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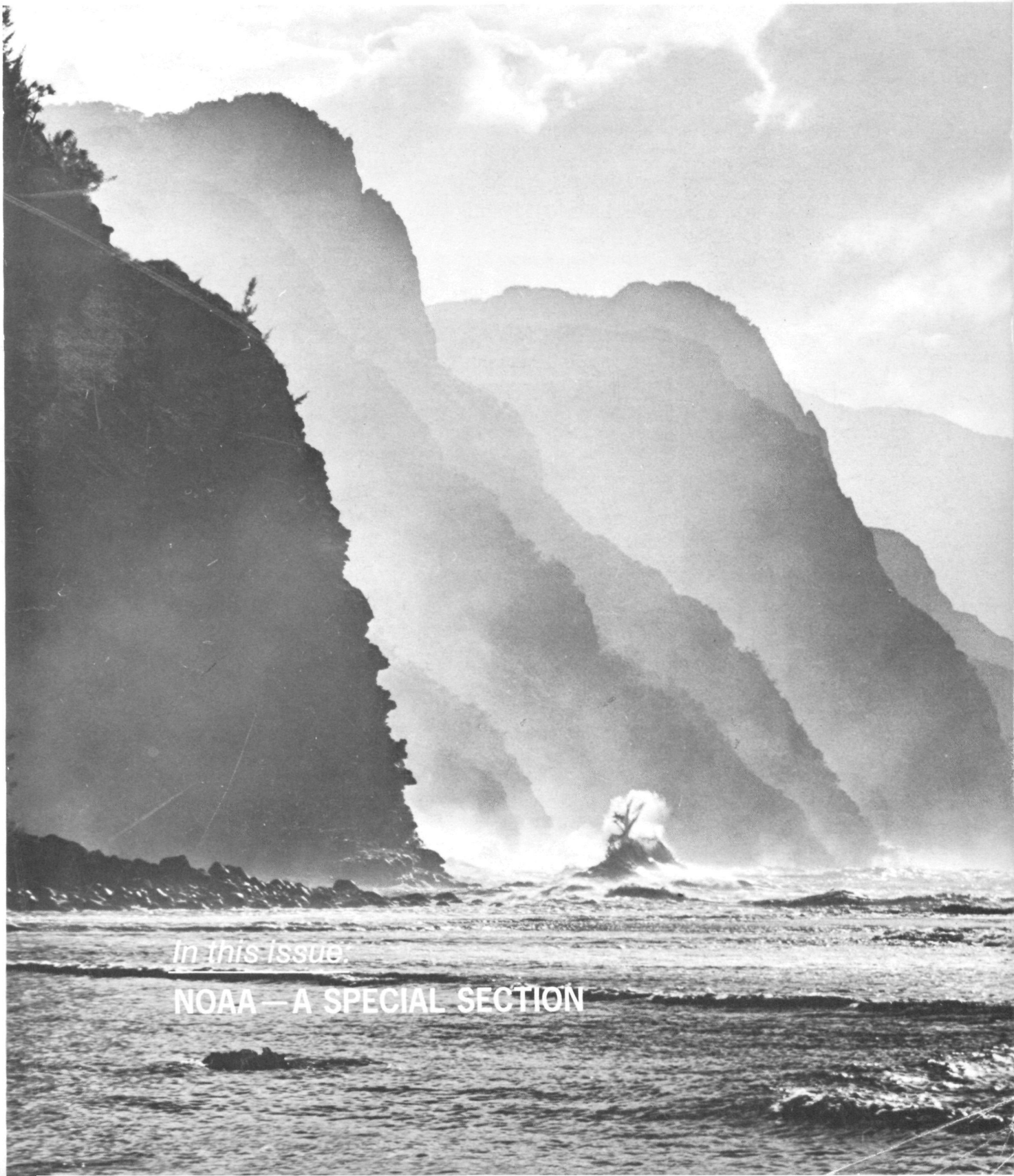

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VOLUME 5
NUMBER 4

National Oceanic and Atmospheric Administration

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U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary
Rocco C. Siciliano, Under Secretary
Myron Tribus, Assistant Secretary for Science and Technology

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Dr. Robert M. White, Administrator
Dr. John W. Townsend, Jr., Deputy Administrator

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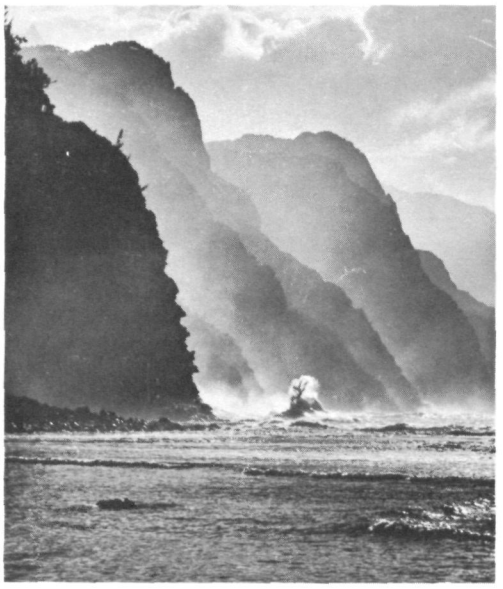

COVER
Mist and sunlit waves along the Kauai, Hawaii, coast. (Ray Atkeson photo)

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STANLEY B. EAMES
Director, Public Information

ANN K. COOK
Associate Editor

MAX M. CHESY
Art Director

ROBERT M. WHITE
ADMINISTRATOR

A Message from the Administrator

President Nixon has proposed the creation of a National Oceanic and Atmospheric Administration, of which ESSA would be a major component. Sending the NOAA proposal to Congress, he gave a powerful argument for the establishment of the new Administration. He said, in part:

"The oceans and the atmosphere are interacting parts of the total environmental system upon which we depend not only for the quality of our lives, but for life itself.

"We face immediate and compelling needs for better protection of life and property from natural hazards, and for a better understanding of the total environment—an understanding which will enable us more effectively to monitor and predict its actions, and ultimately, perhaps to exercise some degree of control over them.

"We also face a compelling need for exploration and development leading to the intelligent use of our marine resources. The global oceans, which constitute nearly three-fourths of the surface of our planet, are today the least understood, the least developed, and the least protected part of our earth. Food from the oceans will increasingly be a key element in the world's fight against hunger. The mineral resources of the ocean beds, and of the oceans themselves, are being increasingly tapped to meet the growing world demand. We must understand the nature of these resources, and assure their development without either contaminating the marine environment or upsetting its balance.

"Establishment of the National Oceanic and Atmospheric Administration—NOAA—within the Department of Commerce would enable us to approach these tasks in a coordinated way. By employing a unified approach to the problems of the oceans and atmosphere, we can increase our knowledge and expand our opportunities not only in those areas, but in the third major component of our environment, the solid earth, as well.

"Scattered through various Federal departments and agencies, we already have the scientific, technological and administrative resources to make an effective, unified approach possible. What we need is to bring them together. Establishment of NOAA would do so. . . .

"Drawing these activities together into a single agency would make possible a balanced Federal program to improve our understanding of the resources of the sea, and permit their development and use while guarding against the sort of thoughtless exploitation that in the past laid waste to so many of our precious natural assets. It would make possible a consolidated program for achieving a more comprehensive understanding of oceanic and atmospheric phenomena, which so greatly affect our lives and activities. It would facilitate the cooperation between public and private interests that can best serve the interests of all.

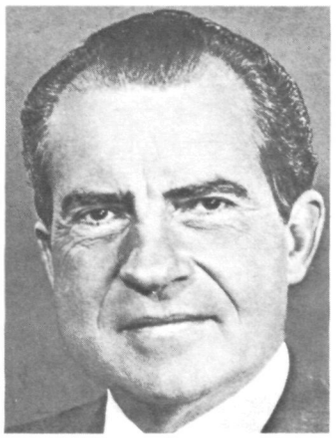
"I expect that NOAA would exercise leadership in developing a national oceanic and atmospheric program of research and development. It would coordinate its own scientific and technical resources with the technical and operational capabilities of other government agencies and private institutions. As important, NOAA would continue to provide those services to other agencies of government, industry and private individuals which have become essential to the efficient operation of our transportation systems, our agriculture and our national security. I expect it to maintain continuing and close liaison with the new Environmental Protection Agency and the Council on Environmental Quality as part of an effort to ensure that environmental questions are dealt with in their totality and that they benefit from the full range of the government's technical and human resources."

Since its creation in 1965, ESSA has striven to fulfill its mission to the very best of its ability. Our far-flung family has my deep gratitude for the excellence and dedication it has displayed. In this, the final issue of **ESSA,** I urge you all to welcome the establishment of NOAA as an opportunity to serve our Nation in an even more vital way.

NOAA / a special section

THE PRESIDENT PROPOSES

The National Oceanic And Atmospheric Administration



A PROPOSAL by President Nixon that a National Oceanic and Atmospheric Administration be created within the Commerce Department went to the Congress on July 9.

The President's reorganization plan combines ESSA with the following entities:

—Elements of the Bureau of Commercial Fisheries (from the Department of the Interior).

—The marine sport fish program of the Bureau of Sport Fisheries and Wildlife (from the Department of the Interior).

—The Marine Minerals Technology Center of the Bureau of Mines (from the Department of the Interior).

—The Office of Sea Grant Programs (from the National Science Foundation).

—Elements of the United States Lake Survey (from the Department of the Army).

—In addition, by executive action, the programs of the following organizations would be transferred to NOAA:

—The National Oceanographic Data Center (from the Department of the Navy).

—The National Oceanographic Instrumentation Center (from the Department of the Navy).

—The National Data Buoy Project (from the Department of Transportation).

ESSA is by far the largest of the components being merged, with some 10,000 employees (83 percent of NOAA's total personnel strength) and estimated fiscal 1970 expenditures of approximately $200 million. Estimated budget of the other elements entering NOAA is approximately $71 million.

Upon approval of the Plan, the President has also directed that there be established a National Advisory Committee for the Oceans and Atmosphere, to provide advice on the progress of governmental and private programs in achieving the nation's oceanic and atmospheric objectives.

The plan provides for the abolition of ESSA and the Bureau of Commercial Fisheries, as such, and reorganiza-

tion on a program basis. Testifying on the proposal before the Executive and Legislative Reorganization Subcommittee of the House Committee on Government Operations, Commerce Secretary Maurice H. Stans offered the Congress his assurance that he will give "the utmost priority to our responsibilities to NOAA in the marine and atmospheric areas. . . . Be assured that we in this Department will make it work."

The importance to be accorded NOAA within the Department is reflected in the President's intention that it be headed by an Executive Level III Administrator who would be of Under Secretary rank, and who would report directly to the Secretary rather than to an Assistant Secretary. Further, NOAA would be created with a single management and budget structure to achieve optimum use of its resources.

The Secretary testified that he has long regarded the establishment of NOAA within the Department of Commerce as a logical extension of its already-considerable scientific and technological activities. "We already have in the Department the solid base of science and technology which will buttress the foundation of an exciting and vigorous NOAA," he said. "We will be able to provide a climate of innovation and clear thinking which will enable such a new agency to flourish and to meet the nation's need for a comprehensive oceanic and atmospheric program. . . ."

Secretary Stans envisioned an impressive set of national benefits resulting from the creation of the new agency. "Examples of the types of benefits which I foresee," he said, "are:

"The combined fleet of vessels from ESSA and from the other agencies being transferred into NOAA will provide this nation with a capability which will be available for work on a wide range of problems. It will allow greater joint utilization in the collection of data to meet needs of fisheries activities from the Bureau of Commercial Fisheries and mapping and charting activities from ESSA, as well as provide the means for the National Oceanographic Instrumentation Center to conduct tests of equipment at sea and the Sea Grant Program to provide training facilities for the education of young people in this exciting and challenging field.

"The Department of Commerce now operates the nation's only operational environmental satellite system. We have and are developing many satellite uses for weather and oceanic monitoring and prediction. It will be of interest to the Bureau of Commercial Fisheries in the application of remote sensing to marine resource problems. I believe that this will offer a new potential for them.

"The Bureau of Commercial Fisheries' needs for environmental information for fishery development can be significantly supported by present elements of ESSA. ESSA marine environmental predictions are a first step in the chain toward producing fishery forecasts. Close work between the program from the Bureau of Commercial Fisheries and that from ESSA can only lead to better utilization and assessment of our marine living resources.

"By combining the environmental data centers we will be able to draw upon common experience and methods of operation to improve the efficiency of all of these centers.

"Probably the most important benefit of all is that in NOAA we will have brought together in one organization an outstanding and competent group of people, including the scientifically trained ESSA Commissioned Officer Corps, which will provide a vital resource in developing a responsive national oceanic and atmospheric program. A force of some 13,000 people, with its impressive spectrum of talent, represents a formidable national capability to move forward."

The Secretary pledged also that the new administration "will work in an innovative way with the nation's universities and industries, and will do everything possible to encourage and assist the tremendous reservoir of creativity and vision that resides within them. In this connection," he added, "there will be within NOAA a special role for the Sea Grant Program."

In conclusion, the Secretary told lawmakers:

"I believe that the new National Oceanic and Atmospheric Administration will enable this nation in the decades ahead to fully and wisely utilize and understand the oceans and the atmosphere. This new initiative . . . will greatly enhance the quality of our environment, our security, our economy, and our ability to meet increased demands for food and raw materials. I regard the establishment of NOAA as an essential step forward."

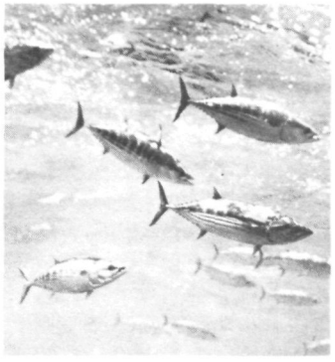
Brief descriptions of the organizations which, with ESSA, would be combined in NOAA are contained in the following pages. □

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Organization	FY '71 Budget (in millions of dollars)	Manpower
Environmental Science Services Administration		
Weather Bureau	106.0	5,125
Coast and Geodetic Survey	43.8	2,465
Research Laboratories	28.0	890
Environmental Data Service	7.6	475
National Environmental Satellite Center	28.6	365
Environmental Science Services Administration Headquarters	20.0	680
ESSA total	$234.0	10,000
Bureau of Commercial Fisheries	44.558	2,800
Sport Fisheries Functions of Interior Dept.	1.19	61
Sea Grant Program	13.0	7
Lake Survey	2.154	120
National Data Buoy Development Program	13.5	50
National Oceanographic Data Center	2.176	130
National Oceanographic Instrumentation Center	1.30	55
Marine Minerals Technology Center	0.925	50
TOTAL	$312.803	13,273

NOAA / a special section

Bureau of Commercial Fisheries



THE Department of the Interior's Bureau of Commercial Fisheries (BCF) would become an important element of NOAA under the President's reorganization plan. BCF is responsible for developing and managing programs to define and identify solutions to the problems of the commercial fisheries which will contribute most toward achieving the Bureau's objectives.

The Bureau's primary role is to obtain, through scientific studies, sufficient knowledge of fish stocks to provide answers to such questions as: What are the stocks? Where are they in terms of time and space? What is their magnitude? How hard or easy are they to capture? And, most important, what is the maximum sustainable yield from each of the stocks?

The scientific base on which the Bureau operates is vital to contributing to programs planned to manage domestic and international fisheries for conservation purposes, and to assure that the resources will be maintained in a healthy condition.

Corollary to this is the need for sufficient scientific information to ensure protection of the aquatic environment.

Another important role, now in the early stages of development, is a cooperative program to develop adequate management techniques at the international, national, and state levels. This plan would permit rational allocations of fish stocks among nations and among user groups in the United States, providing maximum economic return to investors within the framework of maximum sustainable yield.

Thirdly, the Bureau assists industry in those areas where institutional barriers, the common property nature of the resource, or both, make it impossible for industry to do the job itself. An example of an institutional barrier is any law or regulation that adversely and unnecessarily affects a fishery. BCF also realizes its responsibility to the consumer to see that he is adequately informed about the product he is buying.

Still another role performed by BCF in cooperation with other Federal agencies deals with assisting emerging nations in developing their fisheries, thus helping meet world food needs.

The basic goal of BCF is conservation—wise use of living aquatic resources. A fundamental tool is a strong and sound biological base. Further, for proper implementation, it requires input from a wide variety of other scientific disciplines, with physical oceanography a most important part. To practice conservation of our aquatic resources in its broadest sense requires a thorough understanding of the economic, legal, and social factors affecting resource use.

The fishery agency has a long and colorful history. Federal concern with fisheries' problems dates back to 1871 when President Ulysses S. Grant signed legislation establishing the U.S. Fish Commission. The one-man commission was charged with responsibility to "ascertain whether any and what diminution in numbers of food fishes of the coasts and lakes of the

United States has taken place; and, if so, to what causes the same is due; and also whether any and what protective, prohibitory or precautionary measures should be adopted . . . (and) report upon the same to Congress."

In 1903, this independent office became the Bureau of Fisheries in the new Department of Commerce and Labor, and remained in Commerce when the Department of Labor was created in 1913. The Bureau of Fisheries stayed in Commerce until 1939, when the unit was transferred to the Department of the Interior. A year later, it was consolidated in Interior with the Bureau of Biological Survey from the Department of Agriculture, to form the U.S. Fish and Wildlife Service. The Fish and Wildlife Act of 1956 made BCF a separate bureau in the Department of the Interior, and it is fundamentally this organization that would move to NOAA under the reorganization.

A few functions of BCF will remain in Interior. These include the BCF activities in Great Lakes biological research, and its sea lamprey program conducted by the Great Lakes Fishery Commission with the support of the U.S. and Canada. Other BCF responsibilities remaining include Missouri River Reservoir research, and trans-Alaska pipeline investigations. The BCF Pesticides Laboratory at Gulf Breeze, Florida, is scheduled to be transferred to the new Environmental Protection Agency.

With headquarters in Washington, the BCF has five regional offices, in Seattle, Washington; St. Petersburg, Florida; Gloucester, Massachusetts; Juneau, Alaska; and Terminal Island, California; nearly 30 major laboratories and centers, and more than 50 lesser installations, such as statistics and market news offices, across the nation. It has a fleet of 25 research vessels, ranging from 40-footers to the $3.3 million, 214-foot MILLER FREEMAN, equipped for various kinds of oceanographic research and fishery exploration.

The major BCF effort is in biological research on fish, shellfish, and some marine mammals off all U.S. coasts, on the high seas, and in waters adjacent to territories and possessions. Bureau biologists are concerned with determining the abundance and availability of fishes; their growth, replenishment, and food habits; species interrelationships; and other biological factors. Their concern: basic knowledge of the fisheries, the environment in which fish live, and the effects of man and nature on both the fishes and the environment, with a view to protection and wise utilization of fishery resources. Increasing attention is being given to environmental studies as the basis for developing scientifically sound recommendations as to water quality which will afford maximum protection to fish and fish food organisms. Bureau scientists are also seeking to develop a clearer understanding of the underlying causes of changes in fish populations and the interrelationships and competitive reactions among the various species that inhabit the oceans.

Closely related to and integrated with biological research is BCF's resource assessment program. Vessels equipped with the latest scientific equipment explore coastal waters to provide information to industry and scientists as to the distribution and concentrations of various fish species and as to the most economical and efficient method of capture. In addition, gear specialists are helping devise economical and efficient harvesting methods calculated to make U.S. fish producers competitive with foreign fisheries.

The Bureau works with the Department of State in activities relating to international agreements affecting fishery resources, and certain sea mammals, including the administration of the Pribilof Islands and its sealing industry.

The U.S. is presently party to nine international fishery conventions and nine shorter term bilateral agreements, and much of the research program is designed to meet international agreements. BCF formulates and implements policy on international fishery matters, and collaborates with other Federal and international agencies in programs of technical assistance to developing countries. In cooperation with the U.S. Coast Guard, BCF conducts enforcement and surveillance operations in Alaska, the Pacific Northwest, California, Puerto Rico, New England, and the mid-Atlantic area.

These programs aim to ensure observance by U.S. and foreign fishing vessels of the provisions of the various international agreements as well as the contiguous fisheries zone and territorial waters, and to gather information on activities of foreign fishing fleets off the U.S., so that such data will be available for negotiations with foreign fishing nations.

Another phase of the Bureau's program—food technological research—is of value in expanding the use of fishery resources. Bureau scientists are studying microbiological, nutritional, and biochemical changes in fish and shellfish in order to find alternative uses, and assist management by taking pressure off certain exploited fisheries.

The Bureau conducts a voluntary grading and inspection program—paid for by the processor. Fishery products that meet established quality standards and product specifications can bear the U.S. Department of the Interior (USDI) shield. To the housewife, this shield guarantees that the product was of high quality when it left the processor.

BCF also maintains a staff of marketing specialists and has home economists who provide services to Federal and state governments, industry, and consumer organizations in using fish and fishery products.

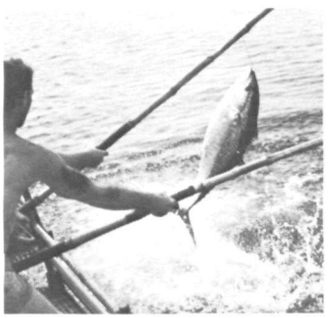
Social and economic studies of man in his utilization of fishery resources are equally important to policy as work on the resource itself. Domestic fishermen, foreign fishermen, processors, distributors, importers, consumers—all play a role in fishery utilization and therefore enter into policy considerations. Results of fishery management must be measured not only in terms of total pounds of available resources or maximum sustainable yields, but also in terms of economic and social values—increased return on investment, increased earnings to fishermen, higher quality, and greater variety of products for consumers. The Bureau maintains a team of economists who conduct fishery economic studies and assist the government in establishing suitable management and trade policies.

To support this economics work as well as resource and technology work, the Bureau also maintains a national program of fishery statistics and market news. Adequate statistics measure the supply of fishery products and reveal their variations in time and by geographic area. Catch and effort statistics are essential to the biologist in measuring the effects of fishing on the stocks. Statistics show the irregularities that arise in the marketing chain—from fishermen to dealer—to manufacturer—to distributor, and—to consumer. They show how imports and exports affect the domestic supply and help in understanding the effect of fishing the living resource. Statistics record the economic progress or lack of it for a specified time, place, or particular fishery and measure the comparative well-being of the people depending on the fisheries for their livelihood.

The Federal fishery agency will observe the 100th anniversary of its founding in 1971. It may have a new name, but some 2,000 skilled and dedicated employees will continue their service to the public, the fishing industry, and the scientific community. □

NOAA / a special section

Marine Sport Fish Program



THE MARINE game fish research program of the Bureau of Sport Fisheries and Wildlife was authorized in 1959 by P.L. 86-359, "A Study of Migratory Game Fish." Much, but not all, of the marine and estuarine research conducted by this Bureau is in response to this Act.

The first laboratory, Sandy Hook Marine Laboratory, New Jersey, was established in 1960. In 1962, the Tiburon Marine Laboratory was established in California, to be followed by the Narragansett Marine Game Fish Laboratory, Rhode Island, in 1966. Two additional facilities, the Eastern Gulf Marine Laboratory, Panama City, Florida, and the Western Gulf Marine Laboratory, Port Aransas, Texas, are under construction.

Marine game fishing is an important aspect of the American recreational scene. In 1955, more than 4.5 million salt water anglers spent $489 million in pursuit of this sport. By 1965, this had increased to 8.3 million people and about $800 million. Today, the number of saltwater anglers is estimated at 13 million. The use of the fish supply is also significant; in 1965, an estimated 1.5 billion pounds of fish were harvested by saltwater sportsmen.

Sandy Hook Marine Laboratory occupies buildings at Fort Hancock, New Jersey, under permit from the Surgeon General of the Army. Dr. Lionel A. Walford is the director. Most of its 43 full-time permanent employees are fishery biologists. Including temporary employees, however, about 100 people are employed at this laboratory. Three research vessels are stationed at Sandy Hook: the 105-foot converted seagoing tug DOLPHIN; the 65-foot CHALLENGER; and the 32-foot MARTHA E., used primarily in the estuaries. A unique facility at this laboratory is a 30,000-gallon behavior tank with light and temperature controls, for studying the feeding and schooling patterns and the effects of various photoperiods on the behavior of several species of fish. The research has generally been balanced between nearshore and estuarine environments, with emphasis on the estuarine dependence of marine fishes. The effect of waste disposal on the marine environment, primarily the New York Bight, has been studied recently. Related to this is an investigation of marine fish diseases and their relationship to sewage and other waste effluents. Important research also has been carried out on artificial fishing reefs.

The Tiburon Marine Laboratory occupies several buildings at the former Navy base at Tiburon, California. The director is Gerald B. Talbot. This laboratory and the Sandy Hook facility have been leaders in measuring sea-surface temperatures from aircraft, using infra-red temperature sensing devices. Two other important research programs at this laboratory include billfish research and studies on the behavior ecology of shore and reef fishes. The billfish program has been a truly cooperative venture, and research cruises have included participants from the Mexican Fisheries Department, the International Game Fish Association, and the Inter American Tropical Tuna Association. A billfish cooperative tagging program was started in 1963, and over a thousand marlin and sailfish have been tagged each year since 1966.

The Narragansett Marine Game Fish Laboratory staff conducts research on big game sharks, the differentiation of races of marine game fish, experimental aquaculture methods, and marine game fish statistics. As the big game shark studies are being completed, a broader study of the distribution and abundance of oceanic big game fishes in relation to ocean currents, temperature, plankton abundance, and other environmental features are replacing them. The oceanic waters near this laboratory comprise one of the areas along the Atlantic Coast where tuna, swordfish, marlin, and dolphin occur within small-boat range. Narragansett is also developing into a center for estuarine research in cold waters.

