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OCEAN STUDIES BOARD

ANNUAL REPORT

1990

Ocean Studies Board

Commission on Geosciences, Environment, and Resources

National Research Council

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The Ocean Studies Board was established in July 1985 to serve as an independent advisor to the federal government on matters of ocean science and policy. It is a unit of the Commission on Geosciences, Environment, and Resources of the National Research Council (NRC). The NRC serves as an independent advisor to the federal government on scientific and technical matters of national importance. Jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, the NRC brings the resources of the entire scientific community to bear on national problems through its volunteer advisory committees.

Work of the Ocean Studies Board is supported by the National Science Foundation, the Office of Naval Research, the National Oceanic and Atmospheric Administration, the Department of Energy, the U.S. Geological Survey, the Department of State, the National Aeronautics and Space Administration, and the Minerals Management Service.

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BACKGROUND

The Ocean Studies Board (OSB), created in July 1985, serves as an independent advisor to the federal government on matters of ocean science and policy. The board is a unit of the Commission on Geociences, Environment, and Resources of the National Research Council (NRC). Jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, the NRC brings the resources of the scientific and engineering communities to bear on national problems through its volunteer advisory committees.

The goals of the Ocean Studies Board are as follows:

- To promote the advancement of scientific understanding of the ocean by overseeing the health of ocean sciences and stimulating their progress;
- To encourage the wise use of the ocean and its resources through the application of scientific knowledge;
- To lead in the formulation of national and international marine policy and to clarify scientific issues that affect this policy; and
- To promote international cooperation in oceanographic research and to strengthen scientific and technical assistance to developing countries.

The Ocean Studies Board is a multidisciplinary body with representatives from the fields of marine biology and biological oceanography, chemical oceanography, physical oceanography, and marine geology and geophysics. Its 18 members serve staggered 3-year terms. The board performs many of its duties through its committees and panels. Some of these are standing groups, whereas others conduct specific studies and are disbanded when their work is completed.

Members of OSB and its subgroups are chosen from academic institutions, national laboratories, and industry on the basis of professional qualifications. They serve as individuals rather than as representatives of organizations. Approximately 75 distinguished persons now serve on the Ocean Studies Board and its subgroups. In addition, several hundred scientists and other experts participate in symposia, workshops, and regional meetings.

On its own initiative or at the request of its federal sponsors, the Ocean Studies Board examines ocean science and policy issues of national and international importance. It meets three times a year to review existing projects and develop new ones, to discuss federal ocean research programs, and to help

formulate U.S. positions on international ocean science issues. Board members identify issues for study, assess study plans and background documents, review draft reports, and serve on committees. They also nominate new committee and board members when necessary, and organize special sessions at professional meetings.

OSB activities are supported primarily by federal agencies, including the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), the Office of Naval Research (ONR), the Office of the Oceanographer of the Navy, the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Department of State (DOS), and the U.S. Geological Survey (USGS).

MAJOR ACTIVITIES

The Ocean Studies Board aims to provide leadership, build consensus, and give timely, proactive advice to the nation on ocean science and policy issues. OSB activities fall into three broad categories: promoting the health of ocean sciences in the United States, encouraging the protection and wise use of the ocean and its resources, and applying ocean science to improve national security. In each area, OSB focuses on basic science and, if appropriate, on how science relates to policy. A brief description of 1990 OSB activities, along with activities planned in 1991 and beyond, is presented below.

Health of Ocean Sciences

One of OSB's goals is to monitor and promote the health of ocean sciences in the United States. In part, OSB accomplishes this by functioning as a liaison between marine scientists and the federal government. The board also carries out other tasks that assure the health of ocean sciences, including assessment of research infrastructure and identifying deficiencies, identifying promising new research areas, advising agencies, promoting science education at all levels, and promoting international cooperation.

