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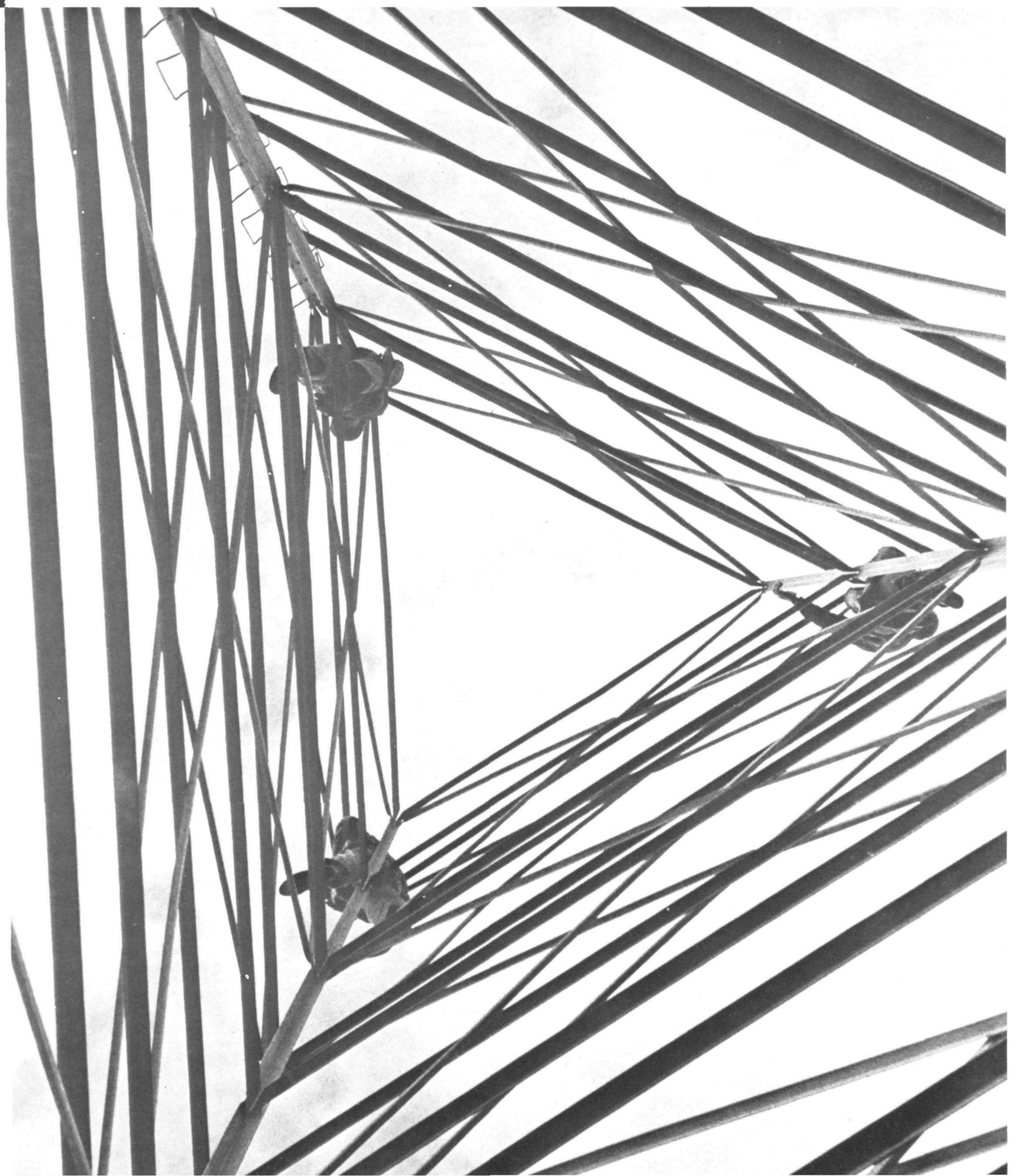
NOAA

U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



VOLUME 1
NUMBER 2

National Oceanic and Atmospheric Administration

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NOAA

U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Dr. Robert M. White, Administrator
Howard W. Pollock, Deputy Administrator
Dr. John W. Townsend, Jr., Associate Administrator

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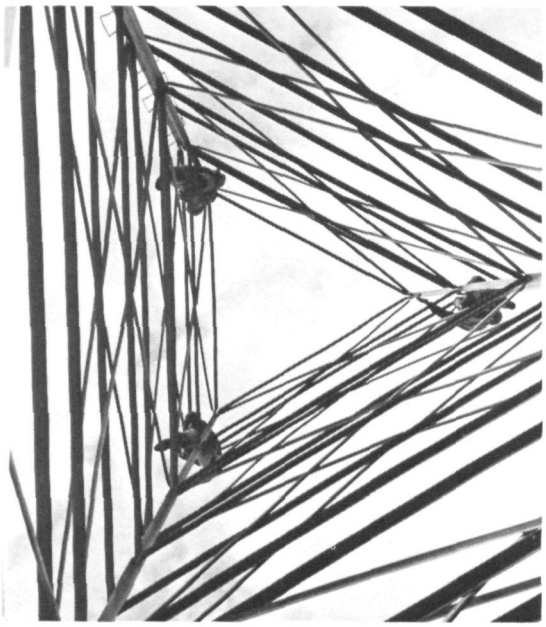

COVER
Wherever a National Ocean Survey triangulation party is at work, Bilby towers dot the landscape. Both front and back covers are views of members of Geodetic Field Party G-23 on the portable steel structures.

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A Message From the Administrator

ROBERT M. WHITE

Over the past several years, we have seen a radical change in the outlook of our government and our society toward the problem of environmental deterioration. President Nixon has taken a number of steps which together constitute a demand for action in the field of environmental protection. The Congress, too, has demonstrated a keen and active interest in restoring the quality of our environment.

Perhaps the cornerstone of the Nation's efforts is the Environmental Policy Act of 1970. It is only now becoming clear how farsighted and all-embracing this Act was, in bringing about purposeful and conscious action on environmental matters by all Federal agencies.

Under the provisions of the Environmental Policy Act, all Federal agencies must file statements of the environmental impact of any action they may be contemplating that "may significantly affect the quality of the human environment." The agency's statement not only must outline the probable environmental impact of the proposed action, but must also explain any unavoidable adverse environmental effects, as well as the alternatives to the proposed action. The Act, furthermore, places the responsibility on each Federal agency to obtain the comments of all other Federal agencies having either legal jurisdiction or special expertise in the particular environmental problem of concern.

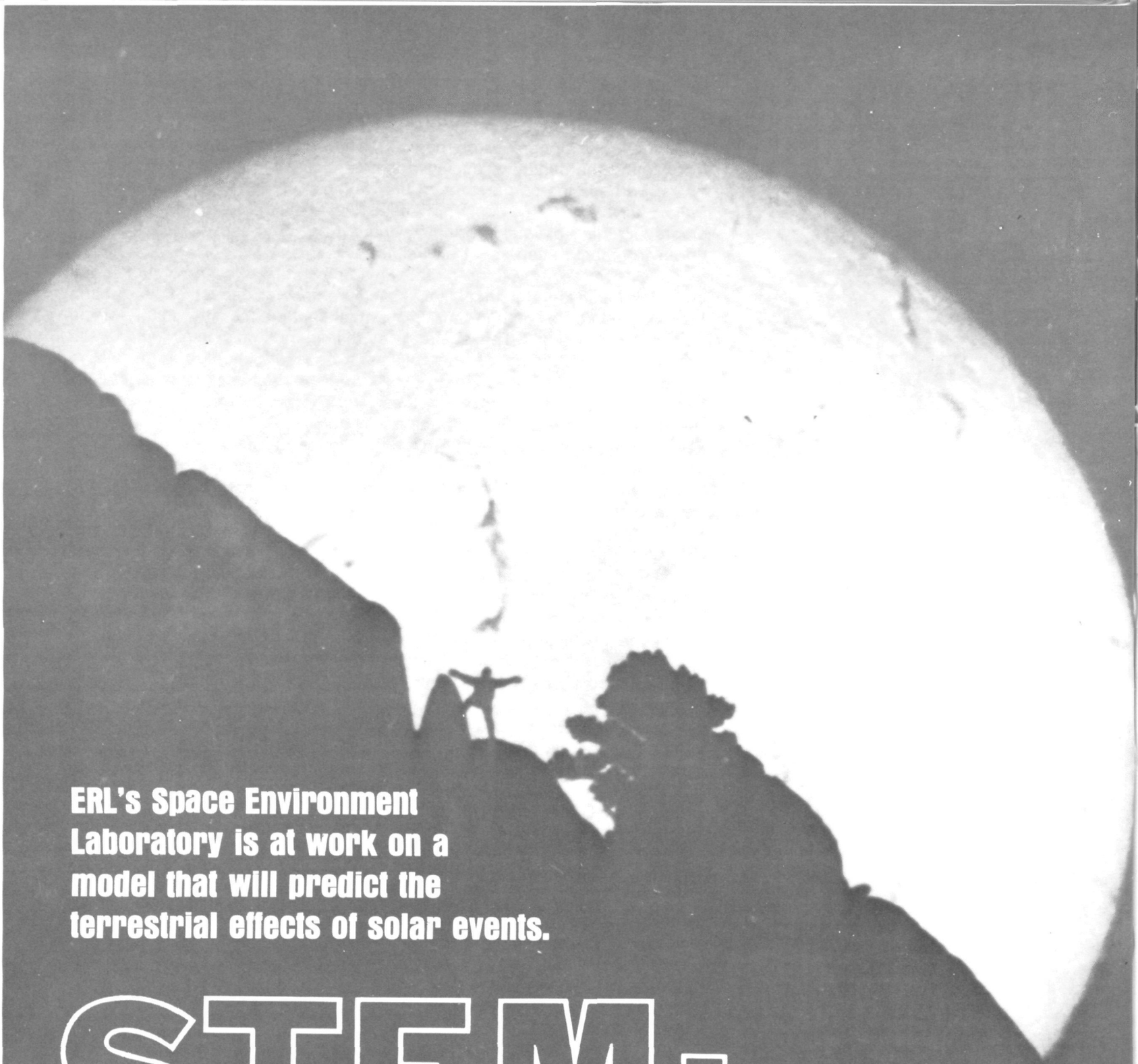
We in NOAA are just beginning to appreciate the extensive role we have in carrying out the provisions of this Act. We are now being asked to comment on environmental impact statements related to the oceans, the atmosphere, and certain aspects of the solid earth. Some of these statements involve major national questions, such as the supersonic transport and the Alaskan pipeline. Others, dealing with issues and problems of more restricted scope, can be handled at the field level. But whatever the scope of the issue, and wherever in our organization we are asked to comment on environmental impact statements, I want to ensure that we provide the best assessments possible within the limits of scientific knowledge.

Obviously, the provisions of this Act impose an unanticipated workload upon us, and we will have to organize ourselves to deal with it. As a start, I am establishing at NOAA headquarters an Office of Ecology and Environmental Conservation. One of its functions will be to assist in organizing NOAA's efforts in responding to the questions raised as a result of the Environmental Policy Act.

There is hardly an organizational group within NOAA that does not have some kind of technical expertise or experience which can be applied to solving environmental problems. Biologists, oceanographers, atmospheric scientists, earthquake engineers, geologists, and their colleagues in the many associated disciplines in our laboratories and field stations, have skills and information to contribute to the battle against environmental decay.

Let us—as individuals and as an organization—welcome the opportunity to have our say on environmental questions in our areas of expertise.

Robert M. White



ERL's Space Environment Laboratory is at work on a model that will predict the terrestrial effects of solar events.

STEM:

A LINK FROM SUN TO EARTH

BY JOANN TEMPLE DENNETT
Environmental Research Laboratories

THE FORECAST goes out from a small teletypewriter room in Boulder, Colorado: THE RATHER SMALL AND SHORT-LIVED SURGE OF ACTIVITY WITNESSED BETWEEN 15 AND 17 APRIL IS EXPECTED TO BE FOLLOWED BY ONE OR TWO ISOLATED MAJOR ERUPTIONS DURING THE NEXT 24 HOURS. THE GEOMAGNETIC FIELD WILL BE SEVERELY DISTURBED FOR THE NEXT 72 HOURS.

People around the world react. Alaskan settlers, whose only link to civilization is their radio set, hurry last-minute messages through and settle back to wait out the coming disturbance, during which no message, however urgent, can be sent.

Power companies in the northern part of the United States put their repair crews on a 24-hour alert, while electric power dispatchers brace themselves for several harrowing days of juggling to keep enough power flowing through the complex, interlocked systems that span many states. An oil company plane in the northern Rockies decides to speed up its departure while radio and magnetic navigation can still guide it safely south.

NASA teams, preparing to launch a manned spacecraft, "scrub" for the month and recycle to their next launch window. Aircraft flying the Great Circle route are re-routed further south, and SST flight passengers are told they will be late, as the planes must descend to the lower and therefore thicker parts of the atmosphere, where increased wind resistance will slow them down.

Teams of scientists in Point Barrow and Ice Station T-3 in the Arctic Circle gear up for a busy few days of observing the coming events from the best ringside seat on the earth.

The year is 1980 and the forecast, based on a decade of work with a computer model of the solar-terrestrial environment developed by ERL's Space Environment Laboratory in Boulder, Colorado, is accurate.

That decade of work is now just beginning. Donald J. Williams, director of the laboratory, explains: "Within our group of 100 employees, we have a unique situation of basic research, applied research, and service activities intermeshed and working together. This means that the latest results of our basic research program are adapted by applied research people to the development of new forecasting techniques, which are then rapidly assimilated into our routine service of forecasting solar flares and their effects on the earth's environment."

From the start of recorded history, and doubtless before, man has recognized the impact of the sun on his life. Ancient religions, in fact, almost always included sun worship. The Egyptians called the sun god Ra. The Sumerians called him Utu; the Indians, Garuda; while the Japanese made the sun a goddess—Amaterasu.

The sun not only provides the heat and light energy necessary for life on earth, but produces many other kinds of energy and radiation. Everything modern scientists know about the sun has been discovered by studying these radiations.

Early astronomers learned a great deal by studying only the visible light or radiation from the sun. They decided, correctly, that the sun is a rotating ball of burning gas made up almost completely (99 percent) of hydrogen and helium. As studies of visible light continued, oxygen, nitrogen, carbon, and most of the elements found on earth were also detected on the fiery sun.

Modern astronomers are not confined to studying light and heat radiation from the sun. Their study of ultraviolet radiation, radio noise, energetic protons, and virtually all solar emissions has shown clearly that the sun affects us here on earth in many ways.

Man in the solar-terrestrial environment—a Space Environment Laboratory photograph of the sun setting behind the Flatirons, a mountain formation west of Boulder.

Solar flares, for example, can affect our day-to-day living. These explosion-like disturbances on the sun's always stormy surface throw masses of invisible radiation and particles out into space. These are very high-energy radiations which can damage men or equipment in space. Although we are protected from these radiations by the blanket of our atmosphere and the earth's magnetic field, enough of them do occasionally find their way through to disrupt long-distance electric transmission lines, confuse radio communications, and create geomagnetic storms and auroras.

Forecasting both flare occurrences and subsequent effects when the charged cloud encounters the earth is the objective toward which the research and services of the Space Environment Laboratory are aimed. It conducts research in the field of solar-terrestrial physics, develops techniques necessary for forecasting solar disturbances and their subsequent effects on the earth environment, and provides environment monitoring, forecast, and data archival services on a continuing basis. This information is compiled for long-term storage by the Aeronomy and Space Data Center and is made available to users throughout the world as a NOAA service.

Since the advent of satellite technology in 1957, great strides have been made in furthering our understanding of the solar-terrestrial environment. From space research programs have come the discovery and mapping of the earth's radiation belts; the mapping of the earth's magnetic field in space; the investigation of the nature of the interplanetary medium, including the solar wind and the interplanetary magnetic field; investigations of the nature of the interaction between planetary environments and the interplanetary medium; and initial investigations of planetary environments themselves, notably those of the earth, moon, Venus, and Mars.

With this new information and the Space Environment Laboratory's coupling of basic science and service, Dr. Williams and his colleagues think they are within a decade of a serviceable working model of the total sun-earth environment. Such a model could be used to forecast the earthly effects of an event 93 million miles away.

Since the causes of such earth effects are on the sun, the model must begin with conditions there. That is, scientists observing the solar disk must be able to recognize early clues indicating that a region is developing into a massive flare. Having spotted the potential flare, they must then be able to estimate the eruption time and subsequent energy release. Then, knowing how much and what kind of energy will be released, they must predict its propagation path through interplanetary space and determine when and where, and in what amounts, the energy will come near enough the earth to encounter its magnetosphere. The final step will be to predict the solar particle interactions with the magnetosphere and then with the earth's ionosphere, and, finally, the point in the earth's upper atmosphere where heavy solar electron and proton precipitation showers will finally occur.

There are, then, six basic parts to a model that describes the processes leading from solar flare to earth disturbance: solar flare model; propagation model; interplanetary medium model; model for energy transfer into the magnetosphere; magnetospheric model; and an ionospheric interaction model.

Three of the necessary six parts of the solar-terrestrial environment model, dubbed STEM, now exist, although in varying stages of development. The magnetospheric model can start either with a satellite's solar wind information or with geostationary magnetic field observations. Given this starting information, the model then describes the resulting location of particle precipitation regions, cosmic ray cut-offs, particle population distributions for quiet times, and some of the changes in these factors with continuing time.

The interplanetary medium model includes a description of the solar wind plasma and of the magnetic field which is embedded in

continued

interplanetary space. Densities, temperatures, velocities, and types of particles in the plasmas, as well as strength, direction and other subtleties (radial gradient) of the magnetic field, can also be included in this model.

Existing propagation models include descriptions of shock wave propagation through the interplanetary medium, as well as predictions for the separate propagation paths of energetic solar particles through the disturbed interplanetary medium. This part of STEM uses flare locations on the sun and ambient interplanetary conditions as its starting point.

"Having three of six parts would seem as though we are halfway to STEM," says Williams, "but the remaining work may well be considerably more than half. As with the existing portions of STEM, future success will depend a great deal on the results of dedicated researchers throughout the international scientific community. First, we need an accurate solar flare model. We get a number of different solar observations—visible hydrogen-alpha and CaK photographs, cm and mm wavelength radio noise, magnetic field polarity and strength, solar proton intensities are a few of the routine solar data we gather. Using such available data, we need to be able to follow the growth of a region, predict the time it will flare, and estimate its energy release—X-ray, ultraviolet, and particle emissions—in detail. Tractable models of solar proton and electron storage in the sun's corona are only now becoming available, and should be helpful in estimating the energy release of a given flare."

Moving closer to the earth, we encounter the next gap in STEM at the fringes of the earth's magnetosphere, a gigantic protective envelope of ionized gas resulting from the collision of the earth's magnetic field with the solar wind, the continuous barrage of electrons, protons, and alpha particles emitted by the sun. The boundary between the magnetosphere and the rarefied interplanetary plasma is called the magnetopause, and occurs 40,000 miles from earth, where the pressures of the magnetic field and the solar wind are equal. Unable to penetrate this shield, the solar wind flows along it, pushing the part of the magnetic field originating in the polar regions back into an invisible magnetic tail extending more than a million miles out from the side of the earth away from the sun. A neutral plasma sheet separates the equal, oppositely directed fields of the Northern and Southern Hemispheres as they are flattened out in this geomagnetic tail.

"Here," Williams says, "we need a model that explains the transfer of energy and particles from space into the magnetosphere of the earth. How the geomagnetic tail and plasma sheet form and behave is not really known. Nor can we aptly model the process whereby solar particles enter the protecting magnetic shield around the earth. Sometimes they are delayed a long time. And, at other times, they apparently burst right through. This must depend on the structure of the magnetosphere, which we do know varies considerably. But exactly how the structure of the magnetosphere determines particle entry is not known.

"Lastly, we need a good ionospheric interaction model that describes how the ionosphere and upper atmosphere respond to a barrage of charged particles. We are aware of some of the communication effects, ground effects, changes in upper atmosphere chemistry, and large-scale atmospheric circulation effects, but we must still document these and tie them directly to a specific cause in our model. In this area, we plan close coordination with ERL researchers in the neighboring Aeronomy Laboratory."

This may sound like a lot to do in ten short years. But the Laboratory is uniquely qualified to do it. Even now, satellite data and space research experiments are providing much of the necessary information. The roster of satellites which now provide data is impressive—Interplanetary Monitoring Platforms, Applications Technology Satellites, International Satellites for Ionospheric Studies, Orbiting Geophysical Observatories, Pioneer, and the NOAA ITOS series of satellites.

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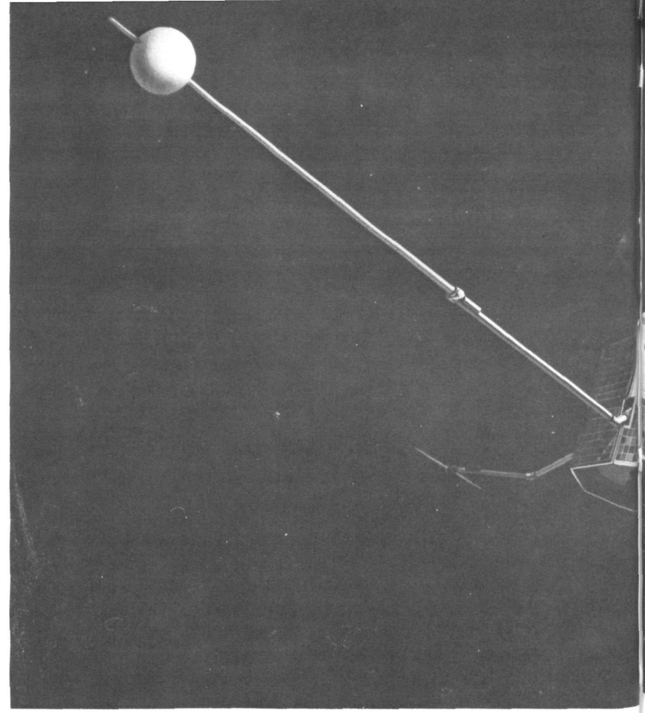
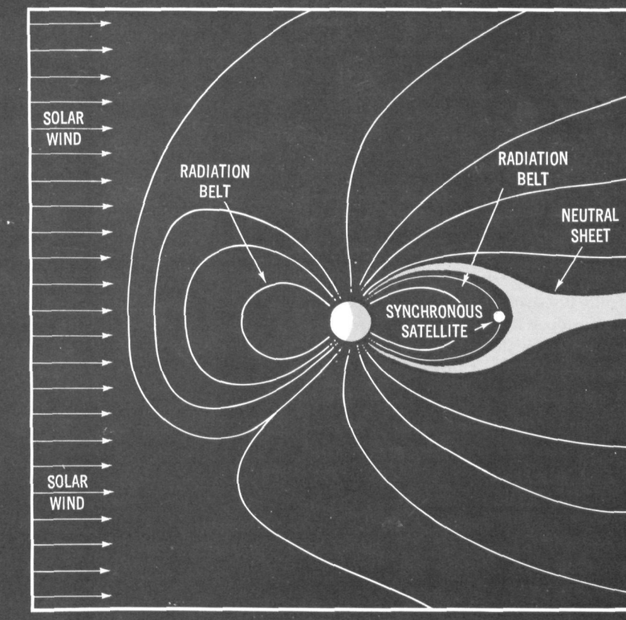




(Right) "We need a model that explains the transfer of energy and particles from space into the magnetosphere of the earth," Donald Williams, SEL director, says. Satellite data are providing much of the necessary information. (Left) NASA's S³ research satellite will gather data on the earth's ring current; on wave-particle interactions in the atmosphere; and on source, loss, and transport mechanisms of particles trapped in the magnetosphere.

PUTTING THE SOLAR-TERRESTRIAL ENVIRONMENT MODEL INTO ORBIT

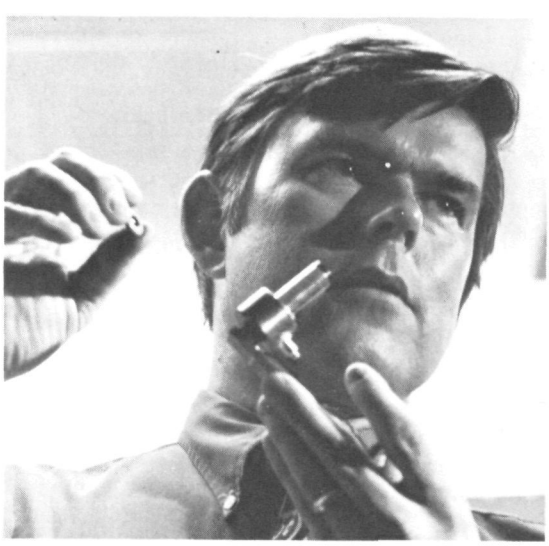
Satellites	From which SEL will get information
Helios—German solar probe	Data on proton, electron and alpha-particle intensities encountered by Helios as it moves in toward the sun will be used to help unravel the mode of propagation of energetic particles from the sun to near-earth space. Principal Investigator, Prof. E. Keppler, Max Planck Institute, Lindau, West Germany.
IMP's (Interplanetary Monitoring Platforms) —NASA spacecraft	Solar proton data from interplanetary space will detail the distribution and energies of these particles in relation to solar events. IMP–F data are complete, G is currently on station, I will be launched shortly, and H and J are slated for 1972 and 1973, respectively.
OGO's (Orbiting Geophysical Observatories) —NASA spacecraft	Data will be used by SEL research teams working on the STEM model. Measurements of trapped, precipitated, and backscattered electrons will be made at significant energy levels, as will measurements of auroral electrons.
ISIS's (International Satellites for Ionospheric Studies) —Joint Canadian-NASA satellites	ISIS A ionograms are being received and processed by SEL. ISIS B will provide similar information.
S³—NASA research satellite	From this small scientific satellite SEL will participate in a study of the earth's ring current; wave-particle interactions in the atmosphere; and source, loss, and transport mechanisms of magnetospherically trapped particles. NASA's S³ will be launched from Kenya into an elliptical orbit stretching out into space some six earth radii.
ATS's (Applications Technology Satellites) —NASA spacecraft	SEL will receive data on the density and energies of protons, alpha-particles, and heavy ions (lithium-beryllium-boron and carbon-nitrogen-oxygen) at 6.6 earth radii as the geostationary satellite ATS–F hovers over one point on the earth. This should aid scientists in tracking down the sources of particles in the earth's radiation belt, as well as provide important clues to particle production in solar flares. A special radio beacon on board will also enable researchers to assess the propagation of different frequencies through the magnetospheric region into the ionosphere of the earth. (ATS–1 is now providing real-time data on solar protons and the geomagnetic field to SEL. Courtesy—Drs. G. Paulikas from Aerospace Corp. and P. Coleman, UCLA.)
SOLRAD HI—Department of Defense Satellite	Instrumentation aboard this satellite will provide monitoring information on the solar wind, solar X-rays, and energetic solar particles at distance of 20 earth radii from the center of the earth.
TIROS M (Improved TOS)—NOAA satellite	The six low-altitude polar satellites scheduled in this series monitor solar proton and radiation belt intensities. Data from the first two launches in this series, TIROS M and NOAA 1, are being used routinely in the SEL real-time data and forecast services.
TIROS N —NOAA satellite	This low-altitude polar satellite is now being planned by NOAA/NESS. SEL plans to continue monitoring solar proton concentrations over the polar caps, especially for very high energies of potential danger to high-altitude aircraft. In addition, plans are being made to monitor the total energy input to the upper atmosphere due to particles precipitating from the radiation belts.
GOES (Geostationary Operational Environmental Satellite)—NOAA satellite	The three GOES geostationary satellites will monitor and report in real time on protons, X-rays, and the magnetic field in space at 6.6 earth radii. The data will be used in SEL for both research and service.
GMS (Geophysical Monitoring Satellite)—Department of Defense and NOAA	This satellite, orbiting at synchronous altitudes in the earth's magnetosphere, may be used to stimulate auroral and ionospheric disturbances for ground and rocket study. It will also provide SEL with real-time data on electrons, protons, and magnetic and electric field strength in the magnetosphere.
SKYLAB—ATM (Apollo Telescope Mount)—NASA manned mission	SEL will provide solar flare forecasts to the SKYLAB astronauts in order to optimize the scientific return of the mission.
Rocket Studies	SEL has various rocket programs planned to study the protons, electrons, and heavy ions in proton-auroral events and to study ionospheric and upper atmospheric interaction processes. One such program is in cooperation with the University of Bergen in Norway.

And the list of future launches and planned satellites is even more impressive. Much of this information finds dual science/service use in the Space Environment Laboratory. While researchers are building improved mathematical models to account for all the new information, the Space Disturbances Forecast Center uses selected data in its forecasts and its real-time data base.

The real-time data base is an up-to-the-minute computerized compilation of all available information concerning the state of the solar-terrestrial environment—from the sun's surface, through the interplanetary medium, into the earth's geomagnetic field, and finally on into the ionosphere and upper atmosphere.

In order to take advantage of new developments resulting from satellite discoveries and new sources of satellite data, the Laboratory has developed a system for providing a base of solar-terrestrial data available in real time to users anywhere in the world. All the information received in Boulder is stored in the memory of a 940 timeshare computer, which is programmed to sort and maintain the data in chronological and geographical order. A user can call the computer and get the precise data he needs immediately. The data in the computer, acquired from the global SPAN network of radio and optical telescopes and the ATS-1, ITOS, and Pioneer satellites, give actual measurements of solar activity, solar protons, trapped electrons, and characteristics of the interplanetary magnetic field. Further data on the ionosphere, terrestrial magnetic field, and cosmic rays are also acquired by NOAA's station in Anchorage, Alaska, and from the U.S. Air Force's Air Weather Service teletypewriter circuit—the Astrogeophysical Transmission Network (ATN). This unique time-share computer and real-time data service of NOAA is gaining wide acceptance in the scientific and technical community. The real-time data base has found users in the Air Weather Service, as well as in research communities.

In addition to satellite experiments to monitor and observe the solar-terrestrial environment, the Space Environment Laboratory is planning a space weather modification experiment. This will give researchers an opportunity to directly interact with the space environment and artificially create ionospheric disturbances and auroras. Subsequent observations and study of the artificially induced effects should serve to fill in some of the missing pieces in the puzzle that is the ionospheric interaction model of STEM.



Laboratory director Donald Williams holds a low-energy electron detector which will be flown in a rocket program scheduled for November 1971 in Norway. In his left hand is the detector holder, in his right is the surface-barrier solid-state detector that measures electrons. The rocket program, to be conducted in cooperation with the University of Bergen, is part of the Laboratory's planned studies of protons, electron-auroral events, and ionospheric and upper atmospheric interaction processes.

Williams explains: "We are now at a stage in our understanding of the magnetospheric environment where space weather modification is becoming a realistic and extremely powerful method of gaining a much fuller understanding of this environment. *Space weather* may be a confusing term. When we speak of winds that blow in space, we do not mean neutral particle winds, but rather, flows of elementary charged particles—protons, electrons, and alpha-particles covering a very wide energy spectrum. The force fields responsible for these winds, the magnetic and electric fields in space, are subject to large time variations and are directly and significantly modified by the particle distributions themselves. Gravity plays no significant role in this realm.

"Storms in the earth's space environment represent large-scale fluctuations in the earth's magnetic field, accompanied by intense precipitations of charged particles into the atmosphere with the consequent development of ionospheric disturbances, auroras, radio blackouts, and a variety of other phenomena. These particles often contribute significant amounts of energy to the upper atmospheric regions and, for example, on the night side of the earth are one of the major ionization sources in the upper atmosphere."

With the knowledge now available concerning the magnetosphere and its environs, it is possible for scientists to design experiments, both passive and active, which can directly test and observe specific mechanisms thought to be responsible for various magnetospheric phenomena, such as magnetic storms and particle precipitation processes causing ionospheric disturbances and auroral displays.

Passive experiments generally observe natural parameters over which they have no control, whereas active experiments directly stimulate the environment and observe the results of such stimulation. The Argus and Starfish high-altitude nuclear explosions, and the injection of accelerator beams into the magnetosphere at altitudies of a few hundred kilometers, are examples of active experiments which have already been conducted. A technique for releasing barium into the magnetosphere has also been successfully used to study magnetospheric electric fields.

By contrast, controlled active experimentation with the earth's space environment, or space weather modification, will afford one of the best possible methods for gaining an understanding of that environment.

The Laboratory hopes to fly an active experiment on a small geophysical monitoring satellite in the mid-1970's. When activated 22,300 miles above the night-time earth, the device will trigger a self-quenching flow of electrons into the upper atmosphere. The experimental technique proposed is to insert into synchronous orbit a small satellite carrying the plasma injection device, along with the instrumentation necessary to monitor the effects of the injection. Repeated injections appear feasible, with direct readout of the on-board instrumentation being used to determine the optimum ambient conditions for each injection.

With the understanding gained through such active experimentation in the space environment, scientists will learn more about the natural processes that cause storms, and should be able to improve their predictions on radar clutter and the quality of polar radio communications in future naturally occurring storms. It is also conceivable that naturally occurring storms may someday be modified or attenuated. Thus, carefully controlled active experimentation with the earth's environment will not only yield a better understanding of our environment, but will also help discover ways to both protect and make use of it. □

CICAR: Progress Report

After years of scientific neglect, the Caribbean is being probed and measured in a cooperative study by fifteen nations.

EXPLORING AMERICA'S MEDITERRANEAN

BY HARRIS B. STEWART, JR.
U.S. National Coordinator for the Cooperative Investigation of the Caribbean and Adjacent Regions

IT IS INTERESTING—if not discouraging—that so little scientific work has been done over the years in "the Mediterranean of the Americas."

The Caribbean Sea with its adjacent Gulf of Mexico is, oceanographically speaking, still poorly described and even less well understood.

Now, its dynamics, its contained life, its bottom topography and tectonic framework, its interactions with the overlying atmosphere, and the dynamics of the atmosphere above it are the subjects of a cooperative international investigation sponsored by the Intergovernmental Oceanographic Commission.

Officially called the Cooperative Investigation of the Caribbean and Adjacent Regions—CICAR for short—its field phase began in 1970 and will continue through 1972. Originally proposed by Dutch oceanographers, the idea won quick accept-

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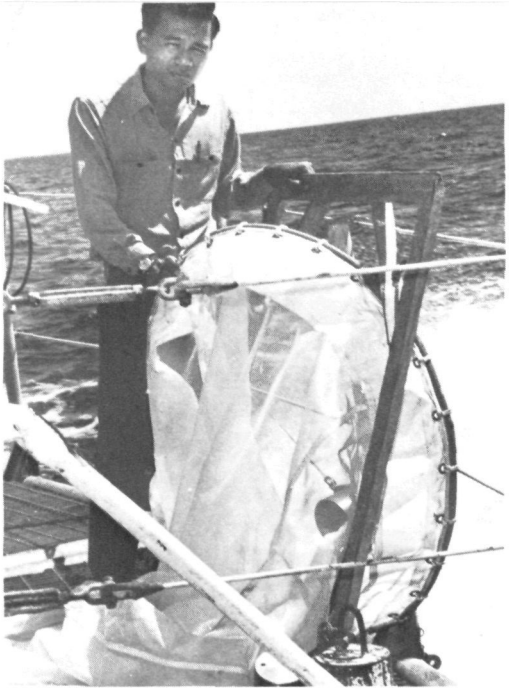


In the Cooperative Investigation of the Caribbean, the Mexican research vessel URIBE (top right) has conducted surveys in conjunction with the NOAA Ship DISCOVERER and the OREGON II. (Top left) Plankton samples were gathered to study the distribution of these organisms. (Bottom) U.S. scientists, on board the OREGON II, demonstrated the use of "bongo nets" to Mexican oceanographers.

ance among the larger Caribbean countries and many of the maritime nations with or without territorial claims in the CICAR region. Since then, several of the smaller countries bordering the Caribbean have also joined in, so that as CICAR enters its second year of field operations some 15 countries are involved: Brazil, Colombia, Cuba, Germany, France, Guatemala, Jamaica, Mexico, Netherlands, Panama, Soviet Union, Trinidad and Tobago, United Kingdom, United States, and Venezuela.

Because so little is known of the oceanography of the Caribbean and the Gulf of Mexico, much of the CICAR effort is of a reconnaissance or survey nature. This is particularly true of the marine geophysics and the marine biological and fisheries programs.

The United Kingdom, the Dutch, and the United States are all involved in systematic surveys of the bathymetry, gravity, and magnetics of the Antillean arc and the A, B, C's, as the islands of Aruba, Bonaire, and Curacao are known.

The Cubans are deeply involved in standard repeat sections of observations along lines radiating out from their island, sections along which they make repeated collections of plankton and measurements of the physical and chemical properties.

The Colombians recently completed a successful cruise along several standard sections to evaluate the upwelling area off the north coast of South America, and NOAA's National Marine Fisheries Service with the OREGON II has made several cruises to evaluate the fisheries potential of the area.

Since the available data in the CICAR area are comparatively few, it has been difficult to identify specific research problems that would lure research oceanographers from their previously planned projects in other portions of the ocean. One outstanding exception among U.S. oceanographers has been the interest in determining circulation patterns in the Caribbean and the Gulf of Mexico. At a meeting held in Miami last summer, physical oceanographers from the eastern seaboard and the gulf coast identified two aspects of the overall circulation that they particularly wanted to investigate in view of the importance of the CICAR area as the source for the Florida Current and much of the water of the Gulf Stream. Highest priority was given to the currents in the Yucatan Channel and the circulation of the Gulf of Mexico. The second problem to be investigated is the complex movement of the waters through the passes between the Antillean Islands.

While the ATLANTIS II of the Woods Hole Oceanographic Institution investigated the currents in the passes, a large cooperative Mexican-U.S. effort was mounted in the Yucatan Channel and the eastern Gulf of Mexico. This latter effort, called the Eastern Gulf of Mexico Expedition, has consisted thus far of three carefully planned multi-ship operations, with a fourth one now in the planning stages. Ships from the several universities of the State University System of Florida, from Texas A&M, the University of Miami, NOAA's DISCOVERER and the URIBE from Mexico worked together to obtain data on the elusive Loop Current in the Gulf of Mexico and on the distribution of eggs, larvae, and other planktonic organisms.