The Eastern Gulf Marine Laboratory at Panama City, Florida, is under construction, but research is being conducted in temporary facilities near the St. Andrew Marina. Eugene Nkamura is the director. Until recently, this laboratory concentrated on the billfish of the Loop Current and the De Sota Canyon area off Destin, Florida. Emphasis is now on estuarine and onshore ecology. Considerable effort has been expended upon the Choctawhatchee Bay and St. Andrews Bay estuarine systems. One vessel, the 42-foot RACHEL CARSON, is assigned to this laboratory.

The Western Gulf Marine Laboratory at Port Aransas, Texas, is also under construction. No research is in progress now, although a project on San Antonio Bay, Texas, is being planned. The proposed project would examine the effects of man-made changes such as oil development and shell dredging on this estuary to determine their effect on the requirements of marine organisms. The endangered Whooping Crane inhabits the edge of this estuary and depends, in large part, on marine organisms and plants for food. □

Office of Sea Grant Programs

THE National Sea Grant Colleges and Programs Act (P.L. 89–688) was signed into law in October 1966. Its purpose is to provide for increased utilization of marine resources, including animal and vegetable life and mineral wealth in United States offshore waters, including the Great Lakes; to develop skilled manpower, including engineers and technicians, and the equipment necessary to use these untapped resources; and to provide greater economic opportunities—including expanded employment and commerce—for the enjoyment and use of the nation's marine resources. Congress assigned implementation of this program to the National Science Foundation.

Under the terms of the Act, the Foundation has provided two major types of Sea Grant activities. One element is Sea Grant institutional support; the other, Sea Grant project support.

Sea Grant institutional support focuses on institutions engaged in comprehensive marine resources programs, including research, education, and advisory services. Institutional Sea Grant support has gone to nine of the largest universities—Hawaii, Miami, Michigan, Oregon State, Rhode Island, Texas A&M, Washington, Wisconsin, and the University of Southern California. In these schools, up to 15 departments cooperate in developing ocean resources and solving institutional problems.

Sea Grant project support aids individual projects, primarily in colleges and universities, in marine resource development. The program has brought more than 30 industries into collaboration with the universities and colleges, and has influenced a half-dozen state governments to participate in ocean science and technology programs.

Among its other activities, the Sea Grant Program now sponsors both undergraduate and postgraduate education of engineers, and the training of about 400 technicians at the two-year college level. Several major universities supported by the Sea Grant Program have established marine extension services, comparable to agriculture extension services.

The President's budget for fiscal year 1971 included a request of $13 million for the National Sea Grant Program. In fiscal year 1970, $9 million was obligated, and in fiscal year 1969, almost $6 million was obligated by the National Science Foundation for Sea Grant Support.

Head of the Office of Sea Grant Programs is Robert B. Abel, who has served with the office since it was instituted at NSF. Previously, he was Executive Secretary of the Interagency Committee on Oceanography, and has held positions with the U.S. Navy Hydrographic Office and at Woods Hole Oceanographic Institution.

Planning and Program Officer is Harold L. Goodwin. Goodwin was previously Assistant Director for Scientific and Technical Information of NASA, and before that, was Science Adviser to the U.S. Information Agency. He has authored 35 books, and most recently co-authored *Challenge of the Seven Seas* with Senator Claiborne Pell.

Arthur G. Alexiou is Program Director for Institutional Support of the Office of Sea Grant Programs. He was formerly with the U.S. Navy Oceanographic Office as Manager of Space Craft Oceanography Project, Director of the Development Engineering Division, and in other positions.

Robert D. Wildman is Program Director for the Sea Grant Projects Program. Before coming to NSF, he was with the U.S. Atomic Energy Commission in Richland, Washington, as Chief of Radiation Sciences Branch and in other positions.

Newest professional staff member is Robert Greenwald, a staff associate formerly with the Census Bureau. □

Typical of activities supported under the National Science Foundation Sea Grant Programs is the Oregon State University project to help fishermen improve their yields.

NOAA / a special section

United States Lake Survey

THE U.S. Lake Survey, although long part of the Army Corps of Engineers, builds no dams, dredges no channels, constructs no breakwaters. It is solely concerned with charting and studying the waters of the Great Lakes.

The Lake Survey prepares and publishes navigational charts and related materials; studies lake levels and river flow; provides consulting services to international bodies that govern the joint use of the border waters; and conducts scientific investigations of coastal engineering and water resources.

The Survey traces its history to an Act of Congress passed on March 31, 1841, designed to aid westward migration by appropriating $15,000 for a "hydrographical survey of the Northern and Northwestern Lakes." The initial survey was assigned to the U.S. Army Topographical Engineers—later merged into the Corps of Engineers—and the Lake Survey was created to conduct the actual survey operations. Since 1845, Detroit, Michigan, has been the Survey's home base. The young organization published, in 1852, its first two nautical charts—covering all of Lake Erie and its shallow westerly end. By 1882, the Lake Survey had charted the waters designated by Congress and had issued some 76 charts. These early charts showed depths only to 18 feet, because at that time the deepest draft vessels on the Lakes required no more than 12 feet of water.

With the entire area surveyed and charted, the Lake Survey's original mission was completed. The organization was disbanded in the belief that the charts would serve navigational needs for many years. Within a few years, it became obvious that the charts were in serious need of revision, and the Lake Survey was reborn in 1901. Since then, the scope of its activities has been widened to include the lakes and navigable waters of the New York State Barge Canal System, Lake Champlain, and the Minnesota-Ontario Border Lakes.

Each spring, field parties set out to gather the data needed to maintain the accuracy of the Lake Survey's 147 charts. Using modern electronic positioning equipment and depth-sounding gear, the inshore sounding team resurveys waters less than 35 feet deep. The horizontal control network with nearly 5,000 marked points and the vertical network of about 2,000 bench marks are checked, maintained, and extended. At least every three years, all U.S. harbors on the Great Lakes are visited by a team known as the Revisory Section, which verifies or corrects hydrographic and topographic features and other pertinent information on harbor charts. New charts, and new editions of existing charts, are prepared by the Compilation

Section and printed by the Map and Chart Plant. In addition to conventional charts, the Lake Survey produces recreational craft charts, training charts, chart symbol books, monthly lake-level bulletins, hydrographs, and the *Great Lakes Pilot,* which contains information that cannot be depicted adequately on charts, such as bridge-opening signals and distances between harbors.

The Lake Survey's second major mission involves lake levels and river flows. Originally, information on water levels was needed only to prepare the charts. Today, it is vital to commercial shipping, power generation, shoreline property owners, and many other interests. Precise water levels are recorded at 50 Lake Survey gages. Using these measurements, and a variety of other data such as that gathered at precipitation gages and stream-measuring stations, the Survey's hydraulics engineers prepare six-month forecasts of lake levels. The predictions are a valuable aid to Lakes-oriented industry and commerce in planning and carrying out their activities. Lake-level records back to 1860 also serve many users, including public and private organizations engaged in marine construction.

Knowing the exact amount of water flowing into a lake from a connecting river is essential to lake-level forecasting. Accurate flow measurement in the Great Lakes' connecting rivers and channels is one aspect of the Lake Survey's hydraulics efforts. Another involves the layout and design of compensating works. When a river is deepened, its capacity increases, permitting a greater volume of water to flow and lowering the level of the upstream lake. In such cases, ways have to be found to compensate for, or retard, the river's increased flow.

Lake Survey engineers, scientists, and technicians work closely with their Canadian counterparts in the fields of charting, hydraulics, water levels, research, and other efforts. For example, when the St. Lawrence Seaway was being built, Lake Survey field teams started at the head of the river and worked downstream, while Canadian Hydrographic Service field teams began at Cornwall, Ontario, and worked upstream. When the two groups met, they exchanged field sheets, thereby giving each agency a complete survey for half the effort and cost.

The Great Lakes Research Center, established by the Survey in 1962, conducts studies in five interrelated fields—two in coastal engineering (water motion and shore processes) and three in water resources (water characteristics, water quantity, and ice and snow).

Water motion research examines the factors which cause water to move and the different forms its motion assumes—waves, tides, surges, seiches, currents, and flows. In a recent study, the Research Center investigated the harbor currents which pose a constant hazard to Great Lakes skippers and navigators. The project is expected to provide the information needed to design and build a device which will show the direction and speed of prevailing harbor currents.

The other research section in the field of coastal engineering is examining shore processes. Here, the emphasis is on analysis of the types and amounts of sediment in a given area, the interaction of water and sediment, and the natural and man-made factors which cause sediment movement along the shoreline.

To gain information on coastal sedimentation, scuba divers work from 30-foot depths to the shoreline, taking detailed bottom profiles. They also collect sediment samples for later laboratory analysis to determine the sorting of the sands by waves and currents. The offseason months are spent analyzing and reducing the data collected during field operations.

The water characteristics project investigates water quality, studying variations in quality between the Lakes and between different areas and different depths in the same lake. Lake Survey's research vessel SHENEHON collects water and bottom samples and makes meteorological and other measurements at preselected stations around a lake at regular intervals. Some samples are analyzed immediately in the vessel's laboratory; others are examined later at Lake Survey's chemical laboratory in Detroit.

The Lake Survey is working toward the establishment of water-quality indexes by station for the entire Great Lakes, to provide the information needed for good water management.

A new study undertaken in recent years is an investigation of the effect of dumping dredged matter from waterways and shore areas in deep lake sites. Material removed from a highly industrialized area may be polluted. The SHENEHON follows dredges from work areas to the dumping sites, collecting samples, before, during, and after dredging.

In recent years, changing lake levels have aroused great public concern. What causes low or high water levels? What are evaporation rates under different conditions? What effect do the lakes have on precipitation? The Lake Survey's water quantity project studies and analyzes the factors affecting water supplies to the Lakes, including inflow rates, outflow, precipitation, evaporation, and storage. It also studies the geological formation and structure of the Lakes and their basins, because these have an important bearing on water supplies, the relationship of water levels to adjacent land masses, and the rate of discharge through the outflow rivers. This research is designed to improve the forecasting of water supplies and future lake levels.

Ice and snow conditions have an important effect on Great Lakes navigation, shore and harbor facilities, power generation, and water supplies. The Lake Survey's ice and snow project studies the formation, thickness, quality, extent, movement, and decay of ice, as well as snow cover and the snow-water equivalent. Major objectives of this work are to perfect ice-forecasting techniques and to investigate possible ice-control systems, with a view to extending the navigational season on the Great Lakes.

The ice and snow project also publishes ice-cover charts during the winter. From late December to early April, data on the extent of Great Lakes ice cover is obtained from U.S. Air Force photomapping flights and from ESSA satellites. In addition, Lake Survey scientists make visual observations from U.S. Coast Guard aircraft.

On the ground, the physical characteristics of the ice cover are investigated in detail. For these studies, field parties occasionally camp out on the ice sheet in polar tents, traveling back and forth to base in motorized toboggans. Igloos are built at key points to hold laboratory equipment, so that on-the-spot analyses can be made. More extensive analyses of the physical and chemical properties of ice specimens are made at Lake Survey's unique Ice and Snow Laboratory in Detroit.

Among the support facilities established to assist the Research Center and Engineering Division in carrying out their programs, are the Great Lakes Regional Data Center, the Technical Library, the Instrument Office, the Ice and Snow Laboratory, the Chemical Laboratory, and the Sedimentation Laboratory.

One-third of the United States' population now works and lives in Great Lakes states. Much of this concentration of people and industry occurred because of the Lakes and still depends on them. But the increasing use of these waters for recreation, commerce, and industry makes it imperative that methods and controls be developed to protect and conserve one of our greatest treasures—the waters of the Great Lakes. □

National Data Buoy Project

THE U.S. Coast Guard's National Data Buoy Development Project was established in December 1967 to carry out the development of a national system of automatic ocean buoys for obtaining oceanic and atmospheric data.

The need to fill the data gap in maritime areas of the globe had long been recognized. Inhabited regions of the world are reasonably well observed, and international cooperative programs are underway to provide better coverage over land and ocean areas. Measurements of the oceans are available from satellites, ships and aircraft of opportunity, a few ocean station vessels, and occasional oceanographic ships sampling the environment. But more detailed information is needed on environmental conditions over vast marine areas.

A logical way to bridge this information gap is the establishment of a network of automatic buoys throughout the oceans, to measure and report environmental parameters. During the early 1960's, a number of Federal agencies and university groups independently began buoy development programs, largely to satisfy their individual needs.

In 1966, a group of Federal agency representatives, working under the auspices of the Interagency Committee on Oceanography, Panel on Ocean Engineering, recommended a national system of ocean data buoys. The Interagency Committee on Oceanography then asked the Coast Guard to undertake a jointly funded study of the feasibility of such a system. The ten-month study, carried out under contract, found: that extensive requirements exist for oceanographic and meteorological information to satisfy operational and research needs in the deep global oceans, coastal waters, bays, estuaries, and Great Lakes; that automatic moored buoys are capable of meeting a significant portion of these needs; and that buoy networks will be an essential part of any overall environmental information and prediction system to monitor, predict, and eventually control the global environment.

The National Council for Marine Resources and Engineering Development, in November 1967, asked the Coast Guard to become the lead agency for conducting the research, development, testing, and evaluation needed for future decisions regarding national data buoy systems. The National Data Buoy Development Project was created within the Department of Transportation's Coast Guard to proceed with the task.

From existing resources, 18 management, technical, and clerical personnel were assigned in the Project Office at Coast Guard headquarters in Washington, D.C. The staff includes a broad spectrum of capabilities and disciplines, including individuals with backgrounds in oceanography, meteorology, engineering physics, naval engineering, communications, sensor development, system analysis, and aids to navigation buoys.

This development is directed toward a National Data Buoy System capable of providing key observations required to describe the marine environment. The information would be provided routinely, reliably, and accurately to those agencies involved in understanding, predicting, or controlling the marine environment.

The systems approach used by the Project includes not only the basic instrumentation and platforms, but also the ships, communications hubs, maintenance bases ashore, trained personnel, quality control of data, supply channels, logistic procedures, and other factors essential to the continued reliable operation of the buoys.

It may be that different types of platforms will be necessary for the deep oceans, coastal waters, estuaries, Great Lakes, and the Arctic. Estuarine requirements, for example, may be satisfied by observational platforms other than automatic buoys, such as sensors mounted on pilings in shallow water, on bridge abutments, or on existing aid to navigation buoys.

Such aproaches are compatible with the Buoy Development Project's work toward a National Data Buoy System. □

NOAA / a special section

National Oceanographic Data Center

THE National Oceanographic Data Center, an arm of the Department of the Navy located in Washington, D.C., was established in 1960 to collect and disseminate oceanographic data accumulated by all Federal agencies. It serves the needs of government, industry, university and research institutions and of the public for an efficient mechanism for processing, exchanging, and storing globally collected marine data and information and provides a central source from which marine data and products may be obtained.

NODC is sponsored by ten agencies with interests in the marine environment: the Atomic Energy Commission; Bureau of Commercial Fisheries; Coast Guard; Coastal Engineering Research Center; Department of the Navy; ESSA; Federal Water Quality Administration; Geological Survey; Department of Health, Education and Welfare; and National Science Foundation. An advisory board—composed of members designated by the sponsoring agencies, plus two others selected by the National Academy of Sciences—provides policy and technical direction for NODC activities.

The Center houses the world's largest useable collection of oceanographic data. Its extensive archive contains:

—Mechanical and expendable bathythermograph data in analog and digital form.

—Oceanographic station (Nansen cast) data for surface and serial depths, giving values of temperature, salinity, oxygen, inorganic phosphate, total phosphorus, nitrite-nitrogen, nitrate-nitrogen, silicate-silicon, and pH.

—Salinity-temperature-depth data in analog form.

—Surface current information obtained by using drift bottles or calculated from ship set and drift.

—Biological data, giving values of plankton standing crop, chlorophyll concentrations, and rates of primary productivity; also papers on marine biology, indexed for rapid retrieval.

—Geological sampling inventory, primarily for the New England Continental Shelf.

—Bottom sample information.

—Seismic reflection records, on microfilm.

In January 1970, the Center's inventory numbered:

Station data (processed as of 30 June 69)	417,600	stations
Station data geosort (Baltic Sea not included)	358,000	stations
Bathythermograph data digitized geosort (as of 30 Sept. 69)	582,000	observations
Bathythermograph analog prints (pre-1967)	800,000	observations
Biological data digital	11,000	stations
Biological papers stored for retrieval	8,100	
Geology information system	32,000	samples
Seismic reflection data	70,000	track miles
Surface current data	3,375,000	observations

Many organizations, domestic and foreign, submit information and various types of scientific data from all oceans, seas, and estuaries. Sources include NODC liaison officers located in certain key areas of the United States; national data centers in other countries; and the World Data Center system. World Data Center A, Oceanography, administered by NODC, receives input from international cooperative investigations and other sources.

Incoming data is received and processed by the Operations Division; outgoing data leaves NODC through the Services Division, which provides copies, summaries, and analysis and information services on request. New systems are developed and instituted, and new applications introduced, through the Development Division. The Center's Computer Processing Division has an IBM 360/40 for high-speed processing, direct-access retrieval, and cathode-ray tube display.

NODC services include data processing; data reproduction in the requested form; analysis and preparation of statistical summaries based on archive holdings; and evaluation of the suitability or limitations of various data records for specific analytical requirements. The services are performed on a reimbursable basis, the cost depending on the number of observations involved, special analysis required, computer time, materials needed, and other factors. □

National Oceanographic Instrumentation Center

THE National Oceanographic Instrumentation Center, in the Department of the Navy, provides a central Federal service for calibrating and testing oceanographic instruments. It is a focal point for national and international cooperation in controlling the quality of ocean measurements.

The Center, located in Washington, D.C., works closely with the National Bureau of Standards in developing techniques and reference standards for oceanographic instrument performance.

NOIC also cooperates with the National Oceanographic Data Center by providing better instruments and standards, thus assuring that the massive oceanographic data collection program provides accurate and useful information.

The major functions of the National Oceanographic Instrumentation Center are these:

—Operate a laboratory for the evaluation of oceanographic instruments.

—Generate a central proposal and specification file and disseminate information on ongoing development efforts for oceanographic instruments.

—Encourage the coordination of national specifications for oceanographic instrument development.

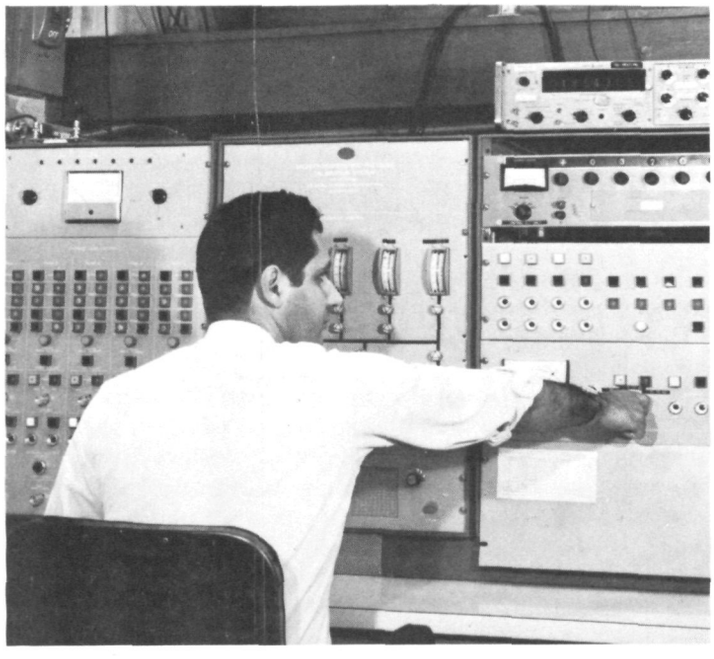
—Conduct cooperative programs among government agencies, the academic laboratories, and the industrial community for the purpose of compiling government-wide requirements on instruments to support the development of standards.

—Establish techniques and secondary reference standards by which oceanographic instrument performance can be assessed.

—Perform laboratory and field testing and calibration of oceanographic instruments for government, academic, and industrial interests.

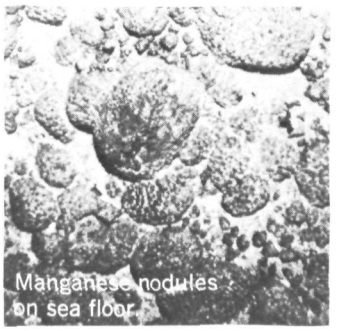
—Collect and disseminate instrument performance and deterioration data as a means of acquiring statistically significant samples on which to base design criteria for improved systems.

—Develop ocean measurement instruments when these instruments cannot be obtained from other sources and equipment needed in the testing and calibration of oceanographic instruments. □



NOAA / a special section

Marine Minerals Technology Center


Manganese nodules on sea floor

LOCATED AT TIBURON, California, the Marine Minerals Technology Center of the Department of Interior's Bureau of Mines is concerned with the development of marine mining technology.

Its program has two major objectives. The first is to assure that the marine mining systems ultimately developed will minimize damage to the marine environment and will not interfere with the development of other marine resources. The second is to provide the necessary tools and techniques for accurate delineation of marine mineral deposits so that their economic potential can be evaluated.

As rich, accessible, dry-land deposits become scarcer, industry's interest is turning to unconventional sources. Many valuable metals and non-metals are known to lie under the ocean in potentially recoverable deposits. The list includes nickel, cobalt, copper, manganese, gold, tin, platinum, iron, titanium, chromium, phosphorite, lime, glauconite, and barite.

Today, offshore extractive operations—using technology adapted from dry-land techniques—are producing a mineral output approaching a value of $2½ billion. This is principally from oil, gas, and sulfur wells, but includes the dredging of sand, gravel, and oyster shells and the extraction of metals, chemicals, and salts directly from sea water. Unfortunately, some of these operations have detrimental consequences, such as oil spills.

The potential environmental impact of marine mining is enormous. Large-scale ocean mining can alter the contour of the sea floor. Currents can transport fine-grained sediments over long distances. Increased turbidity could absorb enough solar energy to interrupt photosynthesis and break the ocean food chain. Mining and processing wastes could damage marine life by altering critical chemical characteristics of the sea.

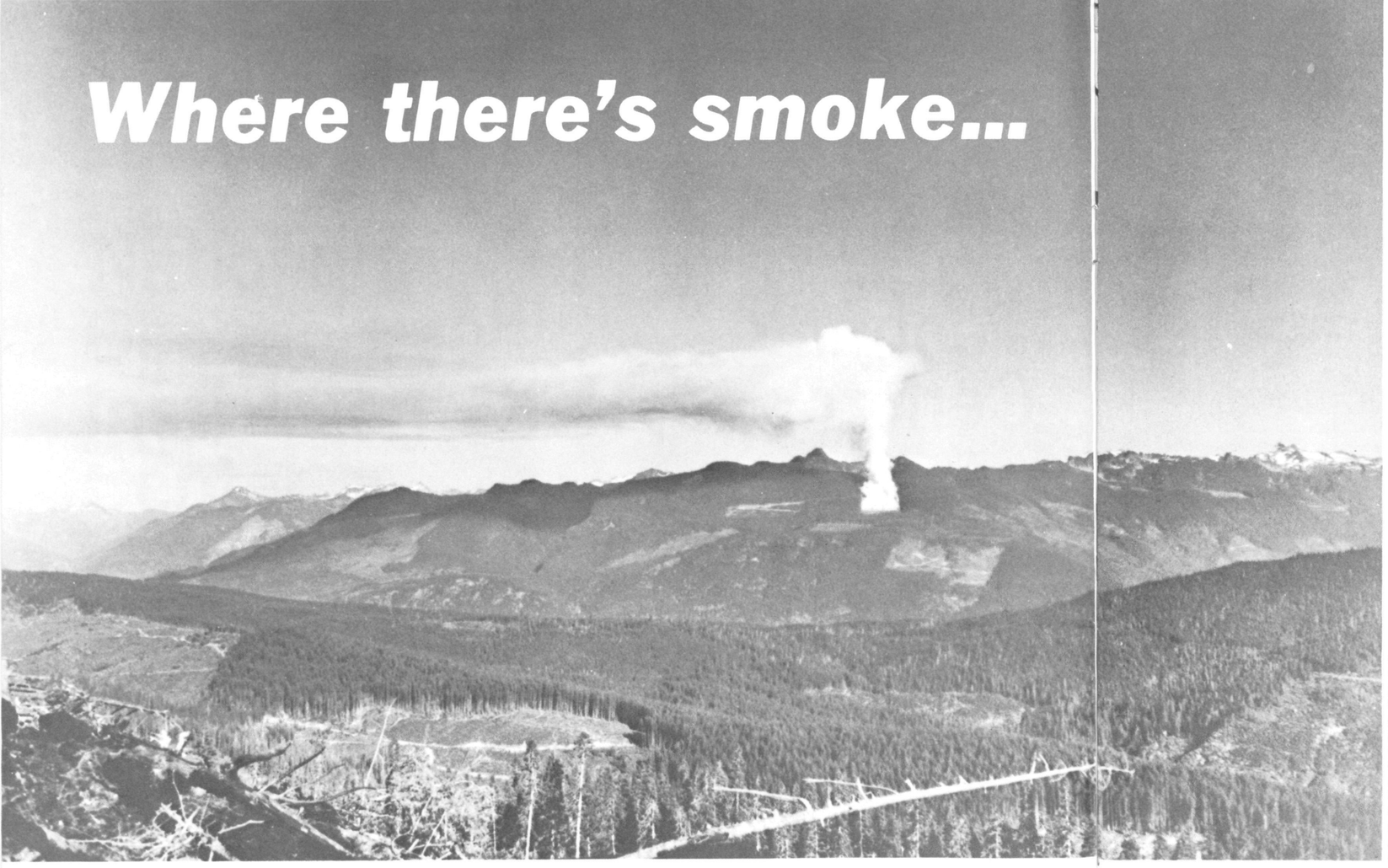
Because ocean mining technology is still in its infancy, it is possible to design and build safeguards into the technology as it develops, so that environmental control will be an integral element of the system. A relatively modest investment now can lead to maximum benefits in the future, when marine mining approaches the size of today's offshore operations.