The Ocean Studies Board is currently reviewing the facilities, funding, and manpower trends in oceanography and is also projecting future research areas. It is conducting disciplinary reviews on the topics of ocean acoustics, marine molecular biology, chemical oceanographic measurement technologies, and the geology and geophysics of continental margins. In addition, OSB subgroups are reviewing the ocean science programs of federal agencies, such as NOAA, DOE, and ONR. In education, the board has identified a vast potential for teaching ocean sciences from kindergarten through high school to interest children in oceanography and other scientific fields.

At the international level, the OSB serves as the U.S. National Committee to the Scientific Committee on Oceanic Research (SCOR), a component of the International Council on Scientific Unions (ICSU), thereby ensuring participation of the U.S. ocean research community in SCOR meetings and associated international research. The board often hosts international meetings, such as those of the World Ocean Circulation Experiment (WOCE), the Joint Global Ocean Flux Study (JGOFS), and the Ridge Inter-Disciplinary Global Experiments (RIDGE). The OSB also plans to work with the NRC Office of International Affairs on projects for cooperative U.S.-Soviet research and for marine technical assistance in and around the Gulf of Mexico and Caribbean Sea. Moreover, OSB seeks to promote international

cooperation through several of its committees, such as the Committee on the Coastal Ocean.

Oceanography for the 1990s (Ongoing Activity)

Oceanography has matured and changed dramatically in the past 20 years. The Ocean Studies Board is conducting a study to assess the impact of present trends in oceanography and recommend appropriate responses; its specific aims are as follows:

- To provide ocean scientists with an integrated view of oceanography and its relationship to societal needs;
- To acquaint government agencies and industry with new areas of oceanographic research;
- To inform the Administration and Congress of benefits to be gained from both basic and applied oceanographic research; and
- To make recommendations concerning funding priorities, required facilities, and coordination with federal agencies.

To accomplish these objectives, the study will be published in three volumes, which will delineate, respectively: (1) the current status of the field; (2) scientific directions; and (3) issues and opportunities. The report will be available early in 1992.

The first volume will document infrastructure trends over the past decade. A workshop on the topic of oceanographic research facilities was convened in May 1990. The purpose of the workshop was to develop a prioritized list of facilities acquisitions to serve as a long-term goal for the oceanographic community to pursue and to provide a plan for meeting the goals of the major new programs and core activities. The workshop report will become a fundamental part of the study report. Staff and board members simultaneously gathered information about trends in oceanographic research funding and manpower. The information was then presented at a special session on "Oceanography for the Twenty-First Century: Forging New Partnerships" at the December 1990 meeting of the American Geophysical Union, to solicit comments from the academic community regarding OSB findings and the structure of the final report. The objectives of the session were to obtain input from the ocean sciences community on how the report is to be structured and to present OSB findings on facilities, manpower, and funding.

The second volume of the report will discuss the probable research directions in the field over the next decade. The report will be organized around the four major subdisciplines (biological, physical, chemical, and geological) plus the interdisciplinary theme of coastal oceanography. The board asked five scientists to write a short article on each of the five topics. Each chairman assembled a small group of coauthors. The board held two regional meetings to obtain as much information as possible for preparation of the individual reports. The regional meetings were held in California and Washington, D.C. Between those attending the two meetings and those contributing material for the reports, about 200 scientists were involved. The findings of the reports were presented at the May 1991 AGU meeting in a session entitled "Future Research Directions in Oceanography."

The third volume of the report will discuss issues and opportunities in ocean sciences. It will attempt to set priorities for funding for research, and will make recommendations with regard to facilities, funding, and manpower requirements for the coming decade.

Ad Hoc Subcommittee on Ocean Acoustics (Ongoing Activity)

Ocean scientists have expressed concern that funding and graduate enrollments in ocean acoustics are low and that acoustic methods, despite their great potential, are underused as oceanographic tools. In response to these concerns, the OSB Navy Panel formed an Ad Hoc Subcommittee on Ocean Acoustics. This subcommittee, cochaired by George Frisk and Terry Ewart, held two workshops in 1990 and will publish a study report in 1991. Workshop participants examined major basic research areas in underwater acoustics (chiefly in water column acoustics, seafloor acoustics, upper ocean wave scattering, and ambient sound), identified oceanographic applications, and discussed ways of improving graduate education in ocean acoustics.

