Chemical Oceanography and the Marine Carbon Cycle

The principles of chemical oceanography provide insight into the processes regulating the marine carbon cycle. These topics are essential to understanding the role of the ocean in regulating the carbon dioxide content of the atmosphere and climate on both human and geological time scales.

Chemical Oceanography and the Marine Carbon Cycle provides both a background in chemical oceanography and a description of how chemical elements in seawater and ocean sediments can be used as tracers of physical, biological, chemical and geological processes in the ocean. The book begins with a description of ocean circulation and biological processes, and then moves on to discuss the chemicals that are dissolved in seawater. Subsequent chapters focus on why the ocean has the chemistry that it does, rather than on details of what is there. The first seven chapters present basic topics of thermodynamics, isotope systematics and carbonate chemistry, and explain the influence of life on ocean chemistry and how it has evolved in the recent (glacial–interglacial) past. This is followed by topics essential to understanding the carbon cycle, including organic geochemistry, air–sea gas exchange, diffusion and reaction kinetics, the marine and atmosphere carbon cycle and diagenesis in marine sediments. The many figures in the book (including full-color versions) are available for download at www.cambridge.org/9780521833134.

Developed by two well-known professors of oceanography, *Chemical Oceanography and the Marine Carbon Cycle* is an ideal textbook for upper-level undergraduates and graduates in oceanography, environmental chemistry, geochemistry and earth science. It is also a valuable reference for researchers in oceanography.

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The late John Hedges was Professor of Oceanography at the University of Washington, specializing in organic geochemistry. He was the recipient in 2000 of the Geochemical Society's Alfred R. Treibs Award for lifetime achievement.

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Preface

The field of chemical oceanography has evolved over the past several decades from one of discovery to an interdisciplinary science that uses chemical distributions to understand physical, biological, geological and chemical processes in the sea. The study of chemical oceanography includes much of the background required to understand the global carbon cycle on all time scales because of the primary role of the marine carbonate system. Thus, we present this book about *Chemical Oceanography and the Marine Carbon Cycle* as a natural outgrowth of the evolution of our scientific field and a necessary background for building intuition to manage the anthropogenic intrusion into the global carbon cycle.

After a long deliberation about whether we had the time, stamina and personalities to write a book about our subject, John Hedges and I decided to do it, using as a guide, the notes we had compiled from teaching Chemical Oceanography together in the School of Oceanography at the University of Washington. During the first three years of the new century we used sabbatical leaves and time borrowed from teaching and research to compile about half of the book. Then, in 2003 John died suddenly and unexpectedly. Everyone John touched was thrown into a state of shock at the loss of a good friend, reliable colleague and brilliant organic geochemist. At this point we had put so much of ourselves into this undertaking that I felt there was no turning back, and I continued to complete what you see here.

The first part of the book (Chapters 1–7) covers a one-quarter-long course for beginning graduate students. Because of the backgrounds of students in this class, we taught the course so that little previous knowledge of oceanography or chemistry was required. All one needed is some experience in thinking scientifically and the desire to learn. We feel this part of the book should also be appropriate for senior-level undergraduate courses on this subject. The final five chapters of the book are compiled from parts of other, more advanced seminars and should serve well as a guide for research and more advanced courses in *Chemical Oceanography and the Carbon Cycle*.

Steven Emerson

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Many of the chapters were reviewed by colleagues, post-docs and former students. We owe special acknowledgement to Kenia Whitehead, who, as co-author of Chapter 8, was responsible for taking a partly finished manuscript left by John Hedges and molding it into a comprehensive chapter on organic geochemistry. Dieter Imboden helped with the discussion about diffusion in Chapter 9. Others who played valuable roles in reviewing individual chapters are Curtis Deutsch, Burke Hales, Roberta Hamme, David Hastings, Taka Ito, Jennifer Morford, Jim Murray, Paul Quay, Amelia Schevenell and Stuart Wakeham. We would like to thank the editors at Cambridge University Press for their patience and skill in presenting the book. Mistakes that persist after these conscientious efforts should be attributed solely to the authors.

John and I believed that the unlikely birth of a textbook about oceanography from two people raised on farms in Ohio resulted from the influence of our early mentors. Our curiosity and approach to science was instilled at the beginning of our careers by Wallace Broecker of Columbia University and Werner Stumm and Dieter Imboden at EAWAG-ETH (SE), and by Pat Parker of the University of Texas and Tom Hoering of the Carnegie Geophysical Laboratory, Washington D.C. (JH). We feel that collaborations with our PhD graduate students have stimulated our discoveries in the field of chemical oceanography and taught us valuable lessons about science and life along the way. These people are: Rick Jahnke, Lucinda Jacobs, John Ertel, Dan McClorkle, David Archer, Greg Cowie, Miguel Goñi, David Hastings, Ann Russell, Brian Bergamaschi, Burke Hales, Matt

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Finally, we dedicate the book to our wives, Julie Emerson and Joyce Hedges, whose support, encouragement and love made it possible to complete this endeavor.