The Marine Minerals Technology Center is performing studies directed toward the development of adequate tools and techniques for evaluating marine mineral deposits; examining mining system requirements; and encouraging private development of total mining systems compatible with the marine environment.

At the present time, sample drilling equipment is being evaluated in a test tank, through cooperative arrangements with industry. To solve the often severe problem of holding position while drilling from a ship, two alternative drilling techniques are being studied. One is a drill platform above the ocean surface supported by legs extending upward from a buoyance vessel submerged below the zone of ocean surface disturbance. The other is an advanced bottom-setting drill designed to operate while loosely connected to a mother ship.

In other projects, the Center is investigating the potential impact of marine mining on other marine resources, analyzing historical information on environmental disturbances caused by activities similar to marine mining, developing operational criteria for avoiding serious offshore environmental damage from mining, and conducting performance evaluations of marine mining subsystems. □

Where there's smoke...



Residue from lumbering operations is burned under Oregon's planned program to prevent uncontrolled forest fires and minimize air pollution. Fire-weather forecasters predict the elements affecting smoke dispersion, including winds aloft, surface winds, and thermal stability. In the area view at left, the smoke from a controlled slash fire rises to upper levels before dispersing, a prime objective of the program. Light patches are cut-over areas which have been, or will be, burned.

Forecasters and foresters join forces in Oregon to combat pollution from burning logging debris

BY HAROLD AYER AND
ROBERT KIRKPATRICK
Weather Bureau

. . . there's not only fire but the possibility of air pollution, and in the timber-rich areas of Oregon and Washington, the Weather Bureau is helping foresters plan their controlled burning operations.

Foresters burn slash or residue from lumbering operations to guard against uncontrolled forest fires. On some days, there may be dozens of controlled fires in the two states, with individual burns ranging in size from less than an acre to a hundred acres or more. The mass of tinder-dry fuel averages over 100 tons per acre and can run as high as 400 tons—a gold mine of smoke and soot during extensive burning operations.

In recent years, the increase of air pollution has made it plain that something must be done not only to control the fires, but also to keep their noxious byproducts away from heavily populated areas of the Pacific Northwest.

Why burn at all?

Timber harvesting in the dense private and public forests leaves in its wake an excessive accumulation of logging debris and culls, choking off new growth and providing fuel for nearly uncontrollable forest fires in dry weather. Wildfires can create episodes of smoke pollution more serious than those caused by debris burning.

During the infamous Tillamook Burn of 1933, a dark cloud of smoke lay over northwestern Oregon for days. With strong east winds blowing at the peak of the fire's spread, ships off the coast had to use running lights and foghorns at midday.

Because of the dangerous potential of logging leftovers, state laws require that a logging operator or landowner burn the slash. In former years, nearly all burning was done in the fall when cooler weather and more frequent rains reduced the danger of wildfires.

Although controlled slash burning reduced the danger of uncontrolled forest fires, the problem of air pollution remained. During periods of slash burning, large amounts of dense smoke sometimes accumulated in the more heavily populated areas west of the Cascade Range, which runs north-south near the middle of Washington and Oregon. Forestry agencies in both states have developed systems to control the smoke.

In Oregon, where about 90 percent of the population is concentrated west of the Cascade Range, joint meetings were underway by 1967 between the State Forestry Department, U.S. Forest Service, Bureau of Land Management, Bureau of Indian Affairs, and the State's Department of Environmental Quality. As a result of these efforts, enabling legislation was passed that allowed the agencies to carry on burning operations throughout the year, under coordination of the State Forester. In 1969, at a meeting of all the agencies in the office of Governor Tom McCall, a Smoke Management Plan was approved. It was designed to minimize smoke accumulation in certain areas of high population density in the western part of the state. The detailed plan became operational in the summer of 1969.

A primary need in such a system is accurate, pinpointed weather forecasting. Slash smoke, unlike many other sources of air pollution, cannot be turned on or off at a moment's notice. Fire-weather forecasters at Medford, Salem, Portland, and Pendleton began to forecast, on a twice-daily basis, the elements affecting smoke dispersion. These forecasts specified the winds aloft, surface winds, and thermal stability conditions, including the levels of any temperature inversions. However, upper-air observations to support and verify the forecasts were lacking in the coastal and mountain areas. Also, the important objective of distributing slash burning times throughout the year, whenever conditions permitted, involved maintaining the forecast capability through the winter season when fire-weather personnel normally pursue other duties.

Asked to provide the field data, instrumentation, and forecaster personnel needed to carry out the Smoke Management Plan, the Weather Bureau responded by making fire-weather forecasters available throughout the year and by requesting funds to provide soundings of winds and temperature in the remote forests and rugged terrain. Automatic surface weather stations, for use in more remote areas during the winter, are also part of the plans.

As an interim measure to obtain the upper-air data needed to determine current and predicted directions of smoke drift, the Forest Service and the State Forester's Office agreed to provide personnel time for making pilot-balloon (pibal) observations, using equipment provided by the Bureau. Several aircraft owned by the two forestry agencies were also equipped with electronic temperature sensors to take temperature soundings during climb and descent when flights were being made. The fire-weather offices at Salem and Portland were instructed to organize the pibal program and train the forest personnel in tracking balloons and computing winds.

The equipment and supplies were ready in April 1970, and the training began. Six station sites were chosen. Together with the three Weather Bureau stations in the area where upper-air soundings are made, the total network of nine stations in western Oregon gives good coverage of the area. The average distance between adjacent stations is about 60 miles.

At each station, three to five employees participated in the training, which was completed in May. Although tracking the balloon and performing the computations requires only one or two persons, it was desirable to have alternates. The forest personnel who received the training were about equally divided among men and women, and their regular job duties ranged from clerk or secretary to station Fire Control Staff Officer.

After five or six practice runs, the trainees became fairly skillful at tracking the gyrating balloons, especially if a second

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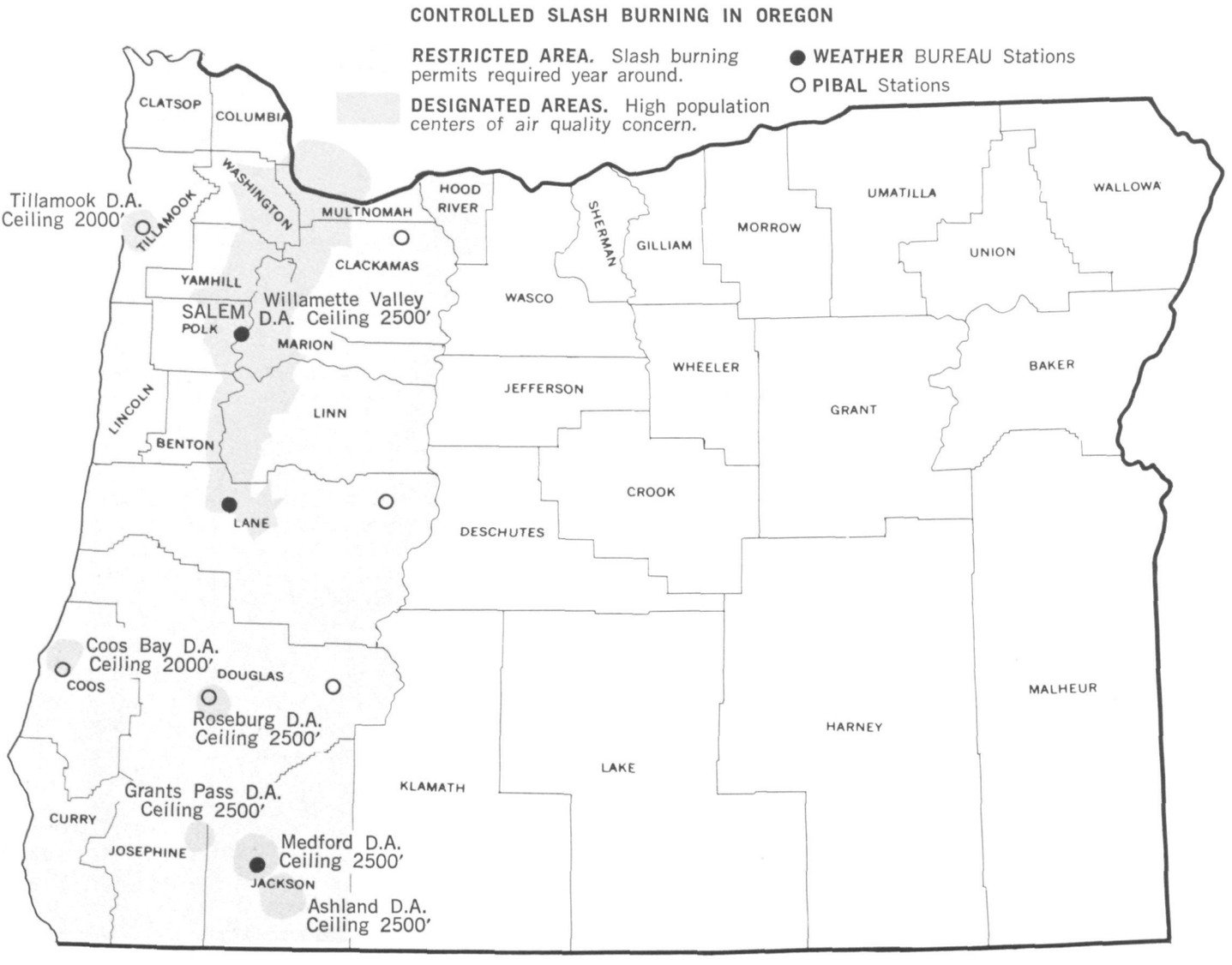
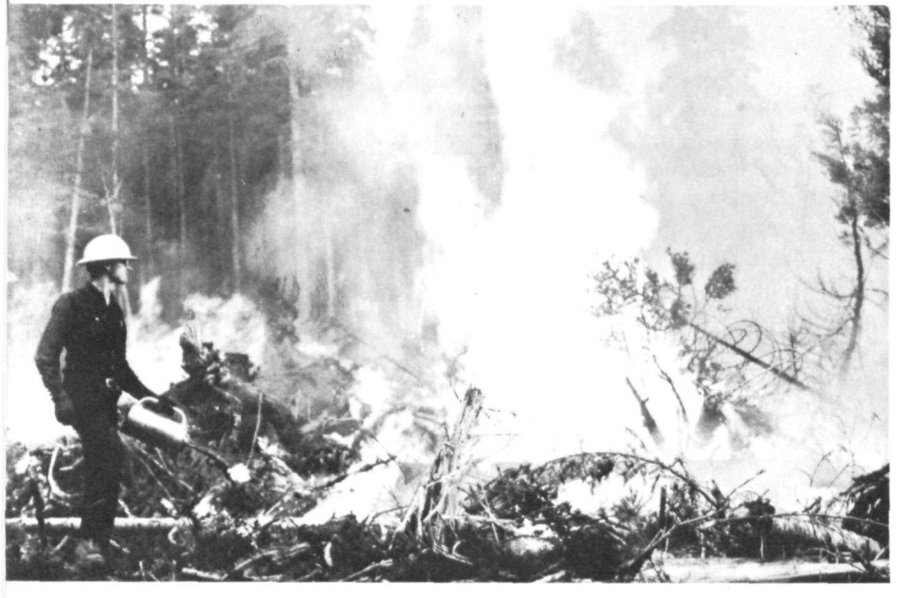




A forestry technician watches a slash fire, which he set after piling the debris to speed burning and reduce smoke.

observer was at hand to record the azimuth and elevation angles each minute. There were some comic moments, such as trainees tripping over the tripod legs when balloons ascended almost vertically in turbulent currents with consequent rapid changes of azimuth angles. During practice runs at one station, when several balloons were released within an hour, a grizzled woods veteran working nearby watched the procedure for a while and then came over to see what it was all about. Told that the basic idea was to control air pollution, he remarked: "It looks to me like you're polluting the air with balloons."

Once the observers were on their own, the Weather Bureau instructors received a few telephone calls asking, "What do we do next?" The plotting and encoding procedures, after the tracking angles were obtained, gave the most trouble since the forestry personnel had to work with a mixture of strange units such as meters and knots. Nevertheless, the training seems to have produced some experts.

The observations are scheduled for 9:30 a.m., Pacific Standard Time, corresponding to one of the daily balloon release times for regular Weather Bureau stations. This places the wind information in the hands of the forecasters before the mid-afternoon forecasts are made. The coded wind messages are relayed by radio or teletypewriter to supervisory offices

and then by forest agency teletypewriter circuits to the two agency headquarters at Salem and Portland and to the various fire-weather forcasting offices. They are also sent by ESSA Weather Wire to other Weather Bureau stations in Oregon for the information of forecasters. The final coded message consists of wind direction and speed at each 1000-ft. level above mean sea level up to 12,000 feet. It is reasoned that the wind field above that height is smooth enough to be represented by soundings from the regular Weather Bureau upper-air stations in the region. But one nice day an enthusiastic observer sent in winds at every 1000-ft. level up to 29,000 feet!

Foresters have a busy schedule during the fire season, and they have to do a great deal of traveling away from their stations. Some have other duties of high priority and responsibility. Therefore, it was decided to have the pibals from any one or more of the stations only on days when slash burning was to be done somewhere in a portion of the state. This requires foreknowledge of burning plans, so the stations can be advised a day ahead when to make the soundings. Each Ranger District or State Forestry District sends in daily reports of slash burning, both planned and accomplished. These reports are posted on a large wall map in the State Forester's headquarters at Salem, so the quantity of burning can be monitored and then limited in certain areas when weather conditions are not favorable. Each day, the fire-weather offices at Portland and Salem consult by telephone to determine which pibal stations will be requested to make wind soundings. On some days, all six might be alerted.

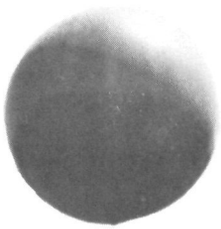
The interagency cooperation and the new Smoke Management forecasts worked well in 1969. In contrast with the preceding two or three years, few episodes of heavy slash-smoke pollution occurred after the program began. Its success can be attributed to three factors: overall coordination and management of burning; extending the burning throughout the year so the volume at any one time of year is reduced; and specific forecasts of the atmospheric variables important to dispersion of the smoke. With the new wind information provided by the foresters' pibal observations, the forecasts now are pinpointing conditions with more accuracy. At the same time, the forecasters are learning some new facts about wind behavior in the mountains and along the coast. The pibal stations occasionally will be asked to take soundings in periods of critical wind situations—such as the strong, dry, east winds—regardless of burning plans. Such data will solve some of the problems of mountain wind behavior that have plagued forecasters for years. Research on these problems, utilizing the pibals and the aircraft temperature soundings, will be undertaken this winter.

What of the long-range plans? Is the Smoke Management Plan considered to be the final answer? Do fire control officials see a need to continue burning indefinitely? The answer is a flat NO! The special forecasts and field data programs are a stopgap measure until such time when improving technology can resolve the problems of logging residue. Intensive research and development programs are underway, both to reduce the amount of visible smoke and particulate matter and to find other ways of disposing of the cull material.

For a number of years, the logging industry and forest researchers have been finding uses for materials that were formerly considered waste. Machinery is now in the woods chopping up tree branches and other material into wood chips, which are either hauled to paper mills or left on the forest floor where they decompose rapidly. Some machinery is large and expensive, and the cost slows the pace somewhat.

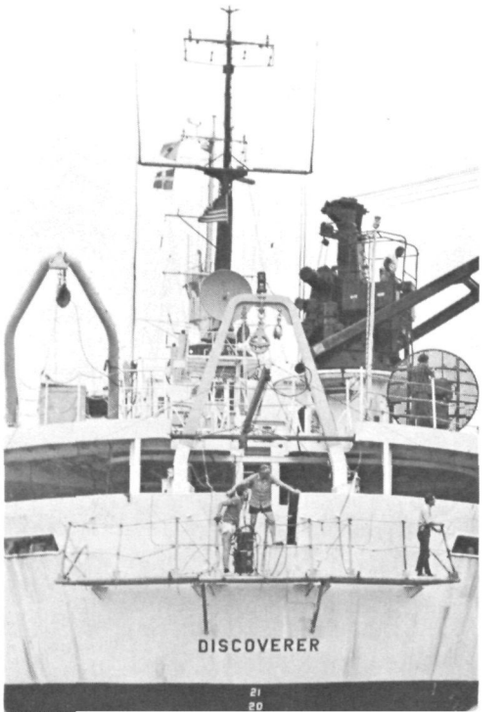
Methods of piling and covering the debris have been in use for several years to permit burning at the most favorable times. Practices are being steadily developed for doing the burning in such a way as to create quick, hot fires with much less smoke. Napalm and multiple ignition spots with electric charges are being tested. For the past two years, two research foresters at the Regional Office of the Forest Service in Portland have been working on these and other techniques and guidelines. The researchers work closely with the fire-weather forecasters. Several forestry experiment stations are examining other solutions to the problem, such as increased utilization of the woods materials.

Soon, the day may come when the great plumes of slash smoke will dwindle to a few wisps. In the meantime, a number of dedicated foresters are tracking pilot balloons in earnest. □



Forestry personnel at six sites were trained to make pilot-balloon observations, using equipment provided by the Weather Bureau. These sites, plus the three Weather Bureau stations where upper-air soundings are made, form a nine-station network that provides good coverage of Western Oregon.

International Science Takes an Instrumental Voyage



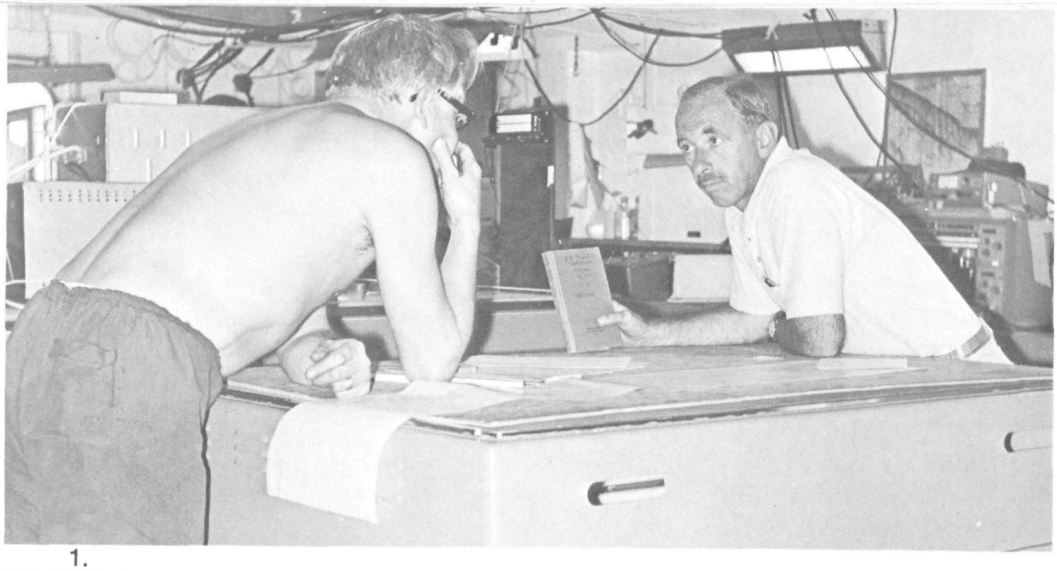
For 25 scientists from nine nations, May 1970 meant a 6,280-mile intercalibration voyage aboard USC&GSS DISCOVERER, and an opportunity to get instruments and methods into approximate global agreement for certain marine and atmospheric processes.

The oceanographic side of the expedition, under the aegis of SCOR (for Scientific Committee on Oceanic Research, part of the International Council of Scientific Unions), emphasized measurements of the sea's primary productivity—the photosynthetic productivity of phytoplankton, the tiny organisms at the center of the sea's elaborate food web. The voyage was designed to permit observations of a wide range of productivity values, from the relative sterility of the Sargasso Sea to the nutrient-rich, highly productive waters off the Pacific Coast of South America.

Of interest here were the ability to measure primary productivity as a function of incoming solar radiation, and the development of standardized international techniques for obtaining these measurements. Marine optical scientists and marine phytoplanktonologists joined forces for this series of observations.

The atmospheric side of the expedition sought to intercalibrate two types of balloon-borne radiometric instruments—devices which sense thermal radiation emitted by the atmosphere and ocean. This was the third such international calibration effort. Previous meetings in Munich, Germany, in 1963, and in Green Bay, Wisconsin, and Miami, Florida, in 1965, indicated that intercomparisons would be better over the uniform ocean surface than they had been over land.

The expedition also gave DISCOVERER photographer Ishmael W. Mason a chance to make a few observations of his own, some of which follow.



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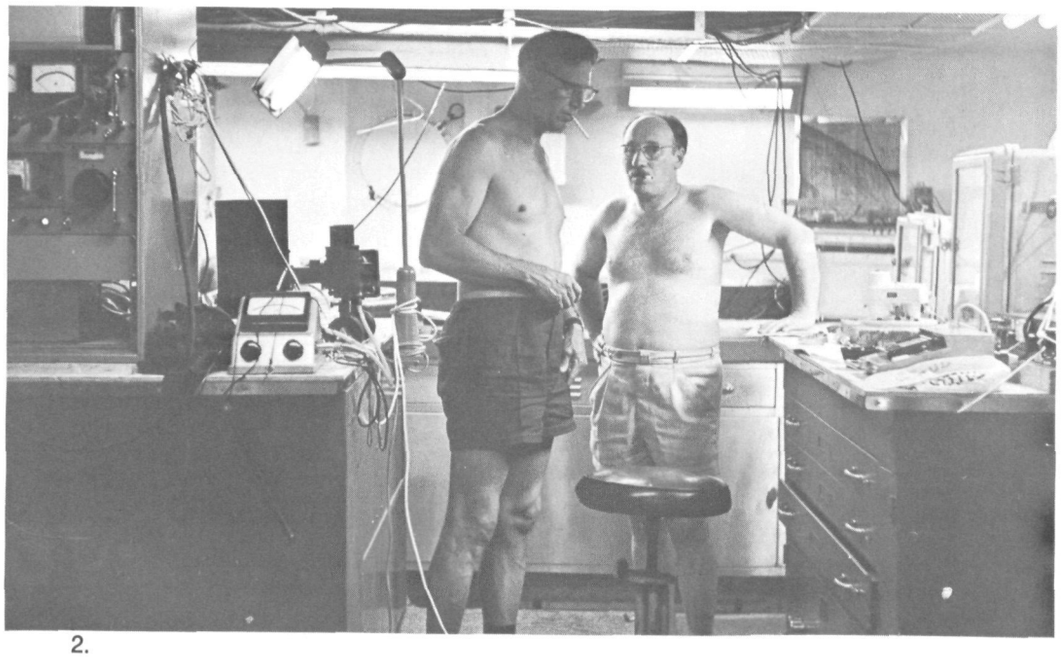

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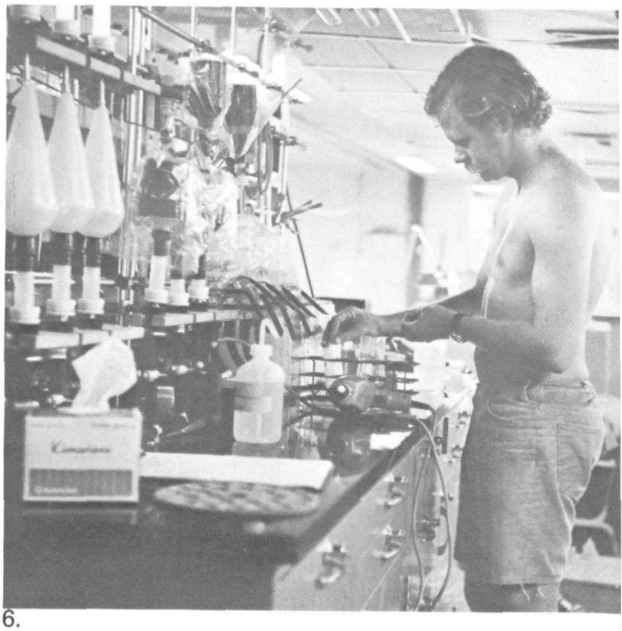

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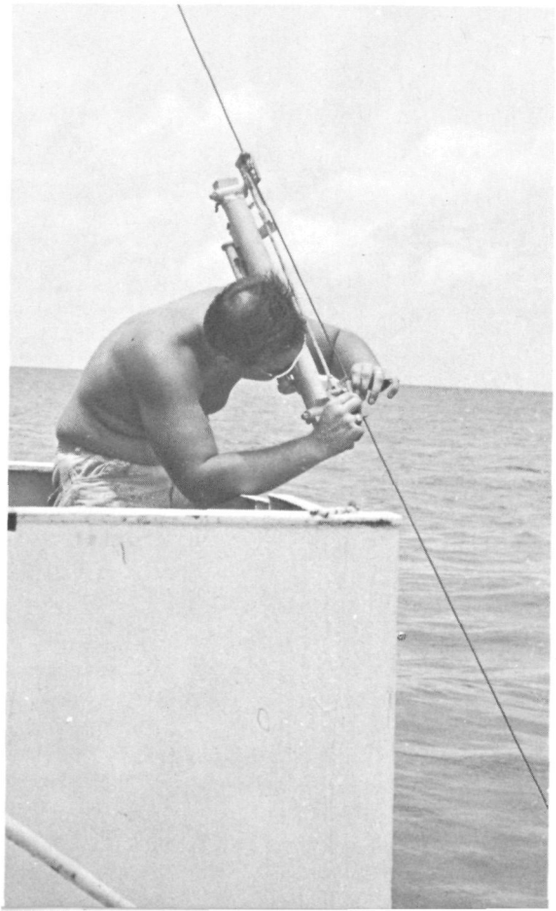

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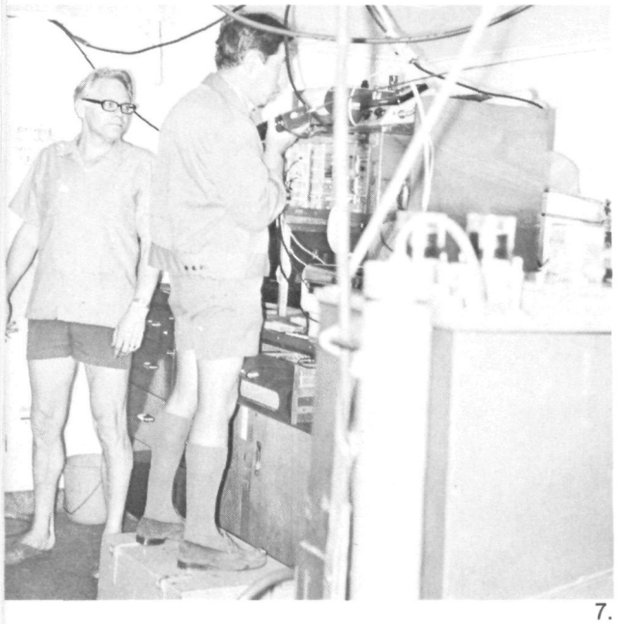
1. In the DISCOVERER's oceanographic lab, Dr. Kjell Nygaard (left), chief engineer at the University of Copenhagen, discusses the SCOR project with AOML director Dr. Harris B. Stewart, Jr., who coordinated the expedition for ESSA. 2. Surrounded by a jungle of wires and experimental apparatus, Prof. Yulen Ochakovsky (right) and engineer Anatol Susliaev, both of the Institute of Oceanology, Moscow, confer in the oceanographic lab. 3. Dr. Jim Alberts of Florida State University preserves tradition with a standard Nansen bottle cast . . . 4. . . . while farther-out Nick Evans of the ship's survey department lowers the STD. 5. Thomas C. Malone of the Hopkins Marine Station, Pacific Grove, California, decants shallow seawater samples into vials . . . 6. . . . and runs an analysis on their chemistry and organic constituents in the ship's oceanographic lab.