Continental Margins Workshops (Ongoing Activity)

Continental margins are the only available record of the long-term interaction of oceanic and continental crust. A workshop in late 1988 brought together 72 terrestrial and marine geologists and geophysicists who study margins. Workshop participants attempted to define the state of knowledge of margin structure and dynamics, identify research areas poised for dramatic progress, and devise a plan for implementation during the next decade. The participants agreed that the scientific goals they identified could best be accomplished by means of a multidisciplinary, coordinated research program.

A workshop report, entitled *The Margins Initiative: Interdisciplinary Studies of Processes Attending Lithospheric Extension and Convergence*, was published in 1990. Three workshops were planned for 1991 and 1992 to formulate a science plan for margins research. The first of these workshops was held in January 1991. It focused on the mechanics of lithospheric deformation, to identify and develop strategies to increase understanding of the fundamental mechanisms and processes attending lithospheric extension and convergence. A workshop report is being prepared. The other two workshops will focus on geochemical processes and sedimentary basin development. The objective of the three workshops is to produce a program for margins research.

Committee on Molecular Marine Biology (Ongoing Activity)

In February 1990, Dennis Powers convened a two-day meeting of marine molecular biologists and representatives of global ocean research programs. The meeting participants produced a document on the present state of molecular biological tools and their potential contribution to the study of marine organisms and processes. As a result of that meeting, a committee will be established in 1991 to focus on applications of marine molecular biology for understanding regional and global processes such as the carbon and nitrogen cycles and the survival of marine larvae to populate future generations. Use of molecular biological methods, which could revolutionize knowledge of individual marine organisms and ocean population structure, should benefit research programs such as JGOFS and the Global Oceans Ecosystems Dynamics (GLOBEC) experiment. The first task of the committee will be to expand the report from the planning meeting and provide recommendations to federal agencies. The committee will also provide advice to the Department of Energy on how molecular biological methods could be used in DOE's oceanographic research. The committee will host workshops on the topics of automated methods and the use of molecular biology to distinguish among marine organisms.

Chemical Measurement Technologies for Ocean Science (Ongoing Activity)

In 1990 the CO_2 Panel (see section on Ocean Environment and Resources below) initiated a study of new ocean measurement technologies, primarily sensors of chemical and biological properties. The study panel, composed mostly of analytical chemists, will recommend new techniques for measuring carbon dioxide, nutrients, trace metals, and other biologically important elements and compounds. This panel plans to issue a report by September 1991.

Panel on the NOAA Coastal Ocean Program (Ongoing Activity)

The NOAA Coastal Ocean Program coordinates new coastal research programs across NOAA's five line offices. An ad hoc panel of the OSB Committee on the Coastal Ocean was formed in 1990 to advise the NOAA Coastal Ocean Program Office on such issues as priority setting among its program areas; scientific planning; proposal solicitation and review; peer review; program management, including data management; information dissemination, and relationships with the technical communities outside NOAA. This panel was officially formed as a separate panel early in 1991 and will issue a report of its program review later in the year.

DOE Marine Program Review (Ongoing Activity)

DOE's Ecological Research Division requested that the Committee on the Coastal Ocean (CoCO; see section on Ocean Environment and Resources) review a workshop report entitled, *Dynamics of the Continental Margins*. The purpose of this workshop was to provide DOE with recommendations for future research on the exchange of energy-related materials between the coastal and interior ocean and the relationship between the ocean margins and global change. Specifically, DOE requested that CoCO present recommendations for future research stemming from this report to consider: (1) the immediacy of research or operational needs before other needs can be addressed and the urgency of beginning long-term measurements; (2) the appropriateness of different geographic continental margins for integrated research; and (3) the need for a study of shelf processes versus shelf-slope-boundary current interactions. This review deals primarily with issues concerning priorities and implementation strategies for various research areas. In addition, the review committee was asked to evaluate the report in the context of the DOE Coastal Margins Program and to develop recommendations for future research directions.

