Polar Research

To the Present, And the Future

Edited by Mary A. McWhinnie

AAAS Selected Symposium 7

Polar Research

To the Present, And the Future

Edited by Mary A. McWhinnie

AAAS Selected Symposium 7

AAAS Selected Symposia Series

Published in 1978 in the United States of America by

Westview Press, Inc.
5500 Central Avenue
Boulder, Colorado 80301
Frederick A. Praeger, Publisher and Editorial Director

Library of Congress Catalog Card Number: 78-52068
ISBN: 0-89158-435-8

Printed and bound in the United States of America

About the Book

Highlighting twenty years of U.S. scientific research conducted since the International Geophysical Year (IGY) of 1957-58, this volume marks a turning point in the history of polar investigations and provides a lucid summary of the contributions of many distinguished scientists. The authors provide an overview of major polar research programs, past and present; explore concepts derived from highly interrelated aspects of physical and life sciences; and seek to offer a glimpse of future polar science and polar development.

The introduction briefly describes major physical, biological, and interdisciplinary research programs, as well as the magnitude, extent, and international character of contemporary polar science. Twenty years of polar biological investigations are then reviewed, and subsequent chapters address principles and advances in meteorology, physical oceanography, glaciology, and the geological evidence that bears on the origin of Antarctica. These physical sciences delineate a matrix for the polar biospheres and provide a background for understanding the major categories of structure and dynamic functioning of the marine ecosystem, polar marine mammals, adaptational physiology, and terrestrial biotic adaptations.

Foreword

The *AAAS Selected Symposia Series* was begun in 1977 to provide a means for more permanently recording and more widely disseminating some of the valuable material which is discussed at the AAAS Annual National Meetings. The volumes in this *Series* are based on symposia held at the Meetings which address topics of current and continuing significance, both within and among the sciences, and in the areas in which science and technology impact on public policy. The *Series* format is designed to provide for rapid dissemination of information, so the papers are not typeset but are reproduced directly from the camera copy submitted by the authors, without copy editing. The papers are reviewed and edited by the symposia organizers who then become the editors of the various volumes. Most papers published in this *Series* are original contributions which have not been previously published, although in some cases additional papers from other sources have been added by an editor to provide a more comprehensive view of a particular topic. Symposia may be reports of new research or reviews of established work, particularly work of an interdisciplinary nature, since the AAAS Annual Meeting typically embraces the full range of the sciences and their societal implications.

WILLIAM D. CAREY
Executive Officer
American Association for
the Advancement of Science

Preface

This volume assembles a collection of interdisciplinary research reports of natural phenomena characteristic of polar regions. It represents the results of countless years of effort in field research in those forbidding and beautiful high latitudes. The physical endurance of scientists and technicians has been sustained by the challenge to understand the environmental forces and their syntheses for the interpretation of natural phenomena which are impossible to study elsewhere.

It has been twenty years since the International Geophysical Year of 1957-1958 and it is appropriate to bring together many of the prominent scientists who have been engaged in polar research since that time. The historical balance of twenty years of study makes it possible to measure our progress in the closely related fields of physical and life sciences. We hope to present in this volume a review of selected categories of biological research as each has emerged through years of intense scientific studies and investigations. We can now point to the future, so far as evident trends, our experience, and our insights will permit.

The symposium on which this volume is based was sponsored by the Biological Sciences Section of the American Association for the Advancement of Science. The organizer of the program deemed it essential to recognize the relationships between the environment and biota of the polar regions. A careful study of Antarctica's history senses the

moving spirit of the exciting stages of discovery. We are optimistic about the continent's future.

The contributions contained in this volume have been made by scientists who are deeply involved in polar research. They include studies on meteorology, physical oceanography, geology, and descriptions of operative biological elements and systems. Some of the papers examine the problems of biological research in marine ecosystem structures, the dynamic functions of marine mammals and their ability to adapt to the harsh conditions under which they survive. All of these studies provide fertile grounds for the exchange of ideas and delineate specific areas for further investigation. If this symposium has stimulated more intensive research in any of these fields of study, some of its objectives will have been achieved.

