IDOE

TERNATIONAL DECADE OF OCEAN EXPLORATION

GRESS REPORT VOLUME 2: July 1972 to April 1973

COVER.

The drawing is the new IDOE logo. New logos for IDOE subprograms also appear throughout the text.

INTERNATIONAL DECADE OF OCEAN EXPLORATION

PROGRESS REPORT VOLUME 2: July 1972 to April 1973

Prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, under contract to the National Science Foundation, Office for the International Decade of Ocean Exploration.

September 1973

PREFACE

The International Decade of Ocean Exploration (IDOE) is a long-term international, cooperative program to improve the use of the ocean and its resources for the benefit of mankind.

The IDOE was announced on March 8, 1968, when the President of the United States proposed "an historic and unprecedented adventure—an International Decade of Ocean Exploration for the 1970's." In December 1968, in Resolution 2414, the United Nations General Assembly endorsed "the concept of an international decade of ocean exploration to be undertaken within the framework of a long-term programme of research and exploration. . . ."

In late 1969, the Vice President of the United States, in his capacity as Chairman of the National Council on Marine Resources and Engineering Development, formally announced the U.S. intention to contribute to the IDOE and assigned responsibility for planning, managing, and funding the U.S. program to the National Science Foundation (NSF). In charging the NSF with this responsibility, the Vice President cited proposed goals relative to man's involvement with the oceans in three broad areas. These were:

- Determine the quality of the ocean environment through accelerated scientific observations of the ocean's natural state, evaluate the impact of man's activity on that environment, and establish a scientific basis for corrective actions necessary to preserve the ocean environment;
- Provide the scientific basis needed to improve environmental forecasting; and
- Determine the potential resources of the sea floor.

An additional program was added during Fiscal Year 1972 to:

- Provide the basic scientific knowledge of biological processes necessary to the intelligent utilization of living marine resources.

One further objective outlined by the Vice President was to:

- Improve worldwide data exchange through modernizing and standardizing national and international marine data collection, processing, and distribution.

In pursuit of this latter objective, the IDOE Office of NSF contracted with the Environmental Data Service (EDS) of the National Oceanic and Atmospheric Administration to manage the scientific data for IDOE. The agreement included publishing this series of reports.

Because the success of the global IDOE program depends heavily on the extent to which many nations contribute their expertise and capabilities, the

NSF Office for IDOE has encouraged foreign institutions and researchers to participate in IDOE directly and through the Intergovernmental Oceanographic Commission (IOC) of UNESCO. IOC recognizes IDOE as an important part of its long-term program, and the United States has invited IOC to endorse a number of NSF-sponsored projects as key elements of the IOC's overall IDOE program. These projects include among others, the Mid-Ocean Dynamics Experiment (MODE), the Geochemical Ocean Sections Study (GEOSECS), and the survey of the Southwest Atlantic Continental Margins.

Over 35 nations, including many in Africa, Asia, Europe, and South America, have scientists and institutions already participating in IDOE projects, and their level of involvement in these projects is increasing. NSF's Office for IDOE and the Department of State are working to encourage and facilitate such participation, both directly and through IOC and the other specialized agencies of the United Nations system. To assist in this effort, the U.S. IDOE Office has given IOC a 2-year grant to enable IOC to convene international scientific workshops to consider and, when appropriate, to recommend new projects for IDOE.

We are looking forward to an active period of oceanographic research under IDOE in which the international aspects of the program will receive increasing emphasis. We hope that in years to come the IDOE will be remembered as a program that benefited all mankind and set a pattern for many other international ventures to follow.

Feenan D. Jennings, Head
Office for the International
Decade of Ocean Exploration

INTRODUCTION

This report, the second in a series, provides the scientific community and other interested persons with information, data inventories, and lists of scientific reports pertinent to IDOE. The first progress report covered the period January 1970 to July 1972.

The text of this report is arranged according to the program areas established for IDOE. Details on subprograms are given under appropriate programs. Bibliographies follow subprogram text.

The Appendix contains the National Marine Data Inventory (NAMDI), a computerized summary of reported observations made at sea during the period covered by this Report. All IDOE grant holders must submit NAMDI or equivalent reporting forms, e.g., Cooperative Investigation of the Caribbean and Adjacent Regions Data Inventory (CICARDI), to the National Oceanographic Data Center (NODC). In this report the NAMDI's are arranged in the same program sequence as the text.

The chart following the Appendix shows ocean areas for which data, NAMDI forms, and track charts have been received by EDS. Areas are delinated by squares of approximately 600 by 600 nautical miles. Although an entire square is shaded on the chart, it may contain only one reported observation.

EDS either has the data, information, track charts, and papers described in this report in one of its center archives or knows where they may be obtained.

Queries may be addressed to any of the following EDS centers:

National Oceanographic Data Center (NODC)
National Oceanic and Atmospheric Administration
Rockville, Md. 20852
Tel: (202) 426-9070
IDOE Project Leader: A. R. Picciolo

Marine Geology and Geophysics Group
National Geophysical and Solar-Terrestrial Data Center (NGSDC)
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Environmental Science Information Center (ESIC)
National Oceanic and Atmospheric Administration
Washington, D.C. 20235
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IDOE Project Leader: R. R. Freeman

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National Oceanic and Atmospheric Administration
Federal Building
Asheville, N.C. 28801
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IDOE Project Leader: R. Quayle

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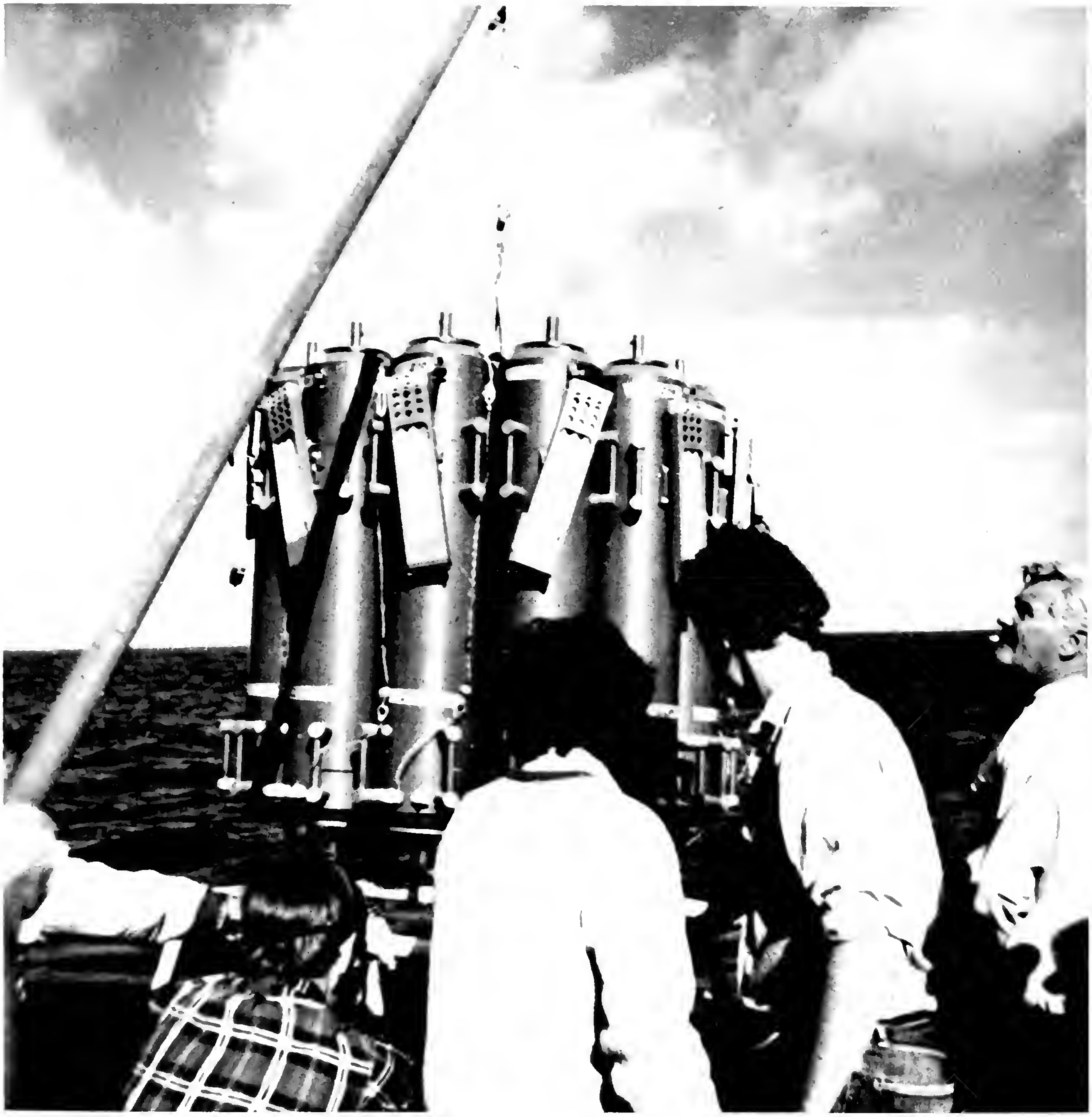


WHOI RV KNORR deploys the GEOSECS underwater sensor package—a rosette of Niskin bottles surrounding a CTD and nephelometer.

Environmental Quality Program

This program consists of long-term, integrated research in marine pollution and geochemical processes. There are three major studies in the program: Geochemical Ocean Sections Study (GEOSECS), which examines the concentration, injection, and transport of the chemical constituents of the ocean in surface and deep water; Baseline Studies, which are designed to establish the concentration of selected important pollutants in biota, seawater, and sediments; and Pollutant Transfer Studies, which investigate the rates, mechanisms, and pathways by which pollutants are transported to the oceans and by which they move through the biota, seawater, and sediments.

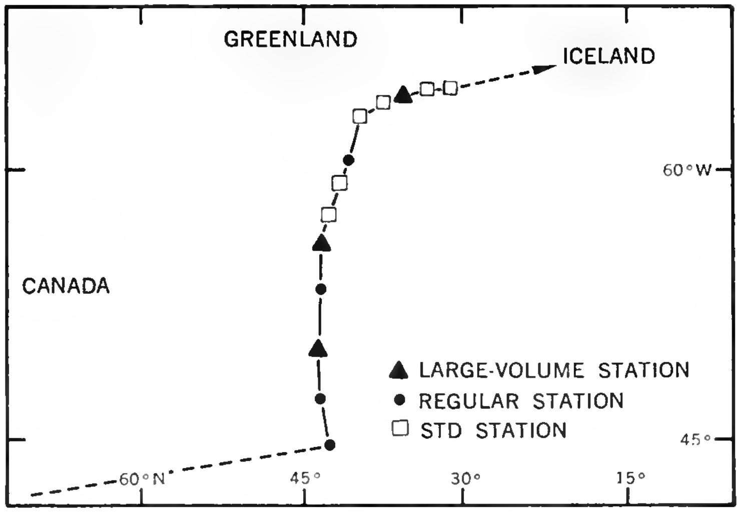


Figure 1.—GEOSECS. Leg 1 of track of RV KNORR, July 18 to August 7, 1972.

Geochemical Ocean Sections (GEOSECS) Study

This international cooperative program applies geochemical and hydrographic measurements to the study of circulation and mixing processes in the world oceans. The GEOSECS research plan is to measure in detail the oceanic constituents at all depths along Arctic to Antarctic sections, in the Atlantic and Pacific Oceans, to provide, for the first time, a set of more than 40 physical and chemical parameters determined from the same water samples. These data not only will provide the input for quantitative studies of oceanic mixing but will serve as a base line for the concentration levels of metals and fission products in the deep sea.

Three types of stations will be routinely occupied during the GEOSECS cruises: (1) Salinity-temperature-depth (STD) stations for continuous hydrographic data; (2) regular stations where hydrographic data are collected with the STD and water samples are collected with Nansen and Niskin bottles for analyses of dissolved gases, nutrients, suspended matter, and trace metals; and (3) large-volume stations where, in addition to the above analyses, very large water samples are collected for radiochemical analyses. In all, about 40 different types of analyses will be performed on the samples collected by GEOSECS.

Research based on the GEOSECS cruises will be carried out at many institutions throughout the world for several years. The sampling transect of the Pacific Ocean will be conducted from the RV MELVILLE of the Scripps Institution of Oceanography during the period July 1973 through April 1974. U. S. institutions participating in GEOSECS are listed on page 1 of the *IDOE Progress Report: January 1970 to July 1972*.

The RV KNORR of the Woods Hole Oceanographic Institution began the GEOSECS program Atlantic Ocean cruise on July 18, 1972.

The KNORR cruise had nine legs.

Leg 1. From Woods Hole to Reykjavik, Iceland (fig. 1). A total of 13 stations were occupied on this leg: excellent weather allowed 6 stations to be completed in addition to the 7 originally planned. D. W. Spencer was chief scientist.

Leg 2. Arctic Ocean from Reykjavik to Reykjavik, Iceland (fig. 2). This leg began and ended from the same port, and 10 stations were completed. Again good weather allowed three extra stations to be completed in the area of the Norwegian Sea overflow into the Atlantic. D. W. Spencer was chief scientist.

Leg 3. Reykjavik, Iceland, to Bridgetown, Barbados (fig. 3). A total of 12 stations were occupied, 2 more than originally planned. Station No. 26 was a reoccupation of station No. 1 from Leg 1. W. S. Broecker was chief scientist.

Leg 4. Bridgetown, Barbados, to Recife, Brazil (fig. 4). Despite several lost days due to a dock strike in Barbados, 14 stations were completed on this leg, which was double the number originally planned. H. Craig was chief scientist.

Leg 5. Recife, Brazil, to Buenos Aires, Argentina (fig. 5). A total of 17 stations were occupied on this leg, 7 more than originally planned. Five of the extra stations were surface stations occupied to measure radon across the Continental Shelf. W. S. Broecker was chief scientist.

Leg 6. Buenos Aires, Argentina, to Ushuaia, Argentina (fig. 6). A total of 14 stations were occupied on this leg, including 7 extra STD stations. Because of bad weather and other conditions, the proposed cruise was altered somewhat and this

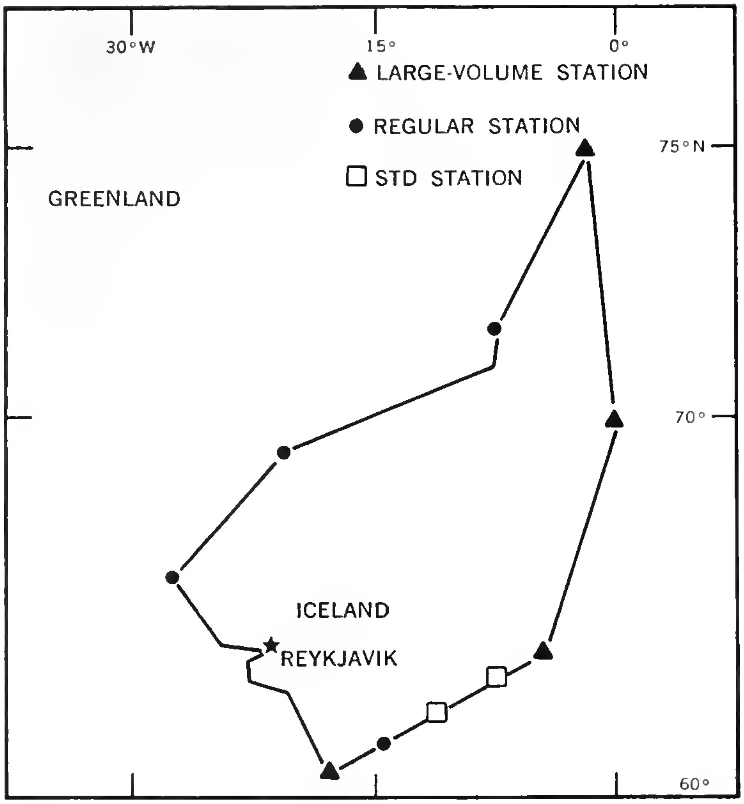


Figure 2.—GEOSECS. Leg 2 of track of RV KNORR, August 12 to 20, 1972.

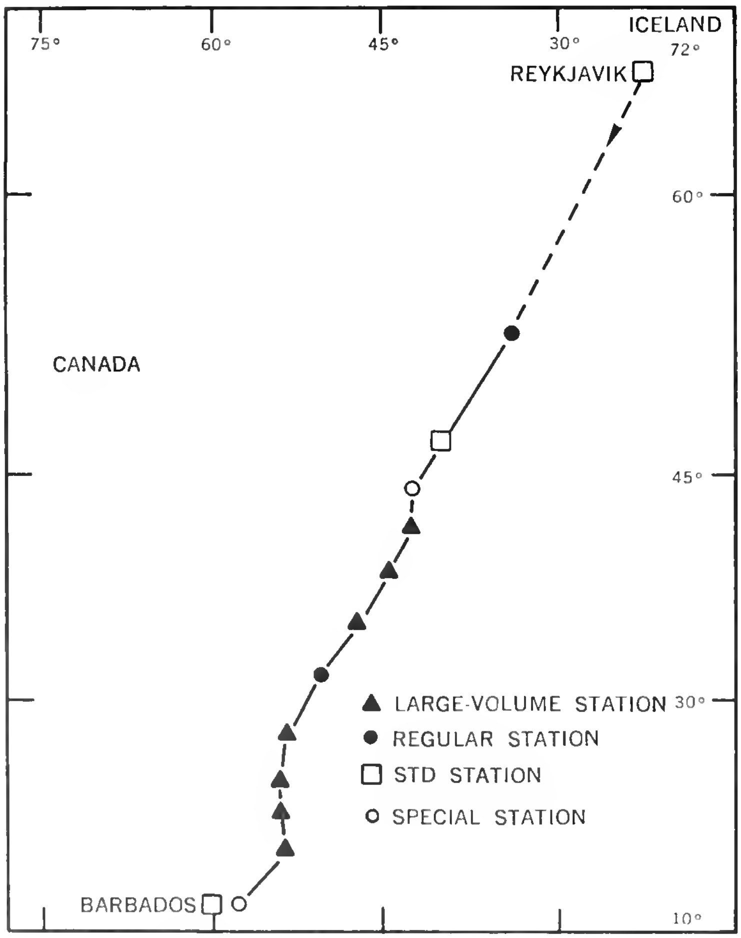


Figure 3.—GEOSECS. Leg 3 of track of RV KNORR, September 4 to October 1, 1972.

leg terminated at Ushuaia, Argentina, instead of Punta Arenas, Chile. P. K. Park was chief scientist.

Leg 7. Ushuaia, Argentina, to Cape Town, South Africa (fig. 7). A total of 19 stations were occupied on this leg, 7 more than originally planned. A series of stations were occupied across the Drake Passage and along the edge of the Antarctic pack ice. A major loss occurred at station 82 when the hydrowire parted on a deep rosette cast. H. Craig was chief scientist.

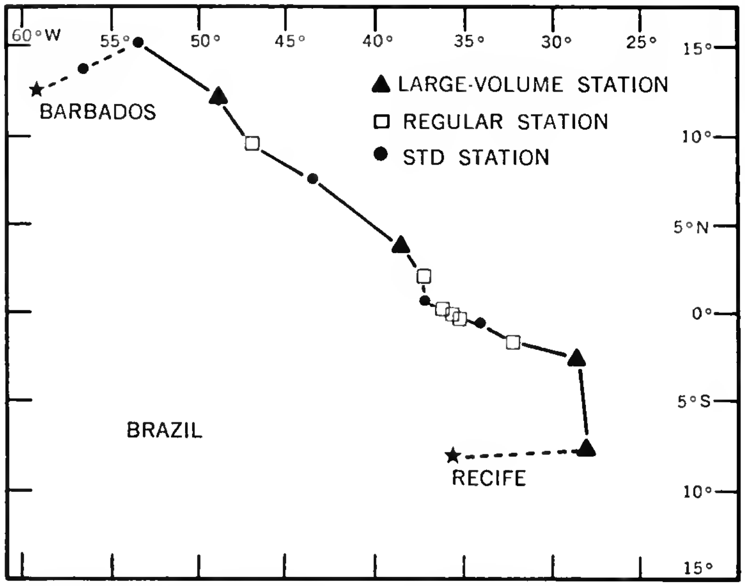
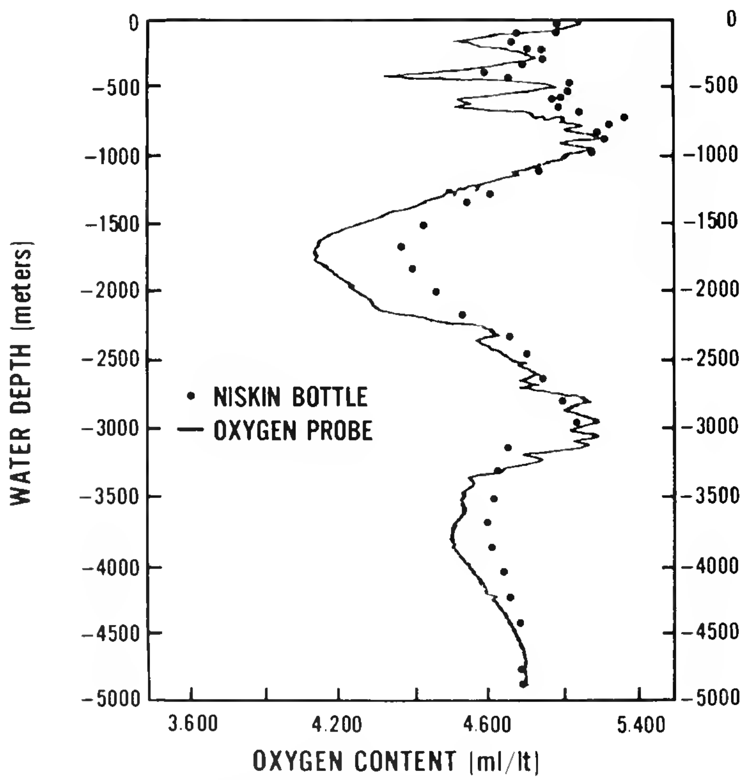


Figure 4.—GEOSECS. Leg 4 of track of RV KNORR, October 9 to 31, 1972.



Comparison of dissolved oxygen measured by Niskin bottle sample analysis and by the GEOSECS oxygen probe points up the increased trace definition capability of the latter.

Leg 8. Cape Town, South Africa, to Dakar, Senegal (fig. 8). In a change from the original cruise track, Leg 8 proceeded up the eastern side of the Atlantic basin. Fourteen stations were occupied on this leg. J. L. Reid was chief scientist.

Leg 9. Dakar, Senegal, to New York, New York (fig. 9). The final leg of the Atlantic GEOSECS cruise was an east-west run across the Atlantic from Dakar, Senegal, to New York. Eight stations were occupied including a reoccupation of station 30 of Leg 3, and of the second GEOSECS interlaboratory calibration station in the Sargasso Sea. T. Takahashi was chief scientist.

The KNORR cruise was completed in April 1973. The in-situ measurement systems for depth, oxygen, salinity, temperature, and turbidity functioned so well that all the preliminary cruise data are already worked up. The shipboard measurements, including argon, $CaCO_3$ saturation, NO_2, NO_3, dissolved O_2, PO_4, and salinity are excellent. A large water library is established at Woods Hole, and samples were distributed to many shore-based labs for measurements of: barium, carbon-13, carbon-14, organic carbon, total CO, cesium-137, deuterium, helium-3, helium-4, neon, oxygen-18, plutonium-238, plutonium-239, radium-226, radium-228, silicon-32, strontium-90, tritium, major ions, particulate chemistry, and trace elements.

Data for most GEOSECS legs are worked up on board the research vessel to assure quality control of sampling and analytical techniques. With the assistance of an IBM 1800 computer, the preliminary data are organized into informal data reports for the use of GEOSECS investigators. Within 1 year or so, the data contained in these reports will have been fully inspected and will be available through the National Oceanographic Data Center.

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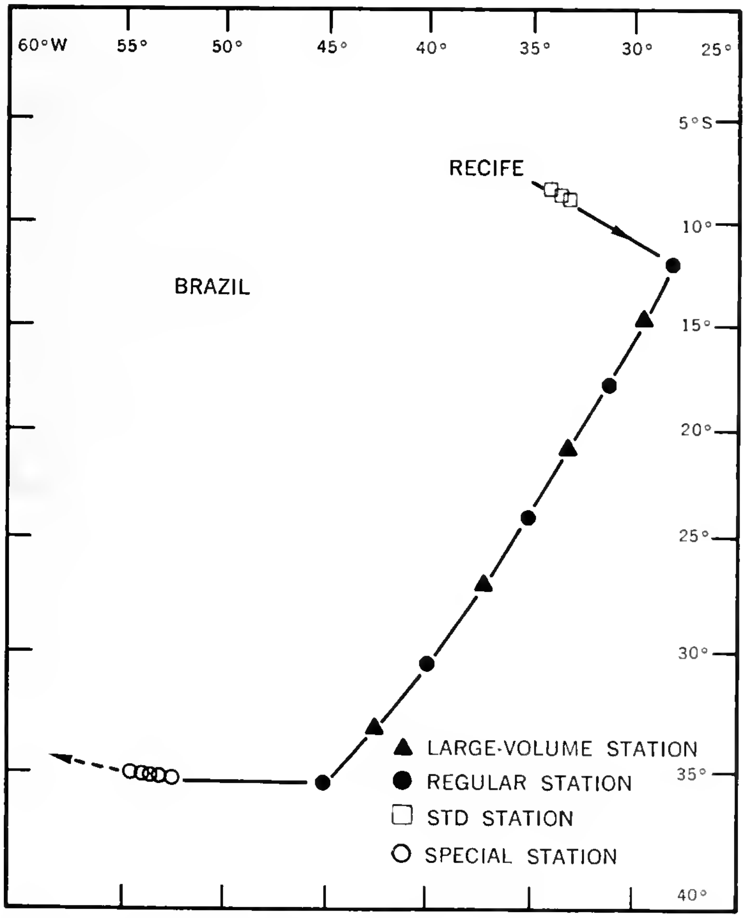

Figure 5.—GEOSECS. Leg 5 of track of RV KNORR, November 4 to 28, 1972.

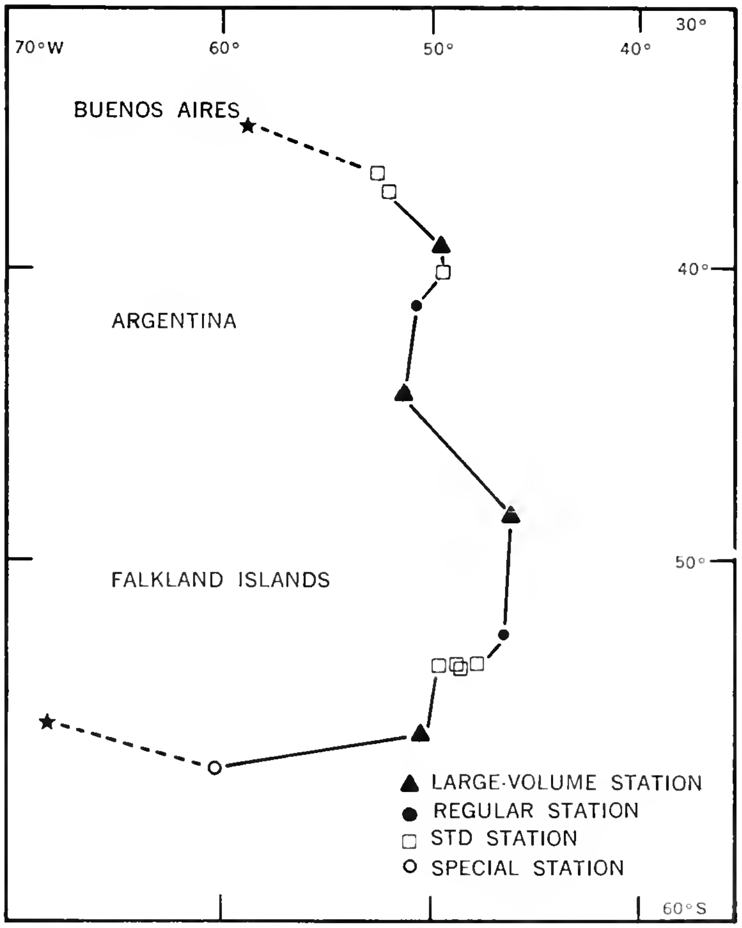

Figure 6.—GEOSECS. Leg 6 or track of RV KNORR, December 2 to 22, 1972.

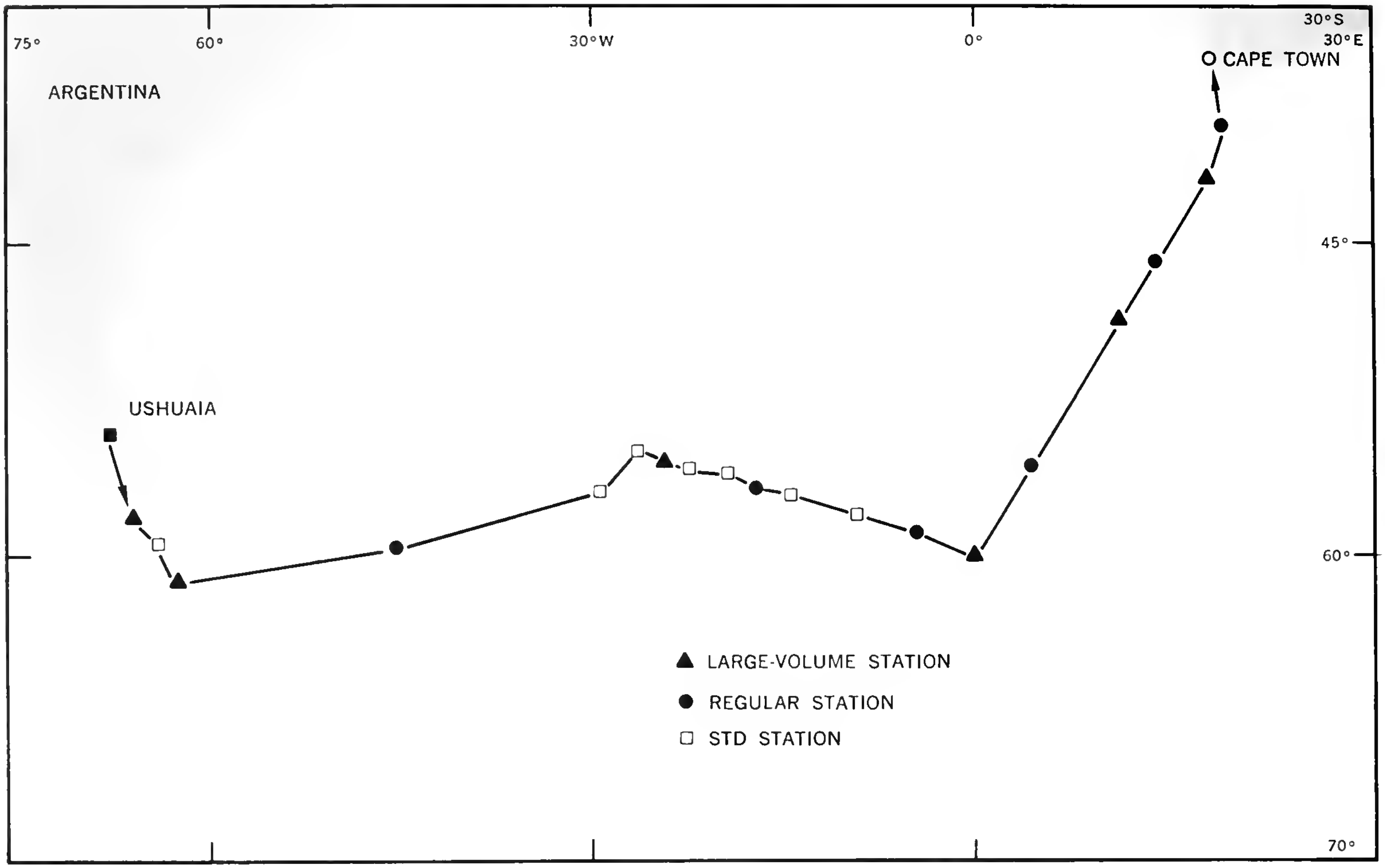

Figure 7.—GEOSECS. Leg 7 of track of RV KNORR, December 30, 1972, to February 5, 1973.

