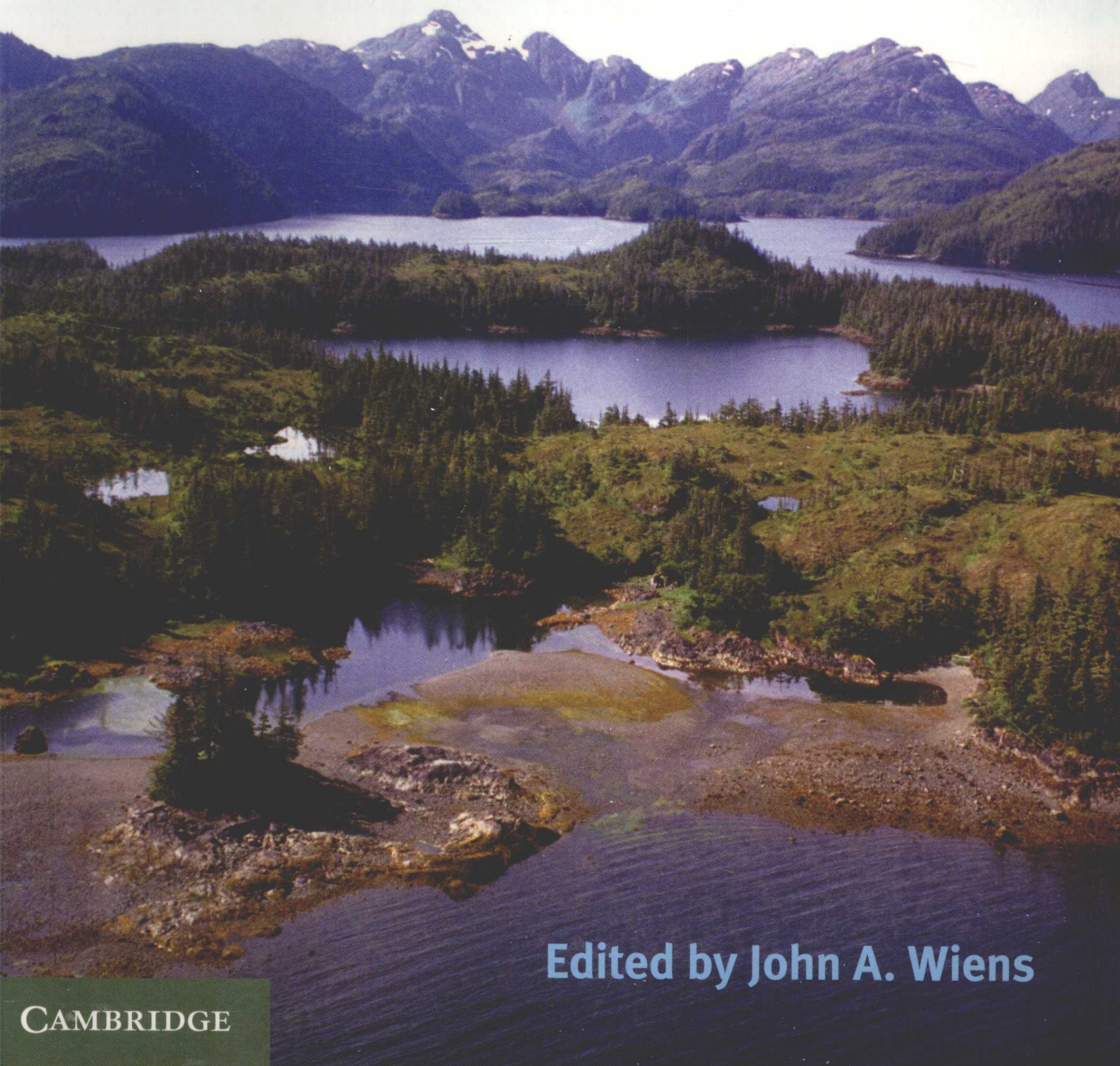


OIL IN THE ENVIRONMENT

Legacies and Lessons of the
Exxon Valdez Oil Spill



Edited by John A. Wiens

CAMBRIDGE

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PRBO CONSERVATION SCIENCE, CALIFORNIA
and THE UNIVERSITY OF WESTERN AUSTRALIA, PERTH



CAMBRIDGE
UNIVERSITY PRESS

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UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

Published in the United States of America by Cambridge University Press, New York

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107027176

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First published 2013

Printed and bound in Europe by Grafos S. A.