The participants in the review were members of the Committee on the Coastal Ocean, whose disciplinary expertise is relevant to the subjects of the report. In addition, several additional reviewers filled disciplinary voids among the CoCO participants. A report has been prepared and will be delivered to DOE in mid-1991.

NOAA Committee (Planned Activity)

The Ocean Studies Board will form a committee in 1991 to advise the National Oceanic and Atmospheric Administration on its research programs. Preliminary discussions have been held with NOAA, and topics of interest to both the agency and university scientists are: (1) the structure of the NOAA funding procedures; (2)

the means to improve NOAA-academic cooperation; and (3) review of the NOAA *Fleet Modernization Study*.

Ocean Sciences Education (Planned Activity)

The Ocean Studies Board plans to encourage the development of innovative ocean sciences education programs for precollege students. Educators consider the precollege years to be crucial in determining an individual's lifetime understanding of, and performance in, science. By sparking students' interest in ocean sciences--and in physics, chemistry, biology, and geology, which are part of oceanography--the OSB hopes to expand the pool of potential scientists, including ocean scientists, and to increase science literacy.

The OSB, if requested, will assist in the development of ocean science curricula for primary school students. These will emphasize hands-on experimentation as a means of understanding the physical, chemical, biological, and geological properties of the ocean.

International Scientific Conference on Joint Global Ocean Flux Study North Atlantic Bloom Experiment (Completed Activity)

The Ocean Studies Board hosted a three-day conference in November 1990 on the JGOFS North Atlantic Bloom Experiment. This conference brought together U.S. and foreign scientists interested in global change to discuss the results of the first JGOFS process experiment. This multinational experiment monitored the annual phytoplankton bloom and related phenomena from March through September 1989. The experiment contributed to a major JGOFS goal: to develop models that can predict ocean uptake of anthropogenic CO_2 and the response of the ocean carbon cycle to climate change. A report is being prepared.

Ocean Environment and Resources

Public concern over the health and vitality of the coastal ocean and its resources is at an all-time high as a result of the widely publicized degradation of some coastal waters and such incidents as beach closures and oil spills. Partially as a result, several government agencies have recently intensified their coastal ocean research efforts or are planning research initiatives to increase understanding of the environment. Many federal agencies are required to protect the marine environment and its resources, and several large ocean research programs are focused on the

ocean environment and its variability. Ocean environment and resource issues are in acute need of new science-driven policy.

Thus, the OSB is also interested in the application of scientific knowledge for the protection and wise use of the ocean and its resources. An additional focus is on processes in the marine environment, including the ocean's role in climate change. The threats to our environment and coastal region have become more serious in recent years. Although destruction of atmospheric ozone and global warming are receiving much attention, substantial degradation of our coasts continues.

Committee on the Coastal Ocean (Ongoing Activity)

In response to increased scientific and public awareness of problems in coastal waters, OSB appointed the Committee on the Coastal Ocean to examine coastal ocean research and identify issues in need of additional study by federal and state agencies.

The goals of CoCO are as follows:

- To promote the advancement of scientific understanding of the coastal ocean, including continental shelves, estuaries, and wetlands, by overseeing the health of coastal sciences and stimulating their progress;

- To encourage the conservation and wise use of the coastal environment and its resources through the application of scientific knowledge;

- To lead in the formulation of national and regional coastal ocean policy and to clarify scientific issues that affect this policy; and

- To maintain close contact with other NRC groups such as the Marine Board and the Board on Environmental Studies and Toxicology.