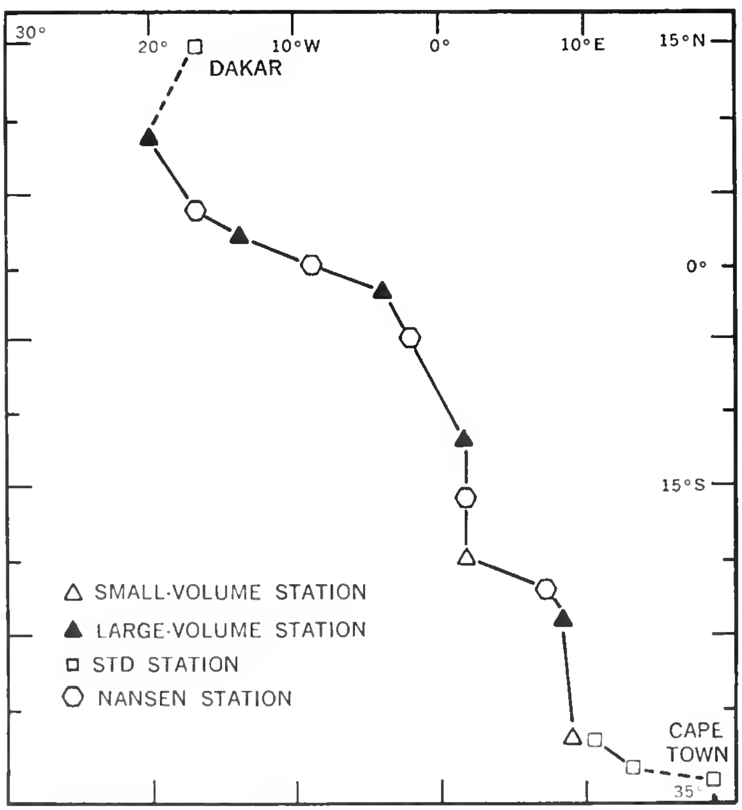

Figure 8.—GEOSECS. Leg 8 of track of RV KNORR, February 10 to March 7, 1973.

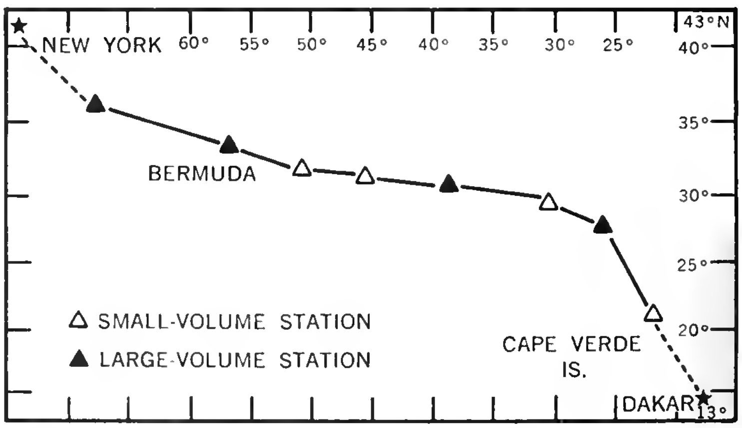

Figure 9.—GEOSECS. Leg 9 of track of RV KNORR, March 10 to April 1, 1973.

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Baseline Studies

During 1971, IDOE supported baseline data acquisition projects in the Atlantic and Pacific Oceans, Caribbean Sea, and Gulf of Mexico to determine the concentration of certain pollutants in the marine environment. Researchers measured levels of chlorinated hydrocarbons (polychlorobiphenyls and DDT), petroleum hydrocarbons, and heavy metals in marine organisms, sea surface films, seawater, and sediments. In May 1972, a scientific meeting was convened to review and appraise the baseline findings. Among those considered significant was the discovery that polychlorobiphenyls and DDT were present in most coastal and open ocean marine organisms examined and that petroleum hydrocarbons were detected in plant and animal communities in the open ocean at concentrations frequently exceeding natural background levels. As a result of these two major findings, the scientists unanimously agreed that halogenated and petroleum hydrocarbons potentially constitute pollutants of global concern. They recommended that research be initiated immediately to determine inputs, dispersal paths, and the effects of the existing levels of these substances on living organisms.

The U. S. IDOE baseline program is essentially complete although analytical studies are being continued as part of the pollutant transfer investigations. Studies of the fate of pollutants are planned.

The list below delineates plots, graphs, lists, or tables submitted to EDS National Oceanographic Data Center (NODC) under the 1971 Baseline Studies.

NODC Accession No.: 72–0735

Organization: University of Rhode Island

Investigator: J. A. Knauss

Project Title: A Study Program to Identify Problems Related to Oceanic Environmental Quality in the North Atlantic

Grant No.: GX–28340

Subproject: Atmosphere and Sea Surface Microlayer

1. Tables of data from surface microlayer samples from estuarine Narragansett Bay (3 samples), New York Bight (5 samples), and North Atlantic open ocean (8 samples), analyzed for chlorinated hydrocarbon pollutants.

Subproject: Trace Metal Measurements in the Marine Atmosphere and Sea Surface Microlayer

1. Table of data from air samples collected over the North Atlantic analyzed for Al, Ca, Cu, Fe, K, Mg, Mn, Na, Pb, Sr, and V.

2. Table of data from atmosphere samples collected over Hawaii and analyzed for Al, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr, and V.

3. Table of the general meteorological situation at each of the air sampling locations.

4. Table of data from surface microlayer samples from Narragansett Bay analyzed for Cu, Fe, Ni, and Pb.

5. Table of data from surface microlayer samples from New York Bight analyzed for Al, Cu, Fe, Mn, Pb, and V.

6. Table of data from surface microlayer samples from open ocean North Atlantic analyzed for Al, Fe, Mn, Pb, and V.

Subproject: Lipid Measurements in the Marine Atmosphere and Sea Surface Microlayer

1. Tables of fatty acid and hydrocarbon concentrations in surface and subsurface samples from Narragansett Bay and the open North Atlantic Ocean.

2. Table of fatty acid concentration in surface and subsurface samples from New York Bight.

3. Tables of fatty acid and hydrocarbon concentrations in atmospheric samples over the North Atlantic.

NODC Accession No.: 72–0735

Organization: University of Connecticut

Investigator:

Project Title: Pb, Cu, and Hg Studies: Quantities Associated with Zooplankton of the Northwest Atlantic Ocean

Grant No.: GX–28340

1. Table of concentration of Pb, Cu, and Hg in mixed zooplankton along a transect from Bermuda to New York Bight.

NODC Accession No.: 72–0737

Organization: Texas A. and M. University

Investigators: W. M. Sackett, C. S. Giam, B. J. Presley

Grant No.: GX–30196

Organization: University of Texas

Investigator: P. L. Parker

Grant No.: GX–30108

Organization: Puerto Rico Nuclear Center

Investigator: W. O. Forster

Grant No.: AG–272

Project Title: A Study Program to Identify Problems Related to Oceanic Environmental Quality in the Gulf of Mexico and Caribbean

1. Graphs of hydrocarbon fluctuations in the Western Gulf of Mexico.

2. Graph of hydrocarbon fluctuations in the Mississippi Delta.

3. Table of chlorinated hydrocarbons in Gulf of Mexico organisms (fishes, penaeid shrimp, plankton, squid, and tunicates).

4. Table of chlorinated hydrocarbons in Gulf and Caribbean plankton.

5. Table of chlorinated hydrocarbons in serranid fishes.

6. Table of percent composition of n-paraffins in *Trichodesmium* blooms in the Gulf of Mexico.

7. Table of percent composition of n-paraffins in *Sargassum* sp. in the Gulf of Mexico.

8. Table of percent composition of n-paraffins in Caribbean water samples.

9. Tables of percent composition of n-paraffins in plankton and fishes of the Gulf of Mexico.

10. Table of percent composition of n-paraffins in Gulf of Mexico water samples.

11. Tables of As, Cd, Cu, Hg, Pb, and Zn concentrations in the muscles of fishes collected in Gulf of Mexico and Bahamian waters.

12. Table of As, Cd, Cu, Hg, and Zn concentrations in assorted invertebrates (cephalopods, decapods, echinoderms, pelecypods, poriferans).

13. Table of total Hg concentrations in Gulf of Mexico water samples.

14. Table of total Hg concentrations of river waters flowing into the Gulf of Mexico.

15. Table of Hg in Gulf of Mexico sediment samples.

16. Tables of methane and other dissolved hydrocarbon concentrations in Gulf of Mexico water samples.

NODC Accession No.: 73–0577

Organization: Skidaway Institute of Oceanography

Investigator: D. Menzel

Project Title: A Study to Identify Problems Related to Oceanic Environmental Quality in the North Atlantic

Grant No.: GX–27946

1. Table of average Zn concentrations in 15 plankton samples (primarily zooplankton).

2. Plots and tables of Hg concentration in U.S. coastal plankton samples from New York Bight to Georgia, and in the area of the Canary Islands.

3. Plots of Hg concentration in coastal Georgia water during summer and winter.

4. Tables of concentration of Cd, Cu, Pb, and Zn in eastern and western North Atlantic plankton samples.

5. Tables of concentration of Cd, Cu, Pb, and Zn in crabs, fishes, and shrimps.

6. Taxonomic list of 21 zooplankton samples collected off Georgia, North Carolina, and South Carolina.

7. Table of concentration of As, Cd, Cu, Pb, and Zn in plankton samples collected off southeastern U.S.

8. Table of Hg concentration in tissues of 13 fishes caught off Georgia and in benthic molluscs from 14 stations off Georgia and South Carolina.

9. Table of Hg concentration in a coastal intertidal versus offshore plant.

10. Table of Hg concentration is tissues of a bottlenose dolphin.

11. Tables of Hg concentrations in fishes, benthic molluscs, shrimp, and squid off coastal Georgia, North Carolina, and South Carolina.

12. Table of Hg concentration in tissues of fishes and benthic molluscs off southeastern U.S.

13. Table of concentration of As, Cd, Cu, Pb, and Zn in tissues of fishes off southeastern U.S.

14. Table of As concentration in plankton samples from New York Bight as well as As, Cd, Cu, Pb, and Zn from Northwest Africa and Georgia coasts.

15. Table of AS concentration in crabs, fishes, and marsh grass.

16. Table of Hg concentration in tissues of common fishes in coastal Georgia.

17. Tables of mean concentrations of As, Cd, Cu, Hg, Pb, and Zn in benthic copepods, decapods, fishes, and molluscs in the North Atlantic.

18. Table of concentration of As, Cd. Cu, Hg, Pb, and Zn in tissues of fish-eating ducks.

Baseline Studies Bibliography

Baseline Studies of Pollutants in the Marine Environment and Research Recommendations: The IDOE Baseline Conference, May 24–26, 1972. Available from the Office for the International Decade of Ocean Exploration, National Science Foundation, Washington, D.C. 20550.

Pollution Research

The pollutant research program includes studies of the transfer and effects of pollutants in the marine environment. The pollutant transfer process program is based in large part on the baseline studies. It is designed to understand the mechanisms that are important in pollutant transfer into and within the environment and the environmental processes affecting these mechanisms. The pollutant effects program will assess and predict the effects of pollutants on marine organisms.

The goals of the transfer process research program are to: (1) Determine which mechanisms are important in pollutant transfer, (2) determine important environmental factors affecting pollutant transfer processes, and (3) identify principles governing transfer of pollutants. Specifically, the quantities and forms of heavy metals, halogenated hydrocarbons, and petroleum hydrocarbons will be determined at the sea surface and in the coastal regions where they enter the marine environment. Special attention is being paid to the concentration and dispersal of pollutants at the air-sea interface, leakage of pollutants through estuaries to continental shelf waters, and the chemical forms of the pollutants. The chemical aspects of this program involve investigations of how the physical and chemical properties are changed by environmental conditions; the biological aspects focus on the mechanisms of pollutant uptake by organisms and the way pollutants are transferred through marine food chains. Projects within this program are listed in table 1.

Organization: California Institute of Technology

Investigator: C. C. Patterson

Project Title: Determination of the Input and Transport of Pollutant Lead in Marine Environments Using Isotope Tracers

Grant No.: GX–31293

Lead is the one toxic metal suspected, with some degree of assurance, of polluting the marine environment. This has become evident from comparisons of the amounts of lead in the oceans with the amounts of industrial lead being dispersed into the environment. Lead is unique in that industrial and natural occurrences have different isotopic compositions, so that it is possible to distinguish between these two kinds of lead in the marine environment.

IDOE Baseline Study results for lead analyses of the or-

Table 1.—IDOE projects for pollutant transfer studies

Organization	Investigator	Project title
California Institute of Technology	C. C. Patterson	Determination of the Input and Transport of Pollutant Lead in Marine Environments Using Isotope Tracers.*
University of California, Bodega Marine Laboratory	R. Risebrough	Formulation of Mass Balance Equations for Polychlorinated Biphenyls in Marine Ecosystems.*
University of California, Scripps Institution of Oceanography	E. Goldberg	The Fluxes of Synthetic Organics in the Marine Environment.*
University of California, Scripps Institution of Oceanography	R. Lasker	Exchange Rates of Chlorinated Hydrocarbons and Similar Chemicals in Marine Food Chains Established in the Laboratory.*
University of Georgia, Skidaway Institute of Oceanography	H. Windom	The Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean.*
Harvard University	J. N. Butler	Transfer of Persistent Pollutants in Sargassum Communities.*
Oregon State University	N. Cutshall	Effects of Ocean Water on the Physico-Chemical Form of Heavy Metals.
University of Rhode Island	R. A. Duce	Atmospheric Pollutant Transfer and Deposition on the Sea Surface.*
Woods Hole Oceanographic Institution	G. R. Harvey	Uptake and Transfer of Chlorinated Hydrocarbons in the Atlantic Ocean.*

* Discussed in following text.

chid leaf, bovine liver, and tuna show that techniques of isotope dilution analysis have the required sensitivity and accuracy to provide reliable data for the low concentrations of lead that are found in marine organisms.

The objectives of Patterson's 5-year research program are:

(1) Measurement of industrial lead input to coastal waters. In the southern California coastal region, virtually all runoff is processed by man and enters the ocean as sewage. Patterson and his associates will collect lead from sewage entering the oceans as well as lead from rain and dust falling on coastal waters, and compare the isotopic composition of these leads with the isotopic composition of lead in coastal water. The results may indicate the degree of industrial pollution.

(2) Measurement of the intrusion of industrial lead into the open ocean. The isotopic composition of lead in fishes in different oceanic localities also can probably be used to study the extent of the intrusion of industrial lead pollution into open waters. It is not known whether lead pollution is as great in the open oceans as in coastal waters. Lead isotope tracers (either industrial or natural) collected by fish from the water and accumulated in different organs have different residence times in those tissues, and samples of lead from these reservoirs at different ages provide a means of studying the problem of ocean lead pollution.

The isotopic compositions of leads will be determined from the tissues of fishes collected from the coastal waters of Alaska, California, Hawaii, and Peru as well as from deep waters.

(3) Investigations of the distribution of lead in fishes. The distribution of lead will be determined in bone, gills, integument, muscle, scales, vascular tissues, and other organs, as well as stomach contents and feces. Other concentrations of metals (Ba, Ca, Sn, Sr) will be measured where appropriate.

(4) Investigations of the distribution of lead among principal reservoirs in marine waters. Total lead within the upper 200 meters of the oceans is contained in organisms and particles, as well as existing in dissolved ionic form. Preliminary indications suggest that ionic lead may represent a small fraction of the total lead. Furthermore, it is possible that the major portion of total lead may not be contained in colloids but may reside in plankton or be attached to surface mucous albuminoids of larger marine organisms.

Patterson's group is developing a method for analyzing ionic and colloid lead in 100 milliliters of seawater using isotope dilution, so as to determine reliably and accurately the ratio of dissolved ionic lead and colloidal lead.

Also under development are seawater standards (for lead content), to be used for interlaboratory calibration, and a lead-free plankton sampler and procedure to obtain contamination-free samples.

A partial summary of Patterson's progress shows that techniques of stable lead isotope dilution analysis are sufficiently sensitive and accurate to provide satisfactory analyses of fish. The IDOE-National Bureau of Standards orchard leaf reference contains too much lead to be useful for marine substances. The bovine-liver reference is satisfactory for materials with a high lead-range. Another reference containing less than one-tenth as much lead is needed, however. The tuna muscle reference material was contaminated by a factor of 10 by a commercial food processor, which suggests that such kinds of activities may introduce considerable amounts of lead into human foods. Lead concentrations in the outermost layer of skin of tuna are 150 times higher than within the muscle. This concentration may be due to the fixation of seawater lead by albuminoids in fish skin mucus. Lead concentrations in skeletal bone, spleen (blood), and stomach contents are twice those in muscle. Lead concentrations in gills are half those in muscles. In albacore, 45 percent of the lead is contained in muscle, 25 percent in the epidermis, and 10 percent in skeletal bone and scale. Lead is not stored in fish bone to the same extent it is stored in mammal bone. Skipjack and yellowfin tunas showed 10-fold higher body burdens of lead than albacore, yet the relative amounts of lead in the bone, fin, and muscle of these fish did not change. Observed lead concentrations in scales are probably high because of cross-contamination with epidermal slime. It is not necessary that significant amounts of lead be absorbed into the main bloodstream from either the epidermis or the gills because the lead content in the food of tuna can account for the observed tuna body burden of lead. Red blood cell/serum lead ratios are probably lower in fish blood compared to humans.

Organization: University of California, Bodega Marine Laboratory

Investigator: R. Risebrough

Project Title: Formulation of Mass Balance Equations for Polychlorinated Biphenyls in Marine Ecosystems

Grant No.: GX–32885

This project will try to formulate the parameters of a mass balance equation for the polychlorinated biphenyls (PBC) in Californial coastal waters, permitting an approach to the problem of determining long-term accumulation rates of PCB in these and other marine ecosystems. Estimates of input will be derived from measurements of PCB in sewage waste waters and in waters of major California rivers.

An approach to the problem of determination of the input from atmospheric fallout will be made by measurements of PCB in the snow of permanent snow fields in the vicinity of Mount Olympus, Wash.

Determination of partition coefficients between concentrations of PCB in water and concentrations in mussels (*Mytilus*) will be carried out under experimental conditions, combined with a study of PCB uptake by phytoplankton. PCB concentrations measured in seawater will be compared with concentrations recorded in mussels from the same area to confirm the values of partition coefficients obtained in laboratory studies. Uptake and loss of PCB in mussels in contaminated and relatively uncontaminated waters will be studied under environmental conditions. In this way estimates of the PCB burden in water masses will be obtained. The possibility that sediments are a sink for PCB will be investigated.

Organization: University of California, Scripps Institution of Oceanography

Investigator. E. Goldberg

Project Title: The Fluxes of Synthetic Organics in the Marine Environment

Grant No.: GX–32977

In this project techniques for the measurement of freons in air were developed as the first phase of investigating how man-generated low molecular weight halogenated hydrocarbons affect the oceans. Freon 11 and Freon 12 have been assayed in the La Jolla-San Diego, Calif., atmosphere. Present work includes seeking a technique for the analyses of these freons in seawater.

Organization: University of California, Scripps Institution of Oceanography

Investigator: R. Lasker

Project Title: Exchange Rates of Chlorinated Hydrocarbons and Similar Chemicals in Marine Food Chains Established in the Laboratory

Grant No.: GX–32977

In this project the first 6 months have been spent developing the techniques necessary to explain the mechanisms of biological transfer of chlorinated hydrocarbons (CHCs) in a marine food chain. Much of the effort has been directed towards designing a system for incorporating CHC into experimental foods chains to simulate, as closely as possible, conditions as they exist in the ocean.

There is good evidence that the great majority of CHCs enter the oceans already absorbed onto fine (< 1 micron) particles. In constructing a laboratory system capable of demonstrating the biological transfer of CHCs in the oceans, it was believed necessary to maintain CHC concentrations at levels known to exist in the California Current and to have these CHCs introduced into the system absorbed onto sub 1 micron particles. With knowledge of the flow rate of the compressed air bubbled through the system and the amount of CHC present in

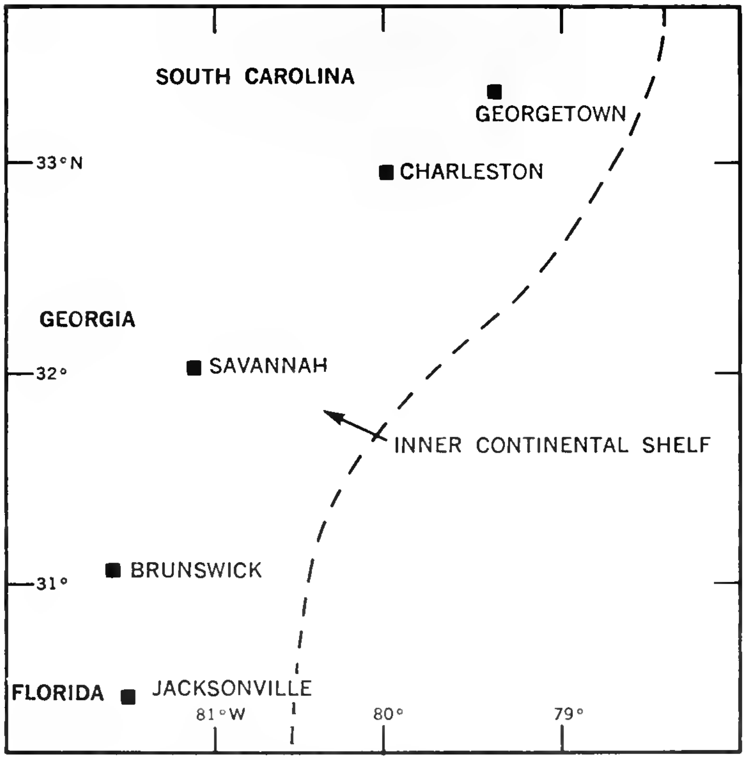


Figure 10.—The Skidaway Institution of Oceanography innercontinental shelf area fur environmental quality studies.

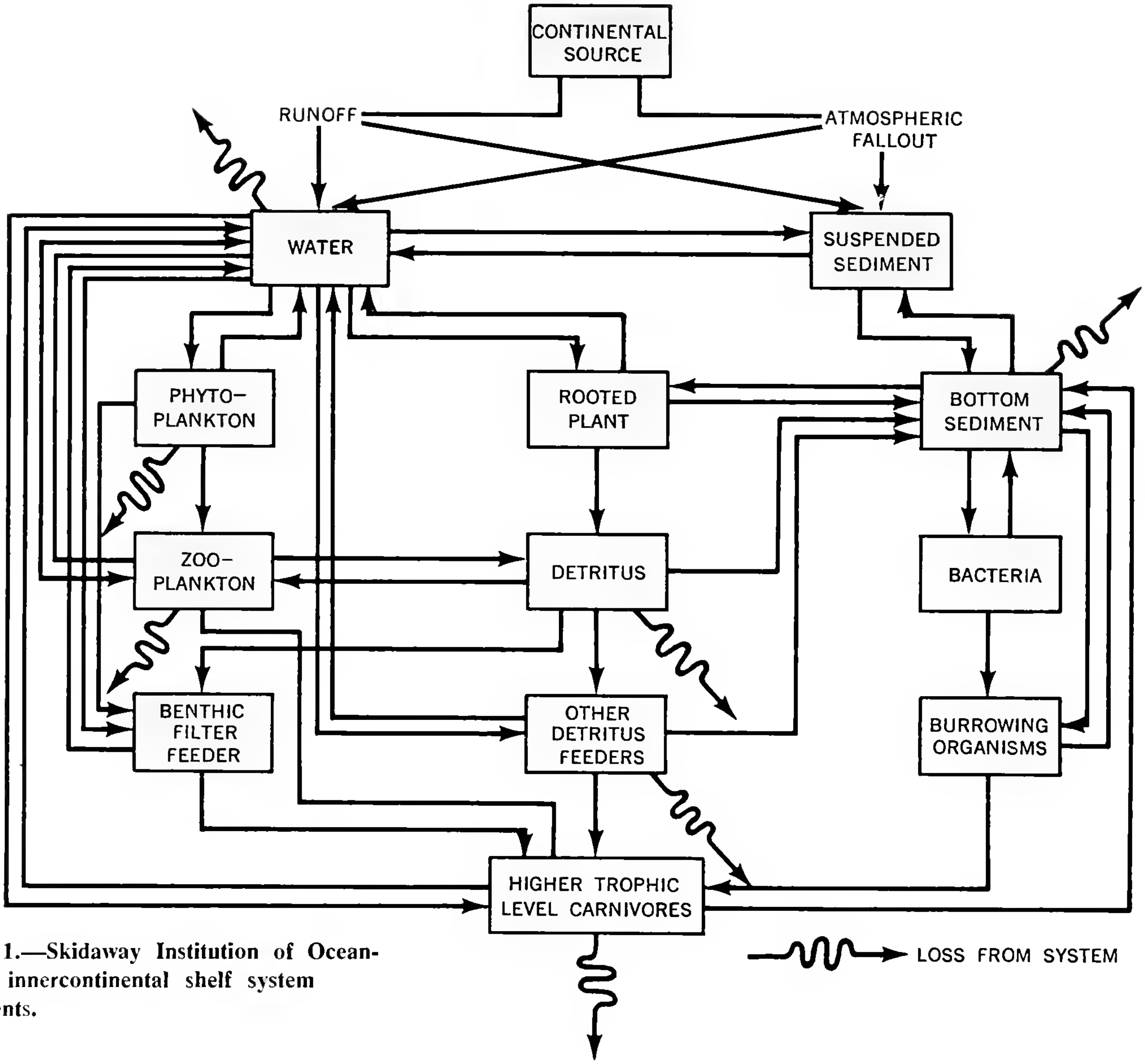


Figure 11.—Skidaway Institution of Oceanography innercontinental shelf system components.

the air at La Jolla, Calif., the quantities of CHCs introduced into the system can be adjusted.

To measure such low levels of CHC in 1-liter quantities of seawater it was necessary to develop a sensitive method for detecting CHC residues. Currently, CHC transfer is being measured in a simple marine food chain: seawater medium → algae → rotifers → anchovy larvae. Twenty-liter cultures of the green flagellate, *Dunaliella*, and the dinoflagellate, *Gymnodinium splendens*, are monitored at 5-day intervals to determine the accumulation of CHCs during exponential growth. Rotifers, *Brachionus plicatilis*, maintained in 20-liter *Dunaliella* cultures are also tested for CHC residues every 5 days.

Anchovy larvae, *Engraulis mordax*, reared on the algae rotifier diet are sampled every 5th day for 20 days. To separate the larger rotifiers from the flagellates, the rotifer-*Dunaliella* cultures are passed through 35 micron screening.

Dunaliella is isolated from the culture media by continuous flow centrifugation. All tissue samples are prepared for gas-chromatographic analysis.

To get an idea of what might be happening still further up the food chain in nature, samples of porpoise and tuna livers were analyzed for CHCs. These samples were obtained by NOAA's National Marine Fisheries Service porpoise observers aboard commercial tuna boats far from any source of CHCs (e.g., Los Angeles, Calif.). Analyses were made to compare biological magnification of CHCs by tunas and porpoise, both presumably feeding on the same forage.

In the future, Lasker intends to make a more detailed investigation of the simple, algae → rotifiers → anchovy larvae food chain. After accurately determining concentration factors, studies will be made on rates of exchange and losses of CHCs in this food chain as well as in more complicated food chains involving adult anchovies and predatory fishes.

Organization: University of Georgia, Skidaway Institute of of Oceanography

Investigator: H. Windom

Project Title: The Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Grant No.: GX–33615

The Skidaway Institute of Oceanography has made considerable progress on both the field assessment and laboratory aspects of this Environmental Quality Program project, the purpose of which is to study the transfer of heavy metals through an inner Continental Shelf system to the open ocean (fig. 10).

The field studies serve as a data base for the interpretation of laboratory results and help to identify system components (fig. 11), which will be given detailed consideration in the laboratory.

The objectives of the field program are to determine the concentrations of Cd, Hg, and Pb in various compartments of the system (fig. 12), and where possible, to determine the form of the metal in each of the compartments (primarily methylmercury in fishes and water). Another objective is to establish budgets of the metals entering and leaving by determining the input rate of the metals from river runoff and atmospheric fallout and the rates of loss from the system by sedimentation and seaward transport. From the difference an estimate can be obtained of the quantity of metals that must migrate through the system via various pathways to the open ocean.

To establish those pathways important in the migration of metals through the system, a relatively detailed understanding of the dominant tropic interrelationships must be obtained. Another objective of the field studies, therefore, is to ascertain which species represent most of the biota at each trophic level. Also needed is a study of the feeding relationships between organisms.

Figure 12 shows the locations of the major rivers emptying into the study area and locations of stations where data are being obtained on rates of metal input from river runoff and atmospheric fallout. Figure 12 also shows locations where cores of marsh sediment are taken. Analysis of these cores will yield data on the loss of the metals from the system due to sedimentation. Samples of the dominant marsh grass, *Spartina alterniflora,* growing at the core locations, are also being analyzed for the various metals.

The first half year of work on this project was dominated by the study of food chains supporting the quantitatively dominant fishes in the southeastern inner Continental Shelf and collection and dissection of organisms used in the determination of levels of background trace metals. Cruises were made at bimonthly intervals in the coastal areas from Georgetown, S.C., to Jacksonville, Fla. Figure 13 shows the sampling areas for obtaining biological samples for analyses of heavy metals and stomach contents. Plankton samples were obtained from most of the sampling stations at night. These samples were frozen and will be analyzed for heavy metal content.

Significant progress has been made in identifying the feeding habits of many of the common estuarine fishes of the study region. Collections will continue so that seasonal patterns can be examined.

Laboratory studies have been designed to investigate the specifics of the transfer processes from compartment to compartment, with initial transfer studies involving the primary producers. Data have been obtained on mercury uptake by phytoplankton, *Spartina alterniflora,* and *S. alterniflora* detritus.

The following tables and raw data sheets are available from NODC. They are cataloged under NODC accession number 73-0575.

1. Tables of tentative account of occurrence of food organisms in the diets of 29 common estuarine fish.

2. Raw data sheets of 25 core analyses of marsh sediment for Eh, moisture, ph and total organic carbon as well as Cd, Cu, Fe, Hg, Mn, Pb, S, and Zn; and analyses of marsh grass for Cd, Cu, Fe, Hg, Mn, Pb, and Zn.

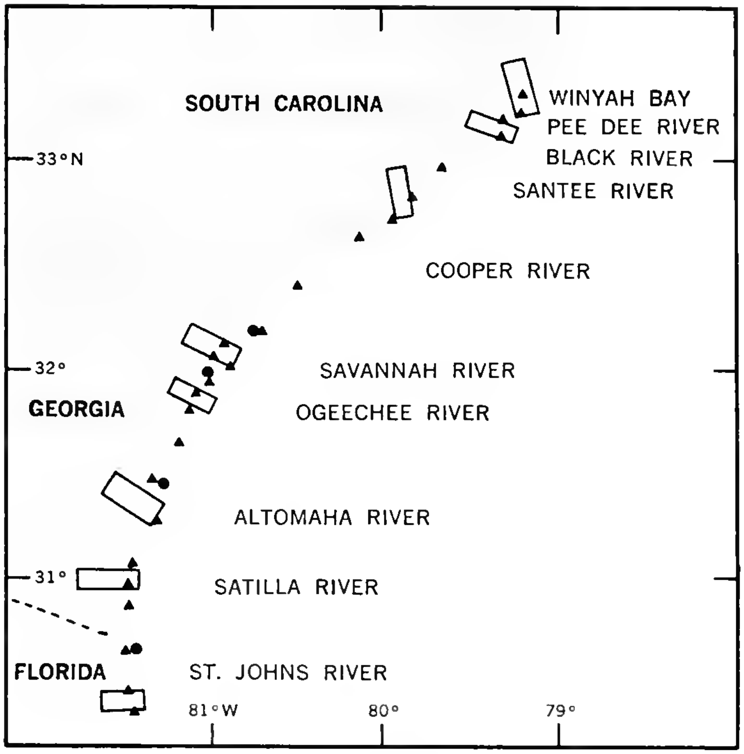


Figure 12.—The major rivers emptying into the Skidaway Institution of Oceanography study area, as well as locations of atmospheric sampling stations (●) and marsh sediment coring stations (▲).