A catalog record for this publication is available from the British Library

Library of Congress Cataloging in Publication data

Oil in the environment: legacies and lessons of the Exxon Valdez oil spill / edited by John A. Wiens, PRBO Conservation Science, California and The University of Western Australia, Perth.
pages cm

Includes bibliographical references and index.

ISBN 978-1-107-02717-6 (Hardback) – ISBN 978-1-107-61469-7 (Paperback)

1. Petroleum–Environmental aspects. 2. Oil spills–Cleanup. 3. Oil pollution of soils.
4. Shore protection. 5. Environmental disturbance–Analysis. 6. Oil pollution of the sea.
7. Oil spills–Cleanup–Alaska–Prince William Sound Region. 8. Exxon Valdez Oil Spill, Alaska, 1989. I. Wiens, John A.

TD196.P4O386 2013

363.738/2097983–dc23

2012041990

ISBN 978-1-107-02717-6 Hardback

ISBN 978-1-107-61469-7 Paperback

Additional resources for this publication at www.cambridge.org/9781107027176

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A subvention of £12 000 toward the production of this book was provided by Exxon Mobil Corporation. The publishers wish to make clear that the subvention was not provided with any conditions constraining the editorial scope or content of the book, nor the freedom of the editor and contributors to express their views.

Oil in the Environment

Legacies and Lessons of the *Exxon Valdez* Oil Spill

What light does nearly 25 years of scientific study of the *Exxon Valdez* oil spill shed on the fate and effects of a spill? How can the results help in assessing future spills? How can ecological risks be assessed and quantified?

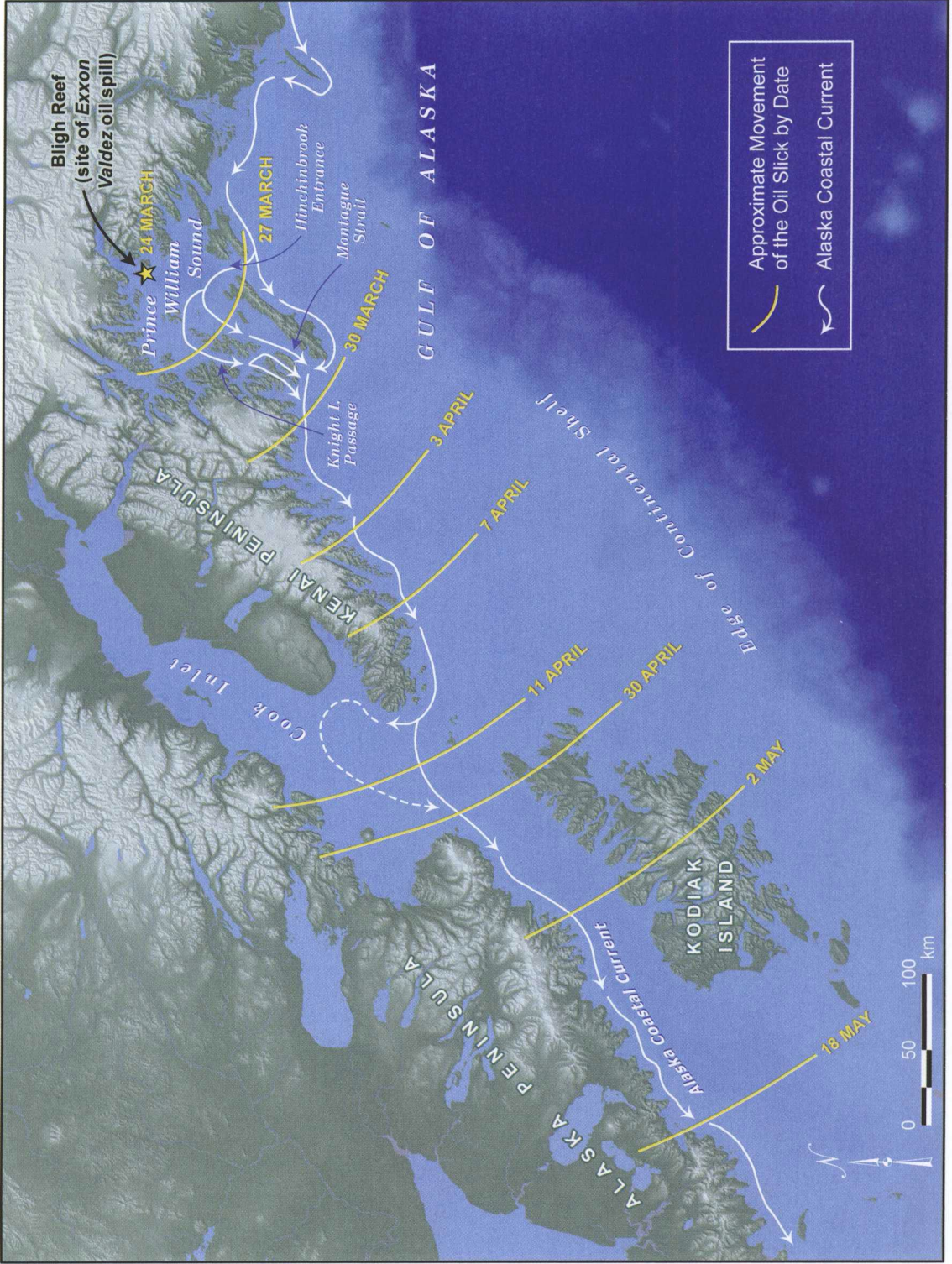
In this, the first book on the effects of *Exxon Valdez* in 15 years, scientists directly involved in studying the spill provide a comprehensive perspective on, and synthesis of, scientific information on long-term spill effects. The coverage is multidisciplinary, with chapters discussing a range of issues including effects on biota; successes and failures of postspill studies and techniques; and areas of continuing disagreement. An even-handed and critical examination of more than two decades of scientific study, this is an invaluable guide for studying future oil spills and, more broadly, for unraveling the consequences of any large environmental disruption.

