon, Eugene*

Laurel Zahn, *Occidental College, Los Angeles, California*