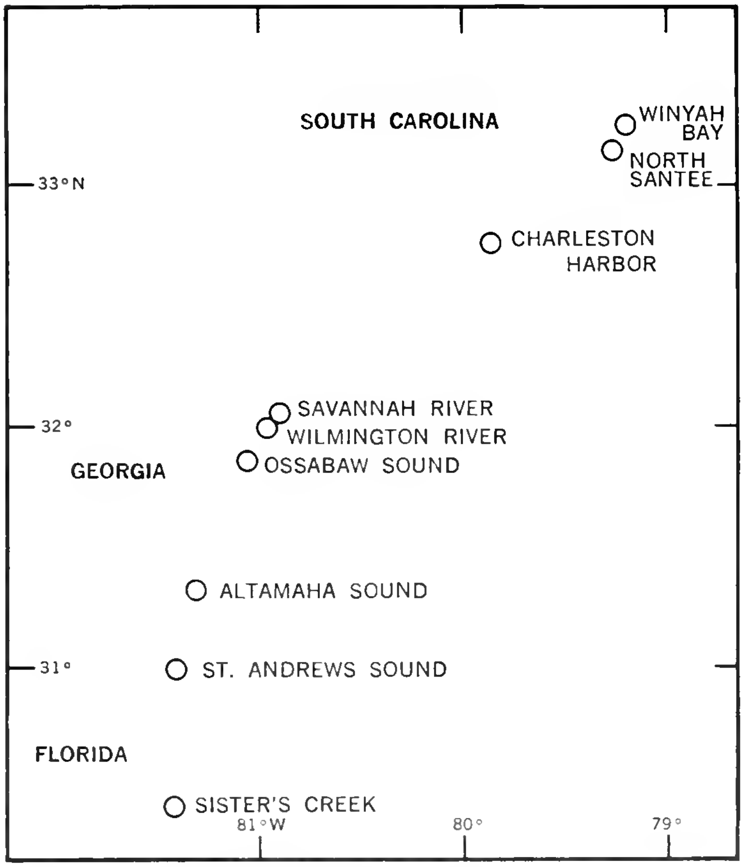


Figure 13.—Skidaway Institution of Oceanography sampling areas utilized for obtaining biological samples for heavy metal analysis and stomach content analysis.

Organization: Harvard University

Investigator: J. N. Butler

Project Title: Transfer of Persistent Pollutants in *Sargassum* Communities

Grant No.: GX–32883

The objectives of this program are to understand the dynamics of persistent pollutants, particularly selected hydrocarbon from petroleum and chlorinated hydrocarbons within the floating colonies of *Sargassum* with their attendant fauna, found in the Sargasso Sea. The Bermuda Biological Station serves as a base of operations for these studies.

To fulfill the objectives of the program, the following studies are in progress:

1. Collections of *Sargassum* communities of varying sizes are being made, and the number and taxonomy of each species in the community is being determined. Detailed studies of the structure, dynamics, and stability of the communities are being made, and trophic levels and modes of transfer will be identified. Attempts will be made to construct suitable mathematical models.

To test the hypothesis that the presence of pelagic tar acts as a stress on the *Sargassum* communities and tends to reduce their diversity, Butler and his associates plan to correlate the diversity of each community with the density of pelagic tar in the same area.

2. The pelagic tar lumps will be analyzed by gas chromatography to determine if the lumps vary significantly or whether they are uniform throughout.

3. The paraffinic hydrocarbon content of the major species in the community will be determined. Comparison of these data with those of the tar itself may make it possible to trace hydrocarbons and their metabolites through the food web of the pelagic ecosystem, as well as determine when significant additional hydrocarbons are present.

4. The chlorinated hydrocarbon content (DDT, dieldrin, and their residues) will be determined both in the pelagic tar lumps and in the various species of the *Sargassum* community.

5. The results of these analytical studies will be interpreted in light of the observed structure, function, and diversity of species, using toxicological data obtained from the literature and new laboratory work on organisms specific to the *Sargassum* community. Models of pollutant transport will be constructed. The organisms most sensitive to pollutants can be used as indicators of environmental quality in future monitoring studies.

A number of samples of tar lumps and *Sargassum* communities were collected near Bermuda in connection with Office of Naval Research Hydrostation S (31°10′N, 64°30′W). Cooperative arrangements have been made for sampling by other vessels making transects of the North Atlantic, in particular the University of Rhode Island RV Trident and also the Westward. An additional program, partially supported by the Bermuda Government, has been underway to sample the tar that washes up on beaches at six representative locations around Bermuda.

To date, Butler and B. Morriss, Bermuda Biological Station, have presented new quantitative results for the amounts of tar in the *Sargasso* Sea and the Northwestern Atlantic Ocean, a quantitative assessment of tar on Bermuda beaches over a period of nearly 1 year, and information on the physical and chemical characteristics of the tar found both at sea and on the beaches.

Organization: University of Rhode Island, Graduate School of Oceanography

Investigators: R. A. Duce, J. L. Fasching, W. F. Fitzgerald, D. R. Kester, C. E. Olney, M. E. Q. Pilson, J. G. Quinn

Project Title: Atmospheric Pollutant Transfer and Deposition on the Sea Surface

Grant No.: GX–33777

The objectives and scope of this research program are as follows:

1. To evaluate the importance of atmospheric transport of such pollutants of the ocean surface as chlorinated hydrocarbons, heavy metals, and petroleum products.

2. To characterize the surface microlayer and top 1 meter of the ocean with respect to (A) the chemical concentration and speciation of naturally occurring and pollutant organic and inorganic substances and (B) physical features such as density stability.

3. To investigate, in the laboratory, the chemical and physical mechanisms of pollutant concentration, stabilization, and dispersion in the surface layer of the ocean.

For many areas of the project, the first 6 months has been a period of design, construction, and testing of new collection equipment. New analytical procedures have been developed, and old ones modified. Coordinated field studies in the various areas of atmospheric transport and surface microlayer chemistry of the various pollutants were begun.

The ship sampling program was conducted on the University of Rhode Island RV Trident. Figure 14 presents the ship tracks for the Trident Cruises, TR–111, TR–114, and TR–123, (February-September 1972), where 30 atmospheric particulate samples were collected for trace metal analyses and 11 for organic analyses. Twenty-three surface microlayer samples were also collected and analyzed for trace metals. Micro-

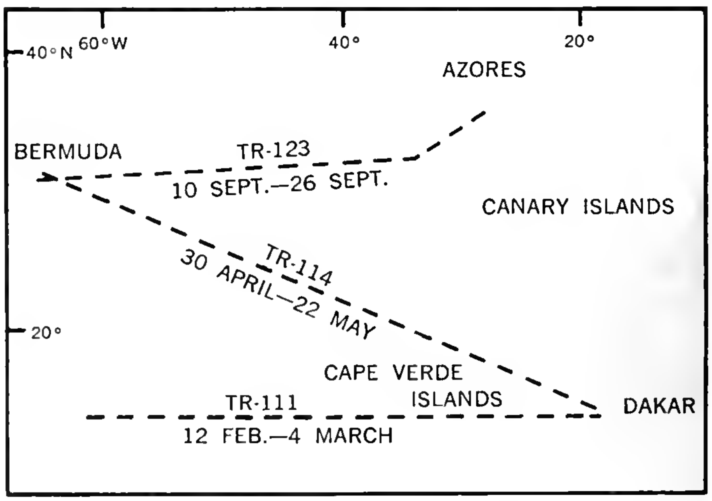


Figure 14.—RV TRIDENT (TR) IDOE Cruises, February to September 1972.

layer samples for organic analysis were collected on cruise TR–123, as were tar balls from several stations. Microlayer samples for trace metal analyses were also collected in Narragansett Bay.

Ninety-five surface profiler samples were collected at 10 locations on Cruise TR–123 between Bermuda and the Azores. The water samples from depths of 0, 10, 20, 30, 40, 50, 70, 90, and 110 centimeters were analyzed for reactive phosphate. The objective of the surface profiler project is to develop a system for determining vertical chemical and physical gradients within 1 meter of the air-sea interface. These gradients will be used to characterize the dynamics of the surface region and the transport of pollutants from the interface to the mixed layer. Phosphate was selected as a chemical indicator of near-surface dynamics because of its surface active tendency and its compatibility for shipboard analysis.

Atmospheric particulate samples for trace metal analysis and organic analysis were also collected from a 20-meter high tower constructed on the southwest coast of Hamilton Island, Bermuda.

The following profiles and tables are available from NODC. They have been cataloged under NODC accession No. 73–0573.

1. Table of trace metals (Al, Ca, Fe, Mg, Mn, Na, Pb) in 24 samples of atmospheric particulate matter.

2. Tables of trace metals (Cu, Fe, Ni, Pb) from seven samples of the surface microlayer in Narragansett Bay.

3. Profiles of four samples of phosphate concentrations in surface microlayer and upper 1 meter.

4. Tables of preliminary data of inorganic, organic, and total organic mercury from Connecticut River, Mystic River, and Long Island Sound.

Organization: Woods Hole Oceanographic Institution

Investigator: G. R. Harvey

Project Title: Uptake and Transfer of Chlorinated Hydrocarbons in the Atlantic Ocean

Grant No.: GX–35212

During summer 1972, three cruises were made in the eastern and western North Atlantic between 26°N and 63°N: WHOI RV CHAIN cruise 105–1, from Newfoundland to Portugal; CHAIN cruise 105–2, Portugal to Ireland; and WHOI RV ATLANTIS II Cruise 71, Woods Hole, Mass., to Bermuda (figs. 15, 16). Stations 1 to 23 were occupied between June 6 and August 8, 1972, on Cruise 105, legs 1 and 2 of the CHAIN; Stations 25 to 41 were occupied between September 21 and October 9, 1972, on Cruise 71 of the ATLANTIS II. Station 24 is the Woods Hole dock, occupied on October 2, 1972. The water samples were analyzed for concentrations of PCBs. A complete analytical facility was set up in the hydrolabs of the ships, and surface and deepwater samples were extracted and analyzed on board within 4 hours of collection.

In addition, over 100 samples of plankton and mesopelagic organisms were collected. Plankton analyses for PCBs have been completed, and mesopelagic organisms are now being analyzed. The prevailing hydrocarbon concentrations within, among, and between species, as well as water concentrations, and geographic position will be correlated and scrutinized for food chain relationships.

A portable air sampling system was constructed that will extract both the particulate and vapor phase chlorinated hydrocarbons from the atmosphere. This sampler was not ready for the summer cruises, but was used to monitor the Woods Hole atmosphere until open ocean sampling can be performed. Harvey will continue to study the relations between vapor phase and particulate concentrations, and for intercalibration will sample the atmosphere on Bermuda simultaneously with the University of Rhode Island investigators.

The following Tables are available from NODC. They have been cataloged under NODC accession No. 73–0573.

1. Table of PCB concentrations in North Atlantic waters.

2. Table of chlorinated hydrocarbon concentrations in the Woods Hole atmosphere.

In 1973, IDOE began a major study of the effects of chemical pollutants on marine organisms and marine communities. The goal of this research is to understand and predict how chronic, long-term, and low-level exposures to pollutants affect marine organisms and communities. Research focuses on all levels of the life process—effects on biochemical reactions, on organs and individual organisms, and on community structure and food chain relationships. A list of projects within this study appears as table 2.

Because biological effects of pollutants may be subtle and difficult to detect at low pollutant levels, researchers are observing the effects of pollutants on many biological parameters. The effect of petroleum on the kinetics of selected enzyme systems in bacteria is being investigated. The physiological effects of water soluble petroleum hydrocarbons on marine invertebrates is being investigated by observing the effect of pollutants on the rhythmic beating of cilia. Other biological rate processes being studied include filtering, oxygen consumption, photosynthesis, reproduction, swimming, and ventilation.

To determine the effects of pollutants on marine plankton communities, IDOE is sponsoring a unique approach to pollution ecology. A research facility is being established at a deep-water, protected inlet that has an oceanic flora and fauna for the purpose of studying the effects of pollutants on marine communities that are maintained in large, carefully controlled experimental enclosures. The enclosures consist of plastic cylinders (2 meters by 10 meters) that are suspended in the water column. The cylinders are open to the atmosphere but closed at the bottom. The enclosed community is the natural one. The project has been named CEPEX—*Controlled Ecosystem Pollution Experiment*. Gradually, enough of these cylinders will be constructed to permit the study of a variety of pollutants and to allow for control-cylinders to which no pollutant is added. The CEPEX approach will permit long-term (up to 90 days) biological effect studies.

Although the U.S./IDOE is taking the lead in establishing the CEPEX experiment, the overall effort is international. Several Canadian scientists are participating in the research, some of which will be carried out in Canada. United Kingdom scientists have constructed a CEPEX type cylinder at Loch Eve, Scotland, and are coordinating their efforts with the planned work. U.S. participants in CEPEX appear in table 3.

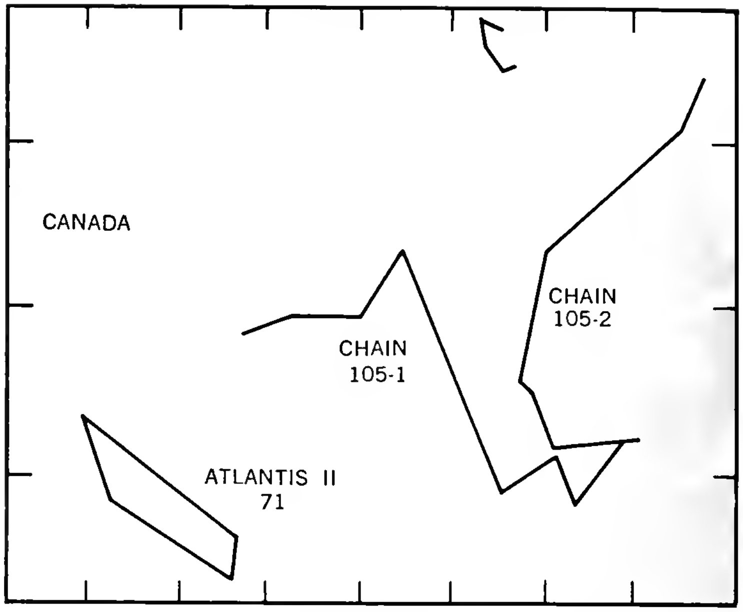


Figure 15.—Tracks for RV CHAIN Cruise 105 and RV ATLANTIS II Cruise 71, June to October 1972.

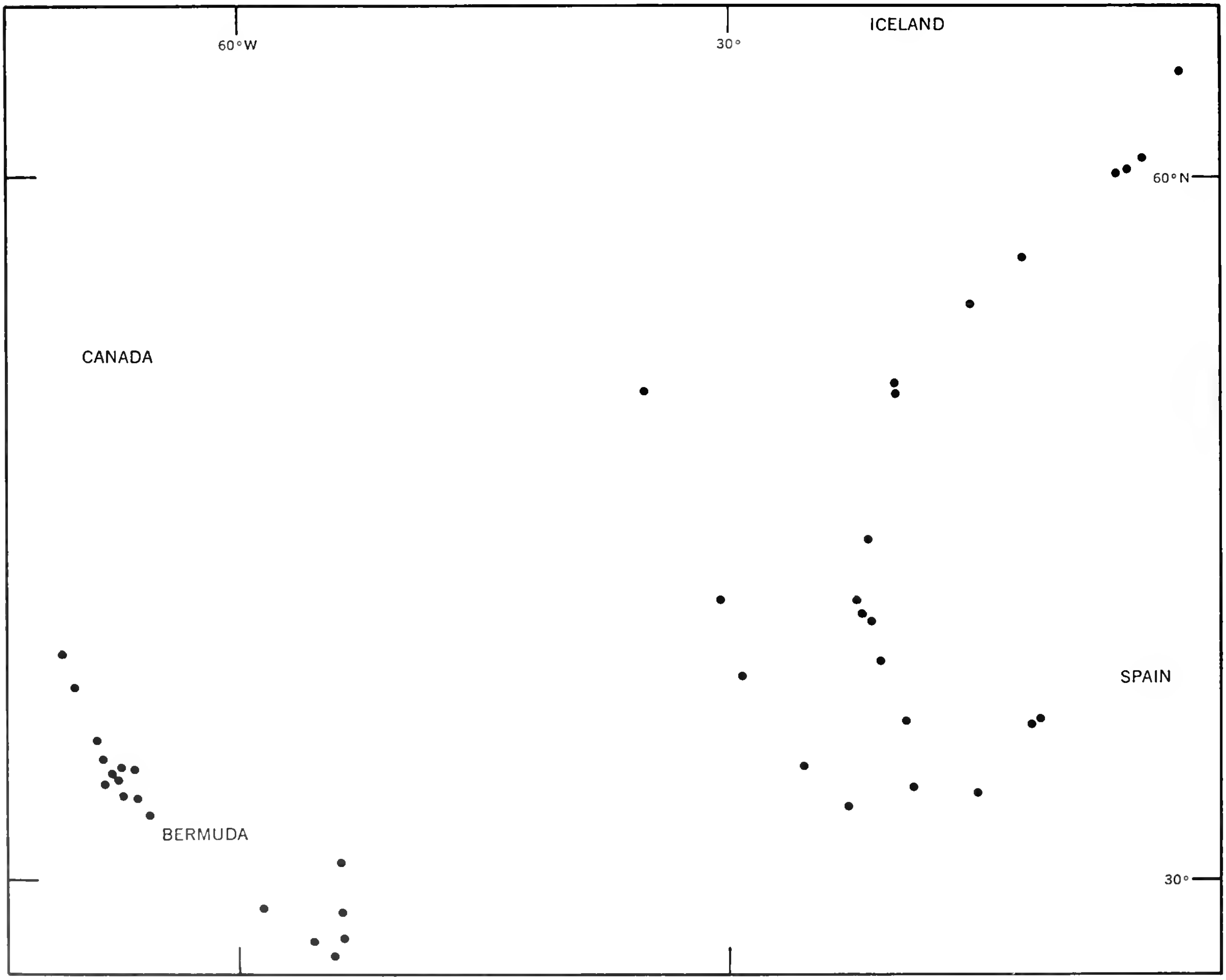


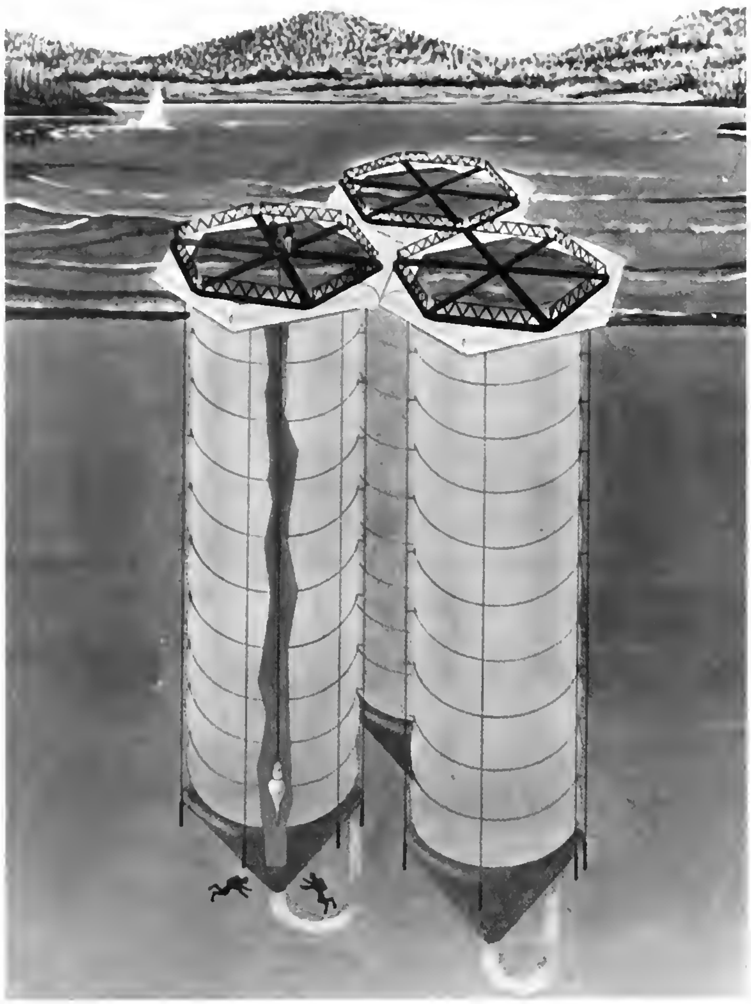
Figure 16.—Station locations for water samples analyzed for polychlorobiphenyls (RV CHAIN Cruise 105 and RV ATLANTIS II Cruise 71).

Table 2.—IDOE projects for biological effects of pollutants studies

Organization	Investigator	Project Title
Florida State University	J. A. Calder	Investigations of the Breakdown and Sublethal Biological Effects of Trace Petroleum Constituents in the Marine Environment
Oregon State University	R. L. Holton	The Effect of Polychlorinated Biphenyls on Marine Organisms
Texas A&M University	W. M. Sackett	Fate, Spatial and Temporal Distribution of Petroleum-Derived Organic Compounds in the Ocean, and Their Sublethal Effects on Marine Organisms
Texas A&M University	B. J. Presley	Sublethal Effects of Heavy Metals on Organisms From the Gulf of Mexico
Texas A&M University	C. S. Giam	Isolation, Characterization, Quantitation, and Biological Effects of Phthalates and Chlorinated Hydrocarbons in Biota from the Gulf of Mexico
University of Texas at Austin	J. A. C. Nicol	Marine Petroleum Pollution: Biological Effects and Chemical Characterization
University of Texas, Galveston Medical Branch	J. S. Kittredge	Physiological Effects of the Water Soluble Hydrocarbons on Marine Invertebrates

Table 3.—U.S. participants in projects for the Controlled Ecosystem Pollution Experiment (CEPEX)

Organization	Investigator	Project Title
University of Calif., Scripps Institution of Oceanography	O. Holm-Hansen W. H. Thomas	CEPEX—Effects of Pollutants on Marine Phytoplankton
University of Calif., Scripps Institution of Oceanography	J. R. Beers	CEPEX—The Role of Microzooplankton in an Environmental Effects Program
University of Miami Rosenstiel School of Marine & Atmospheric Science	M. R. Reeve E. J. Zillioux	CEPEX—The Role of Zooplankton in an Environmental Effects Program
Skidaway Institute of Oceanography	D. W. Menzel	CEPEX—Integrated Field Studies & Operations
Skidaway Institute of Oceanography	H. L. Windom	CEPEX—Heavy Metal Variations in Natural & Polluted Ecosystems
Skidaway Institute of Oceanography	L. P. Atkinson	CEPEX—Assessment of Natural and Manmade Levels of Light Hydrocarbons in Saanich Inlet
Woods Hole Oceanographic Institution	R. F. Vaccaro	CEPEX—The Complementary Role of Heterotrophic Microbial Measurements in an Environmental Effects Program



CEPEX plastic cylinders 10 meters in diameter will enclose natural communities and added pollutants. Nets will be used to draw samples from the cylinders. Deep water bottom intakes are planned.

Pollution Research Bibliography

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Environmental Forecasting Program

Long-range and accurate environmental forecasting depends on understanding the processes and mechanisms at work in the oceans as well as in the atmosphere. The Environmental Forecasting Program focuses on projects designed to explain the coupling between sea and air, and the influence of the oceans on weather and climate: the Midocean Dynamics Experiment (MODE); the North Pacific Experiment (NORPAX); the Climate—Long-Range Investigation, Mapping, and Prediction (CLIMAP) programs. The program also funds several NOAA projects.

MODE

Midocean Dynamics Experiment (MODE)

The purpose of MODE is to establish the dynamics and statistics of mesoscale motions, their energy source, and their role in the general circulation. MODE consists of a continuing theoretical effort as well as field experiments—MODE-O, MODE-I, and (Possibly) MODE-II. The site chosen for the field experiments is a small area 400 kilometers in diameter and 5 kilometers dep near the Tropic of Cancer, south of Bermuda. The program is jointly supported by IDOE and the Office of Naval Research.

MODE began in July, 1971. The first year and a half was spent making pilot experiments in the MODE area and developing theoretical models and objective analysis schemes. During the MODE-O field experiments, the preliminary phase of MODE-I prior to the main field program, three major current meter arrays were set: (1) With close horizontal spacing over a smooth and relatively flat bottom, (2) with close horizontal spacing over the rough abyssal hills, and (3) with larger spacing predominately over the smooth area. The results from these arrays shaped the design of the MODE-I array primarily by showing the horizontal eddy-scale to be larger than had been anticipated. In MODE-I, scientists from a number of different universities and institutions have begun a study of the oceanic eddies that combines theoretical/numerical modelling and field experimentation. The major field experiment, of over 4 months' duration, began in March 1973. The experimental site, centered at 28°N 69°40′W was chosen because it is typical of the open ocean, remote from boundaries and features, and logistically feasible (i.e., for SOFAR float tracking and ships' port steaming time).

The program is composed of a number of directly funded independent projects, the scientific responsibility for which resides in the individual principal investigators. A list of projects, investigators, and organizations is given in table 4.

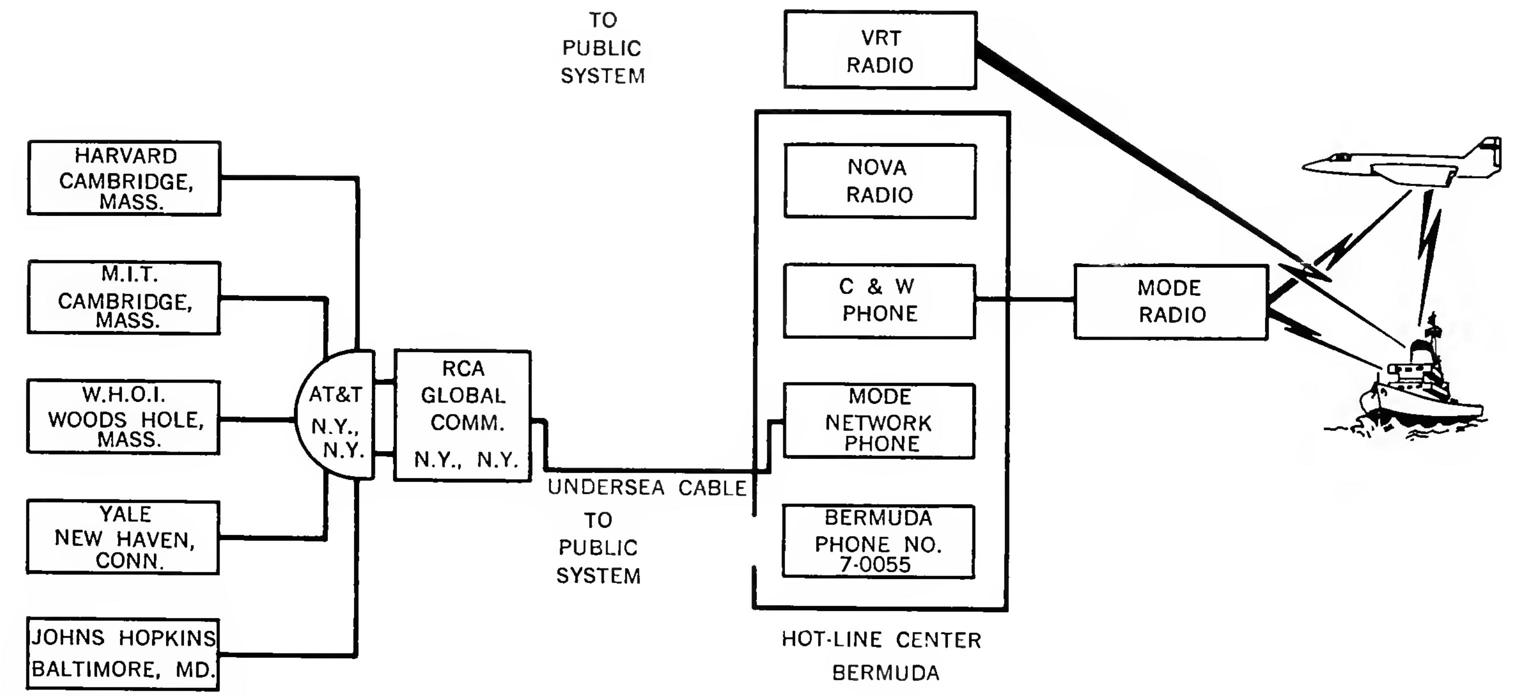

Figure 17.—MODE-I Communications Network

Table 4—Midocean Dynamics Experiment (MODE) projects

Project	Investigator	Organization
MOORED CURRENT METER ARRAYS		
16 moorings with current-temperature meters	N. Fofonoff, W. Schmitz, F. Webster	Woods Hole Oceanographic Institution
5 moorings with 4 current meters each	J. Swallow	National Institute of Oceanography, England
BOTTOM-MOUNTED INSTRUMENTS		
2 IGPP capsules (1-month lifetime), 1 IGPP capsule (1-year lifetime) (temperature, current, pressure bottom)	W. Munk, F. Snodgrass, W. Brown	Institute of Geophysics and Planetary Physics, University of California, San Diego
6 inverted echo sounders	T. Rossby	Yale University
3 electric field recorders	C. Cox, V. Vacquier, J. Filloux, R. Parker	Scripps Institution of Oceanography, University of California, San Diego
5 bottom pressure recorders, fused silica bourdon type	J. Baker	Harvard University
6 to 8 bottom-mounted current recorders, 1 to 3 current meters each	J. Knauss T. Sturges	University of Rhode Island Florida State University
FLOAT TRACKING		
20 long-range SOFAR type floats using MILS tracking	A. Voorhis, D. Webb, T. Rossby	Woods Hole Oceanographic Institution and Yale University
50 intermediate-range acoustic floats with 5 buoy hydrophone array	J. Swallow	National Institute of Oceanography, England
Hydrophone arrays for tracking SOFAR floats	R. Walden, H. Berteaux	Woods Hole Oceanographic Institution
DENSITY MEASUREMENTS		
Shipboard STD and CTD casts	J. Crease	National Institute of Oceanography, England
	D. Hansen, A. Leetmaa	Atlantic Oceanographic and Meteorological Laboratory, NOAA
	R. Scarlet	Massachusetts Institute of Technology
MOORED THERMAL ARRAY		
Thermal array	C. Wunsch	Draper Laboratory, Massachusetts Institute of Technology
TOWED INSTRUMENTS		
STD tows to map isopycnal surfaces	E. Katz, R. Nowak	Woods Hole Oceanographic Institution
FREE-FALL INSTRUMENTS		
Velocity profiler, accoustically tracked by bottom-mounted beacons	T. Pochapsky	Columbia University
Electric field free-falling probe and bottom recorders	T. Sanford	Woods Hole Oceanographic Institution
Displacement type current probe; airborne expendable	W. Richardson	Nova University
NUMERICAL MODELLING AND THEORETICAL STUDIES		
Synoptic maps	F. Bretherton	The Johns Hopkins University
Interactions between short internal waves and larger scale motions in the ocean	K. Hasselmann	University of Hamburg, West Germany
Array design as an inverse problem	M. Hendershott, R. Davis, W. Munk	Scripps Institution of Oceanography
Theory and computer experiments on oceanic eddies and waves	P. Rhines	Woods Hole Oceanographic Institution
Analytic and numerical studies of meso-scale motions	A. Robinson	Harvard University
Theoretical-numerical study of geostrophic eddy motions in the oceans	P. Welander	University of Gothenberg, Sweden
ADMINISTRATIVE		
Executive Office	H. Stommel, D. Moore	Massachusetts Institute of Technology
Hot Line Center	F. Webster	Woods Hole Oceanographic Institution

During the MODE-I field experiment, the MODE Hot Line Center will be operating at the Bermuda Biological Station for Research. The Hot Line Center will be a central point for information and communication during the MODE-I field experiment.