A full bibliography of related literature is available online at www.cambridge.org/9781107027176.

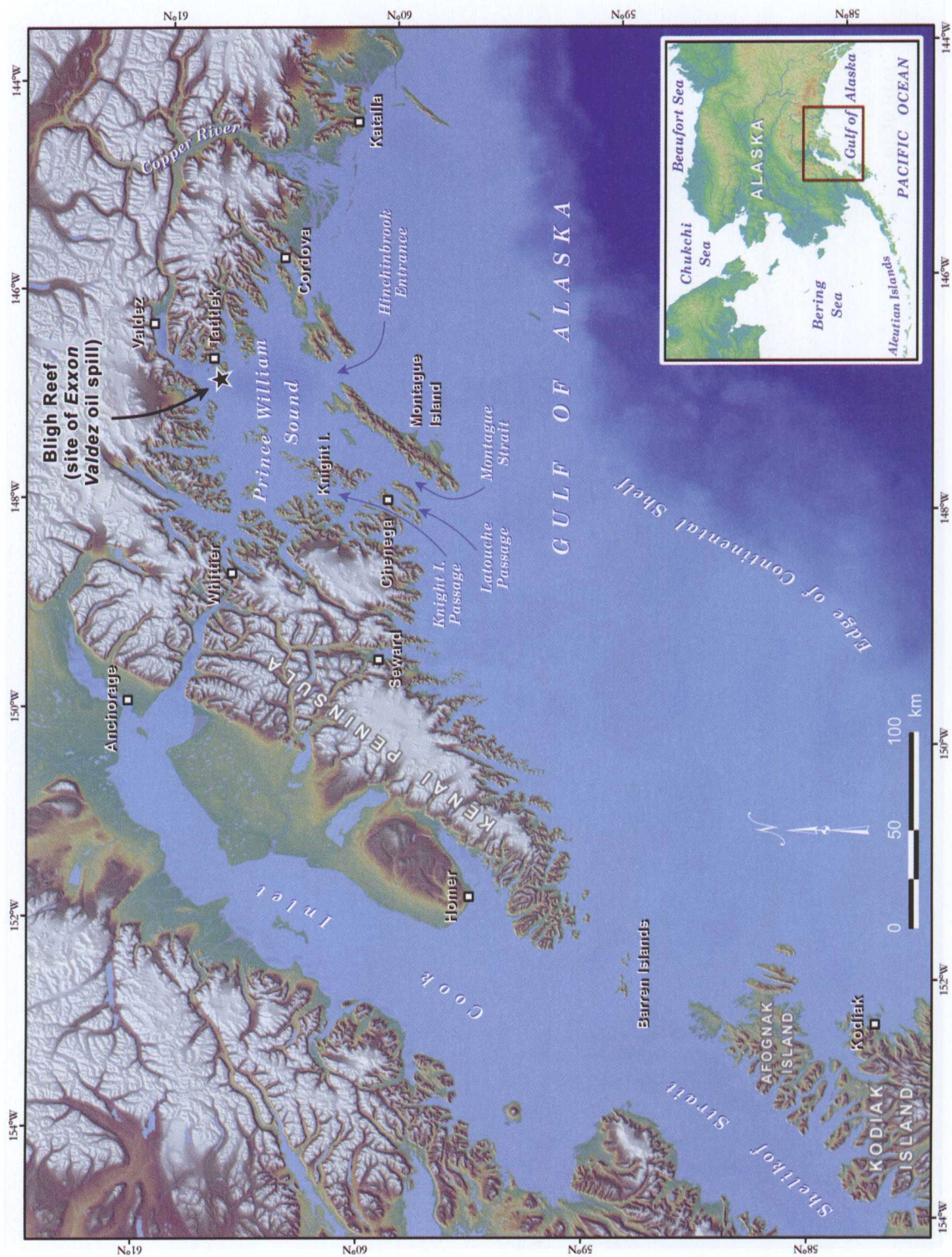
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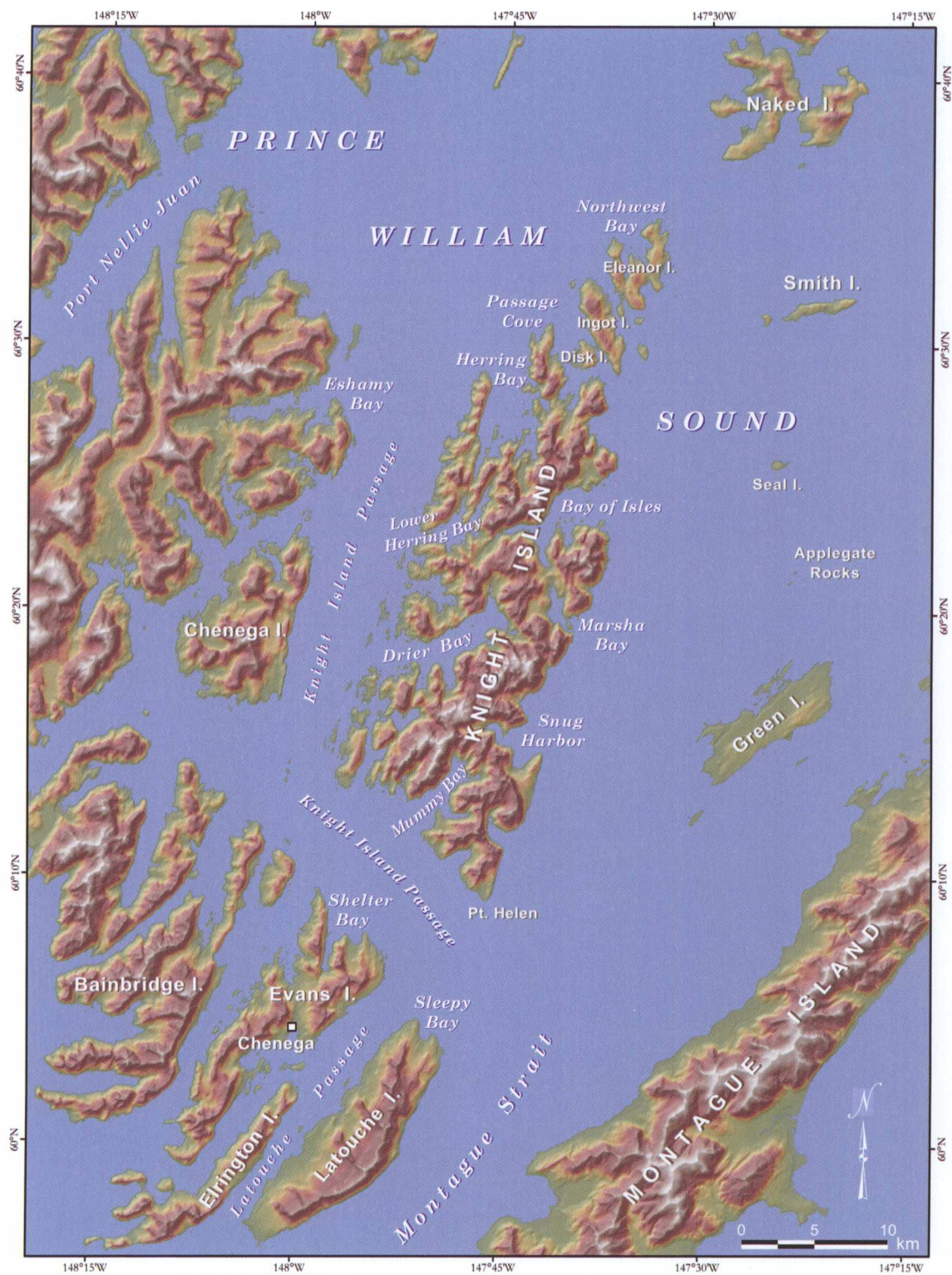
Frontispiece. Southeastern Herring Bay, Knight Island, Prince William Sound, Alaska, July 2008.
Herring Bay was one of the areas most heavily oiled by the *Exxon Valdez* oil spill in 1989.
Photo: John A. Wiens.