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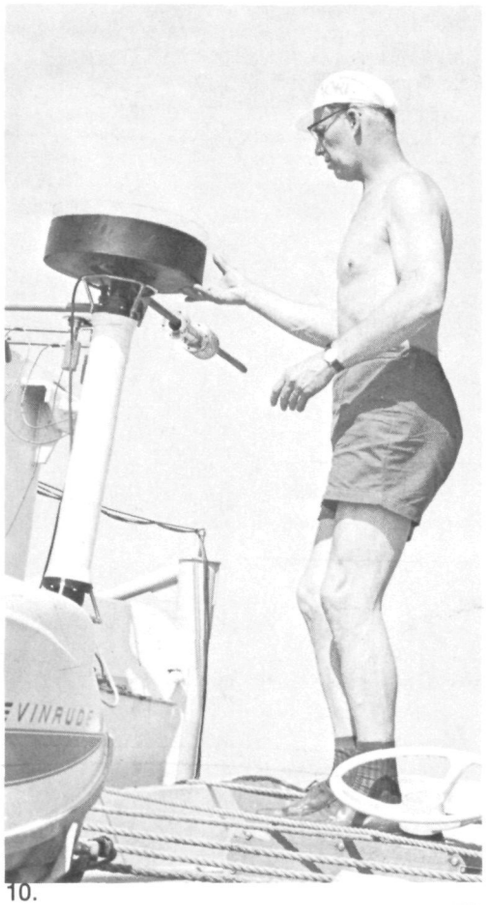

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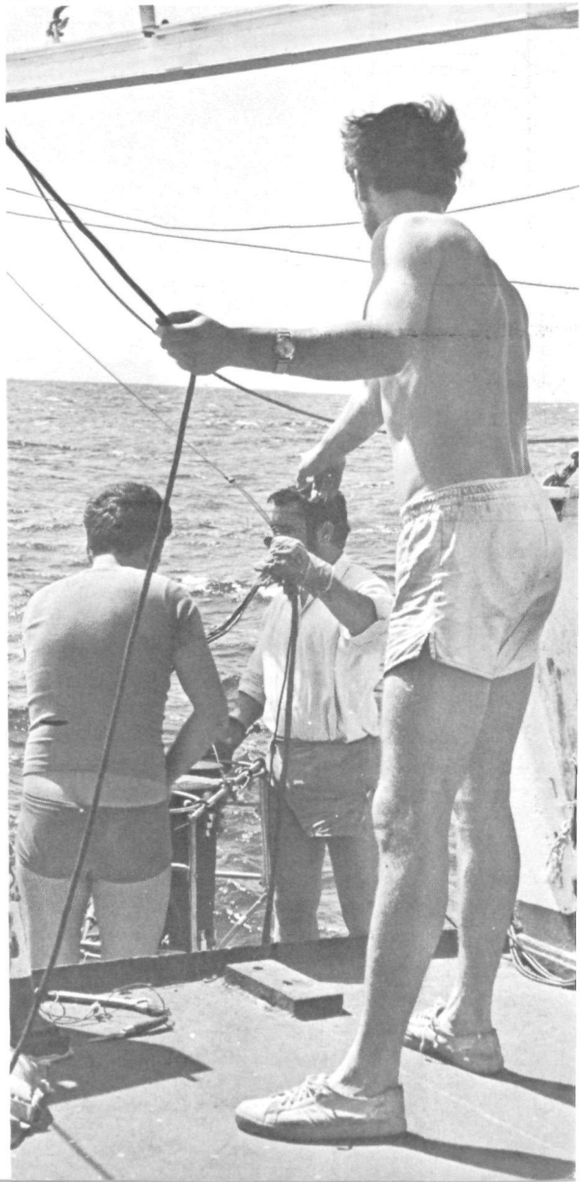
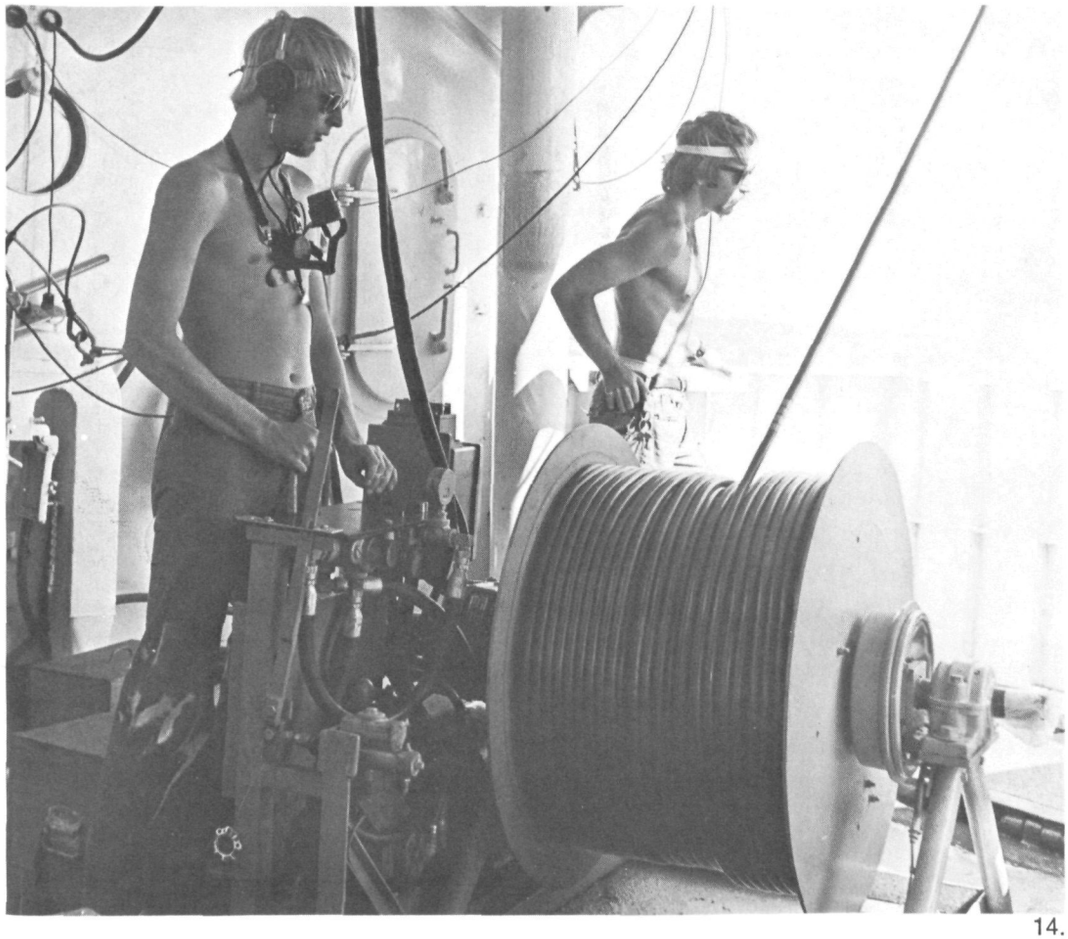


7. Aided by Dr. Nygaard, Dr. Harry R. Jitts (right), senior research scientist at Australia's Commonwealth Scientific Industrial Research Organization, compares data coming in from sensors astern with his incubator-raised laboratory samples. 8. Armed with microscope and reference book, Dr. Jahn Throndsen, of the University of Oslo, counts and classifies the tiny phytoplanktonic creatures brought aboard. 9. Measuring productivity as a function of solar radiation is a problem in marine optics. One useful parameter is the ability of sea water to transmit light, which is what Roswell Austin of the Scripps Institution of Oceanography is measuring here. 10. Anatol Susliaev adjusts an Amici (pronounced Ameche) prism, used to divide the solar beam into a spectrum for analysis.



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11. One of the photometers used to measure light reaching various depths in the *shallow euphotic zone is readied for in*tercalibration, by (from left) SCOR group leader John E. Tyler, of the Scripps Institution's Visibility Laboratory, Anatol Susliaev, Dr. Nygaard, Prof. Yùlen Ochakovsky, and ship's machinist James Jones. 12. A quanta meter, used to measure changes in light energy levels, is given a last-minute check by Niels Hojerslev (left), research associate at the University of Copenhagen, and Scripps' Roswell Austin. . . . 13. . . . and put over the side by (from left) Dr. Jean-Pierre Bethoux, attache of research, National Center for Scientific Research, Paris, Dr. André Morel, maitre assistant, University of Paris and Niels Hojerslev. 14. Brian Young (left) and Nick Evans, both of the ship's survey department, do some winching to support the daily routine of photometer and quanta meter casts. 15. Dr. Yatsuka Saijo, of Nagoya University, and Nobutada Nakamoto, doctoral student at Tokyo Metropolitan University, prepare samples for their photometer buoy experiment. 16. The buoy, christened "Saijo Maru," was launched daily at noon and allowed to drift free of the ship (and the ship's influence on productivity), then retrieved toward dusk. The set of in-situ productivity data acquired by the 22 buoy-launchings may be the most varied and extensive ever obtained.

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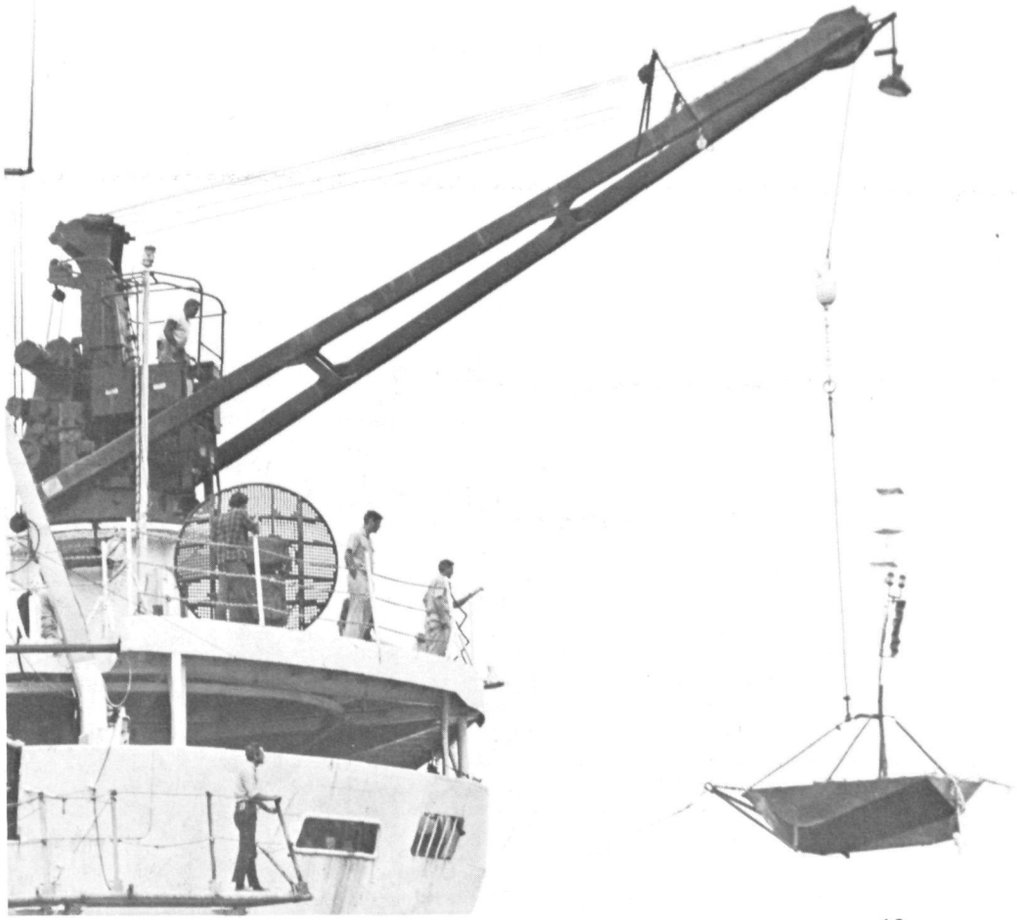

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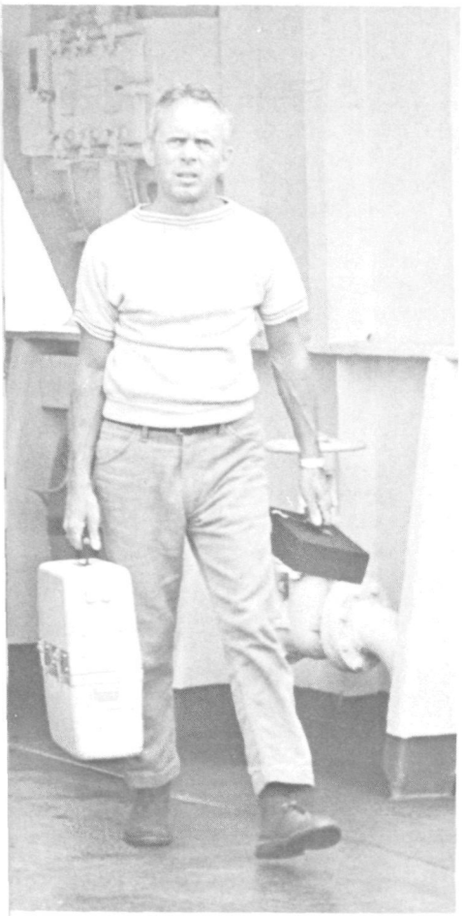

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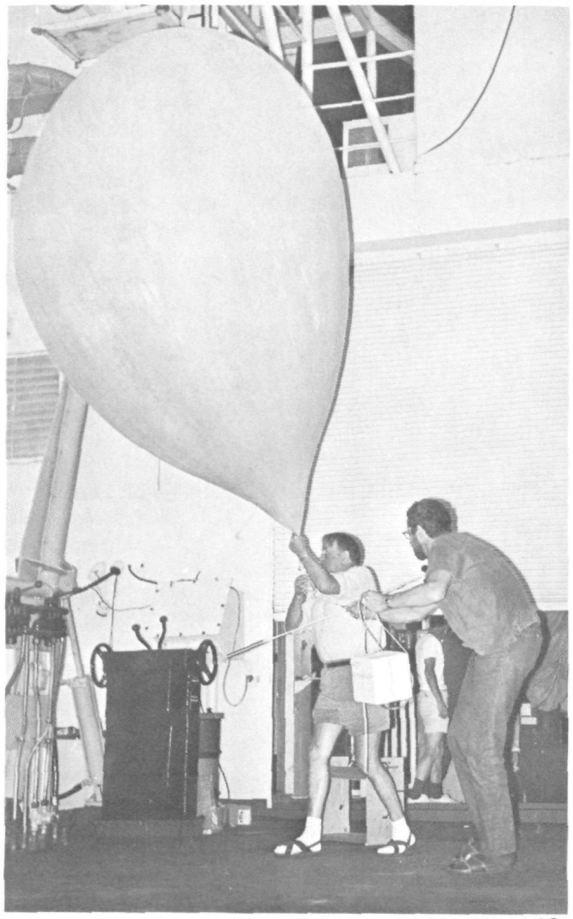

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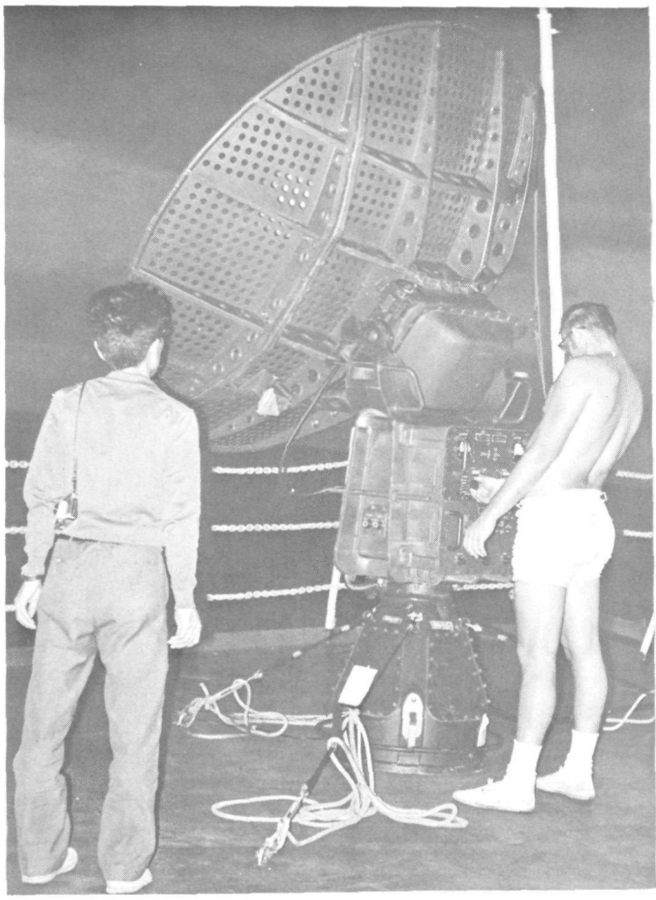

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17. Dr. Peter M. Kuhn, of the ESSA Atmospheric Physics and Chemistry Laboratory, walks an encased radiometer to its morning rendezvous with one of the 42 balloon launchings made during the expedition. Two sensor packages were tested on consecutive launchings each morning. The first was a West German design which sensed six radiometric parameters and ambient air temperature, the other a United States-Japan package sensing four radiation parameters plus ambient humidity, air temperature, and pressure. 18. The radiometersonde goes up, launched by Prof. Dr. Hans G. Muller, director, and H. Fimpel, technical assistant, of the Institute for Atmospheric Physics of the German Research and Experimental Institute for Air and Space. . . . 19. . . . and is tracked by USAF Sgt. Roger Blankenheim on the deck-mounted radar. Others participating in the Third International Radiometersonde Intercomparison were Masyoshi Shimizu and Akira Yata, of the Japan Meteorological Agency, and Monte Poindexter of AOML. 20. Davy Jones' Locker was the most distant country represented on the expedition, and here Mr. Jones himself (in the person of Junior Gray, Chief Steward) speaks to pollywog Morris Jones about the benefits and hazards of crossing the Equator at sea.

20.

ESSA Profile

With feet firmly on the ground Mary Hodge has made a career of improving upper-air observations.

The Woman Behind The Radiosonde

BY HELEN SILVER
Weather Bureau

IT WAS CURIOSITY that prompted Mary Hodge to study meteorology and led her to become a pioneer in the development of instruments that probe the upper air.

In 28 years with the Weather Bureau, she has been associated with the evolution of several generations of the radiosonde, the small balloon-borne device that gathers data on temperature, pressure, relative humidity, and winds as it rises through the atmosphere. She is an expert on the response of the instrument's sensors under various conditions and the corrections needed to make the readings accurate.

Mary Hodge was a physics student at the University of Mississippi, her native state, where she helped one of her professors keep the records of the cooperative observing station he maintained for the Weather Bureau. This task, her first contact with meteorology, caused her to wonder, she recalls, "What makes weather tick?"

"My interest in meteorology soon began taking the forefront," Dr. Hodge remembers, although she continued to hold assistantships and instructorships of increasing responsibility in physics and astronomy in addition to her studies. Her free hours were spent absorbing as much of the current literature on meteorology as she could find.

After receiving a doctorate in physics from the University of North Carolina in 1938, she returned to the University of Mississippi as a physics instructor. She also taught elementary courses in meteorology, resumed her cooperative observer duties, and the official title of Cooperative Observer was transferred to her name.

During World War II, Dr. Hodge learned that meteorology instructors were badly needed in the early pilot training programs. She qualified to teach the courses to the student pilots, and this experience further stimulated her growing interest in making meteorology her career.

Thus it was a natural transition when she joined the Weather Bureau in 1942 at New Orleans, La., as an observer, becoming one of the thousands of women who served as weather observers during the wartime manpower shortage.

Then, after a short stay at Washington's Weather Bureau headquarters, she was assigned to a special project in the Department of Meteorology at the University of Chicago. She worked with Dr. Oliver R. Wulf, also of the Weather Bureau, and together with Capt. Stanley J. Obloy of the U.S. Army Air Force, completed a study of weather patterns at 10-, 13-, and 16-kilometer levels as observed by radiosonde flights over the United States. This study, which established that the daily pressures and the pressure patterns existing at the base of the stratosphere over the United States undergo seasonal changes that exhibit considerable regularity, was an advance in knowledge of movement and changes in weather patterns at these levels.

In August 1945, Dr. Hodge returned to the Washington Weather Bureau Instrument Section to work again with the radiosonde, determining the accuracy of its temperature and pressure measurements as it travels upward, subject to warm or freezing temperatures, calm or cruel winds, and radiation from the sun.

She became Chief of the Atmosphere Section of the Physical Science Laboratory in 1963. Here she began a study on clear air turbulence. More recently, as a member of the Equipment Development Laboratory of the Systems Development Office, she worked with Harold B. Cole and DeVer Colson of the Techniques Development Laboratory on a study of the relationship between rawinsonde ascension rates and clear air turbulence, particularly clear air turbulence as reported by pilots of airplanes.

All of Dr. Hodge's work has not been in the laboratory. She has had the opportunity to participate in such field work as the early development of the ozonesonde, an instrument for measuring ozone in the atmosphere. As a result of these tests at Lowry Air Force Base in Denver, Colorado, balloon-borne ozone sensors used in conjunction with radiosondes have become a valuable tool in studies of ozone distribution in the atmosphere.

She also participated in field work at Brownsville, Texas, where the angle of the sun is the highest of any radiosonde station in the U. S., lofting radiosondes herself to determine the corrections which should be applied as a result of the sun shining on the instrument. Her findings were incorporated in the Bureau's manual of radiosonde observations.

Dr. Hodge is now assigned to the Design Analysis Group, working toward the development of yet another generation of upper-air sounding system for the mid-seventies. In her research, she is testing temperature and pressure sensors for speed and accuracy of response.

As a change of pace from wind tunnels, thermometers, anemometers, charts, and equations, Dr. Hodge finds relaxation tending the flowers and the yard of her home in Kensington, Maryland.

Professional societies as well as the Weather Bureau have enjoyed the benefits of Mary Hodge's participation. She has long been active in the South Eastern Section, American Physical Society; American Meteorological Society; and the Philosophical Society of Washington.

Each day, while weathermen throughout the United States launch hundreds of radiosondes to gather data for forecasts, Mary Hodge is at work in the laboratory improving the instrument, with her continuing patience for detail, enthusiasm, and, of course, curiosity. □

The Rocks' Magnetic Message

The history of the earth's magnetic field is recorded in layers of lava

BY RUSSELL B. STONER
ESSA Research Laboratories

Scientists at a new ESSA facility in Colorado are reading some of the oldest records of the earth's history.

This history is recorded in the strength and alignment of tiny magnetic particles in ancient lava flows. The study of these records is called paleomagnetism.

During the billions of years the earth has repeated its endless orbit of the sun, molten lava has spasmodically bubbled up through the wounds and cracks in its surface. As the lava cooled, any magnetic material within the flow aligned itself with the magnetic field at that moment. There it was frozen in the solid rock as a perpetual record of the strength and direction of the earth's main magnetic field at that particular time.