As arranger of the symposium and editor of this volume, I acknowledge with gratitude the uncommon cooperation of the authors who have contributed to it. In addition, I must acknowledge the many polar scientists who have assisted Duwayne M. Anderson and me in the development of a view of contemporary research in high latitudes. In particular, we acknowledge the assistance of, D. James Baker, Jr. and Richard S. Greenfield (GARP; Polar Sub-Experiment), Charles R. Bentley, Terence J. Hughes, Ian M. Whillans, Kendall N. Moulton, Robert H. Thomas and Richard L. Cameron (RIGGS; IAGP; WISP), John W. Clough and John F. Splettstösser (RISP), Curtis A. Collins and Victor T. Neal (ISOS), Ian W. D. Dalziel and Mortimer D. Turner (Scotia Arc-Antarctic Peninsula Tectonics Program), Sayed Z. El-Sayed (BIOMASS), Theodore D. Foster (IWSOE; Weddell Gyre), Benson T. Fogle, Robert A. Helliwell and L. J. Lanzerotti (Solar-Terrestrial Physics), Donald W. Hood (PROBES), Charles J. Jonkel and Bart O'Gara (Arctic Mammal Program), Chester C. Langway, Jr. (GISP), George A. Llano (RATE; Man in the Arctic Program; Tundra Biome), Lyle D. McGinnis (DVDP), Troy L. Pewe (Permafrost) and Norbert Untersteiner (AIDJEX; POLEX; NDS).

As Editor I owe a personal debt to many but I must identify Horace D. Porter for his generous editorial advice and assistance; Edward W.

Londregan who greatly improved our Introduction; Gerald Pagano who contributed much to the historical accuracy; Lloyd G. Blanchard for his continued help through all phases of this undertaking; Walter R. Sellig for his creative and gently underspoken design on page xxx of this volume, and Vivina I. Ortner and Eleanor C. Swiatly whose skill and patience with manuscript details and preparation brought development of this volume to a finished state. Not least among the foregoing, I am grateful also to the American Association for the Advancement of Science for publication of this volume.

September, 1977

M. A. McWhinnie
De Paul University

About the Editor

Mary A. McWhinnie is a professor in the Department of Biological Sciences at De Paul University. Her research has focused on comparative physiology, particularly the metabolic basis of low temperature adaptation in cold-blooded animals and the life cycle of Euphausia superba *(krill) and she has published widely on these subjects. She was the first American woman scientist to work in Antarctica, to winter-over at McMurdo Station, and to serve as station scientific leader. She has participated in seven cruises on the antarctic research ship USNS* Eltanin *and was chief scientist in 1972. She chaired the Advisory Committee for Processes and Resources of the Bering Sea (PROBES) and is a member of the Polar Research Board of the National Academy of Sciences and of many other national and international groups concerned with polar activities.*

About the Authors

Duwayne M. Anderson is chief scientist with the Division of Polar Programs at the National Science Foundation; his work has focused on geology, soil chemistry, physical chemistry, physical chemistry and plant physiology. His former positions include principal investigator of the Viking (Mars Lander) Team and chief of the Earth Sciences Branch of the U.S. Army Cold Regions Research and Engineering Laboratory. He is coeditor of Geotechnical Engineering for Cold Regions *(in press).*

Campbell Craddock, professor of geology at the University of Wisconsin-Madison, has directed numerous field programs in Antarctica and Alaska. He was co-chief scientist of the Deep Sea Drilling Project, Leg 35, in Antarctica and is U.S. delegate and chairman of the Scientific Committee on Antarctic Research (SCAR) Working Group on Geology. He has compiled geologic maps of Antarctica and was awarded the U.S. Antarctic Service Medal (1968) and the Bellingshausen-Lazarev Medal from the Soviet Academy of Sciences (1970).

Arthur L. DeVries is assistant professor in the Department of Physiology and Biophysics at the University of Illinois at Urbana. He has conducted extensive investigations of the physiological and biochemical basis of freezing resistance in antarctic fishes, and was the discoverer of a unique glycopeptide antifreeze compound which protects fish swimming in ice-laden seawater.