Information collected at the Bermuda Hot Line Center will be used for decision-making on shipboard and for collective strategy decisions, where needed, by MODE scientists who are not at sea. Chief Scientists and others at sea will be able to use the Hot Line Center information for precruise briefings. In turn, at the end of cruise legs, selected basic information will be deposited at the Hot Line Center. The Hot Line Center will communicate with the MODE ships by commercial radio telephone and with some U.S. points by telephone (fig. 17).

MODE-I results will be published by individual authors and projects in the traditional manner in scientific journals. Contribution numbers will be assigned to publications about MODE to form a list of all MODE works. MODE I data, mostly on magnetic tape, will be deposited with NODC by the summer of 1974.

Individual publications will be complemented by an overall synthesis. Plans are to publish summary volumes in three categories: (1) An atlas of maps and sections of the observed field and some derived quantities, (2) an analysis of the intercomparison of different types of measurements, and (3) a final statement of the nature of the dynamics of the eddies as revealed by the experiment.

Upon completion of the MODE I field program in mid-July, 1973, a year of data analysis and comparison of experimental results with theoretical models will be undertaken, culminating in summer 1974, with three parallel working groups synthesizing results.

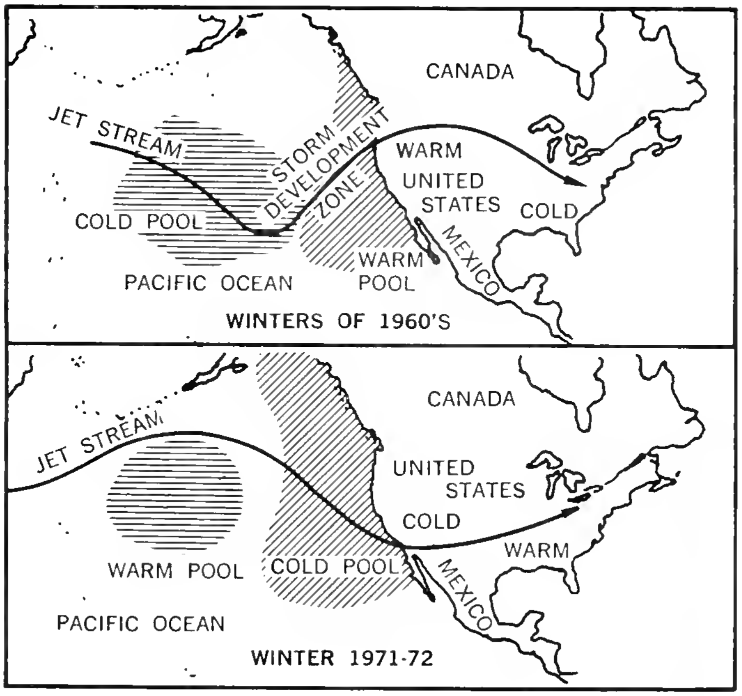

Figure 18.—Diagram of statistical results of North Pacific study showing the relationship between sea surface temperature anomalies, the jet stream path, and the severity of winter.

North Pacific Experiment (NORPAX)

NORPAX is concerned with long-period, large-scale, ocean atmosphere interactions, and is jointly sponsored by IDOE and the Office of Naval Research. The goal of NORPAX is to develop a basis for understanding the physical processes responsible for large-scale thermal anomalies that occur at midlatitudes in the upper layer of the North Pacific Ocean, and to determine the influence of these ocean anomalies on weather patterns over North America (fig. 18). Achieving these goals will require field experiments to determine heat and momentum fluxes across the air-sea interface, in the mixed layer, and at the bottom of the mixed layer. Measurements will be made from satellites, aircraft, ships, and buoys.

The first NORPAX field experiment is planned for 1974, and present activity consists of designing this experiment: historical data are being used to test hypotheses, numerical models are under development, and instruments are being designed and tested. Particularly being examined are the utility of island stations, large discus-hull moored buoys, surface drifting buoys, observations from merchant marine ships, and satellite observations. Project headquarters is on the Scripps Institution of Oceanography, La Jolla, California, campus.

Prior to NORPAX, the Scripps RV Agassiz moored a discus-hull buoy that will gather and transmit environmental data to a shore station for 1 year.

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NORPAX depends heavily on EDS archives for basic observational data as input to its science program. Since the program involves air-sea interaction, both EDS National Oceanographic Data Center (NODC) and National Climatic Center (NCC) are involved. NORPAX has ordered NODC's entire, revised, geographically sorted oceanographic station data file of over 12 million observations, which contains the recently augmented North Pacific data. In addition, the Fleet Numerical Weather Center's copy of NCC's marine deck is being updated in a cooperative effort with NORPAX. Recently, data from selective meteorological stations over the North Pacific basin have been ordered from NCC to augment data currently held at NORPAX.

NORPAX includes a visiting scientist program, which provides support for a limited number of expectionally qualified scientists from any country to work on various aspects of the problem at any of the participating institutions. The NORPAX projects, investigators, and organizations are listed in the *IDOE Progress Report*: *January 1970 to July 1972*.

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Climate: Long Range Investigation, Mapping, and Prediction (CLIMAP) Study

The objectives of this project are the description and understanding of climatic changes over the past 700,000 years. An accurate definition of these changes over such a time scale is mandatory if scientists are to understand the transition between what are currently considered the two stable states of global climate—the ice age and the temperate age. By comparing an accurate description of this transition to that predicted by models of global climate, a better understanding of the mechanisms of climatic change will be achieved. The CLIMAP project should shed light on such basic questions as whether changes in climate are due to fluctuations in solar radiation or whether they are caused by changes in the earth's hydrosphere. A thorough understanding of climatic changes is necessary if we are to comprehend our present place in the natural cycle. Moreover, such knowledge is important in order to assess and to anticipate the effects of man's activity on the global environment.

The CLIMAP project seeks to answer the questions cited above through the study of deep-sea sediments. When compared to the scanty record kept by man on changes in the oceans and atmosphere, the layers of sediment on the seafloor provide a rich source of data. Indeed, an excellent chronological record has been captured in the ocean-bottom sediment cores which are preserved in marine geological archives. (Sample location of cores used thus far in the North Atlantic is shown in fig. 19.) Recent advances in dating techniques, automated analyses of individual sediment cores, and computer correlation of the many features in the sediment strata, make it possible to generate global-scale summaries of past sea surface conditions.

Paleo-oceanographic maps are being constructed for four selected times: 6,000 years ago (the postglacial thermal maximum), 17,000 years ago (the last glacial stage), 120,000 years (the last interglacial stage), and 700,000 years ago (the mid-Pleistocene base). Comparable maps for present time form the basis for interpretation.

The general plan of research work includes:

1. A survey of existing core collections to determine those most suitable for use in the base grid for the paleo-oceanographic study. This survey consisted primarily of routine paleontological examinations and was completed during the first year of the project.

2. The acquisition and initial interpretation of paleontological, sedimentological, and geochemical data on suitable grids for all "time" levels.

3. Extension and consolidation of present work on

quantitative relationships between the oceanic environment and sediment properties will be followed by multivariate analysis to provide interpretative paleo-oceanographic maps for each level.

4. Close coordination of the results of this study with those of the ongoing examination of Greenland and Antarctic ice cores. These comparisons promise to yield critical information regarding high latitude glacial and interglacial climates and their effect on the temperature and salinity of bottom and surface ocean waters.

The activities described above have been applied to produce a map of the sea surface temperatures in the North Atlantic 17,000 years before the present. Figure 20 shows a comparison of this pattern with that now observed in the North Atlantic and shown in the inset. The differences between these two surface temperature patterns can be plotted as anomaly charts as represented in figure 21. Such maps can now be used as an input to or to check the product of numerical models.

In the CLIMAP project, some data are produced by many individual specialists and experts, but data interpretation is a joint effort of all participants. Coordination is achieved by a managing structure, consisting of a project manager and a number of task leaders. The task leaders are listed in table 5. The Executive Committee consists of five members who: 1) Assume overall responsibility for the project, 2) coordinate and assure the free flow of information among institutions, 3) assure coordination among task groups, and 4) set and implement policy.

International participation has included scientists from University of Copenhagen, Denmark; University of Cambridge, England; University of Kiel, Germany; and Geological Institute, Zurich, Switzerland. The project had logistic assistance from the government of Barbados.

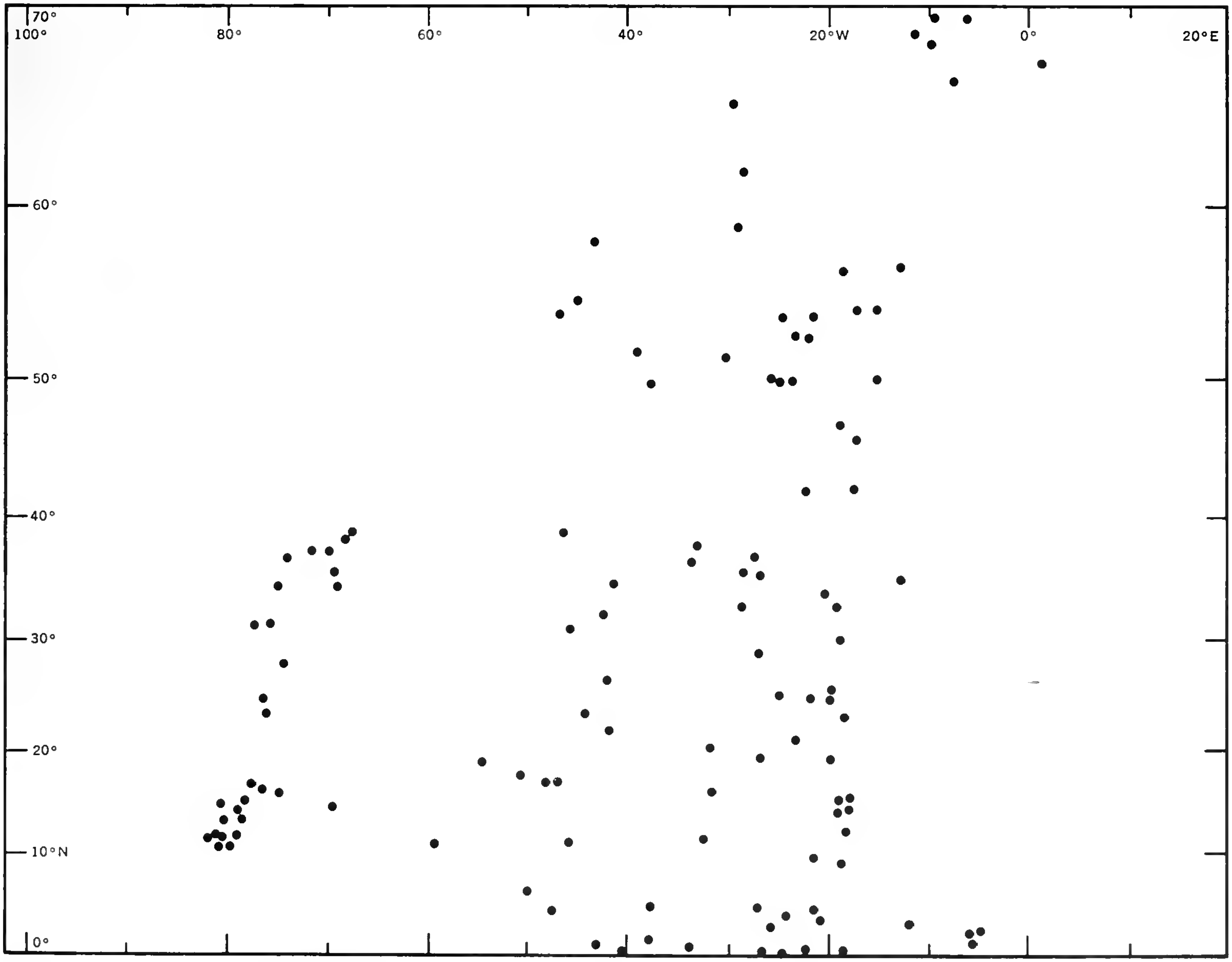

Figure 19.—Sample location and distribution of cores in the North Atlantic and adjoining regions, providing data on conditions in that area 17,000 years ago.

Figure 20.—Climatic maps showing summer sea surface temperature distributions in the North Atlantic and adjoining regions for the present and 17,000 years ago.

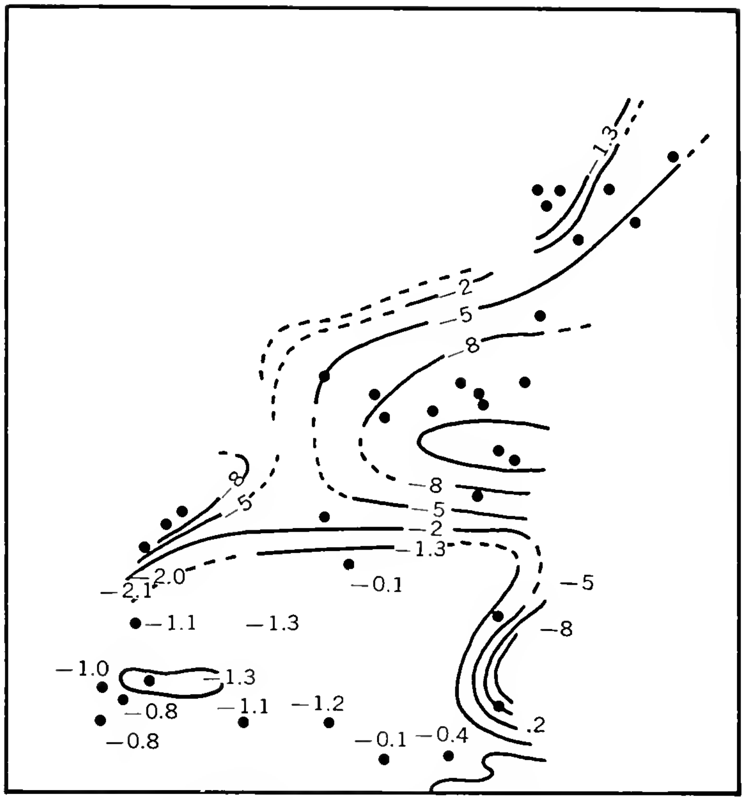

Figure 21.—Anomaly map showing surface temperature changes for August in the North Atlantic and adjoining regions. Temperature 17,000 years ago minus present temperatures in C°.

A Lamont-Doherty Geological Observatory scientist carries out paleontological examinations of bottom cores to help construct CLIMAP paleooceanographic maps.

Table 5.—United States task leaders in the Climate Long-Range Investigation, Mapping, and Prediction (CLIMAP) program

Organization	Investigator	Task
Brown University	J. Imbrie	Marine paleoclimatology
	R. Matthews	Sea level history
	T. Webb, III	Land-sea interaction
Columbia University, Lamont-Doherty Geological Observatory	A Bé	Planktonic foraminifera
	P. Biscay and K. Venkatarathnam	Clay mineralogy
	L. Burckle	Diatoms
	J. D. Hays	Radiolaria
	A. McIntyre	Coccolithophorida
	C. D. Ninkovich	Volcanic ash layers
	N. Opdyke	Paleomagnetism
	T. Saito	Foraminifera
	J. van Donk	Oxygen isotopes
	G. Kukla	Glaciation and land-sea correlation
Oregon State University	T. Moore and G. Ross Heath	Sedimentology

NOAA Projects

Several projects that were initiated by the National Oceanic and Atmospheric Administration (NOAA) prior to 1970 are now being funded under the IDOE Environmental Forecasting Program. The status and accomplishments of the NOAA projects are discussed in the text that follows.

Organization: NOAA/NMFS-LaJolla

Investigator: J. F. T. Saur

Project Title: Ships of Opportunity: Time-Series Expendable Bathythermograph Sections, Tropical and North Pacific Ocean

Grant No.: AG–256

This 3-year program to obtain ocean salinity, surface temperature, temperature-vs-depth (XBT), and weather observations aboard merchant vessels (ships of opportunity) is into its final year.

NODC has accessioned most of the 1969–72 data (3,572 digitized XBT records). Figure 22 shows the Marsden Squares for which time-series XBT data have been collected and will be available from the NODC.

Organization: NOAA/POL

Investigator: D. Halpern

Project Title: Near-surface Circulation Studies

Grant No.: AG–253

On August 4, 1971, the NOAA Pacific Oceanographic Laboratory (POL), Seattle, Wash., began taking measurements of surface winds, currents, and temperatures in the upper layers of the Pacific Ocean (from about 5 to 50 meters). Records were recorded for 32.7 days at one location in the Northeast Pacific, remote from intense boundary currents and from continental boundaries. The experimental site, which was located at 47°03.37′N, 128°17.17′W, was about 250 kilometers from the continental shelf break and about 220 kilometers from the Cobb Seamount of the Juan de Fuca Ridge.

A salinity-depth-temperature (STD) survey of the area surrounding the data collection platform (a Richardson buoy) was completed after its mooring and repeated before its recovery. Locations of the STD casts appear in the *IDOE Progress Report: January 1970 to July 1972*.

The STD and current meter data have been accessioned by NODC on magnetic tape (accession number 720953 and 720448, respectively). The sampling scheme for measuring

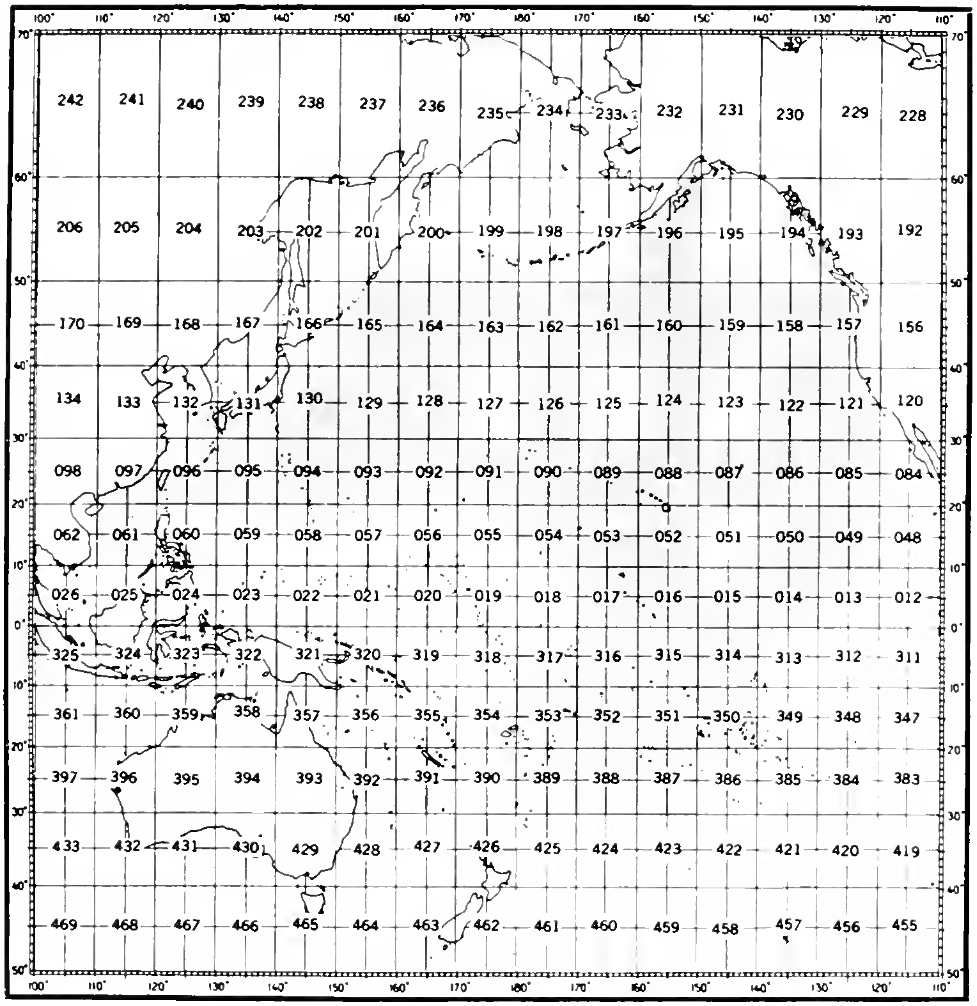

Figure 22.—Marsden squares in which XBT data have been collected during 1969-1973 by ships of opportunity.

currents and winds consisted of a burst of six samples recorded every 3.75 minutes; each of the six samples, consisting of speed, compass, and vane, was measured at 4.95-second intervals.

Organization: NOAA/AOML

Investigator: H. Mofjeld

Project Title: Circulation Studies for CICAR: Tides in the CICAR Region

Grant No.: AG–253

NOAA's Atlantic Oceanographic and Meteorological Laboratories (AOML) has continued its research into the distribution and dynamics of the tides in the Caribbean Sea and the Gulf of Mexico. In addition, field experiments on tides outside the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR) area and for longer period motions have been carried out or are in preparation.

To help define the positions of amphidromes in the Caribbean Sea, a deep-sea tide gage was deployed from May 1972 to November 1972 (16°32.5′N, 64°52.9′W) at a depth of 3,970 meters. The pressure record, probably the longest ever obtained from a self-recording gage in deep water, is useful not only as a lengthy record of tides with a high signal-to-noise ratio but also in the study of longer period pressure fluctuations. Analyses are being carried out both by NOAA scientists, using harmonic techniques, and by scientists at Nova University using the response method.

A gage was deployed in the Gulf of Mexico (24°46.1′N, 89°38.9′W, at a depth of 3,460 meters) during November 1972. The gage was implanted in deep water to measure the daily dominant tidal constituents of the Gulf and to determine whether the semidaily tides have amphidromes. The gage, recovered during January 1973, operated for 3 months, and the record is now being analyzed.

The focus of the international deep-sea tides program has been changed from studies on the amphidromes to studies of several "action centers" and tide modifications on the continental margins. AOML is modifying its tide project in line with these new goals.

To understand how tides in the open ocean are related to coastal observations, it has become evident that the behavior of the tides on the continental shelves must be understood. To study the tides on the shelf, the tide group at AOML deployed tide gages with current meters off North Carolina at 34°09.3′N, 75°37.5′W (27 meters); 35°55.5′N, 76°37.3′W (43 meters); and 32°41.5′N, 75°37.5′W (3,350 meters). These instruments, which were deployed during July 1972 and recovered during August 1972, recorded not only the transition of the tides from the open ocean toward the shore but also currents and temperature changes due to meanderings of the Gulf Stream.

The study of shelf tides will be continued during autumn 1973 in the Middle Atlantic Bight area. It will be necessary to develop shallow water tide gages for this study.

Organization: AOML/NOAA

Investigators: R. Molinari, F. Chew, D. V. Hansen

Project Title: Circulation Studies for CICAR: Lagrangian Measurements of Ocean Currents

Grant No.: AG–253

The data collection phase of the Lagrangian Current measurement experiment was conducted from July 14 to September 1, 1971. The information collected in the western Caribbean Sea included Lagrangian drifter data and density data. These data were collected during two cruises, the first leg lasting from July 14 to August 2 and the second leg from August 10 to August 21. The second leg was shortened because of a hurricane threat in the area.

Figure 23 is a plot of the tracklines occupied during leg 1, and the approximate drift of the ship during the drogue tracking operation. The type of information collected on each line is also noted. Figure 24 presents the tracklines of leg 2.

The reduction of the data to a form suitable for interpretation has been completed. The analytical methods developed will be applicable to other Lagrangian drifter studies planned by this laboratory.

The primary navigation fixes were reviewed to eliminate spurious satellite positions. The satellite data were then used to calibrate the 15-minute Omega fixes by first determining the average difference between concurrent satellite and Omega positions and then by applying this difference to all Omega fixes.

A further edit was performed to eliminate those spurious Omega rates that were not found during the first iteration. Drogue positions relative to the ship were converted to geographic positions by a program developed at AOML.

The density data were obtained with a conductivity-temperature-depth sensor, which was used operationally for the first time on this cruise. Shipboard reviews of the salinity data indicated a discrepancy between historical salinity values and those being collected. This necessitated a calibration of the instrument for what appeared to be a pressure effect on the conductivity sensor.

The expendable bathythermograph (XBT) and mechanical bathythermograph (MBT) analogs were edited to eliminate bad traces. Temperature values obtained from both systems were compared to conductivity-temperature-depth (CTD) temperature values, and neither system exhibited any systematic differences from the latter data.

A report describing in detail the analysis techniques that were applied to the data has been written for potential users of these data. This report as well as the data may be obtained from NODC. The data summary will be published in a NOAA series and will be available from NTIS.

Organization: NOAA/AOML

Investigator: D. Hansen

Project Title: Large-Scale Measurements of the Antilles Current

Grant No.: AG–253

During the past year it has been possible to initiate what is probably the largest scale Lagrangian measurement project ever conducted on the ocean currents. This was made possible through collaboration with NASA and the French Centre National d'Etudes Spaciales (CNES) from which AOML obtained the use of five transponder packages designed for use in the French EOLE constant-level balloon experiment. The packages were installed in five 12.5-meter aluminum spar buoys and deployed between 23.5°N and 28.0°N along 67°W (between Bermuda and Puerto Rico) in mid-September to obtain information on surface currents in the same area as the MODE-I experiment and in the Antilles Current, generally.

It was judged from inferences based upon pilot chart data that it might be possible to retrieve the buoys in the Cape Hatteras/Bermuda/Nova Scotia triangle shortly before the satellite project (and associated tracking operations) terminated at the end of December 1972. The points of deployment and buoy trajectories for the first 7 weeks of the experiment are shown in figure 25.

It soon became apparent that the trajectories were so unlike indications from the pilot charts that the plan for recovering the buoys was inadequate. Fortunately, the lifetime of the project was extended 6 months—to June 30, 1973. Buoy 2 was recovered for engineering evaluation in mid-December. The attached parachute drogue and all other rigging hardware were in near-perfect condition. The transponders on buoys 1 and 3 had failed, however, and the buoys were lost.

At the end of February, buoys 4 and 5 were still functioning satisfactorily in the Antilles Current. Movement during the last 3 months has been characterized by steady cyclonic eddying of a time scale of about 1 month or longer. After nearly 6 months, these buoys were less than 290 kilometers west of their deployment longitude. The variability of movement of these buoys is so great relative to the mean motion and the difference between buoys so great that the previously planned streamline analysis now appears to be inappropriate or impossible, except in a negative sense. The observations already negate, for example, the existence of an Antilles Countercurrent. The most meaningful result to be obtained from the observations will probably be a determination of the statistical structure of surface currents in the region, such as the correlation length for deep currents that plays a key role in design of the MODE-I array.

The following data were submitted to NODC from the Lagrangian Current Measurement Project NSF Grant No. AG–235. NODC Accession Number 720922.

Ship	Cruise	Data Type	No. Records
DISCOVERER	RP–9D1–71	XBT	334
RESEARCHER	RP–9–RE–71	XBT	398
		MBT	262
		Serial Stations	33
		CTD	81

The following data were submitted to NODC from the NOAA–AOML Air-Sea Interaction and Mixed Layer Project, NSF Grant No. AG–253. NODC Accession Number 730598.

Ship	Cruise	Data Type	No. Records
DISCOVERER	RP–11–D1–71	XBT	125

Halpern, D. Wind Recorder, Current Meter and Thermistor Chain Measurements in the Northeast Pacific. August/September 1971. *NOAA Tech. Rep. ERL 240–POL 12,* 37 pp., 1972.

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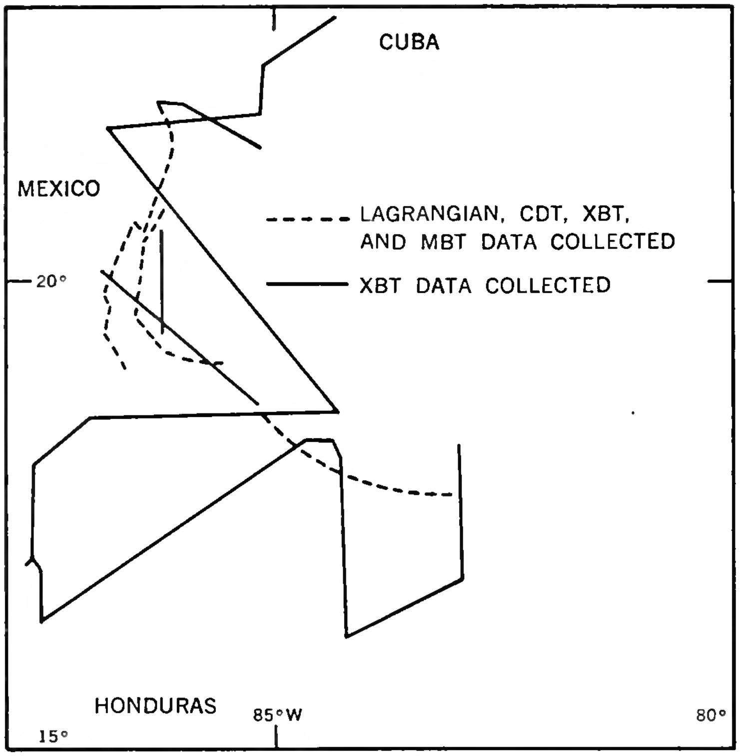

Figure 23.—Tracklines of leg 1 of NOAA RV RESEARCHER in the Western Caribbean, July 14 to August 2, 1971.

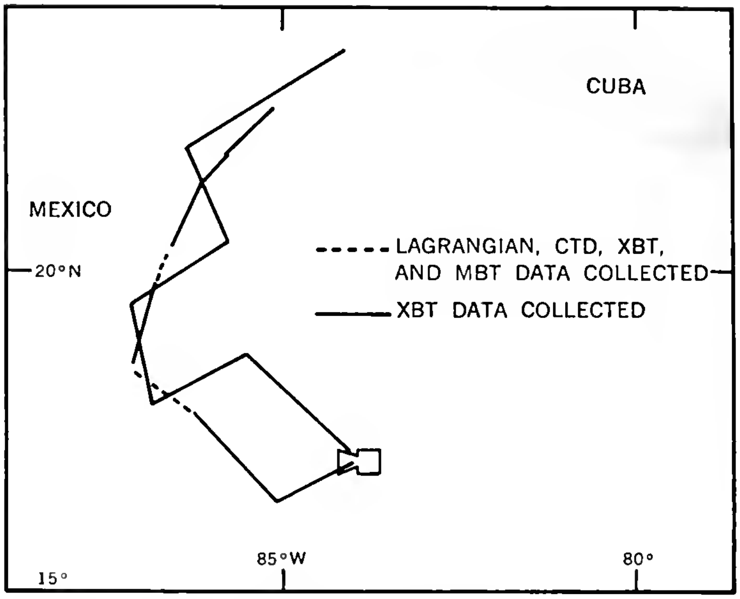

Figure 24.—Tracklines of leg 2 of NOAA RV RESEARCHER in the Western Caribbean, August 10 to 21, 1971.

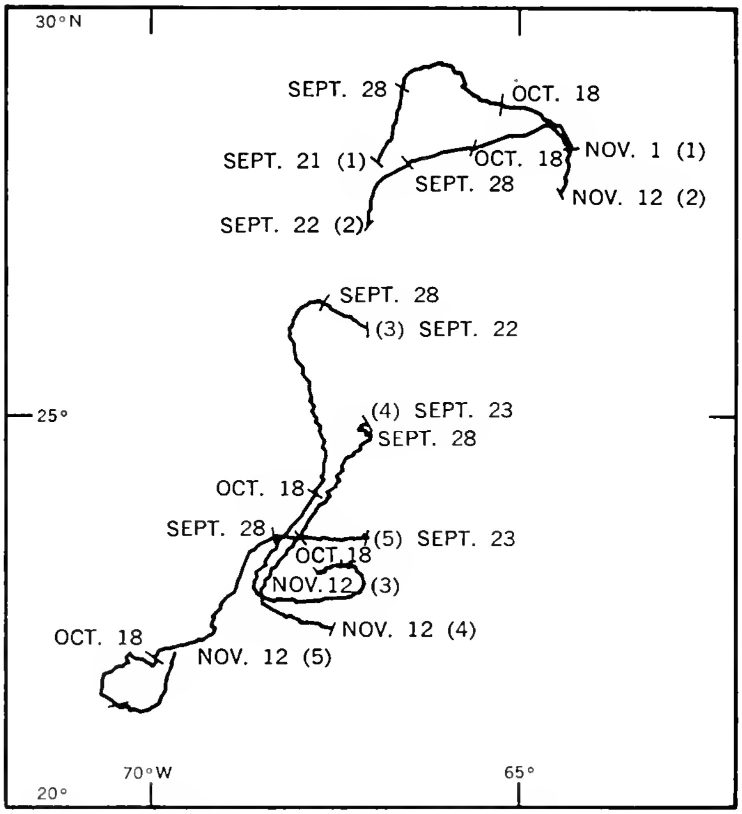

Figure 25.—Trajectories of French EOLE drift buoys in the Sargasso Sea, September to November 1972.