By measuring the remanent or residual magnetism in successive lava flows, the shifts and changes in the magnetic field can be traced. Radiometric dating processes (lead-strontium or potassium-argon) can then be used to fix the time of the particular flow from which a sample core is taken.

Comparison of the direction and strength of magnetism in the dated lava flows provides a chronological history of the fluctuations of the field. This information is used by scientists studying the dynamics of the circulation patterns in the planet's molten core.

This chronology also provides a possible basis for predicting future changes in the earth's magnetic field. The outlook for the future is of special concern today, because the magnetic field has been weakening by five percent a century for the past several hundred years. Dr. Keith L. McDonald, a consultant to ESSA's Earth Sciences Laboratories, has pointed out that the field will substantially disappear by about 3991 A.D., if it continues to decrease at the present rate. Since the magnetic fields protect the earth from solar and cosmic radiation, loss of this shield could alter the earth's environment drastically.

The evidence preserved in lava has applications in many fields of scientific research. It has, for example, lent support to theories of continental drift. Samples of lava flows from different continents of approximately the same time period have displayed what appeared to be contradictory evidence about the direction of the earth's field lines. When the continents are manipulated to conform to the predicted rate of movement due to continental drift, the discrepancies in the magnetic field line directions begin to resolve themselves and reach substantial agreement. If Asia is assumed to be the stationary continent and the others all wanderers, the agreement becomes quite good. Other sources, such as ocean sediment cores and land-based observations, corroborate the paleomagnetic data.

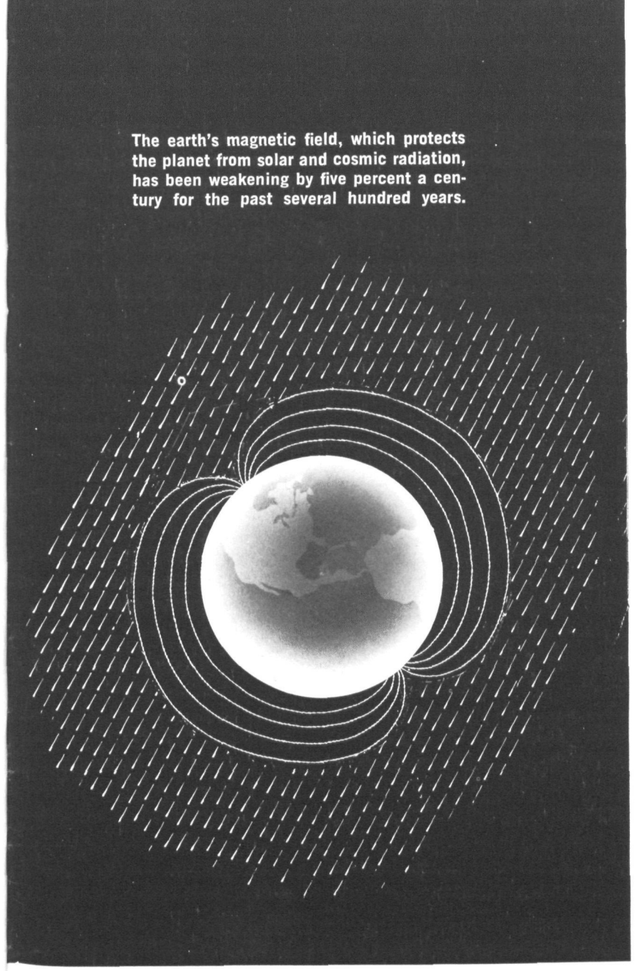
ESSA's new paleomagnetism facility is under the direction of Donald E. Watson, a geophysicist in the Earth Sciences Laboratories, and is physically located at the Coast and Geodetic Survey magnetic observatory on Table Mountain. It is equipped to demagnetize rock cores by thermal and electrical means. Not all rock is equally stable magnetically. If a sample is easily demagnetized, the information from that core is suspect. By demagnetizing sample cores, Watson eliminates those samplings that are magnetically unstable.

Any material with thermally induced remanent magnetism loses this quality if heated above a certain temperature, called its Curie point. This critical temperature changes for different materials and can be as low as 200 degrees Centigrade or as high as 700 degrees Centigrade. The Curie temperature of a rock can give information about its chemical nature and, in turn, its thermal history.

Cores from basalt flows like the Snake River Plain or the Columbia Basin are particularly tenacious of their magnetic properties. Samples taken from such an area can be used with confidence that the remanent magnetism observed is truly representative of the time period at which the flow occurred.

The Snake River Plain with layers of lava flows thousands of feet deep is geologically very recent, within the last several million years. In the Craters of the Moon area, some of these flows have occurred within the past few hundred years. Because of their recent origin and relatively high magnetic material content, these flows are of special interest in the study of geologically recent magnetic field variations.

Of even more recent origin are the lava flows on Mt. Kilauea, one of the five volcanoes which created the island of Hawaii. This still-active lava dome periodically spews out new lava which can be studied and compared with magnetic field readings taken at the exact time of the flow. It is possible to determine in this way that magnetic particles within the flow do indeed line up with the field lines of that time, and that the remanent magnetism is a measure of the strength of the field.



The earth's magnetic field, which protects the planet from solar and cosmic radiation, has been weakening by five percent a century for the past several hundred years.

Paleomagnetic studies have shown that the earth's magnetic field changes in strength and direction with time. Complete reversals of the field have been found. By a careful study of cores taken from lava flows over geological ages, Watson hopes to document these changes in greater detail. This will improve the understanding of recent variations in the field, help explain the dynamics of circulation within the earth's core, and enable scientists to develop theories that may be used in forecasting future magnetic conditions.

While paleomagnetic studies have found evidence of magnetic field reversals, no indications of neutral magnetic periods have been discovered. The weakest fields during a transition of polarity, judging from remanent magnetism, have been perhaps one-fifth as strong as the present field. If the magnetic field really goes through zero during a reversal, no one has yet found material in which the zero field is frozen. Watson hopes to find the elusive evidence some day.

To obtain samples of lava flow for study, Watson uses a hollow diamond drill to cut cores 6 to 12 inches long from the selected site. The core must be carefully oriented to either magnetic or geographic north and marked for future reference. Back in the laboratory, a small, rounded cube is cut from the core for study. A spherical sample would be the ideal shape to work with, but for ease of cutting and orientation, the rounded cube is more practical.

When the cube has been cut and marked for orientation, it is placed in a spinner magnetometer, also called a rock generator. The sample sits in a turbine which is rotated at high speed by air pressure (155 revolutions per second). The local magnetic fields are removed from the space occupied by the sample by putting a current through a set of coils surrounding the turbine.

As the sample is rotated, it acts as a spinning magnet,

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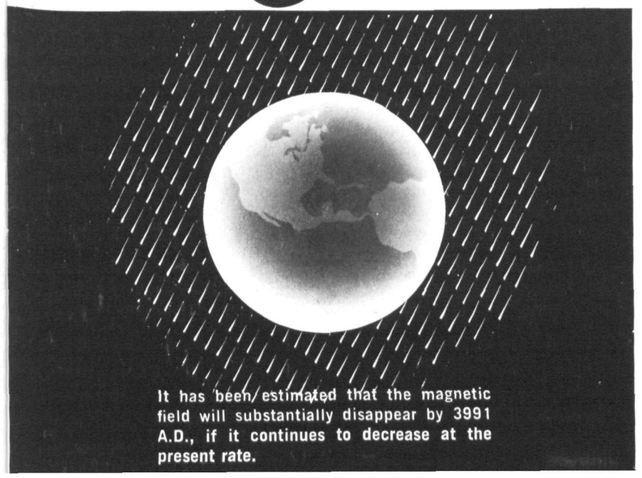


It has been estimated that the magnetic field will substantially disappear by 3991 A.D., if it continues to decrease at the present rate.

The evidence preserved in lava has applications in many fields of scientific research.

generating a current that is detected by a sensing coil. The sample is spun in three different positions, mutually perpendicular to each other. The combined signal detected through the sensing coil can then be used to give the total intensity and direction of alignment of the magnetic material within the cube.

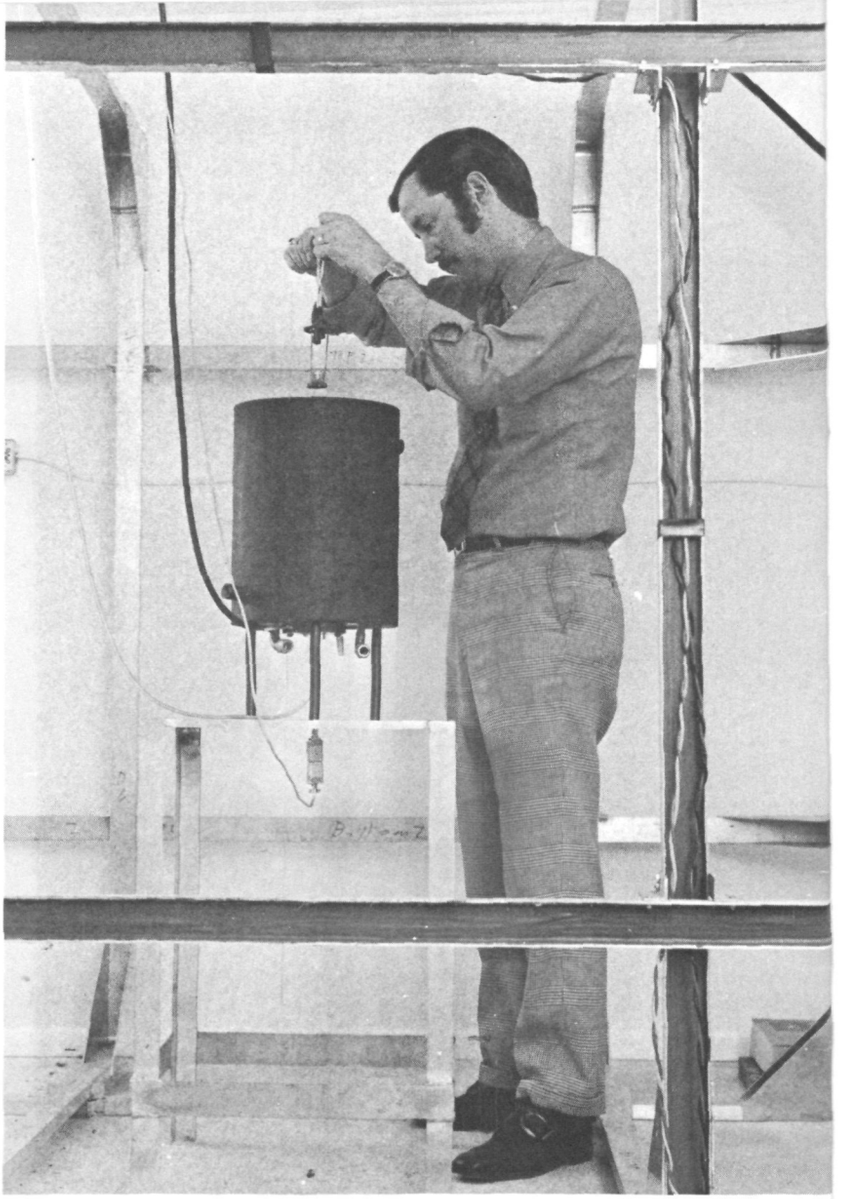
If the sample is magnetically stable, the special magnetic properties of the rock, in all likelihood, have remained constant through time. To determine this stability, a sample from the same core can be demagnetized either thermally or electrically. The thermal demagnetization is accomplished by placing the sample in a small furnace surrounded by six large coils. A current is fed to these coils to cancel the magnetic field around the furnace while the sample is being studied. The temperature within the furnace is increased, and the changing magnetic properties of the sample are monitored until the remanent magnetism in the rock is destroyed. This process not only determines stability, but also removes any unwanted noise or error.

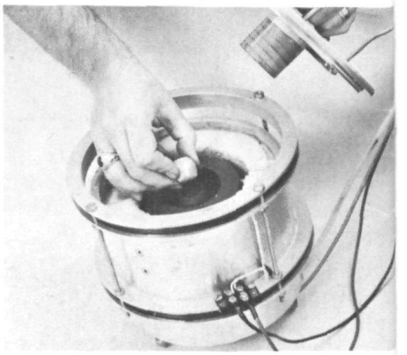
After heating the sample above its Curie point, if it is allowed to cool while the coils are cancelling the local field, the magnetic particles in the cube are randomly aligned. If it were then spun in the rock generator, the random orientation of the individual particles would cancel each other so the total signal will be zero. A lava flow which occurred when the earth's field was at zero would register in the same way.

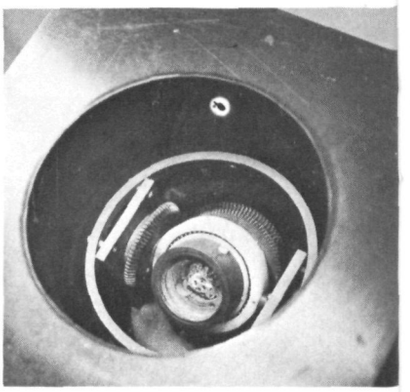
If the heated sample is allowed to cool outside the protecting coils, the magnetic particles will align with the earth's magnetic field at that moment, just as they did when it cooled from molten lava as much as two and one-half billion years ago. Placed in the rock generator, the sample would produce a signal that would correspond to the present strength and direction of the local earth's field.

After a rock has acquired its original magnetization, various natural phenomena such as lightning strikes or oxidation can alter it. To filter out these later changes, a second method of demagnetizing rock samples is used. This is accomplished by using alternating current (60 cycle) in conjunction with a special tumbling device designed by Watson. A strong magnetic field, generated by a large coil that surrounds the rock, is passed back and forth through the sample while it is tumbling about three axes simultaneously. Demagnetization is continued until a predetermined amount of the remanent magnetism is destroyed. This technique, as with the thermal demagnetization method, indicates the stability of the rock's magnetic properties in addition to eliminating unwanted noise.

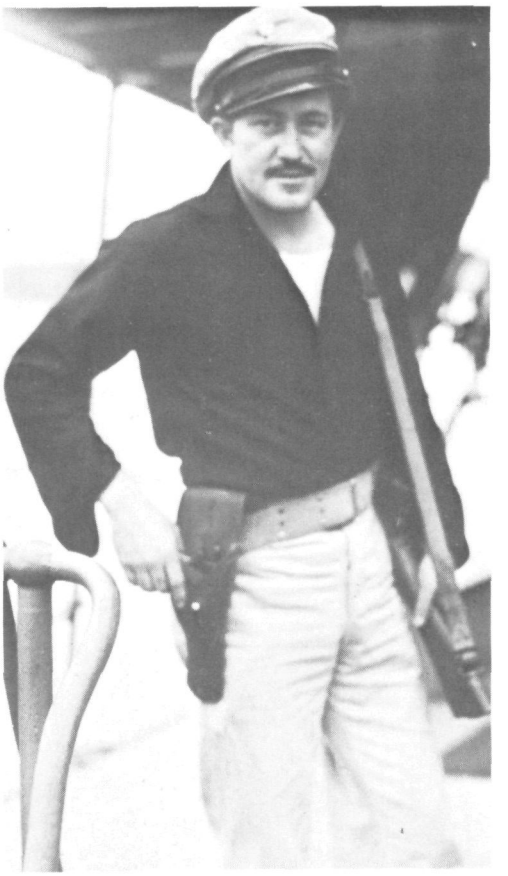
The ERL paleomagnetism facility is still a very new effort. No startling discoveries have been reported from the preliminary studies conducted at the Table Mountain site. But Watson, like A. Conan Doyle's quiet, substantial character, patiently sifts the clues found in each sample for information that will improve man's understanding of the planet which is his home. □







The paleomagnetism facility on Table Mountain is equipped to demagnetize rock cores by thermal and electrical means. (Above) Donald E. Watson, a geophysicist in the Earth Sciences Laboratories, inserts a lava sample into the thermal demagnetization furnace to check the intensity of its remanent magnetism. The frame-work surrounding the furnace contains the coils which are used to cancel the local magnetic field. (Right, above) Measurements of remanent magnetism are made in a spinning magnetometer. The sample is spun in three mutually perpendicular positions, and the sum of observed signals recorded, to arrive at the wanted information. The sample chamber is enclosed in coils which cancel the local field. The turbine is powered by compressed air, since an electric motor would introduce an unwanted field. (Right, below) Electrical destruction of remanent magnetism is accomplished in this device. The rock sample is placed in the chamber and tumbled, while strong, electrically induced magnetic fields are passed through it.



Bos'n Bob Savage signed on for one year and stayed 39 more

Salt of the Survey

BY RAYMOND WILCOVE
Coast and Geodetic Survey

THE FATHER gazed at the boy standing before him. Then he picked up his son's plate, broke it in two, and gave him $5 and his blessing. Robert C. Savage had joined the Coast and Geodetic Survey, and this was good-bye to his family.

It was 1930 when the 17-year-old began his first one-year hitch with the Coast Survey, a hitch that was to be extended to a career of nearly 40 years.

He sailed on steam-propelled ships and on modern electronically equipped diesel-engine floating oceanographic laboratories on a tour of duty that included J. P. Morgan's yacht CORSAIR II, converted Navy sub-chasers, tired old scows, a rowboat, and the sleek, gleaming white ships of the Coast Survey's modern fleet.

During his two-score years with the Coast Survey, he sailed up and down the Atlantic and Pacific coasts and the Gulf of Mexico, and to the West Indies, South America, and Europe. He was in the Aleutians when the Japanese were there, and he watched Russian ships sail into Cuban waters as the world teetered on the brink of nuclear war.

Savage spent two wartime years in the Aleutians. On one occasion, Japanese planes attacked the EXPLORER. Savage was aboard the SURVEYOR. "We were lucky," he remarks. "We were at sea at the time and missed the bombardment."

Savage was on the HYDROGRAPHER when the Cuban missile crisis exploded. "We first worked out of St. Petersburg, Fla., in 1960, conducting surveys in Cuban territorial waters. We were on friendly terms then with the Cuban government and part of our hydrographic surveying took us close to Cuba. We worked well inside the three-mile limit, sometimes as close as 1½ miles off shore. We had the proper diplomatic clearance, and Cuban naval personnel came aboard a few times to view our operations. There were no surveying operations in the vicinity of Cuban waters in 1961 and 1962, but in 1963 the HYDROGRAPHER was on the job again. By this time, however, things had worsened, and the ship never entered Cuban territorial waters. We stayed more than 12 miles from shore as we conducted our surveys. From there we watched the Russian ships laying to off Havana harbor, waiting to sail in."

The HYDROGRAPHER vacated the threatened area in time to avoid being caught up in the turmoil. "After the crisis blew over," he said, "we returned and finished the job."

Savage began his career as a contemporary of many of the men who later went on to become leaders of the Coast Survey. Rear Adm. Don A. Jones, Director of the Coast Survey, was an ensign when Savage signed on the old OCEANOGRAPHER, the former Morgan yacht, for his first tour of duty. Before Savage left the ship 13 years later, he rubbed shoulders with two more future Directors of the Coast Survey—Robert F. A. Studds and L. O. Colbert. When he retired in 1969—after a career that covered 39 years, eight months, 11 days—among the many at the Atlantic Marine Center who shook his hand and wished him Godspeed was Rear Adm. Allen L. Powell, the Director of AMC, with whom Savage had served in 1950 when Powell was a lieutenant, junior grade.

In Savage's almost four decades at sea, he trod the decks of 18 ships. Fifteen of them have since been decommissioned. In addition to the first OCEANOGRAPHER, they included the PARKER, BOWEN, and STIRNI, former Navy sub-chasers converted for wire drag and hydrographic work; the old SURVEYOR; the GILBERT, LYDONIA, FERRIS, SOSBEE, HODGSON, WAINWRIGHT, MARMER, HYDROGRAPHER, PATTON, and the LAUNCH ELSIE III. During the final decade of his service, he sailed aboard the newer ships, the MCARTHUR and DAVIDSON and, last of all, the MT MITCHELL.

The rowboat? Admiral Powell contributed that to the Savage saga. "We had a request from the Navy in the early 1950's to survey Little Creek near Norfolk, Va., where the big Navy amphibious base is now located. The harbor there was too small for a power launch, so we took a rowboat. Al Thorson, who was then skipper of the P-B-S ships (the PARKER, BOWEN, and STIRNI), rowed the boat, Savage threw the lead for the soundings, and I plotted our position. The whole operation was somewhat of an anachronism. Lead soundings from rowboats were long since a thing of the past, but that's what the situation called for, so we did it. We were probably the last in the Coast Survey to employ this method."

Savage recalls vividly his tour of duty aboard the old OCEANOGRAPHER. When she was acquired from J. P. Morgan in 1930 for $1, she was as fine a yacht as ever sailed the seas and one of the most famous vessels in the world. She was 270 feet long on the water line and 324 feet overall, longer than the present-day 303-foot OCEANOGRAPHER. At 1600 tons displacement, she was, however, less than half that of her 3800-ton successor. Morgan turned the CORSAIR II over to the Navy during World War I and she was on escort duty out of Brest, France, until the war ended.

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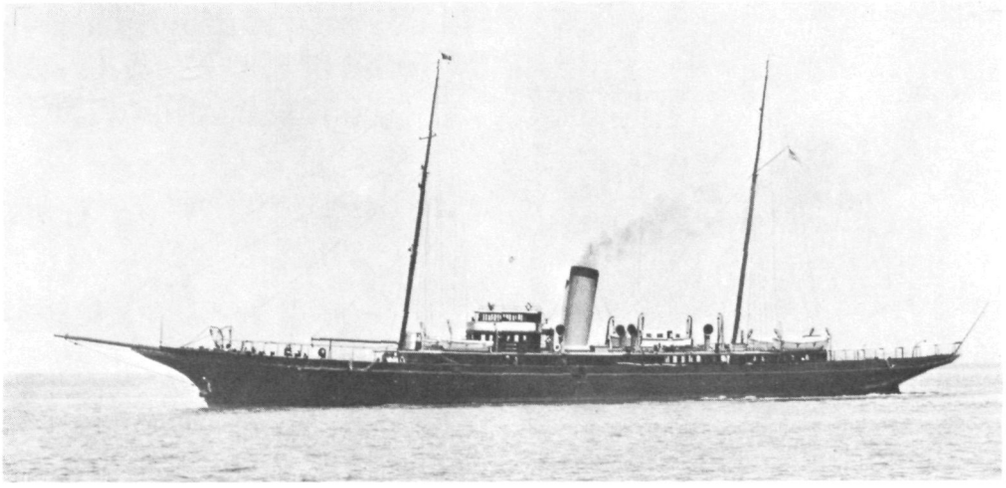


The Coast Survey career of Bob Savage (upper right) spanned an era from steam-propelled ships to modern diesel-engine floating laboratories. He sailed the Atlantic, Pacific, and Gulf coasts and to the West Indies, South America, and Europe. (Top left) In 1930, he signed aboard the old OCEANOGRAPHER, which had been J. P. Morgan's yacht, CORSAIR II. (Lower left) His career afforded unexcelled oportunities for fishing. (Lower right) The Chief Bos'n expressed his pleasure at a retirement gift to his last CO, Cdr. K.A. MacDonald.

She was returned to the Wall Street financier in 1919. Morgan used her as his yacht until January 1, 1930, when she was transferred to the Coast Survey.

"She was a handsome vessel," remembers Savage. "Her decks were made of teakwood, and we scrubbed them down every morning before breakfast. When the men came up from the engine room, they took off their greasy shoes and replaced them with regular shoes so the fine decks wouldn't get dirtied.

"The superstructure was made of teakwood and mahogany. We washed it with buckets of water and then went over it with chamois cloth. The housing and mast, which towered 100 feet above the deck, were varnished and the stack was buffed. Her hull was black. There's never been another ship like her in the Coast Survey, or elsewhere, for that matter."

The OCEANOGRAPHER had a complement of about 60 commissioned officers and crew. Her first skipper was Lt. Fred Peacock, followed by Commanding Officers H. A. Seran, Frank S. Borden, and L. O. Colbert. "Pete" Peterson was the Chief Boatswain for the entire 13 years Savage served aboard the ship. Savage remembers that especially because, before he completed his own stint with the Coast Survey, he himself was one of the best known Chief Bos'ns in the service. When Savage retired, he had been Bos'n for 10 years and prior to that a quartermaster for 29 years.

Savage was at the wheel when the OCEANOGRAPHER was turned over to the Navy at Portsmouth, Va., in 1943 for her second wartime tour of duty. She served during the war in the Pacific. Her work completed, she was completely destroyed, in line with Morgan's instructions that nothing was to

be left of the old vessel when she was finally retired from service.

Savage says he was apparently made for the sea. "It always had an attraction for me. In 1928, when I was 16, I signed on as a seaman aboard a passenger line steamship in New York for eight months and then went to work for the U. S. Shipping Board in Norfolk, again as a seaman, but this time fitting out ships for sea duty. After a year there, I returned home.

"One day, my brother Jack signed up on the 'Oceo' in Hampton Roads. Three days later, I went to the ship to bring him his clothes. I had no intention of joining up. All I intended to do was deliver his clothes, but before I left Lieutenant Studds signed me up, too." His pay: $780 a year.

"We started at $65 a month. That included our keep. Those were the days when, if things got slack, men were furloughed. Translated into plain English, that meant they were given time off without pay. It was not until much later that paid vacations—annual leave—were put into effect.

"We had to buy our own uniforms, and naturally we bought the best we could. I had mine tailor-made in Boston. It cost me $18, more than one week's pay. But having a uniform helped us keep up our morale. We took pride in our uniforms.

"The work was hard, very hard. There was no air conditioning then. I had two pillows in my bunk. When one got wet from sweat, I had a dry one to use. During the depression in the 1930's, no one got rated for seven years. There were no promotions. But we worked with a dedicated bunch of people.

