

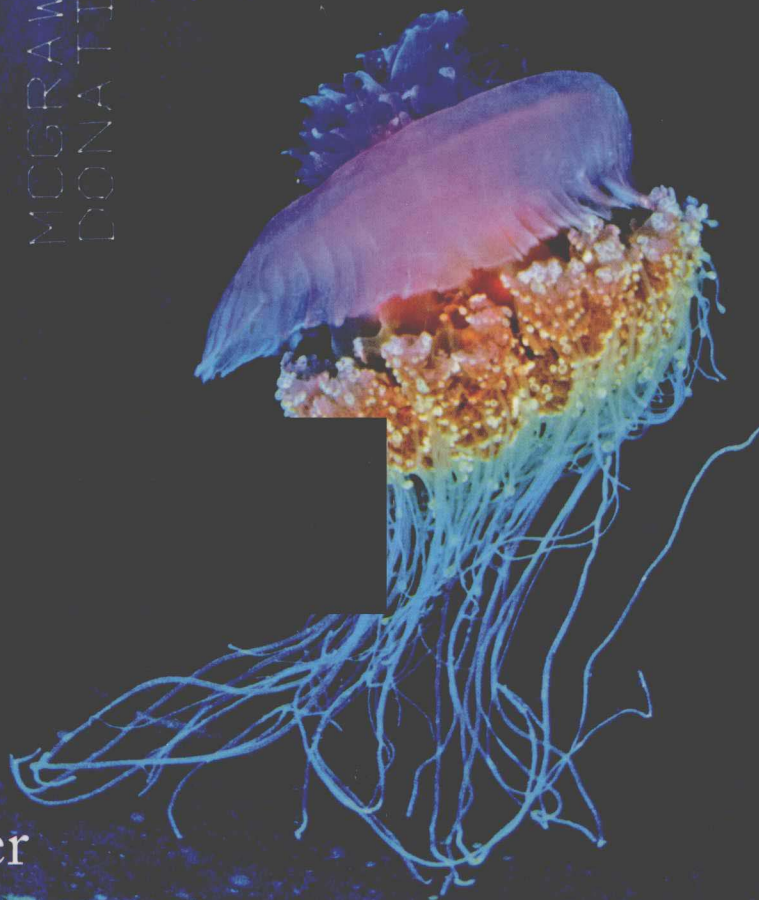
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Marine BIOLOGY

sixth edition

Peter Castro

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Global Coastal Strategies
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Marine **BIOLOGY**

Sixth Edition

ORIGINAL ARTWORK BY

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and

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MARINE BIOLOGY, SIXTH EDITION

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To all future marine biologists

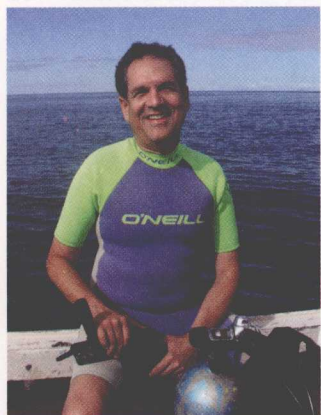
—Peter Castro—



To Mason, Erin, and Kerry, for every
little thing and to my parents for
unfailing support.

—Michael Huber—

About the Authors



Peter Castro, Ph. D.

Peter Castro realized that he had to become a marine biologist during a high school field trip to the coral reefs in his native Puerto Rico. He obtained a B.S. in biology from the University of Puerto Rico, Mayagüez, but left the warm Caribbean for warm Hawaii to obtain a Ph.D. in marine zoology from the University of Hawaii, Manoa. His first experience with cold water was a

year of post-doctoral research at Hopkins Marine Station of Stanford University in California. He is currently professor at California State Polytechnic University, Pomona. He also holds a B.A. in history and art history from his home institution, something that took him eighteen years to accomplish as a part-time student. He is fluent in five languages and taught marine biology (in English and Spanish) as a Fulbright Scholar in the former Soviet Union. His research specialty is the biology of crustaceans symbiotic with reef corals and other invertebrates, a research that has taken him anywhere where the water is warm enough to dive. For the last decade he has also been doing research on the systematics of deep-water crabs, mostly, of all places, in Paris, France.



Michael Huber, Ph. D.

Michael was immediately fascinated by aquatic organisms when he caught his first trout on an Alaskan lake at age two. His interest in marine biology continued to grow over his ensuing school years, and he went on to obtain B.S. degrees in zoology and oceanography from the University of Washington in Seattle. After spending an Alaskan winter managing a laboratory for the trans-Alaskan oil pipeline project, he entered graduate school at Scripps Institution of Oceanography, at the University of California, San Diego. In 1983 he received his doctorate for research on a group of crabs that live symbiotically with corals. He remained at Scripps as a research biologist, working on such diverse research topics as the genetics and cell biology of unicellular algae and bioluminescence in midwater organisms. In 1988 he moved to the Biology Department at the University of Papua New Guinea, where he had the opportunity to work on some of the world's most spectacular coral reefs and was Head of the University's Motupore Island Research Station. He also became increasingly involved in marine environmental science, especially with regard to reefs, mangroves, seagrass beds, and other tropical systems. This interest continued to grow when he left Papua New Guinea in 1994 to become the Scientific Director of James Cook University's Orpheus Island Research Station on Australia's Great Barrier Reef. In 1998 he became a full-time environmental advisor, providing scientific information and advice on marine environmental issues and the development of conservation programs to international agencies, governments, and private industry. Dr. Huber is the Chair of GESAMP, an international scientific body that advises the United Nations system on marine environmental issues, and is currently assisting with the establishment of a permanent UN system to assess and report to governments on the state of the global marine environment.

