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Invitation to
Oceanography
SEVENTH EDITION
To Marita E. Hyman, a wise, passionate, caring partner who shares her life with me living on a special parcel of land on a large Earth in a vast universe.
# Contents in Brief

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Growth of Oceanography</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>The Planet Oceanus</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>The Origin of Ocean Basins</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>Marine Sedimentation</td>
<td>84</td>
</tr>
<tr>
<td>5</td>
<td>The Properties of Seawater</td>
<td>130</td>
</tr>
<tr>
<td>6</td>
<td>Wind and Ocean Circulation</td>
<td>186</td>
</tr>
<tr>
<td>7</td>
<td>Waves in the Ocean</td>
<td>232</td>
</tr>
<tr>
<td>8</td>
<td>Tides</td>
<td>264</td>
</tr>
<tr>
<td>9</td>
<td>Marine Ecology</td>
<td>294</td>
</tr>
<tr>
<td>10</td>
<td>Biological Productivity in the Ocean</td>
<td>340</td>
</tr>
<tr>
<td>11</td>
<td>The Dynamic Shoreline</td>
<td>386</td>
</tr>
<tr>
<td>12</td>
<td>Coastal Habitats</td>
<td>432</td>
</tr>
<tr>
<td>13</td>
<td>Ocean Habitats and Their Biota</td>
<td>474</td>
</tr>
<tr>
<td>14</td>
<td>The Ocean’s Resources</td>
<td>502</td>
</tr>
<tr>
<td>15</td>
<td>The Human Presence in the Ocean</td>
<td>524</td>
</tr>
<tr>
<td>16</td>
<td>Global Climate Change and the Oceans</td>
<td>570</td>
</tr>
<tr>
<td></td>
<td>Appendices</td>
<td>612</td>
</tr>
</tbody>
</table>
Contents

Preface ........................................... xiv
About the Author ................................... xxi
Acknowledgments .................................... xxii

CHAPTER 1  The Growth of Oceanography .......... 2
1-1 Oceanography: What Is It? ............... 4
1-2 Historical Review of Oceanography ...... 5
    Ocean Exploration .......................... 5
    Early Scientific Investigations ........... 15
    Modern Oceanography .................... 22
1-3 Current and Future Oceanographic Research ........ 23
Study Guide ...................................... 26

Features
Science by the Numbers: Graphs ............... 18
The Process of Science: The Scientific Process ... 19
Science by the Numbers: Conversions ......... 25

CHAPTER 2  The Planet Oceanus ............... 30
2-1 The Earth’s Structure ...................... 32
    The Earth’s Interior Spheres ............. 32
    The Earth’s Exterior Envelopes ......... 34
2-2 The Physiography of the Ocean Floor ......... 34
    Bathymetric Provinces ................. 34
2-3 Geologic Differences between Continents and Ocean Basins ....... 38

CHAPTER 3  The Origin of Ocean Basins ....... 50
3-1 Continental Drift ............................ 52
3-2 Seafloor Spreading ......................... 54
    The Geomagnetic Field ................. 56
    Spreading Ocean Ridges .............. 59
3-3 Global Plate Tectonics ..................... 61
    Subduction Zones ....................... 61
    Plate-Tectonic Model ................. 63
    The Opening and Closing of Ocean Basins ........ 68
    A Summary of Global Plate Tectonics .... 73
3-4 Future Discoveries ......................... 73
Study Guide ...................................... 79

Features
Science by the Numbers: Powers of 10 ........ 42
Geology: Probing the Seafloor ............ 43
Geology: The San Andreas Fault ........ 70
Geology: The Red Sea ....................... 75
Science by the Numbers: Seafloor Spreading Rates ..................... 78
CHAPTER 4  Marine Sedimentation ........................................ 84

4-1 Sediment in the Sea ........................................ 86
   Classification of Marine Sediment .................................. 86
   Factors that Control Sedimentation .................................. 87

4-2 Sedimentation in the Ocean ............................ 91
   Shelf Sedimentation .................................................. 91
   Deep-Sea Sedimentation ........................................... 106
   Deep-Sea Stratigraphy .................................................. 119

4-3 Future Discoveries ........................................ 120

Study Guide ........................................................... 126

Features
   Geology: Probing the Seafloor ...................................... 88
   Geology: Dust Storms ............................................... 98
   The Process of Science: Climate Variability and
   Change ................................................................. 104
   Geology: Catastrophic Meltwater Scouring
   and Deposition ..................................................... 108
   Geology: The Drying Up of the
   Mediterranean Sea .................................................... 122
   Science by the Numbers: Sedimentation Rates ................... 125