Seabed Assessment Program

This program is designed to increase understanding of the geologic processes active along the continental margins, midoceanic ridges, and deep ocean basins. These processes generate the raw material of modern industrial civilization—petroleum and heavy metals. Since the obvious, near-surface deposits of natural resources have already been found and are being depleted at a high rate, new deposits must be located. The Seabed Assessment Program aims at understanding geologic processes and deriving new principles and new models of the earth that the resource geologist should find valuable in planning more detailed exploration studies. The projects supported by IDOE do not duplicate the efforts of oil and mining companies. Seabed Assessment Program scientists are investigating the Atlantic continental margins, Mid-Atlantic Ridge, and basins of the Gulf of California, as well as the processes involved in plate tectonics and metallogenesis. They also convened a workshop on ocean minerals.

Continental Margins Studies

The purpose of the continental margin studies is to understand the origin and evolution of the present day margins and to reconstruct the geological conditions at each stage in the sea floor spreading of the South Atlantic. The data obtained will facilitate the interpretation of relationship between the fracture zones and the thick accumulation of sediments, as well as between the aseismic ridges and the deposition of massive salt formations. Moreover, the existence of multimillion barrel oil fields beneath the continental shelves cannot be explained by present day geological conditions.

Both sides of the Atlantic are being investigated simultaneously. All major geophysical and geological measurement techniques are being used. K. O. Emery, Woods Hole Oceanographic Institution (WHOI), is serving as chief scientist aboard the WHOI ATLANTIS II investigating the zone from South Africa to Portugal, and from the African coast to the Mid-Atlantic Ridge. The field work will be completed this year. J. Milliman, WHOI, is serving as chief scientist on a project supported by the Brazilian government with emphasis on the location of detrital minerals. G. Bryan is serving as coordinator for a team of Lamont-Doherty Geological Observatory (LDGO) scientists whose studies extend from the Scotia Arc to the Caribbean. I. Dalziel, LDGO, is carrying out complementary geological investigations on the island of South Georgia. Field work will continue through 1975.

WHOI and LDGO scientists are publishing results as they become available. One major goal of this cooperative effort will be a series of paleogeographic maps, one for each successive opening of the South Atlantic Ocean. A preliminary stratigraphic correlation chart for Africa and South America is also planned. Reconstruction of geological conditions in this area where the fit of the continents is relatively straightforward should be applicable to other more complex parts of the world.

The first phase of a 4-year program to study the geology and geophysics of a relatively unknown area of the Atlantic Ocean floor between Western Africa and the Mid-Atlantic Ridge was successfully concluded in July 1972. From January 20 to July 1, 1972, the WHOI RV ATLANTIS II completed nearly 50,000 trackline kilometers of geological and geophysical surveying on 7 legs between Port Elizabeth, Republic of South Africa, and the Congo River (figure 26) with particular emphasis on the continental margin.

During these cruises, continuous profiles were made with simultaneous recordings of bathymetry at 3.5 kilohertz, seismic reflection, refraction using sonobuoys, gravity, and magnetics. Navigation was primarily by satellite supplemented by radar and other methods near the coast. Five computers aboard ship permitted rapid processing of the geophysical data on a 24-hour interval both as superimposed profiles as well as in map form, so that readjustments of subsequent traverses could be made to provide the best coverage of geological structures.

This initial cruise yielded interesting information on deep ocean geology including the Cape Agulhas Fracture Zone, as well as another major unnamed fracture zone, the Walvis Ridge, and the stratigraphy of Cape Agulhas and the Angola

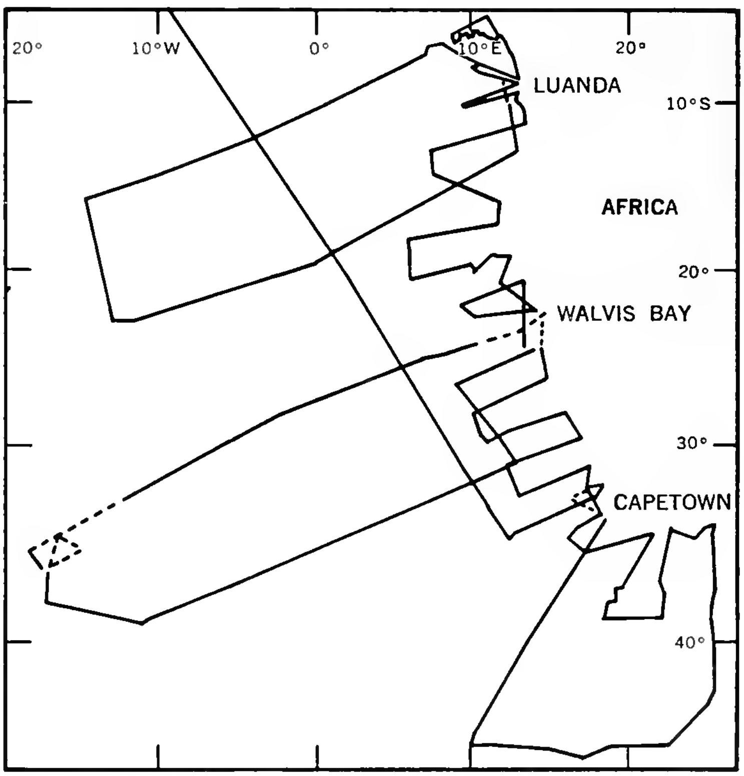

Figure 26.—Geological and geophysical survey lines of WHOI's RV ATLANTIS II, January 20 to July 1, 1972.

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Basin. It also showed that the continental shelf along most of southwestern Africa is due to simple progradation of sediments and that no tectonic barrier underlies the shelf.

Two geologic features of the continental margin may be possible sites of oil and gas accumulation with potential economic significance: a huge ancient Delta off the Orange River and a field of numerous diapirs extending from Angola to Nigeria.

The ancient Orange Delta, shown by bathymetric contours to be convex seaward, contains sediments having a total volume of about 1.9 million cubic kilometers beneath water depths of 100 to 3,600 meters. Relationships with earlier sedimentary accumulations suggest that the Delta began to be deposited soon after Africa rifted from South America and that deposition continued into Tertiary time, but essentially ended before the middle Tertiary.

The second feature is a large area of diapiric structures in water depths of 800 to 300 meters off Angola. Some 3,000 kilometers of seismic profiles indicate that the diapir field extends from latitude 13°30′S to north of latitude 5°00′S.

All data, with the exception of some deepwater gravity data from the field work accomplished in 1972, are now available from the National Geophysical and Solar-Terrestrial Data Center. Microfilm copies of the seismic profiles as well as digitized and plotted bathymetric, magnetic, and gravity data can be obtained by contacting the Marine Geology and Geophysics Group of NGSDC.

Data in similar format from the 1973 cruise (fig. 27) are expected to be available in early 1974.

The broad objectives of a 3-year plan to study the continental margin of Argentina and Brazil are to find the true edge of the South American continent and determine the nature of the transition zone, to determine the nature and extent of diapirism observed on the continental margin with particular attention to its economic potential, and to test previous hypotheses on the formation of marginal fracture ridges and on the effect of these ridges on the structural framework of continental margins. Additional investigations will be made on the Malvinas (Falkland) Plateau and Scotia Ridge structures to formulate a model of continental breakup and subsequent motion. The total areas to be surveyed will extend along the western margin of the South Atlantic from the Scotia Ridge to the

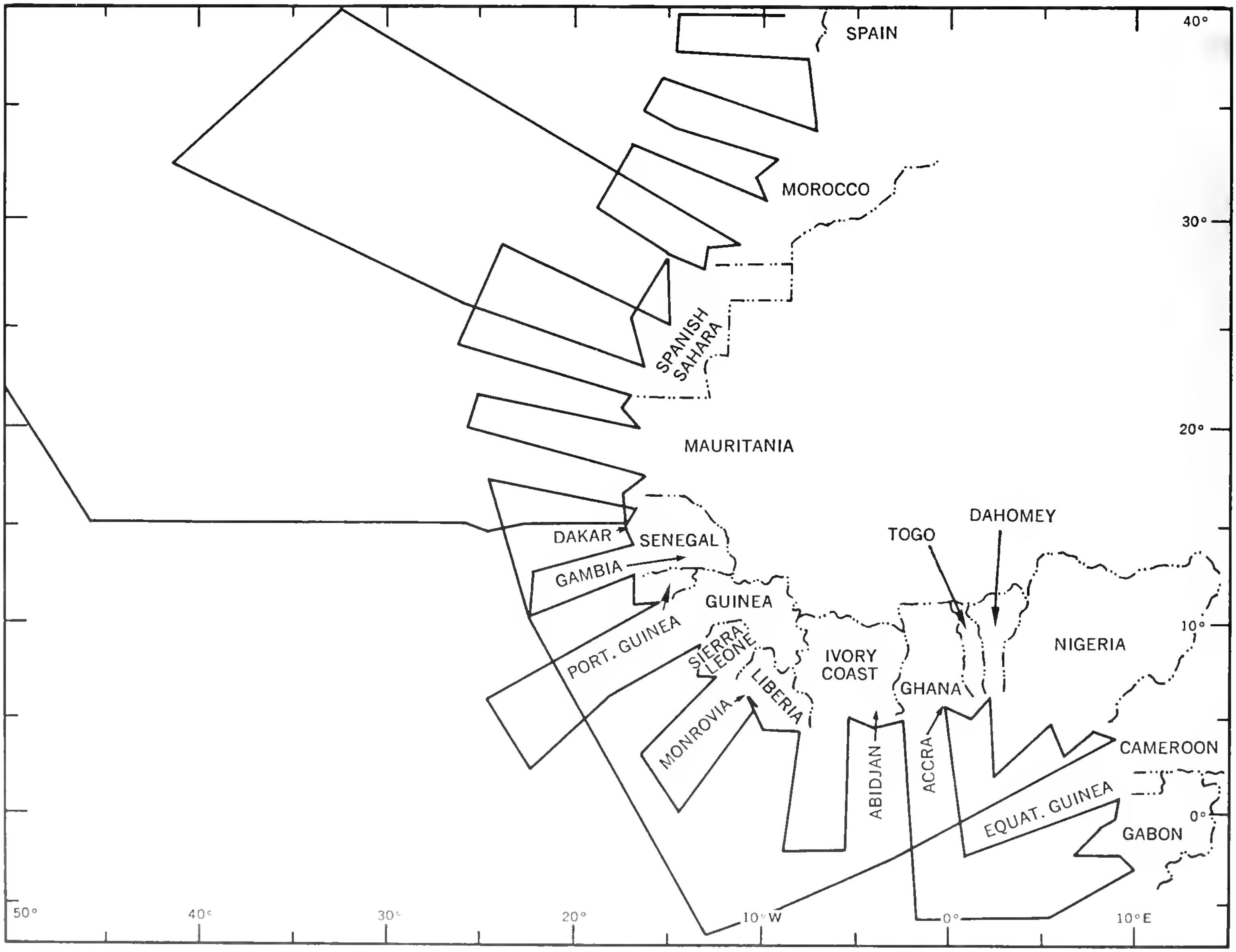

Figure 27.—Geological and geophysical survey lines of WHOI's RV ATLANTIS II, January 20 June 30, 1973.

Guiana Basin.

Underway data will include (along the entire track) bathymetric, gravity, magnetic, and seismic reflection measurements. Station work, at the rate of approximately one station per day, will consist of measurements of bottom currents and heat flow, as well as bottom photography, nephelometry, and piston coring. Seismic refraction work and dredging stations will be added when appropriate.

During May through July 1972, the RV ROBERT D. CONRAD of Lamont-Doherty Geological Observatory made reconnaissance geophysical studies on the continental margin of Brazil (fig. 28). Brazilian scientists from Petrobras and the National Department of Mineral Production participated in planning the cruise and assisted in gathering and reducing the data.

Although the scope of the 1972 field work was primarily of a reconnaissance nature to determine whether more detailed studies will be needed, significant accomplishments were recorded.

The North Brazilian Ridge was found to be primarily a discontinuous feature extending from 34°W to 45.5°W except for a section between 34°W and 38°W. The ridge contains gaps which progressively widen west of 38°W. The acoustic basement is consistently 1 to 2 kilometers deeper on the landward side of the ridge than on the seaward side.

The Romanche Fracture Zone can be traced into the North Brazilian Ridge 1°48'S, and the Chain Fracture Zone extends into the Fernando de Noronha and Atol das Rocas chain of seamounts.

Diapiric structures, attributed to salt, were observed on the continental margin of southern Brazil. The zone of offshore diapirs is roughly triangular, with the Sao Paulo plateau as the base. The northern apex of the zone is not closely defined and appears to be located at the junction of the Brazilian coast and the Columbia Seamount chain. Sonobuoy refraction and reflection information and normal reflection data were used to outline the diapir zone.

Mid-Atlantic Ridge Study

A better understanding of the geological processes operating along midocean ridges is the basis for study of the Mid-Atlantic Ridge. Despite numerous individual studies of this feature, little is known and nothing on a scale smaller than approximately 20 to 50 kilometers.

Prior to undertaking a major study of the Mid-Atlantic Ridge, IDOE supported a National Academy of Sciences workshop to examine major questions concerning the processes operating along the crest. Scientists from Canada, France, Iceland, Netherlands, United Kingdom, and United States met at Princeton, N.J., in January 1972. The workshop results summarize present knowledge and outline a comprehensive program for a concerted attack on the major problems.

Scientific exploration of the ocean floor will enter a new phase with the Mid-Atlantic Ridge Study. Present knowledge, based on studies from surface ships, is analogous to geophysical surveys of the land made from altitudes of 4,500 meters. Submersible craft will enable scientists to make firsthand observations of the active zones, collect samples, and emplace instruments with precision. French and United States submersibles and the British vehicle, *Gloria* (side-scan radar technique), will be used in the diving area southwest of the Azores (fig. 29).

Preliminary surveys are now being done to select the most geologically active points in the rift valley of the ridge. The techniques include detailed bathymetry, heat flow, sampling, seismic reflection, and seismicity. In addition to England, France, and the United States, Canada, Iceland, and Portugal plan to participate. The first submersible dives by the French vessel, *Archimede,* took place in July 1973. A joint United States-French program is scheduled for summer 1974.

Other studies of processes operating along the Mid-Atlantic Ridge include work in Iceland, the Azores, and along the equatorial zone in the vicinity of the Romanche Fracture Zone.

J. F. Hermance of Brown University, a geophysicist specializing in the field of magnetotelluric measurements, is investigating the deep tectonic processes that generate geothermal activity at the surface in Iceland. This study is being carried out in cooperation with the National Energy Authority of Iceland. The mechanism by which heat generated by deep-seated processes, such as those associated with sea floor spreading as related to hydrothermal activity in the crust, is obscure at this time.

N. D. Opdyke of Lamont-Doherty Geological Observatory, in cooperation with scientists at Dalhousie University, Nova Scotia, plans a 1,500-meter borehole on the island of San

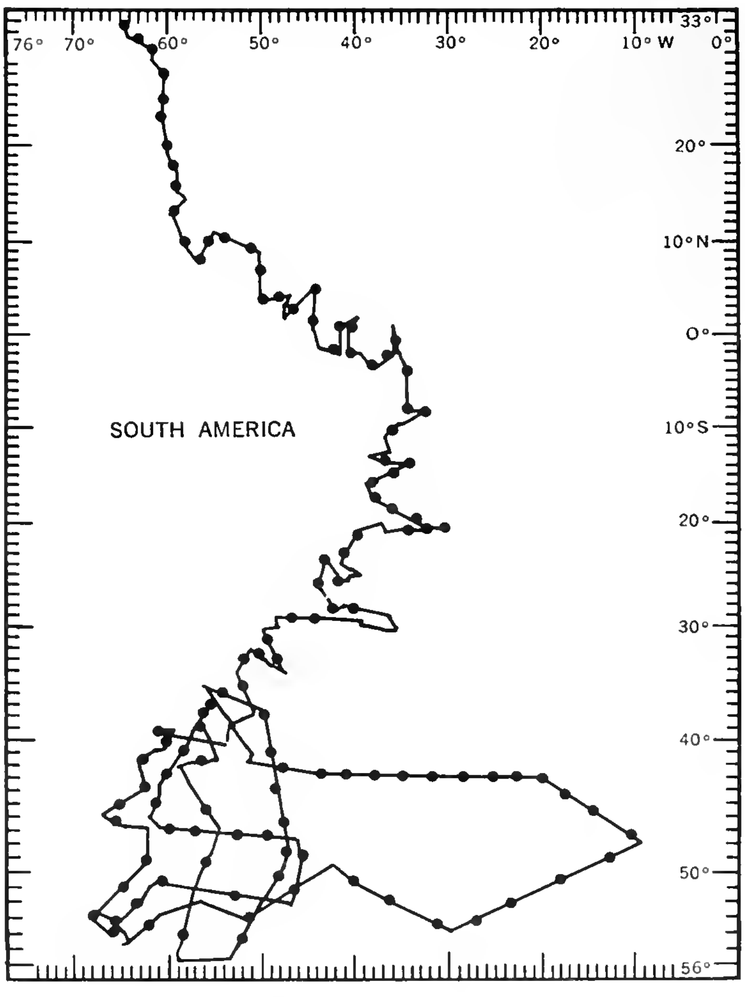

Figure 28.—Lamont-Doherty Geological Observatory's RV CONRAD tracklines during 1972.

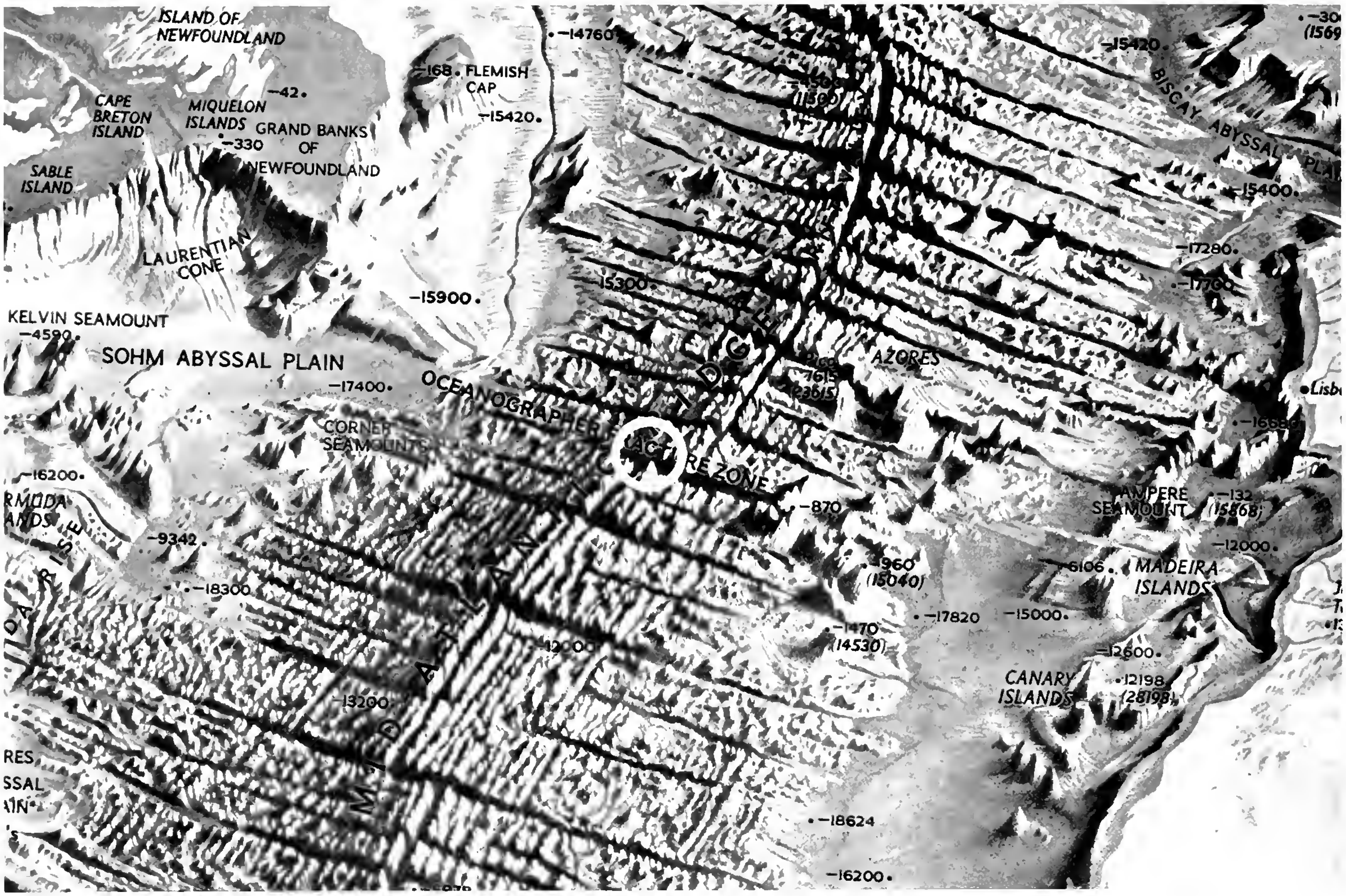

Figure 29.—Circled area shows planned location of international investigations of portion of Mid-Atlantic Ridge. (Reproduced with the permission of the National Geographic Society.)

Miguel in the Azores. In addition to acquiring new data on processes that form the crust, there is reason to expect hydrothermal solutions to be encountered at depths of 300 to 600 meters. Study of these solutions and their interactions with volcanic rocks could add to our knowledge of the sources of metals in the earth's crust and the forces that mobilize them.

The Romanche Fracture Zone, which extends through the equatorial Atlantic from Africa to South America, has an estimated depth of 6 kilometers. Sampling at this tremendous depth offers the opportunity of studying the deep crust and possibly the upper mantle. E. Bonatti and K. G. V. Bostrom (University of Miami) will study the alteration of these deeper rocks by interaction with sea water and any sedimentary deposits located on the flanks of the Mid-Atlantic Ridge in this area.

Mid-Atlantic Ridge Bibliography

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Gulf of California Study

The Scripps Institution of Oceanography made a multidisciplinary study of the Gulf of California during March and April 1972. Many scientists from different organizations and many fields of study participated. Data collected during this 14,800-kilometer cruise (fig. 30) include coring and dredging, sonobouy recorded earthquake data, heat flow measurements, as well as underway measurements of bathymetry, gravity, magnetics, and seismic reflection profiling.

The gravity measurements show that the central part of the Gulf of California is underlain by an oceanic crust that narrows towards the north, where the effects of thick accumulations of sediment are indicated. These results agree with previous work done in this area and should help to better define the boundary of the oceanic crust over a broad part of the Gulf. The seismic reflection and magnetic data indicate that two basins within the Gulf, the Farallon and Guaymas Basins, are centers of sea floor spreading. The spreading is now taking place as Baja California drifts to the northwest while it separates from the main America plate. Pillow basalts dredged from the wall of the Salsipuedes Basin suggest that this same process is occurring as far north as 29 N. Earthquakes recorded on the sonobuoys showed a swarm of 50 events per hour for several hours. A search in eight closed deeps in five basins, using heat flow measurements, gravity cores, and reversing thermometers, failed to reveal the presence of deep hot brines similar to those found in the Red Sea.

Plate Tectonics and Metallogenesis Studies

The concept of plate tectonics, which has provided a unifying theory to the study of the earth, is also providing a new framework within which the origin and genesis of the substantial economic mineral deposits associated with subduction zones can be studied. This framework is embodied in the "geostill" concept which in essence states that these economic minerals (1) have their initial source at active spreading centers; (2) are to some extent mobilized, altered, and concentrated during their emplacement at and transport away from spreading centers; (3) are further mobilized to a significant extent in subduction zones; and (4) are transported and concentrated to form economic mineral deposits such as porphyry coppers, massive sulfides, Ag, Pb, and Zn ores in the near surface rocks above the subducting oceanic lithospheric plate (fig. 31).

A comprehensive research program designed to test and refine this geostill concept would clearly need to address all of the numerous questions that can be derived from the component parts of the concept as listed above. Many of these questions can be most reasonably answered by studies of the ore deposits themselves and of their geological, geochemical, and geophysical setting on the continents. Many, however, can only or best be addressed by marine studies of the lithospheric plates themselves.

As part of its program in Seabed Assessment, IDOE supports basic research studies that contribute to our understanding of the genesis of metallic ore formations. The IDOE interest is based on hypotheses on the origin of ores that developed from the concept of plate tectonics. Since many metallic ore deposits were formed under marine conditions, better understanding of these conditions will provide more powerful exploration tools in the search for new deposits of strategic metals. Conversely, it is recognized that the occurrence of the metals in themselves provides evidence of the conditions under which the earth's crust is formed.

Since the scope of the subject is so broad, IDOE must limit its support to the study of those processes that operate on the sea floor. Those processes are summarized as follows:

1. Active spreading centers are sites of new crustal formation. Knowledge of the processes active along the ridge crests should help determine metal sources and their initial mobilizing forces. Geophysical methods, heat flow, and seismicity will help localize the more active zones. Chemical measurements will help understand: (1) the processes by which metals are transferred by circulating solutions; (2) chemical interactions among fresh oceanic crust, seawater, and sediments; (3) rates of chemical change. Determination of the sources should include investigation of the upper mantle, crust, surface sediments, and the overlying seawater.

2. The metals may be mobilized during transport from the spreading center towards the subduction zone. Chemical processes in the stable plate during transport include exchange of elements among crust, sediments, and seawater as a function of time. Changes will be progressive with increasing distance from the spreading center. Processes of crustal formation may also be active within the stable plate. Occurrence of metalliferous sediments in ponds or basins within the stable plate may be evidence of fissures along which new crustal material is being added.

3. Study of trench sediments and rocks will indicate what metals are being carried down into the subduction zones. In order to follow the pathways of the metals from source to deposition, comparison of materials at ridges and landward ore deposits will help elucidate the processes in the geostill, which is predicted to be operating in the subduction zone at a depth of approximately 100 kilometers. At the present state of technology, the concept of the geostill can be studied only from the input at the subduction zone and the output on the landward side. The program, however, remains open to proposals that could provide insights into the workings of the geostill at depth.

The Nazca Plate was selected for a detailed investigation of the complete tectonic cycle from crustal formation along the East Pacific Rise to its consumption along the Peru-Chile Trench. Occurrences of metalliferous sediments along the East Pacific Rise parallel a major trend of ore deposits in the Andes from southern Chile to northern Peru, suggesting that these

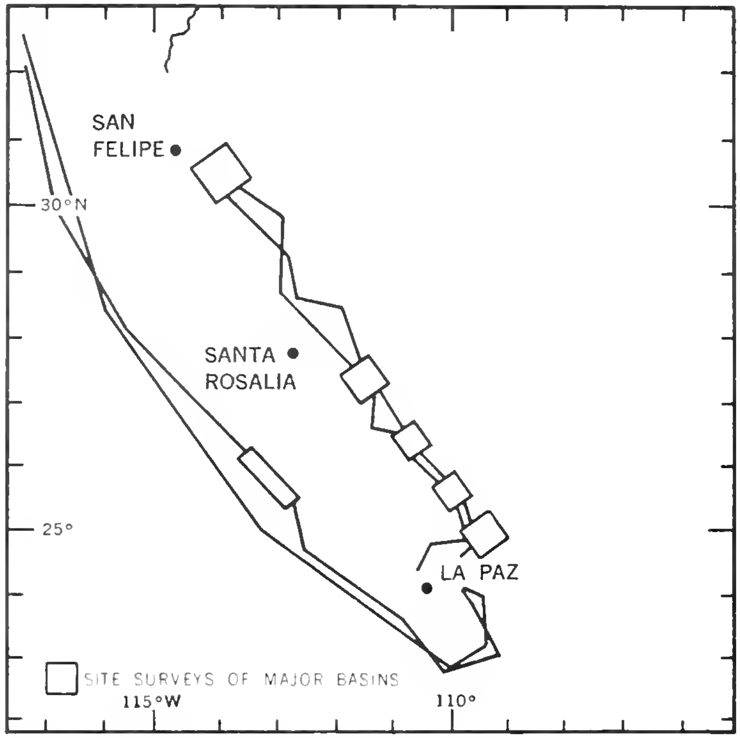

Figure 30.—Gulf of California Study tracklines of Scripps Institution of Oceanagraphy.

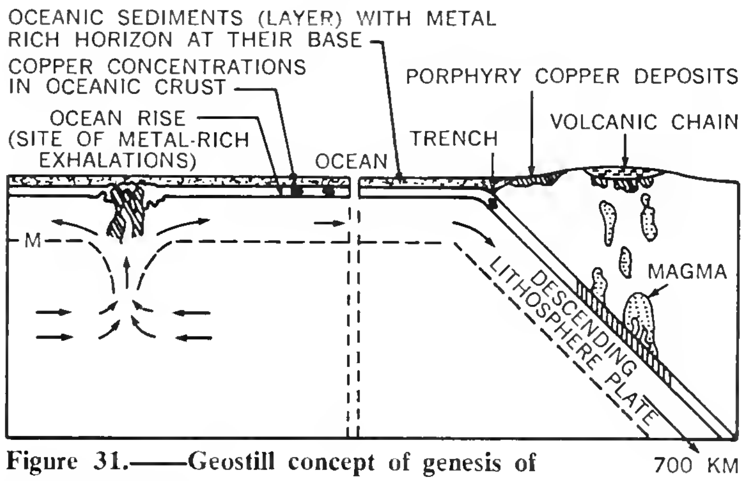

Figure 31.——Geostill concept of genesis of copper deposits.

two phenomena are related. The plate is small enough to be studied as a single geologic entity yet large enough to be representative of the great lithospheric plates that make up the surface of the earth. Since the spreading rate along the East Pacific Rise is among the fastest measured, the volcanic processes producing metalliferous crust and sediments must be quite intense. Furthermore, the dilution process must be minimal because the Plate itself receives little sediment from the land.

The Hawaiian Institute of Geophysics (HIG), Oregon State University (OSU), and the Pacific Oceanographic Laboratory of NOAA are studying the plate margins using complementary geochemical, geological, and geophysical techniques. Scientists from Chile, Colombia, Ecuador, and Peru are actively participating in the cruises and data analysis. A large-scale study of the subduction zone under the Andes as it extends from Colombia south through Chile is simultaneously being done. Although this study goes beyond the scope of IDOE, the data on the subduction zone have obvious implications for the Nazca Plate metallogenesis study and vice versa.

Joint regional investigations by HIG and OSU were begun in 1972, using the HIG RV Kana Keoki and OSU's RV Yaquina, to provide the framework needed for further detailed studies scheduled to be accomplished through 1975. The area that will be surveyed is bounded by the East Pacific Rise and the coast of South America, and by latitudes 4°N and 47°S.

A series of marine geological and geophysical traverses during the initial field season were located at 6°S and 11°S; operations were concentrated at the East Pacific Rise and the Peru-Chile Trench (fig. 32).

A combined total of about 36.500 square kilometers was surveyed on the East Pacific Rise crest by the RV Kana Keoki and RV Yaquina. Tracklines were planned so that each ship's survey consisted of four to six traverses, orthogonal to the rise axis, spaced 4 to 6 miles apart. Data obtained include 12 kilohertz bathymetry, gravity, heat flow measurements, total field magnetics, as well as seismic reflection and refraction profiles. In addition, 115 cores (including 64 piston cores), dredges, and grabs were collected.