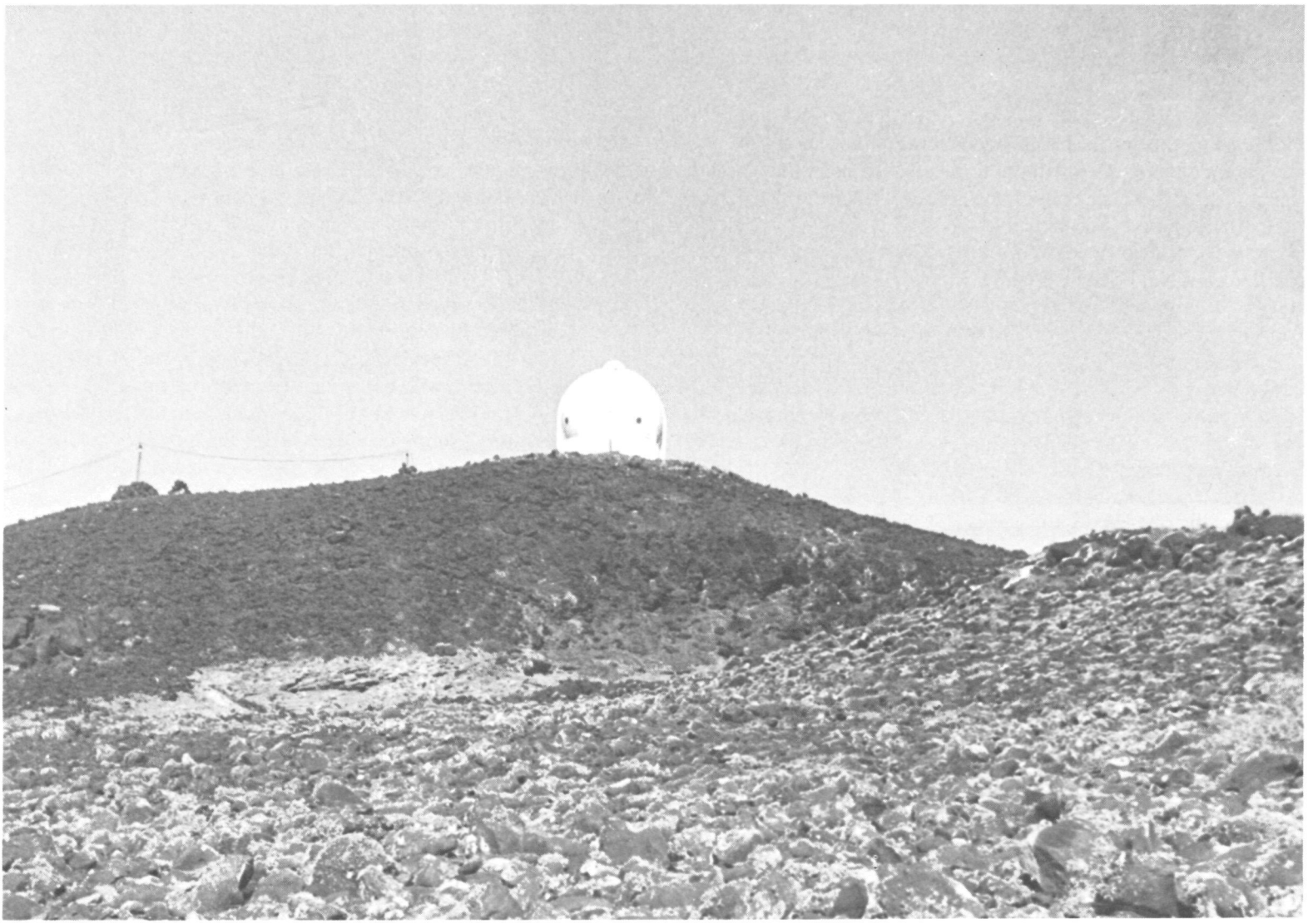
A CICAR Tides Program under the international direction of Bernard Zetler of NOAA's Atlantic Oceanographic and Meteorological Labs in Miami is well underway. Records from tide gages on the coasts of Cuba and Mexico have recently gone to the National Ocean Survey for analysis, and data from six Ocean Survey gages throughout the Lesser Antilles are being used to piece together the tidal picture for the whole region. A NOAA deep-sea tides projects will place bottom-mounted pressure-type tide gages at critical points throughout the area to help in determining the tidal characteristics of the entire basin. More specifically, two one-month sets of open-sea tide measurements will be made with bottom-mounted gages deployed by the NOAA Ship DISCOVERER this fall in the area of the semidiurnal amphidromic point in the eastern Caribbean. Tidal current analyses are even now being run on the data from near-bottom current observations obtained by the DISCOVERER in the Yucatan Channel in 1970, and analyses are planned on current data obtained by Woods Hole oceanographers in the passes between the Antillean Islands.

The United States' effort in CICAR is truly a cooperative one. From the federal government, personnel and facilities are committed from the Geological Survey, the Navy, the Coast Guard, the National Science Foundation, and NOAA's various components. From the university community, there is broad representation including Woods Hole, University of Rhode Island, Lamont-Doherty Geological Observatory, Princeton, Duke, Florida State University, University of South Florida, Florida Institute of Technology, University of Miami, Texas A&M, University of Puerto Rico, and the Scripps Institution of Oceanography.

The National Marine Fisheries Service, particularly with the OREGON II, is heavily involved in the fisheries aspects of the CICAR program. In January of this year, the OREGON II and the URIBE from Mexico met near Alacran Reef (22°30′N, 89°45′W) to intercalibrate various nets for sampling larval and juvenile fishes and to demonstrate the use of the so-called "bongo nets" to the Mexicans. This operation was under the direction of Ken Honey from the NMFS Lab at Boothbay Harbor, Maine, as Chief Scientist, and Bengt Arpi of the FAO mission in Mexico was in charge aboard the URIBE.

NOAA's Tropical Atlantic Biological Laboratory at Miami is serving as the central agency for the CICAR drift bottle program. Feodor Ostapoff of the Atlantic Oceanographic and Meteorological Laboratories is the International Coordinator for CICAR meteorology, and plans to conduct sea-air interaction research aboard the DISCOVERER in the CICAR area this fall. Zetler is the subject leader for tides, and his own project in this field is progressing well. NOAA's ships are participating. NOAA's physical oceanographers, NOAA's fisheries scientists, and NOAA's marine geophysicists are involved, and the National Oceanographic Data Center is heavily involved as the central data repository and distributory for CICAR.

Through the International Decade of Ocean Exploration, first-year funding has just become available from the National Science Foundation for the CICAR program, and it is anticipated that NOAA's role in CICAR will continue to be a large portion of the United States' contribution to this international cooperative venture. □



STORM SENTINEL AT GUADALUPE

An upper-air station established by the U.S. and Mexico on an offshore island fills a serious weather data gap.

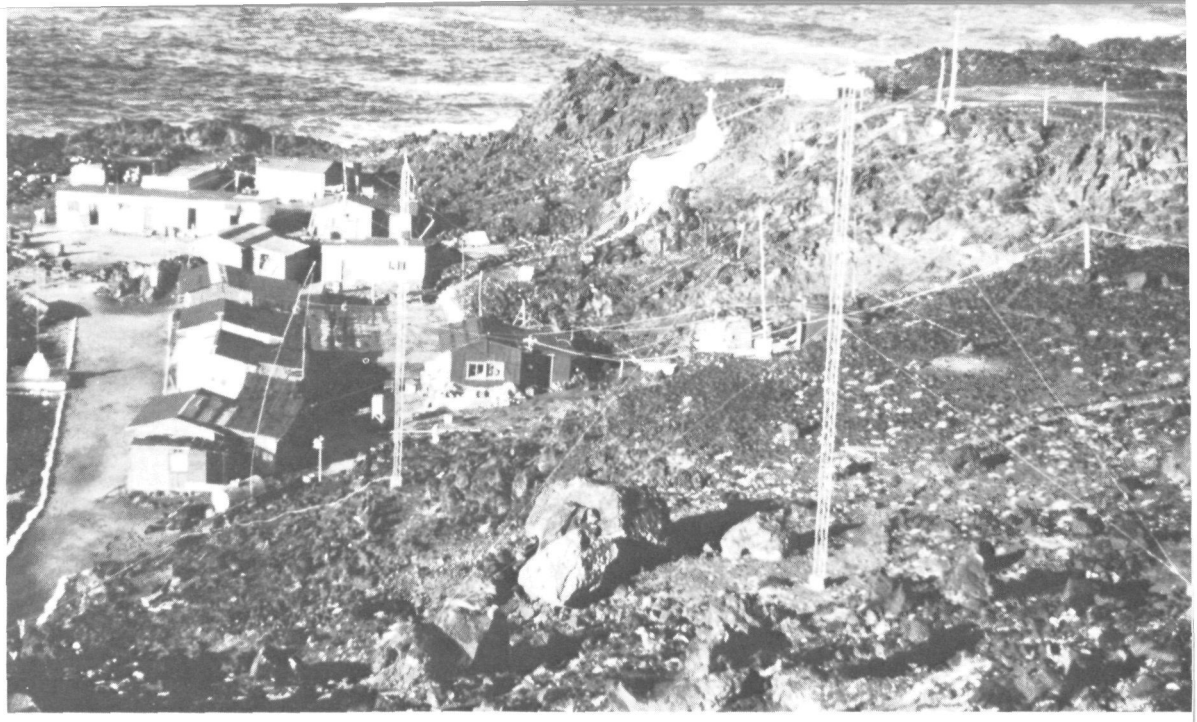
BY EDWIN P. WEIGEL
National Weather Service

A BARREN, rocky outcropping in the Pacific Ocean off Lower California, Guadalupe Island was once a haven for pirates. Today, its only human inhabitants are the staff of a small Mexican Navy base and their families.

A lone Weather Service man came ashore at Guadalupe on November 24, 1970. He was Phillip Gale, electronic technician turned construction engineer, who was to aid the establishment of a weather station in this forbidding corner of the earth.

Less than two months later, on January 16, 1971, the first upper-air observations by rawinsonde from the Mexican-owned island clattered off the teletypewriters at the National Meteorological Center in Suitland, Maryland. The data, obtained from instrumented balloons released by Mexican weather personnel, filled a void meteorologists have been fretting over for more than a decade.

George P. Cressman, director of the National Weather Service, recalls feeling the need for information on the lofty air currents sweeping shoreward from Guadalupe as long ago as 1955, when the Joint Numerical Weather Prediction Unit— predecessor



(Left) Crowning a rocky hill on Guadalupe is the dome housing electronic equipment for tracking balloon-borne instruments. (Right) The only human habitation on the island is a small village housing Mexican naval personnel and their families. There are no roads or vehicles, and all supplies including water are brought in by ship. Radio antennas for the weather station are in the foreground.

to the National Meteorological Center—began daily operations.

"We all appreciated then that accurate and timely forecasting of storms destined for much of Mexico and the U.S. required upper-air data from that part of the Pacific," he said.

"Now that we are getting such data, we should be able to get a better fix on lows that result in flash floods in Mexico and California, tornadoes in the Midwest, and even heavy snowfall along the U.S. east coast—more than 2,500 miles away."

The new cooperative station culminates several years of negotiations between Mexico and the United States. Michael Sunray, the Weather Service technical representative at the American Embassy in Mexico City, was the intermediary.

Under an agreement signed September 14, 1970, the United States supplied buildings and much of the equipment for the new station, while Mexico is providing personnel to carry out the upper-air observations, made twice a day. The U.S. contribution to the establishment of the station was carried out by the Weather Service's Overseas Operations Division—under its chief, Vaughn Rockney, and operations chief Arthur Youmans.

The completed facility consists of a main building, a radome housing electronic equipment for tracking balloon-borne radiosondes, a balloon-inflation shelter, a storage building and a power plant. How it was put together is a story in itself.

Guadalupe is a rugged volcanic island—18 miles long by 3 miles wide—about 250 miles southwest of San Diego, California. Situated in a climatic desert zone that girdles the globe, it is extremely dry with an average annual rainfall of only 2½ inches. What little vegetation there is gets nibbled away by thousands of goats. These are said to be carryovers from days when pirates lived on the island.

For a number of years the only habitation on Guadalupe has been a small village occupied on a station-keeping basis by Mexican naval personnel and their families. They have no roads and no vehicles, and all their provisions are supplied by a ship which makes monthly visits.

Even water is brought in by ship, because Guadalupe is so dry. The scanty rainfall that occurs in winter is not even worth collecting, because it's so mixed with wind-driven salt spray that it's not fit to drink.

Aside from the goats, the wildlife on the island consists of seabirds, domestic cats gone wild, which feed on rats, and a colony of elephant seals.

There are rock lobster and abalone in the shallows and plenty of fish in the surrounding waters, which are clear, blue, and cold. Fishermen from ports in both countries should benefit from improved data from Guadalupe.

Near the top of the island, which rises to an elevation of more than 4,000 feet, is an airfield—really just two unimproved runways on a plateau, the longest extending about 3,500 feet. A C-46 transport makes regular visits, sometimes bringing planeloads of Indians to procure fresh goat meat for airlifting back to the mainland. The airfield is about seven miles from the naval station, by foot, over a rocky trail.

Gale sailed into this setting on November 24—as the only U.S. representative to help erect the station—aboard the Mexican minesweeper DRAGAMINA II, a 180-foot vessel. Aboard were empty fuel drums for a raft, and building materials and equipment for the station.

"One of the smartest things Phil did was to build a raft out of fuel drums to lighter the equipment ashore," explained Rockney. "Guadalupe has no pier for unloading and the shoreline is a jumbled mass of rocks the size of basketballs. Only a raft could negotiate those rocks, without being stove in."

Some of the equipment required a dozen men to manhandle it ashore. Especially cumbersome were two 1,500-pound diesel-electric generators the size of upright pianos, and an even-larger hydrogen-gas generator weighing 1,800 pounds. Another heavy item was the radome, with its eight "banana peel" sections weighing about 200 pounds apiece.

In two days, 60,000 pounds of equipment and building materials were ferried ashore by raft and manhandled, with the aid of block and tackle, up a rocky, 30-degree slope to a landing area, where the various elements were grouped according to destination. "The Mexican Navy personnel engaged in this backbreaking work, some of whom were officers, really did a commendable job," comments Gale.

Excerpts from Gale's log sketch the story.

Nov. 25: Made raft out of 12 oil drums . . . offloaded electric generators . . . no problems . . .

Nov. 26: Offloaded hydrogen generator . . . three hours to get it up the hill . . . all items offloaded . . . ship departed 1600, leaving 13 men . . .

Nov. 27: Both electric generators in . . . serviced one, fired it off, worked fine . . . started power poles to dome, finished all except three . . . cement work on storage

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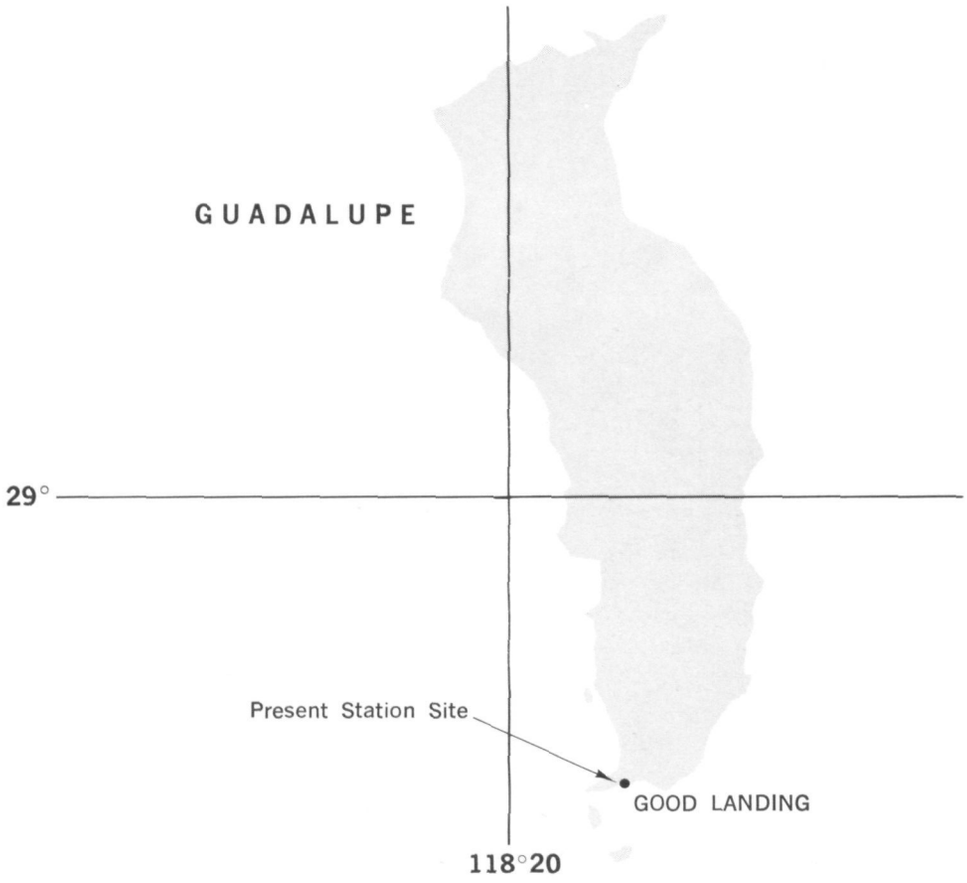
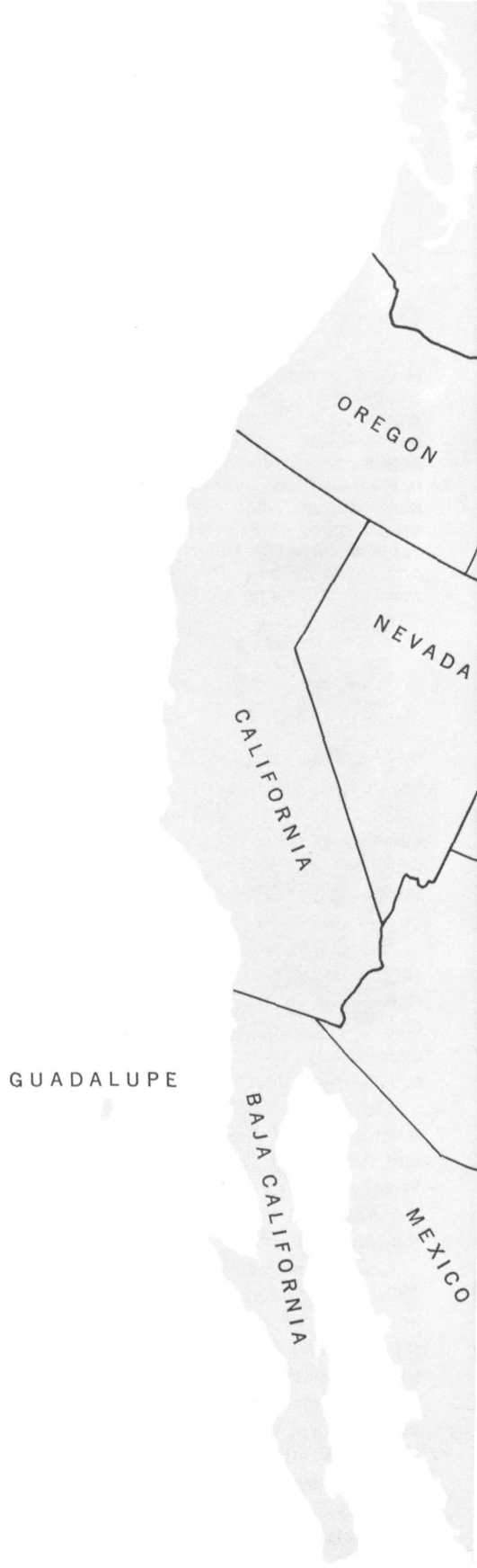




building three-fourths done . . .

Nov. 28: All cables run to radome site . . . ran water line to inflation building . . . pump works well . . . cement work finished at storage site . . .

Nov. 29: Started putting in power poles to inflation building . . . cement work at storage building finished . . . started sand work at radome site . . .

Nov. 30: Started clearing dome site . . . ran cable for wind system and intercom for inflation area . . . sorted and layed out storage building for erection . . . message from Mexico City wanted to know when I would be on the air with the new radio . . . much work to be done before that . . .

Dec. 1: Erected corners of storage building . . . started cement work for balloon-inflation and hydrogen-generator area . . .

Dec. 2: Ship arrived today . . . offloaded 25 tons of water, departed with workers, leaving myself, two masons, and station personnel . . .

Dec. 3: Erected walls for storage building . . . pumped 250 gallons of water for cement work . . . cut and laid floor in meteorological office . . . built a small wagon for children on station . . . only four workers available to work . . .

Dec. 4: Roof and door put on storage building . . . floor poured for inflation and hydrogen building . . .

Dec. 5: Storage building finished except for lights . . . ran power to meteorological office . . . concrete forms made for radome and wind tower . . .

Dec. 6: Started racks for water storage . . . must hold 5 tons water . . . cement poured for inflation wall and wind tower . . .

Dec. 7: Finished rack for water tanks . . . wired and assembled wind tower . . . cement work finished for dome and inflation building . . . cement workers will leave on aircraft tomorrow . . .

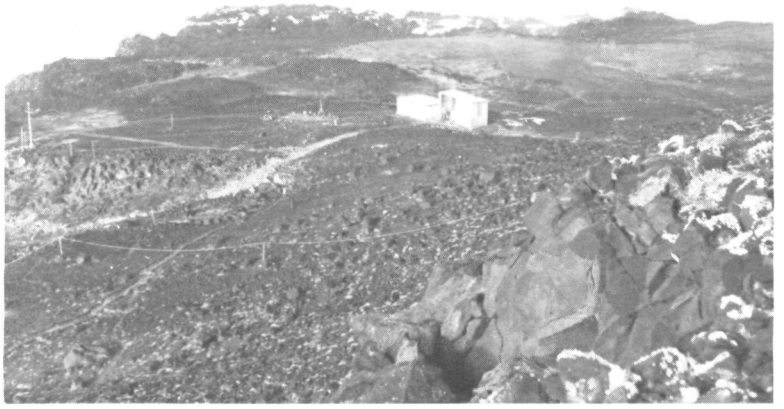
Dec. 8: Both masons departed by aircraft 1430 . . . located and marked where 50-foot radio-antenna towers will be located . . .

Dec. 9: Hydrogen generator put in place . . . four 275-gallon water tanks installed . . . should make enough water to produce hydrogen for 27 balloon flights at two a day (20 gallons per flight) . . .

Dec. 10: Forms and cement work finished for antenna towers . . . laid out part of inflation building . . . hooked up wind mast . . .

Dec. 11: Radome erected . . .

Dec. 12: Today local holiday . . . no



(Top left) "One of the smartest things Phil did was to build a raft out of fuel drums to lighter the equipment ashore. Guadalupe has no pier for unloading and the shoreline is a jumbled mass of rocks the size of basketballs." In two days, 60,000 pounds of equipment and building materials were ferried ashore. (Top right) The completed inflation shelter and storage building. (Lower left) Construction of the inflation shelter begins. (Center) Wind towers. (Lower right) Phillip Gale spent two months supervising construction of the station at Guadalupe.

workers . . . reinforced water-storage tanks . . .

Dec. 13: Erected one radio tower . . . started erection of inflation building . . .

Dec. 14: Very high winds, 25-35 knots . . . finished erection of inflation building with exception of roll door . . . started erection of second radio-antenna tower . . . only 30 feet erected due to high winds . . . hooked up wind meters . . .

Dec. 15: SCR-658 tracking system installed and ready for hook-up . . . radio towers installed and secured . . . 75-foot wire antenna installed . . . radio installed and tested . . . talked with Tacubaya, Mexico . . . started hydrogen-generator building . . . installed fluorescent lighting in meteorological office.

Dec. 16: Finished cabling and hookup in radome . . . installed window in wall of meteorological office . . . worked on walls . . . equipment rack almost completed.

Dec. 18: Finished inflation building . . .

Dec. 22: Departed station 4:30 a.m. to hitch ride on fishing boat . . . all boats had left area . . . returned to station at 10 a.m. . . . winds 20 to 30 knots, seas rough . . .

Dec. 23: Re-erected two power poles blown down during storm . . .

Dec. 24: Worked on radio . . .

Dec. 26: Received word at 1515 local time to depart station for airstrip . . . departed station 1530 by motorboat for fishing camp . . . arrived camp at 1730 . . . departed camp at 1730 . . . arrived airstrip at 2030 . . . aircraft had arrived and departed at 1530 . . .

Dec. 27: Waiting for aircraft . . .

Dec. 28: Aircraft arrived at 1030, departed for return to Washington.

Dec. 29: Arrived Washington at noon.

During those two days waiting for the plane, Gale lived with the Indians, sharing their food, including fresh-killed goat.

He takes such novel situations in stride. At 34, he has already had seven years in the U.S. Air Force and tours in both the Arctic and the Antarctic for the Weather Service. He worked on Pershing missile development and tracking gear for the Atlantic Missile Range, and has been occupied with classified projects for the Defense Department. Married, he has two daughters and three sons.

Although he had had no previous experience as a construction engineer, he found the experience on Guadalupe invigorating. "I enjoyed the challenge." □

SEA STORY: *The Hydrographer Remembered*

THE SAGA OF A GALLANT SHIP

BY ALBERT STANLEY
National Ocean Survey

By no stretch of the imagination could the ship HYDROGRAPHER have been called romantic. Wide-beamed, flat-bottomed, she was a workhorse, built for just one mission—surveys.

But when she retired in 1963, oldest vessel in the Coast and Geodetic Survey (now the National Ocean Survey) fleet, she had seen high adventure during her 31-year career. She had ridden out hurricanes of terrible fury. She had helped the Navy fight World War II—and had fought a bit herself. She had added substantially to America's knowledge of the global sea. She had served her nation well, and hundreds of Surveymen will always remember her with affection.

Most of her peacetime service was in the Gulf of Mexico where, in 1953, she met and somehow survived Hurricane Florence.

She was engaged in hydrographic operations midway between the Yucatan Peninsula and the mouth of the Mississippi River on the evening of September 24, when a radio broadcast stated that a hurricane was forming west of Cuba and the Yucatan Channel. Captain Leonard S. Hubbard was commanding. He immediately headed east-northeasterly pending further information which was expected from the Weather Bureau Hurricane Advisory Center at the next scheduled broadcast. This report informed him that the hurricane was now in the Gulf of Mexico and was moving toward the northwest. All factors were considered, and it was decided to continue on the east-northeast course and then change to an easterly course.

On the following morning, the Hurricane Advisory noted that the hurricane was advancing at great speed, was recurving to the east, and would pass somewhere near the ship's position. The fast-moving storm was increasing in intensity as the Captain stood at the clear-vision screen scouring the tumultuous sea with binoculars. These were not the familiar gulf waters in which the HYDROGRAPHER had always worked. Huge mountains of water were everywhere with pointed tops rushing here and there at great speeds. The wind seemed to pick the skin off the waves, leaving white-pocked patches. Waves broke and then swallowed their own foam. Violent squalls of water bounced raindrops off the sea.

After studying the chart, Captain Hubbard decided that the storm would pass somewhere near the center of his position. At that time, the wind velocity was 75 knots during the heavier squalls. The barometer was falling fast, and the wind increased greatly within the next few hours. Captain Hubbard's orders were to secure all gear and alert all hands for emergency duty. He ordered half speed and then brought the ship hard left with the order to ease the wheel. The wheel was brought amidship, and the quartermaster held it firm. The boat deck was checked by one of the junior officers to be sure that the launches were secure.

The HYDROGRAPHER was rolling and pitching with increasing violence. Going about the deck against the increased wind was like going up a steep hill with the bodies of the men slanted forward. The continuous rushing shriek of the gale which was audible in the wheelhouse was a deafening roar on the outside. Water sloshing over the bow was atomized by the wind and blew aft as a mist. Water on the rails was swept off in little glittering fans.

A huge waterslide, capped by a high white line of foam, was torn apart from a moving mountain of water and broke over the bow of the ship with a resounding slap. Then the mountain itself struck the ship in a swirling tumult, tumbling tons of water over the rail.

At this stage, the chocks securing the heavy 35-foot starboard launch gave way, so that it swung dangerously with each motion of the HYDROGRAPHER. There was great danger that the superstructure would be damaged and the launch smashed to bits. Worse still, if the launch should swing out and fill with water, the ship would list dangerously.

The bosun and several helpers took on the dangerous task of securing the launch before irreparable damage had been done. They finished just as the force of the wind increased, so that not even the impact of the sea could be heard above the low-pitched roar of the storm. The waves were streaked with white spindrift and crested with foaming breakers. Scattered over the dark surface of the sea were large patches of light green. Huge walls of water, moving with the speed of an express train, followed unbelievably close upon each other. The ship no sooner mounted one wave and plunged down into the following trough than it shot up the steep slope of the next wave. Dense and furious rain squalls struck frequently, making the onrushing sea barely visible.

Angry walls of sea broke over the rail and tons of water roared down the slanting deck, then swept away to leeward, and the broad-beamed old vessel staggered and rose again.

Water was being swept in through the ventilators into the compartments below. Despite the efforts of the mess force, objects in the quarters were adrift. The Captain ordered a shift in the vessel with the wind on the starboard bow and the engines at half speed. At times, the bow would fall off, and full speed was necessary to bring the ship back to her heading.

As the afternoon wore on, the wind became even more unsteady, causing rifts in the spray. Through one of the rifts, it could be discerned from the bridge that the forward hatch cover had been carried away. The sea in its fury had cut the tarpaulin covering, and the wind had sucked the cover off as a cork is drawn from a bottle. The hatch had to be protected before too much water found its way below. To complicate matters, the engine-room skylight was smashed, adding to the difficulties of the engine room crew, standing a continuous throttle watch. As the ponderous ship tumbled over one crest after another into deep valleys of water, the propeller would surface. To keep it from racing and whipping off the shaft, the Chief Engineer cut the throttle each time he received the signal to do so, when the vessel took a nose dive with the stern and the propeller lifted out of the water. As the ship surfaced, the power had to be restored instantly.

A junior officer and several men were given the task of covering the engine-room skylight. They made their way slowly along the perilous deck. Each obstruction caused hollow conical gaps in the spray that took on weird forms. Where there had once been a skylight was now an open hole. It was impossible to close the gap with timber and after rummaging in a deck locker, an extra tarpaulin was found. As it was being dragged across the deck toward the broken skylight, the stiff section of canvas was lifted by a sudden gust of wind. It rose over the struggling men like a wall, knocking them down and flattening them to the deck under unyielding weight; then a monstrous wall of water struck the ship, flooding the deck with a raging torrent which almost crushed the men under the tarpaulin. As the deck took a sharp upward slant and the water raced over the stern, the battered seamen crawled out. Struggling, they succeeded in pulling the tarpaulin over the opening, although the wind kept getting under the canvas and almost dragging them into the raging sea. When the heavy material was fitted over the hole and lashed tight, the men quickly crowded into the narrow doorway of the passage which led to the bridge and quarterdeck. They

continued

Wide-beamed and flat-bottomed though she was, the HYDROGRAPHER was the last word in survey vessels during her 1931 sea trials.

escaped none too soon; the wind increased in violence and the open deck became impassable.

The wind roared on and the gigantic feathered sea still curled down over the ship, but some of the ocean's fury seemed to have been lost. In the early hours of the night, the barometer began to rise slowly. It continued upward during the night, and by dawn the wind had slackened noticeably. By midmorning, the wind had shifted direction, and the storm had abated. The weary old ship and her battered crew continued through the day in the still-turbulent sea toward St. Petersburg. It was nine o'clock at night when the HYDROGRAPHER labored slowly past Egmont Key to St. Petersburg Harbor.

Equally dramatic were engagements by the HYDROGRAPHER while serving as a survey ship with naval forces during World War II. Early in the spring of 1942, the HYDROGRAPHER, by Presidential Order, was transferred to military service. The Coast and Geodetic Survey furnished instruments, experienced engineers, the commanding officer, and other members of the Coast and Geodetic Survey Commissioned Corps. Her first assignment was the fogbound north Atlantic, where the ship engaged in charting the harbor and approaches at Argentia, Newfoundland. On completion of this assignment, minor alterations were made at Norfolk, and she got underway for San Diego by way of Guantanamo Bay and the Panama Canal.

In late February of 1943, the HYDROGRAPHER cleared San Diego and proceeded to Kodiak, Alaska, the takeoff point for the working grounds along Atka Island in the Aleutians. After this assignment, the ship moved to Adak Island to plot the ocean floor at various locations. By early May of that year, the HYDROGRAPHER was operating with assault forces at Attu Island. Steaming into Massacre Bay, the launches working from the ship surveyed for safe anchorages and ship lanes to be used by the attack transports and other Navy auxiliaries. Uncharted pinnacle rocks that could have done severe damage to the Navy ships were discovered.

Exploring parties from the HYDROGRAPHER were the first to go ashore at tiny Shemya Island and there plotted safe landing areas for the forthcoming operation. It was stated by the Commander of the Shemya Task Force that, for the first time in LST history, the technical services of hydrographic engineers were used in a coordinated landing operation at Shemya. The results were considered so satisfactory that a similar procedure was established for landings in the Mediterranean and, whenever possible, in the Pacific.

The ship also operated with the landing forces at Kiska Island, searching out safe passage for the transports. This work in the unknown and dangerous Aleutian waters under adverse weather conditions was highly commended by naval commanders. At the completion of this assignment, the ship returned to San Diego for repairs, then joined Command Squadron II at Pearl Harbor and was made ready for tropical duty.

Her next assignments were in the central and western Pacific, where she worked for the remainder of the war. Projects were accomplished at various places in the Gilbert, Marshall, and Palau Islands, and in the waters surrounding Guam and Wake Islands, in spite of enemy attacks.

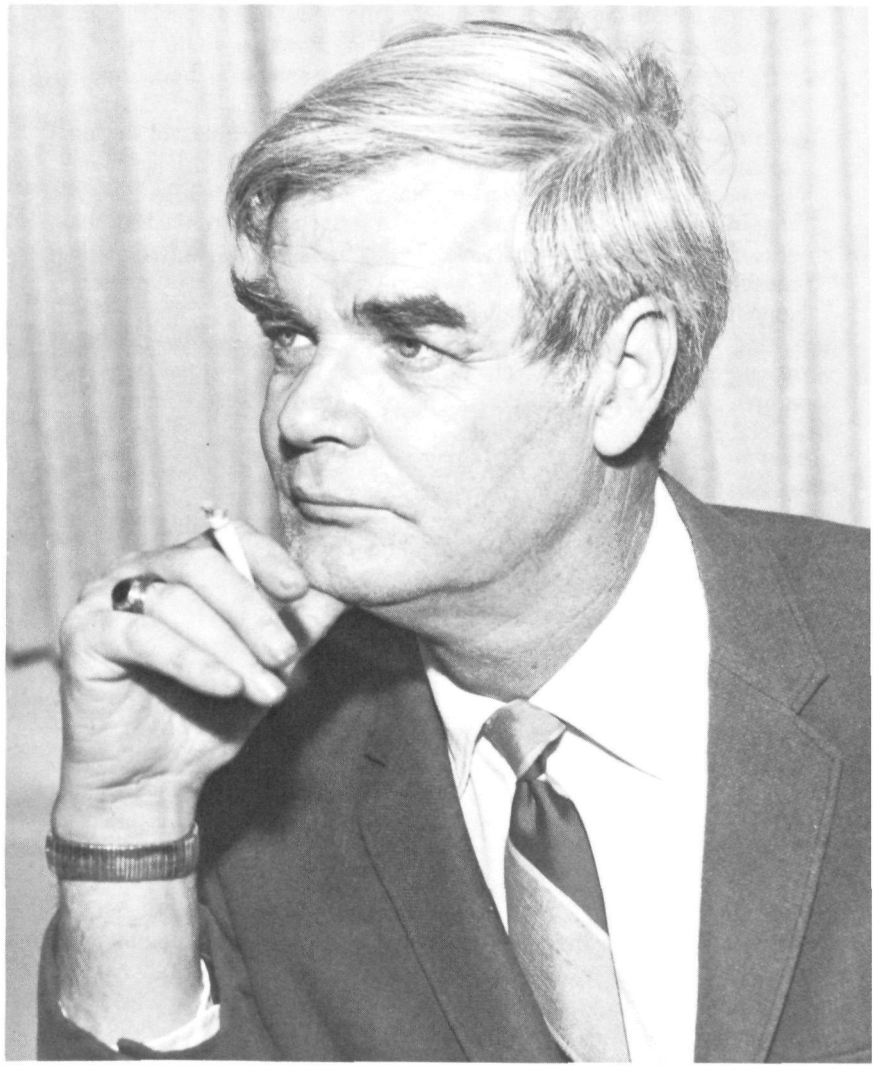
In December 1943, the HYDROGRAPHER sailed in convoy to Tarawa in the Gilberts and then moved south to Apamama, where preliminary surveys were conducted of the surrounding waters. The ship was shifted to Makin Island and surveyed and charted the entrance to the main harbor on the island. On completing work in the Gilberts, the HYDROGRAPHER blasted coral heads at Roi Anchorage at the north end of Kwajalein Atoll. Orders were to "survey and improve the anchorage." Diving equipment and divers were obtained, and members of the crew were trained in diving and in handling explosives. Some 75 coral heads, many of which were awash, were blasted out to a depth of 30 feet. As a result of this operation, naval ships were able to anchor from one to two miles closer to the beach.

After this assignment, the ship went to Guam in 1944 and made surveys of Apra Harbor and other coves around Guam's coastline. Guam was under attack, and members of the ship's party making alongshore surveys were frequently fired on by Japanese snipers. Establishment of aids to navigation, both floating and fixed, and installation of mooring equipment were among the duties of the survey ship. Buoys were often improvised from oil drums or other materials at hand. Lights were placed on buoys and beacons in Apra Harbor for use of ships if a typhoon or enemy action should make it necessary to clear the harbor at night.

The HYDROGRAPHER continued detailed surveys in the central and western Pacific, and charted and buoyed strategic passes in enemy-infested waters. She frequently traded blows with the enemy and once during a night attack, destroyed a three-man assault team which sought to blow up the ship while it was lying at anchor. During that period, the ship was frequently subjected to night raids launched by the enemy from their garrison islands to the north.