CHAPTER 5  The Properties of Seawater ................. 130

5-1 Basic Chemical Notions .............................. 132
   5-2 Basic Physical Notions ....................................... 133
   5-3 The Water Molecule ........................................... 134
      The Solutes of Seawater ....................................... 137

5-4 Salinity ......................................................... 141
   Principle of Constant Proportion ................................ 142
   Factors That Regulate the Salinity of Seawater ............... 144
   Effects of Salinity on the Properties of Water ................. 149

5-5 Chemical and Physical Structure of the Oceans . 149
   Temperature ......................................................... 150
   Salinity .............................................................. 152
   Density .............................................................. 155

5-6 Gases in Seawater ........................................ 157
   Oxygen ............................................................. 159
   Carbon Dioxide ...................................................... 160

5-7 The Ocean as a Physical Chemical System ....... 166
   Reservoirs of Water .............................................. 166
   The Global Water Cycle .......................................... 172
   The Ocean as a Biogeochemical System .................... 173

Study Guide ........................................................... 179

Features
   Science by the Numbers: Parts per Thousand .............. 139
   Chemistry: Chemical Techniques .............................. 143
   Chemistry: Desalination ......................................... 161
   Physics: Other Physical Properties of Water .............. 167
   Chemistry: The Sea-Surface Microlayer ..................... 175
   Science by the Numbers: Order of Magnitude .............. 178

CHAPTER 6  Wind and Ocean Circulation ............. 186

6-1 Atmospheric Processes ............................ 188
   Air Pressure ...................................................... 188
   Coriolis Deflection .............................................. 188
   General Wind Circulation ........................................ 192

6-2 Surface Ocean Currents ............................. 194
   The Wind-Driven Currents of the Sea Surface ............ 194
   Types of Surface Flows ........................................ 200
   A Model of Geostrophic Flow .................................. 204
   Refinement of the Geostrophic-Flow Model ............... 205

6-3 Deep-Ocean Circulation ............................. 211
   Water Masses and Density-Driven Water Flow ............ 212
   A General Model of Thermohaline Circulation ............ 214
CHAPTER 7 Waves in the Ocean

7-1 Properties of Ocean Waves 234
Wind Generation of Waves 235

7-2 Wave Motions 237
The Motion of Water Particles Beneath Waves 237
Motion of the Wave Form 241

7-3 The Life History of Ocean Waves 241
Growth of Waves in the Fetch Area 241
Storm Waves Outside the Generating Area 243
Waves in Shallow Water 245
Shoreline Under Storm Conditions 247

7-4 Standing Waves 249

7-5 Other Types of Progressive Waves 256
Internal Waves 256
Tsunamis 259

Study Guide 260

Features
Physics: Wave-Measuring Techniques 239
Science by the Numbers: Wave Celerity (Speed) 242
Physics: Tiny Waves and Giant Waves 252
Physics: The Megatsunamis of December 26, 2004 and March 11, 2011 257
Contents

14-1 Law of the Sea

14-2 Mineral Resources

14-3 Future Discoveries

Study Guide

14 The Ocean's Resources

14-1 Law of the Sea

14-2 Mineral Resources

14-3 Living Resources

Study Guide

Features

15 The Human Presence in the Ocean

15-1 Pollution: What Is It?