Dr. Huber lives in Brisbane, Australia with his wife and two children. His hobbies are fishing, diving, swimming, jazz and rock music, reading, and gardening.



Preface

The beauty, mystery, and power of the sea fascinate people all over the world, including; of course, students enrolled in undergraduate marine biology courses. 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 superb television documentaries about the ocean. Many students are also concerned about the increasing impacts of humans on marine ecosystems. ***Marine Biology, Sixth Edition***, was written to reinforce and enhance our readers' enchantment with marine life while providing a rigorous introduction to the science of marine biology.

Marine Biology is used by high school, undergraduate, graduate, and adult education students, and by interested laypersons not enrolled in formal courses. We are gratified that even some professional marine biologists find the book useful. While keeping this range of users in mind, we have written the text primarily 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 some 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.

We recognize that general science content is not a requirement for all marine

biology courses, either because the course is not intended to satisfy general education requirements or because students already have a background in science. 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 career in marine science. 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 abovementioned 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, for better or worse, becomes increasingly relevant with each passing year is the interaction of humans with the marine environment.

Marine Biology, Sixth 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 our lives.

Changes in the Sixth Edition

We have introduced a new feature to the sixth edition of ***Marine Biology***: each chapter includes an **Eye on Science** box; a vignette of a particular piece of ongoing or planned research. Rather than simply presenting factual information and summarizing results, the emphasis is on giving students a glimpse of what scientists actually do—the questions being asked, their significance, and how a scientist or research team has set about answering them. We hope this helps science seem less remote and gives students better insight into the daily process of scientific enquiry.

As in previous editions we have updated the text throughout to reflect recent events, new research, and changes in perspective, and to include information requested by reviewers. A few examples of such revisions or additions are:

- Larger, more attractive, and more detailed maps of the sea floor and the major coastal habitats of North America, now as an end-piece foldout
- A description of the importance of the United States Exploring Expedition (the Wilkes Expedition), which predated the *Challenger* expedition, to the history of marine biology
- A rewritten “Waves That Kill” boxed reading with in-depth coverage of the December 2004 tsunami in the Indian Ocean
- Updated coverage of the origin of chloroplasts by endosymbiosis
- Thorough revision of Table 5.1 on prokaryote metabolism to make it simpler, less imposing, and easier to understand

- New cladograms depicting phylogenetic relationships within both the invertebrates and the vertebrates
- An expanded Figure 9.18 showing various whale species
- A new boxed reading on deep-water coral communities and human impacts on them
- New findings about the benefits to hosts in the anemone-anemonefish symbiosis
- Additional information about trophic cascades
- Coverage on the effects of Hurricane Katrina

In addition to these and many other changes we have as usual updated facts and figures, corrected errors, and reorganized some sections to improve balance and logic flow. In every edition we seek to improve the illustrations and photographs, and in the sixth edition we have adopted a more colorful and open interior design that we think will better engage students and reinforce their fascination with marine life.

Organization

Marine Biology is organized into four parts. **Part 1** (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 critical that students understand how and why science works, and also 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 cover 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 2 (Chapters 5 through 9) surveys the diversity of marine life from the perspective of organismal biology. As in Part 1, 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 illustration in 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. Nomenclature follows for the most part the FAO Species Catalog and Species Identification Guides for groups covered by these references.

Part 3 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 for Chapter 4, important concepts presented here are reviewed elsewhere in the In-text Glossary boxes. The remaining six chapters of Part 3 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.

Finally, **Part 4** 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 and mariculture, but also at more modern aspects such as the pharmacological use of marine natural products and the application of genetic engineering to mariculture. Chapter 18 discusses human-induced degradation of the marine environment, balanced by an examination of marine conservation and habitat restoration. The book closes with an essay on the interactions between the ocean and the human culture (Chapter 19) that we hope will stimulate students to reflect on the past and future significance of the world ocean to all our lives.

Acknowledgments

Bill Ober and Claire Garrison have again done a wonderful job of bringing new life to the illustrations. We are delighted by the new design by Jamie O'Neal. We also thank the many contributors of photographs that add so much to the book, especially A. Charles Arneson, who has provided many excellent photos, and appreciate the diligent efforts of LouAnn Wilson in locating new photos. We are grateful to the editorial staff at McGraw-Hill Publishers, particularly Margaret Kemp, Publisher, Debra Henricks, Developmental Editor, Joyce Watters, Project Manager, and Karen Dorman, copy editor, for their patience, support, and efficiency in managing an enormous amount of detail.

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.