L. Lee Eberhardt is staff scientist at Battelle-Northwest, Richland, Washington, and affiliate professor at the Center for Quantitative Science in Fisheries at the University of Washington. His areas of specialization are wildlife management and biostatistics, and he has conducted research projects in Antarctica, New Zealand, and Australia. He is a Fellow of the American Association for the Advancement of Science.

Sayed Z. El-Sayed, professor of biological oceanography at Texas A&M University, has participated in many antarctic expeditions and has been chief scientist on several **Eltanin** *cruises. His areas of interest are marine phytoplankton, primary productivity, marine ecosystems and living resources, and population dynamics of marine fisheries.*

Joseph O. Fletcher, deputy director of the Environmental Research Laboratories at the National Oceanic and Atmospheric Administration, has worked extensively in arctic research, specifically climatic variation and fluctuation. In 1952 he led an expedition which established a research station on Fletcher's Ice Island, a massive chunk of drifting ice in the Arctic Ocean. He was formerly head of the National Science Foundation's Office of Polar Programs, and is current chairman of the U.S.-Soviet Joint Working Group of Experts on Large-Scale Ocean Atmosphere Interaction.

Theodore D. Foster, associate research oceanographer at Scripps Institution of Oceanography, University of California, San Diego, has conducted studies and published numerous articles concerning physical oceanography in the polar regions. He was scientific leader of the International Weddell Sea Oceanographic Expedition to the Southern Ocean for three seasons.

Laurence M. Gould, professor of geosciences at the University of Arizona, specializes in Antarctic glaciology and geology. He was second in command and senior scientist of the Byrd Antarctic Expedition (1928-1930), director of the U.S. International Geophysical Year Antarctic Program, chairman of the Committee on Polar Research at the National Academy of Sciences, and president of SCAR.

John J. Kelley is director of the Naval Arctic Research Laboratory and assistant professor, Institute of Marine Science, University of Alaska. He has engaged in research on the causes of variations and exchange of atmospheric CO_2 in polar marine and terrestrial systems and has published over 50 articles and monographs on gas exchange and polar microclimate. He is former co-principal investigator with the Tundra Biome, U.S. International Biological Programme.

George A. Llano, program manager in the Division of Polar Programs at the National Science Foundation, specializes in lichenology and polar ecology. He has worked in Alaska and Antarctica and was chief scientist on five oceanographic cruises. He has published numerous articles and five books, most recently the **SCAR Symposium of Antarctic Biology, Third: Proceedings of Adaptations with Antarctic Ecosystems** *(Gulf, 1977).*