One of the most significant facts learned on these surveys

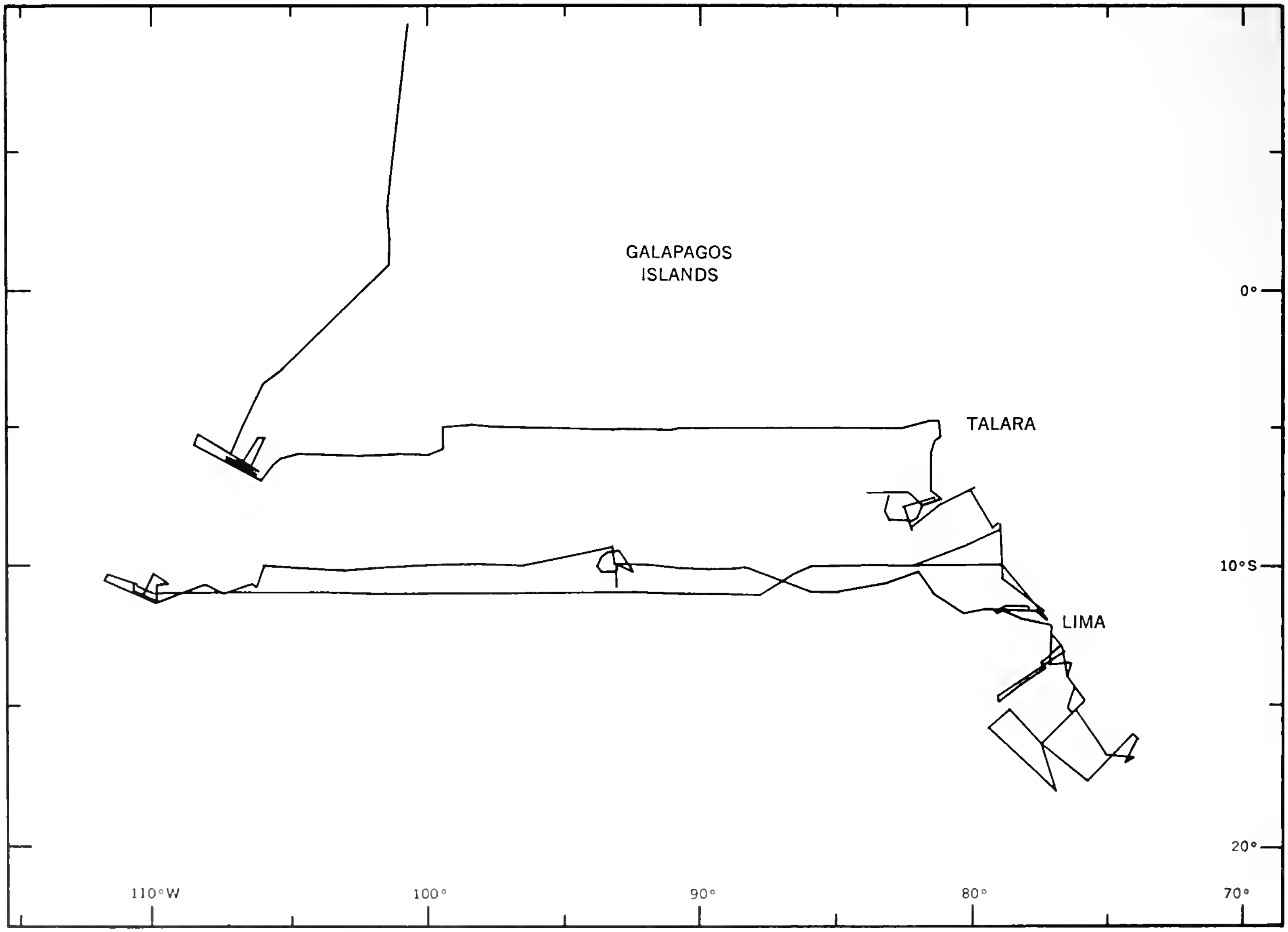

Figure 32.—Geological and geophysical survey lines of RV KANA KEOKI and RV YAQUINA.

is that the crest of the East Pacific Rise is not a smooth, broad arch without a well-defined topographic axis as has been thought in the past. Rather, the topography is very rugged with local relief of several hundred meters. The axis is denoted by a well-defined topographic block, 25 to 35 kilometers wide, standing about 200 meters above the surrounding region. Areas adjacent to the axial block display topographic steps descending from the axis, somewhat similar to the topography present on some portions of the Mid-Atlantic Ridge.

Other preliminary results of this study include the discovery of unexpectedly large magnetic anomalies encountered at latitudes 6°S near the magnetic equator, thereby allowing definition of the more recent magnetic events. Spreading half-rates for the area calculated from these initial data are far higher than earlier estimates.

Geological sampling further suggests that metalliferous sediments rich in transitional elements (Co, Cu, Fe, Mn, Ni) are abundant on the East Pacific Rise, with measured accumulations of up to 17 meters. The Bauer Deep, an elongated sediment trap on the eastern flank of the East Pacific Rise, contains the highest concentration of these transitional metals so far measured in open-ocean metalliferous sediments.

The continental shelf, slope, and Peru-Chile Trench between latitudes 7°S and 17°S were surveyed in a reconnaissance fashion by OSU's RV YAQUINA using seismic reflection profiles. HIG's RV KANA KEOKI also conducted separate and joint work in this area.

Acoustic basement was traced from the Nazca Plate into the Peru Trench and beneath the lower continental slope for a distance of about 10 kilometers. In some areas, a broad zone of deformation occurs over a distance of 10 kilometers in the trench-margin complex. Uplifted turbidite basins separated by a long linear volcanic ridge characterize the trench axis.

Deformed calcareous sediments from the Nazca Ridge were discovered in the Peru Trench-Margin complex suggesting that Nazca Plate sediments have been scraped off onto the lower continental slope landward of the trench axis.

Field investigations are now continuing with both the RV KANA KEOKI and the NOAA RV OCEANOGRAPHER participating in detailed studies.

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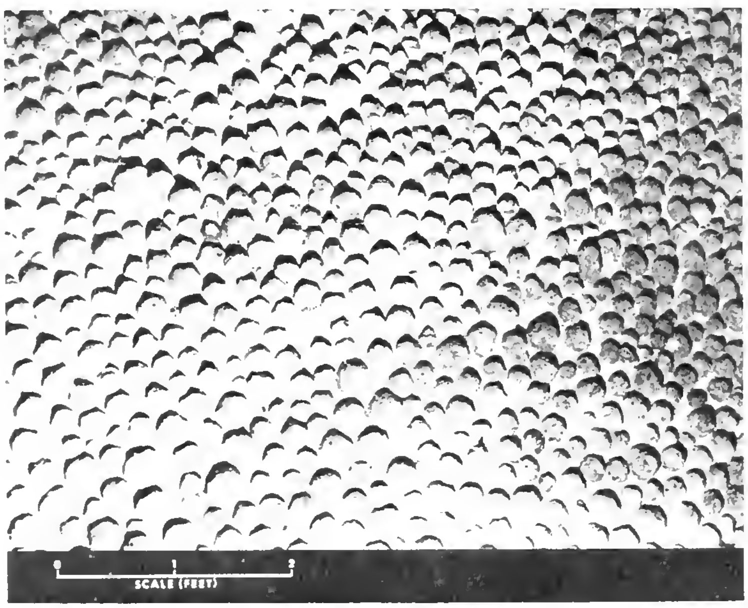

Lamont Doherty Geological Observatory scientists photographed a large accumulation of ferromanganese nodules on the seafloor 5,320 m deep in the Central South Pacific.

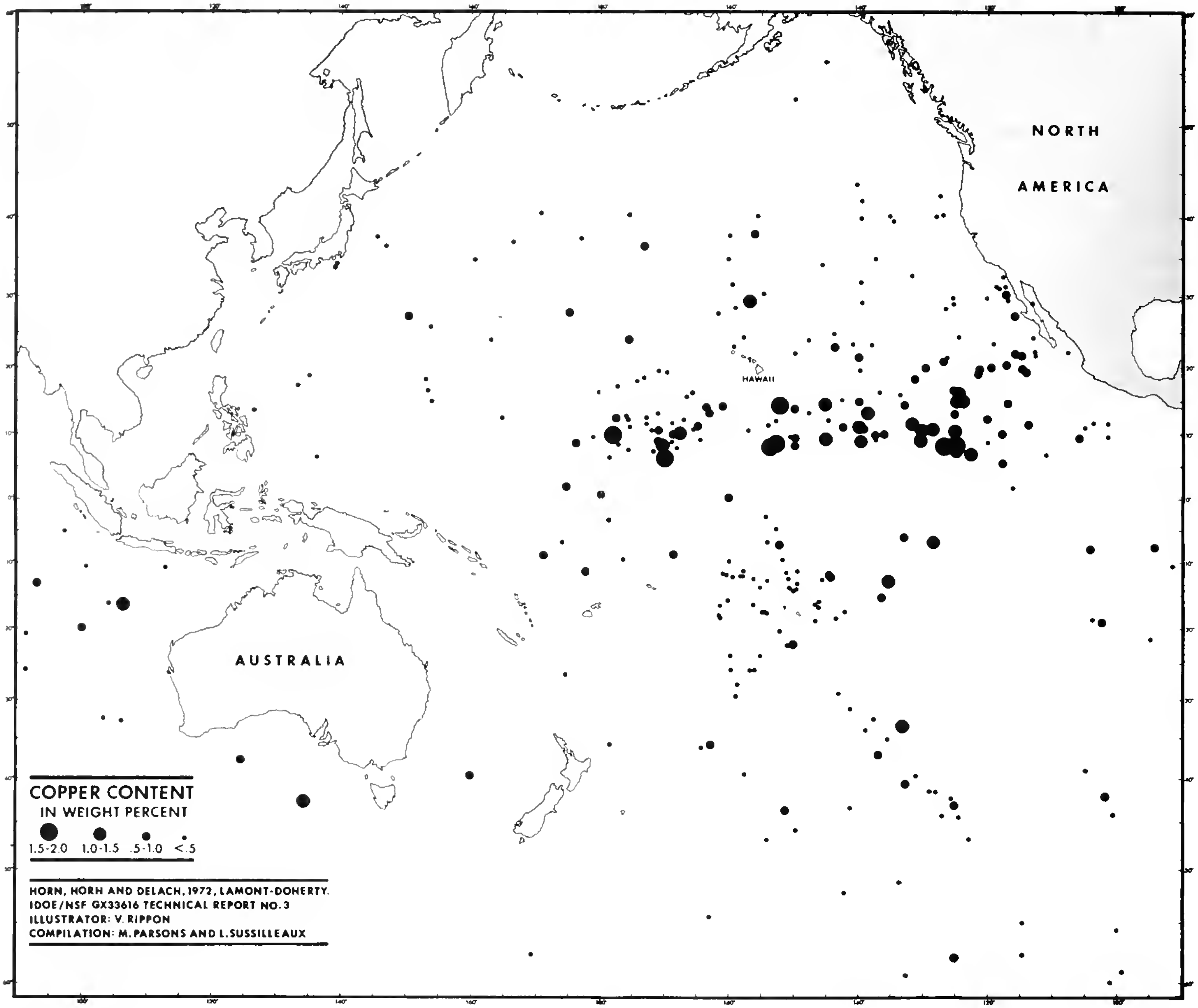

Figure 33.—Cooper deposits in the Pacific Ocean.

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Ocean Minerals Studies

Another IDOE concern is the origin and distribution of manganese nodules. "Polymetallic" nodules is a more descriptive term since, in addition to high percentages of iron and manganese, nodules may contain cobalt, copper, and nickel in economically attractive amounts. In contrast to projects in metallogenesis, where the metals originating on the ocean floor end up on landward formations, the nodules occur extensively on the abyssal plains of the ocean. Since they occur at great depths, the nodules, until recently, were regarded as little more than a geological curiosity. Like the Green River oil shales and the taconite deposits in Minnesota, changing technology makes the nodules economically more attractive.

To assess the present state of knowledge and plan future studies, the Lamont-Doherty Geological Observatory (LDGO) held a workshop/conference under IDOE auspices. The workshop covered scientific, technological, economic, and environmental aspects of the subject. Since most deposits lie at great

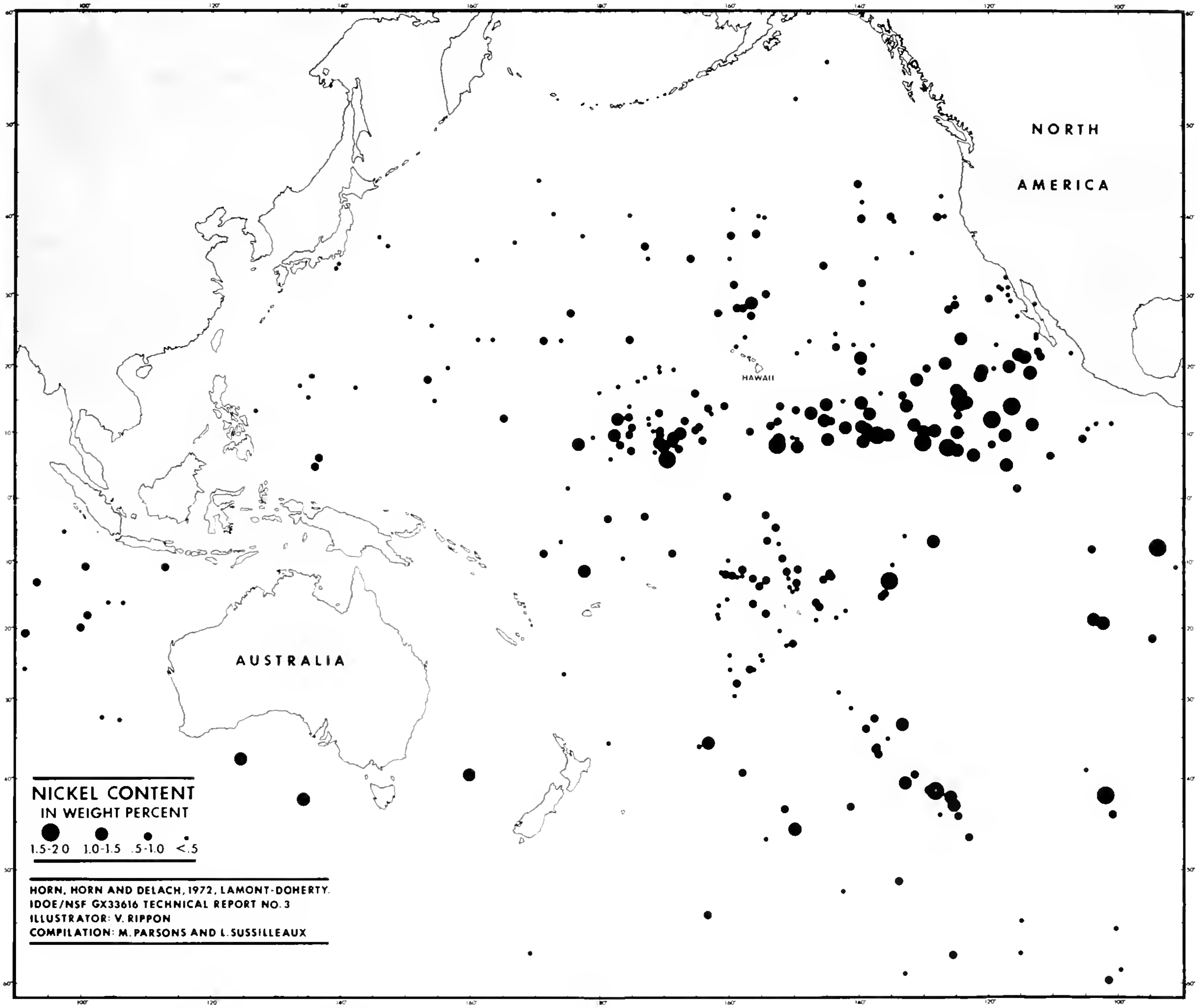

Figure 34.—Nickel deposits in the Pacific Ocean.

depths beyond the claims of any sovereign states to offshore rights, some attention was given to international legal considerations. Thirty papers were presented, and the workshop results have recently been published. Papers on properties of ocean sediments have also been published. Figures 33 and 34 are based on analysis of samples at LDGO. A coordinating office was set up at LDGO to administer a multifaceted definition study being done by 10 investigators from Columbia University and 10 others from as many other institutions. The results of the definition study and recommendations for future research have been published.

The report and recommendations can be used as guidelines for future research by all groups interested in studying the mineral potential of the ocean. IDOE will be especially concerned with those aspects that relate to the origin and distrbution of the nodules.

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Living Resources Program

The goal of the Living Resources Program, which became the fourth IDOE program area in 1971, is a better understanding of the processes and relationships existing between the biological aspects of marine organisms and the chemical, physical, and geological environment in which they live. Currently, the program is concentrating on marine ecosystems analysis through Coastal Upwelling Ecosystems Analysis (CUEA) projects. The basic goal of CUEA is to understand the coastal upwelling ecosystem so that the response of the system to change may be predicted from monitoring a few biological, physical, or meteorological variables (fig. 35). United States participants in CUEA are listed in table 6.

Coastal upwelling is a predominant mesoscale ocean-atmosphere process along the low-latitude and midlatitude western coasts of most continents. Fishery reports have suggested that perhaps 50 percent of the world's fish supply is produced in upwelling regions. By increasing the understanding of the dynamics of the upwelling system and by relating the physical dynamics to the biological and chemical dynamics in upwelling ecosystems, it may eventually be possible to predict the size of commercially important nekton stocks. Knowledge of a few oceanographic and meteorological variables may facilitate such a prediction.

Progress in both the theory and measurement of upwelling processes over the past few years has reached the point where a concerted scientific research effort may make it possible to predict upwelling and to understand the processes taking place within the food chain. Such effort will surely help man to improve his use of the oceans as a source of food.

The following are basic to the work in the CUEA program:

1. Description in spatial and temporal detail of the circulation and distribution of organisms and properties in coastal upwelling regions.
2. Elucidation of the physical processes and mechanisms causing and affecting upwelling and their importance in contributing to the observed spatial and temporal variability.
3. Computer simulation models of upwelling ecosystems, based upon a combination of field observation and laboratory and shipboard experimentation.
4. Comparisons of model predictions and field observations of real systems. (A validation field measurement step is required.

The approach that has been developed by the CUEA scientists will be used to continue studies of upwelling ecosystems (figs. 36 and 37). Figure 36 is concerned with the philosophy and interaction of environmental data, experimental work, data analysis, and simulation models essential for investigation of total ecosystems. Flow of information is cyclic where the initial inability of a simulation model to describe adequately the experimental and field results is shown to serve as necessary feedback to ongoing work. Construction of an upwelling systems model is viewed as the method of channelling information within subprograms and of maintaining continuity of data required for input to the various process submodels making up the system model. The interactions between the physical, chemical, and biological components of the program are shown with the idea that existing submodels are compared with the real world. With each pass through this cycle the discrepancies are used to guide experimental design of the next set of field and laboratory efforts, to improve the next set of process submodels, and to update the system model.

Figure 37 is concerned with the implementation of system philosophy. A reasonably sophisticated understanding and the ability to predict the dynamics of a marine ecosystem require a directed and coordinated effort in data collection. In the figure the circulation, upper ocean dynamics, and abiotic submodels (inhibition, light, nutrients, and temperature) are used as input to the coupled biological state variable submodels. Temporal and spatial distributions are computed through the individual process submodels (nutrient uptake, photosynthesis, sinking, metabolic losses of excretion and respiration, grazing, behavior, predation, and heterotrophic assimilation).

The foundation for the CUEA program has been established by the work of physical and biological oceanographers in several preliminary experiments. MESCAL–I and II were primarily biological cruises off Baja California in March 1972 and 1973 and were designed to obtain time series measurements on variables such as chlorophyll, nitrogen, silicon, and temperature and to examine associated biological processes in the development stages of an upwelling system.

During summer of 1972, the first Coastal Upwelling Experiment (CUE–I) was conducted off the northwestern coast of the United States. The goals were to define the time and space scales of the upwelling process, test theoretical hypotheses and models, as well as prove out experimental hardware and techniques for future studies of upwelling ecosystems.

CUE–II will be the second physical experiment off the coast of Oregon in as many years. The time frame for operations is July and August 1973 and will involve the use of four oceanographic vessels from three research facilities. The RV OCEANOGRAPHER, from Pacific Oceanographic Laboratories, NOAA, will make extensive hydrographic surveys of the study area; the RV CAYUSE and RV YAQUINA, from Oregon State

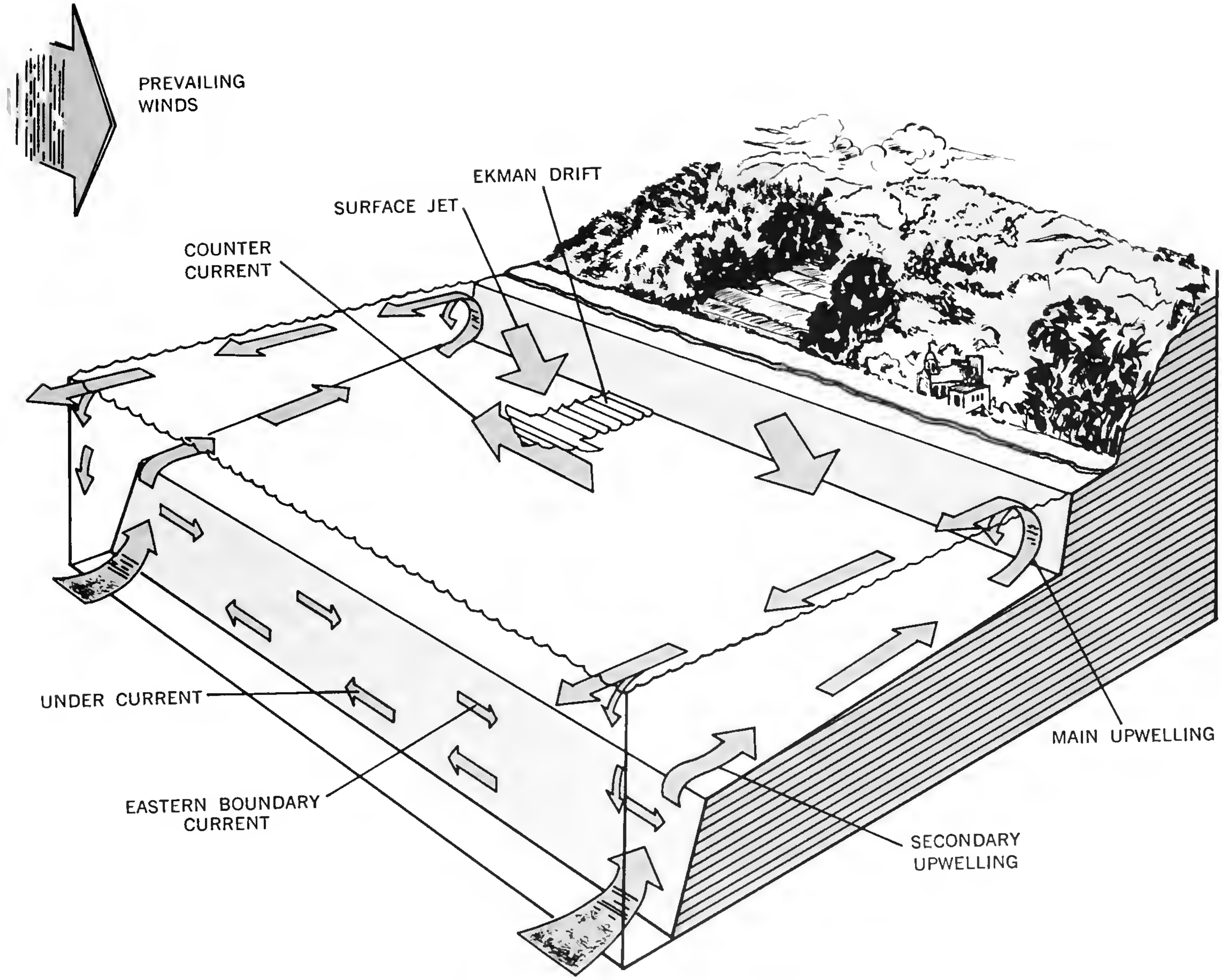
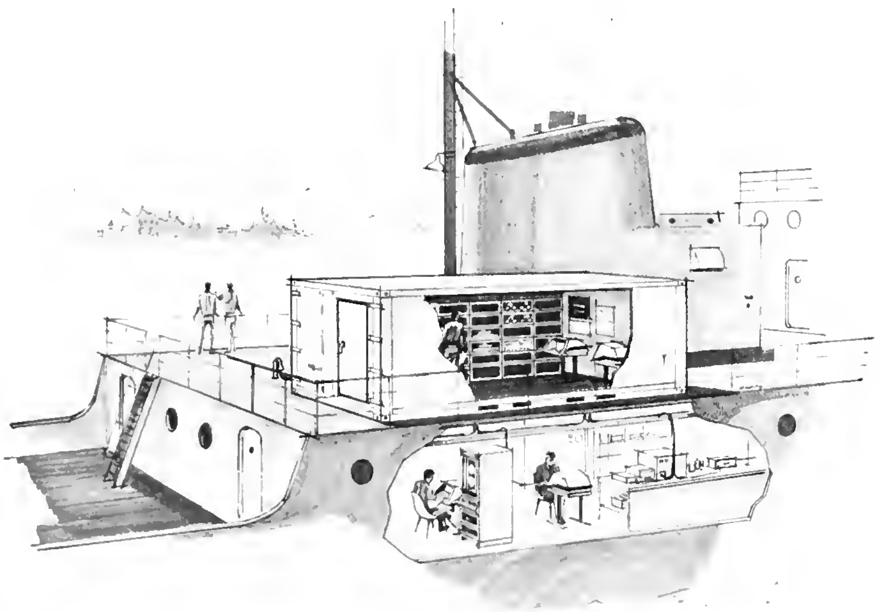


Figure 35.—Schematic view of coastal upwelling. When favorable winds blow towards the Equator, the earth's rotation produces an offshore or Ekman drift of the upper ocean layers along the coast. This drift in turn produces an upwelling of colder, deeper waters near the coast, often a narrow band 10 to 15 kilometers wide. The rich nutrients of the upwelled deeper water cause a rapid growth in the plankton population, which results in a rich feeding ground for fish. This phenomenon is significant because an estimated 50 percent of the world's fish supply comes from major upwelling areas.

Table 6.—United States participants in the Coastal Upwelling Ecosystem Analysis (CUEA) project

Organization	Investigator	Project Title
University of California, Scripps Institution of Oceanography	M. Blackburn	Behavior and Biology of Nekton
University of Connecticut	R. W. Garvine	Theoretical Studies of Physical Dynamics
Duke University	R. T. Barber	Primary Production, Chelation, and Toxicity
Florida State University	J. J. O'Brien	Simulation of Time-Dependent Circulation
Florida State University	D. W. Stuart	Meteorological Research in the CUE–II and JOINT–I Experiments
University of Miami	C. N. K. Mooers	Physical Dynamics of the Frontal Zone
University of Miami	J. C. Van Leer	Cyclesonde Measurements of the Frontal Zone
Oregon State University	J. S. Allen	Analytical, Numerical Studies of Processes
Oregon State University	B. W. Frost	Grazing and Zooplankton Fields
Oregon State University	R. Smith	Mesoscale, Descriptive Physical Oceanography
University of Rhode Island	T. J. Smayda	Phytoplankton Species, Succession, Sinking
University of Washington	R. C. Dugdale	Kinetics of Nutrient Uptake
University of Washington	J. C. Kelley	Nutrient and Phytoplankton Fields
University of Washington	T. T. Packard	Enzymatic Determination of Transformations
University of Washington	R. Thorne and O. Mathiesen	Acoustic Assessment and Modelling of Nekton
University of Washington	J. J. Walsh	Systems Model of Upwelling Ecosystems
University of Wisconsin	D. L. Cutchin and D. B. Rao	Internal and External Edgewaves
Woods Hole Oceanographic Institution	G. T. Rowe and K. Smith	Nutrient Cycles and the Benthos



The CUEA Interactive Real-time Information System (IRIS) is a new modular computer system designed to acquire, edit, and analyze real-time data from a sensor array and present these data at interactive graphic terminals.

University, will be used for buoy placement (fig. 38) and recovery as well as for hydrographic surveys, respectively. The RV THOMAS G. THOMPSON from the University of Washington will be used for both physical and biological oceanography.

In addition to the four research vessels, specially instrumented aircraft from the National Center for Atmospheric Research in Boulder, Colo., will be used in conjunction with shore installations to gather meteorological and sea surface information.

Data from the CUE–I and MESCAL experiments will provide the descriptive and theoretical basis for the JOINT–I experiment, scheduled to take place off the Northwest Africa Coast in early 1974. JOINT–I is the first full-scale integrated experiment on a marine ecosystem. Its primary research objective is the same as the central scientific objective of the CUEA program, i.e., a theoretical and experimental investigation of the physical, chemical, and biological dynamics of coastal upwelling, in order to develop a total system model of this complex ecosystem. JOINT–I is the first major experiment of the CUEA program. All previous cruises are considered as preparatory experiments for JOINT–I. It is scheduled for February-April 1974 in the region of the northwest Africa Coast between Cap Blanc and Cap Verde (fig. 39). The selection of the northwest coast of Africa for this first major experiment was based on the presence of a powerful upwelling system in that region and the extensive scientific foundation provided by the Cooperative Investigations of the Northeast Central Atlantic (CINECA) program. More than 20 cruises by oceanographic and fisheries research vessels of 8 countries have been made in the CINECA region to date, and an intensive multiship effort is taking place in 1973. This 1973 program is the first of two CINECA phases and is primarily devoted to a detailed physical, chemical, and biological survey of the dynamics of the Canary Current and the coastal upwelling system. A possible link between those systems will also be investigated during transects from the coast to 550 kilometers offshore. U.S. scientists from the CUEA project have taken part in seven past cooperative cruises in this area and will lead the second major CINECA phase on upwelling process studies during 1974. The JOINT–I experiment will be a major attempt to understand each component of upwelling as it develops from the offshore movement of surface water; surface water replacement by nutrient-rich waters from deeper, cooler layers; the growth of plants that feed on these nutrients; the growth of microscopic animals that feed on the plants; and finally, the influx and growth of fishes that feed on these smaller organisms.

Coastal Upwelling Experiment (CUE)-I

This project was an intensive detailed field experiment, designed in close coordination with numerical models and theoretical hypothesis, to study the physical dynamics of coastal upwelling. The objective of CUE–I was an understanding of the time and space scales of the coastal upwelling phenomenon and the development of the ability to estimate its three-dimensional velocity and distribution of properties. This objective is viewed as a first step toward attaining the capability to predict the complex integrated processes (biological and physical) in upwelling ecosystems.

The principal tool of CUE–I was an instrument array that included recording current meters, temperature and salinity sensors, as well as anemometers. The arrays were deployed in an intensive 2-month time-series study of the circulation, density field, and winds off the Oregon coast during summer 1972.

Figure 40 shows the experimental area mooring locations, and hydrography stations off the Oregon coast. The principal moored array, the CUE BUOY FARM, consisted of two lines of buoys, the Newport and Depoe Bay lines. On the Newport line, current meter strings were installed at the Alpha, Beta, Gamma, and Delta locations. At each location, 2, 3, or 4 current meters were mounted. A surface buoy recorded wind speed and direction as well as air and water temperatures. The Depoe Bay line has subsurface moorings at the Epsilon, Theta and Zeta locations. Surface buoys for wind and temperature were also maintained at Epsilon, Iota, and Zeta.

In the center of the grid at the Kappa location, the NOAA Pacific Oceanographic Laboratory installed a moored array that intensively measured the upper ocean layers and meteorological parameters.

The 5 meter-SODS (Small Ocean Data System) buoy was located in about 100 meters of water on the Newport line. The Oregon State University TOTEM buoy was at 45° N on the Depoe Bay line.