We also give special thanks to the following researchers who provided information, photographs, and other assistance in the preparation of the new “Eye on Science” boxes:

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Reviewers

The following people have reviewed the fifth edition, and have provided useful commentary for preparation of the sixth edition:

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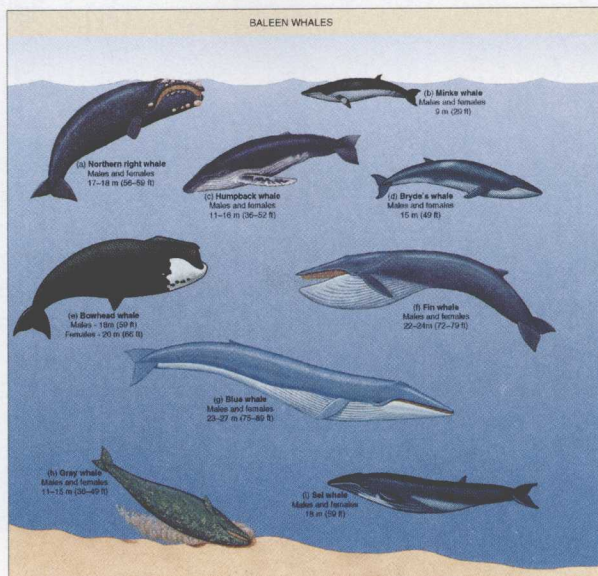


FIGURE 9.15 Representative baleen and toothed whales.

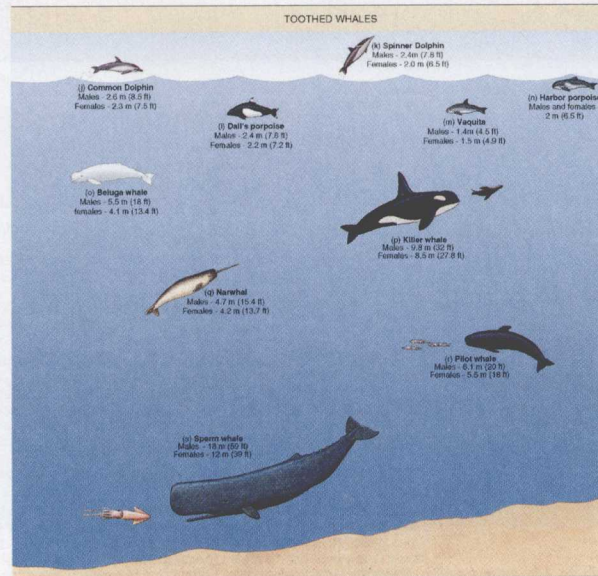
included among the rorquals, feed by gulping up schools of fish and swarms of krill. The lower part of the throat expands when feeding, hence the distinctive accordion-like grooves on the underside of these whales. Krill is the most important part of the rorqual diet, especially in the Southern Hemisphere. Humpback whales often herd

fishes like herring and mackerel by blowing curtains of bubbles around them.

The right whales (*Eubalaena*, *Copæna*, Fig. 9.15a) and the bowhead whale (*Balaena mysticetus*, Fig. 9.15d) are primarily bottom feeders. When examined, their stomachs contain mostly amphipods that inhabit soft bottoms (Table 9.1). Grays stir up the bottom with their jointed

(Fig. 9.17). This allows them to filter small plankton like copepods and some krill (Table 9.1).

Gray whales (*Eichthyrus robustus*) are primarily bottom feeders. When examined, their stomachs contain mostly amphipods that inhabit soft bottoms (Table 9.1). Grays stir up the bottom with their jointed



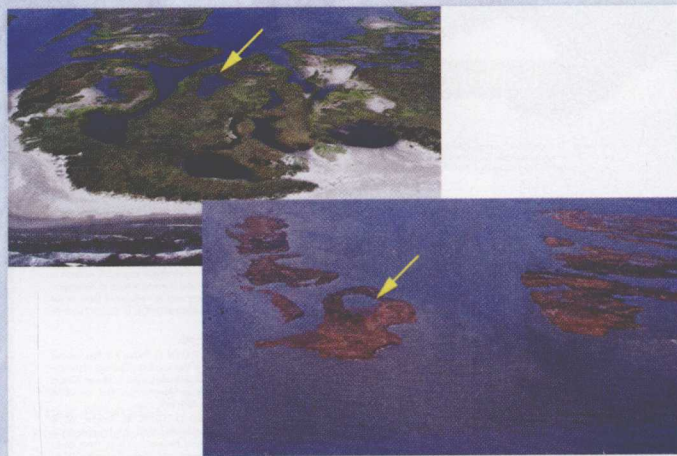
snouts and then filter the sediment (Fig. 9.18b), leaving characteristic pits on the bottom. Most appear to feed on their right sides because the baleen on this side is more worn. Some, however, are "left-handed" and feed on the left side. A 10-week-old female kept in captivity in San Diego, California, ate over 815 kg (1,800 lb)

of squid every day, gaining weight at the rate of 1 kg (2.2 lb) an hour!

The roughly 80 remaining species of cetaceans are toothed whales. Their teeth are adapted for a diet of fish, squid, and other prey. They use the teeth only to catch and hold prey, not to chew it. Food is swallowed whole. As in all cetaceans, food is ground up

in one of the three compartments of the stomach. The blowhole has one opening, as opposed to two in the baleen whales.

Amphipods Small crustaceans whose bodies are compressed from side to side.
• Chapter 7, p. 137 Figure 7.30



Effects of Hurricane Katrina, August 2005 (bottom) on barrier island off the Louisiana coast.

Illustrations and photographs have been carefully designed and selected to complement and reinforce the text. The sixth edition contains many new illustrations and photographs.