The committee met three times in 1990 to determine potential areas of agency interaction in coastal ocean research and to discuss academic coastal research initiatives. In March 1990, scientists from 10 agencies briefed committee members on agency research programs. The committee recommended increased inter-agency cooperation in the following coastal ocean research areas: (1) the Northern Gulf of Mexico; (2) wetlands and habitats; (3) environmental monitoring; (4) material fluxes through the coastal ocean; and (5) coastal hazards.

In 1991, the committee plans to convene a workshop on Northern Gulf of Mexico research. CoCO is also planning several activities related to coastal environment and resources, including a regional symposium series on the relation between coastal research and policy in the United States, improved management of marine fish populations, and a study on nonindigenous marine species. Each of these activities will be carried out by panels of CoCO, including representatives of the parent committee.

Workshop on Marine Science and Coastal Policy in the United States (Planned Activity)

Many local, state, and federal agencies, as well as public and private universities, fund or carry out research in coastal areas. CoCO plans to bring together 25 marine scientists, foundation representatives, and agency administrators to decide whether a series of regional symposia on improved links between coastal research and policy is warranted. These symposia would highlight policy areas that need more input from marine scientists and would identify new data required to improve coastal management. The first symposium will focus on California.

Improved Management of Fish Populations (Planned Activity)

In September 1989, the Ocean Studies Board held a workshop on "Contemporary Issues of U.S. Marine Fisheries," attended by nine NRC staff members and eleven external scientists. Workshop participants decided that an study of science issues related to fisheries policy is needed. The OSB plans to begin this study in 1991, addressing: (1) biological and economic overfishing, (2) enhancement of fisheries production through mariculture, (3) the effect of habitat alteration on fish populations, and (4) allocation of fisheries resources to a variety of users.

Nonindigenous Marine Species (Planned Activity)

Since the arrival of the first Old World settlers, many aquatic species have been accidentally introduced to the U.S. Marine species have long arrived on the hulls of ships, and, more recently, marine and freshwater species have been introduced via ship ballast water, releases from home aquaria, live bait releases, and escapes from aquaculture operations. The problems associated with aquatic introductions and the technical and policy options for preventing new introductions have not been adequately documented. In May 1991, the OSB held a planning meeting of academic and agency scientists and other federal policy makers to

discuss whether the NRC should conduct a study of the science issues surrounding accidental and intentional introductions. It was determined that such a study is needed, and CoCO plans to begin this study in 1991.

Committee on the Ocean's Role in Global Change (Ongoing Activity)

The Committee on the Ocean's Role in Global Change was established in 1989. The committee's goals are as follows:

- To identify the major physical, chemical, biological, and geological ocean processes that play a role in global change;
- To develop and rank the programs needed to understand these processes;
- To assess the desirability and feasibility of additional global ocean observation experiments in the late 1990s to measure the climatic state and circulation of the ocean, and detect global change; and
- To serve as the liaison between the U.S. ocean research community and the international Committee on Climatic Changes and the Ocean (CCCO).

In its liaison role, the committee has conferred with the CCCO on U.S. ocean research programs related to global change. The committee will host a CCCO meeting in June 1991.

The committee's 1990 report, *The Ocean's Role in Global Change: The Contemporary System*, described the major ocean science research programs. In 1991, the committee will issue a report on the geological aspects of global change and research programs that contribute to its understanding.

CO_2 Committee (Ongoing Activity)

The CO_2 Committee was formed in 1987 to oversee the study of the role of oceanic carbon and related biogenic elements in regulating biogeochemical and other climate cycles. Since its formation, the committee has focused on:

- Standards for atmospheric CO_2 measurements;

- Design of a carbon measurement program for the World Ocean Circulation Experiment; and

- New technologies for measuring ocean CO_2, radiocarbon, and organic carbon.

The OSB and the NRC Commission on Physical Sciences, Mathematics, and Resources (CGER's predecessor) asked the CO_2 Committee to study atmospheric CO_2 standards and calibration. The committee expects to publish a report on this issue in 1991.