After completing the work in the Palaus and other south Pacific areas, the ship returned to San Francisco for overhaul and needed repairs. In August 1945, she sailed again for Pearl Harbor and then to Eniwetok, for a recheck of surveys and aids to navigation. She completed this assignment in December. On January 3, 1946, the HYDROGRAPHER returned to the United States from Pearl Harbor and departed soon thereafter through the Panama Canal to the Norfolk base.

Her wartime career ended on July 1, 1946, when she was decommissioned by the Navy at Norfolk and returned to the Coast and Geodetic Survey for duty. The noble old ship was decommissioned on January 5, 1967, with the late Rear Admiral John Bull officiating. □



One of science's most critical challenges is to find its way out of

THE DATA MAZE

TOMORROW'S PROGRESS is built on yesterday's data, says Dr. Thomas S. Austin, Acting Director of the Environmental Data Service—but how to make that data available in the quantity and quality which will be needed?

The problem—and Dr. Austin's views on it—are explored in the following interview.

Q. Dr. Austin, after six months with NOAA, what is your concept of an Environmental Data Service?

A. EDS is the Government's first major line organization created specifically to manage scientific data. Its creation under ESSA in 1965 was a prophetic and pioneer action, an attempt to develop a data management system to replace the fragmentary and diverse practices that had increasingly become one of the greater obstacles to progress in our understanding of the global environment.

Q. Is this a relatively new problem then?

A. Not really, the need for systematic data management has been recognized for centuries; it is only now that the concept is coming of age. Back in the 18th century, Dr. Samuel Johnson put the concept in a nutshell: "Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it." The second alternative is really what an environmental data service is all about.

Q. What has brought this concept to fruition?

A. The scope of critical environmental problems facing man today. The old habit of putting off data management problems indefinitely can no longer be tolerated. The volume of environmental data being collected has expanded exponentially; larger and larger quantities of data are needed—in an ever-increasing variety of forms and formats—and in a much shorter time. The problem has been put into words in *Man's Impact on the Global Environment,* a recently published MIT report on studies of critical environmental problems, which states: ". . . it is important to note the deficiencies in the data and projections related to problems of global concern . . . it can be argued that the single greatest contributor to environmental pollution is ignorance."

Q. Is this need for an environmental data system approach widely recognized today?

continued

A. Not universally, certainly, but more and more scientists and organizations actively involved in solving today's environmental problems are citing it as a prerequisite for progress in their respective fields. The most recent example is the National Science Foundation's policy statement on environmental data to be collected during the International Decade of Ocean Exploration (IDOE). The opening paragraph reads: "The wide interest and potential long-term value of the data which will be collected on programs funded by the Office of the IDOE warrants the implementation of a systematic procedure to assure that these data will be adequately documented, catalogued, disseminated, and permanently archived."

Comparable statements have been made across the environmental discipline spectrum in recent years by the Oceanographer of the Navy, the President's Science Advisory Committee, the National Academy of Sciences/National Academy of Engineers, the United Nations (UNESCO-IOC), the COSATI Task Group on National Systems, and many others. To use the words of the National Council on Marine Resources and Engineering Development in its third annual report to the President (January, 1969), we are in an "environmental data labyrinth." Our problem is to find our way out—and soon!

Q. I understand that the Environmental Data Service will be heavily involved in the IDOE.

A. Yes. The office for the IDOE has designated EDS' National Oceanographic Data Center (NODC), National Geophysical Data Center (NGDC), and National Climatic Center (NCC), and the Smithsonian Oceanographic Sorting Center (SOSC) to handle IDOE data. NODC will be the lead center for IDOE data inventories and information, and for chemical, geological, physical, and biological data. NGDC will be the lead for geophysical data; NCC for meteorological data; and SOSC for collections of biological specimens.

Q. What steps have been taken by EDS/NOAA to find the way out of the data management maze?

A. I think one of the most significant developments since I came on board has been the NOAA policy statement on the management of environmental data approved by Dr. White, the NOAA Administrator, in early February. This is the foundation EDS needed to further development of its capacity to meet the needs of data users. Two of the statement's paragraphs summarize the EDS/NOAA data management concept:

1. "Unclassified environmental data collected or obtained . . . by NOAA or other Federal or Federally supported activities are public property. It is, therefore, the Department of Commerce's and thus NOAA's policy to make available worldwide environmental data to all interested users . . .", and

2. "The Environmental Data Service has the NOAA program responsibility in the management of environmental data for non-realtime uses, both in NOAA itself and in the national and international user communities, once the immediate purposes for which the data were collected have been satisfied."

The principle involved here is deceptively simple: the purpose of an environmental data system is not only to store data, but more importantly to provide an information service, to make the most effective, efficient, and economic use of environmental data and data information *for all users*. Experience has shown that these data are useful for many purposes after they have satisfied the original need—purposes whose values may outweigh in some cases those of the initial program.

Q. What is the biggest single problem you face in developing an EDS capable of meeting these needs?

A. Data and data management simply are not sexy. Although essential, they are too easy to defer and extremely difficult to "sell." Think how dull it must be to compile the telephone directory for a large city—yet where would you be without it? We sometimes act as if collecting environmental data is more important than using them.

To quote the National Council on Marine Resources and Engineering Development once again (referring to oceanographic

"We intend to move in the direction of fully automated data products, so the user may obtain the data he needs in the format he desires—from data listings to computer-generated graphics."

data): "The potential of this information does not necessarily lie in the quantity of material collected but in the efficient use and integration of high quality, reliable data for whatever requirement it fulfills for the data using community."

Q. What are some of the major misconceptions about data management among scientists?

A. Well, I can think of a few right offhand:

One, that nobody else is interested in data when the scientist is finished with them.

Two, that the scientist, as an "insider," knows where all the data are and how to get them . . . overlooking his mortality and the simple fact that someday his sons and daughters—and grandchildren—may need the data.

Three, that data management consists of throwing almost useless data into dusty bins, forgetting that tomorrow's environmental model will be built on yesterday's data.

Q. What is the relationship between EDS and NOAA's other components, with respect to environmental data management?

A. The other components of NOAA both generate environmental data and use EDS services and products, but we must not overlook the fact that approximately 80 percent of the users of EDS' data are non-NOAA people—the national and international scientific community, other Government agencies, industry, commerce, and the general public.

Q. What are EDS' short-term goals to meet the needs we have been discussing?

A. First, to improve automation to reduce user costs and provide faster, more efficient service. Second, to treat the environmental problems less as separate disciplines and more as a total environmental concern to provide the user an ecosystem approach to his specific environmental problem.

Q. And what are your long-term goals?

A. To manage our environmental data resources so as to provide the scientific data base needed to predict and protect man from environmental problems; ideally, to remove the phrase "inadvertent modification" from our vocabulary.

Q. How would you summarize EDS' mission?

A. I can do no better than to quote from ESSA's Data Activities' Study of 1968: ". . . a true environmental data service is . . . *a full service*—one that responds to user requirements and requests by providing raw and processed environmental data . . . with proper qualification from a data storage and retrieval system . . . Data storage and retrieval activities should serve both their related disciplines and external users."

Q. What are the less obvious benefits of such a concept?

A. Manipulation and applications of environmental data are possible in a data center which are impossible cost effectively anywhere else. NODC, for example, with approximately 700,000 digitized bathythermograph observations on file, can easily generate worldwide surface and subsurface marine temperature analyses needed by the nation's fishermen. Such a task would be awesome indeed for a single scientist or agency to undertake if they had to track down the data among their colleagues.

Another benefit is that the data center provides the scientist with a place to work where all of the tedious tasks, such as data sorting, evaluation, summation, and the like have already been done. He starts at a point a similar scientist without data center services might never reach, after bogging down in these "preliminary" efforts.

Q. Technologically, what specific changes are in store for EDS' data centers and their customers?

A. We intend to move in the direction of fully automated data products, so the user may obtain the data he needs in the format he desires—from data listings to computer-generated graphics.

We plan to establish a true environmental data system network, with each of EDS' data centers electronically linked to the others and to other data repositories, to provide the data user a "one-stop" terminal-to-terminal shopping capability.

Finally, we want to make it possible for the user to interact directly with EDS' data files through his own computer terminal, without going through the respective data center or EDS office at all.

Q. Have you developed any sort of timetable for implementation of the policies and changes we have been discussing?

A. Well, as Dr. White put it in his address to the Marine Technology Society in 1968: "The time to eliminate tomorrow's data bottleneck is now." □

Dr. Thomas S. Austin, Acting Director of the Environmental Data Service, is an international authority on the ocean environment who was formerly Director of the National Oceanographic Data Center.

A native of Olean, New York, Dr. Austin holds a bachelor's degree in biology and master's degrees in both zoology and limnology—the study of fresh waters. During World War II, he was an oceanographer with the Woods Hole Oceanographic Institution and in 1946-47 participated in the Bikini Atoll atomic tests. After working from 1946 to 1952 at the Naval Oceanographic Office, he joined the Bureau of Commercial Fisheries—now NOAA's National Marine Fisheries Service—where he worked for the next 15 years, serving as assistant director and then director of various laboratories. He became Director of the National Oceanographic Data Center in 1967.

Dr. Austin planned and coordinated the first international survey sponsored by the Intergovernmental Oceanographic Commission (IOC)—the International Cooperative Investigations of the Tropical Atlantic—demonstrating that large areas of the ocean can be studied successfully through international programs. He has also participated in meetings of the International Council for the Exploration of the Sea, concerned with the development of marine science and data systems for European countries, and is active in the IOC Working Group on Integrated Global Ocean Station Systems, a group involved in planning and managing an international system of marine buoys and other fixed platforms for collecting oceanographic data.

Currently, he is chairman of the IOC Working Group on Oceanographic Data Exchange and vice chairman of a Panel on International Programs and International Cooperative Organizations of the President's National Council for Marine Resources and Engineering Development. This panel develops the U.S. position on international marine science matters and nominates U.S. representatives to international marine science meetings.

Dr. Austin has received many honors and awards, including an honorary doctorate from Grove City College, Pennsylvania. He is a member of the Marine Technology Society, American Society of Limnology and Oceanography, American Meteorological Society, American Society for Oceanography, and American Geophysical Union.

From tax deductions to health, from airport design to marketing research, if your problem involves past weather,

ASK ASHEVILLE

BY PATRICK HUGHES
Environmental Data Service

During the next few months NOAA's National Climatic Center in Asheville, N.C., may receive an Internal Revenue Service query about your income tax return, if you claimed a weather-related loss last year. This data center, the largest of six operated by NOAA's Environmental Data Service, is the national repository of historical weather data.

Few people realize the great number and variety of uses of past weather data. In 1968, for example, the California State Department of Public Health wrote to the National Climatic Center for historical weather information essential to its investigation of the relationship, if any, between the occurrence of jaundice among newborn infants in Imperial Valley and the exposure of the babies' mothers to agricultural pesticides applied in fields near their homes during pregnancy.

In the same year, a major manufacturer needed a comparison of temperature extremes and altitude for various locations in the United States to determine the efficiency rating of a diesel engine used in its locomotives.

The Bureau of Indian Affairs in 1964 requested wind data for 37 native villages in Alaska in connection with an electrification program. The Bureau was considering the possibility of using windmills to produce electricity, as an alternative to diesel-powered generators.

In 1969, the Nantucket Airport Commission wrote concerning a critical problem. The town of Nantucket is located on Nantucket Island, off the Massachusetts coast. During gale or near-gale conditions, steamship service to the island was cancelled. At the same time, aircraft serving the island could not land or take off in the strong crosswinds associated with such weather, because of the orientation of the runway at Nantucket's airport. Thus the townspeople were completely cut off from the mainland. The town wanted to construct a new runway so the planes could land or take off into the wind during such periods, and the National Climatic Center was asked to provide up-to-date wind analyses needed to plan the runway's construction.

The Curator of Archeology at San Diego's Museum of Man in 1967 requested temperature records for the Stove Pipe Wells Station in Death Valley, California. The records were needed to date artifacts of earlier American cultures uncovered in the desert by the museum's archaeologists.

A letter received at the Center in 1963 came from an attorney representing a client whose insured horse had panicked in a stable and killed itself. The insurance company refused to pay the claim unless it could be reasonably established that the horse was frightened by a storm. Since the weather information requested was to be used as evidence in court, it had to be certified as the official and authentic record of the United States Government, a routine service provided by the National Climatic Center.

In 1967, a woman needed weather information to establish the exact birth date of a family member. She asked the Center to check the records for Bound Brook, N.J., for November 25, 1923, from midnight until 2 a.m., to establish the time that rain or mist had begun and ended. Although there were no weather observations available for Bound Brook for 1923, records from the nearest reporting stations were provided.

In the same year, the owner of a California bee farm wrote requesting climatic or characteristic weather data for various sites in his state. His farm was located in an area where the January, February, March, and April weather was too marginal for queen bees to mate, and he was looking for a more favorable location. The queens, who mate in flight, need a minimum temperature of 72 degrees between 11 a.m. and 2 p.m., with no wind.

Two years ago, the Center received a letter from a graduate student working to develop a method to predict the outbreak and severity of bubonic plague in India. He had established some correlations between weather and plague mortality rates, and needed detailed temperature and humidity measurements for various parts of India to continue his work.

An American importer and distributor of a foreign compact car wrote in the spring of 1968 to locate an area of the United States or Canada where temperatures would be consistently below zero for a period of two weeks; the colder, windier, and wetter the better. The dealer wanted to test his product thoroughly for American winter driving.

In 1967, a father wrote seeking a place in the United States with climatic conditions similar to those of Mexico City, where his asthmatic son's health had improved markedly during a summer visit. The father hoped that a family move might permanently improve his son's health.

These are only a few of the approximately 11,000 requests for past weather records or climatic information answered annually by the Environmental Data Service's National Climatic Center. The economic, social, and individual benefits of such applications of historical weather or climatic data frequently outweigh the benefits of the original purposes for which the data were collected.

Among many others, user applications include the planning of government, state, and local projects and programs such as flood control; atmospheric pollution studies; the relation of weather and climate to social problems; the distribution and use of fuel oil and electricity; space vehicle reentry and retrieval problems; the purchase of snow removal equipment; the design of airports; litigation involving weather-related damage or accidents; myriad commercial and industrial applications; research; and the aspirations and projects of the average citizen—more often than not associated with his health, recreation, or retirement.

About 12 percent of the requests received at the National Climatic Center come from government agencies, about 2 percent from state and local governments, and the rest—by far the largest group—from businessmen, lawyers, scientists, and private citizens. Although these requests range through a broad spectrum of applications, most fall into one of the categories of health, business, litigation, or research.

In one health-related letter, the Camarillo State Hospital of California in 1963 asked for weather data needed in its research on the social relations of psychotic children. In another request, a woman in 1969 wanted humidity data for a western city. She had arthritis and was looking for a place to live where the climate was the most favorable to her condition.

In August 1968, a more unusual letter from a school of dental medicine requested data for six American cities and for Dublin, Ireland, to determine the possible effects of temperature, humidity, and barometric pressure on the duration of anesthesia.

Weather conditions also have a wide and varied impact upon business and industry. One of the nation's largest food distributors, for example, requested data in 1968 to determine the effect of temperature on coffee consumption in the United States.

In February 1963, a New York firm wanted to know the frequency of rainy Easter Sundays and rainy April days for 61 American cities. The request was related to a raincoat sales campaign planned for the coming spring.

A piano manufacturer wrote in 1964 for information on average temperatures and humidities throughout the country. The company was interested in determining the most suitable glues to use for various climatic conditions.

A New England greenhouse owner had an unusual problem in May 1963. There had been a serious crop failure in flower-bulb forcing for Easter in the Providence, Rhode Island, area. The owner needed detailed local weather information to send to a Netherlands laboratory which was trying to determine why the bulbs had not rooted.

A more typical request came from a New

continued

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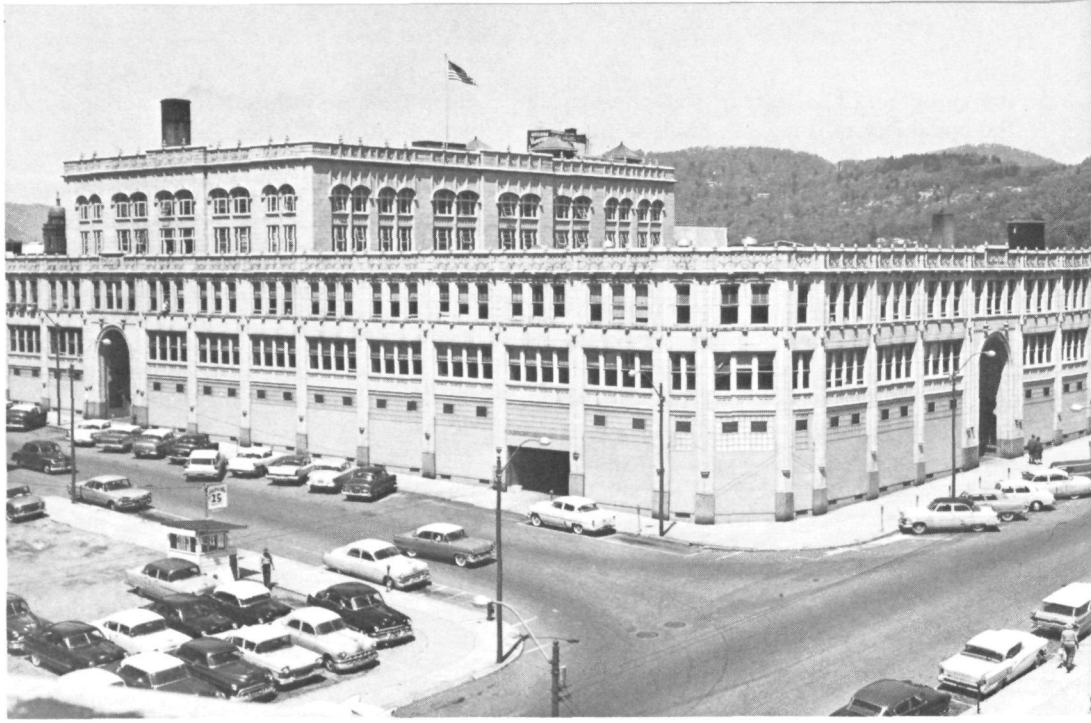
A New York firm, planning a raincoat sales campaign, asked Asheville for data on the frequency of rainy days in 61 United States cities.



York travel agency in 1963. It was arranging a business meeting for 85 men at either Phoenix, Arizona, or Fort Lauderdale, Florida, and wanted to know the winter weather in each city for the five previous years so it could make a choice.

Industry is also a frequent user of past weather and climatic data. A west coast gas and electric company, for example, wrote the National Climatic Center in 1969 to seek information it needed to investigate eight unexplained breakdowns in a power transmission line. The company suspected that gusty winds had caused the electrical conductors to start "galloping" and touch each other, and needed to know the local weather conditions during the failures to check their theory.

A much larger problem faced a consulting engineer firm which contacted the Center in 1969. The company was a consultant on a study for a buried communication system for most of North America. It needed information on the variation of soil temperatures from one to ten feet below the surface. The NCC was able to provide several sources of such data.

In 1968, a mechanical contractor wrote for information on lake conditions and storms for the previous five years for Lake Huron, Michigan. The company was constructing a caisson 190 feet below the surface and needed information to plan its construction schedule.

Flight operations planning and flight research studies are heavily dependent on historical weather data. In 1963, the owners of an airport operated exclusively for rotocraft queried the National Climatic Center concerning the possibility of establishing a night helicopter operation in southeastern Kentucky. They needed to estimate the percentage of trips that could be completed from a weather standpoint, and more particularly, how many nights a year they would be faced with the problem of ground fog. The NCC was able to provide the information.

In the research area, a letter from an airline in 1964 concerned a study the company was conducting on aircraft lightning strikes. The airline wanted copies of weather observations associated with known lightning strikes on its planes in flight.

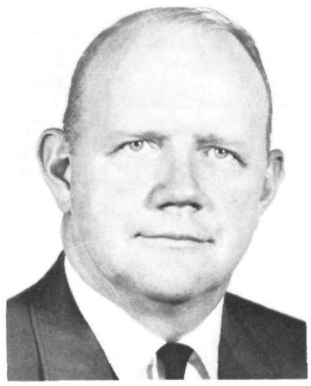
The cattle industry is intensely interested in climatic data. In 1969, a Michigan packing company was setting up a feed lot to accommodate 30,000 head of cattle. To construct it efficiently and to provide the greatest protection for the animals, the company needed to know the characteristic weather conditions for the site; aside from the protection aspect, temperature and wind also affect how well cattle convert their feed to meat.

In 1963, the Tanners Council of America wrote the Center requesting detailed information on weather conditions in Argentina the previous year. A severe drought in that country had forced farmers to liquidate their cattle herds, and caused a sharp increase in cattlehide exports. Conditions in 1963 seemed better and, if so, it would probably be a year of herd rebuilding, with cattlehide exports falling off sharply. Adequate information on Argentina's weather conditions was vital to the Council's analysis of the world cattlehide supply for 1963.

Legal actions are the subject of many of the requests received by the Environmental Data Service's National Climatic Center. Often these involve insurance claims result-

(Top left) Richard Davis explains the National Climatic Center's computer operations to a group of visitors. (Right) The Federal Building in Asheville houses the National Climatic Center, the nation's repository for historical weather records. (Below) Northern Hemisphere weather data are converted to digital form for computer processing by a large-area record reader.

THE NATIONAL CLIMATIC CENTER



William H. Haggard
Director of the Environmental Data Service's National Climatic Center

The National Climatic Center's weather records range from the contents of 18th-century journals to the meteorological data currently collected by federal agencies, as well as weather observations from foreign countries and from cooperative programs with state and local agencies. The Center currently receives more than 100 million observations a year from a global network of surface and upper-air stations. Its total archive is estimated to contain in excess of 70 billion meteorological values.

Each year, the Center mails out some 1,300,000 copies of its climatological publications to subscribers, and an average 250,000 additional copies are distributed to answer requests for climatic data. The National Climatic Center also helps solve specific user problems by furnishing data in the particular form and quantity needed, and by preparing special tabulations or summaries on request, at the expense of the user. Nongovernment users who require assistance in interpreting and applying climatic information to their specific problems are referred to a private meteorological consultant.

User charges depend upon the data or service requested, and may vary from less than a dollar for a simple inquiry that can be answered with a publication, to thousands of dollars when computer programs are involved. For large or complex projects, the Center provides advance cost estimates.

The National Climatic Center often conducts major studies for other government agencies. Reports on these investigations are frequently published and are available at reproduction cost.

Requests for National Climatic Center information or services should be addressed to the National Climatic Center, NOAA, Federal Building, Asheville, N.C. 28801.

ing from storm damage to property, particularly from such storms as hurricane Camille, which slashed across the U.S. southland in late August 1969. Letters concerning Camille are still coming in.

A letter from an Oklahoma claim service in 1969 concerned a different type of weather-related loss. A 175,000-gallon municipal water storage tank had allegedly been damaged by two hard freezes in December of 1968. The claim service represented the insurance company and wanted to document the temperatures on the nights in question.

In a more typical litigation request, a law firm representing the owner of a sailing vessel damaged and abandoned some 300 miles southeast of Honshu, Japan, needed the weather conditions at the time and place of the accident, to determine responsibility for the damage to the vessel.

One of the larger categories of letters received relate to scientific research. Many of these concern studies of the weather itself, but others are concerned with the effects or applications of weather events or data.

In 1963, the Boston Museum of Science wrote seeking information as to the best months of the year to study Mount McKinley from the air. It was interested in the number of clear or mostly clear days per month over a 20-year period.

Many inquiries concern biological research. In 1963, for example, an engineer of the Mississippi State Board of Health needed climatological records for his research on pollution in shellfish growing waters off the Mississippi Gulf Coast. In a similar project the same year, the College of Fisheries of the University of Washington wanted solar radiation data for its study of paralytic shellfish toxicity in the waters near Ketchikan, Alaska.

A more intriguing, if somewhat specialized, study by Southern Illinois University involved wind observations. The University's Cooperative Wildlife Research group was attempting to determine the relationship between the orientation of the bobwhite quail's nest and local wind movements.

The California Department of Public Health wrote in 1963 in connection with a study of mosquitoes. The agency was trying to relate mosquito movements in western San Joaquin, Stanislaus, and Merced counties with the winds prevalent in these counties.

In 1964, the U.S. Department of Agriculture requested climatic information to evaluate methods of controlling the imported fire ant and other insect pests; in the same year an entomologist working in South Carolina wrote for climatic data needed to study the influence of weather on outbreaks of the southern pine beetle.

Three years later, a dentist researching secret operations performed on President Cleveland, aboard the yacht ONEIDA in July 1893, wanted to know the weather conditions on the days of the operations.

Many letters do not fall into any general category. In 1969, for example, the National Climatic Center received a letter from a Midwest newspaper challenging the front-page story of a paper in a neighboring city, which claimed twice as much snow for the season as the writer's city had. Unfortunately, the records verified the rival's claim.

A more esthetic application of weather records was involved in a request received in 1963. A building contractor was conducting a research program to determine the lightfastness of pigments used in the company's acrylic church windows, and needed solar radiation data to predict the expected window life for various parts of the country.

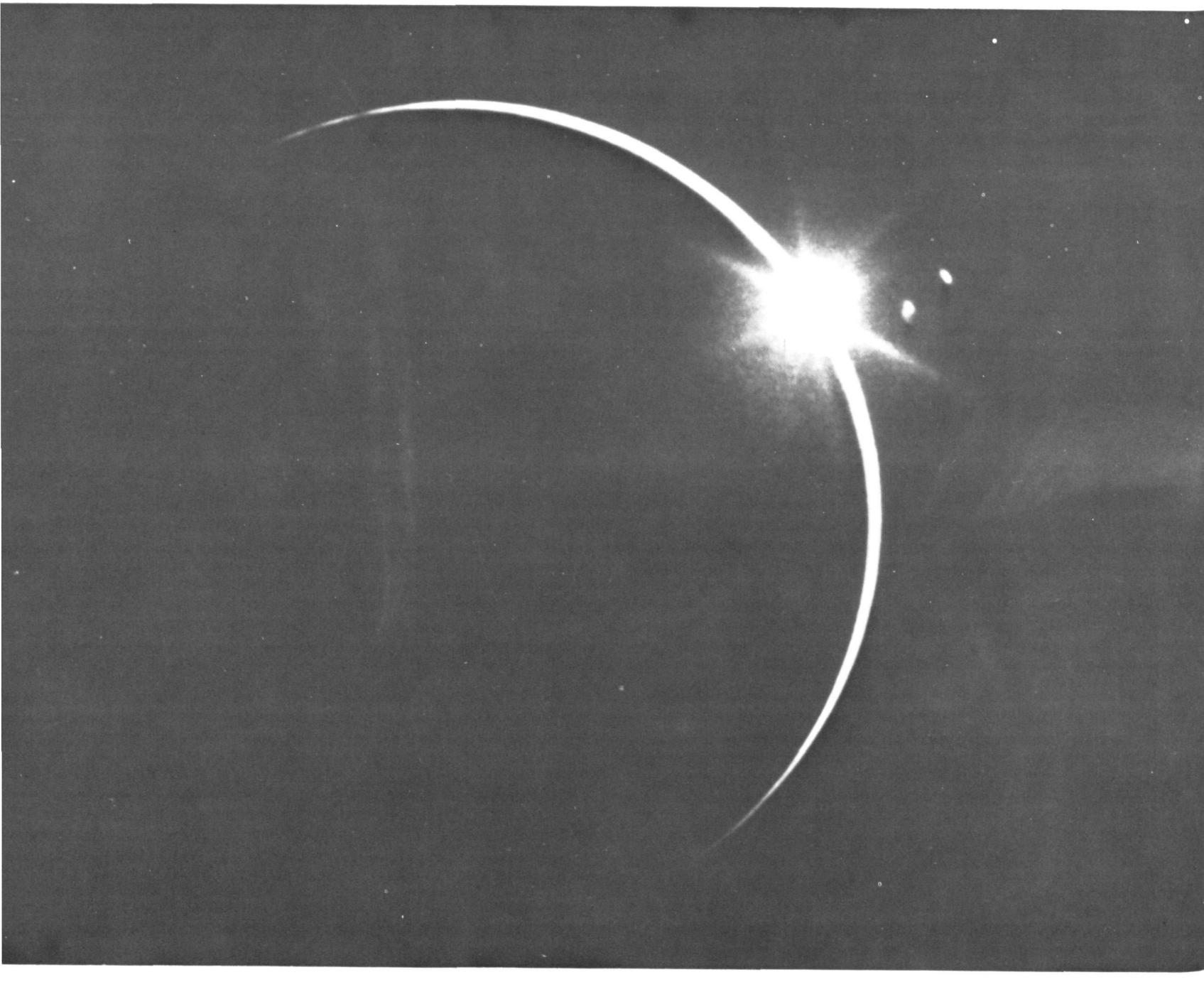
Britton Chance, Fleet Captain of the International 5.5 Metre Class Association of the United States, wrote in January 1964 for weather records needed in planning the Americas Cup Race scheduled for September. In a follow-up letter thanking the Center for the prompt servicing of his request, Mr. Chance wrote that the weather data supplied were ". . . of key importance in our decision to consider holding the trials fifteen days later . . . to get a better wind pattern."

One of the most interesting letters received by the Center came from a scientist in Cambridge, England, in 1963. He had previously written for weather data needed in his study of the physical environment of the caribou inhabiting Alaska. A week later, he wrote again. It seems that while undertaking his research on caribou, he had come across two incidents of snowshoe rabbit migration that seemed closely related to changes in the weather. Such a mass snowshoe rabbit movement is extremely rare; the scientist had been able to substantiate only one other occurrence, in northern Minnesota in 1912. He wanted additional climatological data so he could analyze the situation and publish an account of the events in a zoological journal.

Obviously, the breadth and scope of possible applications of past weather and climatic data are almost limitless. From income taxes to rabbit migrations, if your question concerns past weather, NOAA's National Climatic Center probably has the answer. □

SPACE

Environmental Vantage Point



(This article is excerpted from a NOAA brochure of the same title, to be published soon.)

SPACE OBJECT 1970-106A sweeps past the rim of sunlight into Arctic night, past the Pole, then southward over Greenland and the dim sparkle of the Atlantic, 900 miles below. Its sensors scan the darkness, the thin layer of dense atmosphere, the exposed surface of the sea.

Then, as the Maritime Provinces pass beneath the satellite, a signal comes: "Tell us what you see." An image made of warms and colds, darks and lights, flows out through the spacecraft antennas to be made into pictures of nighttime cloud cover by men and machines on the ground.

As revolutions, hours, days go by, the satellite's masters test and interrogate. "What do your cameras see? Your radiometers? Your proton counters? Are your panels drawing power from the sun? How do you feel?"

This is NOAA-1, launched December 11, 1970, the descendant of TIROS, Nimbus, and a decade of environmental satellite technology. Like a modern child, the spacecraft is larger and more sophisticated than most of its ancestors. NOAA-1, and its second-generation successors, represent a new effort to use this technology to ease the human burden of storms on land and sea, of thunderstorms and tornadoes, hurricanes and typhoons, floods and winter storms, catastrophic heat and catastrophic drought, and the myriad atmospheric and solar variations which enhance, discomfort, or threaten human life and prospects.

In a lower orbit flies 1960-Beta-2, the now-silent TIROS I*, which first took television cameras into space. Nine other experimental TIROS spacecraft are still aloft, as are the nine TIROS Operational Satellites called ESSA and the second-generation prototype, launched January 23, 1970, called ITOS-1. Some are dead, some are dormant, some continue with the work ITOS-1 and the NOAA operational series are assuming in the 1970's.

Some 20,000 miles farther into space, suspended like silver spiders above the planet's equator, two satellites nearly a hemisphere apart consolidate their claim upon the future. Cameras carried into earth-synchronous (or geostationary) orbits by these Applications Technology Satellites have confirmed that a near-continuous view of the earth's surface is one of the greatest gifts environmental scientists have had from space technology.

The new satellites—ITOS and ATS—are the keystone of a National Operational Environmental Satellite system, first authorized as a meteorological system after those early, rather rudimentary television pictures were returned from space, and since matured to a broader point of view. The national system is operated and managed by the National Environmental Satellite Service of NOAA.

The emphasis upon an environmental, rather than a meteorological view has pervaded this effort to use satellite technology to help describe man's physical world—the interacting composite of earth, sun, and atmosphere, of oceans and oceanic life. The Pageos satellite is the photographic target for the satellite geodesists of NOAA's National Ocean Survey, which is linking continents with precise triangulation schemes. SOLRAD and the Explorer spacecraft series are long-time contributors to the attempts of the Environmental Research Laboratories to describe and predict earth-sun interactions. Now an environmental satellite system has begun to pull together this broad descriptive task.

Infrared Sensing—Sight on a Blind Side

The description of first-generation meteorological satellites as "weather eyes in the sky" accents what was most remarkable about them—from space they returned photographs that were something like the eye would see, although without the resolution or the color. But this same feature also describes their most serious limitation. The eye, and the "weather eye," are blind to all but a narrow band of electromagnetic radiation.

This means that the larger world of energy is invisible to us and to our satellite cameras. Everything at temperatures between about 7,000 and minus 300 degrees Fahrenheit emits energy in the infrared region of the spectrum, the longer-than-optical waves of heat energy, the pervasive store of force that drives the great engines of ocean and atmosphere. To get more than a photograph of the visible, to get an insight, a measurement, scientists looked toward sensors which could see the dynamic warms and colds, absorptions and emissions, of our planet.

TIROS II, III, IV, VII, and the ESSA stored-data spacecraft carried low-resolution radiometers to measure total incoming solar radiation and radiation emitted and reflected by the earth. Information of this type is needed to determine the effect of radiation on large-scale circulation processes in the atmosphere.

Infrared sensors with better resolution held the key to sight for instruments scanning the night side of the earth, and to useful determinations of atmospheric heat distribution. The first high-resolution infrared radiometer went into orbit with Nimbus 1, and sent back information which found a variety of uses; subsequent Nimbus satellites also carried the high-resolution radiometers. A two-channel variety of this instrument is built into the ITOS system.

Interpreted graphically, infrared data can be presented as pictures of nighttime cloud cover, and, as demonstrated by Nimbus II, either stored for central analysis or broadcast over the satellite's Automatic Picture Transmission, or APT, channels. This technique promised to increase the frequency of satellite observations available to ground stations from APT cameras.

Interpreted in quantitative terms, high-resolution infrared sensings provide information about temperatures of earth, sea, and clouds. Because the energy received at the sensor increases with the temperature of the object being viewed, and because temperatures in the troposphere normally decrease with height, it is possible to determine cloud-top heights from infrared data, and so to make a more objective determination of cloud types. In cloud-free areas, the data can be used to measure sea-surface temperatures and to distinguish between warm and cold ocean currents, clouds and snow, ice and water. This makes infrared sensing valuable to oceanographers as well as weathermen.

Scientists working on numerical weather prediction—the use of mathematically simulated atmospheres and real data to forecast weather—have desperately needed more and better information to plug into predictive models. The greatest lack has been profiles for the atmospheric column above the open ocean area and less developed continents; but there has also been a need for more continuity than the synoptic schedules for rawinsonde (twice daily) and radiosonde (four times daily) balloon profiles can provide.

If satellites could provide daily, global profiles of temperature, water vapor, and other weather elements, numerical prediction models could be brought closer to reality, and tested on the coming generation of bigger, faster electronic computers, and weather forecasting could take an unprecedented 10-day step into the atmospheric future.

Next to development of weather satellites themselves, this was the most difficult objective for system developers to achieve. But sensors provided such soundings before the first decade of satellite meteorology had ended.

In April 1969, signals received from a new instrument aboard Nimbus III indicated that a major breakthrough had been achieved in this area. Called SIRS-A (for Satellite InfraRed Spectrometer; "A" indicates first model), the instrument was developed by the National Environmental Satellite Service to measure radiation

continued

* TIROS is the acronym for Television InfraRed Observational Satellite; TOS, the acronym for TIROS Operational System, in which the spacecraft themselves were called ESSA, for Environmental Survey Satellite. ITOS is the acronym for Improved TIROS Operational System, the first of which was designated TIROS M until successfully launched, then ITOS-1. Successive satellites in the ITOS series will be designated NOAA, for the operating agency, and numbered consecutively. ATS is the acronym for Applications Technology Satellite; GOES for Geostationary Operational Environmental Satellite.

flux from the atmosphere and earth's surface, sensing in eight channels of the infrared spectrum beyond the visible.

Water vapor and carbon dioxide, although comparatively small constituents of the atmospheric gas mixture, are decisive in maintaining the planet's heat balance. Like greenhouse glass, they admit large amounts of solar radiation in the shorter, optical wavelengths, but absorb much of the longer-wave radiation from the earth. The exceptions to this are two bands, called atmospheric "windows," one near visible red and another at about 11 microns.

SIRS-A measures radiance in one spectral interval near the "window" at 11 microns, where the atmosphere is virtually transparent to infrared radiation and where the earth's emissions are strongest; and at seven spectral intervals from 13.3 to 14.9 microns, leading toward the center of the carbon dioxide absorption band at 15 microns. Radiances sensed at 11 microns originate from the surface or from the tops of clouds; radiance at the other seven intervals originates from progressively higher layers of the atmosphere as the intervals approach the maximum carbon dioxide absorption at 15 microns.

The quality of SIRS-A data matched the optimism of its developers. During the first two weeks of the Nimbus III flight, a verification and testing program compared SIRS-derived temperature and pressure-height profiles with those obtained from special radiosonde profiles. SIRS-A results showed excellent agreement with radiosonde data, and some six weeks after Nimbus III was launched, the satellite soundings became a regular input to the hemispheric analyses of the National Weather Service.

SIRS-B, a smaller, lighter, more sophisticated descendant of SIRS-A, was launched aboard Nimbus IV in 1970. This device senses earth radiances in 14 spectral intervals, eight of which are about the same as those on SIRS-A, and six of which lie between 18 and 37 microns; the additional channels provide data from which gross vertical water-vapor distribution can be calculated. The improved instrument's beam is step-scanned to provide a side-looking capability which permits soundings between, as well as along, orbital tracks, improving geographic coverage. SIRS-B provides soundings with a maximum spacing of about 435 miles.