Map 1 The general path of the Alaska coastal current and the approximate progression of the oil spill from its source at Bligh Reef in Prince William Sound on March 23, 1989. (Source: Exxon Corporation).



Map 2 Important features of the northern Gulf of Alaska where the Exxon Valdez oil spill occurred.



Map 3 An expanded map of western Prince William Sound, identifying important locations mentioned throughout this book.

CONTRIBUTORS

John A. Wiens, the editor of this volume as well as a contributor, has conducted research on birds in semiarid environments, marine birds, landscape ecology, and conservation in three continents, producing over 250 scientific publications and several books. He held faculty positions at Oregon State University, the University of New Mexico, and Colorado State University, where he is a Distinguished Professor Emeritus. John has also been a visiting professor or research scientist in Norway, Canada, and Australia. He was Chief Scientist for The Nature Conservancy, and currently holds appointments as Chief Scientist at PRBO Conservation Science in California and is a Winthrop Research Professor in the School of Plant Biology at the University of Western Australia. He worked on the *Exxon Valdez* spill from 1989 through the editing of this book. He received M.S. and Ph.D. degrees in zoology from the University of Wisconsin–Madison after his B.S. degree (zoology) at the University of Oklahoma. John has served as the president of the International Association for Landscape Ecology and has received a Fulbright Senior Scholar Award, the Elliott Coues Award (American Ornithologists' Union), the Distinguished Landscape Ecologist Award and Distinguished Service Award (International Association for Landscape Ecology), and the Loy and Alden Miller Research Award (Cooper Ornithological Society). He is the Editor in Chief of Cambridge University Press's Series on Landscape Ecology and serves or has been a member of the editorial boards for *The Wildlife Professional*, *Landscape Ecology*, *Ecosystems*, *Avian Conservation and Ecology*, and *Ecological Applications*.

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USE OF ACRONYMS

Acronyms are often mystical and cryptic, known only to those who work in a discipline. They interrupt the flow of a text, leading the reader to lurch from phrase to phrase. An acronym in a sentence is like a speed bump in a road. At the same time, some acronyms are widely understood and, once grasped, allow one to read a passage without getting bogged down in cumbersome terminology or labels. Here we list the acronyms that will appear frequently throughout this book; all will also be defined on their first mention in a chapter.

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ASTM	American Society for Testing and Materials
BTEX	Benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CYP1A	Cytochrome P450 1A
EPA	United States Environmental Protection Agency
ERA	Ecological risk assessment
EROD	7-ethoxyresorufin-o-deethylase
GC-FID	Gas chromatography–flame ionization detection
GC-MS	Gas chromatography–mass spectrometry
GIS	Geographic Information System(s)
GOA	Gulf of Alaska
FAC	Fluorescent aromatic compounds
MDL	Method detection limit
MAYSAP	May 1991 shoreline assessment program
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
OPA 90	Oil Pollution Act of 1990
PAH	Polycyclic aromatic hydrocarbon (singular or plural)
ppb	Part per billion; $\text{ng}\cdot\text{g}^{-1}$ or $\mu\text{g}\cdot\text{L}^{-1}$
ppm	Part per million; $\mu\text{g}\cdot\text{g}^{-1}$ or $\text{mg}\cdot\text{L}^{-1}$
PWS	Prince William Sound
SCAT	Shoreline Cleanup Assessment Technique
SEP	Shoreline ecology program
SOR	Surface oil residues
SSOR	Subsurface oil residues
TEH	Total extractable hydrocarbons
TPAH	Total PAH
TPH	Total petroleum hydrocarbons
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service