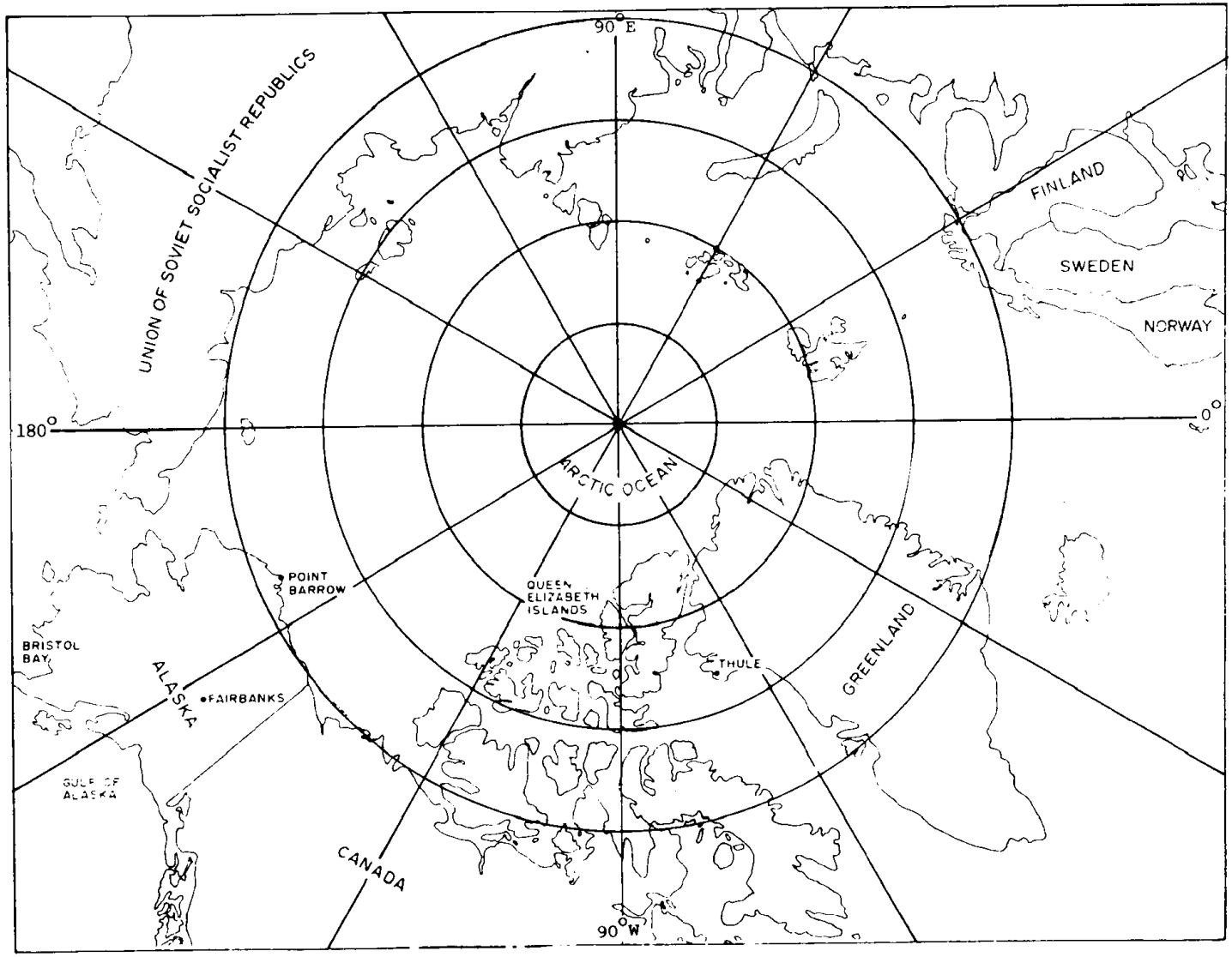
Bruce C. Parker is a professor of botany at Virginia Polytechnic Institute and State University specializing in psychology and microbial ecology. He directed preparation of the first Environmental Impact Assessment in Antarctica. He has published three books, most recently Conservation Problems in Antarctica *(University Press of Virginia, 1977).*

Robert H. Rutford, vice-chancellor for research and graduate studies at the University of Nebraska-Lincoln, specializes in glacial geomorphology and has conducted extensive research in Antarctica. He is former director of the Ross Ice Shelf Progject and former division director of Polar Programs at the National Science Foundation.