Despite the high quality of their data, today's SIRS are primitive progenitors of a more advanced line. ITOS will eventually carry the Vertical Temperature Profile Radiometer (VTPR), which senses in eight infrared spectral intervals (six in the carbon dioxide absorption band, one in the water vapor window, and one in the water vapor rotation band); the Infrared Temperature Profile Radiometer (ITPR), to be flown on the next Nimbus, will sense in seven channels, of which four will be in the carbon dioxide absorption band, one in the water vapor rotation band, and two in the water vapor windows at 3.8 and 11 microns. Both VTPR and ITPR will permit derivations of temperature distribution even in the presence of considerable cloudiness. Spacing of good soundings down to the earth's surface should be about 300 miles with these instruments, and both will provide measurements used to calculate the horizontal distribution of total precipitable water.

The Nimbus series has also been flight-evaluating IRIS, (InfraRed Interferometer Spectrometer), a NASA-developed instrument which not only senses temperature and water vapor profiles, but which also provides data on carbon dioxide, nitrous oxide, and methane levels in the atmosphere. These constituents have special significance in an age threatened by catastrophic pollution of the air.

Other prototype infrared devices flying on Nimbus include the selective chopper radiometer, an experiment developed in England, which measures the temperature profile from cloud-top levels to altitudes of about 40 miles.

If there is a single "quantum jump" between the TOS system of the 1960's and ITOS system of the 1970's, it is the development of these advanced instruments. For the meteorological users of the National Operational Environmental Satellite System, they have meant the virtual realization of several very elusive technical objectives.

For environmental science, they have meant a meaningful, quantitative look into the world of energy linking sun and solid earth, atmosphere and oceans, and oceanic life.

Second Generation, Second Decade

With ITOS, the capability of the first operational system was dramatically exceeded, and the national system moved closer to achieving its goals. The second-generation spacecraft, twice the size and weight of the operational TIROS vehicle, combines the direct-readout and stored-data functions of both ESSA vehicles, and adds an important new capability: high-resolution scanning radiometers obtain direct-readout and stored images of the earth's night side, providing global coverage at 12-hour, rather than 24-hour, intervals. The infrared sensors also gather data which can be used to infer cloud-top heights and temperatures, and sea-surface temperatures.

Initially designated TIROS-M, the prototype satellite in the new series was renamed ITOS-1 after its successful launch in January 1970, and entered operational service later in the year. Subsequent spacecraft in the ITOS' series are designated as NOAA satellites, and numbered consecutively. Like ESSA predecessors, NOAA satellites are controlled by the National Environmental Satellite Service, Suitland, Md., via two command and data acquisition stations, one at Wallops, Va., the other at Gilmore Creek, Alaska.

ITOS itself is quite unlike the old "hatbox" weather satellites. The equipment module is an oblong box, about 40 inches square and 48 inches long. The solar array consists of three panels, which present a total area of 48 square feet to the sun. The spacecraft weights about 700 pounds and, with the solar panels deployed, is about 14 feet across.

ITOS keeps its cameras and other earth-directed sensors pointing along the local vertical, and the solar panels approximately in the plane of the orbit, facing the sun. A magnetic torquing system and a special motor-driven momentum flywheel on the equipment module stabilize the satellite, and are the key to ITOS control. A pitch-control system regulates flywheel speed based on signals from infrared earth-sky horizon sensors. Magnetic coils correct roll and yaw errors, and liquid dampers reduce satellite nutation, or nodding. The sensor plate is kept pointing earthward by maintaining a satellite rotation rate of one revolution per orbit.

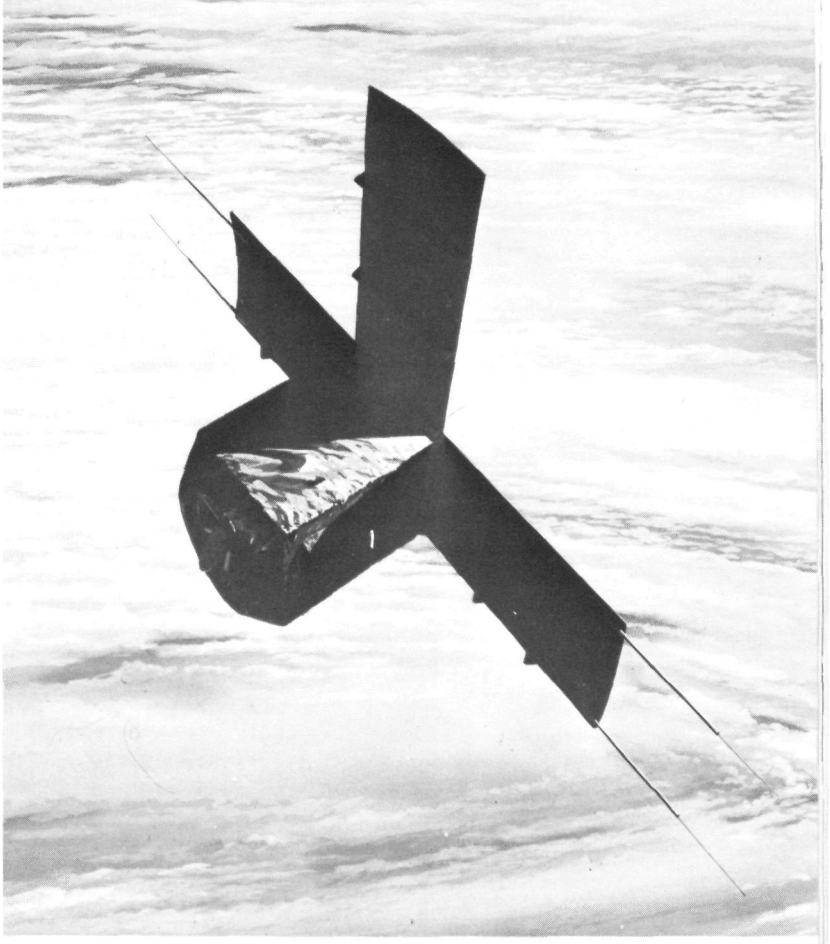
Thermal control of the satellite is a mix of passive and active techniques. Most of the satellite, except for primary sensor openings and the areas used for active thermal control, is covered with multilayer insulation blankets, and a "thermal fence" on one end of the satellite limits the amount of solar heating. To provide a still narrower range of operating temperatures, thermal flaps which automatically open and close in response to temperature changes are installed on the equipment module.

A nominal ITOS orbit is a circular, 909-mile-high, near polar orbit, inclined about 102 degrees to the plane of the earth's equator. The orbital period for ITOS is 115 minutes, during which the earth turns about 28.5 degrees to the east; the slightly retrograde polar orbit makes successive photographs run almost north and south.

The orbit is sun-synchronous, with ITOS crossing the equator northbound about three hours (45°) behind the local noon point of the sun, and, southbound, about three hours behind local midnight. An eastward drift (or precession) of the ITOS orbit of about one degree per day keeps the satellite properly oriented through the earth's year-long journey around the sun.

To do the work of a pair of ESSA spacecraft, NOAA satellites carry four cameras: two AVCS units and two APT cameras. One of each can handle the ITOS mission; the second units are backup in the event of equipment failure. Picture-taking operations of the

The nominal ITOS orbit is about 900 miles high, nearly circular, and nearly polar. ITOS crosses the Equator northbound at 3 a.m. and 3 p.m. local time. This second-generation spacecraft combines the direct readout and stored data functions in one vehicle and also obtains images of the earth's night side, providing global coverage at 12-hour, rather than 24-hour, intervals.



AVCS are controlled by a program of instructions transmitted to the satellite by a command and data acquisition station. The APT cameras, once turned on by ground command, transmit continuously in real time to receivers within range.

Both systems take 11-picture sequences, with each picture taken at 260-second intervals. Each picture covers an approximate 2,000-mile square, or about 4 million square miles of cloud cover, with a resolution of about two miles.

The scanning radiometers aboard ITOS work day and night. During the daylight portion of the orbit, the radiometers sense reflected radiation in the 0.52- to 0.73-micron region of the visible spectrum, and emitted radiation in the 10.5- to 12.5-micron region of the infrared spectrum during orbital day and night. This technique permits measurement of surface temperatures—ground, sea, or cloud tops—during both the dark and sunlit portions of the orbit. Measurements in the visible range have a higher calibration accuracy and dynamic range than television camera systems now in use, and are not subject to the shading which occurs across the face of the vidicon cameras. The ITOS radiometer data is available as either stored-data or direct-readout transmission and covers about the same area as the cameras.

As with the camera systems, the satellite carries two radiometers, to ensure a backup instrument. As the spacecraft moves along its orbit, the radiometer repeatedly scans the surface from horizon to horizon, at right angles to the orbital plane. Scanning is done by a continuously rotating, inclined mirror.

ITOS, like its operational predecessors, carries a flat plate radiometer array that measures the amount of heat emitted by the earth. In addition to helping determine the planet's heat balance, this program hopes to determine long-term changes in earth emissions, which will indicate whether we are heating up or cooling down.

The second-generation meteorological satellite is also a first-generation environmental satellite. Its scanning radiometer permits measurement of sea surface temperatures, which should lead to valuable products for marine environmental activities, including research. The solar proton monitor aboard ITOS is designed to measure proton fluxes at satellite altitudes, and to convert these measurements to a digital record for transmission to ground stations. From data obtained by ITOS (and by other solar-monitoring satellites), NOAA's Space Disturbances Forecast Center can provide timely warnings of bursts of solar energy that could endanger astronauts in space, and air travelers at high altitudes, where the atmospheric shield is very thin. The warnings also indicate disruptions of certain regions of the radio telecommunications spectrum, permitting operators to change frequencies during the interruptions.

As the ITOS series matures, the flexible satellite will carry a broader and more sophisticated array of environmental sensors. Beginning in 1972, the scanning radiometers introduced on ITOS-1 will fully assume the duties of present APT and advanced vidicon cameras, and ITOS will carry a very high resolution radiometer to provide ½-mile resolution pictures, day and night, for direct readout by local receivers. This information will require more complex ground equipment than that used with today's radiometer and APT systems.

Vertical sounders will appear on ITOS in 1972, providing global temperature soundings and gross moisture data for use in numerical weather prediction programs and large-scale analyses. This information will be collected centrally, as the stored-data photographs are now, and distributed internationally as appropriate.

Satellites of the late 1970's may carry instruments that sense radiation in other spectral regions, as, for example, the ultraviolet and the microwave. They may also carry a data-relay capability by which observations can be collected by radio from such in-situ environmental sensing platforms as buoys, ships, and free-drifting balloons.

Goes—The Next Step

Remarkable as the development of polar-orbiting, low-altitude satellites has been, it represents only half an achievement. The operational system required two additional capabilities: continuous viewing of the earth's cloud cover, and a data-relay between weather centers and outpost sensor platforms. While the first low-altitude, polar-orbiting series began returning its operational products, space scientists were readying equipment to meet these objectives.

There was nothing theoretically new about placing satellites into geostationary orbits. An object injected at sufficient speed, in the right direction, can be orbited at any altitude above the atmosphere; however, as the distance between satellite and planet increases, the speed required to maintain an orbit decreases. At an altitude of about 22,300 miles, the orbital speed is down to about 6,800 miles per hour, and the period of a circular orbit becomes 24 hours. If this 22,300-mile-high orbit lies in the plane of the earth's equator, the satellite and earth turn through the same arc distance in the same time, so that the satellite is always above the same point on the equator. Earth-synchronous, geosynchronous, and geostationary are the terms coined to describe such an orbit.

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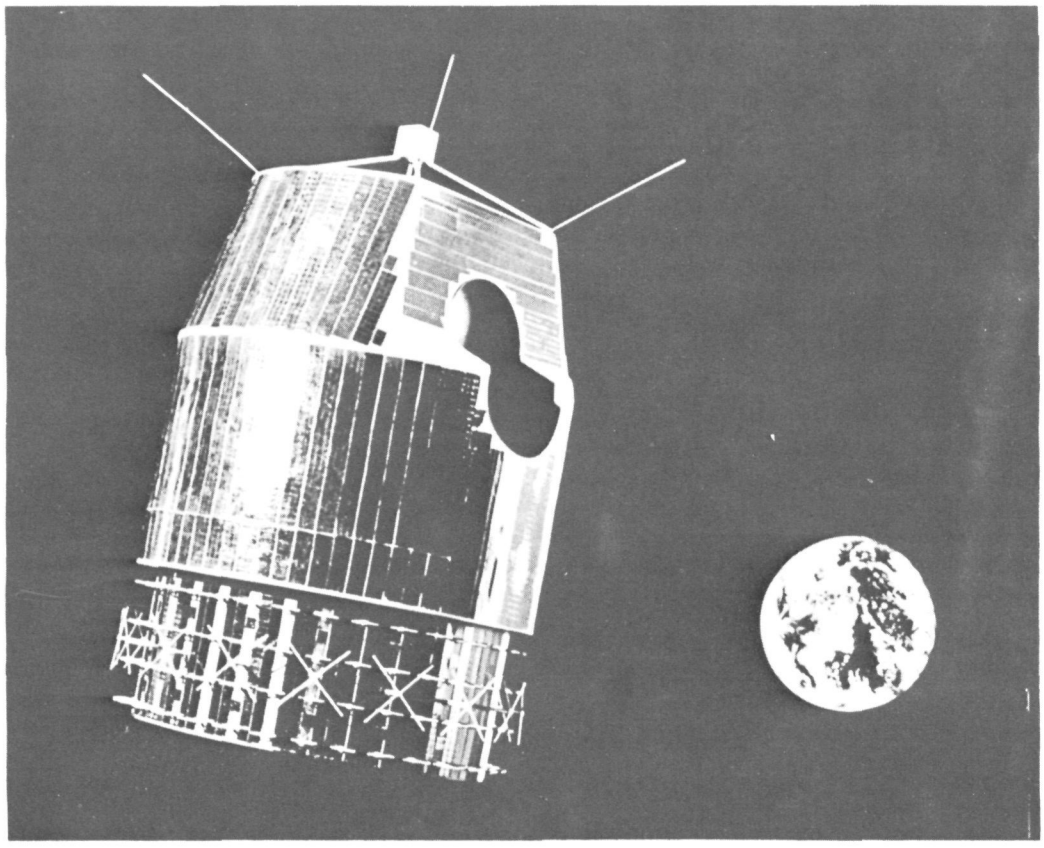


From geostationary orbit, 22,300 miles above the Equator, Applications Technology Satellites photograph the earth's disc every 22 minutes. (Above) A dawn-to-dusk series from one day's photography. (Right) The first GOES—Geostationary Operational Environmental Satellite—will be lofted into earth-synchronous orbit in 1972. GOES will provide wind and cloud-top data, relay environmental information between distant points, and watch the middle-scale, short-term atmospheric events which enhance or threaten life on our temperate continent.

By 1966, considerable expertise in achieving geostationary orbits had been developed on civilian communications projects like Early Bird, launched in April 1965, and some military projects. The first meteorologically important system began NASA's Applications Technology Satellite (ATS) series.

Launched December 7, 1966, ATS-1 went into a geostationary orbit, over a Pacific equatorial point at about 150 degrees west longitude. On December 11, its spin-scan cloud camera began transmitting essentially continuous photographic coverage of most of the Pacific Basin. The photographs, taken by scanning from 55 degrees north to 55 degrees south latitude as the spin-stabilized satellite turns, are completed every 22 minutes, and have a central resolution of about two miles. The camera is peak-sensitive in the green region of the visible spectrum which permits maximum information to be obtained from black and white photographs.

Even after four years, this very successful experimental satellite continues to transmit photographs and has become an important part of analysis and forecast activity for this data-sparse ocean area. The National Environmental Satellite Service controls ATS-1 video during much of its daylight hours, and the spacecraft's graphic data have found a wide variety of uses. Because the viewing is nearly continuous, it is possible to make motion-picture loops of cloud-system movement from which low-level winds can be measured. Film loops also show storm system life-cycles, air mass migration, interhemispheric mixing, and weather systems of such short duration that their development cannot be traced by the long intervals between polar-orbiting satellite coverage.

For meteorologists analyzing weather patterns over the southern hemisphere and Pacific Ocean area, the ATS-1 graphics have meant the first significant filling of a virtual information vacuum.

ATS-3, launched November 5, 1967, was also a major success. From its geostationary vantage point, the satellite's field of view covers much of the North and South Atlantic Ocean area, all of South America, much of North America, and the western edges of Africa and Europe. This experimental spacecraft carried a multicolor spin-scan camera, which operated much the same way the ATS-1 camera does, but returned red, green, and blue outputs—or did until its red channel failed during the first year of operation. Until Apollo gave men a better camera on a higher platform, ATS-3 photographs provided the best view ever obtained of our planet's full face.

Both ATS-1 and ATS-3 also pioneered important weather communications techniques, for example, the transmission of weather data from a command and data acquisition station to the satellite and back down to local APT receivers. Data were in the form of weather maps and nephanalyses transmitted from NOAA's Suitland, Md., facility, to the satellite and APT stations.

In another series of important experiments, the ATS spacecraft

were used to collect data from remotely located sensors. For example, the satellite was used to interrogate rain and river gages, and to relay their observations to a river forecast center. In other cases, such as drifting buoys, ships, and aircraft, the location of the platform also had to be determined. Here, the platforms also received Omega navigation signals and relayed them, along with the sensor data, via ATS to a central analysis point. Omega is a global navigation system which uses the principle that position can be determined by comparing the phases of very-low frequency (VLF) signals received from widely separated transmitters. Omega signals received by a platform and relayed to a central point via the satellite are processed to learn the platform's location.

Perhaps more important than cloud-system and windfield data available from the geostationary satellite photographs is the relatively small scale of events which can be continuously watched. It takes 12 hours for the earth to turn far enough to bring a budding storm system back beneath the ITOS cameras for a second view, and most local events—the ones of such crucial importance to human safety—have formed, done their damage, and decayed long before that time has elapsed.

The ATS cameras, repeating their photographs at about 20-minute intervals, can watch a thunderstorm develop from cumulus clouds, and, possibly, improve the early detection of severe local storms and tornadoes. Attempts to correlate the photographs with tornado occurrences in the central United States have had some promising results, and ATS-3 photographs are now being received routinely in real time at the National Severe Storms Forecast Center, in Kansas City, Mo. Taken with radar, ground, radiosonde, and other observations, the ATS photographs contribute to effective tornado warning operations.

ATS data have also become a routine part of the information available to the National Hurricane Center in Coral Gables, Fla. Used in conjunction with ITOS and other satellite data, and radar and aircraft reconnaissance reports, the geostationary view can improve the warning operation. Hurricane Camille of August 1969 was tracked by ATS-3, a definite factor in there having been a reliable and timely warning for the threatened area of the Gulf coast.

The ATS successes form the technological base from which GOES, the Geostationary Operational Environmental Satellite, will begin. Like its experimental predecessors, GOES will be a spin-stabilized cylinder whose sensors will use the satellite's spin (parallel to the plane of the equator) for horizontal scanning of the earth's disc.

Where present geostationary satellites view the earth only in daylight, GOES will carry a 16-inch aperture telescope for visible and infrared scanning. This sensor will permit day-and-night objective determinations of cloud types, temperatures, and heights, and wind fields, using film loop and computerized wind-determining techniques.

GOES will collect and relay data sensed by remotely located environmental observing platforms, including river gages, ocean buoys, ships, and perhaps balloons and aircraft. The satellite will provide communications links for the Pacific Tsunami Warning System, relaying data from ocean-wide networks of seismometers and tide gages to a central facility at NOAA's Honolulu Observatory. The geostationary spacecraft will also be capable of disseminating certain products from the National Meteorological Center and National Environmental Satellite Service using the technique successfully demonstrated with ATS-1 and ATS-3.

National System, Global Job

During 1972, the first GOES unit will be lofted into a geostationary orbit over the equator at about 100 degrees west longitude, joining the ITOS spacecraft in the national operational environmental satellite system. ITOS will be the polar-orbiting element of this system, providing global imaging and direct readout services, probably with scanning radiometers rather than vidicon cameras, and also providing regular soundings for temperature, humidity, and certain atmospheric constituents. GOES will provide wind and cloud-top data, relay environmental information between distant points, and watch the middle-scale, short-term atmospheric events which enhance or threaten life on our temperate continent. Image data from the GOES will be transmitted to a central command and data acquisition station, then rebroadcast through the satellite to the super APT stations which the 1970's will see.

This single GOES and single ITOS combination represents a minimum national system. In 1973, assuming a long life for the first GOES, a second geostationary unit will be placed in operation. The two spacecraft will be positioned to provide near-continuous coverage of the Pacific, the Americas, and the Atlantic. Between them, these three satellites could provide solid coverage for North America's present and future weather.

But this national system also constitutes the American contribution of satellite technology to the World Weather Program, an intergovernmental research and observation effort under the auspices of the World Meteorological Organization and the International Council of Scientific Unions.

To achieve the full, global capability required for the World Weather Watch and Global Atmospheric Research Program, the GOES-ITOS system must be enhanced by the addition of two more geostationary satellites, so that four satellites 90 degrees apart can completely cover the globe with real-time observations; and by a second polar-orbiting satellite, to reduce the time-span between sets of atmospheric soundings and polar video coverage.

This expansion is expected to be a truly cooperative and international undertaking, along the free-exchange lines already a tradition in meteorology. The United States and Soviet Union have exchanged satellite data over direct Washington-Moscow circuits for years, and such free trading of scientific data is becoming more and more the rule, distributing important information not only between major industrial powers but to less-developed nations as well. Certainly everyone linked through the World Meteorological Organization will enjoy the results of the numerical prediction techniques developed around satellite-sounding of the atmosphere—and present and future APT systems represent a kind of shirtsleeve data exchange.

The 1970's will see highly concentrated observations programs made internationally, and very much dependent upon satellite support. There will also be man's most ambitious attempt to comprehend the complex air-sea interaction: the Atlantic tropical oceanographic and meteorological experiment, bringing together many nations—and many environmental satellites—to explore man's physical environment. It is too large a task for single nations.

The forces which makes science and technology converge across national boundaries have also blurred the boundaries between scientific disciplines. Increasingly, the view of meteorologists, oceanographers, aeronomers, geodesists, geologists, seismologists, hydrologists, geomagneticians, marine biologists is an environmental one, linked and interwoven with other disciplines to much the same degree that earth, sun, atmosphere, oceans and oceanic life are linked through interactions.

Satellites have reflected this diffusion of interest, this broadening of viewpoint. Meteorological satellites of the 1960's sensed radiation as well as visible weather. Those of the 1970's measure processes in the solar atmosphere as well as the terrestrial one, in the ocean of water as well as the ocean of air. Soon the technology of environmental satellites will send off another branch, that of earth resources monitoring, and another decade will bring a host of valuable applications which are inconceivably remote today. The only certainties are that the vantage point in space is a good one, getting better, and that our uses of it will multiply and mature. □

Seventeen mobile communities rove the nation's length and breadth to maintain its geodetic networks.

LIFE OF THE PARTY

BY RAYMOND WILCOVE
National Ocean Survey

More than half a million bronze markers, set in cement or bedrock, are points in the otherwise invisible webs of the nation's geodetic networks.

The markers are the footprints left behind by geodetic field parties of the National Ocean Survey. There are 17 of these parties now surveying the United States—perhaps the nation's last nomads, roaming the country year around, determining elevations or latitudes and longitudes.

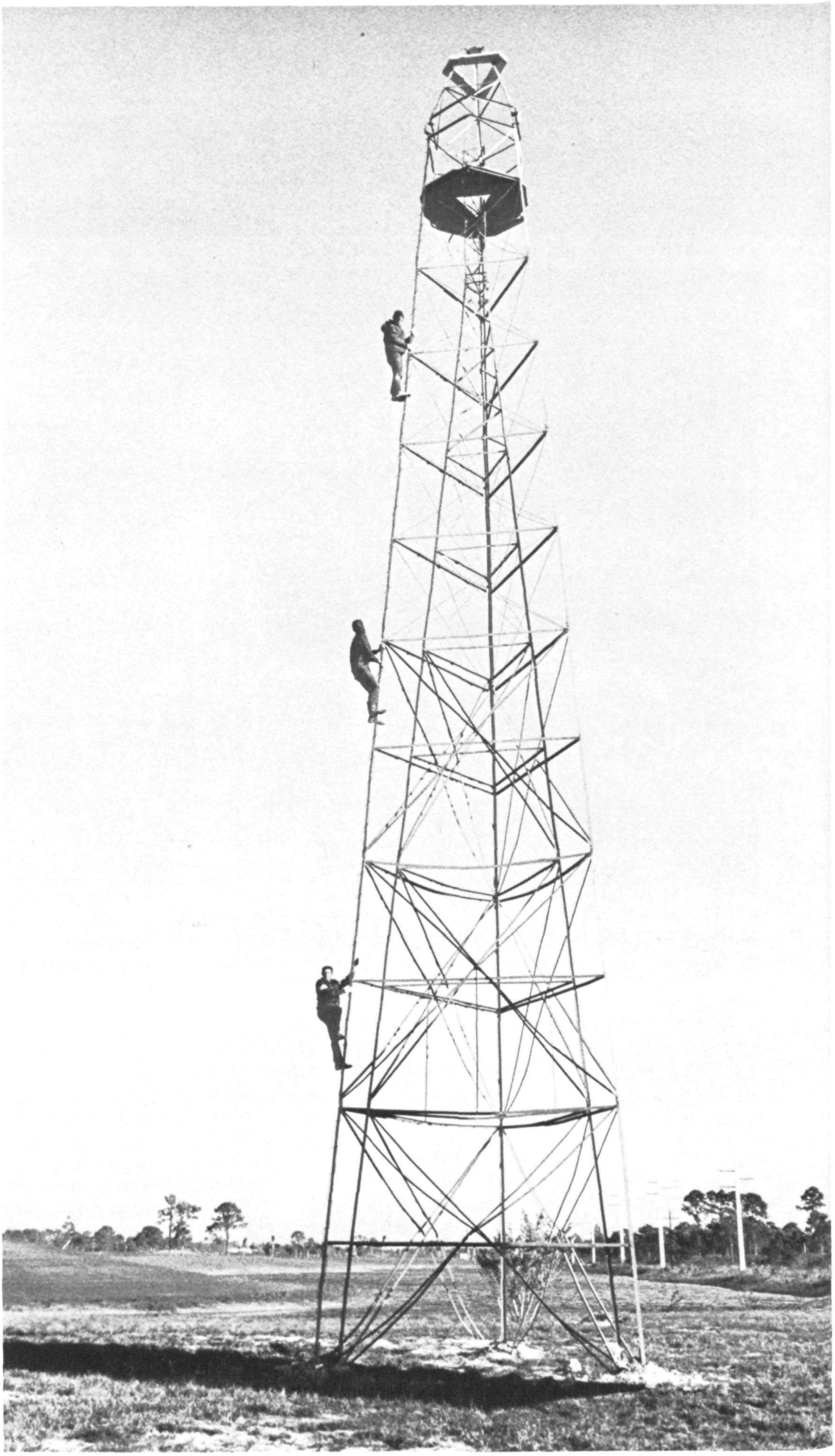
Geodetic Field Party G-23—with its 49 men, women, and children—has worked throughout the United States. It is a triangulation party, determining latitudes and longitudes of various points. Other groups, called leveling parties, determine elevations.

Now based near Pompano Beach, Florida, G-23 is conducting a five-month survey of Broward County, Florida, including Fort Lauderdale and Hollywood. The $256,000 project is being carried out in cooperation with the county to establish the latitude and longitude of more than 80 geographic positions. The control network they establish will be used to aid future development of the county.

Preliminary field work for the project was conducted by the two-man reconnaissance party, G-32—Jerry C. Layton and Donald D. Rexrode. In cooperation with local officials, they developed a plan for establishing the geographic positions.

The actual 1200-square-mile survey is being done by G-23. It will provide accurate and accessible starting data to enable county and city surveyors to conduct their measurements with increased accuracy and ease. The data will be converted to state plane coordinates, a simplified system designed to facilitate the use of the national geodetic network. They will be used for mapping, developing the land, locating permanent boundaries, and planning the alignment of highways and public utilities, as well as for many other engineering projects.

Chief of G-23 is Lt. Cdr. Ned C. Austin, a commissioned officer of the National



Photos by John Roseborough

Oceanic and Atmospheric Administration. He assumed the position of Chief of Party last September and will probably remain a year or two, then be reassigned, possibly to another party, or perhaps to an administrative position, or as an officer aboard one of NOAA's ships. Some parties are headed by Civil Service personnel who serve as chief of the same party for years.

In addition to Austin, Party G-23's roster consists of Ulis O. Jones, Harold L. Miller, Harvey D. McKinney, Charles C. Johnson, Albert Sulfridge, Harold D. Ellis, John D. Rigney, Edward L. Word, Gary M. Beaulieu, Woodrow Letchworth, William B. Mink, Wesley R. Odum, Lonnie K. Zurfluh, Charles W. Wright, Francis C. Fowler, Alleyn V. Shackleton, Andrew J. Lindsay, and Virgil C. Durr.

Triangulation parties work both in daylight and at night, in contrast to leveling parties, whose operations are conducted entirely during the day. To see over obstacles and compensate for the earth's curvature, the triangulation parties make extensive use of portable Bilby towers. Ranging between 37 and 116 feet tall, these structures consist of a tower within a tower. The inner one supports only the delicate surveying instruments; observing personnel can climb the outer tower and stand and work on its platform without disturbing the precise measurements.

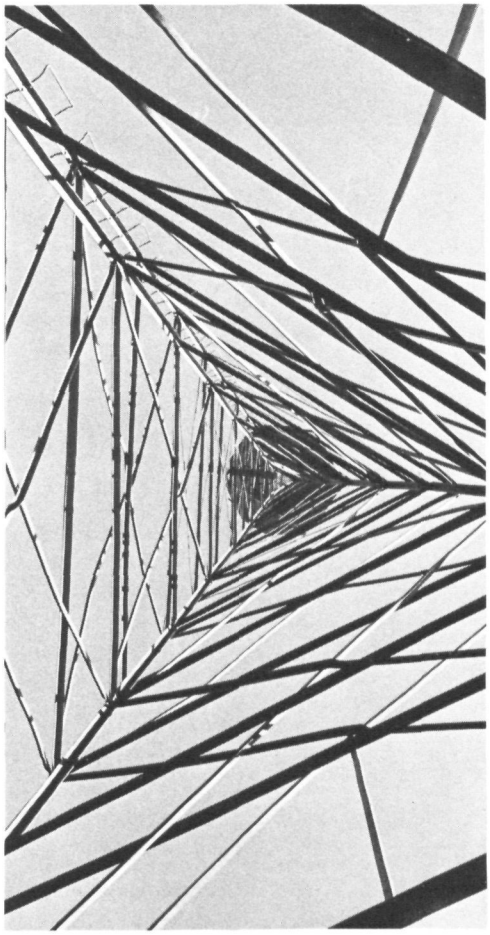
The principal instruments used are the theodolite, which measures direction, and laser electronic distance measuring (EDM) equipment, which determines linear distances.

Since the parties have no permanent base and are always on the move, married men are accompanied by their families. They travel about and live in their trailers. Summer takes them to northern climes, and when the temperature drops and snow dots the landscape, they generally move southward. But sometimes a survey has to be completed before the party can move on, and they're caught by winter. Occasionally they remain in northern areas all winter.

It's a good life for an outdoor man. Most of the women and children seem to like it, too.

In 12½ years on the road, Jerry Layton's wife, Barbara, has been in all but five states of the continental United States. As chief of Reconnaissance Party G-32, Layton is one of the two advance men who did the preparatory work in Broward County for field party G-23, determining where the towers would be set up and obtaining permission from the landowners.

The Layton's four children are Mitchell, Jeri Lynn, Becky, and Michael. Mitchell arrived in 1960 in Pomona, Calif., where Layton's parents lived. The party was working at the time in Bakersfield, Calif. Jeri Lynn came in 1962 in Hollister, Calif. Becky was born in 1963 and narrowly missed arriving on an Indian reservation. The party was in Browning, Mont., and the nearest hospital was in Cutbank, Mont., 30 miles away. "We had to race for it," said Mrs. Layton.



Michael was born in 1967 in Port Allegany, Pa. "About two weeks before Michael was born," recalled Mrs. Layton, "the party moved to Roulette, Pa., and I had to find a new doctor. The nearest hospital was 12 miles away, in Port Allegany. For the first time, Jerry was out working in the field when my time came. I dashed out looking for a baby sitter and someone to drive me to the hospital. Fortunately, I found both in time."

Mrs. Layton said one problem she faced, other than getting to the hospital on time, was finding doctors willing to take her. "I had 12 doctors for my four children," she remarked.

Mrs. Layton said most people believe that the education of the children traveling with field parties suffers as a result of changing schools so often. "It's a feeling that many teachers express, when we seek to enroll our children, but it hasn't worked out that way. Michael, Jeri Lynn, and Becky are all A and B students, even though, between them, they've already gone to as many as 25 schools."

She ticked off on her fingers the schools each child had attended. Mitchell, 11, has been to 12 schools, including three in kindergarten, three in the first grade, one each in the second and third grades, and two each in the fourth and fifth grades, the final two in Alaska and Florida.

Jeri Lynn, 9, has been in eight schools, including one each in kindergarten and first grade and three each in the second and third grades. Seven-year-old Becky has gone to five schools, including one in kindergarten and two each in the first and second grades.

Did the children have any trouble moving from one school to another? Jeri Lynn spoke for all of them. "We don't mind going to more than one school. We miss the friends we made, but we make new friends when we move."

And there's this to consider also, said Mrs. Layton. "Our children just don't have time to get in trouble. They're too busy moving and keeping up with their school work."

Mrs. Layton looks forward to visiting the states she's missed, Minnesota, North and South Dakota, Wisconsin, and Maine, adding that "it's given us and the children a wonderful opportunity to see the country."

Some find romance along the road. Patricia Word, "Trish" to her friends, was busy decorating the Roy, New Mexico, school gym for the 1960 Senior Prom, when a schoolmate burst in with the glad tidings that "a bunch of boys just arrived in town."

In a small community with a few hundred people, that's big news. "So I jumped on a motor scooter with one of my friends, and we dashed down the main street to find them," Mrs. Word recalled.

In the three months the party remained in Roy, Mrs. Word dated some of the men, but not Ed Word. Five years later, her family moved to Magnolia, Ark., and she recalled that Word came from Camden, Ark., about 30 miles away. She phoned. Word was home for Thanksgiving. They dated and, in 1967, were married. Word says he married her to save on the long distance calls to Magnolia from all over the country. Word should know about big phone bills. He once called his mother from Fairbanks, Alaska, and the 30-minute conversation cost him $74.

Word joined his first field party in 1960 in Mt. Vernon, Mo. "I'd never been to more than about four states," he said. "Now I've been to all but four."

Word has held various jobs with the field party, but he's been a full-time observer, operating a theodolite, since 1969. Each afternoon, about 3 or 3:30 p.m. he leaves the trailer park where G-23 is based and heads for the site from which he will operate his theodolite. With Word is his assistant, the recorder.

After completing preliminary groundwork, Word and his assistant hoist their equipment to the top of the tower, some by pulley, some on their backs. Then the main part of his task begins. Word points his theodolite at a light on another tower, three to six miles distant. He then measures the direction between this and other lights in other towers while his recorder jots down his observations. Each direction is measured 32 times to ensure accuracy.

Word works with perhaps eight other towers, measuring the direction to them. Depending upon the amount of work to be done on a particular night, he will be back in camp around 9:30 p.m. At times he works until 2 a.m. or later, training his theodolite at as many as 10 or 11 towers. He might

continued

have to travel as far as 100 miles from camp to his work site, but usually the towers are much closer.

In the morning, Word will spend two to three hours in the office trailer, working on the observations gathered the night before.

When the weather is warm and things are quiet, Word doesn't mind working at night. But cold nights are another matter.

"It got so cold when we were in Rhode Island that we had to keep our ballpoint pens under our armpits to keep the ink from freezing," he recalled. "We were trying to finish the job before we moved south." If the wind blows too hard, work has to be suspended because the measuring instruments cannot be kept stationary.

Word climbs the tall towers now without any qualms, but hasn't forgotten how he was first initiated. "I reported for work, was handed a wrench and told to tighten the bolths as I climbed up." The tower was 77 feet tall, almost eight stories high.

The party has several men experienced in the operation of the EDM equipment for determining linear distances. John D. Rigney began using the equipment in the fall of 1967, the first in the agency to employ this instrument in the field for measurements. The beam emitted from the equipment travels at the speed of light, about 186,281 miles per second. A distance of two to three miles is measured with an accuracy of two centimeters; that is, within about three-quarters of an inch of the actual distance. With the EDM equipment, a set of distance measurements can be completed in about 20 minutes, or about the time it took a party in the past to get its equipment out of a truck.

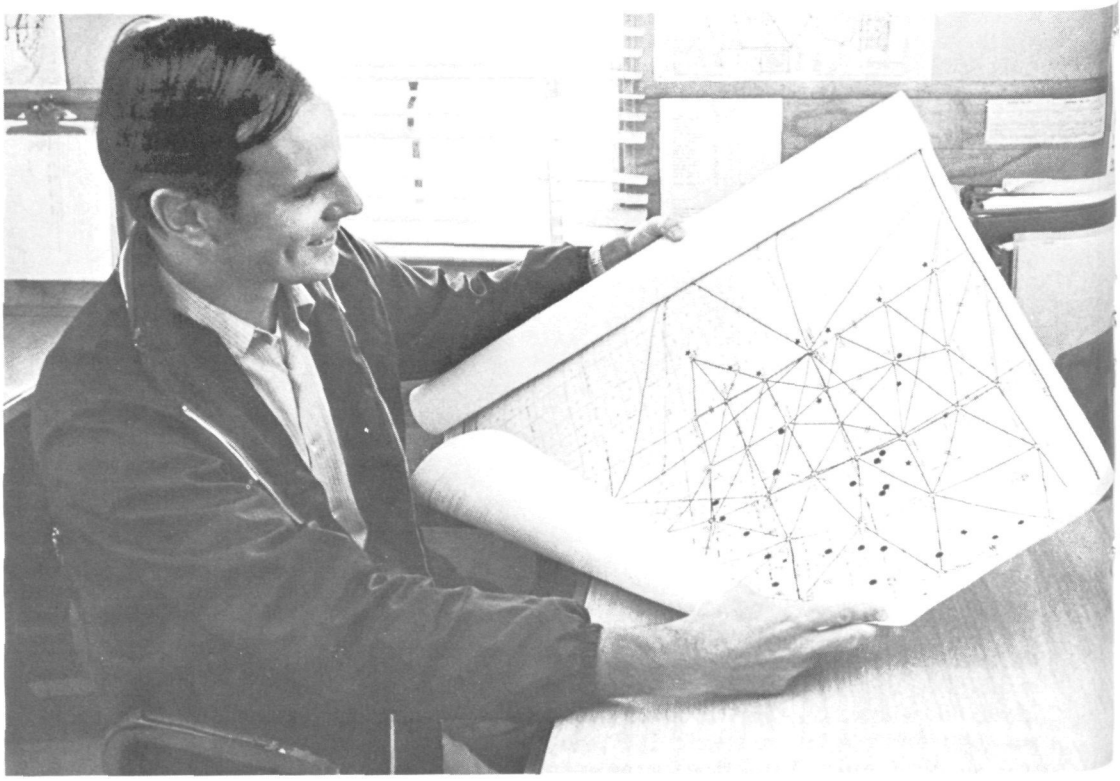
"We do now with two men, in a matter of minutes, what it took five or six men up to three days to accomplish with the old method of measurement," says John Rigney. "Previously, the distance was laboriously measured with tape. How long the task took depended upon the nature of the terrain. If it was difficult, part of the task would involve cutting down trees obstructing the view and clearing out the brush."