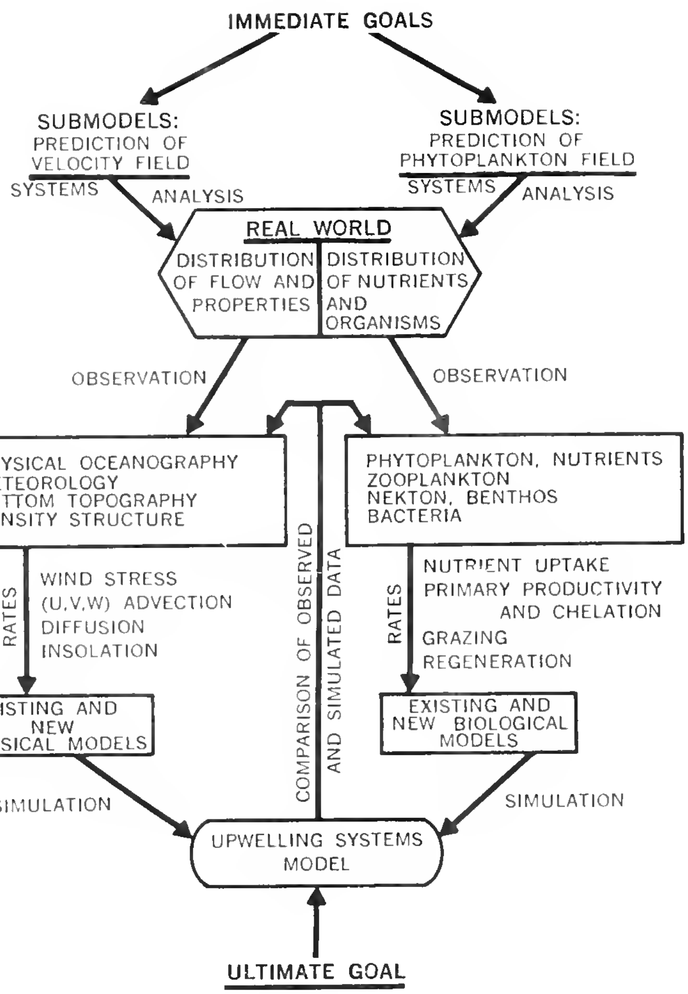


Figure 36.—Diagram of systems approach to understanding of upwelling ecosystems.

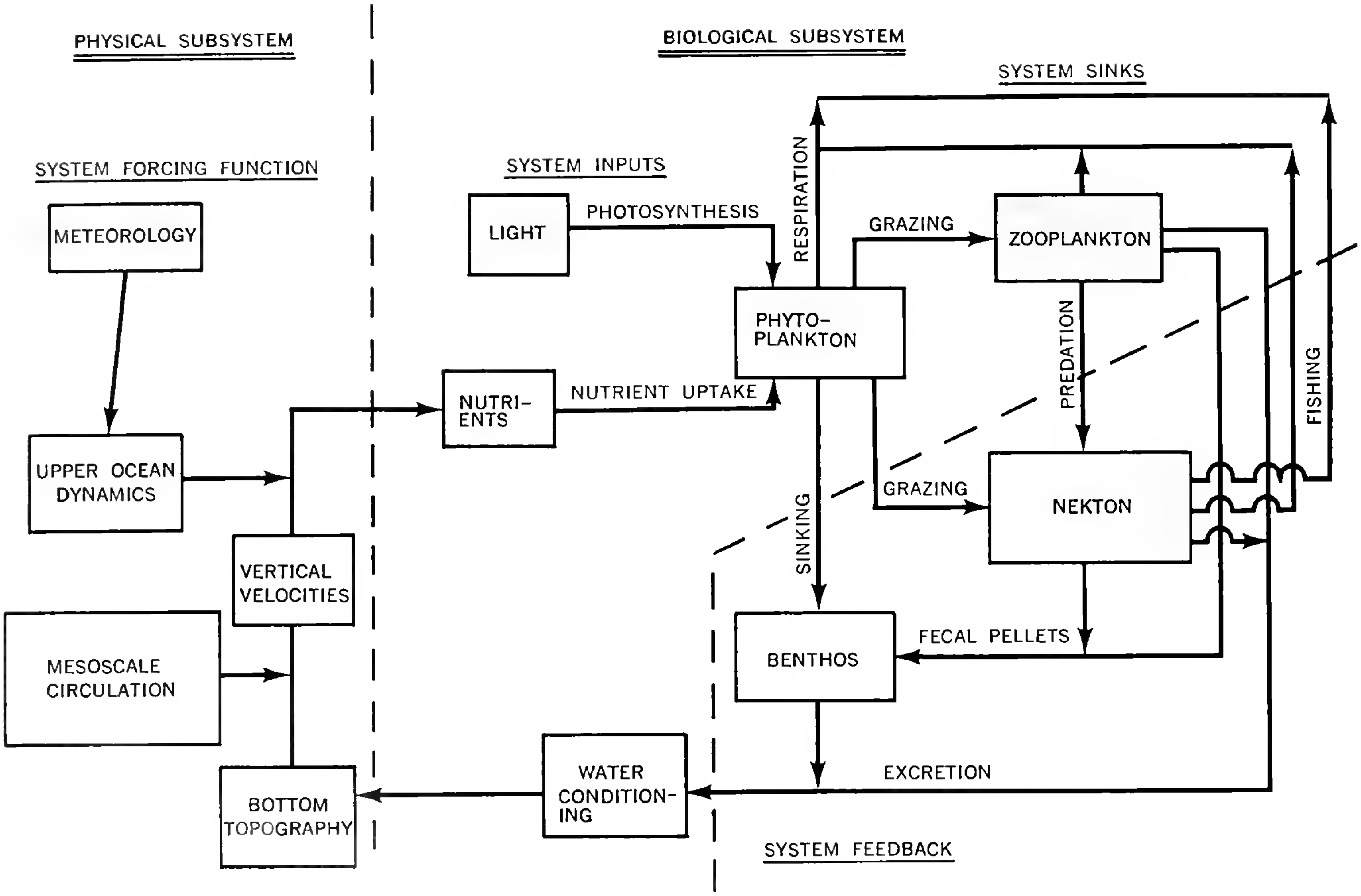


Figure 37.—The submodel structure of an upwelling ecosystem model.

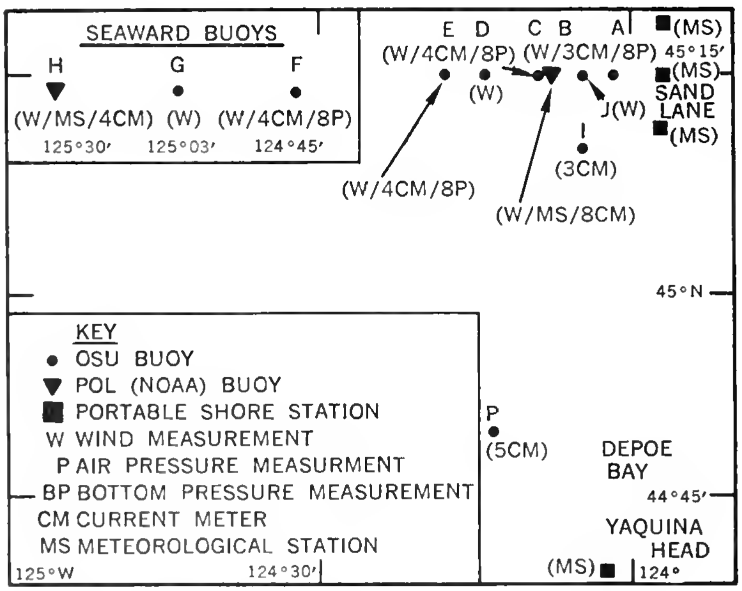


Figure 38.—Proposed CUE-II buoy array.

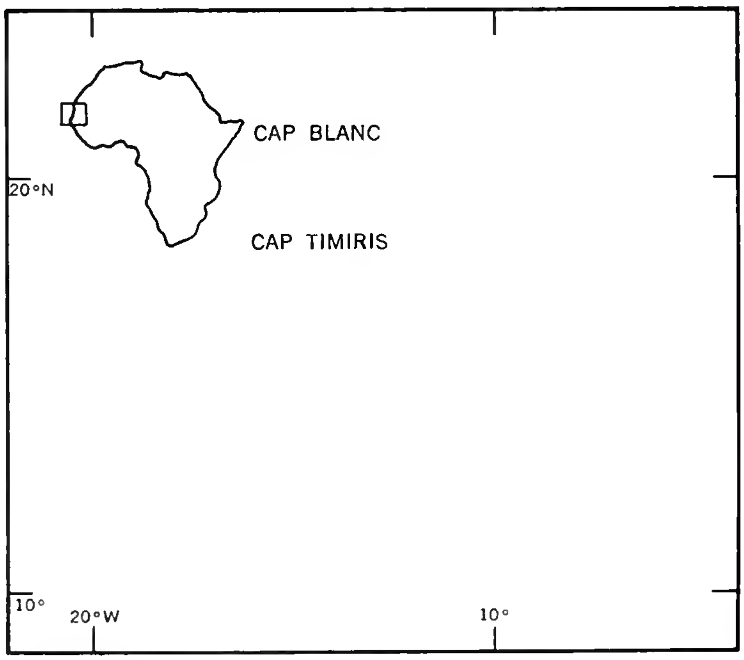


Figure 39.—JOINT-I study area.

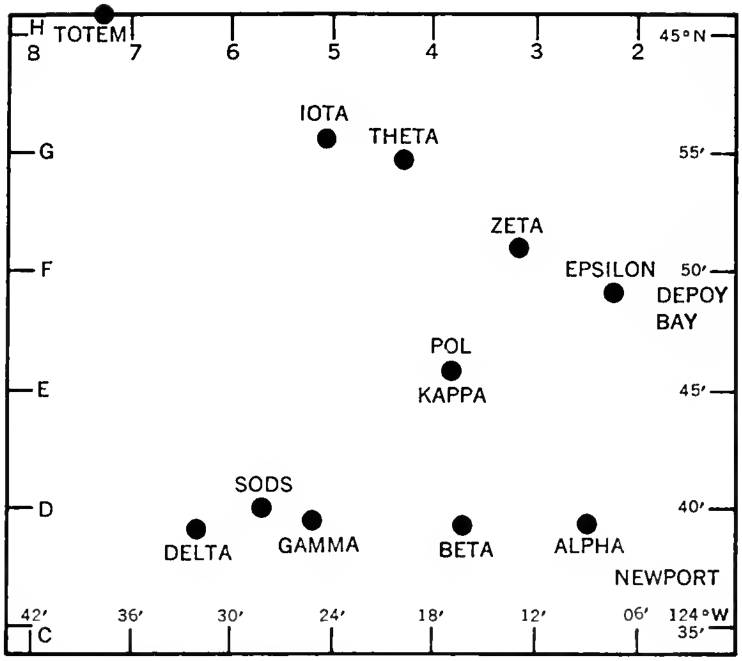


Figure 40.—The CUE-I region. The solid circles indicate the location of the various buoy moorings. The small dots form a grid that indicates the repeatable hydrography stations. Hydrography lines c, d, e, f, g, and h with stations 2-8 are shown.

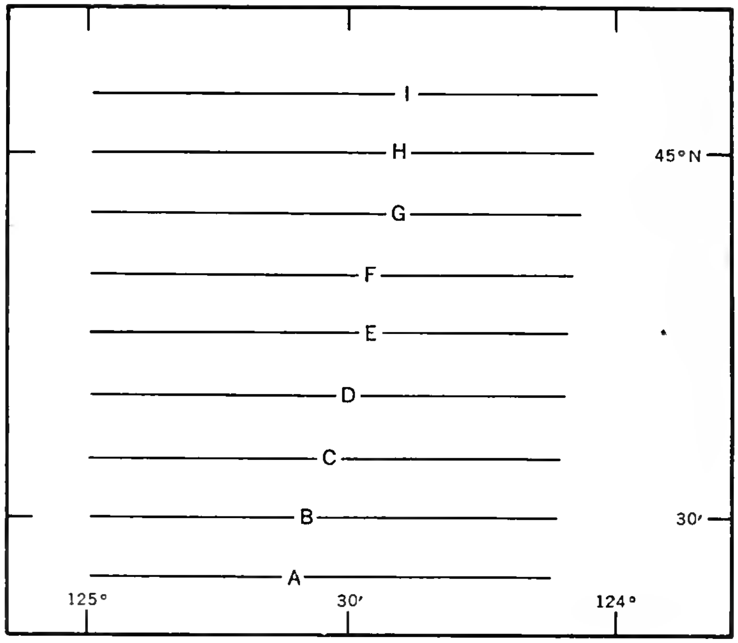


Figure 41.—Location of east-west lines along which STD measurements were made from the NOAA RV OCEANOGRAPHER. The lines are separated by 5 mintues of latitude.

The SODS buoy measures thermocline oscillations and an apparent bottom mixed layer during CUE–I.

Dale Pillsbury and Ben Moore ready a CUE–I Aanderra current meter that will be suspended beneath the OSU buoy.

Additional wind measurements on shore were made by the Marine Meteorological Station at Newport, Oreg. Data from a tide gage at Newport were used to measure the variation in sea level associated with upwelling. Variations in slope of the sea surface was monitored by comparison of tide gage data with pressures recorded by the instruments moored at sea.

Synoptic observations over a larger region were made both by ship and aircraft. The three research vessels—CAYUSE, YAQUINA, and OCEANOGRAPHER—made repeated detailed hydrographic sections through the area to define the density and nutrient fields and their variations. An instrumented research aircraft from the National Center for Atmospheric Research was used to obtain synoptic maps of ocean surface temperature, as well as flight-level air temperature, relative humidity, and winds.

Drogues were used to study the flow in the near-surface Ekman layer. Upwelling patches, plumes, or other features of interest revealed by the aircraft or ship surveys were investigated in detail by the research vessels. Profiling current meters, expendable BT's, and other instruments were kept aboard the ships for this purpose. Two or three spare instrumented moorings were kept aboard the YAQUINA for short-term deployment to study such transient features.

From May through October 1972, the RV YAQUINA of Oregon State University (OSU) made its series of cruises that formed part of CUE–I. The purposes of the cruises were to obtain hydrographic data in the grid adjacent to the Oregon coast. Current meters of the CUE–I array were moored and recovered during some of the cruises. In addition to hydrographic and current data, water samples for optics, phytoplankton, and nutrient analyses were collected on several cruises. Also while the ship, was underway, a continuous nutrient analysis of the water was made at 2 meters.

On the July 10–18, and the July 31 to August 7 cruises (Cruises Y7207B and Y7201E), vertical current meters were deployed and recovered.

In addition to the sampling done by OSU the SODS buoy was moored at about 44°39′N, 124°30′W in the CUE–I region to observe oscillations in the thermocline and to explore what appeared to be a bottom mixed layer.

Another salinity-temperature-depth study of the area was made by NOAA's Pacific Oceanographic Laboratory (POL) using the RV OCEANOGRAPHER (fig. 41).

Appendix—National Marine Data Inventory (NAMDI)* Summaries

In the following information summaries, unless stated otherwise, all institutions or activities are U.S. participants in IDOE and all projects are part of the Declared National Program (DNP) in oceanography. All NAMDIs received by EDS from July 1972 to February 1973 are included in this Appendix. Information is presented in the following order.

Line 1:

- Institution of IDOE grant holder as identified in the List of Abbreviations; platform or vessel used to collect data; cruise number and leg, where applicable; cruise period; and number of days.

Line 2:

- NODC record number (reference to this number when requesting NAMDIs facilitates retrieval); general geographic area; available extra information in parentheses.

Line 3:

- Chief scientist(s); supporting organization(s) indicated in parentheses, as identified in List of Abbreviations; and Marsden square(s) as shown in chart following Appendix.

Line 4:

- Grant number (NSF reference); supplementary comments; followed by listing of parameters and number of stations or samples.

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* See Introduction

LIST OF ABBREVIATIONS

Institution of IDOE Grant Holder:

HIG	Hawaii Institute of Geophysics
LDGO	Lamont-Doherty Geological Observatory
NMFS	National Marine Fisheries Service, NOAA
OSU	Oregon State University
POL	Pacific Oceanographic Laboratory, NOAA
SIO	Scripps Institution of Oceanography
URI	University of Rhode Island
WHOI	Woods Hole Oceanographic Institution

Organizations providing support:

NSF IDOE	National Science Foundation—International Decade of Ocean Exploration program
ONR	Office of Naval Research
EPA	Environmental Protection Agency

ENVIRONMENTAL QUALITY PROGRAM

GEOCHEMICAL OCEAN SECTIONS (GEOSECS) STUDY

- OSU YAQUINA Cruise C7204–GG, April 1972, 1 day
- NODC Record No. 06493, Northeast Pacific, additional information: narrative
- Seifert, E. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28167, Organic carbon tests

Descriptive oceanography	Stations or samples
carbon-particulate	40

- SIO MELVILLE, November to December 1971, 17 days
- NODC Record No. 06860, Northeast Pacific
- Craig, H., and A. Bainbridge. (NSF IDOE) Marsden square 120
- NSF Grant No. GX–28162, IDOE GEOSECS Project/ Expedition GO-GO I—California coast

Descriptive oceanography	Stations or samples
ocean serial station	56
STD	41
oxygen	18
phosphates	6
nitrates	6
nitrites	6
trace elements	25
pH	9
alkalinity	9
silicates	6
radioactivity	25
isotope chemistry	25
dissolved gases	8
salinity	10
Meteorology	
surface meteorological observations	—

- SIO MELVILLE, GO-GO II Expedition, April and May 1972, 8 days
- NODC Record No. 07623, Northeast Pacific
- Weiss (NSF IDOE) Marsden square 85
- GEOSECS

Descriptive oceanography	Stations or samples
STD	8
oxygen	—
phosphates	—
nitrates	—
alkalinity	—
silicates	—
isotope chemistry	—
dissolved gasses	—

- WHOI KNORR Cruise 29, July 1972, 10 days
- NODC Record No. 07499, North Atlantic
- Spencer, D. W. (NSF IDOE) Marsden squares 115, 116, 152
- GEOSECS shakedown

Descriptive oceanography	Stations or samples
ocean serial station	2
STD	2
oxygen	2
phosphates	1
nitrates	1
trace elements	1
pH	1
alkalinity	1
silicates	1
radioactivity	1
isotope chemistry	1
dissolved gases	1
bathythermograph expendable (no. of drops)	4
bottom temperature (10 m or less from bottom)	2
sea-surface temperature	—

- WHOI KNORR Cruise 30, Leg 1, July to August 1972, 21 days
- NODC Record No. 07305, North Atlantic/Arctic
- Spencer, D. W. (NSF IDOE) Marsden squares 149, 150, 151, 185, 219, 220, 221
- Continuous underway salinity, temperature, PC02, and pH

Descriptive oceanography	Stations or samples
ocean serial station	13
STD	13
oxygen	7
phosphates	7
nitrates	7
trace elements	7
pH	7
alkalinity	7
silicates	7
radioactivity	7
isotope chemistry	7
dissolved gases	7
bathythermograph expendable (no. of drops)	61
bottom temperature (10 m or less from bottom)	13
sea-surface temperature	13
pollution-oil	3
Meteorology	
water vapor-isotopes	—

- WHOI KNORR Cruise 30, Leg 2, August 1972, 20 days
- NODC Record No. 07145, Arctic
- Spencer, D. W. (NSF IDOE) Marsden squares 217, 218, 219, 253

Descriptive oceanography	Stations or samples
ocean serial station	10
STD	10
oxygen	8
phosphates	8
nitrates	8
trace elements	7
pH	8
alkalintiy	4
silicates	8
isotope chemistry	4
bathythermograph expendable (no. of drops)	15
bottom temperature (10 m or less from bottom)	10
sea-surface temperature	—
carbon dioxide	4
carbon 14	4
cesium 137	4
nitrogen	8
strontium 90	4
tritium	4
radon 222	10
argon	8
neon	8
nephelometer	10
helium	8
radium 226	4
radium 228	4
Biology	
dissolved organic matter	1

- WHOI KNORR Cruise 30, Leg 3, September to October 1972, 28 days
- NODC Record No. 07306, North Atlantic/Arctic
- Broecker, C. S. (NSF IDOE) Marsden squares 43, 78, 113, 114, 148, 149, 183, 184, 219
- Continuous underway salinity, temperature, PC02, and pH

Descriptive oceanography	Stations or samples
ocean serial station	12
STD	11
oxygen	10
phosphates	10
nitrates	10
nitrites	11
trace elements	10
pH	10
alkalinity	10
silicates	10
radioactivity	10
isotope chemistry	10
dissolved gases	10
bottom temperature (10 m or less from bottom)	12
sea-surface temperature	12
pollution-oil	3
Meteorology	
water vapor-isotopes	—

- WHOI KNORR Cruise 30, Leg 4, October 1972, 25 days
- NODC Record No. 07307, North Atlantic/South Atlantic
- Craig, H. (NSF IDOE) Marsden squares 4, 5, 6, 42, 302, 303
- Continuous underway salinity, temperature, PC02, and surface particulates

Descriptive oceanography	Stations or samples
ocean serial station	14
STD	14
oxygen	13
phosphates	8
nitrates	8
trace elements	5
alkalinity	8
silicates	8
radioactivity	8
isotope chemistry	8
dissolved gases	8
bathythermograph expendable (no. of drops)	49
bottom temperature (10 m or less from bottom)	13
sea-surface temperature	—
Meteorology	
water vapor for isotope measurements	—

- WHOI KNORR Cruise 30, Leg 5, November 1972, 25 days
- NODC Record No. 07308, South Atlantic
- Broecker, J. (NSF IDOE) Marsden squares 303, 339, 375, 411, 412, 413
- Saturometer and Langmuir cell measurements, continuous underway salinity, temperature, PC02, and surface particulates

Descriptive oceanography	Stations or samples
ocean serial station	17
STD	17
oxygen	12
phosphates	12
nitrates	12
trace elements	4
alkalinity	9
silicates	12
radioactivity	7
isotope chemistry	7
dissolved gases	9
bathythermograph expendable (no. of drops)	45
bottom temperature (10 m or less from bottom)	12
sea-surface temperature	—
pollution-oil	2
Meteorology	
surface meteorological observations	—
water vapor-isotopes	—

- WHOI KNORR Cruise 30, Leg 6, December 1972, 21 days
- NODC Record No. 07309, North Atlantic
- Park, K. (NSF IDOE) Marsden squares 413, 449, 485, 486
- Continuous underway temperature, salinity, PC02, and surface particulates

Descriptive oceanography	Stations or samples
ocean serial station	14
STD	14
oxygen	12
phosphates	12
nitrates	12
trace elements	3
alkalinity	6
silicates	12
radioactivity	5
isotope chemistry	5
dissolved gases	6
bathythermograph expendable (no. of drops)	47
sea-surface temperature	—
pollution-oil	1
Meteorology	
surface meteorological observations	—
water vapor-isotopes	—

- WHOI KNORR Cruise 30, Leg 7, December 1972 to February 1973, 38 days
- NODC Record No. 07500, South Atlantic/Antarctic
- Craig, H. (NSF IDOE) Marsden squares 442, 478, 479, 480, 482, 483, 484, 485, 486, 515, 521, 522
- Continuous underway temperature, salinity, PC02, and surface particulates

Descriptive oceanography	Stations or samples
ocean serial station	19
STD	19
oxygen	19
phosphates	19
nitrates	19
trace elements	6
alkalinity	11
silicates	19
radioactivity	6
isotope chemistry	6
dissolved gases	12
bathythermograph expendable (no. of drops)	6
bottom temperature (10 m or less from bottom)	4
sea-surface temperature	—
Meteorology	
surface meteorological observations	—
water vapor for isotope measurements	—

- WHOI KNORR Cruise 30, Leg 8, February 1973, 26 days
- NODC Record No. 07501, South Atlantic
- Reid, J. (NSF IDOE) Marsden squares 2, 3, 300, 371, 407, 442, 443
- Continuous underway Temperature, salinity, PC02, and surface particulates

Descriptive oceanography	Stations or samples
ocean serial station	14
STD	10
oxygen	14
phosphates	12
nitrates	12
trace elements	4
alkalinity	7
silicates	12
radioactivity	5
isotope chemistry	5
dissolved gases	7
bathythermograph expendable (no. of drops)	96
bottom temperature (10 m or less from bottom)	7
sea-surface temperature	—
pollution-oil	1
Meteorology	
surface meteorological observations	—
water vapor-isotopes	—

- WHOI KNORR Cruise 30, Leg 9, March and April, 1973, 23 days
- NODC Record No. 07731, North Atlantic
- Takahashi, T. (NSF IDOE) Marsden squares 38, 75, 76, 112, 113, 114, 115, 116
- NSF Grant GX–33293. Also measured: underway continuous salinity, PC02, and surface particulates; performed langmuir cell study

Descriptive oceanography	Stations or samples
ocean serial station	8
STD	7
oxygen	8
phosphates	8
nitrates	8
trace elements	3
alkalinity	8
silicates	8
radioactivity	3
isotope chemistry	3
dissolved gases	8
bathythermograph expendable (no. of drops)	100
bottom temperature	8
sea-surface temperature	—
pollution-oil	5
nephelometer	5
Meteorology	
surface meteorological observations	—
water vapor for isotope measurements	—

BASELINE STUDIES—No NAMDIs received for this volume.

POLLUTION RESEARCH

- Harvard University PANULIRUS II Cruise Station S—No. 361, May 1972, 1 day
- NODC Record No. 06445, North Atlantic
- Morris, B. (NSF IDOE) Marsden square 115
- NSF Grant No. GX–32883, Transfer of Persistent Pollutants in Sargassum Communities, J. N. Butler, Harvard University, grant holder

Descriptive oceanography	Stations or samples
petroleum residues	—
Biological	
Sargassum communities	—

- Harvard University PANULIRUS II Hydrostation S—No. 362–363, June 1972, 2 days
- NODC Record No. 06824, North Atlantic
- Morris, B. (NSF IDOE) Marsden square 115
- NSF Grant No. GX–32883, Transfer of Persistent Pollutants in Sargassum Communitnes, J. N. Butler, Harvard University, grant holder

Descriptive oceanography	Stations or samples
petroleum residues	2
Biological	
Sargassum communities	2

- Harvard University PANULIRUS II Hydrostation S—No. 364–365, July to August 1972, 2 days
- NODC Record No. 06826, North Atlantic
- Morris, B. (NSF IDOE) Marsden square 115
- NSF Grant No. GX–32833, Transfer of Persistent Pollutants in Sargassum Communities, J. N. Butler, Harvard University, grant holder

Descriptive oceanography	Stations or samples
petroleum residues	2
Biological	
Sargassum communities	2

- Skidaway Institute of Oceanography GOLDEN ISLES 72–12, May 1972, 4 days
- NODC Record No. 06444, North Atlantic
- Windom, H. L. (NSF IDOE, EPA) Marsden squares 116, 117
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
STD	19
oxygen	19
phosphates	19
nitrates	19
nitrites	19
trace elements	19
Geology and geophysics	
dredge/grab samples (no. of samples)	10
Biology	
zooplankton	2
invertebrate nekton	2
pelagic fishes	2

- Skidaway Institute of Oceanography GOLDEN ISLES 72–15, May 1972, 4 days
- NODC Record No. 06443, North Atlantic
- Windom, H. L. (NSF IDOE, EPA) Marsden square 117
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
STD	25
oxygen	25
phosphates	25
nitrates	25
nitrites	25
trace elements	25
sea surface temperature	
Geology and geophysics	
dredge/grab samples (no. of samples)	5
Biology	
invertebrate nekton	3
pelagic fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, July 1972, 4 days
- NODC Record No. 07382, North Atlantic
- Windom, H. L. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	—
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
dermersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, July 1972, 4 days
- NODC Record No. 07383, North Atlantic
- Smith, R. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, September 1972, 4 days
- NODC Record No. 07384, North Atlantic
- Smith, R. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, September 1972, 4 days
- NODC Record No. 07385, North Atlantic
- Windom, H. L. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, October to November 1972, 4 days
- NODC Record No. 07386, North Atlantic
- Smith, R. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	Stations or samples
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, November 1972, 4 days
- NODC Record No. 07387, North Atlantic
- Stickney, R. R. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	**Stations or samples**
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography KIT JONES, January 1973, 3 days
- NODC Record No. 07388, North Atlantic
- Taylor, F. (NSF, IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	**Stations or samples**
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, March 1973, 4 days
- NODC Record No. 07502, North Atlantic
- Stickney, R. (NSF, IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	**Stations or samples**
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography KIT JONES, January to February 1973, 4 days
- NODC Record No. 07389, North Atlantic
- Taylor, F. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	**Stations or samples**
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- Skidaway Institute of Oceanography GOLDEN ISLES, March 1973, 5 days
- NODC Record No. 07503, North Atlantic
- Stickney, R. (NSF IDOE, EPA) Marsden square 116
- NSF Grant No. GX–33615, the Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean

Descriptive oceanography	**Stations or samples**
oxygen	30
phosphates	30
nitrates	30
trace elements	30
pH	30
sea-surface temperature	—
Biology	
zooplankton	2
invertebrate nekton	3
pelagic fishes	3
demersal fishes	3

- URI TRIDENT Cruise 114, April and May 1972, 23 days
- NODC Record No. 07535, North Atlantic
- Swift, E. (IDOE) Marsden squares 38, 39, 75–77, 113–115
- NSF Grant GX–33777, Atmospheric Pollutant Transfer and Deposition on the Sea Surface

Meteorology	**Stations or samples**
atmospheric dust	14
Other	
sea-surface microlayer samples	9

- URI TRIDENT Cruise 123, September 1972, 17 days
- NODC Record No. 07536, North Atlantic
- Kester, D. R. (IDOE) Marsden squares 111–115
- NSF Grant GX–33777, Atmospheric Pollutant Transfer and Deposition on the Sea Surface

Descriptive oceanography	Stations or samples
serial stations	1
STD	7
oxygen	7
phosphates	8
trace elements	8
bathythermograph expendable (no. of drops)	23
Meteorology	
atmospheric dust	11
Geology and geophysics	
dredge/grab samples (no. of samples)	3
seismic reflection profiles (no. of naut. miles)	400
magnetic (no. of naut. miles)	400
chemical analysis of sediment	—
bathymetry-wide beam (no. of naut. miles)	400
Other	
sea surface microlayer samples	8
surface profiler samples	—

ENVIRONMENTAL FORECASTING PROGRAM

MIDOCEAN DYNAMICS EXPERIMENT (MODE)

- Duke University EASTWARD Cruise E–14–72, August 1972, 13 days
- NODC Record No. 06828, North Atlantic
- Baker, D. J. [Harvard Univ.] (NSF IDOE, MODE–I) Marsden square 79
- NSF Grant No. GX–28846(1), Engineering tests of new equipment

Descriptive oceanography	Stations or samples
bottom temperature (10 m or less from bottom)	2
bottom pressure	2

- Duke University EASTWARD Cruise E–21–72, November to December 1972, 14 days
- NODC Record No. 07320, North Atlantic
- Baker, D. J. [Harvard Univ.] (NSF IDOE, ONR) Marsden square 79
- NSF Grant No. GX–28846(1), Bottom pressure and temperature measured every 2 minutes for 3 months

Descriptive oceanography	Stations or samples
bottom temperature (10 m or less from bottom)	—
bottom pressure	—

- WHOI CHAIN Cruise 107, October to November 1972, 20 days
- NODC Record No. 07390, North Atlantic. Additional information: narrative
- Gifford, J. E. (IDOE) Marsden squares 79, 80
- NSF Grant No. GX–29054

Current measurements	Stations or samples
current meter	2

- WHOI CHAIN Cruise 112, Leg I, March 1973, 15 days
- NODC Record No. 07871, North Atlantic
- Heinmiller, R. (IDOE) Marsden squares 79, 80, 115, 116, 151, 152

Descriptive oceanography	Stations or samples
STD	8
Current measurements	
current meters—continuous time series (no. of days)	8
Meteorology	
surface meteorological observations	—
Geology and geophysics	
gravity (no. naut. miles)	—
bathymetry-wide beam (no. naut. miles)	—

- WHOI CHAIN Cruise 112, Leg 2, March and April 1973, 12 days
- NODC Record No. 07872, North Atlantic
- Heinmiller, R. (IDOE) Marsden squares 79, 80, 115, 116

Descriptive oceanography	Stations or samples
STD	4
Current measurements	
current meters—continuous time series (no. of days)	11
Meteorology	
surface meteorological observations	—
Geology and geophysics	
bathymetry-wide beam (no. naut. miles)	—

- WHOI KNORR Cruise 26, May and June, 1972, 20 days
- NODC Record No. 07452, North Atlantic
- Gifford, J. E. (NSF IDOE) Marsden squares 79, 80
- NSF Grant GX–29054. Nine current station moorings at MODE site

NORTH PACIFIC EXPERIMENT (NORPAX)—No NAMDIs received for this volume.

