Marine Minerals: Exploring Our New Ocean Frontier

July 1987

NTIS order #PB87-217725
Foreword

Throughout history, man has been fascinated by the mysteries that lay hidden below the ocean surface. Jules Verne, the 19th century novelist, author of 20,000 Leagues Under the Sea, captured the imagination and curiosity of the public with his fictional—but nonetheless farsighted—accounts of undersea exploration and adventure. Since his classic portrayal of life beneath the ocean, technology has enabled us to bridge the gap between Jules Verne's fiction and the realities that are found in ocean space. Although the technological triumphs in ocean exploration are phenomenal, the extent of our current knowledge about the resources that lie in the seabed is very limited.

In 1983, the United States asserted control over the ocean resources within a 200-nautical mile band off its coast, as did a large number of other maritime countries. Within this so-called Exclusive Economic Zone (EEZ) is a vast area of seabed that might contain significant amounts of minerals. It is truly the Nation's "New Frontier.

This report on exploring the EEZ for its mineral potential is in response to a joint request from the House Committee on Merchant Marine and Fisheries and the House Committee on Science, Space, and Technology. It examines the current knowledge about the hard mineral resources within the EEZ, explores the economic and security potential of seabed resources, assesses the technologies available to both explore for and mine those resources, identifies issues that face the Congress and the executive branch, and finally presents options to the Congress for dealing with these issues.

Substantial assistance was received from many organizations and individuals in the course of this study. We would like to express special thanks to the OTA advisory panel; the numerous participants in our workshops; the project's contractors and consultants for contributing their special expertise; the staffs of the executive agencies that gave selflessly of their knowledge and counsel; the many reviewers who kept us intellectually honest and factually accurate; and our sister congressional agency, the Congressional Research Service, for making available its expertise in seabed minerals. OTA, however, remains solely responsible for the contents of this Report.

JOHN H. GIBBONS
Director
OTA Ocean Frontier Advisory Panel

John V. Byrne, Chah-
President, Oregon State University

Robert Bailey
Department of Land Conservation and Development
State of Oregon

James Brodus
Director, Ocean Policy Center
Woods Hole Oceanographic Institute

Frank Busby
Busby Associates, Inc.

Clifton Curtis
President
Oceanic Society

Richard Greenwald
General Counsel
Ocean Mining Associates

Robert R. Hessler
Scripps Institution of Oceanography

Alex Krem
Vice President
Bank of America

John La Brecque
Senior Research Scientist
Lamont-Doherty Geophysical Observatory

Donna Moffitt
Office of Marine Affairs
State of North Carolina

J. Robert Moore
Department of Marine Studies
University of Texas

W. Jason Morgan
Department of Geological and Geophysical Sciences
Princeton University

Jack E. Thompson
President, Newmont Mining Company

NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.
OTA Ocean Frontier Project Staff

John Andelin, Assistant Director, OTA
Science, Information, and Natural Resources Division

Robert W. Niblock, Oceans and Environment Program Manager

James W. Curlin, Project Director

Project Staff
Rosina M. Bierbaum, Analyst
James E. Mielke, Specialist in Marine and Earth Sciences
William E. Westermeyer, Analyst
Jonathan Chudnoff, Research Assistant
Elizabeth Cheng, Stanford Summer Fellow

Consultant
Francois Lampietti

Contractors
W. William Harvey, Arlington Technical Services
Edward E. Horton, Deep Oil Technology, Inc.
Lynn M. Powers
Richard C. Vetter

Administrative Staff
Kathleen A. Beil, Administrative Assistant
Jim Brewer, Jr., P.C. Specialist
Brenda B. Miller, Secretary

\[1\] Congressional Research Service, Science Policy Division, Library of Congress.
Acknowledgments

We are grateful to the many individuals who shared their special knowledge, expertise, and information about marine minerals, oceanography, and mining systems with the OTA staff in the course of this study. Others provided critical evaluation and review during the compilation of the report. These individuals are listed in Appendix F in this report.

Special thanks also go to the government organizations and academic institutions with whom these experts are affiliated. These include:

U.S. Geological Survey:
Office of Energy and Marine Geology
Strategic and Critical Materials Program
Western Regional Office, Menlo Park, CA

National Oceanic and Atmospheric Administration:
Ocean Assessment Division
Charting and Geodetic Services
Office of Ocean and Coastal Resource Management
Atlantic Oceanographic and Meteorological Laboratory

U.S. Bureau of Mines:
Division of Minerals Policy and Analysis
Division of Minerals Availability
Bureau of Mines Research Centers—
  Twin Cities, Minneapolis, MN
  Salt Lake City, UT
  Spokane, WA
  Reno, NV
  Avondale, MD

Minerals Management Service:
Office of Strategic and International Minerals

We are particularly indebted to the Marine Policy Center, Woods Hole Oceanographic Institution, Woods Hole, MA, and the LaSells Stewart Center and Hatfield Marine Science Center of Oregon State University, Corvallis, OR, who graciously hosted OTA workshops at their facilities.