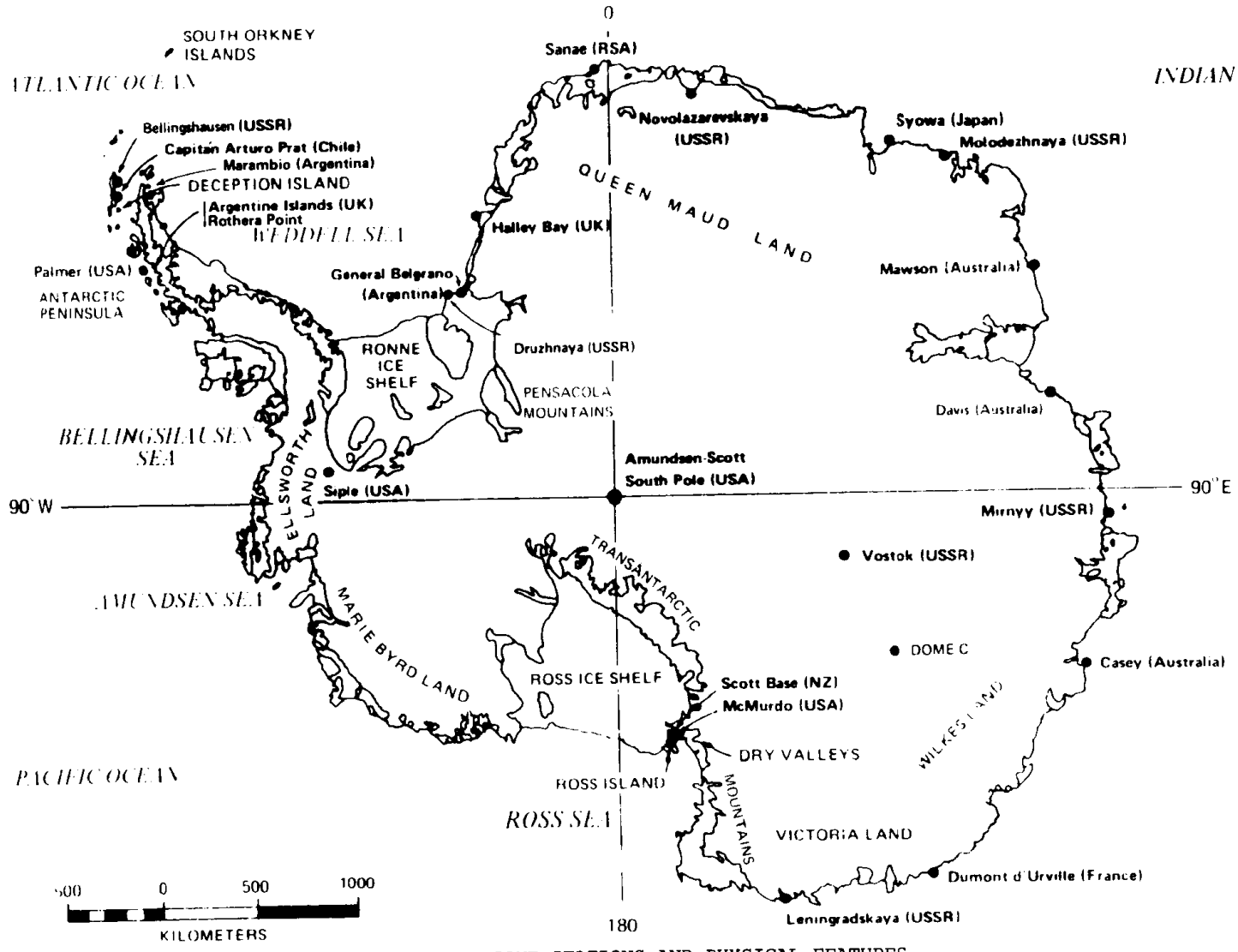
Donald B. Siniff, professor in the Department of Ecology and Behavioral Biology at the University of Minnesota, is currently principal investigator in studies on Antarctic seal population dynamics, biota of the Antarctic pack ice and related biotelemetry and data analysis. He is presently Commissioner of the Marine Mammal Commission. His specialty is vertebrate ecology and he has published over 40 articles and monographs, most recently Ecology of the Red Fox *(with A.B. Sargent and D.W. Warner, in press.*

Ian Stirling, research scientist with the Canadian Wildlife Service at Environment Canada, is also chairman of the Marine Mammal Committee of the American Society of Mammalogists and chairman of the Canadian Federal-Provincial Technical Committee for Polar Bear Research and Management. His main areas of interest are population ecology and seal and polar bear behavior; he has published extensively in these fields.

Gene C. Valentine is public affairs officer, U.S. Navy Support Force, Antarctica. He is a psychologist by training and has served for 3 years with the United States Antarctic Program, Operation Deep Freeze.


90° E
UNION OF SOVIET SOCIALIST REPUBLICS
FINLAND
SWEDEN
NORWAY
180°
0°
ARCTIC OCEAN
POINT BARROW
QUEEN ELIZABETH ISLANDS
BRISTOL BAY
ALASKA
FAIRBANKS
THULE
GREENLAND
GULF OF ALASKA
CANADA
90° W

ARCTIC



ANTARCTICA: SOME STATIONS AND PHYSICAL FEATURES.

Drawing by Walter R. Sellig

Contents