Working with Word in the Florida operation, Rigney trained the EDM equipment on the top of a tower occupied by Word. A mirror atop the tower pinpointed Word's location. The two men used walkie-talkies to coordinate their activities.

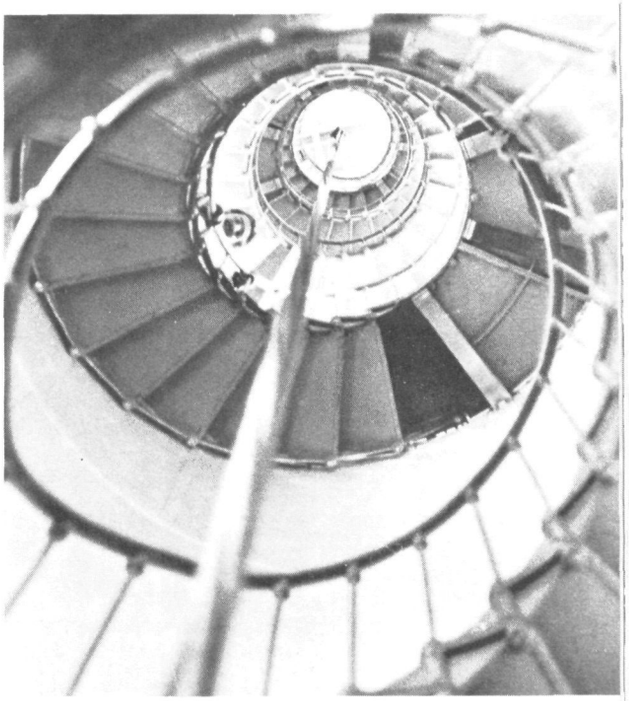
As Rigney called off the distances, Harold D. Ellis, sitting beside him, jotted them down. In the morning, Rigney would take about 15 minutes to check each measurement with the aid of a desk-type computer.

Rigney said one thing which simplified the party's work was the development of a compact 40-pound generator which supplied the power for the EDM equipment. The portable generator can be carried by one man, an important consideration when rough terrain is involved and a truck cannot be driven to the site. "The generator we previously used," says Rigney, "was a monster and took two men to carry."

The Bilby towers are employed only by



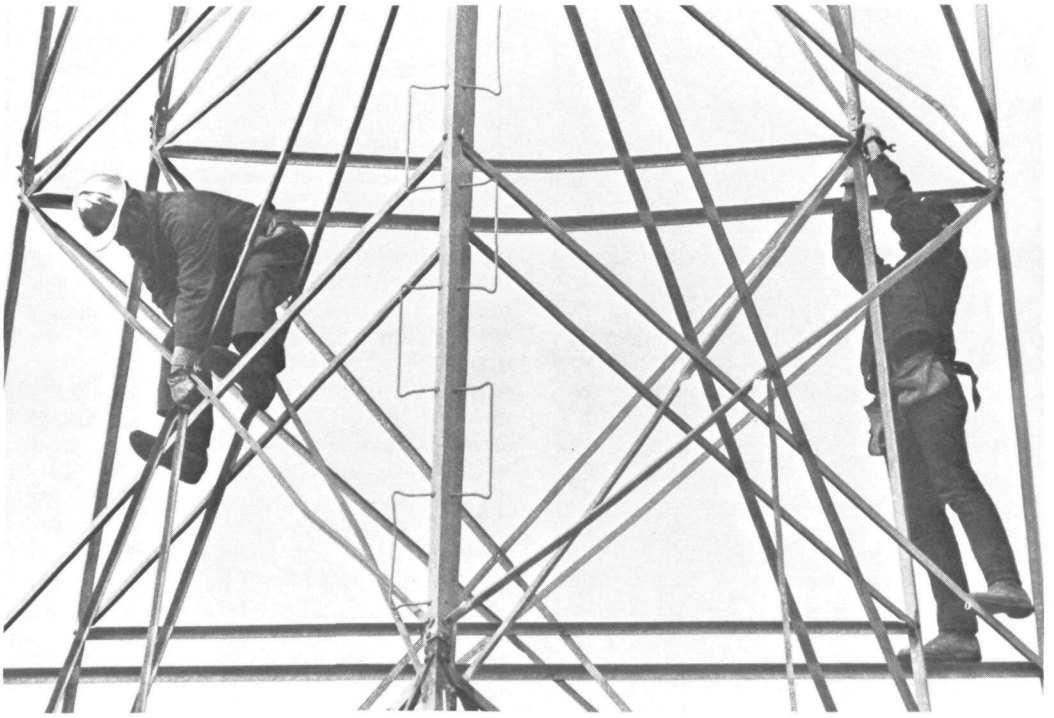
(Top) Lt. Cdr. Ned C. Austin, party chief, checks survey's progress. (Left) John Rigney prepares to haul laser geodimeter equipment to the top of a tower. (Above) Rigney calls out distance measurements, as Harold Ellis records.

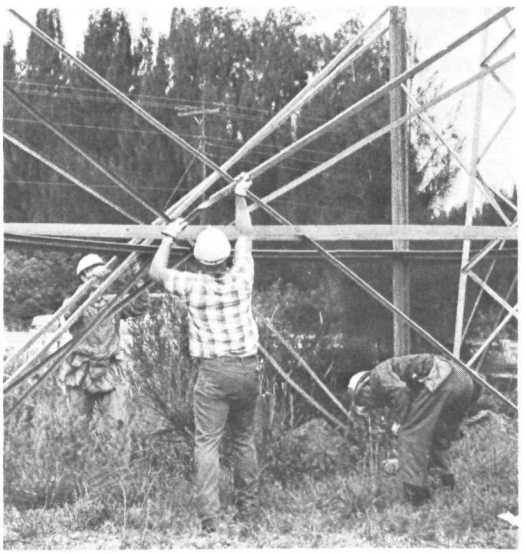


After carrying equipment up the 150 steps to the top of Hillsboro Inlet Lighthouse near Pompano Beach, Florida, Edward Word (left) sets up his light over a survey monument cemented into the platform. The light will be observed by another team some five miles distant. (Below) Where no surface obstacles interfere with their measurements, the parties do not need to use towers. Gary Beaulieu uses a theodolite to determine the coordinates of a marker to be placed in the ground beneath the instrument, while Lonnie Zurfluh records the readings.

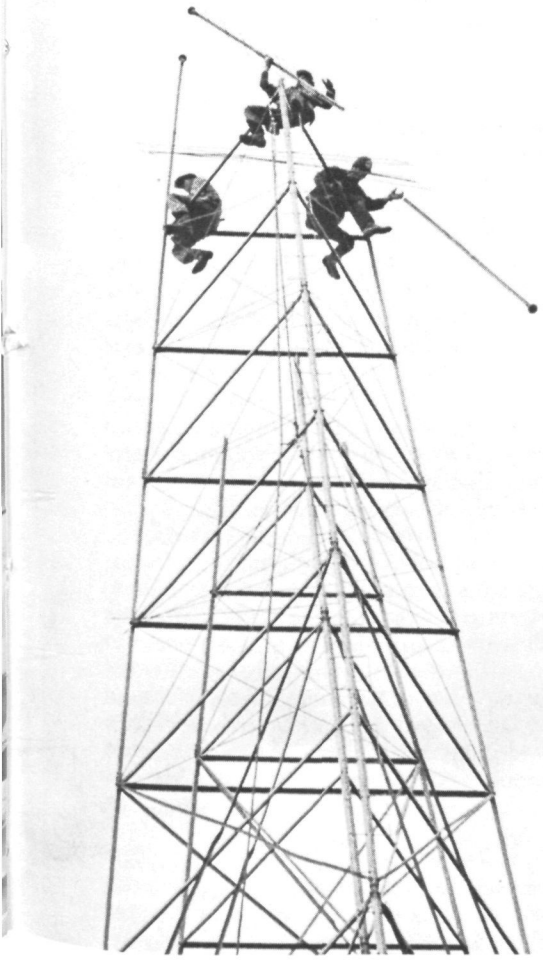
continued

(Top) For the 49 people traveling with Party G-23, home is a trailer park that can accommodate the party's 40 vehicles. A typical small community, the families vary in size and span the generations. (Above left) Patricia and Edward Word, married in 1967, have one child, Judson. (Above right) Barbara Layton, with three of her four children, Mitchell, Michael, and Jeri Lynn. (Far right) The Fowlers are the party's newlyweds, married last October. (Right) Phyllis Miller has traveled with the party for 17 years. Her son grew up on the road and is married now.





Party G-23 took 90 minutes to dismantle a 113-foot tower near Margate, Florida. William B. Mink (top left) was the first to scamper up the tower and began by removing the lightplate. (Top right) Meanwhile, Albert Sulfridge, the building teardown foreman, and Joe Lindsay began dismantling the inner tower which had supported the delicate instruments. (Far left) Tossing down the "knoblegs." (Left) Teardown is nearly complete, as only the bottom section remains. (Below) Woodrow Letchworth and Ulis Jones load the tower sections aboard a truck.



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triangulation parties. Leveling parties can be recognized by the tripods the surveymen use to hold their instruments. Since leveling parties often work along the right-of-way of highways, railroads, bridges, and tunnels, where traffic makes their work hazardous, they wear orange vests to warn motorists of their presence. On bright, sunny days, orange-colored umbrellas provide shade for the delicately balanced surveying instruments whose accuracy could otherwise be affected by the sun's rays.

The tower, which somewhat resembles an oil derrick, was designed by Jasper S. Bilby, a signalman of the Coast and Geodetic Survey (predecessor of the National Ocean Survey) and the Aermotor Company. It was first used by the Coast Survey in 1927, and now is employed by surveying parties in many countries. Before the Bilby tower was developed, wooden structures were built wherever a tower was needed. The record height for a wooden tower was probably a 23-story one built in the Philippines in 1916 by a Coast Survey party. It took 16 men 19 days to complete it.

More than 200 towers are in use today by the field parties. Depending on height, the cost per tower runs from $2000 to $2500 and their average lifetime is estimated at 10 years.

Party G-23 uses 30 towers. At one time or another, all 30 dotted the landscape of Palm Beach and Broward counties, to the mystification of many residents.

A tower can be set up in a day. Normally, not much is made of this, although some men have been known to "cap" the tower by standing atop the 9- to 12-story structure. One man reputedly stood there on his head to celebrate its completion. That was years ago. Safety rules are much more stringent now.

There are, of course, a few men who quit rather than climb the towers. One man didn't even wait to be ordered up. Charles Johnson, the party's accountant, recalls the time he picked up a new employee at the bus station in Sedalia, Mo. As they were driving to the trailer camp, they passed a nine-story tower.

"That's the type of tower you'll help erect and dismantle," said Johnson to the new recruit.

The man glanced out the car window at the tower and grunted, "You can turn around and take me right back to the bus station."

Party G-23 took 90 minutes to dismantle a 113-foot tower near Margate, Fla. It was no longer needed at that site and would later be erected elsewhere as the survey progressed.

William B. Mink was the first to scamper up the tower. His task was to remove the triangular platform atop the tower—the platform where surveymen stood to make their measurements. Using a pulley operated from a nearby truck, he lowered the platform to the ground. Once that was done, he clambered further to the very top of the tower to remove the metal piece called a lightplate, which holds a mirror on which the electronic surveying instruments and theodolite were focused from other towers.

Mink said he climbed a 12½-story tower his first day on the job. "You get used to it," he said, "but it's no place for anyone with a fear of heights."

Once the top of the tower was down, three men began dismantling the remainder of the 11-story tower, working from the top and either lowering by rope pulley or tossing the galvanized steel ties, diagonals, rods and legs to the ground, where others gathered them up and stowed them on the trucks.

In addition to Mink, the teardown party included Albert Sulfridge, the building-teardown foreman, Wes Odum, Woodrow Letchworth, and Joe Lindsay. Overseeing the job was Ulis O. Jones, in charge of G-23's field operations.

In setting up a tower, digging the anchor hole for the towers is the hardest part of the job, Jones said, especially when the ground is rocky. On the other hand, if the site is marshy, the foundations have to be strengthened with rocks and bags of sand. Sometimes wooden stands, about 4½ feet tall, are used when the terrain is fairly level and unobstructed, or are set up as observing platforms atop tall buildings. If an adequate tall structure can be found, the party doesn't need to set up a tower.

One such structure used by G-23 was the Coast Guard's Hillsboro Inlet Lighthouse near Pompano Beach. Word was entrusted with the task of climbing the lighthouse to a circular outside platform near the top where he would place a light over the survey monument cemented into the platform.

He arrived at the base of the lighthouse to find it guarded by a dog fastened to a long rope. Aware that this was just another of the many hazards which face surveymen in carrying on their functions, he fixed his eyes resolutely on the canine and marched straight ahead. The animal leaped upon him. Word, encumbered with a 25-pound pack, staggered, almost thrown off his feet by the impact. The animal licked his face and gamboled all over him.

There were 150 steps in the circular stairway leading to the top of the lighthouse, and although Word is in good physical shape, he had to pause frequently on his way up. He spent about 3½ hours at the lighthouse, serving as light keeper for an observing party in a tower about five miles distant. Seven light stations were used that night, the light keepers being arrayed generally in a circle around the survey tower holding the observing party. One of the other light keepers was stationed atop the library of Florida Atlantic University and another on the roof of the Boca Raton Hotel, the area's tallest structure.

Jones, the G-23 field foreman, said arrangements were made in advance for the structures to be used by the party. This sometimes presents a problem, as authority to use a structure often cannot be obtained locally. In the case of the lighthouse, Coast Guard permission had to be obtained from the Commander of the 7th Coast Guard District in Miami.

Jones, a 25-year veteran, recalled how he had been hired in 1946 "at about $1460 a year. That came to $28 a week, but there weren't any withholding taxes in those days, so I got all of it on payday. Three weeks later, I got a raise to $1610 a year, about $31 a week. In addition, I received $2 a day per diem." No hazardous duty pay was given for building or dismantling towers, in contrast to the present 25 percent provided for those working on towers more than 50 feet high and the 6 percent night differential for the crew working between 6 p.m. and 12 p.m. Per diem has also been increased to $10 a day when in camp and $20 when traveling on party moves.

During Jones' entire quarter century with the National Ocean Survey and the Coast and Geodetic Survey, his wife has traveled with him. He's worked in 42 states and in Guam.

Jones recalls using pack horses, as recently as 1957, in the Big Horn Mountains of Wyoming and other rugged areas. "Now we use mostly helicopters to fly us into hard-to-reach areas at a considerable saving in time, let alone backbreaking effort."

Another who remembers the pack horses is Charles Johnson, the party accountant. "Some years ago," he relates, "when we were working in the mountains of Oregon and New Mexico, there weren't any roads, so we used pack horses to get our gear in. In the Gulf of Mexico, off Louisiana, we used small boats to reach the islands there. Ten years later, we had float planes and helicopters when we resurveyed the islands."

Johnson, who joined the Survey in 1948, regards mosquitoes as one of the worst afflictions to be endured by field party personnel. "They make life very difficult at times and the southern ones are just as bad as those we ran up against in the Arctic. "Why, I saw caribou fleeing into the Arctic Ocean to escape them. As soon as you stepped into the tundra, the bugs swarmed up around you. But those in the South are just as bad."

Johnson went to the Arctic two years after he joined the Survey. He recalled that Rear Adm. Harley Nygren, now Director of the NOAA Corps of commissioned personnel, then an ensign, was a member of the party. The group worked for three years in the Prudhoe Bay area, where vast oil fields have been discovered recently.

Born and raised in South Dakota, he doesn't know which he found the most disagreeable: the mosquitoes, the 50-below-zero Arctic weather, or the humid 92 to 94 degrees above in Florida.

When the use of mobile field parties for surveying the land began shortly after World War I, the number of parties was very limited. If funds were available and weather permitted, a party was sent from Washington for a specific task and returned when the job was done.

The present system of permanent, year-round mobile parties began in the early 1930's. Since living in boarding houses, motels or hotels would have been too costly,

the men traveled with their families in trailers.

One of the parties' major problems is locating suitable trailer camps. Owners generally favor permanent residents, rather than transients, such as the field parties. Furthermore, many trailer camps do not have room to accommodate a large number of trailers and trucks all at once. Party G-23, for example, requires space for 40 vehicles, including 23 trucks, 13 private trailers, two office trailers, and two supply trailers.

The likeliest prospects are trailer camps just being developed. These are more amenable to transients, since they have not yet acquired enough permanent residents to fill the camp.

But their newness has drawbacks, too. At one Florida camp, the party members had to sod the ground to make the place liveable. Otherwise, they found themselves combating sand bugs and burrs every time they set foot outside their trailers.

Sulfridge, whose tenure dates back to about 1953 and who has traveled in every state but Hawaii, recalled that he paid $15 a month rental then for his trailer, but provided his own facilities. "We usually camped in fairgrounds or open fields," he commented. Johnson remembers when the Chamber of Commerce in Litchfield, Minn., leased space for their vehicles for $1. The men provided their own facilities, including electric power and individual septic tanks.

"That was about 10 years ago," said Johnson, "and doesn't happen any more. For one thing, most localities have regulations which require you to camp in an established trailer park."

Traveling with trailers also poses a problem. Before camp breaks up and the party moves to its next destination, those members with trailers more than 50 feet long (including the truck which tows them) have to obtain permits from some of the states they pass through. The permits generally don't cost much, but getting them takes some planning.

Government trucks, which also have to be moved to their next destination, are used to pull the family trailers. Wives and children follow in the family car. Each family travels separately, because it is difficult to find space in motel parking lots for trailers. Also, a caravan of trucks and trailers would be a hazard on the highway.

So each family is on its own. New problems keep cropping up. Some police insist that the smaller trailers without permits stop at official highway stations to make sure their length does not exceed the limit. Sometimes, a state trooper flags down the orange-colored government truck pulling a private trailer. When that happened to him, Charles W. Wright had to convince the policeman that he hadn't stolen government property.

Driving a truck pulling a 10-foot-wide trailer requires a special touch, and the driver must have training. Some states will not allow trailer owners to pull 10-foot-wide trailers, and others require that a car precede the trailer with a "Wide Load Following" sign.

The trailers used by the party range from 35 to about 50 feet. The Letchworth family's trailer is fairly typical—38 feet long, with a bedroom, living room, kitchen, and bathroom.

"When traveling from one site to another," said Letchworth, "we usually start between 7 and 8 a.m. At 4:30 to 5 p.m., we start looking for a place to stop for the night."

Letchworth and his wife, Merle, have been married about five years. Both are from Mississippi, Letchworth from Monticello and his wife from Wesson. "I didn't like it at first," says Mrs. Letchworth, "because I hadn't done it before. I don't know if I'll ever like it."

Party G-23 also has a pair of newlyweds. They are Francis and Carol Fowler, married last October 17. Fowler took a week off to get married, including three days enroute back to the camp for their honeymoon.

"I like it pretty good now," said Mrs. Fowler. "I always wanted to travel, but I do get awful homesick at times. Frank works mostly at night, so he's home most of the day, which is nice. It's a relaxing life. I'm not rushed. I do my housework and some painting. For recreation, we usually go to the beach, movies, or sightseeing."

How do the kids feel about traveling with a field party? Like their parents, their outlook varies, but generally they are content. Some think it's great.

"I like it because when we're traveling I don't have to go to school," says Larry Sulfridge, 13.

Larry estimates that he's been a student in about 30 schools, while traveling with four different parties. He didn't especially like the trailer camp they were in at the time. "It's too crowded here," he declared. But the camp is built around a lake, and he can fish whenever he likes.

Bob Rigney, who is also 13, thought the place was "pretty nice." Bob would "rather do this than something else." Staying in one place too long is "boring."

"We have interesting experiences traveling around," Bob says. "We see lots of stuff I've read about and heard in class." He ticked off some of the places he'd been, including Washington, D.C., St. Augustine, Fla., Tucson and Phoenix, Ariz., Los Angeles, and Montana.

Bob is a seventh-grade student at Margate Junior High, where Larry attends the eighth grade. Bob figures that he's been in 21 schools. He doesn't mind leaving school before a term ends, although he finds that it's harder to catch up in some schools, while others are not so advanced. Bob's brother, David, 10, attends the Coconut Creek Elementary School.

Eleven-year-old Jeff McKinley doesn't like going to different schools. "You lose too many friends," he explains. He also finds some schools easier than others.

The Millers, Harold and Phyllis, have a rented trailer; theirs was damaged by snow. Mrs. Miller has been traveling off and on with the party for the past 17 years. She recalled that she joined the party in El Centro, Calif., on February 8, 1954, the same day Leonard S. Baker took over as party chief. Captain Baker is now Chief of the Geodesy Division.

More than half a million bronze markers, set in cement or bedrock, are the footprints left behind by geodetic field parties.

The Miller's son Harold (Butch to the family) was 4½ when the family joined the party. In the next 13 years, he attended 54 schools.

"Butch just loved traveling," said Mrs. Miller. "Every time we came to a new place, first he found his church, then the Boy Scout troop, then his school." Mrs. Miller noted with pride that her son became an Eagle Scout when he was 14½. Butch is now 21, married, and attending college.

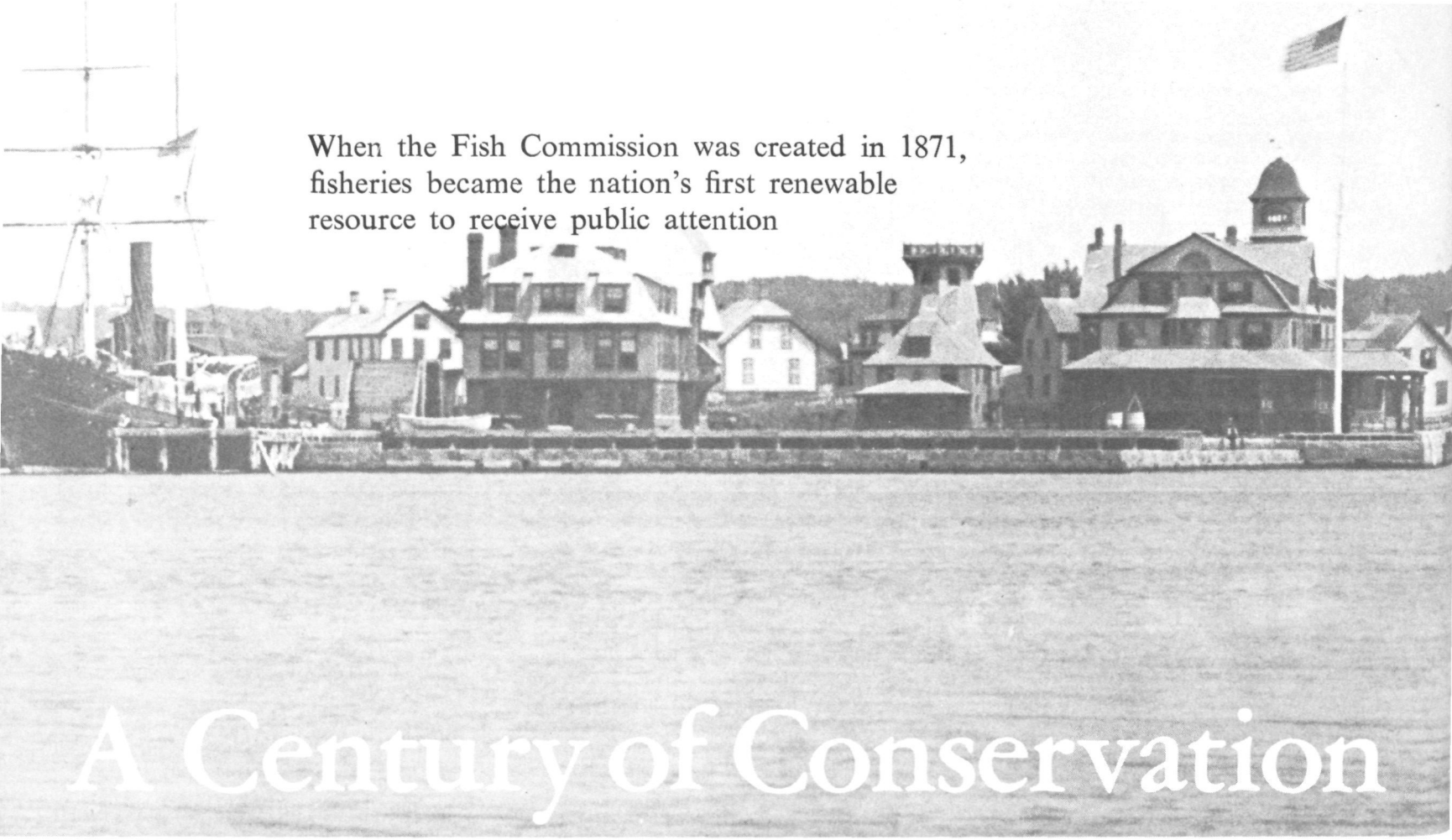
Mrs. Miller admits she's prejudiced against Florida. At one camp there, a bolt of lightning came through a water pipe and knocked her off her feet. But all in all, she added, "I've really enjoyed it. It's been very educational traveling about." Mrs. Miller's husband has been with the agency for almost 30 years.

Frank Fowler, the newlywed, hasn't been with the agency long, but he is typical of the men who join young and stay on, often until retirement.

Fowler's brother Mike, who's been on field work for many years, suggested he might like to join. Frank did so in October 1967 in Kansas City, Mo. Since then he has worked in Illinois, Florida (twice), Georgia, Rhode Island, New York, and North and South Carolina.

In 40 months with field parties, his duties have included some tower building, but mostly acting as light keeper.

"I find this work very interesting," Fowler says. "You never know what you're going to experience from day to day. You don't punch a clock and when you get through, you go home and you don't take your headaches with you." □



When the Fish Commission was created in 1871, fisheries became the nation's first renewable resource to receive public attention

A Century of Conservation

BY JOHN A. GUINAN AND RALPH E. CURTISS
National Marine Fisheries Service

THE NATIONAL MARINE FISHERIES SERVICE has existed only since October 3, 1970, but the federal fishery agency celebrated its "de facto" centennial on February 9, 1971, and will continue the observance throughout the calendar year.

On February 9, 1871, President Grant signed a bill recognizing a national interest in fisheries conservation by creating the independent Office of Commissioner of Fish and Fisheries, also sometimes known as the Fish Commission. The bill authorized the President, with the advice and consent of the Senate, to appoint a Commissioner from among the civil officers or employees of the Government. The Commissioner would receive no additional salary, but the sum of $5,000 was appropriated for a study of "the decrease of the food fishes of the seacoasts and lakes of the United States, and to suggest remedial measures."

Because fish were an important source of food, the fisheries were the first renewable resource to receive public attention in our nation.

Spencer Fullerton Baird, Assistant Secretary of the Smithsonian Institution, wrote to Congress in January 1871, calling attention to the problem of depletion of food fishes of the seacoasts and lakes of the United States and offering suggestions for remedial measures.

A Joint Resolution proposing a study of the problem had a difficult time in the House, according to debate reported in the Congressional Globe, predecessor of the Congressional Record. Committee Chairman Henry Laurens Dawes, Republican of Massachusetts, described the terms of the Resolution, but Rep. Farnsworth, Republican of Illinois, sought to kill it with ridicule. The Congressional Globe for January 18, 1871, reports:

"The Resolution was read and the opposition reserved all points of order whereupon Chairman Dawes read the letter from Mr. Baird and added his own testimony to the need for scientific investigation."

The record, as reported in the Congressional Globe, indicated that other scientists involved also would serve without additional salary, and would be recruited from among personnel of the Smithsonian.

Following the presentation by Chairman Dawes, there was the following dialogue:

> Mr. Farnsworth: Add to your resolution a direction to inquire in reference to grasshoppers and potato-bugs.
>
> Mr. Dawes: My friend from Illinois may think this is a subject of no importance whatever; but I assure him that along the coasts of New Jersey and New York, and all up our coast to the British possessions, this is a matter of vital importance.
>
> Mr. Farnsworth: So is the inquiry in reference to the potato bug.

After further discussion, Mr. Farnsworth stated that he objected to the matter. And so the Resolution was deferred.

Five days later, on January 23, Chairman Dawes again asked for unanimous consent to introduce the same resolution for immediate action. This time it was opposed by Congressman Benjamin of Missouri, who is listed in the Biographical Directory of the American Congress as a "Radical Republican."

(Above) Spencer Fullerton Baird was the first Commissioner of Fish and Fisheries, serving from 1871 to 1887.
(Left) After his appointment, Baird promptly established headquarters at Woods Hole, Mass., a Cape Cod village that was to become a world-famous oceanographic and marine research center.

After considerable discussion in which Mr. Farnsworth again joined, a vote was taken and it was decided in the affirmative —yea's 137, nay's 47, not voting 54. This was the beginning of what we now know as the National Marine Fisheries Service.

Shortly after the affirmative vote, the President appointed Professor Baird as the first Commissioner. Headquarters were promptly established at Woods Hole, Mass., where he soon began studies of striped bass, blue fish, and other species. In the century that followed, the little village on Cape Cod became a world-famous oceanographic and marine research center.

Commissioner Baird supervised construction of the first federal fishery research laboratory at Woods Hole in 1885. The old building was replaced with a modern structure in 1960, and it is now one of the most modern biological research laboratories operated by NMFS.

Although the new Commissioner's primary interest was in biological research, his horizons in fisheries were surprisingly broad for the period. In 1872, with support from the American Fish Culturists Association, he established a marine hatchery at Woods Hole for artificial propagation of fish. When the cod fishermen of New England were unable to obtain herring for bait, he introduced Norwegian cod gilnets and taught the use of net preservatives. With Baird's encouragement, one of his associates was the first to identify the adverse effects of bacterial action on salt cod and to develop control procedures for bacterial discoloration.

In 1879, Baird arranged for his staff to work with the Census Office on the first comprehensive statistical survey of the U.S. fishing industry.

After Commissioner Baird's death in 1887, his multidiscipline approach to fisheries was largely discarded. For many years thereafter, fish culture was foremost in the federal fishery program, although time demonstrated that this was an oversimplified solution to the complex problem of maintaining high fishery yields.

The original act establishing the office of Commissioner of Fish and Fisheries, was amended on January 20, 1888, to authorize a salary of $5,000 per year for the Commissioner. The amendment required that he not hold any other office or employment.

The Fish Commission and the Office of the Commissioner of Fish and Fisheries continued as an independent establishment of the federal government from its inception until July 1, 1903, when it was placed in the newly created Department of Commerce and Labor. The same legislation transferred from the Department of the Treasury to the Department of Commerce and Labor, jurisdiction, supervision, and control over the fur seal, salmon, and other fisheries of the Territory of Alaska. The federal fishery agency was also renamed the Bureau of Fisheries.

The Act of March 4, 1913, split the Department of Commerce and Labor into two separate departments, and the Bureau of Fisheries remained in the Department of Commerce until July 1, 1939. Then the 1939 Reorganization Plan No. II transferred the Bureau of Fisheries to the Department of the Interior. The same Reorganization Plan transferred the Bureau of Biological Survey from the Department of Agriculture to the Department of the Interior.

Another reorganization followed shortly. On June 30, 1940, Reorganization Plan No. III consolidated the Bureau of Fisheries and the Bureau of Biological Survey into a new agency to be known as the Fish and Wildlife Service in the Department of the Interior.

An organizational status quo was maintained for about 16 years. In 1956, the name was changed to United States Fish and Wildlife Service. The new organization consisted of two separate agencies, each with the status of a federal bureau—the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife.

On July 9, 1970, President Nixon proposed Reorganization Plan No. IV which would transfer to the Department of Commerce from the Department of the Interior those functions administered through or primarily related to the Bureau of Commercial Fisheries. Excepted from the proposed transfer were Great Lakes fishery re-

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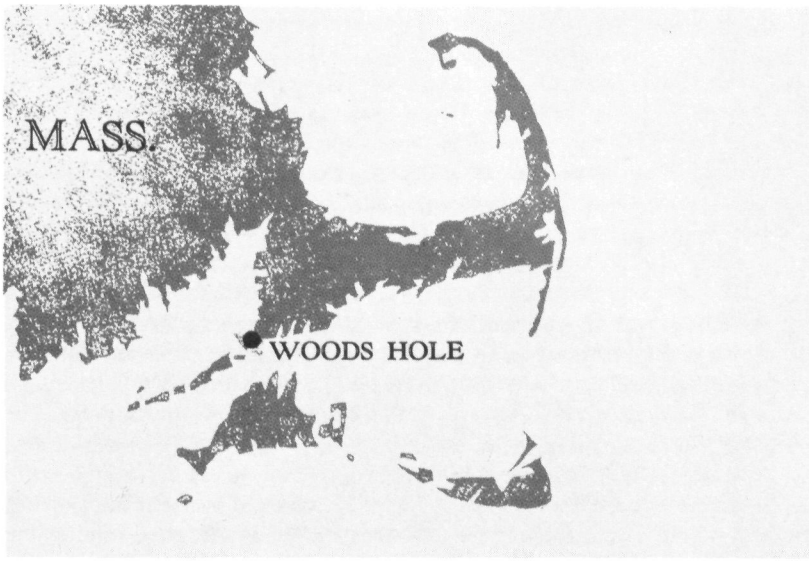

search and activities related to the Great Lakes Fisheries Commission, Missouri River Reservoir research, the Gulf Breeze, Fla., biological laboratory, and the Trans-Alaska Pipeline Investigations. These excepted functions remained in Interior with the Bureau of Sport Fisheries and Wildlife. The Reorganization also transferred to Commerce the functions related to the marine game fish programs which had been the responsibility of the Bureau of Sport Fisheries and Wildlife. The former Bureau of Commercial Fisheries was renamed the National Marine Fisheries Service and joined several other government units in Commerce's National Oceanic and Atmospheric Administration, when the plan became effective October 3, 1970, and a new era in marine fisheries began.

History shows that Congress has had a continuing interest in our nation's fisheries. The concern actually predates 1871 because the very first Congress took action to assist the new nation's first industry.

Because the fishing industry was a heavy user of salt, Congress provided relief from the import duty of six cents a bushel on salt by authorizing a payment of five cents for each quintal (220 pounds) or barrel of pickled fish exported.

The Second Congress was more direct in support of fisheries by repealing the provision of the five-cent payments and substituting a direct subsidy to both owners and fishermen. Depending on the tonnage of fishing vessels, a subsidy of up to $170 was paid annually, three-eighths to the owners and five-eighths to the fishermen. It is not generally known what $170 would buy in the days of the Second Congress, but we do know that the Secretary of the Treasury, who administered the program was paid less than $300 per month, and members of Congress received $6 per day.

Since 1871, Congress has given the federal fishery agency a broad mandate to study aquatic resources. Under specific statutes, the NMFS serves as the research agency for the Atlantic States Marine Fisheries Commission, the Gulf States Marine Fisheries Commission, and the United States Section of the International North Pacific Fisheries Commission. NMFS is heavily committed to management research in support of U.S. obligations and interests under nine international fishery commissions and a number of bilateral agreements. Not only has such research been essential for the wise use of the resources, but in many cases the data have served to protect our interest in, and our access to, the resources.

An example is evident in the research program of the United States under the International Convention for the High Seas Fisheries of the North Pacific Ocean, agreed to by the United States, Canada, and Japan in 1952.

Under the Convention, research in red salmon spawned in the streams and lakes of western Alaska has provided a broad base of scientific data for the North Pacific Convention area. The data include abundance and life history information, migration patterns of various year classes of salmon during their years at sea, and information on the areas and extent that salmon of North American origin and salmon of Asian origin intermingle at sea. The Alaska Department of Fish and Game also has supplied essential elements of red salmon research. Because of the scientific data, and working within the framework of the 1952 Convention, the United States has achieved a high degree of protection for its Alaska red salmon resources. In most years the impact of high seas salmon fishing on Alaska red salmon has been minimized because of the willingness of the Convention signatories to limit fishing effort in critical areas.

Over the past 60 years, the U.S. catch has varied greatly in species composition, due in part to changes in abundance of the various stocks, to the discovery of new resources and processing techniques and to changes in consumer taste preferences. For example, in 1908 shad, sea trout, and carp were among the ten most valuable U.S. fishery products, accounting for nearly 10 percent of the total catch value. In 1970, while still important, these fisheries combined contributed only about one percent of the total catch value. Conversely, in 1908, tuna barely showed in the industry statistics, and shrimp accounted for only about one percent of the total catch.

In more recent years, shrimp has accounted for more than a fifth of the total value of the U.S. fishery catch. In 1970, the preliminary data shows that the total shrimp catch of all species was worth about $130 million to the fishermen—about 23 percent of the total value of the entire U.S. catch. In 1970, tuna landings will show a slight increase over the 323 million pounds for 1969, when the catch was valued at $54 million at dockside. Salmon, oysters, lobsters, crabs, and, until recently, haddock have consistently ranked among our most valuable fisheries through the years since shortly after the turn of the century.

In 1970, according to preliminary information, the total U.S. catch was about 4.8 billion pounds, worth about $570 million to the fishermen. Both the value and volume were up sharply from 1969—in fact, the value was the highest ever paid U.S. fishermen for a one-year catch, and the total volume was the eighth largest on record and the highest since 1962.

As recently as 1968, more than 75 percent of our total domestic supply of all fishery products came from imports. In 1969, the import figure dropped to 64 percent, and in 1970 it was about 57 percent. The pattern has developed because of sharply reduced imports of fishmeal.