15-2 Hydrocarbons in the Sea

15-3 Municipal and Industrial Effluent

15-4 Ocean Dredging and Mining

15-5 Overfishing

15-6 The Ocean's Future

15-7 Future Discoveries

Study Guide

Features

16 The Ocean's Climate

16-1 Introduction

16-2 Global Climate Change

16-3 Ocean Currents

16-4 Climate and Oceanography

Study Guide

Features

17 The Ocean's Tides

17-1 Introduction

17-2 Tidal Range

17-3 Tidal Energy

Study Guide

Features

18 The Ocean's Waves

18-1 Introduction

18-2 Wave Generation

18-3 Wave Energy

Study Guide

Features

19 The Ocean's Bottom

19-1 Introduction

19-2 Sedimentary Environments

19-3 Tectonic Environments

Study Guide

Features

20 Controversies in Ocean Science

20-1 Introduction

20-2 The Exxon Valdez Oil Spill

20-3 The Deepwater Horizon Oil Spill

Study Guide

Features

21 The Ocean's Future

21-1 Introduction

21-2 Ocean Acidification

21-3 Marine Biodiversity

Study Guide

Features

22 Technology and Ocean Management

22-1 Introduction

22-2 Ocean Exploration

22-3 Ocean Management

Study Guide

Features

Index
# CHAPTER 16 Global Climate Change and the Oceans

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-1</td>
<td>Climate Change</td>
<td>570</td>
</tr>
<tr>
<td>16-2</td>
<td>Global Climate Impact on the Coast</td>
<td>579</td>
</tr>
<tr>
<td></td>
<td>Sea-Level Change</td>
<td>580</td>
</tr>
<tr>
<td></td>
<td>Water Temperature</td>
<td>584</td>
</tr>
<tr>
<td>16-3</td>
<td>The Impact of Global Climate Change in the Open Ocean</td>
<td>589</td>
</tr>
<tr>
<td></td>
<td>The Thermohaline Conveyor Belt</td>
<td>590</td>
</tr>
<tr>
<td></td>
<td>The Arctic Ocean and its Cover of Sea Ice</td>
<td>592</td>
</tr>
<tr>
<td></td>
<td>Ocean Plankton</td>
<td>593</td>
</tr>
<tr>
<td></td>
<td>Seawater Chemistry</td>
<td>594</td>
</tr>
<tr>
<td>16-4</td>
<td>What Do We Know, What Do We Do?</td>
<td>601</td>
</tr>
</tbody>
</table>

## Appendices

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Properties of the Earth</td>
<td>612</td>
</tr>
<tr>
<td>II</td>
<td>Conversion Factors</td>
<td>613</td>
</tr>
<tr>
<td>III</td>
<td>Geologic Time</td>
<td>615</td>
</tr>
<tr>
<td>IV</td>
<td>Maps and Topographic Profiles</td>
<td>616</td>
</tr>
<tr>
<td>V</td>
<td>Principal Marine Organisms</td>
<td>620</td>
</tr>
<tr>
<td>VI</td>
<td>The Coriolis Deflection</td>
<td>621</td>
</tr>
</tbody>
</table>

Glossary | 623  |
Index | 641  |
Preface

This book deals with the workings of the ocean, the dynamic processes that affect its water, seafloor, and abundant life forms. The approach used is a broad one, relying on basic concepts to explain the ocean’s many mysteries. Anybody—whether sailor, surfer, beachcomber, or student—can learn about the processes and creatures of the oceans. No background in science is required to grasp the many important ideas that are relevant to the working of the oceans. Wherever appropriate, the underlying science is first explained clearly, and only then is it used to account for ocean processes. These overarching scientific concepts are summarized conveniently as “Key Concepts” at the end of every chapter. In order to help those unfamiliar with the practice of science, a series of “process of science” boxes provides an explanation of how scientists reason and draw conclusions about the natural world. In the glossary, important words are clearly defined and many are accompanied by figure numbers that refer you to the figure that illustrates the term.

The figures and their accompanying captions do not merely illustrate but also supplement the written text. All the drawings have been beautifully and accurately rendered by a team of talented artists and illustrators in order to present in visual form ideas that are at times necessarily abstract. They should be studied carefully before advancing to the next section of the chapter, because they help provide concreteness to the ideas discussed. It has been the author’s experience that those students who truly understand the “ins and outs” of the illustrations tend to have a solid grasp of the chapters’ main concepts. This will take a bit of time, but it is time well invested.

ORGANIZATION

The seventh edition of Invitation to Oceanography incorporates new and updated material, based on the many valuable suggestions made by faculty and students who have worked with the previous editions of the book. This means that the organization of the material, the development of the ideas, and the quality of the prose and illustrations are better than ever. We are always working to improve each succeeding version of the book, and so we welcome all comments and criticisms from our readers. Both faculty and students agree that the development of key oceanographic concepts flows logically and systematically from chapter to chapter, as well as from section to section.