The WOCE Steering Committee asked the CO_2 Committee to prepare an implementation plan for a WOCE carbon measurement program. The committee issued a preliminary plan in November 1988; parts of this plan were incorporated in a DOE Request for Proposal published in July 1989. The committee also helps other national and international working groups coordinate their efforts in carbon measurement.

In the future, the CO_2 Committee will address seawater CO_2 standards, which are being developed for WOCE and JGOFS, and oceanic CO_2 data management. The data collection components of DOE, NOAA, WOCE, JGOFS, and other international programs have no plans at present for central data access. Access to the best data would aid ocean observers and modelers.

The CO_2 Committee also plans to convene a workshop on carbon dioxide exchange across the air-sea interface. The relationship between gas exchange rate and wind speed, crucial for linking gas exchange models to observations, is known only to within a factor of two. This workshop will bring the CO_2 Committee together with approximately 15 atmospheric and ocean scientists, chemical and mechanical engineers, and experts from related fields. Workshop participants will consider the use of various chemical and isotopic tracers to understand ocean CO_2 uptake.

Global Ocean Observing System Study (Planned Activity)

There is intense interest in understanding the ocean's role in climate change and other global processes. Major research and observation programs now under way aim to increase our knowledge of ocean processes. Ultimately, success in understanding and predicting global variability and change depends on carrying out long-term uninterrupted ocean measurements with improved accuracy and scope.

At the request of NOAA, and as a result of discussions with other agencies interested in ocean monitoring, the Ocean Studies Board, the Marine Board, and the

Board on Atmospheric Sciences and Climate will form a committee to assist in the design of a global ocean observing system (GOOS). A GOOS would be an integrated system of platforms, sensors, and data services that would carry out long-term global observations of physical, chemical, and biological ocean parameters, especially those relevant to climate variability and change.

During an initial nine-month phase of study in 1991, this committee will address and report on:

- Objectives for a global ocean observing system; and
- Scientific measurements to be made in support of those objectives, including which parameters to measure and where, when, and how to measure them.

After completing the initial report, the committee may, in 1992, report further on the following:

- Management structure and evolution of a global ocean observing system. The committee will assess the adequacy of existing national and international management structures and advise on how to move from existing structures and programs (e.g., the World Weather Watch, the Global Sea Level Observing System, WOCE, JGOFS, and the Tropical Ocean-Global Atmosphere program) to long-term global ocean observing; and
- Science and technology initiatives needed to assess alternative observing strategies and deploy a cost-effective observing system.

The committee reports should be of interest to scientists, engineers, and federal agencies, both in the United States and abroad.

National Security

National security is a science- and technology-intensive enterprise. A fundamental tenet of U.S. defense planning is to use our advanced science and technology to offset any adversary's numerical advantage. The U.S. Navy has been a major supporter of oceanographic research since World War II. Therefore, the Ocean Studies Board's third area of interest is the application of ocean sciences to national security. The Chief of Naval Research and the Oceanographer of the Navy have asked the OSB to provide advice on Navy marine science programs and on potential oceanographic contributions to national security.

Navy Panel (Ongoing Activity)

The Navy Panel was formed to help the Navy develop a long-range plan for ocean science research and development, to identify Navy research priorities, to review documents describing Navy programs, and to provide other guidance, as requested. In 1991, the panel will recommend oceanographic research topics for future accelerated research initiatives in the subdisciplines of chemical oceanography and marine geology and geophysics.

Symposium on Tactical Oceanography (Ongoing Activity)

At the request of Admiral Richard F. Pittenger, the Oceanographer of the Navy, a Symposium on Tactical Oceanography was held in March 1990 at the Naval Postgraduate School in Monterey, California. The symposium was organized by the Navy Panel and supported by the Office of the Oceanographer of the Navy and the Office of Naval Research. The purpose was to provide an opportunity for discussion and an exchange of ideas between academic scientists and Navy users of their research. The symposium concentrated on the use of acoustics in antisubmarine warfare (ASW). ASW has been the Navy's highest operational priority for the last five years because of increasing concern about the significant acoustic quieting of new Soviet submarines. About 125 individuals participated, half from the academic community and half from the military community. The symposium was held at the SECRET level. An unclassified summary of the symposium is being prepared by the Navy Panel for sponsors of oceanography within and outside the Navy, in the Administration, and Congress.