Deep-Water Coral Communities

The corals that build tropical coral reefs bask in the sunlight of shallow water, but more than 700 species of corals live in the perpetual cold and darkness of deep water. Deep-water corals occur in all the world's oceans to depths of over 6,000 m (20,000 ft). They do not harbor zooxanthellae, which in the absence of sunlight would be of no use to the host coral. They feed by capturing zooplankton with their tentacles, and generally grow where there are strong currents to bring in food.

About 20 deep-water coral species build or contribute to large mounds on the sea floor known as bioherms. The mounds are usually found on the continental slope or on seamounts and other underwater features at depths of up to 1,500 m (5,000 ft). In some places, Norwegian fjords for example, they occur in water as shallow as 40 m (130 ft). These structures are often called "coral reefs," but the term "reefs" was originally a nautical term for areas of hard bottom shallow enough for ships to run aground, and the geological definition of coral reefs refers to a solid calcium carbonate structure built by corals. Although deep-water coral mounds contain large amounts of calcareous coral fragments, they are mostly mud. It also appears that the mounds form not so much because of coral growth as because of water circulation patterns that favor sediment accumulation. Scientists have also speculated that the mounds might form around cold seeps and rely in part on chemosynthesis.

The largest known deep-water coral mounds, dominated by the branching coral *Lophelia pertusa*, are found in the northeastern Atlantic

off the coast of Britain and Scandinavia. Individual mounds grow to a height of more than 300 m (1,000 ft) above the surrounding muddy bottom, with a base more than 5 km (3 mi) in diameter. Mound complexes can extend for as far as 45 km (30 mi). Whether you call them coral reefs or not, *Lophelia* mounds support rich and diverse communities. The coral branches and broken fragments provide shelter and a hard surface where other sessile species can attach. Relatively few fishes, about 25 species, are known to associate with *Lophelia* mounds, but so far biologists have found more than 1,300 invertebrate species. There could well be more. The *Lophelia* mounds in the northeastern Atlantic have been known since the nineteenth century but have been studied intensively only in the last two decades when improvements in deep-sea exploration technology revealed their true extent and diversity. Mounds made by *Lophelia* and other deep-water corals occur in many other parts of the ocean and support similarly diverse communities, and new mounds are regularly discovered as deep-sea exploration continues.

Like seamount communities (see "Biodiversity in the Deep Sea," p. 311), deep-water coral communities on the continental slope are increasingly threatened by trawling. Many shallow-water fisheries are depleted, forcing trawlers into deeper water. The trawls shatter the fragile corals and dig great gouges in the sea bed. A number of countries have prohibited trawling in areas of known coral mounds, but unfortunately many of these diverse communities remain unprotected.

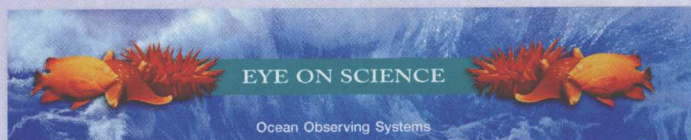


Intact *Lophelia pertusa* mounds are home to many fishes and invertebrates.



Trawl damage to a *Lophelia* mound.

Boxed Essays present interesting supplemental information on varied subjects such as deep-water coral communities, tsunamis, and red tides.



The ocean is constantly changing, and what happens in one place often has far-reaching influences on the rest of the ocean. Unfortunately, research tools like ships and submarines provide only snapshots of a particular time and place, and though repeated visits can give us a series of snapshots we still don't get an uninterrupted picture. Satellites provide a more continuous view, but only of the very surface. To really understand what is going on in the ocean we need an ongoing presence there, an integrated ocean observing system. Much of the necessary technology has already been developed. Satellites, moored and drifting instrument buoys, seafloor instruments, ROVs and AUVs, underwater cameras, and other devices are already in use (see "Marine Biology Today," p. 9). Some of these have been deployed on a very large scale. In the Argo system, for example, floats that measure water temperature and salinity are scattered throughout the ocean. Dropped from a ship or airplane, each float descends to a depth of 2,000 m (6,600 ft), drifts with the current for about 10 days, and surfaces to transmit data via satellite before sinking to start a new cycle. The first floats were launched in 1999 and some 3,000 floats will dot the oceans when the system is fully operational in 2006.

Most ocean observation systems so far, however, cover only a very small part of the ocean, and there are other limitations. Surface buoys can be powered by solar panels and transmit their data by satellite, but neither of these options work underwater. Subsurface instruments have to be regularly retrieved to recharge batteries and download data. Data can also be transmitted underwater by sound waves but only over relatively short distances, so instruments that communicate by sound must be tended by ships or located near hydrophones connected to shore. As one scientist has said, one of the big problems in studying the ocean has been the lack of "televisual outlets and phone jacks on the seafloor."