The total supply of fishery products for human food in-

Today, Philip M. Roedel (above) is Director of the National Marine Fisheries Service, and many of the nation's foremost oceanographic institutions have laboratories at Woods Hole, the research center started by Commissioner Baird. (Right) The modern building facing the water is a biological laboratory of the National Marine Fisheries Service.

creased from 5.6 billion pounds in 1969 to 6.3 billion pounds in 1970, reflecting increased demand for quality seafood items. A greater percentage of the total food fish supply was of domestic origin than in the previous two years, even though imports of edible products rose in 1970.

A fish unknown to most Americans accounts for the largest share of our landings. That fish is the menhaden, a herring-like species used primarily for manufacturing fishmeal, an important additive in poultry rations. Of the total U.S. catch of 4.8 billion pounds, nearly 2 billion pounds was menhaden caught along the Atlantic coast and in the Gulf of Mexico.

The frequent reorganizations and transfers of the federal fishery agency indicate constantly changing conditions, calling for changes in the federal approach to the changing problems. Change appears to be a dominant word in the history of our fisheries.

After the old Bureau of Commercial Fisheries became the National Marine Fisheries Service, and other organizations with missions in the atmosphere and the oceans were united in NOAA, Secretary of Commerce Maurice H. Stans issued the following statement:

> "The establishment of the National Oceanic and Atmospheric Administration in the Department of Commerce marks a significant consolidation of research, exploration, development, conservation, monitoring and educational activities as they relate to the oceans and atmosphere. The intelligent use of the oceans, which constitute three-fourths of the entire earth's surface, is vital if we are to strike a proper balance between development and conservation of its vast but surely not unlimited resources. In many respects we are more familiar with the surface of the moon than we are with the ocean depths of our own planet. Until now, in spite of sincere efforts, government has failed to organize itself to meet effectively the challenge and opportunities of operating in an ocean environment. Instead of 23 departments and agencies of government competing for various parts of the Federal mission in the ocean and the atmosphere, we will now have a single agency providing a unified national thrust in delivering on both the promise and potential of this last great frontier on earth."

The Secretary added:

> "Among the fields in which NOAA will assume Federal civilian leadership will be the mapping and charting of the global oceans and the Great Lakes; ocean fish exploration and conservation; aquaculture development; marine biological research; fish technology and industry services; technology of the air and sea; the monitoring of such geophysical phenomena as pollution, seismicity, climate and geomagnetism; and scientific and technological data collection and dissemination."

The first Director of the new NMFS is Philip M. Roedel of California, who had served for a year as Director of BCF. Mr. Roedel joined the federal service after some 30 years as an inter-

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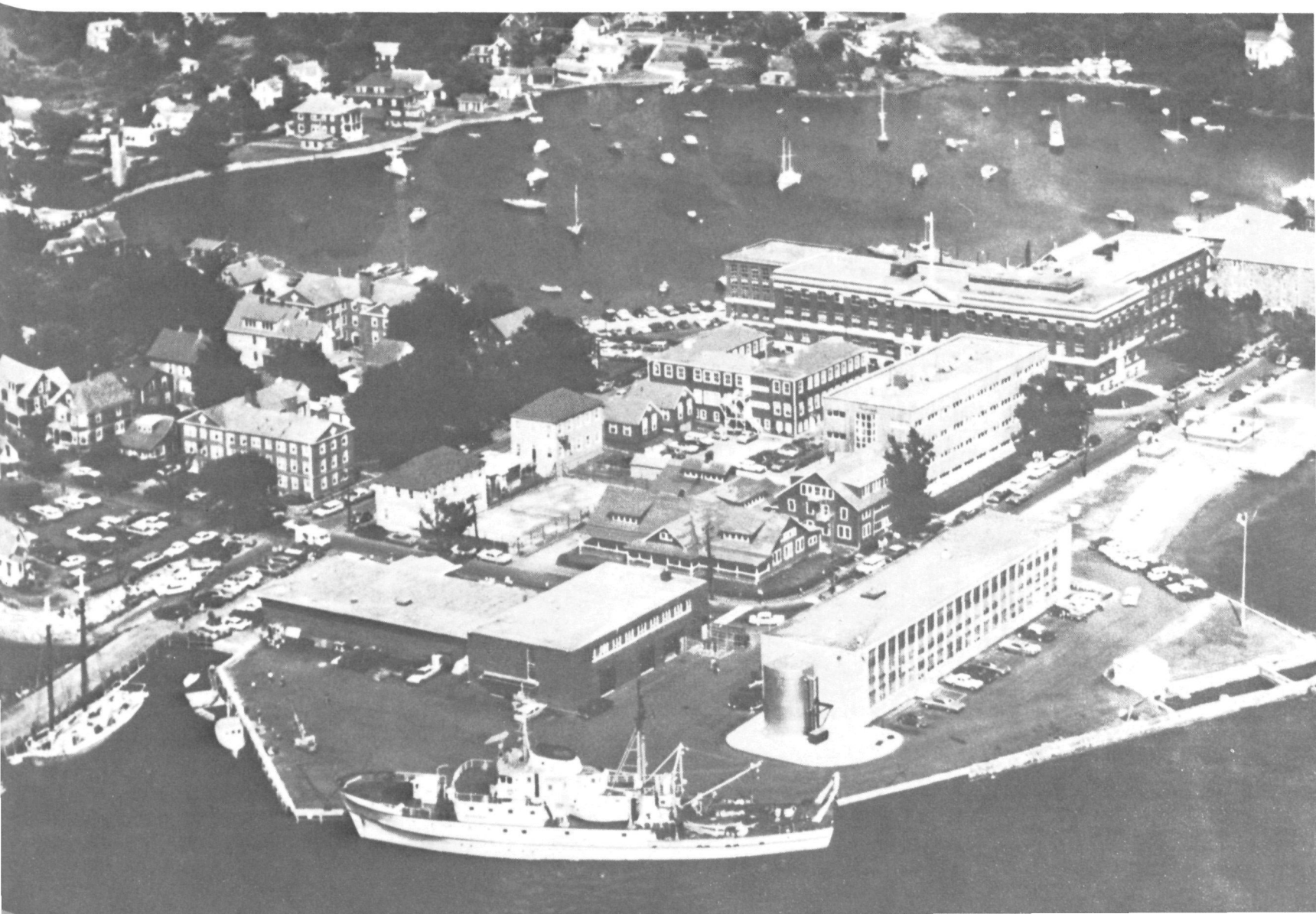


nationally known scientist and administrator in the California Department of Fish and Game. His latest state assignment was as Director of the California Marine Fish Program, and he has served as a representative of both the state and federal government at dozens of international conferences and meetings. When NOAA was formed, he said:

"We feel that the creation of NOAA marks the birth of a new era for marine fisheries in the United States. As the National Marine Fisheries Service, our responsibilities are broader than they were as the Bureau of Commercial Fisheries. We now have the responsibility for the total living marine resources including both commercial and recreational interests."

Mr. Roedel added: "We have realigned our internal structure to include our broader responsibilities and to enable us to approach fishery problems in totality rather than on a piecemeal basis. We view NMFS as having a responsibility in two major areas: one dealing with problems relating to the living marine resources; the other with problems that arise after they are caught.

"It is our feeling that consideration of the resource must come first," Mr. Roedel said, "because without the resource, there would be neither commercial nor recreational users."

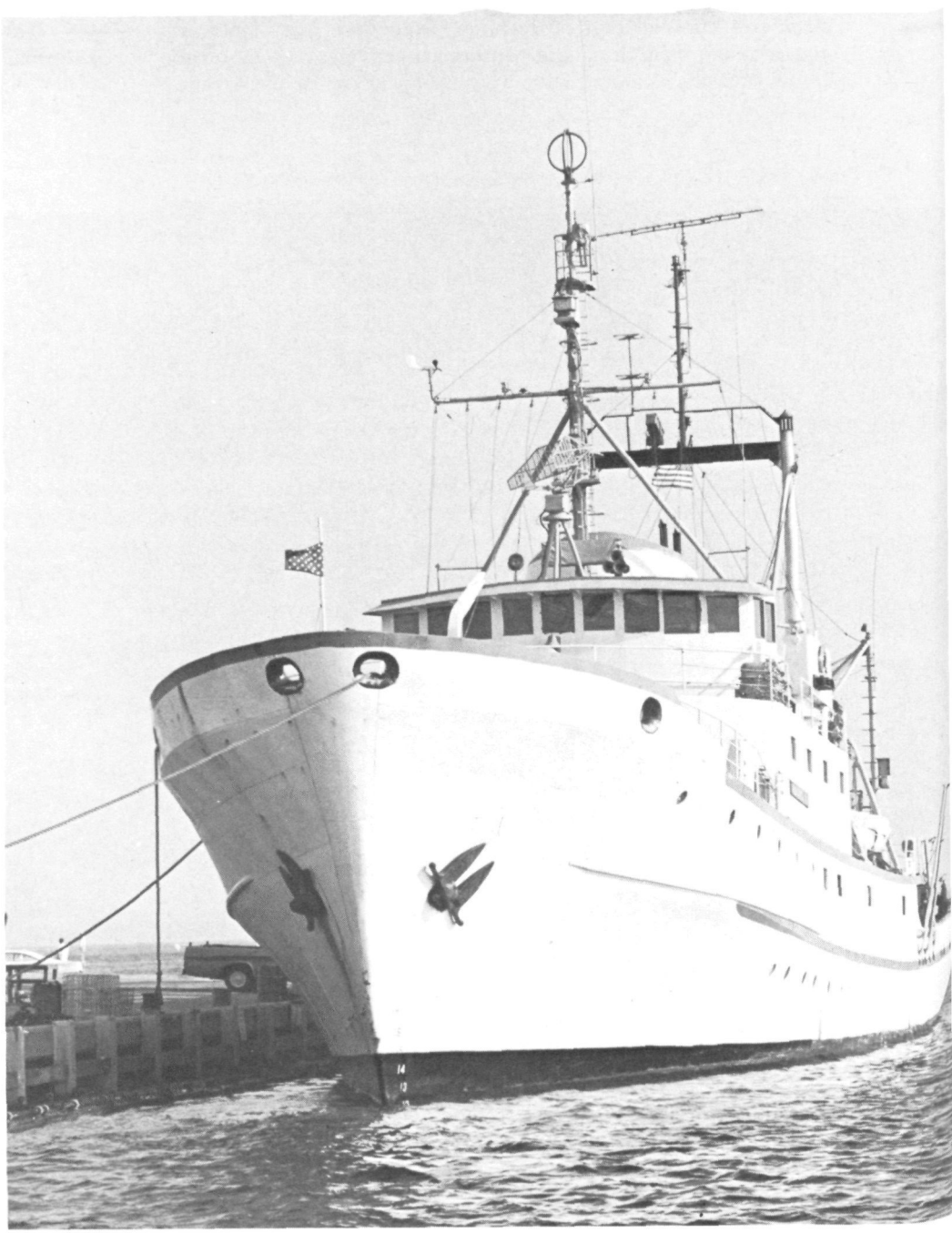
Asked about the basic goal of the National Marine Fisheries Service, Mr. Roedel said that the basic goal is conservation—that is, the wise use of the resource. He said that a strong, sound, biological base is fundamental to the goal.

On the occasion of the centennial, Director Roedel said that in years past it was the custom of the federal fishery agency to try to adapt to problems such as split jurisdiction over fisheries matters and institutional barriers placing unrealistic and sometimes prohibitive restrictions on commercial fishing.

It is apparent, he said, that this premise has not produced viable solutions to the complex problems. "It is generally agreed that there is a need for strengthening and improving the management of our fisheries, and it is our intention to look at all possibilities of a new federal-state partnership under which we would manage the resource jointly in the best interests of all concerned." □

Commissioners of the Bureau of Fisheries and Directors of the U.S. Fish and Wildlife Service

1871–1887	Spencer Fullerton Baird
1887–1888	G. Brown Goode
1888–1895	Marshall McDonald
1895–1896	Herbert A. Gill (acting)
1896–1898	John J. Brice
1898–1913	George M. Bowers
1913–1922	Hugh M. Smith
1922–1933	Henry O'Malley
1933–1939	Frank T. Bell
1939–1941	Charles E. Jackson (acting)
1941–1945	Ira N. Gabrielson, Director, Fish and Wildlife Service
1945–1952	Albert M. Day, Director, Fish and Wildlife Service
1953–1956	John L. Farley, Director, Fish and Wildlife Service
1956–1960	Arnie L. Suomela, Commissioner, Fish and Wildlife Service
1960–1966	Donald L. McKernan, Director, Bureau of Commercial Fisheries
1966–1969	Harold E. Crowther, Director, Bureau of Commercial Fisheries
1969–1970	Dayton L. Alverson (acting), Director, Bureau of Commercial Fisheries
1970–	Philip M. Roedel, Director (organization name changed to National Marine Fisheries Service, NOAA, Department of Commerce Oct. 3, 1970)



(Right) The National Marine Fisheries Service vessel ALBATROSS IV, based at Woods Hole, conducts exploratory fishing and biological studies of groundfish and sea scallops and other oceanographic research.

WET TORNADO

The waterspout could be a guinea pig for studies of its more violent twin.

BY RALPH SEGMAN
Environmental Research Laboratories

A man and wife were painting their sailing boat on the western shore of Boca Grande Key, Florida, in mid-May 1969. Suddenly, a large waterspout developed on the other side of the Key. It cut across the island, and the couple realized it was aiming straight at them.

The only protection available was a nearby Coast Guard shelter, anchored at each corner by concrete-filled drums. They ran for the shelter. It was locked. Desperately, each of them grabbed a heavy drum as the waterspout reached them.

Struck full force by the wet whirlwind, the shelter, the drums, and the man and woman clinging to them, were lifted clear off the ground. After a short, harrowing flight—peak altitude about 50 feet— the shelter and its passengers were dumped in a thick mangrove forest some 50 feet away. The couple escaped with minor injuries.

What is a waterspout? Is it a tornado over water, or are there fundamental differences between the two? Joseph H. Golden of the Weather Service's National Hurricane Center has been working on this problem for nearly four years. Until Golden became interested in waterspouts, as a result of a chance encounter with them in September 1967, scientific literature on the phenomenon was virtually nonexistent. With support from the National Hurricane Center, Florida State University, and three of NOAA's Environmental Research Laboratories—Experimental Meteorology Laboratory, National Severe Storms Laboratory, and Research Flight Facility—he has made a remarkable series of observations.

One of the reasons Golden is excited about waterspout research, and a strong rationale for the support he received from the National Severe Storms Laboratory, is that it can lead to a better understanding of tornadoes, improved tornado warnings, and perhaps a measure of control of these destructive storms.

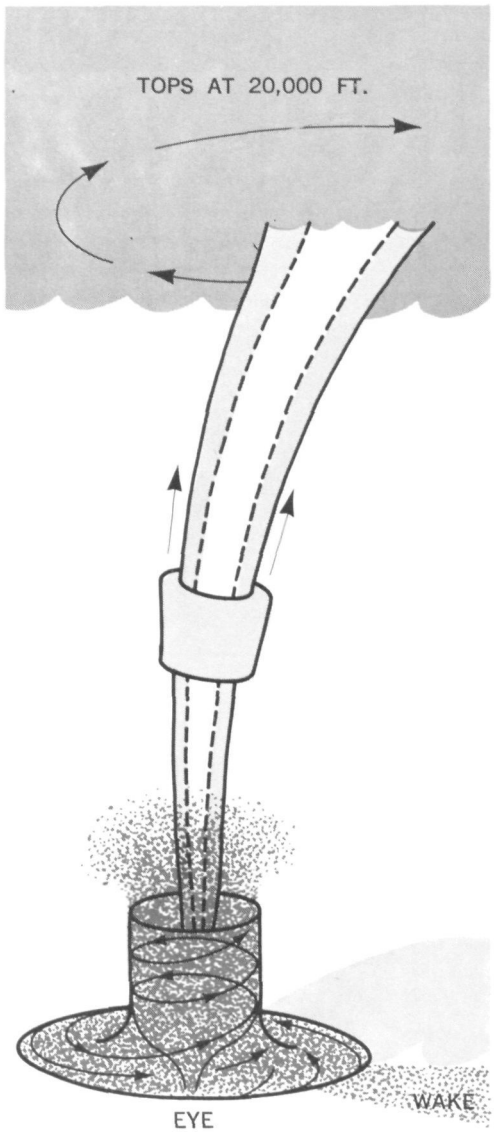
The major observed differences between tornadoes and waterspouts are intensity, duration, and speed of movement, tornadoes being greater in each category. While tornadoes are most often associated with severe thunderstorms, waterspouts may originate in developing cumulus congestus clouds, with tops frequently no higher than 12,000 feet, and in shallow stratocumulus clouds.

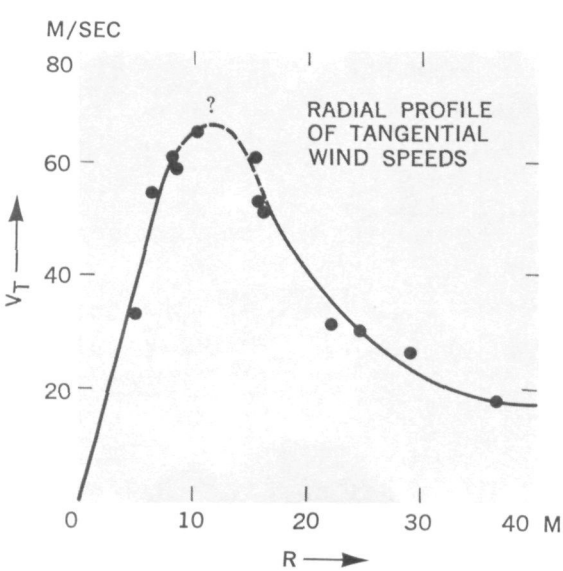
Both types of vortices are caused by convection, which in south Florida is the upward and downward movement of air induced by temperature differences and enhanced in the Keys region by the island chain itself and the surrounding warm, shallow water.

"The classical tornado," says Golden, "occurs in the right-rear flank of squall lines or in an air mass with pronounced low-level instability and vertical wind-shear;

continued

Waterspouts, like tornadoes, are tight, concentrated vortex systems. Spiral patterns appear in the water around the waterspout's visible spray vortex. These patterns vary in diameter from 1200 to 3000 feet.





(Top) A three-dimensional model of a waterspout, based on detailed aircraft observations at close range. A wake of disturbed sea water trails the spout's vortex over the sea surface. (Bottom) A radial profile of tangential wind speeds through a waterspout's spray vortex.

both of these conditions are typically absent from the environment of the south Florida waterspout.

"Although waterspouts and tornadoes are radically different, I have lately begun to regard them as similar in some important respects. They both are tight, concentrated vortex systems. In one case we measured, by photographically tracking spray particles, a maximum wind velocity of 150 miles per hour about 40 feet from the vortex center. And the wind dropped off from there to the center almost as if the waterspout were a rotating solid body like a car wheel. The diameter of the visible vortex was 240 feet. One large photographically documented waterspout displayed a rotating hook on a radar screen similar to those associated with many tornado images."

Golden feels that waterspouts are intimately related to the development of neighboring showers, and that spout movement and decay are controlled by the outflow of air from the rainshower region. He sees Florida waterspouts as the end product of the interactions of five scales of meteorological motion that occur in the summer months around the Keys. In order of descending size they are:

(1) Synoptic scale up to thousands of miles in extent;
(2) Cloudline scale of tens of miles;
(3) The individual cloud or cell within the cloudline;
(4) The new and unexpected spiral scale, which extends beyond the visible vortex; and
(5) The funnel or waterspout scale, which may vary in diameter from 10 feet to 350 feet.

The geography and tropical environment also contribute, making the Keys region more prolific for waterspouts than the Midwest is for tornadoes. During the five-month 1969 season, 391 funnels were observed and documented, about 75 percent of them within 30 miles of Key West, over waters generally four or five deep deep.

Golden noted spiral patterns in the water surrounding the visible spray vortex. The patterns, somehow caused by wind stress, were from 1200 feet to 3000 feet in diameter. Sometimes, patterns were visible where funnels were not.

The typical waterspout develops in distinct stages, starting with a short funnel dropping below the cloud base. Directly beneath the funnel, or sometimes before the funnel develops, a pronounced dark spot appears on the water surface. On several occasions, Golden used smoke flares to demonstrate that the air over the dark spot was rotating.

In the next stage, the water surface is streaked with the large spiral pattern. A spray vortex begins to form above the sea surface, followed shortly thereafter by rainshowers advancing behind the spout. The funnel then broadens and descends toward the spray vortex. Generally, the visible funnel does not reach the spray vortex, which simply means that part of the spout is not visible.

When the visible funnel does reach the sea surface, the spray vortex forms a sheath around it. What makes the funnel visible is condensed water vapor, while the sheath consists of spray spiralling upward. Observations of albatross riding the updrafts around watersprouts have convinced Golden that the upward spiralling air penetrates the cloud base. In the rare double-wall spout, the outer wall grows downward from the cloud, but spray circulating upward probably contributes to its formation.

The outflow of relatively cooler and drier air from the rainshowers usually contributes to the rapid decay of the funnel. The average lifetime of a waterspout is about eight minutes, although some can persist up to forty minutes.

Golden's earliest encounter with waterspouts not only gave him a focus for his meteorological research career, but also provided the first accurate data on waterspout intensity and structure. On September 2, 1967, he studied three spouts and sighted three others. The following excerpts from a Golden article in the British journal *Weather* describe the aerial encounter with the first observed waterspout:

"The purpose of making the flight from Miami to Key West, Florida, on that Saturday in my friend Bill Woodley's twin-engine aircraft was to go sightseeing. Besides myself and Bill (Experimental Meteorology Laboratory), there were Brad Halter and Jim Bunting. From about Key Largo to Key West, I noticed en route a nearly continuous line of precipitating small cumulus clouds, just downwind from and parallel to the Keys. We landed at the Key West airport at around 1300 EDT. About three hours later we decided to head back to Miami before the usual late-afternoon thunderstorm activity over the Florida peninsula reached its peak. As we expected, large thunderstorms built up rapidly over the southern portion of the Florida peninsula some 50 miles to the north of our flight track. As it turned out, our haste to make an early departure for Miami was well founded.

"After approximately half an hour in the air, we were approaching Lower Matecumbe Key. Suddenly, someone yelled from the back seat: 'Hey, in that cloud-line straight ahead, there's a waterspout!' I peered through the front window of the plane. Just a miles ahead was Lower Matecumbe Key and extending across the island in a NNE-SSW direction was a line of cumulus congestus clouds. These clouds were all in the immature developing stage, and none of them had the flat anvil tops characteristic of thunderstorm clouds reaching a height well above the freezing level. Our best visual estimate placed the maximum cloud tops in the line at no more than 20,000 feet above sea level. None of the clouds appeared to be precipitating. Extending downward from the base of a cloud near the southern end of this line was indeed a well-formed waterspout. As we approached, a number of interesting details came into view. The waterspout was moving in a north-northeasterly direction along the cloud line at a rate of about 10 mph.

"When first sighted, the waterspout's funnel was about two miles south of Lower Matecumbe Key and displayed a translucent, hollow structure most apparent when viewed against the sun. Without hesitation, Bill decided to fly the plane in a tight clockwise circle round the waterspout, so that I could photograph the spectacular features of its circulation. Although all of us were very much caught up in the excitement of what we were witnessing, we did take careful note of the following: our flight altitude was 2000 feet and the cloud base was at 2200 feet.

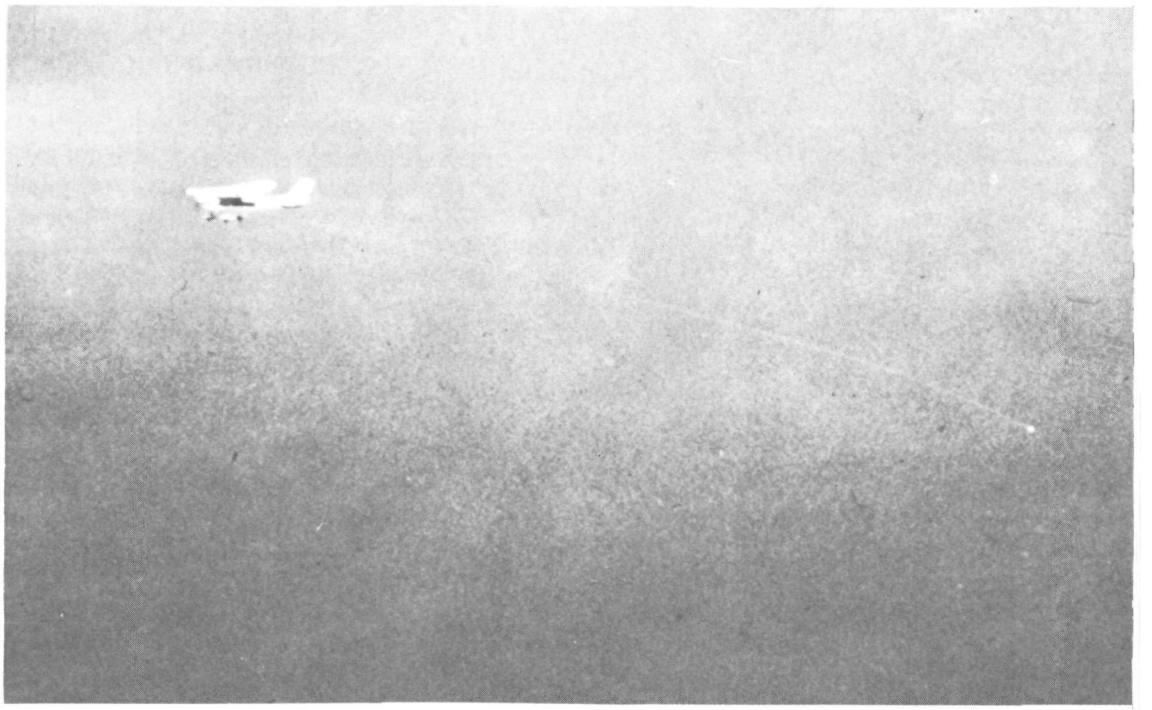
"At first, only the upper two-thirds or so of the waterspout was visible as a funnel cloud of condensed moisture. The lower portion of this and subsequent waterspouts seen that day apparently consisted largely of spray picked up from the ocean and carried outward and upward around the vortex created at the waterspout's intersection with the sea surface. There was a long narrow wake to the rear of the waterspout's spray vortex over the sea surface.

"We were able to document fully the landfall and passage across the Key of the first waterspout as the aircraft was circling at a near constant altitude of 2000 feet. At the moment it made landfall, the visible condensation funnel of the waterspout slowly retracted back up toward the cloud base. The hollow nature of the funnel became more apparent, and the bottom of the waterspout was seen only as a diffuse swirling cloud of dust. At its weakest point, when over the middle of the Key, the waterspout was reduced to a conical pendant hanging out of the cloud base. We saw a small but vigorous spray vortex circulation reappear on the sea surface with a well-defined wake trailing behind. No funnel was visible, at first; a few seconds later a very narrow rope-like funnel came into view, developing upwards from the spray vortex near the surface. Gradually, this rope-like funnel (even narrower than when the waterspout was first sighted south of the Key) became fully extended, from the ocean surface to the cloud base.

"Photogrammetric calculations indicate that the overall length of the funnel was about 2500 feet and the height of the 'spray sheath' 500 feet. The waterspout was monitored by the aircraft for a total of 15 minutes, by which time it had begun to appear somewhat weaker than when first sighted."

Tornadoes are not as amenable to investigation as are waterspouts. They are more violent, generally, and extremely hazardous to aircraft. They are known to concentrate in the midwestern plains of the United States, but the region is so large that it is chiefly luck that brings tornadoes and the right kinds of meteorological instruments to the same place at the same time. The National Severe Storms Laboratory has set up, for example, a grid of up to 60 surface observing stations over a 700-square-mile area in Oklahoma. Rarely does a tornado enter this instrumented network.

With scores of waterspouts occurring within 30 miles of Key West, Golden repeatedly has the opportunity to take instruments directly to the short-lived funnels. He has used a variety of aircraft: a highly instrumented DC-6 of the Research Flight Facility; a Piper Tri-Pacer with its side door removed, flown by George Faraldo, manager of the Key West Airport; and a Cessna Cardinal. In order to trace horizontal and vertical air motion, he has dropped smoke flares on the sea surface, released constant-altitude balloons of different colors, and has fired a Very-pistol smoke flare through a funnel. He has also made numerous movies and still photos. Considerable radar support was provided by the Key West station of the National Weather Service.



In the effort to learn more about waterspouts, a small aircraft towed a probe close to the funnels, to gather temperature data. The measurements were made by passing around the right side within 50 to 100 feet of the funnel.

Perhaps the most important breakthrough last summer was the acquisition of funnel core and near-core temperature data with a towed probe, designed and constructed by two Purdue University electrical engineering graduate students, Thomas Zimmerman and John Geddes. The probe trailed out the left-side baggage door of a Cessna-172 from 280 feet of plastic-coated electrical cable reinforced with nylon cord. The measurements were obtained by passing around the right side within 50 to 100 feet of the funnel. The probe was observed penetrating directly through the center of five waterspouts.

Also during last summer's field program, the pilot dipped the outer four or five feet of the left wing of the Apache aircraft into a waterspout funnel. The waterspout dissipated shortly after the wing penetration. In four other cases, waterspouts dissipated after small planes flew within 50 to 80 feet of the funnels. Due to the small number of samples, however Golden cannot say whether the spouts decayed naturally or as a result of interaction with wingtip vortices or the generally disturbing effect of the aircraft. Approaching the funnels, the plane encountered the expected rising air motion, but also was affected by a sharp downward force on the left wing at the moment of fly-by.

In the future, Golden hopes to employ Doppler radar from NOAA's Wave Propagation Laboratory to determine wind velocities in the upper and lower portions of waterspouts. The NOAA Atmospheric Physics and Chemistry Laboratory's Dr. Peter M. Kuhn may make remote funnel and sea surface temperature measurements with an extremely sensitive and accurate radiometer aboard a Research Flight Facility aircraft. Zimmerman and Geddes, working under a National Aeronautics and Space Administration contract, are developing an improved, steerable probe with temperature and pressure sensors for the waterspout research.

Another direction being considered is experimental modification of waterspouts, using cloud seeding techniques. What is learned about cloud physics and dynamics from a modification experiment could, the NOAA scientist believes, contribute to the broad understanding of severe storms.

Golden feels that much has been learned about waterspouts in the past three and a half years. They have become a subject for scientific research rather than a "meteorological oddity."

"Very little observational data has been accumulated," Golden says, "with the result that practically nothing can be said with certainty about the structure, energetics, or causes of waterspouts. I believe that, if we are successful with the waterspout field program, much light will be shed not only on waterspouts themselves but also on tornadoes and hurricanes and the convective processes that spawn them." □

"The mills and manufactories upon our rivers and streams, though they have banished the former denizens of these waters, furnish a compensation immeasurable as compared with all the fish that have ever floated in their bosom."

Speech by Gov. Samuel Cony of Maine, 1865, quoted in Vol. Three of "Maine Law Affecting Marine Resources"

"We have lost a million dollars worth of scallops. We have lost our recreation. We have lost everything due to pollution. . . . Now, why, for God's sake, can't we clean up this mess? . . . When I go to the end of my wharf and I look over and see chicken feathers, and see entrails go by, I damn you up and down. Why? Why? Why?"

Statement at Conference on Pollution of Penobscot Bay, 1967, quoted in Vol. Three of "Maine Law Affecting Marine Resources"

Law of the Sea and the Coastal Zone

As Maine Goes...

BY ROLAND D. PAINE, JR.

. . . SO GOES THE NATION. Once an electoral weathervane, that old saw no longer has much political validity. But in other fields important to Maine's economy, it just might be true—for example in the vital, though seemingly esoteric, field of marine law and the coastal zone.

Working under a Sea Grant, the University of Maine School of Law in Portland has produced a four-volume report of Maine law and administration affecting marine resources that is probably the most complete and useful of its kind ever published.

The Maine report came in response to a growing awareness of the need for clarification of coastal zone law, coupled with a growing public concern for what is happening along the Maine coast. This landmark publication will be joined by reports on related work being undertaken by several other universities whose NOAA Sea Grant programs include marine law projects. The law schools of the University of Miami, Louisiana State University, and the University of Rhode Island all have active research and education programs in marine law. Some emphasize law of the coastal zone, some deep-water and international marine law.

On the gulf coast, Texas A & M University held one conference dealing with law and the coastal zone, and published papers issuing from an earlier conference on the subject sponsored by the Gulf Universities Research Corporation.

Along the Pacific, Sea Grant marine law projects are underway or planned at the University of Southern California, the University of Washington, and the University of Oregon—the latter through a Sea Grant to Oregon State.

Maine led the way. The project began in mid-1968, under the provision of the National Sea Grant College and Program Act of 1966 which includes "the study of the economic, legal, medical, or sociological problems arising out of the management, use, development, recovery, and control of the natural resources of the marine environment." It was originally envisioned as a study of state statutory and administrative regulations that deal with the coastal zone. Almost immediately, it became apparent to the study directors that the structure of the governmental bodies making and administering the laws is as important as the laws themselves.

Professor David J. Halperin and Harriett P. Henry of the Maine Law School—project director and research director, respectively—therefore expanded their plans to include structure as well as substance.

Slightly over one year later the first volume of their report appeared, and it dealt precisely with the aspect of governmental structure that had been found to be so significant.

State Government Organization: Agencies Dealing With Marine Resources shows that of the more than 200 state entities (offices, boards, commissions, and the like), approximately 50 are concerned with marine resources. The report describes the activities of these agencies insofar as they impinge upon marine affairs, and then details the potential for state reorganization to make more effective its marine affairs administration.

The study directors report on their inquiries into attitudes and philosophies with respect to reorganization, including both reasons for and reasons against realignment.

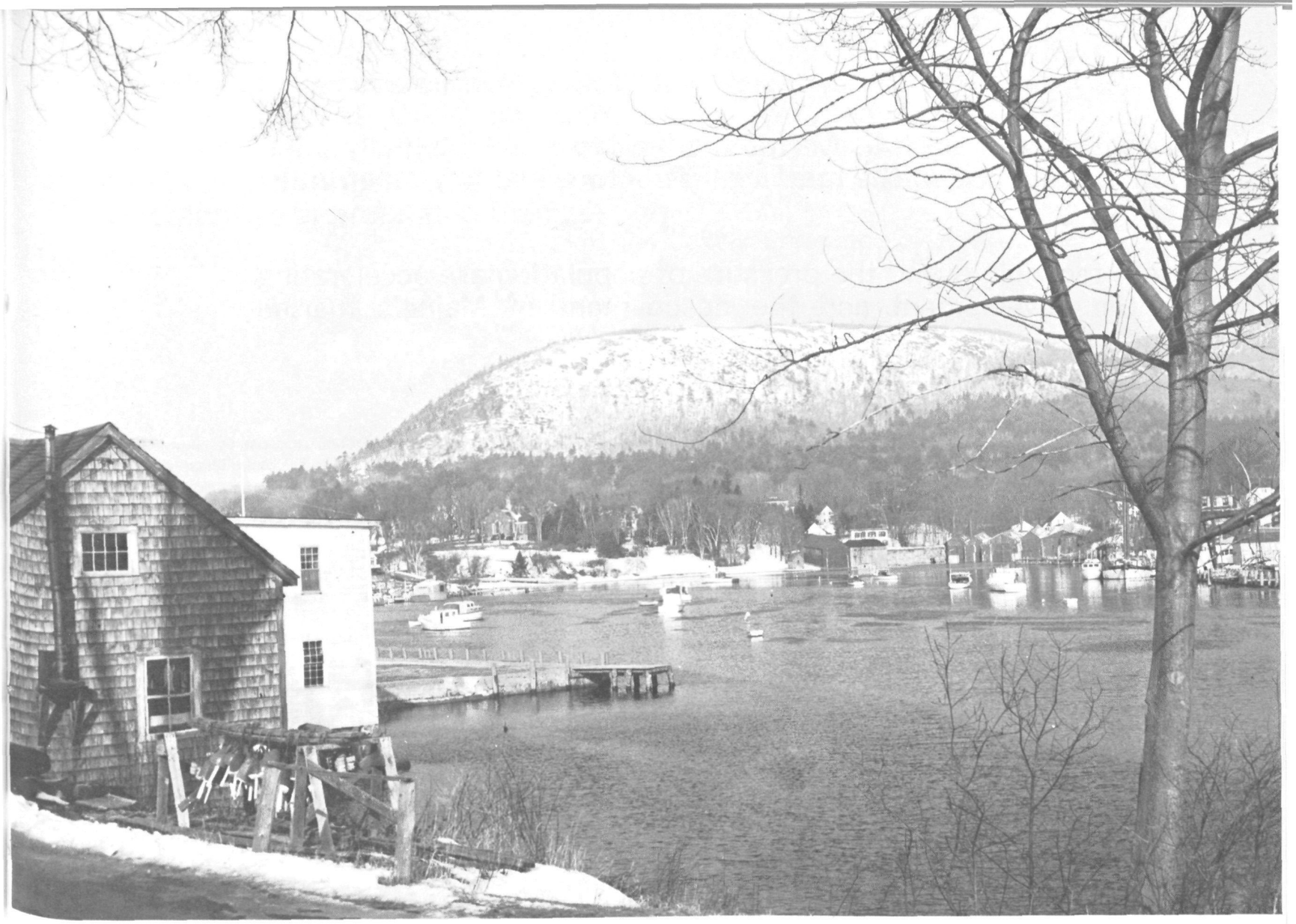


Photo courtesy of Maine Department of Economic Development

Maine has experienced growing and conflicting demands on its waters, both fresh and salt—the conflicting demands of economic development, private use, and natural resource conservation. Maine supplies lobsters, clams, and other seafoods to the nation's tables, but industrial waste-disposal practices, together with massive municipal pollution, have fouled Maine's rivers and streams, and they in turn have polluted clam flats and coastal regions.

Finally, their report presents selected proposals for governmental reorganization, beginning as far back as Governor Carl E. Milliken's 1917 recommendation that a nonpartisan commission of five policymakers replace the Departments of Inland Fisheries and Game, and Sea and Shore Fisheries.