"We enjoyed what we did even though we didn't make much money. We knew that our work served a very useful purpose. We were making the coasts safe for thousands of ships and for fishermen, yachtsmen, and sportsmen. We always came back with a job well done."

As quartermaster and bos'n, Savage estimates that he helped train hundreds of officers in the art of seamanship. "Most of them came aboard as green as grass, fresh out of college. Some of them had never set foot aboard a ship. But most of them caught on fast, and it wasn't long before they got the hang of it. By the time many of them retired, they were as fine a bunch of officers as you'd care to find in any man's fleet."

Among the many officers he helped to train in the ways of the sea were Rear Admiral Jones; Rear Admiral Powell; Cdr. H. S. Seran, former skipper of the 'Oceo'; Captain Harold J. Seaborg, former Director of the Pacific Marine Center in Seattle; Captain Cornelius D. Meaney, former CO of the old OCEANOGRAPHER and SURVEYOR; Captain Raymond E. Stone, San Francisco Field Representative; Cdr. Edwin K. McCaffrey, Commanding Officer of the MT MITCHELL; Captain Merlyn E. Natto, former skipper of the present OCEANOGRAPHER; Captain Edward Brown, who commanded the EXPLORER and headed the Kansas City, Mo., regional office; Cdr. Kelly E. Taggart, Program Planning and Coordinating Officer in the Office of Hydrography and Oceanography; and Cdr. Charles A. Burroughs, Program Planning Officer in the Director's Office.

Savage always tried to inculcate in the men with whom he worked rules of safety that would protect them and their companions from injury and safeguard the ship. Some are worth repeating.

"Never be in a hurry. Take your time and you will get there and get the job done quicker and safer.

"Safety first aboard a survey vessel depends on good, alert petty officers and leading men. There are no set rules that can be applied to a survey vessel. Due to the hazardous work and new men at the start of each field season, petty officers and leading men have to be alert and on their toes.

"A leading man should never get mad and yell at his crew if they make a mistake. This could cause an accident. Take them aside and show them their mistake. Then show them the way to do their job."

And this also:

"Never take things for granted. Inspect. Be sure, not sorry.

"Keep alert at all times when standing anchor or lookout watch in a fog or heavy rain. The safety of your ship may depend on you.

"Safety first aboard ship is everyone's job. Be alert. Think before you act.

"Have patience and train your crew. A well-trained crew is a safe crew."

Bob Savage was the type of sailor that other men liked to ship with. Admiral Jones was impressed with Savage's work when he served aboard the old 'Oceo' from 1939 to 1942 as ensign. "His ability as coxswain aboard the Oceo is phenomenal," Jones wrote more than a quarter century ago. "He was invariably called to the wheel when in dangerous channels and when approaching and picking up buoys at sea."

Captain Meaney, with whom Savage served on the old 'Oceo' in the late 1930's and again on the old SURVEYOR during the mid-1940's, commented recently: "When I knew him he was chief quartermaster on the OCEANOGRAPHER and SURVEYOR. He was skillful, reliable, alert, courteous, competent, and patriotic. He always did an excellent job, whether he was steering the ship while coming alongside, casting off, or overseeing the work of other quartermasters at sea or in port. You could always depend on him to carry out his assignments with distinction." High words indeed by a CO for an old salt.

For Rear Adm. Alvin C. Thorson, skipper of the old PARKER, BOWEN, and STIRNI, now residing in Seattle, the trait that stands out the most when he recalls Savage's work aboard the ships is Savage's unfailing good humor.

"I shall always remember his meeting me in the morning with a cup of coffee and a cheerful 'good morning'," says Thorson. It was a privilege to have a man of Bob's character aboard our ships."

Captain John C. Mathisson, recalling Savage's service aboard the same ships some years later, credits Savage with contributing to the safety of the three vessels during three hurricanes which assaulted them while they were wire dragging off treacherous Cape Hatteras, N. C.

"Due to the superior seamanship of Bob Savage and other members of the party, the three drag boats weathered three rather intense hurricanes that passed over the Cape Hatteras area during the summer of 1955 with no loss greater than part of the ground tackle of one of the units," says Mathisson.

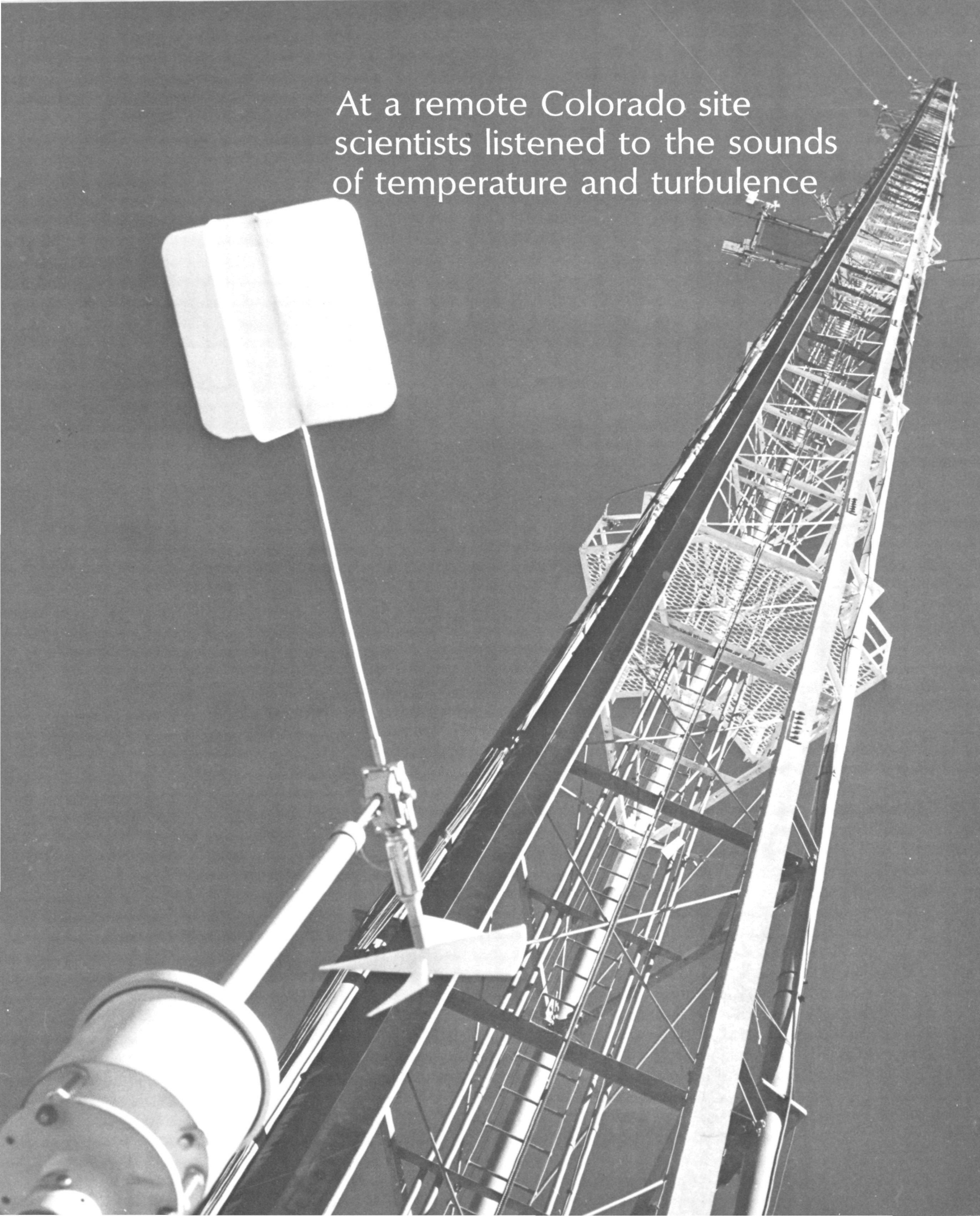
Captain Harry D. Reed, Jr., who skippered the HYDROGRAPHER during 1965-66 when Savage served as Chief Bos'n, remembers Savage as a man who could be depended upon.

"His true worth was not measured in terms of spectacular performances," says Reed, "but lay in his thorough knowledge of his job, his loyalty and dependability, and in the steady and efficient manner in which he worked. Very often, he had to operate under all-too-familiar handicaps of personnel and equipment shortages, but due to his outstanding leadership and his ability to make the best use of what was available, his department always functioned efficiently. Bob's achievements went well beyond normal requirements and expectations."

In 1966, on the occasion of his 35th anniversary with the Coast Survey, Vice Admiral H. Arnold Karo, then Deputy Administrator of ESSA, summed up what others were saying about Savage when he was awarded the Department of Commerce Bronze Medal. It was being awarded, Karo wrote Savage, "in recognition of your outstanding performance as an able, dependable, and dedicated employee."

One of the brighter aspects of Savage's work was the unexcelled opportunities for some fine fishing. His associates knew him as an inveterate fisherman. Almost as faithfully as the anchor light was displayed in the evening, Savage would have a light over the side to attract squid for bait. Many of the wrecks (Savage estimates that from 1950 to 1957 he helped chart at least 500 wrecks, including perhaps as many as 10 German submarines, between New York and Cape Kennedy) were generally unknown to local fishermen.

"When our drag line hung in," recalls one of Savage's officers, "it disturbed the rigging of a sunken vessel and thousands of fish of numerous varieties would come boiling to the surface of the sea. Frequently, while taking in the drag, a dolphin (not a porpoise, but the colorful long, slim ocean fish) would follow the wire right up to the stern of the boat. There were few occasions when Bob would not have a baited hook over the side ready to take advantage of the situation. He seldom missed." □


At a remote Colorado site
scientists listened to the sounds
of temperature and turbulence

A WEATHER EAR

BY RALPH SEGMAN
ESSA Research Laboratories

ON THE HIGH, quiet plains of southeastern Colorado, an international group of environmental scientists has performed a remarkable cooperative study of the atmosphere, using perhaps the most advanced array of meteorological instruments ever combined in a single research project.

At a remote site near Haswell, Colorado, scientists from Australia, Canada, and the United States probed the lower atmosphere with acoustic sounders, 14-mile-long microwave and laser beams, Doppler radars, and a 500-foot instrumented tower.

Knowledge gained by the international team may lead to new methods of monitoring air pollution in major cities, guiding jet aircraft through rough air during airport approaches, and prewarning of flash floods by monitoring heavy rains in remote areas.

Conducted in September and October 1969, under the Hornig agreement for the exchange of scientific and technical information between the United States and Australia, the experiment was conceived as a result of the successful acoustic "radar" research by Lindsay McAllister and J. R. Pollard of the Australian Department of Supply.

The acoustic sounding technique, developed by the Australian group, is based on the extreme sensitivity of sound waves to turbulence and temperature fluctuations. Echoes are obtained from these changes in the atmosphere.

According to Dr. C. Gordon Little, director of ESSA's Wave Propagation Laboratory, the chief objectives of the Colorado project were to evaluate these important new instruments by studying their performance alongside a meteorological tower, and to learn considerably more about the processes occurring in the lowest 5000 feet of the atmosphere, known as the boundary layer.

High correlation was found between the measurements made on the tower and those obtained by the acoustic sounders. This suggests that meteorologists will soon have a powerful new ground-based tool for practical and research uses.

Another early finding concerns the nighttime layering of the few hundred feet of the atmosphere closest to the earth. Project Senior Scientist Bradford R. Bean, also of the Wave Propagation Laboratory, says that the acoustic sounders developed by the Australian group have shown that the layers are very stable and sometimes have waves on them, depending on the winds just above them.

The 500-foot meteorological tower at Haswell, Colo., had three instrument platforms on its left side. The anemometer in the foreground is at ground level.

"The acoustic sounders and to a lesser extent the tower instruments," Dr. Bean said, "have shown many small stable layers in the atmosphere that seem to be constantly forming, particularly at night. They are about a half-mile to two miles long. Some even seem to descend from greater heights to altitudes as low as 100 feet.

"A wind often develops above the layers, rising to a maximum, then interacting with the layers, developing waves, and finally breaking up the layers. This process usually works in cycles of 20 to 30 minutes, although waves may remain for hours. The waves are generally of the order of 3000 feet in length. Some have been found 250 feet from peak to trough.

"These phenomena are quite different from the things meteorologists are used to working with."

Early experiments in Australia had demonstrated that sound pulses propagated straight up into the clear atmosphere were backscattered from regions of turbulence and different temperatures. The altitude to which the sound echoes were obtained was also a function of the frequency and intensity of the acoustic waves.

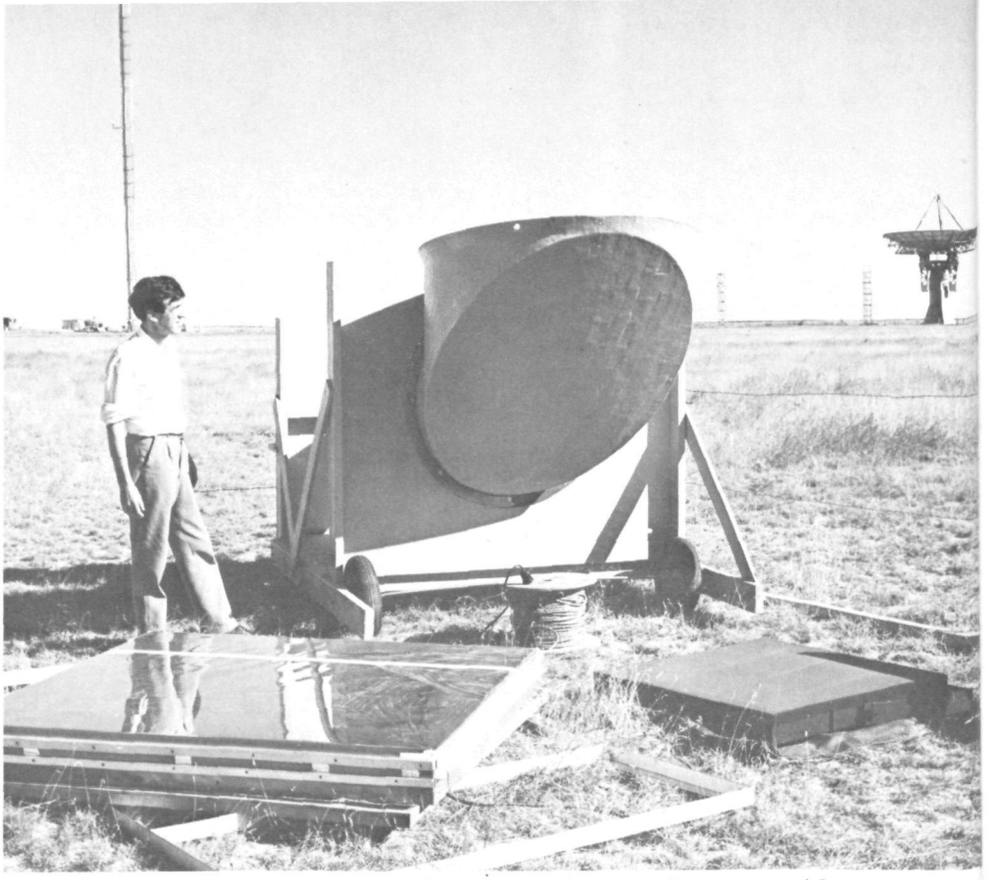
Commenting on the the Australian research, Dr. Little said the McAllister group "used a 200-foot tower with a thermometer and an anemometer on top and were able to confirm the nature of the meteorological regions from which the echoes were returning. At ESSA, we were impressed by reports of their work in the scientific journals. It seemed that if the acoustic sounder could be developed to give us quantitative data, that is, the actual temperature and wind changes rather than only the fact that there are inversions and turbulent regions, the device could add an important dimension to atmospheric remote sensing. On this basis, we and the Australians decided to work together alongside a 500-foot tower instrumented for the specific needs of the acoustic sounding test."

The site selected for the project was about 130 miles southeast of Denver, near Haswell (population 169). Acoustically, the site is quiet, and a tower had been erected there some years before for telecommunications research by the National Bureau of Standards.

Most important, however, was the area's natural bowl shape—14 miles across and 200 feet deep. It is like a great laboratory in which nature exerts fairly precise and predictable controls over a variety of atmospheric conditions. At night, cool air drains into the bowl creating a stable atmosphere marked by a temperature inversion—a pool of cool air topped by warmer air. The situation changes drastically in the morn-

continued

Project Senior Scientist Bradford R. Bean checks data in the underground central data display, processing, and storage facility. Time-code broadcasts from the National Bureau of Standards were keyed into the data records.



J.R. Pollard of the Australian Department of Supply stands between his flat-array echo sounder (49 loudspeaker/microphones covered by metal foil) and the ESSA Mark I acoustical horn antenna.

ings. Heated by the early sun, the lower air rises in convective plumes to break the inversion.

In the center of this bowl stood the 500-foot-high tower with instrumentation located on platforms at 128, 311, and 492 feet. Additional instruments rode on an elevator that could move 50 feet a minute or could be positioned at any level. The instruments, nearly identical on each platform, included:

Microwave refractometers for humidity measurements; high-speed thermometers to record temperature differences between two points spaced eight inches apart at rates up to 100 readings per second; hot wire anemometers for the measurement of the differences in wind velocity over an eight-inch spacing; and bivanes for three-dimensional wind measurements. (The eight-inch spacing was chosen to coincide approximately with half an acoustic wavelength, since theory shows that the acoustic sounders would be especially sensitive to atmospheric turbulence and temperature eddies of this size.)

Using the Haswell tower only, ESSA ran an intensive micrometeorological study of atmospheric turbulence. The sensitive, quick-responding instruments measured the fluxes, or transport within the atmosphere, of heat, energy, water vapor, and air particles.

The three acoustic sounders were located 750 feet northwest of the tower to prevent interference by echoes from the high structure. Two sounders operated by the Australians, McAllister and Pollard, were basically five-foot-square arrays of 49 loudspeaker/microphones working in the 800- to 950-cycle-per-second (cps) range. The third sounder, operated by the Australian team under Dr. Little, had horn-shaped antennas, generated 1,000 to 5,000 cps sound, and was more directional in its sound wave propagation.

During the five-week program, the Australian and ESSA sounders observed and measured atmospheric turbulence and temperature fluctuations as a function of their three-dimensional size; downwind and crosswind dimensions of rising plumes of warm air during the day; dimensions of low-lying horizontal layers of night air; speed, direction, and size of waves at the interface of the night air layers; and natural background acoustic noise levels.

The sounders were checked to see if interpretations of the echoes stood up against meteorological measurements of known accuracy made by the highly sophisticated instruments on the tower. It is hoped that acoustic sounders can be successfully converted from instruments that recognize regions of the lower atmosphere by virtue of temperature and wind variations to highly sensitive instruments that can accurately measure the variations. Preliminary results of the Haswell experiment indicate that it should be possible to use acoustic echoes to derive profiles of wind speed and direction. McAllister and Dr. Little believe it is now possible to design acoustic sounders that can sense and measure important temperature and turbulence conditions up to several thousand feet without depending on an instrumented tower for confirmation.

Microwave and laser transmitters were set up on the south rim of the Haswell bowl, 14 miles away from their receiving antennas on the north rim. Their parallel beams passed 500 feet east of the tower at the 200-foot level and measured the average temperature and water vapor along the entire path. A small Doppler radar was used to measure the velocity of raindrops.

Unlike the tower instruments and acoustic sounders, which make spot measurements, microwave and laser systems measure average conditions along a path, which may be quite long. The purpose of this program was to evaluate a different type of remote sensing system.

In traversing the 14 miles from rim to rim of the Haswell bowl, the microwave beam was influenced by the combined effects of air temperature and water vapor, and the laser beam

was altered only by the temperature. These refractive influences amounted to exquisitely small changes in the velocities of the two beams. Measurements of the velocity changes enabled the scientists to determine the average temperature from the laser and the average water vapor content by subtracting the temperature effect out of the microwave reading. Temperature and water vapor may vary considerably from point to point, and a reading by a conventional instrument at a point may not be representative of a whole region.

Radio waves transmitted from rim to rim of the Haswell bowl in the early morning faded drastically, indicating that the signals were arriving at the receivers over several different paths and from different directions. The changes in path and direction of the signals were the result of refraction from early morning atmospheric stratifications. These effects are important in radio and optical techniques of satellite tracking at low angles, radio geodesy, and line-of-sight communications.

The microwave system was also used to measure the fading of microwave signals as a result of scattering and absorption by rain. Rainfall rate and velocity of rain drops were measured along the beam path. Although remote sensing was involved here, this was more of a corollary study of the attenuation of radio wave propagation for telecommunications purposes.

Dr. Bean said the Weather Bureau is interested in the microwave/laser instruments for special purposes in relatively inaccessible regions (they are too expensive at present for widespread use in weather forecasting). The Bureau is currently evaluating the system for measuring humidity and precipitation in remote watersheds in order to issue flash-flood warnings.

Another remote sensing program at Haswell was the measurement of wind velocity at a distance with two spaced infrared radiometer beams. Turbulent characteristics of a parcel of air were detected by one radiometer, and when the same turbulence crossed the second infrared beam, all that was needed for computing the wind velocity was the distance between beams and the time it took for the parcel to make the crossing.

The observations from this array of instruments were transmitted to a central data display, processing, and storage facility, giving project scientists sufficient immediate information to modify the experiment as they went along.

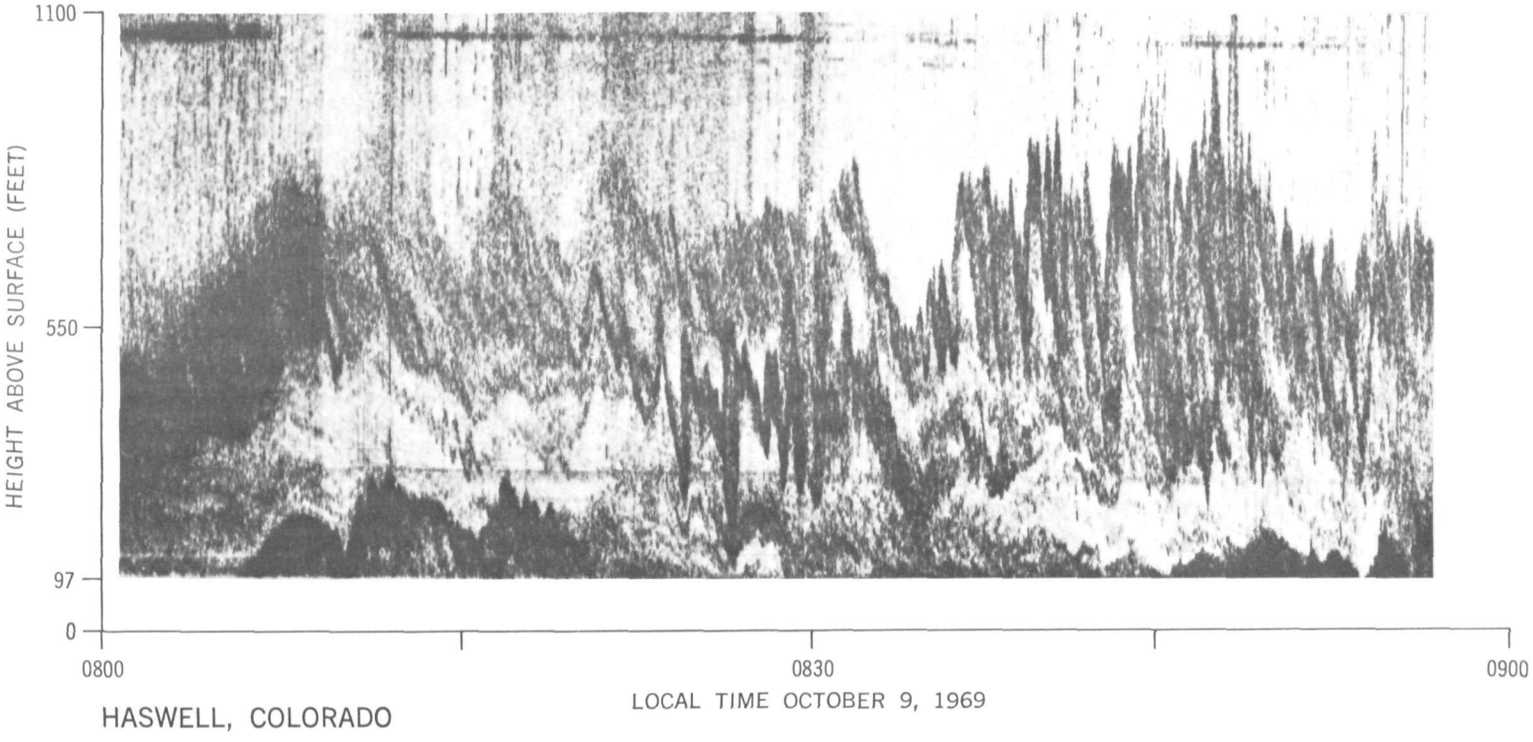
The time that each bit of data was collected was recorded with such accuracy that simultaneous meteorological conditions, as measured by all the instruments in the experiment, are known for analysis purposes from one fraction of a second to the next. This accuracy was built into the experiment by keying time-code broadcasts from the National Bureau of Standards station WWV into all data records.

The availability of the site and instrumentation encouraged scientists to come to Haswell for cooperative studies. Amongst these were optical radiometric studies headed by Prof. V. Sanborn of Colorado State University. One of the main goals of this study conducted by Dr. F. Krause of the National Aeronautics and Space Administration's Marshall Space Flight Center, Huntsville, Alabama, was to evaluate the basic differences between optical and infrared radiometers as wind and turbulence sensors.