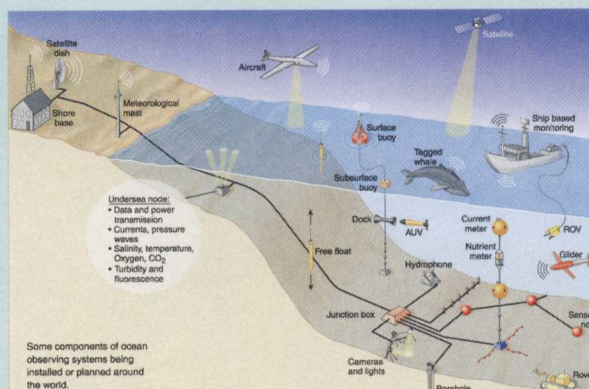
All that is set to change. Today marine scientists envision large-scale ocean observatories. Networks of cable will bring power and communications to a variety of equipment on the sea floor and in the water column. In addition to permanent instrumentation, there will be docking stations where free-ranging AUVs can charge batteries and download

photographs and data, junction boxes where additional instruments can be plugged in as new experiments are designed and new technology becomes available, and hydrophones to gather data from buoys and even instruments attached to animals, all augmented by ship- and satellite-based systems.

Installation of one prototype, the Long-term Ecosystem Observatory (LEO-15) off the coast of New Jersey, commenced in 1994. Another, the Hawaii-2 Observatory (H2O), was established in 1998 when a junction box with several instruments was attached to a decommissioned telephone cable midway between California and Hawaii. Another example is the Monterey Accelerated Research System (MARS), established off Monterey, California, in 2005. These and other observatories at locations around the world cover relatively small areas but are the testing grounds for much larger systems being planned. The North East Pacific Time-integrated Undersea Networked Experiments (NEPTUNE) Observatory aims to establish a system off the west coast of North America from British Columbia to Oregon. Similar systems are being developed in Europe and Japan. Dozens of countries have agreed to one day network these larger systems into a single Global Ocean Observing System (GOOS) that will provide a continuous window on the entire world ocean.

These ambitious plans will take decades to come to fruition but ocean observing systems will greatly improve our understanding of the ocean and have many practical benefits. Students and teachers around the world will be able to learn firsthand what's going on in the sea. We will have much-improved weather forecasting and better warning systems for earthquakes, tsunamis, and storms. Ships of all kinds will have detailed, reliable forecasts of sea conditions. Scientists hope not only to monitor fish populations but also to predict their reproductive success and food supply. These and many other benefits of ocean observatories should one day save both lives and money, and help humanity make wiser use of the oceans—and indeed the entire ocean planet.

For more information, explore the links provided on the Marine Biology Online Learning Center.



Some components of ocean observing systems being installed or planned around the world.

because they allow scientists to rapidly analyze huge amounts of information. Space technology has also aided the study of the sea. Satellites peer down at the ocean and because they are so far away can capture the big picture, viewing broad areas of the ocean all at once (Fig. 1.14).

With the aid of computers, scientists use the information gathered by satellites to measure the temperature of the sea surface, track ocean currents, determine the

abundance and kinds of organisms present, and monitor human impacts on the oceans. Much of our knowledge of large-scale features like ocean currents has been provided by this remote sensing technology, or technology used to study the earth and its oceans from afar. The technology is also being applied at smaller scales. For example, satellites are used to track the migrations of whales, fish, and other organisms that have been fitted with miniature trans-

mitters. Electronic buoys released at oil spill sites drift along with the oil and are tracked by satellite to monitor the path of the spill. These are just a few of the many and ever-increasing applications of remote sensing.

Marine biologists today use every available tool in their study of the sea, even some decidedly low-tech ones (Fig. 1.15). Information about the ocean pours in at an ever-increasing pace. Much remains to

be learned, however, and the oceans remain a realm of great mystery and excitement.

The Scientific Method

Marine biology is an adventure, to be sure, but it is also a science. Scientists, including marine biologists, share a certain way of looking at the world. Students of marine

biology need to be familiar with this approach and how it affects our understanding of the natural world, including the ocean.

We live in an age of science. Advertisers constantly boast of new "scientific" improvements to their products. Newspapers regularly report new breakthroughs, and many television stations have special science reporters. Governments and private companies spend billions of dollars every year on scientific research and science

education. Why has science come to occupy a position of such prestige in our society? The answer, quite simply, is that it works! Science has been among the most successful of human endeavors. Modern society would be impossible without the knowledge and technology produced by science. The lives of almost everyone have been enriched by scientific advances in medicine, agriculture, communication, transportation, art, and countless other fields.

New! Eye on Science boxes reflect current scientific research and technology in the field of marine biology. Sample topics include: ocean observing systems, deep-ocean drilling, female mimicry in cuttlefishes, restoration of seagrass beds, search for the giant squid, etc.

Each chapter ends with an **Interactive Exploration** to be used in conjunction with the Marine Biology Online Learning Center. Students are encouraged to visit www.mhhe.com/castrohuber6 for access to chapter quizzing, interactive chapter summaries, key terms flashcards, marine biology video clips and web links to chapter-related material.

Critical thinking questions challenge students to think more deeply about the chapter material and also help stimulate class discussion.

For Further Reading lists "General Interest" articles in publications such as Scientific American, Discover and National Geographic, which are appropriate for students with limited backgrounds in science; and "In Depth" readings for students who want to study particular topics in detail. Live links for some of the articles may be available in the *Marine Biology* Online Learning Center.

New! A foldout map at the end of text provides quick reference to the World Ocean.

Interactive Exploration

The Marine Biology Online Learning Center is a great place to check your understanding of chapter material. Visit www.mhhe.com/castrohuber6 for access to interactive chapter summaries, key terms, and quizzes! Further enhance your knowledge with marine biology videoclips and web links to chapter-related material.