Since that time, one governor after another has made pleas for reform—an inaugural address suggestion in 1949 for consolidation of the two departments mentioned above; a similar suggestion in an inaugural address in 1955; a suggestion for reorganization of the Department of Economic Development to improve natural resource and coastal zone management, in a 1967 inaugural address. The list ends with proposals submitted to the State Legislature in 1969.

Of particular importance is the strong impact on the coastal zone exerted by areas of law and administration that on their face are not marine-related. The structure of land ownership and land tenure rules greatly affects what happens to the ocean boundary, as does the tax structure. Determination of who has title to land has an unforeseen but quite direct impact on the coast.

In the summary of findings, the authors of the report note that "there are certain basic deficiencies in the organizational structure for the management of the state's marine resources"; their list is a catalog of problems that other legal scholars can look for in their own states or regions. In addition to the multiplicity of agencies already noted—one out of four in the entire state government having some marine effect or interest—they found overlapping or conflicting jurisdictions, areas where no agency has responsibility, inadequate or complicated financing, and lack of a forum below the Governor's office for decision-making or conflict resolution.

The second volume—*State, Public, and Private Rights, Privileges, and Powers*—appeared early in 1970. It describes the legal

continued

Quotations from Volume Two of "Maine Law Affecting Marine Resources"

In a coastal state such as Maine, marine law is so integrally interwoven in the fabric of the total legal structure that any cutoff must be arbitrary.

Modern technology and the pressure of population are accelerating both the development and the despoilment of Maine's marine resources.

balance of public and private prerogatives in such areas as marine boundaries, the seashore and tidal waters, and state power to control the use of state marine resources.

Among the special aspects of Maine coastal law are the provisions of the Colony Ordinance of 1641-7 of the Colony of Massachusetts Bay, which were early recognized as part of Maine's common law. They reflect the dependence of the colonists on fishing and hunting for a livelihood. They also showed, "in an age of small populations and large amounts of ocean footage, what a small significance and value was attached to the shore and flats themselves," the report says, and later notes that "jokes about swindles in buying land underwater are still in vogue, belying the fact that in some instances marsh land and underwater areas are 10 times as productive as comparable areas on dry land."

The problems of adjusting old laws and old customs to changing needs and circumstances is illuminated in this volume, and the authors carry forward their interests in reform and improvement by noting:

"The report as a whole represents a synthesis and composite of a wide variety of legal and non-legal sources as well as individual opinions . . . (it) has attempted to definitively set forth what Maine law *is*. The legal and interdisciplinary analysis and critique of present law has indicated in a general manner what the law *should be*. Hopefully the report will be helpful for those who decide what the law *will be*."

Issues of the most widespread public interest are discussed in the third volume. Two of the volume's six chapters, those on pollution and on recreation, constitute more than half of the book. Land use control, taxation of marine resources, erosion, and new legislation are also analyzed in *Regulation of the Coast: Land and Water Uses*.

The chapter on pollution considers the extent of marine pollution in the state, its effects from an economic and conservation point of view, and the adequacy of state law to help better the situation. It points out that Maine, like other areas of the nation, was slow to come to grips with the problems of pollution. Although a Sanitary Water Board was created as far back as 1941 to deal with water pollution, its appropriation that year was only $400. It grew very slowly, with gradual accretions of authority and funds, and changes in name, until it became the Environmental Improvement Commission, with a 1969 appropriation of $199,030.

Meanwhile, the state has experienced growing and conflicting demands on its waters, both fresh and salt—the conflicting demands of economic development, private use, and natural resource conservation. Maine supplies lobsters, clams, and other seafoods to the nation's tables. She is also a great timber and potato-growing state, and has encouraged textiles, poultry production, and other industry. But the waste-disposal practices of many of these industrial activities, together with massive municipal pollution, have fouled Maine's rivers and streams, and they in turn have polluted clam flats and coastal regions. Three relatively new sources of potential pollution—oil, thermal emissions from nuclear plants, and radioactivity—are now also appearing in the state.

It is a measure of the problem that 70,000 acres of inshore flats and waters of the Maine coast, representing 20 percent of areas available for bivalve shellfish production— clams, quahogs, mussels, and oysters —and 50 percent of the total supply in terms of productivity, have been closed because of bacterial pollution.

Municipalities have been major sources of pollution, the report notes, because they dump great amounts of untreated sanitary waste and untreated industrial waste directly into the waters. Of more than 400 Maine communities, public sewers existed in only 121 at the time the report was written. Of these, only 16 had secondary treatment plants. The largest city in Maine did not even have a primary treatment plant.

As the effects of this pollution came to be more widely recognized, and with the help of the Federal government, the State of Maine is now taking steps to alleviate the situation, and many new treatment plants are planned or under construction.

The recounting of statutory and administrative efforts to regulate pollution in Maine can be read with profit by out-of-staters involved in similar problems in their own areas, and with interest by anyone wishing to add to his own general knowledge of the subject.

The succeeding chapter emphasizes the municipal, regional, and state planning efforts that have been undertaken concerning recreational uses of the Maine coast. It concludes that there is no significant regulation of land use and development along about two-thirds of Maine's coast, for any purpose.

In the final volume of their report, *Resources From the Sea and Federal Limitations on State Control*, the Maine Law authors examine Federal and state relationships with respect to marine resources, the conflicts of interest among various marine-oriented groups, and Maine's policies on fisheries, aquaculture, marine mining, and food law as expressed in statutes and in practice. International problems bearing upon the marine resources of Maine, particularly the coastal zone, are also examined.

A second Sea Grant study of law of the coastal regions, with a somewhat different approach, has been undertaken by the University of Miami School of Law. Recognizing the need for a systematic, detailed, and comprehensive study of coastal resources, Dennis O'Connor of the Miami Law School instituted a research survey of Florida Coastal Law. Legislative, executive, and judicial decisions were examined, and a two-volume report drafted.

In addition, to bring together in one place a resource study of legal decisions and case law in the coastal zone, the Miami group made a detailed and comprehensive outline of the legal problems of the coastal region on a national basis. It then carefully examined reported decisions, noting that "since traditional categories of legal doctrine are not classified accordng to key words such as environment, estuary, conservation,

Every inhabitant who is an householder shall have free fishing and fowling in any great ponds, bays, coves and rivers, so far as the sea ebbs and flows within the precincts of the town where they dwell, unless the freemen of the same town, or the general court, have otherwise appropriated them.

—*Colony Ordinance of 1641–7.*

many thousands of cases must be scanned in order to complete coding." The group has located approximately 12,000 decisions, nationwide, that are relevant to its outline of coastal zone law.

At present, the Miami Sea Grant law group is undertaking the compilation of these coastal region decisions, in a form for publication.

The University of Rhode Island has taken a quite different tack in its ocean law activities, and since 1966 has held summer conferences dealing with national and international problems of ocean law. It has also been involved with coastal zone marine law, however, and since receiving its first Sea Grant funds has supplied information and advice to the State of Rhode Island on the delimitation of its offshore boundaries, and on the need for rules and regulations in the management of its coastal areas. The Law of the Sea Institute at Rhode Island has also assisted the Governor's Technical Committee on Narragansett Bay and the Coastal Zone.

As has the University of Miami, it has broadened its scope of interest in coastal zone law beyond the immediate boundaries of the state, and is planning additional activities involving the mutual concerns of the whole Northeast.

The Texas A & M University Sea Grant program made a special contribution to understanding of the laws of the coastal margin by publishing in 1970 selected papers from an earlier conference on that subject, sponsored by the Gulf Universities Research Corporation. Problems of mapping, insurance, real estate development, mineral and water resources, and coastal navigation were examined in the papers published by the University.

One of the outgrowths of the conference was the recognition, which had previously been noted by the Maine study directors in their state, that laws applying to coastal areas frequently are based on erroneous notions of biology and ecology. "After examining coastal law in Louisiana, one participant at the workshop pointed out that as high as 70 percent of the laws in that state have no basis in scientific fact," the Texas A & M conference summary notes. Among the areas recommended by the conferees for further study was the need to extend to all gulf states the work then being undertaken by Louisiana, Mississippi, and Alabama in cataloging and analyzing their laws relating to the marine environment.

In this and related ways, the conference laid the groundwork for greater cooperation between law and science in the Gulf of Mexico coastal zone.

Cataloging and analysis of Louisiana's laws affecting coastal and marine resources has been undertaken by the Louisiana State University Law Center, as part of the LSU Sea Grant. Under the direction of H. Gary Knight, the group first examined the state constitution, codes, statutes, administrative regulations, judicial decisions, and related material, and has prepared a volume containing this material.

A later phase of the study is analysis, including interviews with representatives of various user groups. Combined with careful data analysis, the findings will be published in a second volume that will also contain recommendations for legislative and other action.

Among other activities at LSU are research activities by two senior law students who hold Coastal Resources Law Assistantships, including a project now underway on the legal, political, economic, and social implications of artificial changes in the land-water configuration of the Mississippi River delta.

A major effort to upgrade west coast and eventually national coastal zone marine law information services is underway with joint participation by the University of Oregon Law School and the Oregon State University Sea Grant Program. The Oregon Law School is concentrating on research and development of Pacific coast marine law, looking toward establishment of a marine law library, with particular attention to resources of the continental shelf and the problems of submerged and submersible lands in estuaries.

Now in the planning stage is publication of a quarterly newsletter summarizing developments in ocean law. It will be prepared by the Oregon Law School and distributed through Oregon State's marine advisory service to all law schools in the nation.

A recent major contribution, aimed primarily at commercial fishermen but also of great use to anyone interested in coastal zone law, is a section of the *Commercial Fisherman's Notebook* devoted to oceanic law. This was also prepared at the University of Oregon and distributed by Oregon State.

Until recently, the law of the coastal zone was a relatively untapped area of legal research. But its importance has become increasingly apparent, though its boundaries may be as unclear as are coastal zone boundaries themselves. It is one more example of the interlocking effects on each other of our natural environment and our social system.

Early on, the Sea Grantees at Maine recognized the problems in their own state and set to work. Their report constitutes the first major legal and administrative study sponsored by Sea Grant, and is a significant contribution to coastal zone law. Today, NOAA Sea Grantees in law schools on every coast are carrying forward, for their own areas and for the nation as a whole, the work begun at Maine. □

Seeking a route to Asia explorers found a land of fur, ore, and timber.

MAN AND THE LAKES

BY JOHN HANNA
Lake Survey Center

FROM PORTS on Lake Superior, freighters loaded with grain, lumber, and iron ore move through the locks at Sault Ste. Marie, into Lake Huron, and on to the great mills and factories lining the shores of Erie and Michigan. On the return voyage, their cargo is manufactured goods—iron, steel, paper, newsprint.

Linked as they are today, Superior, Huron, Michigan, Erie, and Ontario form the most important inland waterway system in the world, stretching nearly halfway across the North American continent. Since the opening of the St. Lawrence Seaway, the products of the lakes' region now reach world markets directly—some traveling the entire 2340-mile water route from Duluth, Minnesota, to reach the open sea.

Nature and man have combined to make the Great Lakes a major center of population and industry. Nature—by providing economical transport and abundant raw materials—set the scene. The role of man has been sometimes heroic, occasionally comic, and often tragic in this still-unfolding history of the Great Lakes.

Eighteen thousand years ago, a solid ice sheet—one to two miles thick—blanketed what is now the Great Lakes region.

Geologists call it the Wisconsin glacier, the last of four known glaciers to cover the Great Lakes and part of the North American continent. Although each of the glaciers made its contribution, the Wisconsin is primarily responsible for the lakes' present configuration.

As this huge mass of ice moved down over the area, it gouged and tore out all but the very hardest of earth's rocky crust. It pushed out the softer material, creating the lakes' basin and left the harder granites and dolomites to form many of the shorelines.

Originally, the lakes were quite narrow, but, as the glacier melted and the earth entered a rainy period, they filled and even overflowed. Their only natural outlet today is through the St. Lawrence River, but in those days water spilled out of the lakes at Chicago, Duluth, and other places.

Geologists reason that during the glacier age so much water was trapped in the ice that the levels of the oceans dropped and a land bridge formed across what is now known as the Bering Strait. Small nomadic bands crossed the land bridge from eastern Siberia to the North American continent, although geologists don't believe the Great Lakes area was occupied until after the last glacial retreat. According to the best estimate, man arrived at the lakes about 11,000 years ago. During the ensuing millenia, various cultures such as the Copper Indians and the Mound Builders established themselves, thrived for a time, and then gradually disappeared. Tribal wars or disease generally caused the extinction of these early civilizations.

Marco Polo, in the 13th century, excited all Europe with his tales of the fabulous riches of Asia. But the trip around the tip of Africa was long and difficut, and a short route to the fabled land was envisioned. The earliest explorers of the North American continent were searching for this route. Jacques Cartier thought he had found it in 1534, when he discovered the St. Lawrence River. He was further encouraged when the Indians told him of great inland seas to the west, but Cartier and those who followed him never found the salt water they knew must be there if a short route to Asia really did exist.

Although discovery of the Great Lakes is generally credited to Samuel de Champlain, most historians admit that his scout Etienne Brulé was probably the first of the early explorers to see some and maybe all of the Great Lakes—the first, that is, unless the Kensington Rune Stone is genuine. This Stone, which is more of a tablet, was found near Lake Superior and contained a Scandinavian inscription dated 1362. Many argue that the Stone is a magnificent hoax, but if it's not, then the Vikings saw Lake Superior long before Champlain or Brulé.

Champlain established the first French settlement in the new world at Quebec on the lower St. Lawrence River. The British, who had settled farther south along the Atlantic coast, were envious of the French and their control of the St. Lawrence River. After years of feuding, war finally broke out in 1628, with the British bent on capturing Champlain's colony at Quebec. Brulé was sent down the St. Lawrence River to guide a convoy of French ships carrying much-needed supplies to Champlain. When the convoy was intercepted by a flotilla of English privateers, Brulé defected to the British and guided them to Quebec. The colony fell, and Champlain was captured. At the war's end, peace terms returned Quebec to the French. Champlain died there a few years later. For Brulé's treachery, his long-time Indian friends, the Hurons, turned on him—torturing, killing, and reportedly eating him.

The first lakes ship larger than a canoe was built by LaSalle near Niagara Falls in 1679. The square-rigged vessel was called the GRIFFIN or GRIFFON and sailed to Green Bay on its maiden cruise. There, tools and supplies were unloaded and a cargo of fur pelts taken aboard. On the return trip, she disappeared, apparently without a trace, although some claim to have found her remains in northern Lake Huron. Besides LaSalle, other famous explorers who helped to open up the Lakes included Frontenac, Nicolet, Marquette, Jolliet, Hennepin, and Cadillac, who built a fort at Detroit in 1701.

New York's Governor, DeWitt Clinton, and the fashionable ladies of Europe each made significant contributions to the development of the Great Lakes in the early 1800's. The decline of Europe's fur resources, the abundant, seemingly inexhaustible supply of rich Great Lakes-area beaver pelts, and the fierce demand for furs sent trappers, speculators, and traders pouring into the area. While satisfying their desire for profit, they were helping to open up this vast, untamed wilderness.

Recognizing that, in those days, traveling by water was faster and easier than land travel, the New York Governor envisioned an all-water route from New York, up the Hudson River and across the State to Buffalo on Lake Erie, as an aid to the mounting westward migration. The Erie Canal was completed in 1825 and was an immediate success. Buffalo, as the stopover point between canal traffic and lake traffic, grew rapidly. In 1834, eighty thousand persons passed through on their way west.

The Lake Survey was established by Congress in 1841, to make surveys, publish, and distribute nautical charts of the Lakes. As a NOAA element, the Lake Survey continues this important work today, with engineering and limnology—or fresh-water oceanography—added.

An interesting sidelight in the development of the Great Lakes country was the war between Ohio and Michigan. Before the Erie Canal was built, the Ohio River served as a major artery in the western movement. As a result, areas bordering the river were settled and became states sooner than other territories. In 1787, before either Michigan or Ohio became states, the border between them was established by Congress. But when Ohio gained statehood in 1803, it used a boundary north of the original line, thereby including in the state the bustling harbor of Port Lawrence, or Toledo as it is known today.

A dispute over the boundary smoldered until it was brought to a head by Michigan's

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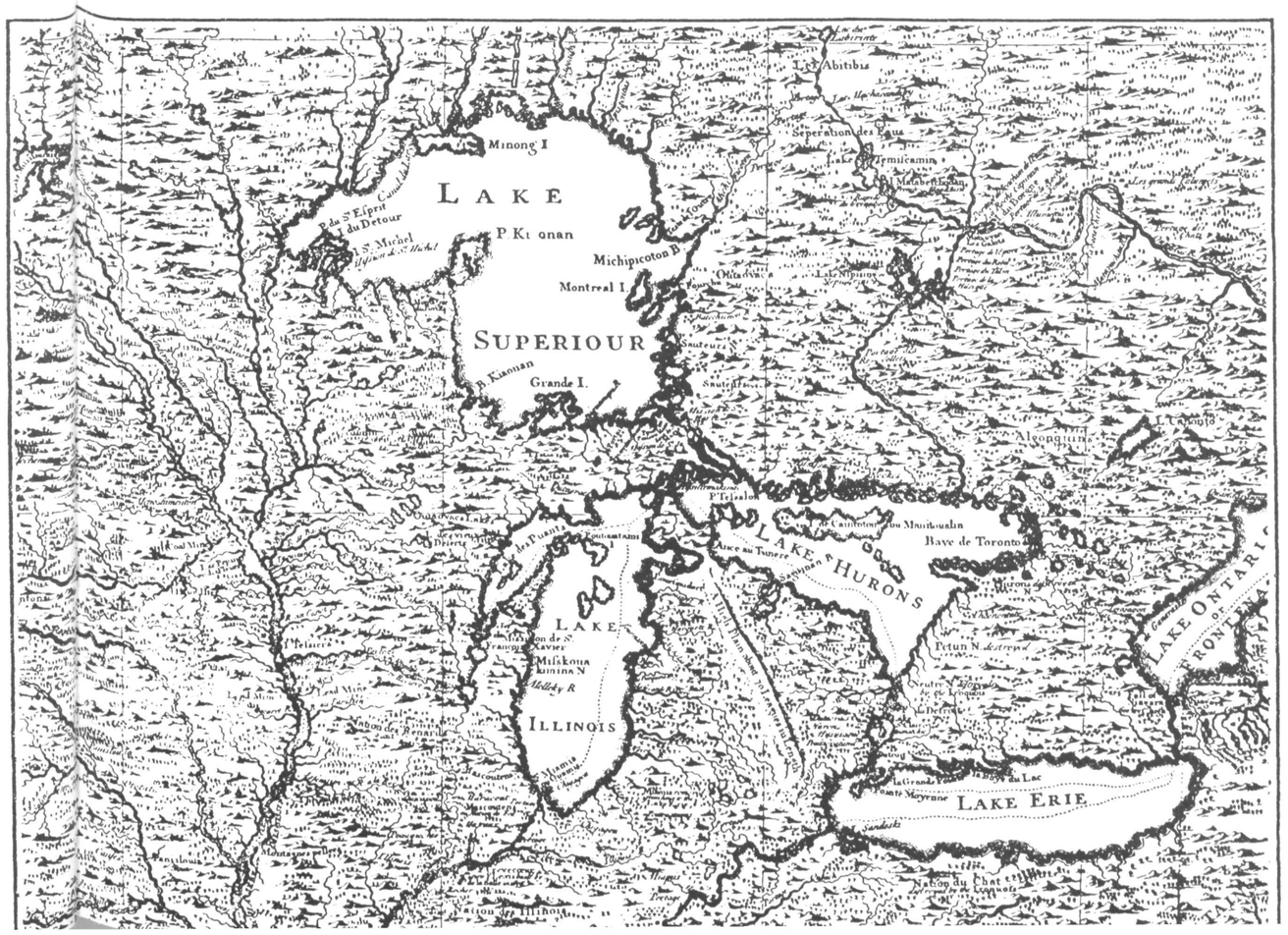
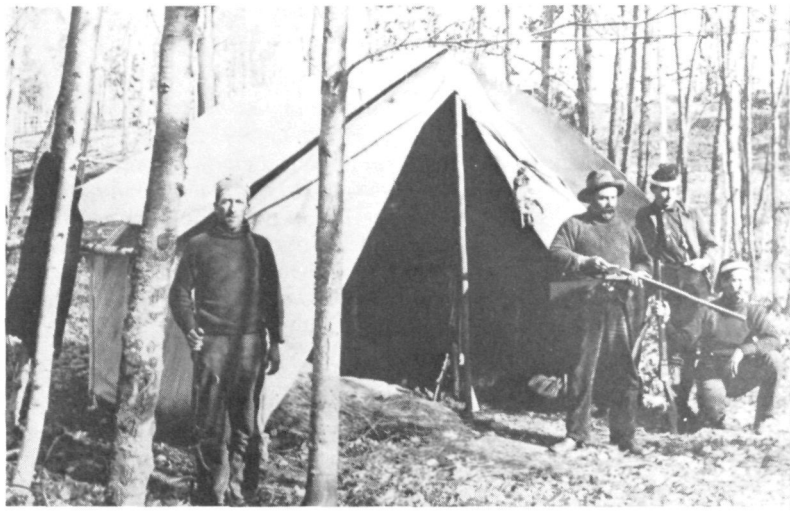
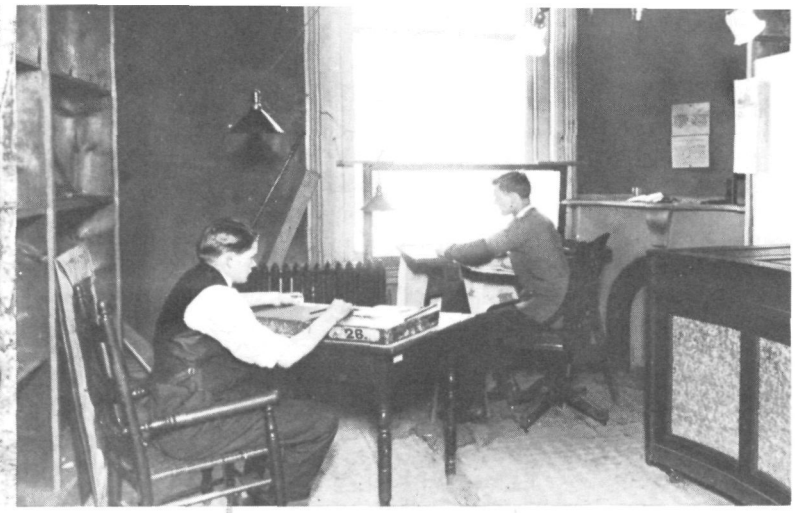
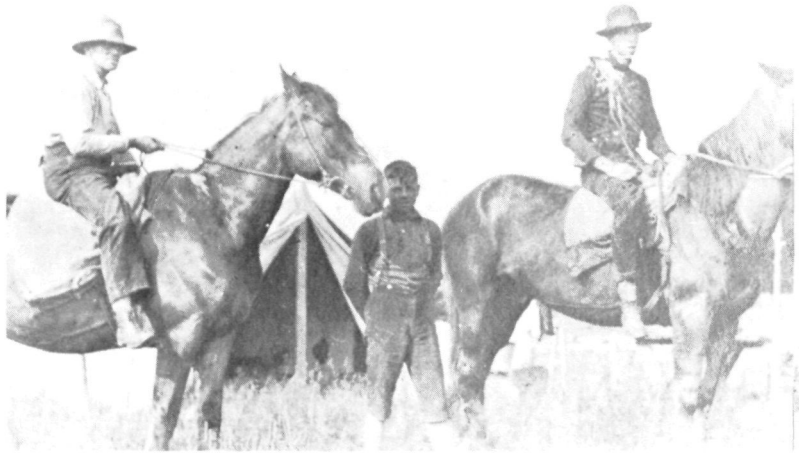


Early mapping of the Great Lakes began about 1570, but two centuries elapsed before explorers were able to produce maps that resembled closely the Lakes' true form. This map, prepared in 1741, shows how explorers of that period envisioned the geography of the region.







The Federal Government began charting the Lakes in 1841, with the establishment of the Lake Survey. (Top left) Early Surveymen often lived off the land, using their guns to provide fresh meat. (Top right) At the turn of the century, charts were engraved on lithographic stones that sometimes weighed as much as 1,150 pounds. (Bottom left) "Official vehicles" in 1900. (Bottom right) Opening of the "Soo" locks brought an increase in shipping, with large cargo ships such as these vessels of the 1890's.

application for admission to the Union in 1834. Michigan and Ohio raised armies, battle lines were drawn, and the situation was tense. But neither army could find the other. Eventually, President Jackson and Congress entered the dispute and gave the so-called "Toledo strip" to Ohio. As a consolation prize, they gave Michigan its Upper Peninsula. All Michigan was enraged at the loss of the Toledo strip, until large deposits of copper and iron ore were discovered in the Upper Peninsula. Then Wisconsin, which originally was to have received the mineral-rich Upper Peninsula, was furious. Michigan became a state in 1837, and Wisconsin eleven years later, but by then, it was too late to protest. So ended one of the most colorful chapters of Great Lakes history.

With the discovery of rich copper and iron ore deposits, a new era began. Douglass Houghton, Michigan's first geologist, probably started the copper boom when he correctly deduced that potential lodes were locked in the Keeweenaw Peninsula's prehistoric lava flows. William A. Burt, a self-taught surveyor working for Houghton, saw his magnetic compass "go crazy" while surveying near the present city of Negaunee. The cause, of course, was the presence of high-purity iron ore.

Mining operations began. Other deposits were discovered later, including the fabulously rich Mesabi Range in northeastern Minnesota.

Then came the lumber boom which left the entire Great Lakes basin all but denuded. Michigan lost almost all of its original stand—some 400 billion board feet—most of it to the lumber industry, but a large percentage to land-clearing operations.

Construction of the first "Soo" locks was completed in 1855, mainly to aid the blossoming copper and iron ore industries. Shipping on the lakes increased so rapidly, and the loss of lives and property in storms became so great, that the need for weather warnings on the Great Lakes gave the major impetus to the establishment of the national weather service in 1870. The Life Saving Service—later to become part of the U.S. Coast Guard—began in 1878. The most vicious storm ever to hit the lakes occurred in November 1913. Over 70 large, powerful "lakers" were sunk, run aground, or severely damaged. The worst single disaster occurred when the pleasure steamer, EASTLAND, capsized at her dock at Chicago in 1915, killing 835 of 2500 passengers on board.

World commerce came to the Great Lakes with the opening of the St. Lawrence Seaway in 1959. The Seaway represents a unique development in world history. Two nations, the United States and Canada, joined forces for the mutual benefit of both, each building a part of this connection to the oceans.

A major new factor in Great Lakes history is the boom in pleasure boating. Once considered a rich man's sport, boating has come into its own since World War II as a major form of recreation. Glass fiber and aluminum hulls, larger, more powerful and more reliable outboard motors, greater affluence, more time to enjoy water-based recreation—all have contributed to the boom.

Another chapter, yet to be written, perhaps will determine the future course of Great Lakes history. In 1972 and 1973, the International Field Year for the Great Lakes will seek a scientific cure for the many wounds man has inflicted on these greatest of earth's inland seas, in the three and a half centuries since Champlain saw them. □

FISH and SHELLFISH ALFRESCO

Food somehow tastes better out of doors. Open air, a relaxed atmosphere, and the aroma of food cooking on a grill whet the appetite and sharpen the taste buds. And, when the temperature climbs, the cook wants to be outside with the rest of the family.

Almost all varieties of fish and shellfish adapt well to outdoor cooking and eating, according to the Marketing Services Office of the National Marine Fisheries Service. You may be fortunate enough to catch your own fish but, if not, there are plenty waiting for you—fresh or frozen—in the grocery store.

A new product of our rapidly changing society has entered the consumer market since the mid-1950's—fish portions and fish sticks. Fish portions and sticks are generally made of cod, haddock, or pollock and are frozen raw or partially cooked. They are cut by machine from large, solidly frozen blocks of fish fillets. The cut pieces are dipped into a batter and coated with breading. Most fish sticks and some portions are then partially cooked.

Fish portions range in size from 1½ to more than 5 ounces and come in square, round, and rectangular shapes. Raw breaded fish portions are required to be at least ⅜-inch thick and to contain not less than 75 percent fish. Partially cooked fish portions must be at least ⅜-inch thick and contain a minimum of 65 percent fish.

Fried fish sticks are 3 to 4 inches long and weigh up to 1½ ounces. They are at least ⅜-inch thick and must contain no less than 60 percent fish.

Within a few short years these products have become an American standard, being featured as "fishburgers" or fish sandwiches in drive-ins and restaurants across the land. Today's homemakers are preparing the very practical portions and sticks in a variety of imaginative ways.

Two ways of serving fish portions are included in the outdoor cooking recipes featured here. Several of the other recipes are reprinted from **Fish and Shellfish Over the Coals,** a 24-page, full-color recipe booklet published by the National Marine Fisheries Service. The publication (Catalog Number I 49.34:14) can be obtained for 40 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Sea Fare

SCALLOP KABOBS

1 pound scallops, fresh or frozen
1 can (13½ ounces) pineapple chunks, drained
1 can (4 ounces) button mushrooms, drained
1 green pepper, cut into 1-inch squares
¼ cup melted fat or oil
¼ cup lemon juice
¼ cup chopped parsley
¼ cup soy sauce
½ teaspoon salt
Dash pepper
12 slices bacon

Thaw frozen scallops. Rinse with cold water to remove any shell particles. Place pineapple, mushrooms, green pepper, and scallops in a bowl. Combine fat, lemon juice, parsley, soy sauce, salt, and pepper. Pour sauce over scallop mixture and let stand for 30 minutes, stirring occasionally. Fry bacon until cooked but not crisp. Cut each slice in half. Using long skewers, alternate scallops, pineapple, mushrooms, green pepper, and bacon until skewers are filled. Cook about 4 inches from moderately hot coals for 5 minutes. Baste with sauce. Turn and cook for 5 to 7 minutes longer or until bacon is crisp. Serves 6. *continued*

CHARCOAL BROILED PORTIONS

12 frozen raw breaded fish portions (2½ to 3 ounces each)
1 cup oil
Paprika
Choron Sauce or Sea Sauce

Dip frozen portions in oil and sprinkle with paprika. Place portions in well-greased, hinged, wire grills, cook about 4 inches from moderately hot coals for 5 to 7 minutes. Turn. Cook for 5 to 7 minutes longer or until fish are brown and flake easily when tested with a fork. Serve with Choron or Sea Sauce. Makes 12 servings.

Choron Sauce

½ cup butter or margarine
¼ cup water
4 egg yolks
2 tablespoons tarragon vinegar
1 teaspoon instant minced onion
1 teaspoon dried parsley flakes
¼ teaspoon salt
Dash cayenne
3 tablespoons tomato paste

Melt butter in water in top of double boiler over direct heat. Remove from heat. Add egg yolks. Beat until mixture almost doubles in bulk. Stir in vinegar, onion, parsley, salt, and cayenne. Cook over hot water 5 minutes or until thick, stirring constantly. Remove from heat. Stir in tomato paste. Serve warm. Makes approximately 2 cups sauce.

Sea Sauce

2 packages (1⅛ to 1¼ ounces each) Hollandaise sauce mix
2 tablespoons salad oil
1½ cups clam juice
2 tablespoons chopped green pepper
2 tablespoons chopped pimiento

Empty sauce mix into a 1-quart saucepan. Add salad oil. Gradually add clam juice and mix well. Add green pepper and pimiento. Cook over moderate heat until thick, stirring constantly. Makes approximately 1¾ cups sauce.

TROPICAL BARBECUED OCEAN PERCH

2 pounds ocean perch fillets or other fish fillets, fresh or frozen
Tropical Barbecue Sauce
Chopped parsley

Thaw frozen fillets. Brush both sides of fillets with Tropical Barbecue Sauce. Place fillets in a single layer in well-greased, hinged, wire grills. Cook about 4 inches from moderately hot coals for 5 to 8 minutes. Baste with sauce. Turn. Cook for 5 to 8 minutes longer or until fish flake easily when tested with a fork. Sprinkle with chopped parsley. Makes 6 servings.

Tropical Barbecue Sauce

¼ cup molasses
¼ cup vinegar
2 tablespoons Worcestershire sauce
1 tablespoon prepared mustard
½ teaspoon liquid hot pepper sauce

Combine all ingredients. Makes approximately ½ cup sauce.

CHESAPEAKE BAY CLAMBAKE

6 dozen soft-shell clams
12 small onions
6 medium baking potatoes
6 ears of corn in the husks
12 live, hard-shell blue crabs
Lemon wedges
Melted butter or margarine

Wash clam shells thorqughly. Peel onions and wash potatoes. Parboil onions and potatoes for 15 minutes; drain. Remove corn silk from corn and replace husks. Cut 12 pieces of cheesecloth and 12 pieces of heavy-duty aluminum foil, 18 x 36 inches each. Place 2 pieces of cheesecloth on top of 2 pieces of foil. Place 2 onions, a potato, ear of corn, 1 dozen clams, and 2 crabs on cheesecloth. Tie opposite corners of the cheesecloth together. Pour 1 cup of water over the package. Bring foil up over the food and close all edges with tight double folds. Make 6 packages. Place packages on a grill about 4 inches from hot coals. Cover with hood or aluminum foil. Cook for 45 to 60 minutes or until onions and potatoes are cooked. Serve with lemon wedges and butter. Serves 6.

TROUT OVER THE COALS

12 pan-dressed rainbow trout (8 ounces each) or other pan-dressed fish, fresh or frozen
1 can (6 ounces) frozen pineapple-orange juice concentrate, thawed
⅓ cup chili sauce
3 tablespoons salad oil
3 tablespoons soy sauce
¼ teaspoon salt
Lemon and orange slices

Thaw frozen fish. Clean, wash, and dry fish. Combine remaining ingredients except lemon and orange slices. Brush fish inside and out with sauce. Place fish in a single layer in well greased, hinged wire grills. Cook about 4 inches from moderately hot coals for 8 to 10 minutes. Baste with sauce. Turn and cook for 7 to 10 minutes longer or until fish flake easily when tested with a fork. Serve with lemon and orange slices. Makes 12 servings.

SALMON FILLETS IN FOIL

2 pounds salmon fillets, fresh or frozen
6 squares heavy duty aluminum foil (12 by 12 inches each)
¼ cup butter or margarine, melted
1 teaspoon salt
¼ teaspoon crushed garlic
¼ teaspoon pepper
Lemon wedges

Thaw frozen fillets. Cut fillets into 6 portions. Place a portion of fish, skin side down, on each piece of foil. Combine remaining ingredients except lemon wedges. Pour sauce over fish. Bring foil up over fish and close all edges with tight double folds. Place packages on a grill about 4 inches from moderately hot coals. Cook for 20 to 30 minutes or until fish flake easily when tested with a fork. Makes 6 servings.

SALMONBURGERS

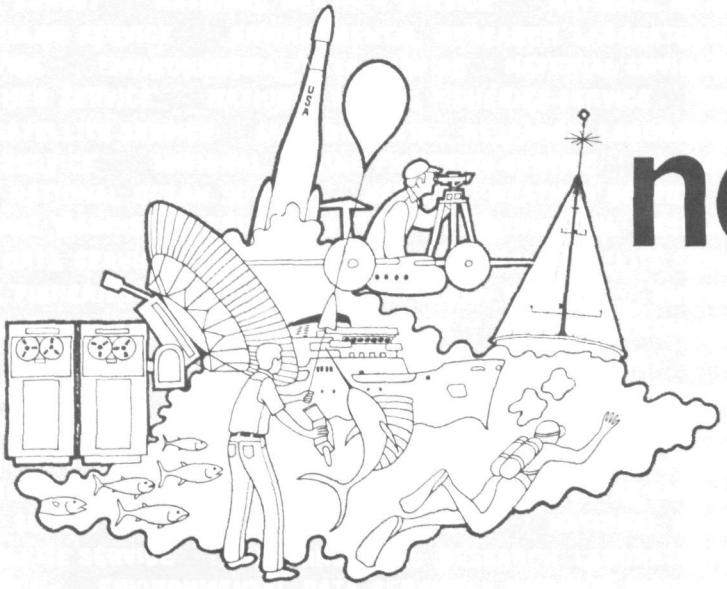
1 can (1 pound) salmon
½ cup chopped onion
¼ cup melted fat or oil
⅓ cup salmon liquid
⅓ cup dry bread crumbs
2 eggs, beaten
¼ cup chopped parsley
1 teaspoon powdered mustard
½ teaspoon salt
½ cup dry bread crumbs
⅓ cup mayonnaise or salad dressing
1 tablespoon chopped sweet pickle
6 buttered hamburger rolls

Drain salmon, reserving liquid. Flake salmon. Cook onion in fat until tender. Add salmon liquid, crumbs, egg, parsley, mustard, salt, and salmon; mix well. Shape into 6 burgers. Roll in crumbs. Fry in hot fat in a heavy fry pan about 4 inches from hot coals for 3 minutes. Turn carefully and fry for 3 to 4 minutes longer or until brown. Drain on absorbent paper. Combine mayonnaise and pickle. Place burgers on bottom half of each roll. Top with approximately 1 tablespoon mayonnaise mixture and top half of roll. Serves 6.

GRILLED SOLE TURNOVERS

4 pounds sole fillets or other skinless fish fillets, fresh or frozen
6 slices sharp cheese (1 ounce each)
½ cup melted butter or margarine
½ cup lemon juice
1 tablespoon salt
2 teaspoons paprika
½ teaspoon pepper
Lemon wedges

Thaw frozen fillets. Cut fillets into 12 portions. Place ½ slice cheese on one end of each piece of fish. Fold the other end of the fish over the cheese. Place turnovers in a single layer in well-greased, hinged wire grills. Combine remaining ingredients except lemon wedges. Brush fish with sauce. Cook about 4 inches from moderately hot coals for 5 to 8 minutes. Baste with sauce. Turn. Cook for 5 to 8 minutes longer or until fish flake easily when tested with a fork. Serve with lemon wedges. Makes 12 servings. Sole turnovers can be served on buns as fishburgers.



news from NOAA

R.M. White Becomes NOAA Administrator As President Names Five to Top Positions

The President's nominations to five top NOAA posts—Dr. Robert M. White as NOAA Administrator; Howard W. Pollock, Deputy Administrator; Dr. John W. Townsend, Jr., Associate Administrator; Rear Admiral Don A. Jones, Director, National Ocean Survey; and Rear Admiral Harley D. Nygren, Director, NOAA Corps—were confirmed by the Senate, February 19.