Professor M. Miyaki of the University of British Columbia compared his sonic anemometer with those of the ESSA group. He also mounted his device upon a National Center for Atmospheric Research (NCAR) aircraft for inter-comparison with tower observations. As an example of the cooperative nature of the experiment, Professor Miyaki also flew "boxes" around the tower at different altitudes in order to help ESSA scientists in evaluating the measurements from the tower.

Dr. Little believes the acoustic sounding technique explored at Haswell could soon be useful at airports where the passenger jets are susceptible to strong turbulence at the lowest 500 feet. It should also find application in air pollution studies and predictions of diffusion and movement of pollutants. In any case, this technique is expected to give meteorologists a new understanding of the weather in the lower part of the atmosphere where people live. □

Record of acoustic echoes from 1800 pulses transmitted during a single hour. The tremendous amount of information on atmospheric structure shown here has only been partially analyzed.



SEICHE: the quiet killer

BY LAWRENCE A. HUGHES Weather Bureau

Its only outward sign is the silent rise of a lake's water level.

If, in reaching for the morning paper, you jostle your cup of coffee, the liquid continues to rock back and forth in the cup after the cup itself has come to rest. This is a seiche in miniature, the same phenomenon that occurs in large bodies of water.

Seiche is defined as a continuation of a water-level disturbance after the external forces causing the disturbance have ceased to act.

In North America, the Great Lakes experience the most notable seiches. The Lakes might be jostled, like the coffee cup, by an earthquake. But while this could happen—as it does in the oceans, to form the dreaded tsunami, or tidal wave—the amount of jostling in past earthquakes has been too small to produce significant shifting of the water surface of the Lakes. The causes of seiches on the Great Lakes are atmospheric.

Returning to the analogy of the coffee cup—if, instead of jostling the cup, you blew on the coffee surface to cool it, the liquid would be displaced to the far side of the cup and would continue to slosh back and forth when the blowing stopped.

This type of seiche, caused by wind, takes place on all lakes, large or small. A very notable example occurred on Florida's Lake Okeechobee where, in September 1928, a hurricane blew so hard over this moderately large but very shallow lake that it tilted the lake surface until the water went over the banks, drowning hundreds of people and destroying much property. If a moderately strong wind of about 30 miles per hour blows along the long axis of Lake Erie for several hours, it moves a considerable amount of water from one end of the lake to the other, also tipping the surface of the lake like the coffee. While the wind

is piling up the water, as in the Lake Okeechobee case, the water disturbance is more properly called a surge than a seiche, as the force causing the disturbance is still acting. When the wind dies down or changes direction, the initial force is no longer acting, and the disturbance becomes a seiche, with the lake surface rocking back and forth for many hours while gradually returning to normal. The maximum water-level displacement in these cases almost always occurs with the initial surge, rather than with the following seiche; however, the difference is purely technical and of no concern to those affected by the water disturbance.

The piled-up water at the downwind end of the lake tries to flow beneath the surface back to where it came from, but in shallow lakes—such as Erie with depths generally less than 100 feet or Okeechobee with depths much less than 100 feet—the bottom friction slows the flow so that a considerable pileup can occur. On Lake Erie, this pileup is usually at Buffalo, because the strong surface winds are mostly westerly. When this happens, the water buildup may be more helpful than harmful, because it provides extra water in the Niagara River for hydroelectric power generation. However, it also lowers the water level at the already shallow western end of the lake, leaving insufficient water depth for large boats. Ore boats and other commercial vessels may be forced to wait for the wind to die and the water to rise again before entering this shallow part of the lake.

When pileup is caused by strong easterly winds, there may be some flooding in areas around the west end of the lake and insufficient water in the east for power generation direct from the river. Previously pooled water must then be used to continue power generation.

Over a recent 20-year period, it was found that the amount of water drop at Toledo on the lake's western end, *plus* the amount of rise at Buffalo, amounted to a maximum of 13 feet and that this figure exceeded eight feet about once each year. The other Great Lakes are deep enough that the subsurface return flow usually prevents sizable pileups of water except in bays such as Saginaw and those on either side of the locks at Sault Ste. Marie.

Objective forecasts of wind-caused water-level deviation on Lake Erie—based on a dynamical-statistical technique and done by an electronic computer at the Weather Bureau's National Meteorological Center—are now being used in an operational-test program.

There is still another kind of atmospherically induced seiche—a quiet seiche—which is more complex and therefore more interesting. The coffee cup analogy can be used again if we compare the water disturbance mechanism to the dunking of a doughnut. The doughnut is a squall line, a line of fairly strong thunderstorms. The downdraft winds and the pressure disturbance of these thunderstorms create a water wave in the lake as the line of thunderstorms moves from land to water. The water wave (there is probably only one) is not the same as those choppy ones that cause boats to toss about. This wave is much like that of a small tsunami, except that it has a different cause. Its wavelength is very long, perhaps 10 or possibly 20 miles, and probably extends for many miles along the squall line. It is very shallow, probably only a few inches high in deep water. Neither this wave nor the tsunami can be seen or felt in deep water, because of their great horizontal and small vertical dimensions.

The tsunami and the seiche wave also are alike in their rate of travel through water. The deeper the water, the faster the wave moves. In the deep oceans, the tsunami wave moves at speeds of hundreds of miles per hour (600 miles per hour with 24,000 foot depth), while the seiche wave in most areas of the four deep Great Lakes could move at speeds of 60 to 120 miles per hour. On Lake Erie, its speed would be more like 35 miles per hour.

As long as the atmospheric squall line is associated with the water wave it created, the water disturbance again is technically a surge, becoming a seiche only after the atmospheric disturbance dissipates or moves back over land while the water disturbance remains.

The speed of the water wave is a key factor, because the overall water disturbance does not amount to much unless the squall line moves with about the same speed as the water wave. Since the average speed of squall lines is about 35 miles per hour, it is unusual for one to move fast enough to create a significant seiche on one of the four deep Great Lakes. Moreover, squall lines are relatively infrequent in the Great Lakes area, so that a moderate-to-strong squall line moving with the right speed over one of the Great Lakes is a rare event. Although the proper conditions for such a seiche do arise on all lakes, significant seiches are probably rare on all but lower Lake Michigan, where several have occurred within a single year. This may be partly due to population, as a seiche wouldn't be significant if no one were affected by it and no one knew about it. With the high population density along the shore of lower Lake Michigan and the large number of marinas and beaches there, few seiches go unnoticed, especially in the daylight hours.

The most recent seiche wave of note struck the south shore of Lake Superior east of the Keweenaw peninsula on June 30, 1968. It was described in a teletypewriter message issued by the Weather Bureau:

YESTERDAY'S SEICHE OCCURRED IN THE BARAGA AREA OF WESTERN UPPER MICHIGAN. BARAGA IS LOCATED IN BARAGA COUNTY ON THE KEWEENAW BAY. THE WATER IN THIS AREA SHOWED FOUR DEFINITE RISES AT APPROXIMATELY 11 AM 1230 PM 230 PM AND 530 PM CDT. THE 1230 PM AND 530 PM RISES WERE THE GREATEST WITH HIGHWAY M41 BETWEEN BARAGA AND L'ANSE BEING COVERED WITH WATER. THE GREATEST RISE WAS SIX FEET ABOVE NORMAL WITH LOW WATER ABOUT FOUR FEET BELOW NORMAL. WIND AND WAVES WERE NOT ASSOCIATED WITH THESE RISES. MANY BOATS AND DOCKS WERE FLOATED AWAY BY THE HIGH WATER. CONSIDERABLE DEBRIS WAS LEFT ON THE HIGHWAY AFTER THE WATER RECEDED. ALSO SOME BASEMENTS IN THE AREA WERE FLOODED. (A RESIDENT) WHO HAS LIVED IN THE AREA ALMOST FORTY YEARS SAID THIS WAS THE HIGHEST HE HAS EVER SEEN THE WATER. HE

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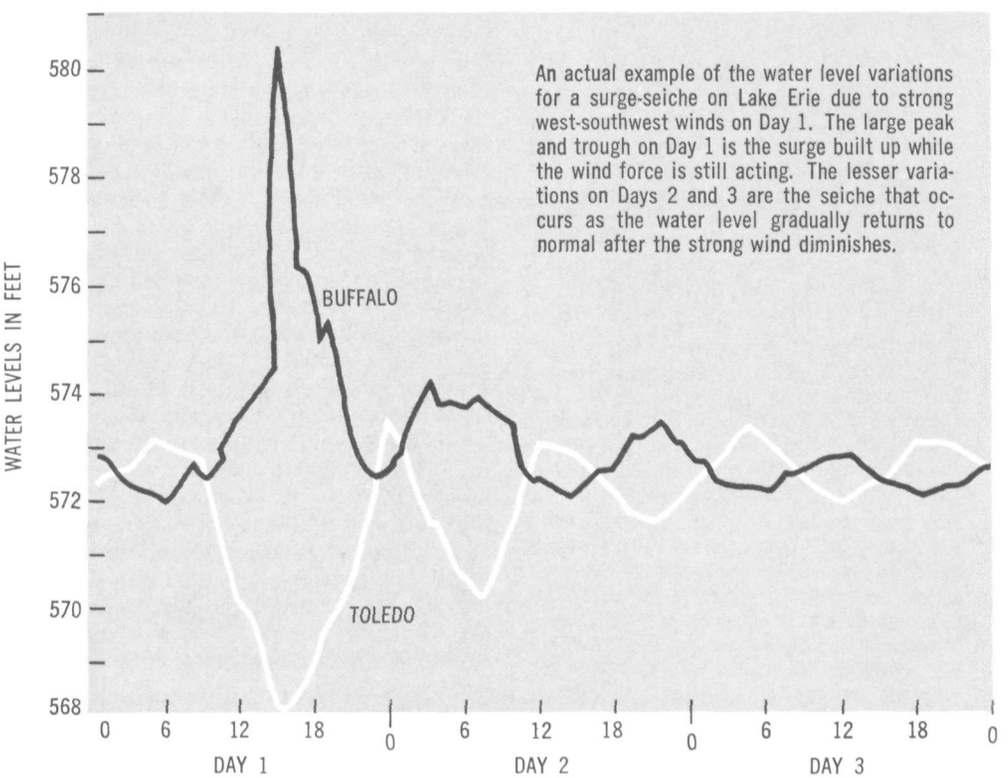
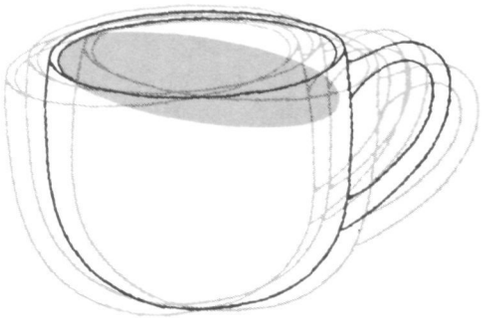


An actual example of the water level variations for a surge-seiche on Lake Erie due to strong west-southwest winds on Day 1. The large peak and trough on Day 1 is the surge built up while the wind force is still acting. The lesser variations on Days 2 and 3 are the seiche that occurs as the water level gradually returns to normal after the strong wind diminishes.

SAID THAT IN THE EARLY 1940'S WAS THE ONLY OTHER TIME THE WATER WAS HIGH ENOUGH TO COVER THE HIGHWAY BETWEEN BARAGA AND L'ANSE.



DISTURBANCES THAT CAUSE SEICHES

Top illustration shows how jostling coffee in cup causes liquid to rock back and forth. This is similar to the action of an earthquake on a large lake.

Illustration below shows how blowing on coffee surface piles up the liquid opposite to the wind pressure, just as a strong wind will act on a lake surface. In both cases, the liquid continues to rock back and forth after the original cause for the disturbance ceases.

Like the tsunami, the seiche wave achieves its great buildup of height as it moves into shallow depths, because bottom friction starts to slow down the forward edge of the wave while the rear edge is still moving fast. Just how much pileup of water will occur from a particular seiche wave, and how quickly, depends on the slope of the bottom as it rises to meet the shore and the shape of the shore itself. In the 1968 instance, the seiche occurred at the pointed end of triangular Keweenaw Bay, a position that favors large wave buildups. If the lake bottom slopes up gradually, there will be a long, steady building of the wave height as the forward portion is slowed more and more and the rear portion continues to overtake the forward portion. Seiche waves on lower Lake Michigan occasionally have caused the water level to rise 8 to 10 feet vertically in the Chicago area, where the phenomenon apparently is most frequent. Of course, the quasi-horizontal shift of the water's edge on the beach can be many times this vertical rise, depending on the slope of the beach.

Because of the great length of the seiche wave, it doesn't build up and break with the suddenness of the wind wave, although the very peak of the crest may have an ordinary wave-like action. The seiche wave's very gradual, silent rise at the shore, usually with quiet winds and nice weather, increases its menace. When the water rises slowly and undramatically, people along the shore may be unaware of what is happening. A nonswimmer, for example, may be out on a long pier and not realize that the water is rising until it is too late to reach shore. On June 26, 1954, several people lost their lives this way when a large seiche wave hit the Chicago shore, causing some piers to be awash, and sweeping people into the lake. Another risk involves small children left near the water without close parental supervision. The quiet rise of water could well escape the parent's attention until it is too late to save the child from drowning. On the other hand, informed or alert people can see the slow, steady rise of water and take appropriate action.

Sometimes the other part of the wave—the withdrawal of water—is more spectacular than the buildup. In one case, a Chicago marina—completely enclosed except for a narrow passageway to the open lake—was little affected by the water rise, but was nearly emptied of water by the trough of a seiche wave. The moored boats rested on the bottom. It would be disconcerting, to say the least, to have been in a small boat negotiating the narrow passageway when the water was rushing out.

The first operational forecast of a squall-line seiche was made on July 6, 1954, by Gordon E. Dunn, then meteorologist-in-charge at the Chicago office of the Weather Bureau. The phenomenon was not understood at that time, but Dunn noted the similarity of the weather situation to that associated with previous seiches, particularly the one a few days earlier mentioned just above. He issued a successful forecast.

These two 1954 seiches generated considerable interest in the phenomenon, and a number of studies were undertaken. The most definitive of these for forecasting was made by Professor George W. Platzman at the University of Chicago. It yielded an objective scheme for predicting the timing and relative magnitude of the seiche at Chicago from meteorological variables readily available to the forecasters. These variables describe the squall line, giving its orientation, speed, time of passage at key points, and the strength of its pressure jump. Later, the strength of its wind gusts was added.

All seiche-producing squall lines move from the west across Lake Michigan, so the windy, rainy weather moves through Chicago first, without significant effect on lake levels. The line moves across the lake, creates the wave, and causes the water level to rise first on the eastern shore with a surge at about the same time as the thunderstorms. The coincidence of the two events gives some protection to the eastern shore, as the approaching thunderstorm is likely to cause people to seek shelter before the surge hits the beach. As the thunderstorms move on into Michigan, the surge then reflects from the eastern shore back to Chicago as a true seiche.

The orientation of the squall line is a key feature for three reasons: (1) because the bottom of the lake is not flat east of Illinois, the orientation of the line determines how the water wave changes orientation as it crosses the lake; (2) since the angles of incidence and reflection are the same for a wave, the angle determines where the reflected wave is aimed; and (3) because the concave shape of the eastern shore acts like a focusing mirror, it concentrates the reflected wave in varying amounts depending on the angle of incidence. The third factor has not been worked into the forecast models adequately.

The seiche hits Chicago about an hour and a half after the squall line has passed the central part of the city. By this time, swimmers have generally returned to the beaches and fishermen to the piers as the weather clears after the storm. Usually, wind warnings are necessary for Chicago as the squall line passes, and forecasters are careful to end the wind warnings before they issue the seiche warning; otherwise, confusion of the two could result, and the public might believe both threats had ended with the clearing weather.

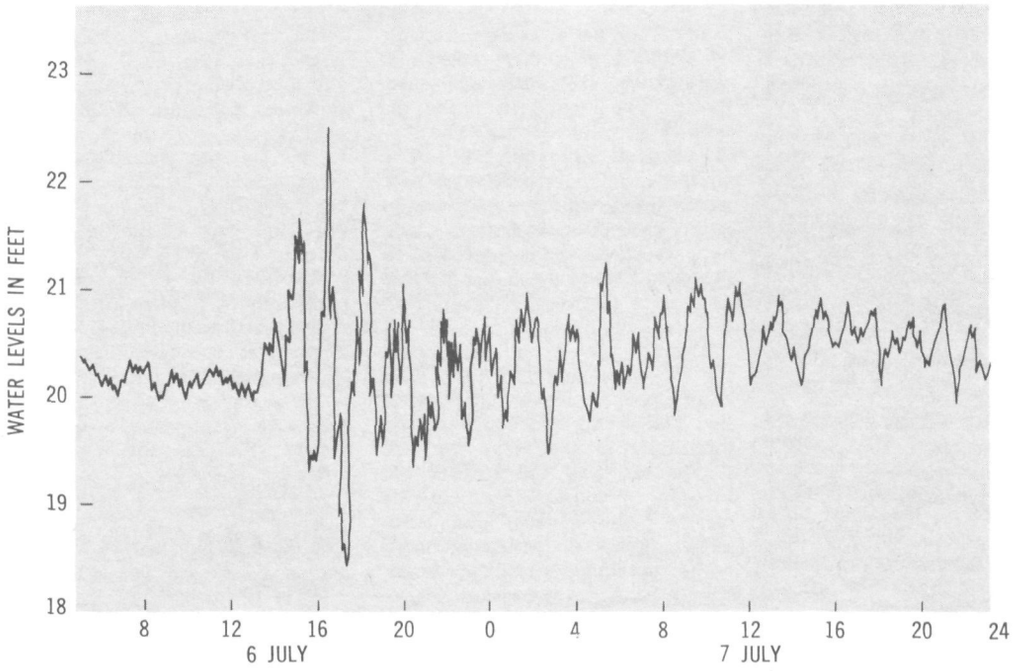
A very successful seiche forecast was issued for Chicago on August 3, 1960, the first such prediction since that of Dunn in 1954. The warning went out on the teletypewriter wire at 1045 CDT:

PROVISIONAL WARNING OF POSSIBLE SEICHE CONDITIONS CHICAGO LAKE SHORE. THE WEATHER CONDITIONS TODAY ARE THOSE UNDER WHICH SEICHES ARE KNOWN TO HAVE OCCURRED ALONG THE CHICAGO SHORE OF LAKE MICHIGAN IN THE PAST. ALL PERSONS ALONG THE LAKE SHORE ARE ADVISED TO TAKE PRECAUTIONS. THE MOST LIKELY TIME OF RISE AND FALL OF WATER LEVELS IF A SEICHE DOES OCCUR IS BETWEEN NOON AND ONE PM CENTRAL DAYLIGHT TIME TODAY WEDNESDAY AUGUST 3. WITH A SEICHE THE WATER LEVEL RISES AND FALLS BY SEVERAL FEET. IF THE FLUCTUATIONS OF WATER LEVEL DO OCCUR, THEY WILL LIKELY BE REPEATED AT INTERVALS DURING THE AFTERNOON BUT WITH LESSER AMOUNT OF RISE AND FALL.

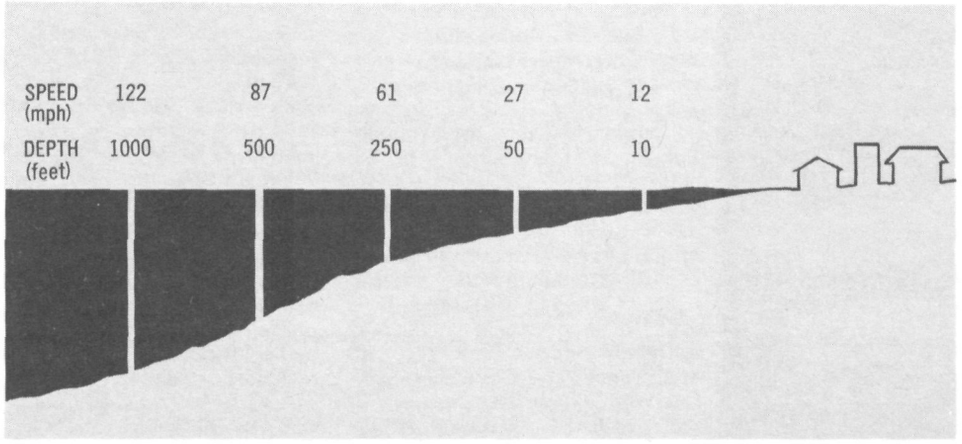
The peak surge was predicted for 1225 CDT, based on Platzman's forecast scheme. The small time range given in the warning was considered adequate because of the similarity of the situation to that of June 26, 1954, the success of the timing in Platzman's study, and the knowledge that factors influencing the speed of the water wave were much more certain than the usual variables in meteorology. Too much leeway in the timing probably would have made it difficult for police to restrain people from returning to their bathing and fishing before the surge hit. On the other hand, no certainty was forecast of magnitude of the surge, since this was dependent on many uncertain meteorological variables.

The seiche arrived right on schedule, starting exactly at noon. It caused some damage, but no lives were lost. The water level rose four feet in a marina where measuring equipment was available, and may have risen as much as six feet or so elsewhere.

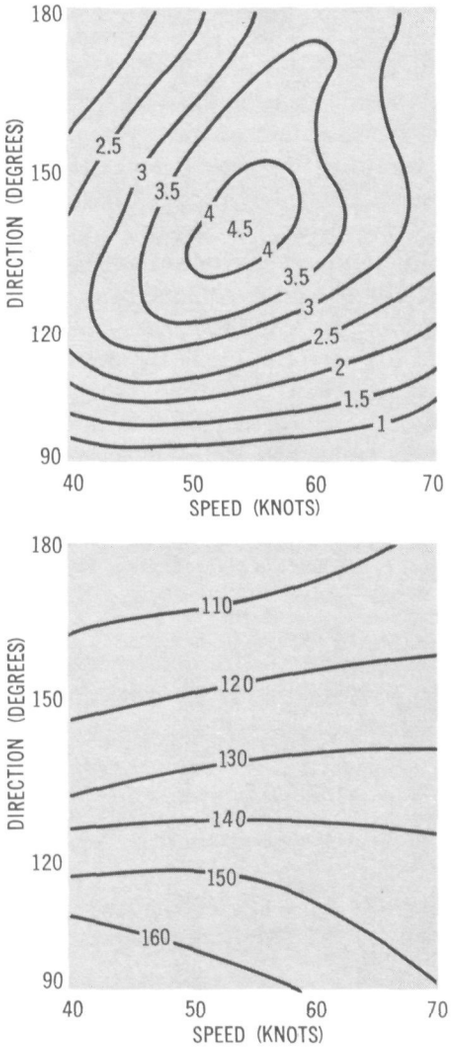
Other seiches have occurred at Chicago since 1960, none so strong as those in 1954 and 1960. Warnings have been issued for a number of these seiches, but not for all. The prime problem remaining is forecasting the magnitude of the water level fluctuation. It is likely that the factors needing further consideration are the length of the squall line and the details of the focusing effect of the eastern shore. Today, radar provides the needed information on the length of the squall line. The shape of the eastern shore is known, so the problem is only one of adequately modeling this feature. While not a simple problem, it is one that could be solved. Someday it will be. □



The 1954 seiche at Chicago, the first of these rare events to be forecast by the ESSA Weather Bureau. The magnitude is not as great as that close to shore, as the gage at the Wilson Ave. Crib is two miles offshore.



The speed of the seiche wave produced by a line of thunderstorms is dependent only on the depth of the water through which it is traveling. To a very close approximation, the speed V in miles per hour is related to the depth in feet (H) simply by V^2 equals 15 H.



The above are similar to the nomograms used in forecasting the seiche at Chicago's Montrose Harbor. The top nomogram gives the amplitude of seiche in feet for a squall-line of average intensity. It shows the maximum seiche occurs with a squall-line speed of about 55 knots and a movement toward about 135 degrees (southeast). The nomogram below gives the time interval in minutes between the arrival of the squall-line at O'Hare Airport and the arrival of the seiche back at Montrose Harbor.

essa NEWS BEAT

U.S. DEPARTMENT OF COMMERCE ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

Ocean Survey Ship RESEARCHER Joins C&GS Fleet at Miami Base

The USC&GSS RESEARCHER will be commissioned this month at her home port of Miami, Fla.

She will then be the 15th vessel in the two-ocean fleet of ships that conduct ocean, hydrographic, and current surveys and wire drag the coastal zones for navigational hazards. The ships are operated by ESSA's Coast and Geodetic Survey.

Constructed in Toledo, Ohio, RESEARCHER made her way last June from her berth in Lake Erie through the St. Lawrence River and down the Atlantic coast to the Atlantic Marine Center in Norfolk, Va. There, she was completely outfitted and prepared for her tasks along the Atlantic and Gulf coasts and in the deep ocean. In Miami, she joined the USC&GSS DISCOVERER. The two ships will work closely with ESSA's Atlantic Oceanographic and Meteorological Laboratories.

The 2800-ton air-conditioned vessel is 278 feet long and has a normal operating range of 13,000 nautical miles. She has 4000 square feet of enclosed laboratory space and accommodations for 13 officers, a crew of 54, and 18 men and women scientists.

The oceanographic floating laboratory is a modified, slightly smaller version of the Coast Survey's largest vessels, the 303-foot, 3805-ton OCEANOGRAPHER and DISCOVERER. She is the first of a new class of survey ships developed to meet present and future requirements.

Christened in October 1968, the nine-million-dollar vessel is capable of handling helicopters and small research submersibles and electronically equipped to probe the ocean's greatest depths. The RESEARCHER is also equipped with a hydraulic ramp on the stern over which heavy oceanographic equipment, such as ocean bottom cores, rock dredges, and buoys can be brought directly from the surface of the sea to the ship's main deck or superstructure deck.