Critical Thinking

1. In unusually cold winters the northern Black Sea sometimes freezes while the nearby Adriatic Sea usually doesn't even if it is just as cold. Freshwater runoff gives the surface of the Black Sea a low salinity of about 18‰. What would you guess about the salinity of the Adriatic?
2. Just for the fun of it, someone in Beaufort, North Carolina, throws a message in a bottle into the sea. Some time later, someone in Perth, on the west coast of Australia, finds the bottle. Referring to Figure 3.20 and fold-out map of this book, can you trace the path the bottle probably took?
3. If you owned a seaside home and a bad storm brought heavy winds and high surf to your coastline, would you prefer it to be during a new moon or a quarter moon? Why?
4. Most tsunamis occur in the Pacific Ocean, as indicated by the map in the "Waves That Kill" boxed reading (see p. 62). How would you explain this?

General Interest

Cronwell, D., 2000. Ocean circulation. *New Scientist*, vol. 166, no. 2239, 20 May. Inside Science supplement no. 130, pp. 1-4. A summary of what is known about ocean currents and current research efforts to learn more.

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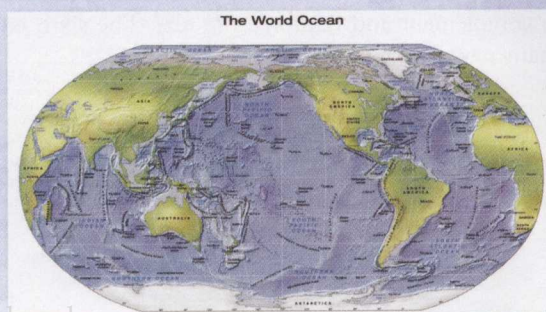
Lim, A., 1983. Oh, what a spin we're in, thanks to the Coriolis effect. *Smithsonian*, vol. 13, no. 11, February, pp. 66-73. A detailed explanation of the Coriolis effect and a look at some of its consequences.

In Depth

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Koeve, W. and H. W. Ducklow, 2001. JGOFS synthesis and modeling: The North Atlantic Ocean. *Deep-Sea Research Part II: Topical Studies in Oceanography*, vol. 48, no. 10, pp. 2141-2154.



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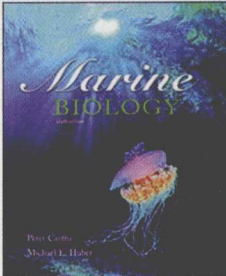
Information Center


Table of Contents
About the Authors
Book Preface
What's New
Feature Summary
List of Reviewers
PageOut
MHHE Catalog
Customize this Text
Locate Your MHHE Sales...

Marine Biology, 6/e
Peter Castro, California State Polytechnic University
Michael E. Huber, Global Coastal Strategies

ISBN: 0072830646
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Marine Biology covers the basics of marine biology with a global approach, using examples from numerous regions and ecosystems worldwide. This introductory, one-semester text is designed for non-majors. Authors Castro and Huber have made a special effort to include solid basic science content needed in a general education course, including the fundamental principles of biology, the physical sciences, and the scientific method. This science coverage is integrated with a stimulating, up-to-date overview of marine biology.



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PREVIOUS • NEXT

cytoskeleton

CLICK TO SEE DEFINITION

A complex framework inside cells made of protein fibers.

Your Results:
The correct answer for each question is indicated by a ✓.

1 CORRECT Ancient Greeks were the first accomplished marine navigators.
Q(A) True
✓ Q(B) False

2 CORRECT Charles Darwin contributed to marine biology by showing for the first time that life exists on the deep-sea floor.
Q(A) True
✓ Q(B) False

3 CORRECT The *Challenger* expedition of the 1870s was the first systematic effort to gather data and samples from oceans around the globe.
✓ Q(A) True
Q(B) False