Dr. White, who had served as Acting Administrator after NOAA's formation, headed the Environmental Science Services Administration from 1965-1970. He holds a bachelor's degree in geology from Harvard University and master's and doctor's degrees in meteorology from the Massachusetts Institute of Technology. He worked on meteorological research and development projects at the Air Force Cambridge Research Center, the Massachusetts Institute of Technology, and The Travelers Insurance Companies, and was President of The Travelers Research Center, Inc., at the time of his appointment in 1963 as Chief of the Weather Bureau—now NOAA's National Weather Service. Dr. White was a member of the Commission on Marine Science, Engineering and Resources which—in its 1969 report, "Our Nation and the Sea"—proposed a program to assure the development of a national capability in the ocean to meet future demands.

Howard Pollock was elected Congressman at Large for the state of Alaska in 1966 and served two terms. He was a member of the House Committee on Merchant Marine and Fisheries, subcommittees on Fisheries and Wildlife Conservation and on Oceanography, and in 1970 was Chief Negotiator of the International Fisheries Agreements at Seoul, Korea, concerning protection of anadromous fisheries in the Northeast Pacific off Alaska. Mr. Pollock has a Doctor of Jurisprudence degree from the University of Houston and a master's degree in industrial management from the Massachusetts Institute of Technology. He served with the Merchant Marine in 1936-37 and in the U.S. Navy during World War II. An Alaskan homesteader in the late 1940's and early 1950's, he has had a varied career in business and government. In 1955, he was named one of the Ten Outstanding Young Men of the United States by the U.S. Junior Chamber of Commerce, and is also a recipient of the George Washington Honor Medal from the Freedoms Foundation.

Dr. Townsend had been serving as Acting Associate Administrator of NOAA, and was Deputy Administrator of ESSA for the previous two years. Before joining ESSA in 1968, he had been with the National Aeronautics and Space Administration for ten years, the last three as Deputy Director of Goddard Space Flight Center. During World War II, he served as an officer in the Air Force. He holds bachelor's and master's degrees in physics and an honorary Sc.D. from Williams College. From 1949 through 1955, he worked at the Naval Research Laboratory, conducting basic research on the very high atmosphere. He became Deputy Science Program Coordinator of Project Vanguard, directing the preparation of scientific instrumentation for two of the original earth satellites. In 1963, he won the Arthur S. Flemming Award as one of the Ten Outstanding Young Men in the Federal Service.

Rear Admiral Jones was appointed Acting Director of the National Ocean Survey on October 26, 1970. He had been Director of ESSA's Coast and Geodetic Survey since 1968. Prior to that, he was Associate Administrator of ESSA. Born in Waldron, Mich., he joined the Coast Survey after graduating from Michigan State University in 1933. During World War II, he served with the Coast Artillery and the Office of Strategic Services, going from the rank of ensign to lieutenant commander. Returning to the Coast Survey, he served at sea and in charge of geodetic surveys. In 1957, he was transferred to the State Department as project chief

Tornadoes Take 113 Lives in One Day; Weather Service Stresses Preparedness

The tornado death toll of 113 on a single day in 1971 far exceeds the total for the entire year of 1970, when 73 fatalities were reported.

On Sunday afternoon, February 21, an outbreak of tornadoes struck the states of Mississippi, Louisiana, and Tennessee. Aerial surveys of the damaged areas disclosed three exceptionally long tornado tracks, varying in width from one-fourth to one-half mile.

One 159-mile track began near Cary, Miss., passed near Belzoni, Greenwood, and Oxford, and ended near Abbeville, Miss. Another tornado first touched down near Delhi, La., and left a 102-mile path of devastation through Delta City, Inverness, and Moorhead, to Schalter, Miss. The third major track extended from Bovina to Lexington, Miss., a distance of 69 miles. There were also several other confirmed tornadoes of shorter duration.

NOAA's National Weather Service is continuing its SKYWARN program in 1971, to tell citizens how to protect themselves from these vicious storms. Most tornadoes are first sighted by private citizens, frequently by volunteer spotters who serve as the Weather Service's "eyes" across large areas of the country. There are thousands of public-spirited spotters organized into networks that report tornadoes to the Weather Service or other official warning centers. One aspect of SKYWARN is to recruit more spotters where needed.

Dr. George P. Cressman, Weather Service Director, says: "While tornado damage to property may be inevitable, large death tolls are not. I am convinced that preparedness programs such as SKYWARN can save many lives that otherwise would be lost."

Six hundred and fifty tornadoes struck the United States in 1970 and 73 persons were killed, the Environmental Data Service reports.

Texas, Oklahoma, and Florida had the highest incidence, with 121, 50, and 46 tornadoes respectively. Only seven states—Alaska, Delaware, Hawaii, Idaho, Maryland, Rhode Island, and Wyoming—had none at all.

The highest 1970 death toll was in Texas, where twisters took 51 lives. Oklahoma had six fatalities, and Mississippi five, although the latter state had far fewer tornadoes than Florida, where no deaths were recorded.

The number of reported tornado fatalities has dropped over the past 40 years. On the average, from 1930 to 1949, there were 222 deaths per year, compared with the 1950-70 average of 118 deaths annually. The high for killer-storm deaths in the 1950-70 period was in 1953, when 516 people perished; the lowest came in 1962, when 28 persons died. The greatest annual number of tornadoes in the same period was 912, recorded in 1967.

In contrast to the downward trend in tornado deaths, property damage figures have increased sharply. Since 1965, the annual economic cost of tornadoes in the United States has soared to $50 million or more. Before 1965, property damage reached that high only twice, in 1957 and 1953. Dense population concentration and settlement of formerly rural areas undoubtedly contribute to the jump in property damage.

President Asks $333 Million For NOAA in '72

The first consolidated budget for the National Oceanic and Atmospheric Administration was presented to Congress in the President's budget message, January 29, 1971.

Appropriations requested for NOAA in Fiscal Year 1972 totaled $333,900,000, an increase of $43,537,000. An additional 824 positions were requested, which would bring NOAA's authorized complement to 12,742.

Programs for which increased funds were asked include the tropical experiment in the Atlantic, the International Field Year for the Great Lakes, acquisition of the Geostationary Operational Environmental Satellite (GOES) system, expanded operational and research programs in air and water pollution, the marine monitoring and assessment program (MARMAP), surveying and mapping of continental shelves and deep ocean basins, short-range forecast improvement, and initiation of a program to use submersible systems for deep exploration.

Continued from page 58

for geodetic control surveys in Ethiopia, remaining there until 1961. His work in Ethiopia brought him the Department of Commerce's Exceptional Service Award. He became Associate Director of the Coast Survey for Hydrography and Oceanography and, on January 1, 1967, was appointed Associate Administrator of ESSA by Administrator Robert M. White.

Rear Admiral Nygren, formerly Associate Administrator of ESSA, had been Acting Director of the NOAA Corps since October 27, 1970. He was graduated from the University of Washington in 1945, and received a degree in mechanical engineering from that institution in 1947. During World War II, he served in the Navy as an enlisted man. He joined the Coast Survey in 1947. During his tour of duty with the Coast Survey, Rear Admiral Nygren served on numerous geodetic field parties, and on ships from the Arctic to the Antarctic. In 1959, he returned to the University of Washington for a one-year course in oceanography. In 1962, he was named Assistant Chief of the Coast Survey planning staff, and was appointed Chief in 1964. Upon the

formation of ESSA in 1965, he was appointed Deputy Director and Chief Planning Analyst for Service Programs in the Office of Planning and Program Evaluation. He commanded the USC&GSS SURVEYOR from 1966 to 1968.

FOUR APPOINTED TO MAJOR NOAA POSTS

Several major appointments have been made as component organizations are realigned within NOAA.

Howard Eckles, formerly Acting Director of the Interior Secretary's Office of Marine Affairs, has been named Assistant to the NOAA Administrator, for marine-related matters. In his previous post, Mr. Eckles represented the Interior Department on several interagency committees, including the Committee for Policy Review of the National Council for Marine Resources and Engineering Development. His office was involved in planning for coastal zone research and management, the International Decade of Ocean Exploration, and other interdisciplinary programs.

Dr. James W. Miller, who was Director of Ocean Technology and Program Manager for Tektite II, in the Department of Interior, is now Special Assistant to the NOAA Assistant Administrator for Environmental Systems. The Tektite II project, in which 54 aquanauts lived for various periods in an undersea habitat in the Virgin Islands, was successfully completed in November 1970. Dr. Miller holds a doctorate in psychology and was Director of Engineering Psychology with the Office of Naval Research before transferring to the Interior Department.

John M. Patton, Jr., formerly Assistant Director for Administration of the National Marine Fisheries Services, is now Special Assistant to the NOAA Assistant Administrator for Administration and Technical Services. He aided in the transfer of administrative activities from the former Bureau of Commercial Fisheries to NOAA headquarters. Now, he is leading a consolidation of the administrative activities of two NOAA field offices at Seattle.

The Regional Administrative Services Office of the National Marine Fisheries Service, and the Administrative Services Office of the Ocean Survey's Pacific Marine Center, are to be consolidated into a single NOAA office serving both components. This consolidation is a pilot project to determine the feasibility of regionalized administrative services offices for NOAA.

John W. Padan has been appointed Director of the Marine Minerals Technology Center in Tiburon, California. He had been Acting Director of the Center since April 1970. Mr. Padan, who holds bachelor's and master's degrees in mining engineering, has been associated with the Marine Minerals Technology Center's program since 1964, both at the Center and as a programming officer on the staff of the Bureau of Mines' Director of Mining Research, under whose direction the Center operated until its transfer to NOAA.

Lake Effect Snow Project Tests Model, Seeding Agents

Snow modification studies, conducted by the Environmental Research Laboratories in a cooperative effort with New York research organizations, concentrated this year on development of a safe, effective technique for controlling intense lake-effect snowstorms.

Lake-effect snowstorms form when intensely cold air flows over the still unfrozen warmer waters of the Great Lakes, picking up heat and moisture from the water and producing bands of precipitating clouds along the downwind shores. The relatively local phenomenon produces as much as 100 inches of snow a year on the eastern and southern shores of Lake Erie.

According to Dr. Helmut Weickmann, director of the Atmospheric Physics and Chemistry Laboratory: "In the past years of study in western New York, we have proven our basic hypothesis—that lake-effect storms can be artificially seeded to produce lighter and more numerous snowflakes that drift farther inland." This year's project was designed to test the computer model of lake-effect storms, to learn more about the role a major city plays by inadvertently seeding snowstorms, and to compare the effectiveness of different seeding agents.

Four techniques of seeding were evaluated—flares which burn leaving a trail of silver iodide smoke; an aircraft-mounted "jet-engine-type" burner which puts out an exhaust of silver iodide smoke; a hopper/crusher that spews fine chunks of dry ice (carbon dioxide); and a flare system that burns lead iodide.

Two DC-6's, operated by NOAA's Research Flight Facility did the dry ice and silver iodide burner test seedings and measured the ice in the cloud after the seeding. Cessna aircraft from the Naval Weapons Center, China Lake, California, released the silver iodide and lead iodide flares. A smaller Aztec aircraft operated by Cornell Aeronautical Labs, aided in the analysis.

The actual seeding during these tests lasted only a few minutes as each aircraft seeded a parallel 10-mile-long strip of cloud. The effects of this comparative seeding research were sufficiently minimal that actual changes in precipitation on the ground were not detectable.

The computer model of lake-effect storms was developed by Professor Ronald Lavoie of Pennsylvania State University and by scientists of the Cornell Aeronautical Laboratories under NOAA contract. With temperature data taken from the real atmosphere and the lake surface, the computer can predict an actual storm's behavior and the effect of seeding on the storm. Refinements in the model, tested this year, include an attempt to predict precipitation rates of natural snowfall and the effects of seeding on the type of snow crystal formed.

Data gathered in the 1970-71 winter season should fill in missing pieces. For example, comparison of natural snowfall near a relatively unpopulated region and that downwind of the metropolitan area may elucidate the role of the city itself in seeding storms.

"We hope," says Weickmann, "that this winter's data will take us still further toward how best to seed and how best to predict the snowfall from the lake-effect storm."

Air Pollution Services Planned

A five-year plan for improving weather services to Federal, state, and local air pollution control agencies was published in January by NOAA's Federal Plans and Coordination Division.

Dr. Robert M. White, Federal Coordinator for Meteorological Services and Supporting Research, said the plan is aimed at specific meteorological services to support air pollution control activities on an urban scale.

A major feature of the plan is the establishment of specially trained and equipped air pollution meteorologist teams to provide expert weather advice to pollution control agencies. Five such teams are already in the field, stationed at St. Louis, Chicago, Philadelphia, New York City, and Washington, D.C. The plan calls for establishment of 21 additional units by mid-1974, to be located at Los Angeles, Pittsburgh, Cleveland, Houston, Seattle, Denver, Louisville, Boston, San Francisco, Portland (Oreg.), Charleston (W. Va.), Detroit, Buffalo, Birmingham, Knoxville, Phoenix, Salt Lake City, Atlanta, Albuquerque, New Orleans, and Milwaukee.

Also high on the list of meteorological support priorities is the establishment of a special unit within the Weather Service's National Meteorological Center, to give full-time service to air pollution support activities.

Other areas of potential improvement in meteorological services provided to air pollution control agencies include the development of better weather sensing devices, forecasting techniques, and information dissemination.

Details of the long-range program are included in the new "Federal Plan for Air Pollution Control Meteorological Services," developed by the Federal Coordinator with the advice and assistance of NOAA and the Air Pollution Control Office of the Environmental Protection Agency.

University To Analyze Fisheries Under Million-Dollar Sea Grant

A $1.1 million Sea Grant was awarded to the University of Washington in January.

The funds from NOAA and the university will make possible expansion of the university's Sea Grant program into its fourth year. One-third of program costs will be matched by the university from non-Federal sources.

The University of Washington's Sea Grant activities have three major emphases—research and development, education and training, and advisory services.

With the new grant from NOAA, the university's researchers will undertake a project dubbed NORFISH, which will attempt to develop a total systems analysis of the North Pacific fisheries, something never before attempted. NORFISH will join the fishing industry, government agencies, and the universities of the Pacific Northwest in an innovative effort directed toward conservation of fishery resources and the utilization of these resources by the U.S. fishing industry.

In the first year of NORFISH, the sea grantees will concentrate on systems development, planning the resources to be used in the study, and developing computer knowledge and techniques necessary to the project.

Other major sea grants were awarded to the New York Zoological Society's Osborn Laboratories of Marine Sciences and to the Oceanic Institute, Waimanalo, Hawaii. In a three-year, $209,000 project, Osborn Laboratories will seek to extract and test antibacterial agents from sponges. The Oceanic Institute, with a $61,350 grant, will design a Manned Open Sea Experiment Station for collecting and harvesting living resources, monitoring pollution, and bringing up nutrient-rich water from great depths.

Aubert Is U.S. Leader for Great Lakes Study

Dr. Eugene J. Aubert has been named U.S. Director of the International Field Year for the Great Lakes (IFYGL).

IFYGL is a joint U.S.-Canadian research program, a part of the International Hydrological Decade, for which NOAA has been designated U.S. lead agency. Its objective is to develop a sound scientific basis for water resource management on the Great Lakes, leading to improved solutions to problems of water quality and quantity.

As Director of the U.S. program, Dr. Aubert will be responsible for planning and executing the interagency program, and working with his Canadian counterparts in the international aspects of the program.

Dr. Aubert comes to NOAA's Office of Environmental Systems from the Center for Environment and Man, Hartford, Conn., where he was Director of Atmospheric Resources Management, in charge of research into weather and climate modification, management of human activities to maintain atmospheric quality, and studies of the impact of weather on human activities.

From 1960 to 1969, he was a Vice President of The Travelers Research Center, Inc., Hartford, Conn., and Director of the Atmospheric and Oceanographic Sciences Department.

Dr. Aubert attended Montclair State College, Montclair, N.J., and Massachusetts Institute of Technology. He later received both B.S. and M.S. degrees from New York University, and his Ph.D. from M.I.T. in 1957. He spent four years as Aerological Officer with the U.S. Navy, and served from 1947 to 1951, as research meteorologist with the Extended Forecast Section, U.S. Weather Bureau (now National Weather Service) in Washington, D.C. He then joined the Geophysics Research Directorate, Air Force Cambridge Research Center.

Initial planning for IFYGL has been carried out by the National Committee for the International Hydrological Decade within the National Research Council. Encompassing physical, biological, and chemical studies of the waters of Lake Ontario and its basin, IFYGL findings will benefit not only science, but also the 35 million U.S. and Canadian citizens who now live along the shores of the Great Lakes, and the 70 million expected to live there by the end of the century.

NOAA Studies Heavy Metals In Fish Catch

A program to define the problems of marine contaminants in fish and fishery products has been announced by NOAA Administrator Dr. Robert M. White.

In a speech before the National Canners' Association, Dr. White said the National Marine Fisheries Service has stepped up research in contaminants. In doing so, he said, it is working closely with the Food and Drug Administration, and industry.

NMFS is seeking to define more clearly the nature and extent of heavy metal contaminants in fish found in coastal and offshore waters. A systematic survey is being undertaken of major commercial and sports species supplied from commercial boats and NOAA research vessels.

Delineation of heavy metal contamination in fishery stocks will be based on differences due to species, age, and geographic location of catch.

NMFS also has initiated a research effort to determine the effects of heavy metals on the physiology and mortality of fish and shellfish, and will seek to relate levels of heavy metals found in fish to levels found in the processed product.

Dr. White said that an initial screening survey had begun of more than 30 fishery products—domestic and imported—to determine if, and to what extent, heavy metals are present. It includes fishery products harvested in waters off all U.S. coasts, as well as in Mexican, Caribbean, and Canadian waters, and other locations. It is hoped that this will uncover actual or potential problem areas for more detailed study.

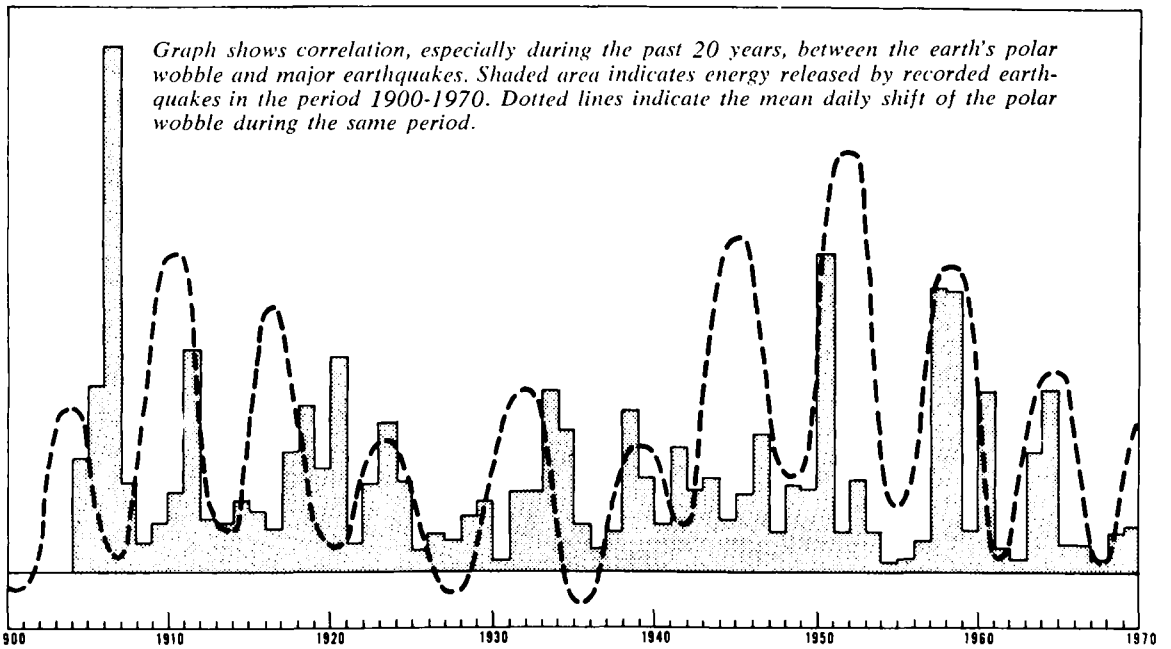
Nearly all of the first 200 samples tested were below the FDA guideline of .5 parts per million of mercury. The samples included 30 tuna from African waters, and only three had mercury content exceeding the guideline. The highest level of mercury found in these was .7 parts per million. Species tested from which all samples were below the FDA guideline were: North Pacific salmon; North Atlantic and Pacific cod; North Pacific hake; North Atlantic and Pacific sole; Chesapeake Bay clams; North Atlantic haddock; North Pacific halibut; Central Atlantic shrimp; and fishmeal made from Central Atlantic and Gulf menhaden and herring.

Turning to a second environmental problem, Dr. White warned that a lack of management mechanisms and a multitude of conflicting uses of estuarine waters has endangered a vital natural resource.

"There is ample evidence that the management void which afflicts our estuaries has created a situation resulting in extensive damage to many of these priceless resources.

"Problems and conflicts associated with increasing use of the marine environment are growing," he said. "Man is changing and planning to change our coastal zone areas, which support at least 80 percent of U.S. commercial fish resources and most of its recreational fishery resources. Most of the degradation is going on in a seemingly unplanned way with the actions of one segment of our society having definite, but often little-known effects on other segments."

Peak in Polar Shift May Bring Major Quakes



Graph shows correlation, especially during the past 20 years, between the earth's polar wobble and major earthquakes. Shaded area indicates energy released by recorded earthquakes in the period 1900-1970. Dotted lines indicate the mean daily shift of the polar wobble during the same period.

National Ocean Survey seismologists are alert for a possible increase in major earthquakes during 1971.

According to Charles A. Whitten, the Survey's chief geodesist, "the year 1971 should be a critical year. This is the year in the seven-year cycle of the earth's wobbling when the daily shift of the pole reaches its maximum."

The earth wobbles slightly as it spins in space and as it does so, its north-south axis of rotation shifts. The maximum range of the polar shift is 72 feet over a 14-month period. The axis zigs and zags around the geographical North Pole in a generally circular motion, shifting as much as six inches per day.

The NOAA geophysicist noted that major earthquakes in 1950 and 1957, and again in 1964, when the great Alaskan earthquake occurred, coincided with years of maximum polar motion. Whitten believes there is a definite correlation between earthquakes and polar motion at various periods when the polar shift reached its maximum. This is especially notable over the past 20 years. "The correlation between the total energy release and the daily movement of the pole during the past 20 years is so strong," he stated, "that I intend to keep 'tuned in' for the next year or two, inasmuch as the daily movement of the pole is increasing and the number of fairly large earthquakes has increased. Most of the major earthquakes in the last 20 years occurred during, or close to, the peak years."

Whitten added that in the half-century prior to that, in those years where a correlation is not definitely shown between major earthquakes and the maximum polar shift, this may be partially due to the inadequate acquisition of data in early years of seismic recording.

California Earthquake Deaths Are First in U.S. Since 1965

The earthquake that rocked southern California on February 9 had a magnitude of 6.6 on the Richter scale, the National Earthquake Information Center reported.

The 64 deaths caused by this earthquake were the first in the United States since 1965, when seven persons died in a Seattle earthquake.

In 1970, 238 earthquakes were felt in the United States. Of these, 130 were felt in California, and 68 in Alaska.

Seismologists at NEIC said the U.S. earthquakes from 1966 to 1970, when there were no fatalities, did not occur in heavily populated areas. The southern California earthquake pointed up the inevitable result of the buildup of populated areas in earthquake-prone regions: the greater danger of fatalities when earthquakes strike.

In a recently published NOAA report—"The Santa Rosa, California, Earthquakes of October 1, 1969"—structural engineer Karl V. Steinbrugge warned that some high-rise buildings in western United States cities could collapse in a great earthquake. Because certain code requirements for design of earthquake-resistant high-rise structures have not kept pace with changing construction practices, Mr. Steinbrugge stated, it is possible to design extremely hazardous structures that meet legal requirements. To prevent a major disaster, he urged local governments to correct inadequacies in their building codes and to eliminate hazards that now exist even in structures conforming to present regulations.

"A designer who follows the letter of the law as expressed in the building code, but lacks experienced judgment when extrapolating code values to new types of structures, can inadvertently design a collapse-hazard structure which is legally safe," the report explained. "Collapse is more probable today than it was several decades ago, before changed practices had reduced a structure's uncounted strengths."

Donald A. Denion has been named Special Assistant to the NOAA Assistant Administrator for Administration and Technical Services. Mr. Denion's most recent post was chief of the General Services Branch, Administrative Operations Division.

Conway G. Lenz, now Acting Chief, General Services Branch, was formerly the Assistant Chief, Division of Procurement and General Services, National Marine Fisheries Services.

Robert E. LeClerg has been appointed Acting Assistant Chief, Administrative Operations Division. Previously, he was chief of the Division of Safety Management in the Fisheries Service.

A. Newton Page, chief of the Management Systems Division in Adtech, is the leader of a project to develop a new NOAA cost accounting and budgeting system. Mr. Page heads a team of system accountants, budget analysts, and management and system analysts, designing the systems and procedures required to implement the cost accounting and budgeting system approved in concept by the General Accounting Office.

Dr. George H. Keller, Director of the Atlantic Oceanographic and Meteorological Laboratories' Marine Geology and Geophysics Laboratory, has been appointed to the Joint Oceanographic Institutions for Deep Earth Sampling Advisory Panel on Sedimentary Petrology and Physical Properties.

Dr. Hyman Orlin, Special Assistant to the Director of the National Ocean Survey for Earth Sciences, has been awarded the Kaarina and Weikko A. Heiskanen Award for 1970 by Ohio State University. Dr. Orlin was judged the individual "who has most successfully forwarded the cause of geodesy and strengthened the reputation of the (Ohio State) Department of Geodetic Science in the field of geodesy."

Leonard E. Peterson has been named Official in Charge of the Weather Service's facility at Duluth, Minn. Mr. Peterson has been with the NWS for 14 years. He transferred to Duluth from Sault Ste. Marie, Mich., in 1960.

Cdr. James S. Midgley has been named Chief of the Processing Division at the National Ocean Survey's Pacific Marine Center, Seattle. Cdr. Midgley was formerly Executive Officer of the NOAA Ship PATHFINDER. He joined the commissioned corps in 1959.

Lt. Thomas E. Gerish, who formerly served on the hydrographic survey ship HYDROGRAPHER and on the NOAA Ships DAVIDSON and MT MITCHELL, is the new Executive Officer of the NOAA circulatory survey ship FERREL. Lt. Gerish joined the commissioned corps in 1966.

Lt. Cdr. James M. Wintermyre has been appointed Projects Officer at the National Ocean Survey's Pacific Marine Center, Seattle. Lt. Cdr. Wintermyre joined the commissioned corps in 1964. He has since served aboard the ships HODGSON, PATHFINDER, RAINIER, and FAIRWEATHER and with satellite triangulation and airport survey teams.

Cdr. Melvin J. Umbach is now Chief of the Photogrammetry Division at the National Ocean Survey's Atlantic Marine Center in Norfolk. Cdr. Umbach was formerly Commanding Officer of the NOAA Ship WHITING. He has served with the NOS and its predecessor the Coast and Geodetic Survey for almost 12 years.

Lt. Cdr. Walter F. Forster II has been appointed the new Operations Officer of the NOAA Ship PATHFINDER. For the past two years, Lt. Cdr. Forster has served with astronomic, triangulation, and leveling parties in the field.

Cdr. Wesley V. Hull is the new National Ocean Survey liaison officer with the Army at Fort Sill, Okla. He was previously Executive Officer of the NOAA Ship OCEANOGRAPHER.

C. Peter Marini, General Radio Inspector for the Coast Guard Auxiliary and a Courtesy Motorboat Examiner and Instructor, recently joined NOAA's General Services Branch as a Communications Specialist.

Lt. Cdr. Ned C. Austin, Naugatuck, Conn., is the new chief of geodetic field party G-23. The 18-man group is headquartered in Pompano Beach, Fla., conducting triangulation surveys of Palm Beach and Broward Counties.

John B. Glude, National Marine Fisheries Service Associate Regional Director for Management and Utilization, is serving as a consultant on shellfish and aquaculture with the South Pacific Islands Fishery Development Agency of the Food and Agriculture Organization of the United Nations. Mr. Glude expects to return to his duties with NMFS in Seattle about July 6.

Herbert L. Blatt and **Richard M. Parsons,** formerly of the Office of the Solicitor, Department of the Interior, have transferred to the Office of the General Counsel, National Oceanic and Atmospheric Administration. They have been assigned to handle legal matters for the National Marine Fisheries Service.

John Sossamon and **Charles Baker** are now officials in charge of Weather Service Offices in the Alaska Region. Mr. Sossamon heads the office at Shemya, Alaska. He formerly served with the NWS at Asheville, N.C.; Nome, Barter Island, and Anchorage, Alaska. Mr. Baker heads the Nome, Alaska, Weather Service Office. His experience includes service with the NWS at Eugene, Oreg.; Bethel, Yakutat, Juneau, and Cold Bay, Alaska. He has been stationed at Alaska Region headquarters for the past four years.

Charles Roberts, of the National Weather Service's Overseas Operations Division, was recently designated an Antarctic Treaty Observer by the Department of State. Mr. Roberts and a party of six inspectors visited a number of foreign stations in Antarctica during February and March.

Lt. John P. Vandermeulen is the new Operations Officer of the Seattle-based NOAA Ship OCEANOGRAPHER. Lt. Vandermeulen served previously as Operations Officer on the RAINIER and the SURVEYOR.

Ralph A. Schoenberg has been appointed chief of the Division of Financial Assistance for the Southeast Region of the National Marine Fisheries Service. The Division of Financial Assistance administers programs to assist commercial fishermen in financing the purchase and repair of vessels and equipment. Mr. Schoenberg has served as regional financial loan examiner for the past four years.

Cdr. Raymond L. Speer is the new Executive Officer of the Seattle-based NOAA Ship RAINIER. He was most recently Operations Officer aboard the NOAA Ship SURVEYOR. Prior to that assignment, he was Chief of the Flight Operations Group in Rockville Md.

Cdr. Sidney C. Miller has become the new Executive Officer of the Seattle-based NOAA Ship PATHFINDER. Cdr. Miller was previously the National Ocean Survey's liaison officer with the Army at Fort Sill, Okla., where he served in an advisory capacity to Army artillery units on geodesy.

Dr. Vernon E. Derr, Director of the Wave Propagation Laboratory's Atmospheric Spectroscopy Program, has been named Acting Director of the Laboratory in the absence of Dr. C. Gordon Little. Dr. Little is on a one-year assignment in Melbourne, Australia, to work with Dr. C. H. B. Priestley, head of the Commonwealth Scientific and Industrial Research Organization.

Commander Charles K. Townsend, Chief of the Office of Plans and Programs' Solid Earth Division, recently received a temporary promotion to the rank of Captain.

Dr. Leroy Alldredge has been named Director of the Postdoctoral Program of NOAA's Environmental Research Laboratories.

Dr. Helmut K. Weickmann, Director of ERL's Atmospheric Physics and Chemistry Laboratory, has been honored with the 150th Anniversary Medal of Leningrad University for his work in organizing international conferences on cloud physics and related subjects.

Miss Marie D. Fellechner, former radar meteorologist at Washington National Airport, has become the NWS Eastern Region's second woman meteorologist in charge and the first woman to be placed in charge of a weather radar station in the country. Miss Fellechner heads the radar facility at Patuxent, Md.

Roland D. Paine, Jr., formerly Public Information Officer for the National Science Foundation, has joined NOAA's Office of Public Information as the Public Affairs Officer for Oceanic Programs.

C. Doyle Innis has been named Executive Officer and Chief of the Executive Support Staff of the National Marine Fisheries Service. Mr. Innis's former position was as NMFS Deputy Assistant Director for Administration.

Captain Jack E. Guth of the NOAA Corps has been named Chief of NOS' Photogrammetry Division. Capt. Guth was formerly Chief of the Ship Facilities Group.

Allen D. Cummings is now the Techniques Improvement Meteorologist on the scientific staff of the National Weather Service's Southern Region headquarters, Fort Worth, Tex.

Finn A. Johnson has become the official in charge of the National Weather Service Office at LaCrosse, Wisc. Prior to his new assignment at LaCrosse, he served at Duluth and Chicago.

Dr. Virgil J. Norton has been named Deputy Assistant Director for Economics in the NMFS. For the past two years, he has served as chairman of the Department of Food and Resource Economics at the University of Rhode Island in Narragansett. Prior to that, he was Chief of the Division of Economic Research for NMFS.

Captain Robert C. Munson has been appointed commanding officer of the NOAA Ship DISCOVERER. For the past three years, he has been director of NOS' Honolulu Field Office and head of the International Tsunami Center.

Commander Richard H. Houlder has assumed command of the hydrographic survey ship FAIRWEATHER. Cdr. Houlder has been Chief of NOS' Photogrammetry Division for the past two years.

Ernest O. Schutter has been appointed to head the NWS Newark, N.J., Office, succeeding Carl Boethling, who retired. Mr. Schutter, a veteran of 22 years' service with the weather service, came to Newark from Bridgeport, Conn., where he had served as a weather service specialist.

Nelson J. Norem has been designated Acting Chief of the National Marine Fisheries Service's Office of Planning.

New U.S., Soviet Space Agreement Under Negotiation

Arthur W. Johnson, Deputy Director of the National Environmental Satellite Service, was a member of the U.S. delegation that met with Soviet representatives in Moscow, January 19-21, to discuss revisions to the 1961 bilateral space agreement between the two countries. The negotiations centered on further cooperation in meteorological sounding rockets, exchange of lunar samples, studies of the natural environment, and expanded exchange of data. Agreement was reached on improvement of facilities for prompt, high-quality exchange of meteorological satellite data.

First Sea Boundary Maps Issued

The first five in a series of 400 maps of Florida's seaward boundaries have been published by the National Ocean Survey. When the six-year program is completed, the maps will provide the first detailed coverage of a state's seaward boundaries.

Construction of the maps is unique. A combination of planimetric mapping, nautical charting and photomosaic techniques are employed to produce these highly precise special purpose maps. Features normally shown on National Ocean Survey nautical charts, such as the mean high-water line and mean low-water line, are depicted by the standard charting symbols except that they are shown in red. Tidal waters are shown in blue, and the onshore interior information is shown by distortion-free aerial photographs in tones of grey. The assembly presents a striking appearance; to the user it resembles a giant aerial photograph where individual buildings, trees, etc., are readily identified and the seaward boundary aspects are emphasized by colors.

The mapping program, which began in 1969, is being carried out by the National Ocean Survey, The Trustees of the Internal Improvement Trust Fund, and the Florida Department of Natural Resources with the costs being borne equally by the state and federal governments. The state determines the priority assigned to each section or region surveyed. The program calls specifically for the mapping of the mean low-water and the mean high-water lines along the tidal waters of the state.

At stake is the ownership of coastal and offshore lands which at one time or another are covered by the tide. The problem involves a determination of federal, state, and private boundaries. In coastal areas, the mean high-water line generally marks the boundary between state and private property, whereas the mean low-water line is the base line, or starting point, for determining the limits between federal and state ownership. The State of Florida claims ownership commencing at the mean high-water line and extending offshore three miles beyond the mean low-water line along the Atlantic coast and to the state's historic boundary not exceeding three marine leagues along the gulf coast.

Short-Term Forecasts Most Needed by Public, National Weather Service Director States

Construction in low areas creates disaster potential.

"The latest observation of the weather and a short-term local forecast" is what the public wants most from the weatherman, says Dr. George P. Cressman, National Weather Service director.

But, he adds, a listing beyond that contains "some surprises." For instance, a recent survey by the American Telephone and Telegraph Company revealed that there "is a psychological requirement for weather services. Apparently many people want the latest forecast simply because it reassures them. It shows that the U.S. Government is watching the weather and that bad weather will arrive and depart more or less on schedule."

Dr. Cressman's comments came in a speech January 14 at the annual meeting of the American Meteorological Society.

"The primary public requirement," said Dr. Cressman, is for "frequent and accurate forecasts containing the bare essentials 6 to 24 hours in advance, with emphasis on the first 12 hours." Longer-range forecasts are extremely important to industry and agriculture, he pointed out.

Speaking of the vital requirement for tornado, hurricane, and flood warnings, Dr. Cressman said population growth is producing a "potential for loss of property and life from these severe natural hazards that is frightening."

The Weather Service director noted that "a different kind of problem comes from hurricanes" because of "mushrooming construction of dwellings" in low-lying coastal areas. He pointed out that Dr. Robert H. Simpson, director of the Weather Service's National Hurricane Center in Miami, Fla., has warned recently that "some of this construction is taking place without the provision of adequate escape routes." Dr. Cressman said in some instances "12 hours at the most" might be "available for evacuation of great numbers of people . . . over inadequate low-lying roads or flimsy bridges" which could "become unusable at an early hour."

The Weather Service director said, "We have to find a way to reverse the trend toward needless exposure of people and property in known areas of danger. . . . A way must be found to ensure that usable evacuation routes are available or constructed when building permits are granted in large numbers for areas exposed to hurricanes or high water."

Sargeant Named to Global Program Post

Dr. Douglas H. Sargeant has been named special assistant for the Global Atmospheric Research Program in NOAA's Office of Environmental Systems.

The Global Atmospheric Research Program (GARP) is one of the two major thrusts of the World Weather Program, the other being the operational World Weather Watch. GARP includes a series of international experiments designed to acquire the increased knowledge of atmospheric processes needed to improve weather forecasts and extend them further in the future. NOAA is the lead agency for United States participation in GARP, which includes important contributions from other government agencies.

As special assistant to NOAA's Assistant Administrator for Environmental Systems, Dr. Sargeant will provide a focal point for coordinating United States positions for international meetings and for developing detailed scientific design and technological requirements of the Global Atmospheric Research Program.

An Associate Professor of Meteorology at the University of Wisconsin, Dr. Sargeant had been on loan since January 1970 to the National Academy of Sciences, serving as Executive Scientist to the United States Committee for the Global Atmospheric Research Program. He was Assistant Professor of Meteorology at the University of Wisconsin from 1965 to 1967, and then served for a year as the U.S. Representative at the International Antarctic Meteorological Research Center in Melbourne, Australia, before returning to the University as Associate Professor.

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