During keel-laying ceremonies for the ship, Sept. 5, 1967, Rear Adm. Don A. Jones, Director of the Coast and Geodetic Survey, took note of the tasks she will engage in. "She will embark on, literally, a treasure hunt in the marine environment," he said. "The quarry will include all manner of oceanographic data to contribute to ESSA's mission to describe and understand the physical, geophysical, chemical, biological, and meteorological parameters and processes under the oceans, in the oceans, and over the oceans, and to predict the variables of the environment. The RESEARCHER will be a seagoing laboratory to find out what goes on in the oceanic areas."

The new vessel is under the command of Captain Steven Hollis, 48, of South Hadley, Mass., a 22-year career officer. Cdr. Robert W. Franklin, 35, of Baldwin, N.Y., is the Executive Officer and Cdr. James G. Grunwell, 38, of Punta Gorda, Fla., is the Operations Officer.

USC&GSS RESEARCHER, *latest in the ESSA fleet of survey vessels, is the first of a new class of ship designed for oceanographic investigation. Together with the* DISCOVERER, *the new ship will be based at Miami, Fla.*

Carnahan Provides Link with Private Meteorologists

Robert L. Carnahan, ESSA Deputy Assistant Administrator, has been designated as Special Assistant for Industrial Meteorology.

The Special Assistant provides a liaison between the Weather Bureau and the nation's private meteorologists. The position is intended to help industry and commerce make full use of weather information available from private as well as public weather services.

Mr. Carnahan will serve in a dual role, continuing as Deputy Assistant Administrator for Administration and Technical Services. He is a former member of the Board of Directors of the Council of Industrial Meteorologists and immediate past chairman of the Industrial Meteorology Committee of the American Meteorological Society.

Seismic Risk Map Guides Builders

A seismic risk map of the United States, prepared by the Coast Survey, has been incorporated into the Uniform Building Code—the authoritative construction guide of the building industry. The map, developed by Dr. S. T. Algermissen, chief of the Coast Survey's Geophysics Research Group, shows the areas of the contiguous United States most vulnerable to earthquakes. A seismic risk map was first made a part of the Uniform Building Code in 1949, but was withdrawn from circulation by the Coast Survey in 1952 as being too general to satisfy the requirements of many users. The Uniform Building Code contains "Earthquake Regulations" which, together with the map, provide a technical guide to the different factors to be taken into consideration in designing structures in earthquake-prone areas. Dr. Algermissen has emphasized that the map is subject to continual revision as new research developments occur.

all in the family PERSONNEL NOTES

Harlan K. Saylor, chief of the Weather Bureau's Analysis and Forecast Division since 1965, has been appointed Deputy Director of the National Meteorological Center. Mr. Saylor joined the Weather Bureau in New York in 1946, after serving in the Air Force during World War II. Mr. Saylor is the recipient of the Department of Commerce Gold and Silver Medals for his distinguished service.

Edwin B. Fawcett has succeeded Mr. Saylor as chief of NMC's Analysis and Forecast Division. Mr. Fawcett first joined the Weather Bureau in 1946 after a tour of duty in the U.S. Air Force. Mr. Fawcett was formerly deputy chief of the Analysis and Forecast Division.

Dr. Ernest K. Smith, Douglass D. Crombie, and **Joseph A. Hull** have been appointed acting associate directors of ERL's Institute for Telecommunication Sciences. Mr. Hull comes to this new post from NASA's Electronics Research Center in Cambridge, Mass., where he was chief of the Optics Technology Branch. Dr. Smith was formerly director of university relations for the Research Laboratories, and Mr. Crombie was group head of ionospheric radio programs for the Institute.

Capt. Herbert R. Lippold, Jr., has assumed command of the USC&GS Ship PATHFINDER. Capt. Lippold has more than 20 years of service in the ESSA Commissioned Corps. This is his second assignment aboard the PATHFINDER. The first was as junior officer in 1951-52. Since then, he has commanded the USC&GS Ship WHITING and served aboard six other vessels.

Robert G. Beebe, former Weather Bureau Industrial Meteorologist, is now Regional User Services Representative in the Weather Bureau's Central Region. Mr. Beebe was previously a research forecaster for the Weather Bureau, serving at the Washington National Airport, Atlanta, Ga., and Kansas City, Mo.

Cdr. Edwin K. McCaffrey has been named commanding officer of the USC&GSS MT MITCHELL. In his most recent post, he was chief of the Marine Science Services Division in ESSA's Office of Plans and Programs. Cdr. McCaffrey has been in the ESSA Commissioned Corps for 18 years and has seen extensive service aboard seven survey vessels, two of which he commanded. He has also served as chief of the Honolulu Observatory.

Cdr. Kenneth A. MacDonald, former commanding officer of the USC&GSS MT MITCHELL, is chief of the Marine Science Services Division in ESSA's Office of Plans and Programs. A veteran of 18 years' service in the ESSA Commissioned Corps, he has seen extensive duty at sea, throughout the United States, and in Ethiopia.

Cdr. Clinton D. Upham is heading the Coast Survey's Marine Data Systems Project—a newly established group in the Office of the Director. Cdr. Upham, formerly Special Projects Officer at the Coast Survey's Atlantic Marine Center, is assisted in his new duties by John Huson, whose last assignment was with the National Environmental Satellite Center.

Anthony E. Tancreto has been named chief of the Weather Bureau's Public Weather Branch. Mr. Tancreto's most recent assignment was as Special Assistant to the Weather Bureau's Eastern Regional Director.

Cdr. J. Austin Yeager is the new chief of the Coast Survey's Satellite Triangulation Division. He served in that post during 1967 and 1968, when he assisted in supervising the world satellite triangulation program completed last June. Cdr. Yeager will now be engaged in work on the North American densification program—a two-year project to complete a geodetic survey network linking Canada with Alaska and the lower 48 states.

Lt. Cdr. Christian Andreason has been appointed chief of the Planning and Methodology Branch of the Coast Survey's Geodesy Division. Last year, he was commanding officer of the Coast Survey's two wire drag vessels, the USC&GSS RUDE and HECK.

Allen Kerner now heads the Facilities Section of the Weather Bureau Eastern Region's Engineering Branch. Mr. Kerner is an engineer with 14 years of federal service, most recently in the Naval Facilities Engineering Command, Eastern Division.

Cdr. Bruce I. Williams has assumed command of the USC&GSS PEIRCE. Cdr. Williams, who joined the ESSA Commissioned Corps in 1960, has had five years of sea duty aboard four ships. He has also served as chief of field parties and as projects officer at the Coast Survey's Atlantic Marine Center, Norfolk, Va.

James V. Taormina, personnel management specialist with ESSA from 1966 to 1969, has been appointed chief, Employee Relations Branch. Gordon D. Shadoan has succeeded Joseph B. Murdock as chief, Operations Division. Mr. Murdock is the new assistant to the ESSA Personnel Officer.

Lawrence B. Luhrs has been appointed to head Systems, Plans, and Analysis in the Coast Survey's Office of Systems Development. Before joining the agency, Mr. Luhrs was a management consultant in the earth, environmental, and computer sciences.

Edwin S. Addison, III, has been named the new meteorologist in charge of the Madison, Wisc., Weather Bureau office, succeeding Stephen J. Rigney. Mr. Addison was formerly the advisory agricultural meteorologist at New Brunswick, N.J.

Stephen J. Rigney has been named meteorologist in charge of the new Weather Bureau office at Portland, Me.

Robert E. Fennell, former meteorologist in charge of the Peoria, Ill., Weather Bureau office, now heads the Tulsa, Okla., weather office. Mr. Fennell joined the Weather Bureau in 1946.

Leroy W. Pankratz has been appointed chief of the Coast Survey's Castle Rock Observatory near Saratoga, Calif. Mr. Pankratz joined the Coast Survey in 1963 following graduation from Mankato (Minn.) State College. He subsequently served at the Fredericksburg Geomagnetic Center, Corbin, Va.; Byrd Station, Antarctica; and the Adak (Alaska) Observatory.

Lt. Cdr. John W. Carpenter is the new Executive Officer of the USC&GSS WHITING. Lt. Cdr. Carpenter joined the Coast Survey in 1964. Previous assignments included service on the USC&GSS PEIRCE, as chief of geodetic field parties, and as technical assistant to the chief of the Geodesy Division.

Edward G. Thorpe is the Coast Survey's new Budget Coordinator succeeding Gene Michael. A veteran government employee with 26 years' service, Mr. Thorpe was previously chief of the Systems Development, Reports and Procedures Branch, in ESSA's Budget Division.

Lt. Cdr. Carl N. Davis is now Executive Officer of the USC&GS PEIRCE. Lt. Cdr. Davis has been with the Coast Survey since 1963, and served previously with the SURVEYOR and with geodetic field parties.

Max M. Chesy of ESSA's Visual Arts Branch has won the Excellence in Design Award in the annual house magazine graphics contest conducted by *Industrial Art Methods*. Mr. Chesy received the award for his work as art director of *ESSA* magazine.

James T. Bradley, formerly on the staff of the Weather Bureau Forecast Office in New York City, is now ESSA State Climatologist for Florida.

Ellis D. Pike, former principal assistant of the Wichita, Kans., Weather Bureau office, now heads the office as meteorologist in charge. He succeeds W. Gordon Wylie. Mr. Pike has been employed with the Weather Bureau for 24 years, 17 of which were spent at Wichita.

Seymour Krepky, a 20-year veteran of the U.S. Marine Corps, has been named official in charge of the Weather Bureau office at Johnston Island.

Robert E. Lucas has been selected as official in charge of the Oakland, Calif., Weather Bureau office.

Six Win Thousand-Dollar Awards

Dr. Oscar Tenenbaum, John J. Smiles, Dr. Joseph Smagorinsky, Edward E. Jones, William H. Haggard, and Dr. C. Gordon Little were this year's winners of the newly established ESSA Awards. Each received one thousand dollars and a plaque at the ESSA Awards Night Dinner Dance in Silver Spring, Md.

The awards recognized unusually significant contributions in four categories — public service, scientific research and achievement, engineering and applications development, and program administration and management.

Dr. Oscar Tenenbaum, meteorologist in charge of the Boston, Mass., Weather Bureau Forecast Office, and John J. Smiles, chief of the Visual Services Branch at ESSA headquarters, won the Awards for Public Service. Dr. Tenenbaum was cited for his leadership in developing an outstanding weather forecast service for the New England area. The Boston Weather Bureau Forecast Office serves not only the city and the state, but is the weather coordination center for all of New England. The outstandingly effective services provided by Dr. Tenenbaum and his staff have earned praise and honors from weather-oriented groups and industries throughout New England.

John J. Smiles won the Public Service Award for his leadership, inspiration, ingenuity, and the high productivity and quality of work performed by his branch, which has enhanced the agency's programs of public service and education. The staff that Mr. Smiles recruited and trained has produced many prize-winning publications and exhibits. Mr. Smiles received the Commerce Department's Creative Communication Award in 1967.

Dr. Joseph Smagorinsky, winner of the Award for Scientific Research and Achievement, was cited for outstanding achievement as a scientist and research leader in studies of the dynamics of the oceans and atmosphere. Dr. Smagorinsky has headed ESSA's Geophysical Fluid Dynamics Laboratory, now located in Princeton, N.J., since its beginning in 1955. He and the Laboratory are recognized worldwide for basic research in mathematical modeling of the atmosphere and oceans. Dr. Smagorinsky received the Gold Medal of the Department of Commerce in 1967 and the Meisinger Award of the American Meteorological Society in the same year.

Edward E. Jones, an electronic engineer with the Coast Survey's Pacific Marine Center in Seattle, Wash., won the Award for Engineering and Applications Development, for his work in designing and developing, from equipment and parts already on hand, a reliable automated data acquisition system. The system was vitally needed for a three-year oceanographic and hydrographic project to be conducted by the USC&GS Ship SURVEYOR in Norton Sound, Alaska, and was so successful that similar systems were built for three other C&GS ships.

The Award for Program Administration and Management, given for unusually significant contributions to the efficiency and quality of ESSA management and administrative activities was given to William H. Haggard, Director of the National Climatic Center (formerly the National Weather Records Center) in Asheville, N.C., and to Dr. C. Gordon Little, Director of the Wave Propagation Laboratory in Boulder, Colo.

Mr. Haggard was cited for distinguished direction and implementation of programs for modernizing operations of the Asheville Center. Under his direction, the Center's highspeed data processing equipment has been modernized, employees retrained, and management restructured for more efficient operations.

Dr. C. Gordon Little received the award for outstanding scientific direction of research in the remote sensing of man's geophysical environment and for creating and establishing a very productive new laboratory. Although it was established only three years ago, the Wave Propagation Laboratory has achieved national recognition for excellence of research in the field of remote sensing. Dr. Little previously won the Department of Commerce Gold Medal for highly distinguished contributions to the physics of radio propagation and to other research programs in radio science.

In addition to the six $1000 awards, 18 ESSA Unit Citations for Special Achievement and seven Department of Commerce Bronze Medals were given at the ESSA Awards Night event. The unit citation—a newly constituted award—recognizes outstanding individual and collective efforts which contribute to ESSA's mission. It was awarded to:

Thirty-six officers and crew members of the USC&GS DAVIDSON, commanded by Cdr. Ray E. Moses.

Seventy-seven employees of the National Environmental Satellite Center.

Dr. Robert M. White, Administrator, welcomed the award winners. From left, John J. Smiles, Dr. Oscar Tenenbaum, Dr. Joseph Smagorinsky, Dr. White, Edward E. Jones, William H. Haggard, and Dr. C. Gordon Little.

Participants in the 1969 *Barbados Oceanographic and Meteorological Experiment* (BOMEX).

The staff of the *Weather Bureau Forecast Office in New Orleans.*

The *Mobile, Ala., Weather Bureau* staff.

The six-man *Warning Coordination Unit* at the Weather Bureau Forecast Office in Chicago.

The *Public Forecast Unit at Minneapolis.*

The staff of the *Weather Bureau Office in Lubbock, Tex.*

The *Weather Bureau Office in Amarillo, Tex.*

The *Oklahoma City Weather Bureau.*

The *Weather Bureau Rawinsonde Section.*

The *Warning Coordination Forecast Unit* at the Weather Bureau's National Severe Storms Forecast Center in Kansas City.

The *Weather Bureau Offices at Bismarck, Williston, Aberdeen, Huron, Rapid City, and Sioux Falls.*

The *Research Flight Facility* had received the first ESSA Unit Citation for Special Achievement on June 5. Dr. Wilmot N. Hess, ERL Director, made the presentation during a banquet held in Miami.

EDS Director Jacobs Retires

Dr. Woodrow C. Jacobs, nationally known oceanographer and meteorologist, has retired as Director of ESSA's Environmental Data Service. Dr. Jacobs became EDS Director in January 1967, after heading the interagency National Oceanographic Data Center for six years.

Born September 11, 1908, in Pasadena, California, he was graduated from the University of California at Los Angeles in 1930, received his master's degree from the University of Southern California in 1934, and his Ph.D. from the University of California (Scripps) in 1948. From 1948 to 1960, he was Director of Climatology at Headquarters, Air Weather Service, leaving in 1960 to accept a post as physical scientist in the Science and Technology Division, Library of Congress.

Dr. Jacobs began his career in meteorology in 1931 with ESSA's Weather Bureau, and in 1946 was Chief of the Climatology Branch and later became Assistant Chief of the Climatology and Hydrologic Service Division. He served as associate editor of the *Bulletin of the American Meteorological Society* from 1948 to 1954, and of the *AMS Journal* from 1956 to 1961. He was associate editor of the *Journal of Applied Meteorology* of the AMS from 1962 to 1969. He was Chairman of the Interagency Committee on Oceanography—Interagency Committee for Atmospheric Sciences working group on air-sea research in 1963 and 1964, and has served on many committees of the National Academy of Sciences and of the Government.

Dr. Jacobs is a member of Sigma Xi, honorary fraternity; Alpha Kappa Psi, professional fraternity; and is active in the work of the American Meteorological Society, serving on its Council from 1961 to 1964 and as Chairman of the Board of Certified Consulting Meteorologists, 1959-1961. He has been an active member of the American Geophysical Union and has served as Secretary of its Section of Meteorology since 1947.

DISCOVERER Seeks Clues to Link Between Africa and U.S. Coast

ESSA oceanographers aboard the USC&GSS DISCOVERER probed the bottom of the North Atlantic between North America and Africa, on a scientific voyage that extended from early June to mid-September.

The primary purpose of the expedition was to obtain continuous data on the ocean bottom and subbottom in a 3500-mile-long strip extending from Cape Hatteras, N.C., to Cap Blanc, Mauretania, in northwest Africa. Electronic instruments recorded the shape of the ocean bottom and subbottom rock strata, including rock layers several miles beneath the ocean floor, and their magnetic and gravity fields.

Data gathered during the voyage should shed new light on the growth and development of the Atlantic Ocean basin as the North American and African continents split and drifted apart to their present positions. According to the continental drift theory, the earth at one time had one or two large land masses which began to split some 200 million years ago. The theory postulates that the continents are drifting at rates of about an inch or so per year in the earth's mantle. The drifting resulted in the separation of the supercontinent or supercontinents. The east coast of the United States and the northwest coast of Africa are believed by many to have been joined aeons ago, with Cape Hatteras against Cap Blanc. If the two capes once were joined, the evidence may be found in the 250-mile-wide strip of ocean floor between Cape Hatteras and Cap Blanc probed by the DISCOVERER.

The investigation was conducted by the Atlantic Oceanographic and Meteorological Laboratories, with Dr. Peter A. Rona serving as chief scientist on the leg to Africa, and Reginald Harbison as chief scientist on the return trip.

During the expedition, two other projects were carried out—a marine geophysical study of the Cape Verde Islands and an investigation of the geological structure of the Caribbean.

The one-week investigation of the Cape Verde Islands, directed by Dr. Louis W. Butler of AOML, sought to determine whether the Cape Verde islands are a seaward extension of mountain ranges in northwest Africa, a segment of deep sea floor elevated and deformed by oceanic forces, or a fragment of continental material which had drifted westward from Africa.

In the other study, the DISCOVERER was gathering evidence that will help to determine whether the Caribbean is tied into the South American landmass or is a separate crustal plate. Electronic sonar equipment aboard the DISCOVERER probed the bottom and subbottom of the Caribbean around Barbados to trace the extension of structural features found during expeditions aboard the same ship in 1968 and 1969. This project, led by AOML marine geologist L. Austin Weeks, was part of the United States contribution to the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR), an international program of UNESCO's Intergovernmental Oceanographic Commission.

Based at Miami, the DISCOVERER is commanded by Captain Hubert W. Keith, Jr.

Lawrence Mahar Directs Bureau's Southern Region

Lawrence R. Mahar, who has headed the Weather Bureau Alaska Region since 1967, became director of the Southern Region on September 1.

Mr. Mahar has had 27 years of meteorological experience. After his graduation from Middlebury College in 1941, he enlisted in the Air Force where he received his early weather training during World War II. He joined the Weather Bureau as a meteorologist in New York City in 1946, and later transferred to Bureau headquarters in Washington, D.C.

In 1952, he was put in charge of the Hartford, Conn., weather station where his outstanding work won him a Commerce Silver Medal in 1957. After two years as director of meteorology for Travelers Research Center in Hartford, Mr. Mahar rejoined the Weather Bureau in 1965 as manager of the Southern Region's operations section.

Special Events Celebrate Anniversary

Open houses, a dinner dance, and special awards marked ESSA's fifth anniversary on July 13.

In the Washington area, six $1000 ESSA Awards, 18 Unit Citations, and seven Bronze Medals were presented at the ESSA Awards Night Dinner Dance, July 10. Among the 380 who attended the event were Rocco C. Siciliano, Under Secretary of Commerce, Larry A. Jobe, Assistant Secretary for Administration, and Dr. Myron Tribus, Assistant Secretary for Science and Technology.

At its open house on Sunday, July 12, the Washington World Weather Center played host to some 1000 visitors.

The USC&GSS FAIRWEATHER held open house at Juneau, Alaska, and 700 people visited the PATHFINDER in Homer, Alaska. At Norfolk, Va., 275 visitors toured the Atlantic Marine Center and the MT MITCHELL. C&GS observatories at Newport, Oreg., and Honolulu welcomed the public, and the Mid-Continent Field Office at Kansas City held a joint open house with the Weather Bureau.

Other open houses included those of the Research Laboratories at Boulder, Colo., and many Weather Bureau stations.

Interagency Center In Idaho Fights Fires On U.S. Lands

The Boise Interagency Fire Center—the only one of its kind in the nation—was formally dedicated at Boise, Idaho, July 25. The Center is administered by the Department of Interior's Bureau of Land Management in cooperation with the Department of Agriculture's Forest Service and the Weather Bureau, to provide a more effective means of fighting forest fires on federal lands. The Weather Bureau provides special fire-related forecasts to the Forest Service and the Bureau of Land Management through a staff of fire-weather meteorologists located at the Center. Participating in the dedication ceremonies were: Dr. George P. Cressman, Weather Bureau Director; H. H. Bedke, Director, Weather Bureau Western Region; Boyd L. Rasmussen, Director, Bureau of Land Management; Edward P. Cliff, Chief of the Forest Service; Idaho Governor Donald Samuelson and Jay S. Amylx, Mayor of Boise.

ESSA—NBS Study Finds No Change in Oxygen

There has been no discernible change in the world's oxygen supply for the last 60 years, two Commerce Department scientists have found.

Dr. Lester Machta, Director of ESSA's Air Resources Laboratory, and Ernest Hughes of the National Bureau of Standards have also concluded that, if all the known recoverable reserves of fossil fuels were ultimately burned, there would be no significant effect of oxygen reduction on human breathing.

The project, conducted over a three-year period, between 50 degrees North and 60 degrees South latitude, was inspired by a request from the late Dr. Lloyd Berkner to the Office of the President's Science Advisor. In a memorandum prepared jointly with L. C. Marshall in 1966, "Potential Degradation of Oxygen in the Earth's Atmosphere," concern was expressed that increases of herbicides and pesticides in the oceans would kill off photo-synthetic plants which they felt were a prime source of atmospheric oxygen.

ESSA and the National Science Foundation collected 78 samples during 1967 and 1968 by the oceanographic ships USC&GSS OCEANOGRAPHER and the NSF's ELTANIN, over the Continental Shelf and the open ocean. The Analytical Chemistry Division of the National Bureau of Standards developed the method of analysis and determined the oxygen content.

Samples were collected, after drying, in one-liter evacuated stainless-steel flasks. The oxygen content of the samples was determined by repeated comparison with a gas of known oxygen content.

Three parts were taken from each sample, and each part was measured at least ten times. The average for all 78 samples is 20.9458 percent by volume of dry air, but the scientists recommended a value for oxygen concentration of dry air of 20.946 percent by volume.

The authors compared their measurements with past observations. There are only five measurements, or series of measurements, of the absolute oxygen concentration in the atmosphere between 1910 and 1970. All reliable data since 1910 fall in the range of 20.945 to 20.952 percent by volume. Machta and Hughes believe the best of these measurements were obtained in 1910 in Boston, and that they, too, demonstrate a value of 20.946 percent by volume.

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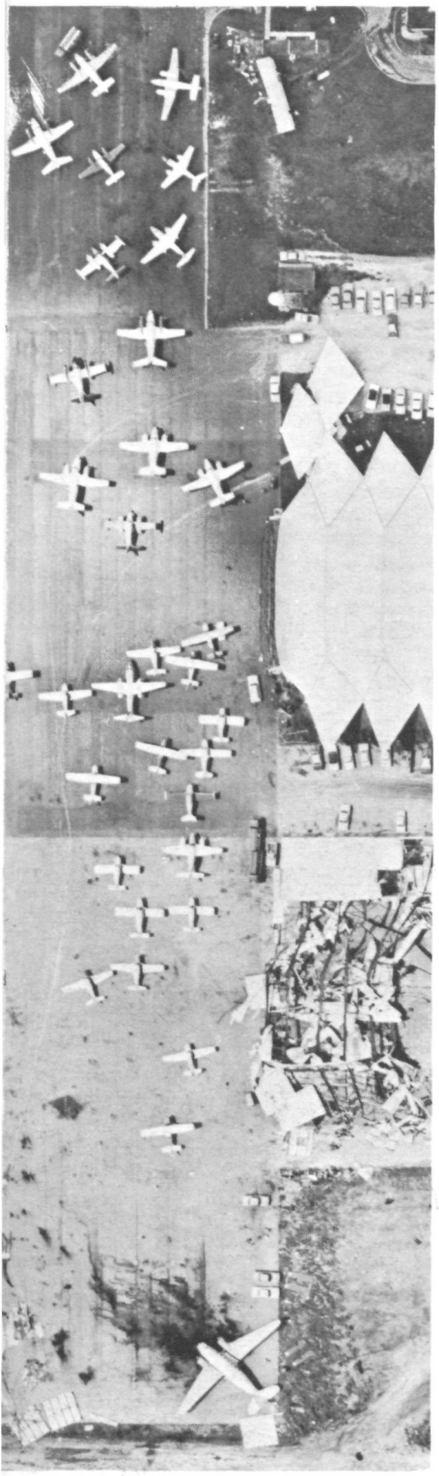

IN CELIA'S WAKE

As hurricane Celia swept ashore on August 4, C&GS Air Photo Mission Number 2 was preparing to move from the Pacific northwest to Florida. The Aero Commander team was diverted to Corpus Christi, Tex., to photograph for possible chart changes. The aerial and ground-level photographs, only a few of which are shown here, did much to tell Celia's destructive story. From left, flown-away aircraft back at Corpus Christi International; heavy damage in a residential area; a petroleum storage tank collapsed in a pillar of fire; a beached shrimp fleet at Aransas Pass.