ACKNOWLEDGMENTS

During the more than 20 years since the *Exxon Valdez* oil spill, hundreds of people have contributed in one way or another to the scientific studies that are the foundation of this book. Field teams surveyed oil on shorelines, collected water and hydrocarbon samples, inventoried cultural sites, and conducted counts and surveys of shoreline biota, fish, birds, and sea otters, all the time with extraordinary attention to proper quality control and data management. Ocean Explorer and its captains and crews (especially some awesome cooks!) of many vessels provided the logistical support that made the studies possible. They took the scientists and field crews to all sorts of places, in all kinds of weather, with a deep commitment to safety. Several laboratories, especially Battelle in Duxbury, Massachusetts, conducted sophisticated analyses of environmental and tissue samples for hydrocarbons, again with careful attention to precision, accuracy, and quality control. Statisticians, particularly John Skalski (University of Washington) and Jim Harner (West Virginia University), helped design ways of analyzing complex and uneven data sets and enhanced the statistical reliability of the results.

Placing the science and the data in context requires a wide variety of background information. The staff of the Alaska Resources Library and Information Services in Anchorage, especially Carrie Holba, have been unfailingly helpful. Valuable assistance was provided by personnel with The *Exxon Valdez* Oil Spill Trustee Council; Anchorage's Z.J. Loussac Public Library and its Alaska Collection; and the information and library staff of agencies involved with the *Exxon Valdez* spill, especially Nancy Tileston. Susan S. Howison (Exxon Mobil Corporation) provided all manner of support. For over 23 years, Laura Rustin (L.R. Rustin Research Consulting) has provided unexcelled library and information support, answering reference questions from the simple to the bizarre (often before they were asked), obtaining the most obscure documents, indexing, abstracting, building databases, and much more.

Bringing all the science together into a book rests on the contributions and support of many individuals and organizations other than those whose names appear on the chapter headings. The many Trustee scientists who also conducted studies – and those who supported them – have made important contributions to our knowledge of Prince William Sound, the *Exxon Valdez* oil spill, and its effects. Many of the authors of chapters in this book contributed to its development well beyond the domains of their individual chapters by sharing their findings and perspectives and participating in wide-ranging discussions. Many authors were supported by their home institutions or organizations during the development of their chapters. Steve Moffitt and Sherri Dresel of the Alaska Department of Fish and Game provided the data and models used to update herring recruitment figures in Chapter 13. Carla Christofferson, Dawn Sestito, and Reuben Wilson (O'Melveny & Myers, LLP) and Barat LaPorte (Patton Boggs, LLP) provided critical input on legal issues and their background.

Finally, several individuals deserve special mention, for without their efforts this book would not exist. Dominic Lewis (Cambridge University Press) helped guide us through the publication process. Mike Smith has been a steadfast supporter of science within Exxon Mobil Corporation and helped spearhead this project. David K. Johnson (Exxon Mobil Corporation) provided invaluable help to the editor and authors during the development of the book. Allison Zusi-Cobb (ABR, Inc.) and Betty Dowd (Exponent,

Inc.) applied their drafting and artistic talents to produce the maps and figures, respectively. Kyra Wiens brought a keen sense of style to bear on the prose through her detailed and sensitive editing, and she and Laura Rustin worked assiduously to create uniformity in referencing and ensure the accuracy of literature citations.

All of us who have contributed to this book, and have worked to learn the lessons of the *Exxon Valdez* oil spill, thank all of these individuals, teams, and organizations, and the many others too numerous to mention. This book is theirs as much as ours.

Financial support to conduct these studies, analyze and interpret the results, and publish and communicate the findings over the years has been provided by Exxon Mobil Corporation and the *Exxon Valdez* Oil Spill Trustee Council. The contents of this book, however, do not necessarily reflect the views of the funding sources.