Symposium participants were informed by Navy officials about the operational needs and requirements in such warfare areas as mines and anti-submarine, amphibious, and special operations. Academic participants discussed the potential contributions of science and technology for support of naval warfare. The symposium was structured to emphasize considerable interactions between the Navy and academic oceanographic communities. Because this symposium was considered successful, a second symposium was convened in early 1991 on the topic of Naval Warfare and Coastal Oceanography.

APPENDIX I

OCEAN STUDIES BOARD

COMMITTEE MEMBERSHIPS

Ad Hoc Subcommittee on Ocean Acoustics, Navy Panel

Terry Ewart, University of Washington, water column acoustics, *Cochairman*
George Frisk, Pennsylvania State University, seafloor acoustics, *Cochairman*
Michael G. Brown, University of Miami, seafloor acoustics
David Farmer, University of British Columbia, wave scattering
John McCoy, Catholic University of America, radiation and ambient noise
Robert Pinkel, Scripps Institution of Oceanography, water column acoustics

Panel on the NOAA Coastal Ocean Program

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Donald F. Boesch, University of Maryland, marine ecology, *Cochairman*
Judith M. Capuzzo, Woods Hole Oceanographic Institution, marine pollution/ecology
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Dale B. Haidvogel, Rutgers University, physical oceanography/modeling
Edward Houde, University of Maryland, marine fisheries
George Jackson, Texas A&M University, biological oceanography
Michael N. Josselyn, San Francisco State University, marine botany
Victor Klemas, University of Delaware, remote sensing
John B. Mooney, Jr., Harbor Branch Oceanographic Institute, ocean engineering
Claire Schelske, University of Florida, limnology/nutrient cycling
Stuart G. Wakeham, Skidaway Institute of Oceanography, marine geochemistry

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Dennis A. Powers, Stanford University, marine molecular ecology, *Cochairman*
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Robert C. Beardsley, Woods Hole Oceanographic Institution, physical oceanography
Biliana Cicin-Sain, University of Delaware, marine policy
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Eileen E. Hofmann, Old Dominion University, physical/biological interactions
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Scott W. Nixon, University of Rhode Island, marine ecology
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Jerry Schubel, State University of New York, marine geology

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Susan M. Henrichs, University of Alaska, chemical oceanography
Warren L. Prell, Brown University, marine geology/paleoceanography
John H. Steele, Woods Hole Oceanographic Institution, biological oceanography
John Toggweiler, Princeton University, marine chemistry

CO_2 Committee

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Wayne E. Esaias, National Aeronautics and Space Administration, satellite oceanography
Richard H. Gammon, University of Washington, physical chemistry
Charles D. Keeling, Scripps Institution of Oceanography, marine chemistry
Roger R. Revelle, University of California, San Diego, oceanography
Eric Sundquist, U.S. Geological Survey, marine geochemistry
Taro Takahashi, Lamont-Doherty Geological Observatory, marine geochemistry
David Walt, Tufts University, analytical chemistry
Ray Weiss, Scripps Institution of Oceanography, marine geochemistry

Navy Panel

John Orcutt, Scripps Institution of Oceanography, marine geophysics, *Chairman*
Craig E. Dorman, Woods Hole Oceanographic Institution, physical oceanography
Peter Jumars, University of Washington, marine biology
Walter H. Munk, Scripps Institution of Oceanography, physical oceanography
James J. O'Brien, Florida State University, meteorology/physical oceanography
John G. Sclater, University of Texas, Austin, oceanography/geophysics
Robert C. Spindel, University of Washington, ocean acoustics
Oliver C. Zafiriou, Woods Hole Oceanographic Institution, geophysics/physical chemistry