4 CORRECT The first permanent marine laboratory was built in 1872 in Naples, Italy.
✓ Q(A) True
Q(B) False

5 CORRECT Sonar uses pulses of radio waves to probe the depths of the oceans.
Q(A) True
✓ Q(B) False

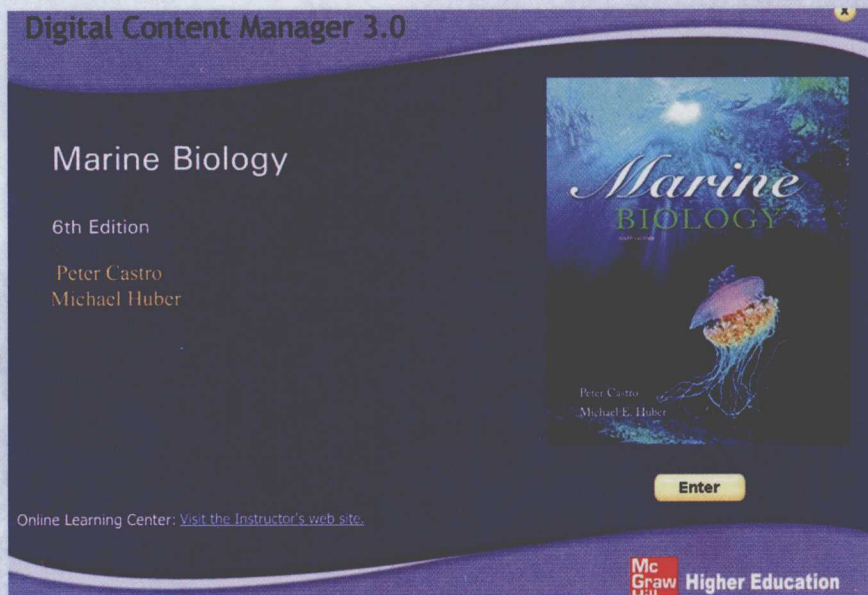


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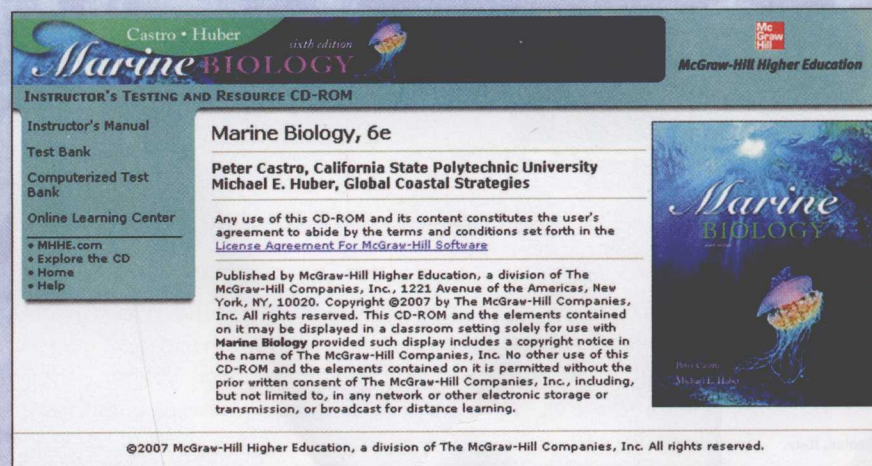
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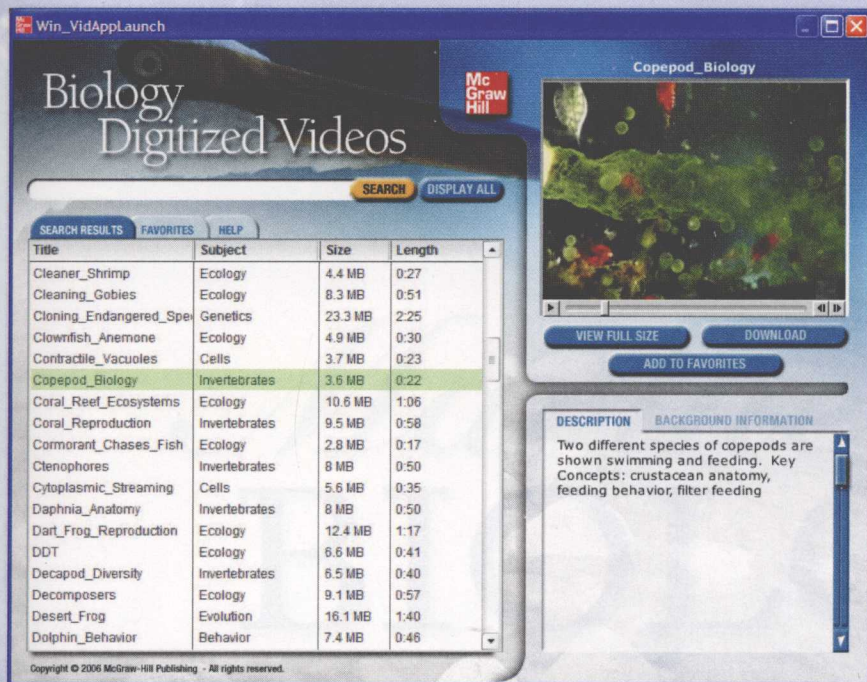
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Brief Contents

Preface xi

Part One Principles of Marine Science

- 1 The Science of Marine Biology 3
- 2 The Sea Floor 22
- 3 Chemical and Physical Features of Seawater and the World Ocean 44
- 4 Fundamentals of Biology 70

Part Two The Organisms of the Sea

- 5 The Microbial World 93
- 6 Multicellular Primary Producers: Seaweeds and Plants 107
- 7 Marine Animals without a Backbone 120
- 8 Marine Fishes 154
- 9 Marine Reptiles, Birds, and Mammals 180

Part Three Structure and Function of Marine Ecosystems

- 10 An Introduction to Marine Ecology 215
- 11 Between the Tides 235
- 12 Estuaries: Where Rivers Meet the Sea 259
- 13 Life on the Continental Shelf 277
- 14 Coral Reefs 297
- 15 Life Near the Surface 324
- 16 The Ocean Depths 354

Part Four Humans and the Sea

- 17 Resources from the Sea 377
- 18 The Impact of Humans on the Marine Environment 402
- 19 The Oceans and Human Affairs 424

Appendix A Units of Measurement 433

Appendix B Selected Field Guides and Other Useful References for the Identification of Marine Organisms 434

Glossary 436

Credits 448

Index 450



Contents

Preface xi

Part One Principles of Marine Science

1 The Science of Marine Biology 3

The Science of Marine Biology 4

- The History of Marine Biology 4
- Marine Biology Today 8

The Scientific Method 11

- Observation: The Currency of Science 12
- Two Ways of Thinking 13
- Testing Ideas 16
- Limitations of the Scientific Method 20