CLIMATE: LONG-RANGE INVESTIGATION, MAPPING, AND PREDICTION (CLIMAP) STUDY—No NAMDIs received for this volume.

NOAA PROJECTS

- NMFS CALIFORNIAN Cruises 171, 175, 177, 179, 180A, 180B, 181–185, 192A, 192B, 193–196, 198, 207, August 1969 to October 1971, 115 days

- NODC Record Nos. 07537–07556, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 86–88, 121, 122
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	584
sea-surface temperature	551
bottom temperature	33

- NMFS CHEVRON CALIFORNIA Cruises 2, 4, 7, 10A, 10B, September 1972 to December 1972, 32 days
- NODC Record Nos. 07612–07616, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 88, 124, 160, 196
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathytheromograph	
expendable (no. of drops)	151
sea-surface temperature	151
salinity-surface	62

- NMFS CHEVRON MISSISSIPPI Cruises 6, 9, 10, 15, December 1972 to March 1973, 33 days
- NODC Record Nos. 07617–07619, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 87, 88, 121, 122, 124, 160, 196
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	135
sea-surface temperature	135
salinity-surface	137

- NMFS HAWAIIAN ENTERPRISE Cruises 32–59, November 1971 to February 1973, 129 days
- NODC Record Nos. 07562–07589, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 87, 88, 121, 122
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	539
sea-surface temperature	539
salinity-surface	582

- NMFS HAWAII STANDARD Cruises 614, 622, April 1972 to June 1972, 13 days
- NODC Record Nos. 07602, 07603, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 88, 124, 160, 196
- NFS Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	64
sea-surface temperature	64
salinity-surface	66

- NMFS IDAHO STANDARD Cruises 1046, 1050, 1054, June 1970 to September 1970, 19 days
- NODC Record Nos. 07559–07561, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 87, 88, 121, 122
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	93
sea-surface temperature	93
salinity-surface	94

- NMFS IDAHO STANDARD Cruises 13, 16, June 1971 and April 1972, 59 days
- NODC Record Nos. 07591, 07592, Northeast Pacific, Northwest Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 61, 87–96, 121–130, 158–165
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	84
sea-surface temperature	84
salinity-surface	45

- NMFS JARVIS Cruises, September 1972 to November 1972, 36 days
- NODC Record Nos. 07620, 07621, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 86–88, 121, 122, 124, 160
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	55
sea-surface temperature	55

- NMFS MacGAREGILL Cruise 1395, September 1970, 6 days
- NODC Record No. 07590, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 87, 88, 121 122
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	28
sea-surface temperature	28

- NMFS MARIPOSA Cruises 18, 22, 24, 26, June 1972–February 1973, 110 days
- NODC Record Nos. 07608–07611, Northeast Pacific, Southeast Pacific, Southwest Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 14–17, 49, 50, 52, 53, 85, 88, 121, 314–317, 350–353, 387–389, 391, 392, 426
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	177
sea-surface temperature	177
salinity-surface	98

- NMFS MICHIGAN Cruises 12, 15, 17–19, August 1971–March 1973, 127 days
- NODC Record Nos. 07593–07597, Northeast Pacific, Northwest Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 61, 95, 96, 121–130, 157–165
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	126
sea-surface temperature	126
salinity-surface	84

- NMFS MONTEREY Cruises 20, 31, 33, 34, April 1972–March 1973, 108 days
- NODC Record Nos. 07604–07607, Northeast Pacific, Southeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 14–16, 49–54, 85, 87, 88, 90, 121, 136, 315, 351, 387
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	187
sea-surface temperature	187
salinity-surface	242

- NMFS NEVADA STANDARD Cruise, November 1971, 6 days
- NODC Record No. 07601, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 88, 124, 160, 196
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	31
sea-surface temperature	31
salinity-surface	31

- NMFS OREGON STANDARD Cruise 1483, September 1971–October 1971, 7 days
- NODC Record No. 07600, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 88, 124, 160, 196
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	36
sea-surface temperature	36
salinity-surface	36

- NMFS PRESIDENT CLEVELAND Cruises 190, 195, October 1971–July 1972, 85 days
- NODC Record Nos. 07598, 07599, Northeast Pacific, Northwest Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 61, 86–92, 96, 97, 121, 122, 128–131
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	71
sea-surface temperature	71
salinity-surface	29

- NMFS WASHINGTON STANDARD Cruises 827A, 827B, June 1970, 12 days
- NODC Record Nos. 07557, 07558, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden squares 87, 88, 121, 122
- NSF Grant AG–256

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	67
sea-surface temperature	67

SEABED ASSESSMENT PROGRAM

CONTINENTAL MARGINS STUDIES

- LDGO CONRAD Cruise RC15–04, December 1971 to February 1972, 40
- NODC Record No. 06498, South Atlantic. Additional information: track chart
- Eittreim, S. (NSF IDOE) Marsden squares 413, 444–449, 481–486
- NSF Grant No. GX–34410

Descriptive oceanography	Stations or samples
transparency (no. of obs.)	32
Geology and geophysics	
dredge/grab samples (no. of samples)	2
cores (no. of cores)	35
seismic-reflection profiles (no. naut. miles)	5,750
gravity (no. naut. miles)	5,750
magnetic (no. naut. miles)	5,750
bottom photography	31
bathymetry-wide beam (no. naut. miles)	5,750
seismic refraction profiles (sonobuoy)	17

- LDGO CONRAD Cruise RC15–05, February to March 1972, 24
- NODC Record No. 06499, South Atlantic. Additional information: track chart
- Windisch, C. (NSF IDOE) Marsden squares 412, 413, 448, 449, 484, 485
- NSF Grant No. GX–34410

Descriptive oceanography	Stations or samples
transparency (no. of obs.)	17
Geology and geophysics	
dredge/grab samples (no. of samples)	3
cores (no. of cores)	19
seismic-reflection profiles (no. naut. miles)	3,340
gravity (no. naut. miles)	3,340
magnetic (no. naut. miles)	3,340
bottom photography	17
bathymetery-wide beam (no. naut. miles)	3,340
seismic refraction profiles (sonobuoy)	23

- LDGO CONRAD Cruise RC15–06, March to April 1972, 30 days
- NODC Record No. 06500, South Atlantic. Additional information: track chart
- Ewing, J. (NSF IDOE) Marsden squares 413, 414, 448, 450, 484–486
- NSF Grant No. GX–34410

Descriptive oceanography	Stations or samples
transparency (no. of obs.)	10
Geology and geophysics	
dredge/grab samples (no. of samples)	1
cores (no. of cores)	11
seismic-reflection profiles (no. naut. miles)	4,250
gravity (no. naut. miles)	4,250
magnetic (no. naut. miles)	4,250
bottom photography	11
bathymetry-wide beam (no. naut. miles)	4,250
seismic refraction profiles (sonobuoy)	54

- LDGO CONRAD Cruise RC15–07, April 1972, 23 days
- NODC Record No. 06501, South Atlantic. Additional information: track chart
- Leyden, R. (NSF IDOE) Marsden squares 375, 376, 411–414, 449
- NSF Grant No. GX–34410

Descriptive oceanography	Stations or samples
transparency (no. of obs.)	12
Geology and geophysics	
dredge/grab samples (no. of samples)	6
cores (no. of cores)	9
seismic-reflection profiles (no. naut. miles)	3,560
gravity (no. naut. miles)	3,560
magnetic (no. naut. miles)	3,560
bottom photography	15
bathymetry-wide beam (no. naut. miles)	3,560
seismic refraction profiles (sonobuoy)	33

- WHOI ATLANTIS II Cruise 73, Leg 1, January and February 1973, 19 days
- NODC Record No. 07750, North Atlantic
- Emery, K. O. (NSF IDOE) Marsden square 38–41, 77–79, 114–116, 152
- NSF Grant GX–28193

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	36
swell	49
sea-surface temperature	52
Geology and geophysics	
seismic reflection profiles	
(no. naut. miles)	1,540
seismic refraction profiles	
seismic refraction profiles	1
gravity (no. naut. miles)	3,774
magnetic (no. naut. miles)	3,500
bathymetry-wide beam	
(no. naut. miles)	3,774
suspended sediments	52

- WHOI ATLANTIS II Cruise 75, Leg II, February and March 1973, 35 days
- NODC Record No. 07751, North Atlantic, South Atlantic
- Emery, K. O. (NSF IDOE) Marsden squares 2, 3, 38, 39, 300, 301, 335
- NSF Grant GX–28193

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	66
swell	75
sea-surface temperature	119
Current measurements	
surface drifters (no. released)	4 sets
Meteorology	
surface meteorological	
observations	119
Geology and geophysics	
dredge and grab samples	14
seismic reflection profiles	
(no. naut. miles)	4,000
seismic refraction profiles	22
gravity (no. naut. miles)	4,200
magnetic (no. naut. miles)	4,100
bathymetry-wide beam	
(no. naut. miles)	4,240
suspended sediments	
Biology	
phytoplankton	11
aves	

- WHOI ATLANTIS II Cruise 75, Leg III, March and April 1973, 24 days
- NODC Record No. 07752, North Atlantic, South Atlantic
- Emery, K. O. (NSF IDOE) Marsden squares 1, 2, 36, 300, 301, 335
- NSF Grant GX–28193

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	77
swell	88
sea-surface temperature	139
Current measurements	
surface drifters (no. released)	225
Meteorology	
surface meteorological	
observations	88
Geology and geophysics	
dredge and grab samples	9
seismic reflection profiles	
(no. naut. miles)	3,750
seismic refraction profiles	12
gravity (no. naut. miles)	4,100
magnetic (no. naut. miles)	4,100
bathymetry-wide beam	
(no. naut. miles)	4,100
suspended sediments	137
Biology	
phytoplankton	25
aves	

- WHOI ATLANTIS II Cruise 75, Leg IV, April and May 1973, 25 days
- NODC Record No. 07870, North Atlantic
- UCHUPI., A. (NSF IDOE) Marsden squares 2, 3, 38, 39
- NSF Grant GX–28193

Descriptive oceanography	Stations or samples
bathythermograph	
expendable (no. of drops)	75
swell	58
sea-surface temperature	116
Meteorology	
surface meteorological observations	58
Geology and geophysics	
dredge and grab samples	4
seismic reflection profiles (no. of naut. miles)	3,325
seismic refraction profiles	42
gravity (no. naut. miles)	3,483
magnetic (no. naut. miles)	3,325
bathymetry-wide beam (no. naut. miles)	3,483
suspended sediments	116
Biology	
phytoplankton pigment concentration	20
zooplankton	46
aves	

MID-ATLANTIC RIDGE STUDY—
No NAMDIs received for this volume.

GULF OF CALIFORNIA STUDY—
No NAMDIs received for this volume.

PLATE TECTONICS AND METALLOGENISIS STUDIES

- HIG KANA KEOKI Cruise 71/04/26, Leg 7, December 1971 to January 1972, 35 days
- NODC Record No. 07218, Southeast Pacific
- Johnson, R. (NSF IDOE) Marsden squares 343–350
- NSF Grant No. AG–329 IDOE portion of this cruise is east of longitude 110°W.

Descriptive oceanography	Stations or samples
sea	—
swell	—
sea-surface temperature	—
Meteorology	
surface meteorological observations	—
Geology and geophysics	
cores (no. of cores)	50
seismic-reflection profiles (no. naut. miles)	5,433
seismic-refraction profiles	1
heat flow	11
gravity (no. naut. miles)	5,433
magnetic (no. naut. miles)	5,433
chemical analysis of sediment	—
physical analysis of sediment	—
paleontology	—
paleomagnetism/rock magnetism	—
geochronology	—
mineral resources	5,433

- HIG KANA KEOKI Cruise 71/04/26, Leg 8, January to February 1972, 32 days
- NODC Record No. 07219, Southeast Pacific
- Hussong, D. (NSF IDOE) Marsden squares 308, 309, 310, 343
- NSF Grant No. AG–329

Descriptive oceanography	Stations or samples
sea	—
swell	—
sea-surface temperature	—
Meteorology	
surface meteorological observations	—
Geology and geophysics	
cores (no. of cores)	29
seismic-reflection profiles (no. naut. miles)	5,319
seismic-refraction profiles	13
heat flow	1
gravity (no. naut. miles)	5,362
magnetic (no. naut. miles)	5,362
chemical analysis of sediment	—
physical analysis of sediment	—
paleontology	—
paleomagnetism/rock magnetism	—
mineral resources	—
bathymetry-wide beam (no. naut. miles)	5,362
seismic refraction profiles (sonobuoy)	18

- HIG KANA KEOKI Cruise 71/04/26, Leg 9, February to March 1972, 16 days
- NODC Record No. 07220, Southeast Pacific
- Hussong, D. (NSF IDOE) Marsden squares 308, 343, 344
- NSF Grant No. AG–329

Descriptive oceanography	Stations or samples
sea	—
swell	—
sea-surface temperature	—
Meteorology	
surface meteorological observations	—
Geology and geophysics	
dredge/grab samples (no. of samples)	1
cores (no. of cores)	8
seismic-reflection profiles (no. naut. miles)	2,400
seismic-refraction profiles	5
heat flow	2
gravity (no. naut. miles)	2,400
magnetic (no. naut. miles)	2,400
chemical analysis of sediment	—
physical analysis of sediment	—
paleontology	—
paleomagnetism/rock magnetism	—
mineral resources	—
bathymetry-wide beam (no. naut. miles)	2,400
seismic refraction profiles (sonobuoy)	3

- HIG KANA KEOKI Cruise 71/04/26, Leg 10, March to April, 1972, 30 days
- NODC Record No. 07221, Southeast Pacific
- Hussong, D. (NSF IDOE) Marsden squares 308, 309, 310
- NSF Grant No. AG–329

Descriptive oceanography	**Stations or samples**
sea	—
swell	—
sea surface temperature	—
Meteorology	
surface meteorological observaitons	—
Geology and geophysics	
dredge/grab samples (no. of samples)	5
cores (no. of cores)	47
seismic-reflection profiles (no. naut. miles)	5,772
seismic-refraction profiles	10
heat flow	16
gravity (no. naut. miles)	5,772
magnetic (no. naut. miles)	5,772
chemical analysis of sediment	—
physical analysis of sediment	—
paleontology	—
paleomagnetism/rock magnetism	—
mineral resources	—
bathymetry-wide beam (no. naut. miles)	5,772

OCEAN MINERALS STUDIES—No NAMDIs received for this volume.

LIVING RESOURCES PROGRAM

COASTAL UPWELLING EXPERIMENT (CUE)—I

- University of Connecticut aircraft, August 1972, 3 days
- NODC Record No. 06830, Northeast Pacific
- Garvine, R. W. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–32211

Current measurements	**Stations or samples**
drogues	—

- University of Connecticut aircraft, August 1972, 3 days
- NODC Record No. 06831, Northeast Pacific
- Garvine, R. W. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–32211

Current measurements	**Stations or samples**
drogues	—

- OSU CAYUSE Cruise C7204–F, April 1972, 1 day
- NODC Record No. 06491, Northeast Pacific, additional information: narrative
- Smith, R. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746, current meter installation

Current measurements	**Stations or samples**
current meter	2

- OSU CAYUSE Cruise C7205–C, May 1972, 1 day
- NODC Record No. 06495, Northeast Pacific, additional information: narrative
- Pillsbury, S. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28745, calibrate current meter transducers

- OSU CAYUSE Cruise C7207–A, July 1972, 1 day
- NODC Record No. 06720, Northeast Pacific, additional information: narrative
- Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746, current meter installation

Current measurements	**Stations or samples**
current meter	6
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7207–C, July 1972, 3 days
- NODC Record No. 06721, Northeast Pacific, additional information: narrative
- Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	**Stations or samples**
tides	—
Current measurements	
current meters—continuous time series (no. of days)	30
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7207–EE, July 1972, 2 days
- NODC Record No. 07341, Northeast Pacific, additional information: narrative
- Moores, C. N. K. [Univ. of Miami] (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	**Stations or samples**
sea-surface temperature	—
salinity-surface	—
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7208–A, August 1972, 4 days
- NODC Record No. 07014, Northeast Pacific, additional information: narrative
- Smith, R. L., O'Brien, J., Pillsbury, R.D. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Current measurements	**Stations or samples**
current meters—continuous time series (no. of days)	300
current meter	15
Meteorology	
surface meterological observations	—

- OSU CAYUSE Cruise C7208–C, August 1972, 2 days
- NODC Record No. 07015, Northeast Pacific, additional information: narrative
- Smith, R. L., O'Brien, J., Pillsbury, R. D. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX–28746

Current measurements	**Stations or samples**
current meters—continuous time series (no of days)	120
current meter	6
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7208–CC, August 1972, 1 day
- NODC Record No. 07310, Northeast Pacific, additional information: narrative
- Vanleer, J. [Univ. of Miami] (NSF IDOE) Marsden Square 157
- NSF Grant No. GX–28746

Current measurements	**Stations or samples**
current meter—continuous time series (no. of days)	6
current meter	1
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7208–E, August 1972, 1 day
- NODC Record No. 07016, Northeast Pacific, additional information: narrative
- Smith, R. L., O'Brien, J., Pillsbury, R. D. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Current measurements	**Stations or samples**
current meters—continuous time series (no. of days)	160
current meter	8
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7208–F, Leg I, August 1972, 4 days
- NODC Record No. 06966, Northeast Pacific, additional information: sampling methods and/or analyses
- Mooers, C. N. K., Vanleer, J. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	**Stations or samples**
STD	107
sea-surface temperture	—
Current measurements	
current meters—continuous time series (no. of days)	9
current meter	3
Meteorology	
surface meteorological observations	—
incident radiation	—
Biology	
phytoplankton pigment concentration	99

- OSU CAYUSE Cruise C7208–F, Leg II, August 1972, 5 days
- NODC Record No. 06967, Northeast Pacific, additional information: narrative
- Smith, R. L., O'Brien, J. J. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	**Stations or samples**
ocean serial station	51
STD	42
bathythermograph—mechanical (no. of drops)	64
sea-surface temperature	—
Current measurements	
current meters—continuous time series (no. of days)	11
current meter	4
Biology	
phytoplankton pigment concentration	106
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7208–H, August 1972, 3 days
- NODC Record No. 07017, Northeast Pacific, additional information: narrative
- Smith, R. L., O'Brien, J., Pillsbury, R. D. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
sea	—
Current measurements	
current meters—continuous time series (no. of days)	560
current meter	27
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise 7209–G, September 1972, 1 day
- NODC Record No. 07018, Northeast Pacific, additional information: narrative
- Smith, R. L., O'Brien, J., Pillsbury, R. D. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Current measurements	Stations or samples
current meters—continuous time series (no. of days)	120
current meter	8
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7209–BB, September 1972, 2 days
- NODC Record No. 07340, Northeast Pacific, additional information: narrative
- Dewey, D. B. [General Dynamics Co.] (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746, no data; towing, mooring, and refurbishment of SODS buoys D–1 and D–2

- OSU CAYUSE Cruise C7211–E, November 1972, 2 days
- NODC Record No. 07342, Northeast pacific, additional information: narrative
- Jones, K. N. [General Dynamics Co.] (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746, attempted retrieval of SODS buoys D–1 and D–2

- OSU CAYUSE Cruise C7212, December 1972, 2 days
- NODC Record No. 07311, Northeast Pacific, additional information: narrative
- Hoover, W. R. [General Dynamics Co.] (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746, SODS buoys D–1 and D–2 recovery

Meteorology	Stations or samples
surface meteorological observations	—

- OSU CAYUSE Cruise C7302–A, February 1973, 1 day
- NODC Record No. 07392, Northeast Pacific, additional information: narrative
- Pillsbury, R. D. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Current measurements	Stations or samples
current meters—continuous time series (no. of days)	90
Meteorology	
surface meteorological observations	—

- OSU CAYUSE Cruise C7304–B, April 1973, 1 day
- NODC Record No. 07622, Northeast Pacific, additional information: narrative
- Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Current measurements	Stations or samples
current meters—continuous time series (no. of days)	56
current meter	1
Meteorology	
surface meteorological observations	—

- OSU YAQUINA Cruise Y7202–A, July 1972, 5 days
- NODC Record No. 06722, Northeast Pacific, additional information: narrative
- Smith, R. L. (NSF IDOE, ONR) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
ocean serial station	13
STD	13
phosphates	—
nitrates	—
pH	—
alkalinity	—
sea surface temperature	—
optics	13
Meteorology	
surface meteorological observations	—
Biology	
phytoplankton pigment concentration	13

- OSU YAQUINA Cruise Y7206–C, June 1972, 5 days
- NODC Record No. 06654, Northeast Pacific, additional information: narrative
- O'Brien, J. J., Pillsbury, R. D., Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
ocean serial station	3
CTD	69
Current Measurements	
current meter	21

- OSU YAQUINA Cruise Y7207–B, July 1972, 9 days
- NODC Record No. 06723, Northeast Pacific, additional information: narrative
- Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
STD	103
sea-surface temperature	—
Current Measurements	
current meters—continuous time series (no. of days)	8
Meteorology	
surface meteorological observations	—

- OSU YAQUINA Cruise Y7207–E, July 1972, 7 days
- NODC Record No. 06724, Northeast Pacific, additional information: narrative
- O'Brien, J., Pillsbury, R., Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
ocean serial station	35
STD	104
phosphates	—
nitrates	—
pH	—
alkalinity	—
transparency (no. of obs.)	20
Current measurements	
current meters—continuous time series (no. of days)	60
surface drifters (no. released)	48
current water	56
Meteorology	
surface meteorological observations	—
Biology	
primary organic production	20

- OSU YAQUINA Cruise Y7208–A, August 1972, 5 days
- NODC Record No. 06965, Northeast Pacific, additional information: narrative
- O'Brien, J., Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
STD	43
transparency (no. of obs.)	15
light scattering	18
Current measurements	
drogues	—
Meteorology	
surface meteorological observations	—
Biological	
primary organic production	1
phytoplankton pigment concentration	116

- OSU YAQUINA Y7208–C, August 1972, 2 days
- NODC Record No. 06969, Northeast Pacific, additional information: narrative
- O'Brien, J., Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
ocean serial station	16
STD	26
sea-surface temperature	—
Meteorology	
surface meteorological observations	—

- OSU YAQUINA Cruise Y7208–CC, August 1972, 4 days
- NODC Record No. 07363, Northeast Pacific, additional information: narrative
- Wyatt, B., Stevensen, M., Zaneveld, R. V. (NSF IDOE, ONR) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
STD	64
Current measurements	
drogues	—
Meteorology	
surface meteorological observations	—
Biology	
phytoplankton pigment concentration	1

- OSU YAQUINA Cruise Y7208–E, August 1972, 4 days
- NODC Record No. 06970, Northeast Pacific, additional information: narrative
- O'Brien, J., Smith, R. L. (NSF IDOE, ONR) Marsden square 157
- NSF Grant GX–28746, Continuous Underway Autoanalyzer Nutrient Analysis

Descriptive oceanography	Stations or samples
STD	70
sea-surface temperature	—
light scattering	16
Meteorology	
surface meteorological observations	—
Biology	
phytoplankton pigment concentration	16

- OSU YAQUINA Cruise 7209–A, September 1972, 3 days
- NODC Record No. 06971, Northeast Pacific, additional information: narrative
- O'Brien, J., Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746, Conductivity/Depth/Temperature Measured with a Geodyne Telemetering CTD

Descriptive oceanography	Stations or samples
ocean serial station	3
CTD	30
sea-surface temperature	—
Meteorology	
surface meteorological observations	—

- OSU YAQUINA Cruise Y7210–B, October to November 1972, 5 days
- NODC Record No. 07261, Northeast Pacific, additional information: narrative
- Smith, R. L. (NSF IDOE) Marsden square 157
- NSF Grant No. GX–28746

Descriptive oceanography	Stations or samples
ocean serial station	16
transparency (no. of obs.)	16
CTD	23
Current measurements	
current meters—continuous time series (no. of days)	421
current meter	3
Meteorology	
surface meteorological observations	—
Biology	
primary organic production	10

- POL OCEANOGRAPHER Cruise RP–4–72, July and August 1972, 29 days
- NODC Record No. 07060, Nortneast Pacific
- (NSF IDOE) Marsden square 157

Descriptive oceanography	Stations or samples
ocean serial stations	421
STD	734
bathythermograph expendable (no. of drops)	239
Current measurements	
current meters—continuous time series (no. of days)	605
current meter	11
Meteorology	
surface meteorological observations	28
Geology and geophysics	
bathymetry-wide beam (no. of naut. mi.)	110

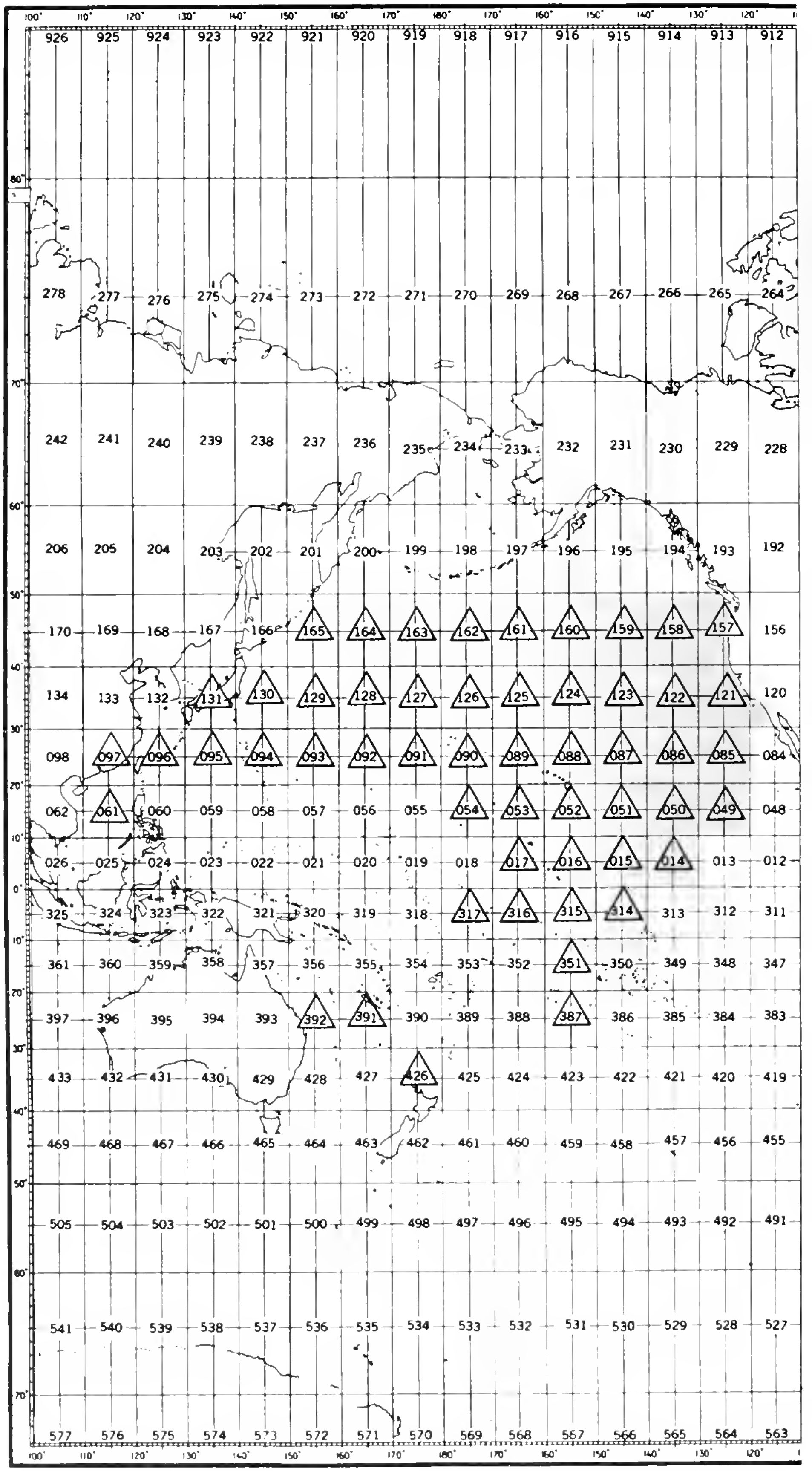
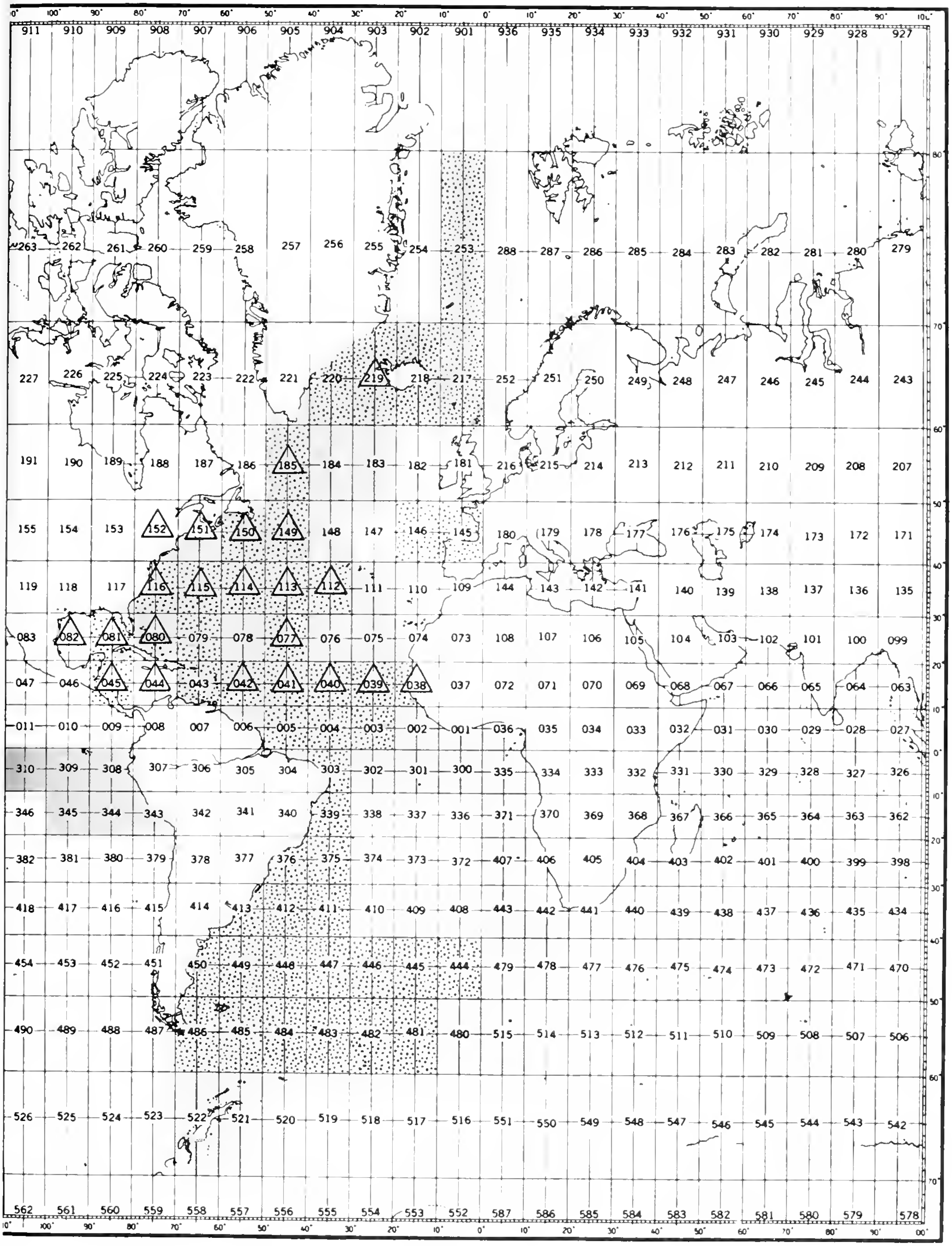


Chart of Marsden square (10° by 10°) areas within which were collected data and information reported in this publication and received by EDS. Although an entire square is shaded on the chart, it may contain only one reported observation.



MARSDEN SQUARE CHART

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