The first two chapters review the long history of ocean exploration and research as well as the fundamental structure of the Earth’s interior and its exterior ocean basins. Chapters 3 through 10 examine the geology, chemistry, physics, and biology of the sea, highlighting the key scientific concepts and latest discoveries in these subdisciplines of oceanography. In some sense, the material and concepts in these seven chapters represent the core ideas of the ocean sciences, and when comprehended and synthesized, they provide the framework for understanding ocean habitats as whole, functional ecosystems—the chapter topics of the remainder of the book. For example, Chapters 11 and 12 examine the intriguing intricacies of dynamic coastal environments, including beaches, dunes, barrier islands, estuaries, deltas, salt marshes, mangrove swamps, lagoons, and coral reefs. Two chapters are devoted to coastal ecosystems, because we are most familiar and come in regular contact with the shoreline rather than the open ocean. It is likely that many of us as voting citizens will be in a position to influence regulatory legislation and management practices of these fragile habitats. Chapter 13 provides an overview of the many fascinating and exotic ecosystems that are found far offshore, either in open water or on the deep-sea floor. Chapter 14 surveys the ocean’s abundant resources, both living (fish) and nonliving (petroleum, metals, phosphate), that are vital for the modern human world. Chapter 15 presents a balanced appraisal of the environmental stresses brought about by human activity, showing the
nature and alarming extent of this impact and providing examples of groups of concerned citizens who are striving hard and successfully to reverse environmental despoilment. Throughout the book, local and regional examples are drawn from all parts of the U.S. coastline, including the Pacific coast as far north as Alaska, the Atlantic seaboard as well as maritime Canada, and the Gulf of Mexico. Examples from foreign seas are used where appropriate.

Chapter 16 examines a most timely global issue—climate change. How will warming of the atmosphere and oceans affect the processes and biodiversity of marine ecosystems? What can we do individually and collectively to mitigate the impacts of global warming so that our children can enjoy the ocean’s beauty?

The Student Experience

Every chapter opens with a succinct list of Learning Objectives. Students should review this list prior to diving into the chapter to help guide their focus. As they progress through the chapter, they should periodically flip back to the Learning Objectives to ensure they are fully grasping that chapter’s key oceanographic concepts. This practice will encourage students to think critically about the fascinating field of ocean science and its four major divisions.

Written in a conversational tone, every chapter also opens with a Preview that introduces the reader to the specific ocean science concepts they are about to study. It is a student-friendly primer that provides a framework for thinking critically about the theme of the chapter.

Featured boxes, The Ocean Sciences, abound in all of the chapters. They consist of four types, based on the principal subfields of oceanography: geology, chemistry, physics, and biology. Each is identified as such by a colorful and distinctive logo placed near the title of the box.

- **Geology** boxes dig deep into key geologic oceanographic concepts by exploring specific places, such as the Red Sea, the San Andreas Fault, the Mediterranean Sea, and other global examples, including a new discussion on the impact of Hurricane Sandy on the New York and New Jersey shorelines.
Chemistry boxes review scientific experiments conducted by oceanographers to investigate the chemical processes of the seas, offering students a chance to explore the techniques oceanographers use in the field.

Physics boxes expand the chapter material and illuminate key concepts by diving deep into specific examples. For instance, hurricanes and typhoons are highlighted in the chapter covering wind and ocean circulation, and the megaluromia of 2006 and 2011 are featured in the chapter discussing waves. These boxes provide students with practical applications of key oceanographic principles.

Biology boxes spotlight specific species that depend on the oceans for survival, such as penguins and killer whales, as well as the unique marine ecology of particular regions, including an exploration of Chesapeake Bay and the Gulf of Mexico. These boxes also discuss recent events that have impacted the seas, including a look into the Exxon Valdez and the Deepwater Horizon oil spills.
The Process of Science presents a hypothesis regarding a global issue, such as climate variability and rising sea levels, and explores the scientific processes employed in gathering and analyzing information to develop a scientific theory. By exploring historical research from leading scientists and current scientific data, students are challenged to think critically about the future landscape of Earth and its seas.

The boxes serve several purposes. Some review common research techniques employed by oceanographers to investigate the seas. Some flesh out a concept merely outlined in the text. Others spotlight case histories in which the oceanography of a specific place is presented in concrete terms from the standpoint of an idea introduced in the text. A few featured boxes review a concept that is simply interesting and that otherwise could not be integrated easily into the main text of the chapter. They are like eating dessert after finishing the main course of a meal. Enjoy them! Two new boxes have been added to this edition. Check the back of the book for a complete listing of the boxes, including the chapter in which each appears.

To assist students in understanding the basic mathematical concepts needed to study oceanography, Science by the Numbers provides a step-by-step solution to a specific problem. These boxes help improve students’ math skills and provide the insights into ocean processes that only numerical calculations reveal.
To ensure readers thoroughly grasp the important concepts, each chapter concludes with a detailed summary of the Key Concepts. Students can review the summary prior to diving into the chapter to guide their focus and can also use it as a study tool to prepare for course lectures and exams. It is important for students at this introductory level to be aware of and understand the terminology oceanographers use in their daily discourse. For this reason, a list of Key Words is also included at the end of every chapter. Furthermore, the key words in the chapter appear in bold to draw the reader’s attention.