■ BOXED READINGS

Eyes (and Ears) in the Ocean 14
John Steinbeck and Ed Ricketts 18

Interactive Exploration 21

2 The Sea Floor 22

The Water Planet 22

- The Geography of the Ocean Basins 22
- The Structure of the Earth 23

The Origin and Structure of the Ocean Basins 25

- Early Evidence of Continental Drift 25
- The Theory of Plate Tectonics 25
- Geological History of the Earth 34

The Geological Provinces of the Ocean 37

- Continental Margins 37
- Deep-Ocean Basins 39
- The Mid-Ocean Ridge and Hydrothermal Vents 39

■ BOXED READING

The Hawaiian Island Hot Spots, and the Great Mantle Plum Debate 40

Interactive Exploration 43

3 Chemical and Physical Features of Seawater and the World Ocean 44

The Waters of the Ocean 44

- The Unique Nature of Pure Water 44
- Seawater 47

Ocean Circulation 53

- Surface Circulation 53
- Thermohaline Circulation and the Great Ocean Conveyor 58

14 Coral Reefs 297

Waves and Tides 61

- Waves 61
- Tides 65

■ BOXED READINGS

Tall Ships and Surface Currents 54
Waves That Kill 62

Interactive Exploration 69

4 Fundamentals of Biology 70

The Ingredients of Life 70

- The Building Blocks 70
- The Fuel of Life 72

Living Machinery 74

- Cells and Organelles 75
- Levels of Organization 76

Challenges of Life in the Sea 77

- Salinity 78
- Temperature 81
- Surface-to-Volume Ratio 82

Perpetuating Life 82

- Modes of Reproduction 83
- Reproductive Strategies 84

The Diversity of Life in the Sea 84

- Natural Selection and Adaptation 86
- Classifying Living Things 86

■ BOXED READING

From Snack to Servant: How Complex Cells Arose 79

Interactive Exploration 90

Part Two The Organisms of the Sea

5 The Microbial World 93

Prokaryotes 94

- Bacteria 94
- Archaea 96
- Prokaryote Metabolism 98

Unicellular Algae 100

- Diatoms 100
- Dinoflagellates 102
- Other Unicellular Algae 102

Protozoans: The Animal-like Protists 103

- Foraminiferans 104
- Radiolarians 105
- Ciliates 105

Fungi 105

■ BOXED READINGS

- Symbiotic Bacteria—The Essential Guests 95
 Tiny Cells, Big Surprises 97
 The Bay of Fire 103

Interactive Exploration 106

6 Multicellular Primary Producers: Seaweeds and Plants 107

Multicellular Algae: The Seaweeds 108

- General Structure 108
- Types of Seaweeds 109
- Life History 112
- Economic Importance 114

Flowering Plants 114

- Seagrasses 116
- Salt-Marsh Plants 116
- Mangroves 118

■ BOXED READING

- Seaweeds for Gourmets 115

Interactive Exploration 119

7 Marine Animals without a Backbone 120

Sponges 121

Cnidarians: Radial Symmetry 123

- Types of Cnidarians 124
- Biology of Cnidarians 125

Comb Jellies: Radial Symmetry Revisited 126

Bilaterally Symmetrical Worms 127

- Flatworms 127
- Ribbon Worms 128
- Nematodes 129
- Segmented Worms 129
- Peanut Worms 131
- Echiurans 131

Molluscs: The Successful Soft Body 131

- Types of Molluscs 133
- Biology of Molluscs 136

Arthropods: The Armored Achievers 137

- Crustaceans 138
- Biology of Crustaceans 140
- Other Marine Arthropods 141

Lophophorates 143

- Bryozoans 143
- Phoronids 143
- Lamp Shells 143

Arrow Worms 143

Echinoderms: Five-Way Symmetry 144

- Types of Echinoderms 145
- Biology of Echinoderms 146

Hemichordates: A “Missing Link”? 147

Chordates without a Backbone 148

- Tunicates 148
- Lancelets 149

■ BOXED READINGS

- The Case of the Killer Cnidarians 126
 How to Discover a New Phylum 132

Interactive Exploration 152

8 Marine Fishes 154

Vertebrates: An Introduction 154

Types of Fishes 154

- Jawless Fishes 155
- Cartilaginous Fishes 155
- Bony Fishes 160

Biology of Fishes 161

- Body Shape 161
- Coloration 161
- Locomotion 162
- Feeding 163
- Digestion 164
- Circulatory System 165
- Respiratory System 165
- Regulation of the Internal Environment 167
- Nervous System and Sensory Organs 167
- Behavior 170
- Reproduction and Life History 173

■ BOXED READINGS

- Shark! 159
 A Fish Called *Latimeria* 174

Interactive Exploration 179

9 Marine Reptiles, Birds, and Mammals 180

Marine Reptiles 182

- Sea Turtles 182
- Other Marine Reptiles 184

Seabirds 185

- Penguins 185
- Tubenoses 186
- Pelicans and Related Birds 186
- Gulls and Related Birds 187
- Shorebirds 187

Marine Mammals 187

- Types of Marine Mammals 188
- Biology of Marine Mammals 199

■ BOXED READINGS

- The Endangered Sea Turtles 183
 The Whales That Walked to Sea 193
 The Other “Big Bang Theory” 203
 How Intelligent Are Cetaceans? 205

Interactive Exploration 212