APPENDIX II

OCEAN STUDIES BOARD

MEETINGS, 1990

Jan. 10	Ad Hoc Committee on the Health of Ocean Sciences, Washington, D.C.
Jan. 16-17	Committee on the Coastal Ocean, Irvine, California
Feb. 1-3	Workshop on Using Molecular Biological Tools To Study Global Ocean Processes, Monterey, California
Feb. 5-7	Ad Hoc Subcommittee on Ocean Acoustics Workshop I, Irvine, California
Feb. 27-28	CO_2 Committee, Washington, D.C.
Mar. 12-15	Symposium on Tactical Oceanography, Monterey, California
Mar. 27-29	Coastal Ocean Research Program Workshop, Washington, D.C.
Apr. 23	Ad Hoc Committee on the Health of Ocean Sciences, Washington, D.C.
Apr. 24-25	Ocean Studies Board, Washington, D.C.
Apr. 26-27	Ad Hoc NOAA Review Panel, Washington, D.C.
May 1-3	Ad Hoc Subcommittee on Ocean Acoustics Workshop II, Washington, D.C.
May 8-10	World Ocean Circulation Experiment Scientific Steering Group, Washington, D.C.
May 10-11	Continental Margins--Phase II, Washington, D.C.
May 18	Navy Panel, Washington, D.C.
May 30-31	Facilities Meeting, Irvine, California

June 12-13	Committee on the Ocean's Role in Global Change, Washington, D.C.
July 17	Oceanography in the 1990s, Washington, D.C.
July 19-20	Committee on the Coastal Ocean, Woods Hole, Massachusetts
Aug. 6	Navy Panel, La Jolla, California
Aug. 7-8	Ocean Studies Board, La Jolla, California
Aug. 13-14	Ad Hoc Panel on New Measurement Technologies for the Ocean, Woods Hole, Massachusetts
Aug. 27-28	Panel on the NOAA Coastal Ocean Program, Solomons, Maryland
Sept. 5	Oceanography in the 1990s, Chicago, Illinois
Sept. 20	Tactical Oceanography Steering Group, Washington, D.C.
Oct. 5	Oceanography in the 1990s, Washington, D.C.
Oct. 17	Social Science Working Group, Cambridge, Maryland
Nov. 1-2	Committee on the Coastal Ocean, Washington, D.C.
Nov. 13-14	Panel on the NOAA Coastal Ocean Program, Washington, D.C.
Nov. 15-16	Ocean Studies Board, Washington, D.C.
Nov. 26-28	International Scientific Conference on Joint Global Ocean Flux Study North Atlantic Bloom Experiment, Washington, D.C.
Nov. 29-30	JGOFS Planning Group, Washington, D.C.
Dec. 3-7	American Geophysical Union, San Francisco, California

APPENDIX III

OCEAN STUDIES BOARD

PUBLICATIONS

Greenland Sea Project (1987)

The Mid-Oceanic Ridge: A Dynamic Global System--Proceedings of a Workshop (1987)

Physical Oceanography for the Year 2000 (1987)

Recruitment Processes and Ecosystem Structure of the Sea (1987)

Oceanography and the Navy: Future Directions (1988)

Background Papers for the Workshop on Continental Margins: Evolution of Passive Continental Margins and Active Marginal Processes (1988)

Ocean Studies Board Annual Report 1988 and Future Plans (1989)

Symposium Commemorating the 25th Anniversary of the Demonstration of the Feasibility of Deep Ocean Drilling (1989)

Margins: A Research Initiative for Interdisciplinary Studies of Processes Attending Lithospheric Extensions and Convergence (1989)

The Navy's Role in Global Change Research (1989)

Ocean Studies Board Annual Report 1989 and Future Plans (1990)

The Ocean's Role in Global Change: The Contemporary System--An Overview of Major Research Programs (1990)

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