Most chapters conclude with a series of questions arranged into three groupings. The first set, the Review of Basic Concepts, is just that. The questions address the main notions developed in the chapter. The second set, the Critical-Thinking Essays, requires more thought because you must synthesize ideas, sometimes drawing from concepts developed in previous chapters. In other words, verbatim answers might not be found anywhere in the book. However, you can develop an answer by thinking deeply about the question posed and applying common sense and logic to the information provided in the book. The third set of questions, Discovering with Numbers, deals with making straightforward calculations about ocean processes. The questions rely on basic mathematics, the kind that any
high school graduate has mastered. In order to assist you, the Science by the Numbers boxes teach the art of computation and are included in most chapters. The trick to answering math questions is to understand conceptually what it is you are trying to solve. These math boxes will help you upgrade your math skills and develop self-assurance about reasoning with numbers.

A reading list is provided at the end of each chapter and includes both classical, but still relevant, references and more recent writings on the ocean’s dynamic processes and diverse habitats. Some are books; most are articles. They should prove valuable for delving deeper into an area of oceanography that intrigues you and for writing term papers. Also, the appendices at the end of the book provide important ancillary material, including conversion factors, a geologic time chart, map-reading techniques, a discussion of the Coriolis deflection, and the classification of marine organisms.

To visually assist readers in understanding key oceanographic processes, Jones & Bartlett Learning has developed Interactive Oceanography Animations. These engaging animations bring fascinating ocean science phenomena to life! Each interactive animation guides students through oceanographic processes and gauges students’ understanding with exercises and assessment questions.

To assist you in teaching this course and supplying your students with the best in teaching aids, Jones & Bartlett Learning has prepared a complete supplemental package available to all adopters. Additional information and review copies of any of the following items are available through your Jones & Bartlett Learning sales representative.

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TEACHING TOOLS

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The Lecture Outline Slides in PowerPoint Format presentation package provides lecture notes, graphs, and images for each chapter of Invitation to Oceanography. Instructors with Microsoft PowerPoint software can customize the outlines, images, and order of presentation.

The Instructor's Manual provided as a text file, includes chapter outlines, teaching tips, learning objectives, and additional concept and essay questions.

The Additional Test Questions are available as straight text files and contain approximately 750 multiple-choice, fill-in-the-blank, essay, and research questions.

A basic sample syllabus is also available to assist instructors who are beginning to plan their courses.
Paul Pinet teaches geology, oceanography, and environmental studies courses at Colgate University, located in central New York state. He earned BA and MS degrees in geology from the University of New Hampshire and the University of Massachusetts, respectively, and a PhD in oceanography from the University of Rhode Island. His research has been focused on the geology of continental margins, coastal bluff erosion, estuarine sedimentation, and more recently, on the philosophical dimensions of deep time. At the moment, he is developing long-term (millennia) conservation strategies for barrier islands in response to rising sea level and for mitigating the ongoing extinction event in New England and its ocean. Pinet spent summers during much of his adult life either climbing mountains around the world or cruising on his small, gaff-headed catboat (Taillefer) off the New England coast. Though an oceanographer, Pinet admits that he fears water more than high, avalanche-prone mountains. At the moment, he is working on a book of essays entitled Shadowed by Deep Time.
Jones & Bartlett Learning is committed to producing the finest introductory textbook in oceanography possible. This seventh edition of Invitation to Oceanography testifies to the staff’s earnest commitment to that ideal. During my long association with these professionals, I was impressed by their patience, their creativity, their willingness to listen carefully and critically to my perspectives, and their attentive concern for visual and written aesthetics. The outcome of our collaborative effort is what you have in front of you. I am especially grateful to Matt Kane, Acquisitions Editor, Raven Heroux, Editorial Assistant, Leah Corrigan, Production Editor, and Lauren Miller, Manager of Photo Research, Rights & Permissions. A textbook of this ilk succeeds only if there is a dynamic balance among syntheses, coverage, and details, which was achievable because of our collaborative effort. The few remaining errors and unintentional misrepresentations in this seventh edition are my own alone. I am truly privileged to be working as an author with Jones & Bartlett Learning.

Paul R. Pinet
Hamilton, New York

Many colleagues at numerous institutions reviewed and constructively criticized drafts of the various editions, vastly improving their quality. Those who were particularly helpful and generous with their time and expertise over the years include:

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